Influence of Textile Waste Water Irrigation on Yield and Heavy Metal Uptake by Jute, Rice and Vegetable Crops

Ph.D. THESIS

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Influence of Textile Waste Water Irrigation on Yield and Heavy Metal Uptake by Jute, Rice and Vegetable Crops

BY

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Declaration

I do hereby declare that the submitted thesis entitled " **Influence of Textile Waste Water Irrigation on Yield and Heavy Metal Uptake by Jute, Rice and Vegetable Crops"** has been composed by me and all the works presented herein are of my own experimental findings. I further declare that this work has not been submitted anywhere for any academic degree, prize or scholarship and not published anywhere in Bangladesh or abroad.

(Monoara Begum)

Dedicated to my

Beloved Father and Mother

Certificate

I have much pleasure to certify that the research work presented in this dissertation entitled **"Influence of Textile Waste Water Irrigation on Yield and Heavy Metal Uptake by Jute, Rice and Vegetable Crops"** has been performed by **Monoara Begum** in the experimental field and laboratory of Bangladesh Jute Research Institute and the Department of Soil, Water and Environment, University of Dhaka, Bangladesh. She accomplished all sorts of research activities under the direct instruction, supervision and guidance of us. The part of this dissertation has not been submitted to elsewhere for any degree or diploma. It is further certified that the work presented herewith is original and very suitable for submission for the award of the degree of Ph.D.

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Abstract

The experiments were carried out to observe the effect of textile waste water on yield and heavy metal uptake by jute, rice and vegetable crops at field of Bangladesh Jute Research Institute, Central Station, Dhaka. For pot experiment soils were collected from Narayanganj and Gazipur districts. The irrigation waste water was also collected from Narayanganj and Gazipur textile industrial areas. Treatments were- T_1 – Control, T_2- 100% RDF+ 0% TWW, T_3 – 50% RDF + 25% TWW, T_4 – 50% RDF + 50% TWW, T_5 – 50% RDF + 75% TWW, T_6 – 50% RDF + 100% TWW. And treatments for residual effects were - T_1 – Control, T_2- 100% RDF+ RE of 0%TWW, T_3 – 50% RDF + RE of 25%TWW, T_4 – 50% RDF + RE of 50% TWW, T_5 – 50% RDF + RE of 75% TWW, T_6 – 50% RDF + RE of 100% TWW. The objectives of the research work were: (1) To evaluate the characteristics of soil and water at different time and stages. (1) To study the effects of textile waste water on the growth and yield of crops. (2) To observe the effects of textile waste water irrigation on the properties of soil. (3) To determine macronutrient and heavy metal uptake by jute, rice and vegetable crops. (4) To observe the residual effects of textile waste water irrigation on soil and crop. (5) To make a suitable integrated dose for the cropping pattern. The high yielding jute variety Tossa (O -795) , T. Aman rice variety Binashail , newly developed BJRI deshi pat shak-1 variety, red amaranth variety Lolita were used in the experiments as test crops. The study showed that irrigation up to 50% textile waste water enhanced the different parameters of growth, yield of jute, rice and vegetables. The experiment also revealed that fresh water irrigation along with 100% RDF is better for the yield of jute, rice and vegetables as compared with textile waste water irrigation. Highest yield of jute, rice and vegetables were achieved with the T_2 . And among the different treatments of textile waste water irrigation T_4 gave the best yield, which was very close to the T_2 and saved 50% chemical fertilizer. Form the findings the integrated treatments may be ranked as $T_2>T_4>T_5>T_3>T_1>T_6$ and $T_2>T_4>T_5>T_3>T_6>T_1$ for jute leaves (pat shak) yield in non contaminated soils of Narayanganj and Gazipur respectively, $T_2>T_4>T_1>T_5>T_3>T_6$ and $T_2>T_4>T_5>T_1>T_6>T_3$ for jute leaves yield in contaminated soil of Narayanganj and Gazipur respectively, $T_2>T_4>T_5>T_6>T_3>T_1$ for fiber yield of jute, $T_2>T_4>T_5>T_6>T_3>T_1$ for grain yield of rice, $T_2>T_4>T_5>T_6>T_3>T_1$ and $T_2>T_4>T_5>T_6>T_3>T_1$ for yield of jute leaves and red amaranth in field. The study showed that in both contaminated and non contaminated soils highest nutrient

content N, P, S, Ca and Mg in leaves of jute leaves were found with T_2, and highest K content was found with T_4 and T_5. In field trial jute leaves content highest N and Mg with T_2, highest P and Ca with T_4, and K and S in T_5 respectively. In rice grain highest N, K and S were found with T_2, highest P, Ca and Mg with T_4, T_5, and T_6 respectively. In leaves of jute leave (pat shak) highest N, P, S, Ca and Mg with T_2, and K with T_5. In leaves of red amaranth highest N, P, K, S, Ca and Mg were found with T_2. The study revealed that heavy metal concentration in crops increased with the increasing of concentration of textile waste water. The highest concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn in all crops were found with T_6. The study indicated that nutrients, heavy metals and organic matter content of post harvest soil increased with the increasing level of the concentration of textile waste water irrigation up to 100%. In all post harvest soils the N, P, K, S, Ca, Mg , Zn, Cu, Ni, Fe, Cd, Cr, Pb, Mn and organic matter content were found maximum with T_6.

Due to the residual effects of textile waste water irrigation highest yield were obtained with T_2 and nearest highest yield were obtain with T_6. In non contaminated soil of Narayanganj the highest N, S, Ca and Mg were found in the leaves of amaranth with T_6, and highest P and K were observed in T_2. In non contaminated soil of Gazipur in leaves of red amaranth highest N, P, K, S, Ca and Mg content were found in T_2 . In contaminated soil of Narayanganj in leaves of red amaranth highest N, P, K, Ca were obtained with T_6. But highest S and Mg were found in T_2. In contaminated soil of Gazipur in leaves of red amaranth highest N, P, K, Ca and Mg were found with T_2 , but S found highest with T_6. The concentration of Zn, Cu, Fe and Mn in leaves of red amaranth were found highest in T_6. In post harvest soil, highest organic matter content was found in T_6, maximum content of N, P, S, K, Ca and Mg were found with T_2, and concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found maximum with T_6.

Research revealed that irrigation of 50% textile waste water enhances the yield of crops and vegetables for providing nutrients in it. Therefore, in a country like Bangladesh where fresh water irrigation is scarce, 50% textile waste water should be recommended priority to be used in jute, rice and vegetables cultivation. Which will also minimize the cost of fertilize, improve soil fertility and give higher yield. The study revealed that 50% textile waste water may be an alternative source of irrigation water in Bangladesh to produce crops. The findings also created an evidence that textile waste water may not a problem, rather its utilization may be enhanced agrarian production in Bangladesh.

CHAPTER - 1
INTRODUCTION

CHAPTER - 1

INTRODUCTION

1.1. Global position of Bangladesh and a review of boosting up the domestic textile industries

Bangladesh is situated at the northern part of South Asia between 20^0 84' and 26^0 38' north latitude and 92^0 4' east longitude with an area of 147570 sq. kilometers (Gani, 2014). The annual rainfall intensity is 1300 to 5000 mm and 90% of rain fall duration occurs in between March to October. The annual temperature ranges from 7.0 to 32^0 Celsius with a minimum range from 7^0 C to 12.77^0 C during winter (November to February) and maximum range of 23.88^0 C to 31.55^0 C during summer (Gani, 2014). It is a densely populated country and gradually increasing the population. As one of the most populous nations in the world with 162.9 million people in 2016, the country is acquainted as the seventh most populous country in the world with a population density of 1103 people per square km (BBS, 2019). In such a situation it needs to feed for increasing people, to create employment opportunity and diverse foreign currency earning way. In the past the country depends on the jute for earning foreign currency. Food sufficiency was also limited. The government of Bangladesh developed model switched from a state-sponsored capitalist mode of industrial development with mainly state-owned enterprises (SOE) to private sector-led industrial growth. Governmental commitment for strengthening the economy of country forwarded the establishment of industry. There by textile sector increased tremendously within few decades. These industries are spread throughout the country. In Bangladesh, the textile sector currently has an export value of nearly 28 billion USD per year which contributes about 82% of the country's total export earnings. It is projected that the annual ready-made garment (RMG) export value will be about 50 billion USD per year by 2021 (Maiko *et al.,* 2019). In spite of this achievement, they are causing threats to environment from different textile industries and commercial establishments posing serious adverse affect, particularly in urban and semi urban areas (Anwar *et al.,* 2010). It is urgent to keep our environment healthy by judicial use of textile waste water. The intention of this study to introduce textile waste water in different crops to mitigate the problems.

1.2. General background

Over the last few decades, enormous pressure has been exerted on the land resources of Bangladesh to meet the demand of its vast population for food and fuel. Due to intensification of agricultural land use for modern crop varieties, soil fertility has declined and deficiency of nutrient elements such as N, P, K, S, Zn and B has arisen (FRG, 2012). There is no doubt that chemical fertilizers are playing a vital role to meet the nutrient requirement of crops and thereby increase their production. However, recently the non- judicious use of chemical fertilizers is posing both economic and ecological problems, which are often difficult to face, particularly in developing countries (Sutton et al., 2011).

In Bangladesh, textile waste water effluents are being discharged at random without treatments directly to soil, canals, and rivers. The solid wastes are also used in land filling. They pollute our soils and natural water systems as well as ground water endangering human health, aquatic lives, and crop production in Bangladesh. In this regard alternative use may be an effort to solve this threat. There are references that textile waste water contain macro nutrients with some heavy metals like Cu, Zn, Pb, Cr, Cd, As, Hg, Mn, and Fe. Some of them are toxic to plants and some others to both plants and animals. There should have a study for future attention. Textile industrial waste water had significant effect on plant height and effective tillers per hill of Boro rice (Begum *et. al.*, 2011). In areas where irrigation water is scarce, the use of industrial wastewater is an important source for supplementing water resources. Furthermore, reuse may help alleviate industrial disposal problems by reducing the volume of industrial waste water involved. Different study therefore sought to evaluate the effects of textile waste water on growth, leaf biomass yield, and its effect on the fertility status of post harvest soil of Bangladesh.

Waste water irrigation has a long development history and has undergone different phase in developing and developed countries. Waste water irrigation currently plays an important role in water reuse and has developed dramatically and varying with economic and social development. According to the Food and Agriculture Organization FAO, untreated or partially treated waste water is applied in more than 20 million ha of land worldwide (Website 1). In recent years, waste water reuses has experienced very rapid growth in different parts of the world. Volumes of waste water reuse have increased 10-29% per year in Europe, the United States, and China and by up to 41% in Australia (Aziz and Farissi, 2014). More than 80% of treated waste water is reused for agriculture in Israel (Angelakis and Snyder, 2015). The organic matter content of industrial effluent is high and its addition to agricultural soils often improve soil physical properties (Antonious, 2009). Waste water and its nutrients and organic matter can be used extensively for irrigation to improve the nutrient and organic matter content of soil. Waste water irrigation affects crops based on water compositions and crops physiological mechanisms. Untreated waste water irrigation leads to heavy metals accumulation in crops and to the development of low quality agricultural products (Qadir *et al.,* 2010, Paranychianakis *et al.,* 2011). When proper treatments and management practices are adopted, waste water irrigation boost the growth of pea, cabbage, lettuce, alfalfa and tomato crops (Balkhair *et al.*, 2013; Biswas, 1991; Khandakar *et al.,* 2014). Recycling of waste water for irrigation purposes may not solve only the disposal problem but also serve as an additional source of the growing crops (Rajeev and Singh, 2015; Joshi *et al.,* 1996; Kannabiram and Harilal, 1992). But indiscriminate discharge of huge amount of waste water into natural water bodies or nearby area by the industries, which is a common practice in India, possess serious problems to cultivating fields specially of the area where fresh water scarcity, farmers are compelled to use the industrial waste water for irrigation without knowing the direct and long term impacts of waste water irrigation (Christou *et al.*, 2014). Recent years such practice is increasing in Bangladesh day by day.

Textile industry is one of the most important and rapidly developing industrial sectors in Bangladesh. It is the most important sector of Bangladesh's economy (Begum *et al.,* 2018). Textile industry release highly polluted and toxic waste waters which are discharged into sewers and drains without any kind of treatment (Islam *et al,.* 2011) . Waste water containing nutrients can be used extensively for irrigation. It can be considered both as a resource and a problem. Previous studies revealed that textile mill effluent particularly at higher concentration inhibit germination and growth of crop plants seedlings (Dutta and Biossya, 1997, Singh *et al,.* 2006) as well as adversely affects on the soil fertility (Nema *et al.,* 1990, Castro *et al.,* 2015) and crop productivity (Ajmal and Khan, 1985; Carr *et al.,* 2011). However, wastewater reuse also exert negative effects on humans and ecological systems, which need to be identified and assessed (Hussain *et al.*, 2002). Heavy metal accumulation in plants depends upon plants species, and the efficiency of different plants in absorbing metals had been evaluated by either plant uptake or soil to plant transfer factor of the metals (Rattan *et al.*, 2005). The concentrations of heavy metals in plants also depends on application rate of waste water, soil reactions, etc. (Zoubi *et al.,* 2008) . Dyes used in textile industries are mainly organic and inorganic chemical substances; if these substances spread out in the environment, they may cause huge adverse impact on the environment. Developing countries have limited capacities of cities to treat their waste water that causes pollution of soils, water bodies and traditional irrigation water sources. Applying waste water to land as irrigation reduces the pollution of rivers, canals and other safe-water resources. This benefits the health of people downstream, who use these water resources for domestic and drinking-water needs. In areas where fresh water is scarce, waste water allows low- income farmers to produce crops. Otherwise they would not able to grow crops. On the other hand, waste water production is continuous, making it a reliable and demand-based source of water that is available to farmers whenever they need it (unlike canal irrigation).Being sure of their water supply, even in the dry season, farmers can grow high-value crops. They can also grow crops that are more sensitive to water stress (e.g. Vegetables). The nutrients that waste water contained are an additional benefit, saving farmers money (in terms of the cost of chemical fertilizers) and increasing crop yield. So, waste water irrigation can also significantly contribute to urban food security and nutrition. Use of industrial wastewater irrigation can also result in serious environmental problems, contaminating ground water with chemical pollutants including heavy metals. For this reason some policies are applied in these experiments to maximizing benefits and minimizing risks, such as- selecting crops that are less likely to transmit pathogens to consumer and conjunctive management of wastewater and fresh water. In our country we have limited financial and physical resources to treat wastewater. The socio-economic situations and the context of urbanization create the conditions for unplanned and uncontrolled waste water use. If we can get maximum benefits by using this textile waste water with these experiments, it will save us from severe environmental pollution. Our poor farmers will also get economic benefits and can achieve more yield of crops and vegetables.

Bangladesh is mainly an agricultural country. Agriculture is the single largest producing sector of the economy and contributes about 10.98% to the total Gross Domestic Product (GDP) of the country. This sector also accommodates around 40.6% (in 2016-17) of labour force. GDP growth rate of Bangladesh mainly depends on the performance of the agriculture sector. Due to natural calamities like flood, cyclone, drought, loss of production in both food and cash crops is almost a regular phenomenon. Yet in recent years, there has been a substantial increase in food grain production. Agricultural holding in Bangladesh is generally small but use of modern machinery and equipment is gradually increasing. Rice, jute, sugarcane, potato, pulses, wheat and tea are the principal crops of Bangladesh. Crop diversification programme, credit supply, extension work, research and input distribution policies pursued by the government are yielding positive results. The country is now on the threshold of attaining self-sufficiency in food grain production (BBS, 2017). Therefore in the proposed study we use different dilutions of textile waste water as irrigation water in vegetables- jute-rice cropping pattern to determine the yield and heavy metal uptake by these crops.

1.3. Importance of jute under the study

Jute is called the golden fiber of Bangladesh. The country is able to supply the highest quality of jute fiber in the world market. In terms of world export of jute fiber, Bangladesh's share is more than 70% which makes the country largest exporter of jute fiber in the world (website 2). It is one of the cheapest and the strongest of all natural fiber and considered as fiber of the future. India, Bangladesh, China and Thailand are the leading producers of jute. It is also produced in southwest Asia and Brazil. India is the largest producer of jute goods in the world, while Bangladesh is the largest cultivator of raw jute (Ghosh and Jethi, 2013). About 90% of jute products produced in Bangladesh is exported (Rahman, 2001). Jute, as a natural fiber, is a biodegradable and eco-friendly. It has many advantages over synthetics and protects the environments and maintains the ecological balance (Hossain and Abdulla, 2015). At present, eco-friendly products and services are highly demandable in the world. Jute and jute products have brought the ecological balance from the environmental pollution caused by synthetics (Mohiuddin, 2015). The following causes are to be noted which bring ecological balance:

- Jute cultivation consumed large quantities of CO_2 .
- Jute cultivation act as air fresher by supplying huge amount of O_2.
- Less amount of fertilizer and pesticides are required for jute cultivation.
- Jute improves the soil condition and erosion for its leaves and roots.
- Jute has high biological efficiency and also reduce deforestation.
- Wide ecological adaptability for growing jute is in the marginal lands like lands with unfavorable/ stress conditions such as drought, salt, flooding, low pH and low fertility.
- Diversified jute products are used in the alteration of petrochemical products.

Bangladesh jute and jute products are known world over as the best quality jute for its colour, texture, luster, length and strength. Now-a-days jute have been facing an intense competition in the international market with synthetic fiber resulting in an acute problem for indigenous jute enterprises. Recently, the cost of cultivation of jute has increased substantially in comparison to its market price due to raise of various input cost. Low price of fiber and low yield production due to depleted soil in the country is also a great problem to increase jute production. But present world demand of using the natural fiber instead of synthetic (to save the environment) is also regaining the past glory of jute. Bangladesh government has also taken different steps for strengthening the jute sector for lifting country's economy (Gani, 2014). So it is important to grow jute by reducing the cost through using alternative source of fertilizer such as textile waste water.

1.4. Importance of rice under the study

The low cost production of rice may be expected by the farmers and consumers. It may be a scope to use the textile waste water in our staple food rice to reduce the cost. Even this it is essential to generate the information about the amount of heavy metal distribution by the textile waste water.

As a cereal grain, rice is the most widely consumed staple food for a large parts of the world's human population, especially in Asia. It is the agricultural commodity with the third-highest worldwide production (Rice, 741.5 million tonnes in 2014), after sugar cane (1.9 billion tonnes) and maize (1.0 billion tonnes) (website-3). Agro-based developing country like Bangladesh is striving hard for rapid development of its economy. So, the economic development of the country is mainly based on agriculture. Among all the crops, rice plays the leading role by contributing 91% of total food grain production. Hence, rice also plays an important role both economically and in terms of food security. Rice is the staple food of the people of Bangladesh. Bangladesh is not only a rice growing country but also a country of rice consuming people (Annonymous, 1998) . Hence the demand for more rice has placed heavy pressure on farmers and agricultural researchers to intensify rice production systems. Rice is grown in three seasons namely, Aus (mid March to mid August), Aman (mid June to November) and Boro (Mid December to mid June). Transplanted Aman rice covers about 50.92% of the rice growing areas of Bangladesh of which modern T. Aman varieties covers 60% (BBS, 2005). Rice provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intake of an average person in the country. Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh. Total rice production in Bangladesh was about 10.59 million tonnes in the year 1971 when the country's population was only about 70.88 millions. However, the country is now producing about 25.0 million tonnes to feed her 135 million people. This indicates that the growth of rice production was much faster than the growth of population. This increased rice production has been possible largely due to the adoption of modern rice varieties on around 66% of the rice land which contributes to about 73% of the country's total rice production (website 4). In this situation it needs to reduce the fertilizer cost through management of nontraditional organic matter.

1.5. Importance of vegetables under the study

Production of vegetable is very important for our over population to have in their daily dishes. Cost effective production through utilization of textile waste water can increased its availability in the market resulting regular consumption by the people. Yet this use of textile waste water also minimize the environmental problem. Vegetables provide vital nutrients for health and maintenance of human body. Vegetables are rich and comparatively cheaper source of vitamins. Consumption of these items provides taste, palatability, increases appetite and provides fiber for digestion and to prevent constipation. They also play key role in neutralizing the acids produced during digestion of fatty foods and also provide valuable roughages which help in movement of food in intestine. Some of the vegetables are good sources of carbohydrates (leguminous vegetables, sweet potato, potato, onion, garlic and methi), proteins (peas, beans, leafy vegetables and garlic), vitamin A (carrot, tomato, drumstick, leafy vegetables), Vitamin B (peas, garlic and tomato), Vitamin C (green chillies, drumstick leaves, Cole crops, leafy vegetables and leaves of radish), minerals (leafy vegetables, drumstick pods). Eating vegetables provides health benefits – people who eat more vegetables and fruits as part of an overall healthy diet are likely to have a reduced risk of some chronic diseases.Some important health benefits of vegetables are:

- Eating a diet rich in vegetables and fruits as part of an overall healthy diet may reduce risk for heart disease, including heart attack and stroke.
- Eating a diet rich in some vegetables and fruits as part of an overall healthy diet may protect against certain types of cancers.
- Diets rich in foods containing fiber, such as some vegetables and fruits, may reduce the risk of heart disease, obesity, and type 2 diabetes.
- Eating vegetables and fruits rich in potassium as part of an overall healthy diet may lower blood pressure, and may also reduce the risk of developing kidney stones and help to decrease bone loss.
- Eating foods such as vegetables that are lower in calories per cup instead of some other higher-calorie food may be useful in helping to lower calorie intake.

The extent of micronutrient deficiency in Bangladesh is far greater than energy malnutrition. About 60% of the total population suffer from various micronutrient deficiencies, which is increasingly recognized as the cause of serious health problems. About 70% of women aged 15-45, and children 0-14 years, and 80% of pregnant and lactating women, suffer from anemia caused by low blood hemoglobin levels. This accounts for about 20% of all deaths among women in Bangladesh. The rate of night blindness in Bangladesh, 1.78% among children aged 6-71 months, is double the World Health Organization cutoff level for identifying vitamin A deficiency as a major public health problem. About 60% of the people in Bangladesh are deficient in iodine, 47% have goiter (of which 9% are visible), and the rate seems to be increasing over time. Micronutrient deficiency not only causes health problems but impacts negatively on economic growth. It also robs many countries of 5% of gross domestic product through death and disability. The root cause of micronutrient deficiency is the monocrop rice farming system, which translates into a simple rice-dominated diet, and low employment opportunities. Only 1.42% of the total cropped area in Bangladesh is under vegetables, compared to 15% in Taiwan (Ali and Hau, 2001). This means that only 40 g of vegetables per person per year are available from farm sources. Vegetables are the most important source of vitamins for the people of our country. Bangladesh has immense prospect for exporting vegetables to the world market and it has also produced high quality exportable fresh vegetable (Hoq *et al.*, 2012).

1.6. Effect of textile waste water on crop

Direct application of textile effluents may cause inhibitory effect on growth of some plants (Wins and Murgan, 2010), but on dilution can impart positive effects (Rehman *et al.*, 2009). It has been reported that dilution of wastewater has significantly increased growth and germination of black gram, green gram, rice, groundnut, sunflower and maize (Elarajan and Bupathi, 2006; Wins and Murgan, 2010). Thus, for beneficial cultivation, farmers can use textile effluent for irrigation with lower concentrations of effluent like 25% dilution (Kumar *et al.*, 2006). Lead (Pb), Zn, Fe, Mn and Cu contents in rice seedlings were significantly increased on application of textile wastewater in comparison to good quality irrigation water (Begum *et al.*, 2011). Considering the above facts as stated, the present study was under taken with the following major objectives:

(1) To study the effects of textile waste water on the growth and yield of crops.

(2) To observe the effects of textile waste water irrigation on the properties of soil.

(3) To determine macronutrient and heavy metal uptake by jute, rice and vegetable crops.

(4) To observe the residual effects of textile waste water irrigation on soil and crop.

(5) To make a suitable integrated dose for the cropping pattern.

CHAPTER - 2
REVIEW OF LITERATURE

CHAPTER – 2

REVIEW OF LITERATURE

Water is a valued universal and most used natural resource without which life cannot sustain on the earth (Afroz *et.al.,* 2010). With increasing global population, the gap between the supply and demand for water is widening and reaching such alarming levels that in some parts of the world. It may be a great threat to human existence in near future. Scientists around the globe are working on new ways of conserving water. It is an opportune time, to refocus on one of the ways to recycle water through the reuse of urban waste water, for irrigation and other purposes. This could release clean water for use in other sectors that need fresh water and provide water to sectors that can be utilized waste water e.g., for irrigation and other ecosystem services. In general, waste water comprises liquid wastes generated by households, industry, commercial sources, as a result of daily usage, production, and consumption activities. Municipal treatment facilities are designed to treat raw wastewater to produce a liquid effluent of suitable quality that can be disposed to the natural surface waters with minimum impact on human health or the environment. The disposal of waste water is a major problem faced by municipalities, particularly in the case of large metropolitan areas, with limited space for land- based treatment and disposal. On the other hand, waste water is also a resource that can be applied for productive uses since wastewater contains nutrients that have the potential for use in agriculture, aquaculture, and other activities (Hussain *et. al.,* 2002).

Waste water and its nutrient content can be used extensively for irrigation and other ecosystem services. Wastewater can be considered as both a source and a problem (Begum *et. al.,* 2018). Its reuse can deliver positive benefits to the farming community, society, and municipalities. However, waste water reuse also causes negative effects on humans and ecological systems, which need to be identified and assessed.

2.1. Textile industry

Since the beginning of human civilization, cloth has been among the 3 basic needs of mankind (i.e. food, clothing, and shelter). Natural products like cotton, silk, wool, and jute are reported to be used for manufacturing of cloth. Due to high consumer demand, presently synthetic fibers like nylon, rayon, polyester, and acrylic are being used to fulfill requirements for natural fibers. The primary textile sector of Bangladesh comprises of the following sub-sectors: spinning mills, weaving , knitting, power loom, hand loom factories and dyeing and finishing units. According to the database of the Department of Inspection for Factories and Establishment about 3000 industries are operating in Dhaka (Annoss, 2019). A present scenery of the no. of textile industries is present in Table 2.1.

Table 2.1. The textile industries at a Glance in Bangladesh

Sub-sector	**Number of units**	**Installed machine capacity**	**Production capacity**	**Employment**
Textile spinning	3507.5 million	spindles (0.2 million rotors)	1,800 million kg	400,000
Textile weaving	400	25,000 Shuttle less/shuttle loom	1,600 million meter	80,000
Specialized textile and power loom	1,065	23,000 Shuttle less/shuttle loom	400 million meter	43,000
Handloom	148,342	498,000 looms	837 million meter	1,020,000
Knitting, knit dyeing	2,800	17,000 knit/Dy/M	4,100 million meter	324,000
Dyeing and finishing	310	--	1,720 million meter	33,000
Export oriented readymade garment (clothing)	4,500	---	475 million dozen	

(Source: Annoss, 2019)

Color has always been a special necessity and so, in every civilization from remote ages to the present day. The art of dyeing has played an important role in adding beauty to the world. At present, approximately 15% of total world production of colorants is lost daily during their synthesis and use for coloring fabrics, which corresponds to almost 128 t/day around the world (Thampi and Paul 1997).

2.2. Textile waste water

The textile dyeing industry consumes large quantities of water and produces large volume of wastewater from different steps in the dyeing and finishing processes. Wastewater from printing and dyeing units is often rich in color, containing residues of reactive dyes and chemicals. Textile industry releases highly polluted and toxic waste water which discharged into sewerage and drains without any kind of treatment (Islam *et. al.,* 2011).

Rabby (2012) reported that the textile industry has been condemned as being one of the world's worst offenders in terms of pollution because it requires a great amount of two components:

• Chemicals: as many as 2,000 different chemicals are used in the textile industry, from dyes to transfer agents; and

• Water: a finite resource that is quickly becoming scarce, and is used at every step of the process both to convey the chemicals used during step and to wash them out before beginning the next step.

The water becomes full of chemical additives and is then expelled as wastewater; which in turn pollutes the environment:

- by the effluent's heat;
- by its increased pH;
- and because it's saturated with dyes, deformers, bleaches, detergents, optical brighteners, equalizers and many other chemicals used during the process.

Table 2.2: Chemicals used in different stages of fiber processing

(Chemicals with particular toxicity are shown in bold)

Process step	Chemicals or chemical groups used	Purpose/product specifics
Fiber production	• **Pesticides**, soda, detergents • **Pesticides,** fertilizers (and irrigation water) • **Heavy metals,** sulphides • **Heavy metals,** acetaldehyde, 1,4-dioxane • nitrile, acrylate, acetate, amide, sulphate, chloride, pyridine	1. Remove wool impurities 2.Cotton 3.Viscose 4.Polyester 5.Acrylic
Yarn manufacturing	**mineral**/vegetable oil; emulsifiers, **antimould agents**	Spinning oil
Spinning and weaving	Starches	sizing agents
Sizing	starch based agents, alcohol, acrylate	
Knitting	**mineral oils (including PAH s)**, waxes	lubricating/emulsifying

(Source: https://www.textiletoday.com.bd/toxicity-concealed-inside-the-chemicals-used-in-textiles/)

2.3 Wet processing toxicity

Bleaching

Islam *et al.*, (2009) reported that the textile effluents contain highly toxic dyes, salts, acids, alkalis and bleaching agents. Chlorine bleach is known to be extremely toxic to the environment and to consumers, yet chlorine-based chemicals are still often used to bleach fabric. Sodium hypochlorite is very hazardous to human health due to the etching effect that may cause skin damage and damage to the lungs. In its compound form it is very toxic to aquatic organisms and bacteria. However the toxic hypochlorite form will never reach the waste water treatment plants or the aquatic environment due to its highly active properties causing it to react with the organic substances in the waste water in the sewer.

Dyeing

Many textile manufacturers use dyes that release aromatic amines (e.g., benzidine, toluidine). Dye bath effluents may contain heavy metals, ammonia, alkali salts, toxic solids and large amounts of pigments – many of which are toxic. About 40% of globally used colorants contain organically bound chlorine, a known carcinogen.

Natural dyes are rarely low-impact, depending on the specific dye and mordant used. Mordants (the substance used to “fix” the color onto the fabric) such as chromium are very toxic and high risk impact. The large quantities of natural dye stuffs required for dyeing, typically equal to or double that of the fiber’s own weight, make natural dyes prepared from wild plants and lichens very high impact. If textile dyes effluents are allowed to flow in drains and rivers it affects the quality of drinking water making unfit for human consumption (Saini, 2017).

Table 2.3: Important chemicals or chemical classes used in different stages of textile and clothing finishing

(Chemicals with particular toxicity are shown in bold)

1. Wet processing finishing:

Process step	**Chemicals or chemical groups used**	**Purpose/product specifics**
	acid, base	
-stiffening	starch, PVA , resins, esters, starch, **chlorides, CMC products**	
-softening	oil, paraffin, wax, alkane, fatty acids, silicones, PE, enzymes	
-stonewashing, antipill.	Enzymes	
-stabilizing	**formaldehyde, triazones, carbamates**, N-alkylol compounds	stabilizing of cellulose, fibre
-anti-shrink	acids, salts, N-alkanol compounds	
-fire-proofing	**heavy metals, halogens, salts, formaldehyde, BFRs, SCCP**	
-water repulsion	salts, paraffins, **Cl/F** and Si compounds, pyridines, **isocyanates**	water repellents
-oil repulsion	acids, polymers and other oil repellents	
-dirt repulsion	oxides, clay minerals, PVC,	

	phosphates, resins, F compounds	
-antistatic treatment	polymers, synthetic tensides	
-biocide treatment	**phenols (also halogen), metals/Ag, NH4, SCCP, DMF**	anti-mold or – microbial
-moth proofing	acids, urea	
-microencapsulation	**fragrances**, softeners,**preservatives/ biocides**, potential drugs	for durable effect
adding parts	metals including **Cr and Ni**in zippers, buttons etc.	

2. Coating:

Process step	**Chemicals or chemical groups used**	**Purpose/product specifics**
-anti-pilling, water Proof	water proof PVC, PU, pigments, inks, lacquers, Si, **PFCs**, waxes	cotton/PE, polyamide
-protective	PVC, PU, lacquer, printing inks	depend on fabric and use
-coating	PU	for polyamide and PE

3. Treatment of finished articles:

Process step	**Chemicals or chemical groups used**	**Purpose/product specifics**
-wet washing	soap, synthetic tensides	active substances
-wet washing	phosphates, zeolites	improve affect of tensides

-wet washing	enzymes, silicates, brighteners, **perfumes, metals, anti-mould**	cleaning, brightening etc.
-wet washing	silicate, phosphonate	fibre protection agents
-wet washing	carboxymethyl cellulose, carboxylate glycol	prevention of greying
-dry cleaning	**tetrachloroethylene, trichloroethane, CFCs**, hydrocarbons	
-bleaching	perborate, percarbonate	bleach stains
-dyeing	e.g. azo dyes, pyridine derivatives (disperse) etc pigments	industrial and domestic
-maintenance	Various	Water , stain proof Coating
-Transport and Storage	**PCP, methyl bromide, chloropicrin, 1,2-dichloroethane**	added as biocides
adding parts	various chemicals, together with physical and bioprocesses	mainly synthetic fibres
Disposal	occasionally various also unintended substances	

(Source: https://www.textiletoday.com.bd/toxicity-concealed-inside-the-chemicals-used-in-textiles/)

2.4. Negative effects occurred by fibers

Rabby (2012) reported that **Cotton** is the most commonly used cellulose fiber. But is the second-most damaging agricultural crop in the world; 25 percent of all pesticides used globally are put on cotton crops. Most cotton is irrigated, and the combination of chemical application (through pesticides and fertilizers) with irrigation which direct conduit for toxic chemicals to circulate in groundwater worldwide.

Now a day's synthetic fibers are widely used and have achieved a great concern regarding their catastrophical effect. **Acrylic** fibers are very popular today. A Canadian study found that women who work with some common synthetic materials could treble their risk of developing breast cancer after menopause. The data included women working in textile factories which produce acrylic fabrics – those women have seven times the risk of developing breast cancer than the normal population, while those working with nylon fibers had double the risk.

Other fibers possessing some negative effects are:

Polyester is the worst fabric. It is made from synthetic polymers that are made from esters of dihydric alcohol and terpthalic acid.

Rayon is recycled wood pulp that must be treated with chemicals like caustic soda, ammonia, acetone and sulphuric acid to survive regular washing and wearing.

Acetate and Triacetate are made from wood fibers called cellulose and undergo extensive chemical processing to produce the finished product.

Anything static resistant, stain resistant, permanent press, wrinkle-free, stain proof or moth repellant. Many of the stain resistant and wrinkle-free fabrics are treated with perfluorinated chemicals (PFCs), like Teflon.

2.5. Characterization of textile waste water

Table 2.4: Characterization values for different textile wastewaters (all values are in mg l^{-1} unless stated otherwise)

Parameter	Fabric type	Desizing	Scouring	Bleaching	Dyeing	Printing
COD	Wool	-	5000-90000	-	7920	-
	Cotton	950-20000	8000	288-13500	1115-4585	-
	Synthetic	-	-	-	620	1515
	Not specified	10000-12000	-	-	-	785-49170
BOD	Wool	-	2270-60000	400	400-2000	-
	Cotton	-	100-2900	90-1700	970-1460	-
	Synthetic	-	500-2800	-	530	590
	Not specified	200-5200	-	-	-	600-1800
Colour (ADMI)	Wool	-	2000	-	2225	-
	Cotton	64-1900	694	153	1450-4750	-
	Synthetic	-	-	-	1750	-
	Not specified	-	-	-	-	1450
Total Solid	Wool	-	28900-49300	910	-	-
	Cotton	-	-	2300-14400	-	-
	Synthetic	-	-	-	-	150-250
	Not specified	7600-42900	-	-	<50000	-
Total Suspended Solids	Wool	-	1000-26200	900	-	-
	Cotton	18-800	184-17400	130-25000	120-190	-
	Synthetic	-	600-3300	-	140	-

	Not specified	400-4000	-	-	-	125-9500
Total Dissolved Solid	Cotton	530-6900	-	4760-19500	-	-
	Not specified	-	-	-	55	-
Carbon (DOC)	Wool	-	5800	-	-	-
	Cotton	250-2750	-	320	-	-
Total Kjeldahl N	Cotton	70	-	40	-	-
	Synthetic	-	-	-	-	164
	Not specified	-	-	-	-	30-1765
NH_4 -N	Wool	-	604	-	-	-
	Cotton	9-19	-	8-19	-	-
	Synthetic	-	-	-	-	129
	Not specified	-	-	-	-	20-370
Total P	Cotton	4-10	-	6-60	-	-
	Synthetic	-	-	-	-	21
PO_4	Wool	-	89.3	-	-	-
Sulphide	Wool	-	0.2	-	-	-
	Cotton	-	-	-	325-900	-
Sulphate Cl	Cotton	-	-	-	1750-2690	-
	Not specified	-	-	90-100	26000	-
Oil and Grease	Wool	-	580-55000	-	-	-
Cr	Wool	-	50	-	-	-
pH	Wool	-	7.6-10.4	6	4.6	-
	Cotton	8.8-9.2	7.2-13	6.5	9.2-10.1	-

	Synthetic	-	8-10	-	11.7	-
	Not specified	6.8	-	-	-	5.8.5
Turbidity	Not specified	930	-	-	-	-
Water usage (1 Kg $^{-1}$ fabric)	Wool	-	4-77.5	-	40-150	280-520
	Cotton	-	2.5-43	30-50	38-143	-
	Synthetic	-	17-67	-	38-143	-
	Not specified	12.5-35	-	-	-	20-300

(Source: https://textilelearner.blogspot.com/2018/08/wastewater-textile-industry.html)

2.6. Impacts of textile waste water on the environment

Khan and Malik (2013) reported that many chemicals used in the textile industry cause environmental problems. Among the many chemicals in textile wastewater, dyes are considered important pollutants. Worldwide environmental problems associated with the textile industry are typically those associated with water pollution caused by the discharge of untreated effluent and those because of use of toxic chemicals especially during processing. The textile industries release a large amount of wastewater containing toxic and hazardous pollutants that badly degrade the environment. Textile industrial wastewater also shows toxic effects on aquatic macrophytes and algae, as it is noticed that, aquatic macrophytes could hardly survive two days on textile effluent.

2.6.1. Water pollution

The degradation of surface and groundwater quality due to industrial and urban waste has been recognized for a long time (Olayinka, 2004). The rivers and stream are the common recipients of industrial effluent all over the world. The deterioration in water quality has an adverse effect on human beings as well as aquatic ecosystem directly or indirectly (Chindah *et al.*, 2004; Ugochukwu, 2004; Emongor *et al.*, 2005).The water pollution is considered to be the biggest environmental threat all over the world. Generally, surface water is used for dyeing, printing, sizing, bleaching and washing, and therefore, this water mixes with the water in rivers and thereby increases pollution (Imtiazuddin, 2018). Mills discharge millions of gallons of this effluent as hazardous toxic waste, full of color and organic chemicals from dyeing and finishing salts. Presence of sulphur, naphthol, vat dyes, nitrates, acetic acid, soaps, chromium compounds and heavy metals like copper, arsenic, lead, cadmium, mercury, nickel, and cobalt and certain auxiliary chemicals all collectively make the effluent highly toxic with high temperature and pH, which makes it extremely damaging. The colors and oil present in wastewater increases its turbidity and give a bad appearance and foul smell to the water (Parshetti *et al.,* 2011). Other harmful chemicals present in the water may be formaldehyde based dye fixing agents, hydro carbon based softeners and non bio degradable dyeing chemicals. It prevents the penetration of sunlight necessary for the process of photosynthesis for aquatic flora and fauna (Bharagava and Chandra, 2010a, 2010b; Chandra *et al.*, 2011, 2012). This interferes with the Oxygen transfer mechanism at air water interface. Depletion of dissolved oxygen in water is the most serious effect of textile waste as dissolved oxygen is very essential for marine life. This also hinders with self purification process of water. The waste water that flows in the drains corrodes and incrustates the sewerage pipes. If allowed to flow in drains and rivers it affects the quality of drinking water in hand pumps making it unfit for human consumption. It also leads to leakage in drains increasing their maintenance cost. Such polluted water can be a breeding ground for bacteria and viruses. Impurities in water affects the textile processing in many ways. In scouring and bleaching they impart a yellow tinge to white fabric. In dyeing stage metallic ions present in water some- times combine with the dyes causes dullness in shades. Textile effluent is a cause of significant amount of environmental degradation and human illnesses. About 40 percent of globally used colorants contain organically bound chlorine, a known carcinogen. All the organic materials present in the waste water from a textile industry are of great concern in water treatment because they react with many disinfectants especially chlorine.

As per the report by Rathore (2012), around 49 MLD (Million Litres/Day) of combined effluent from more than 800 textile dyeing and printing industries with domestic sewage is being discharged in Bandi river at Pali. The physicochemical parameters Cl^- , SO_4^{-2} , NO_3^- , suspended solids, chemical oxygen demand and biological oxygen demand assessed in the combined effluent were higher than the recommended standards for discharge of industrial effluent by BIS. The overall pollution load in Bandi river in terms of chemical oxygen demand, biological oxygen demand, suspended solids and total alkalinity is 57,520 kg/ day, 38,160 kg/day, 61,950 kg/day and 74570 kg/day, respectively. Therefore, the pollution load estimated clearly illustrates the environmental degradation in the study area to a great extent.

2.6.2. Air pollution

Uddin (2018) reported that most processes performed in the textile mills produce atmospheric emissions. Gaseous emissions have been identified as the second greatest pollution problem (after effluent quality) for the textile industry. The major air pollution problem in the textile industry occurs during the finishing stages, where various processes are employed for coating the fabrics. Coating materials include lubricating oils, plasticizers, paints and water repellent chemicals essentially, organic compounds such as oils, waxes or solvents, acid vapour, odors and boiler exhausts (Mahmoud *et al.,* 2007). The cleaning and production changes result in sludge in the tanks with process chemicals, which may contain toxic compounds and metals (Modak, 1991). Chemicals evaporate into the air we breathe or are absorbed through our skin and show up as allergic reactions and may cause harm to children even before birth.

2.6.3. Soil pollution

The effluent discharged by these industries not only affects the exterior and groundwater, but also dangerously affect the soil properties (Mycin, 2016). In addition, when this effluent is allowed to flow in the fields it clogs the pores of the soil resulting in loss of soil productivity. The texture of soil gets hardened and penetration of roots is prevented. The textile wastewater pollutes the soil. The soil is the most important medium for growing plant, bushes, crops, etc. The quality of crops depends upon the quality of the soil. So, when the quality of the soil decreases due to polluted industrial wastewater, subsequently, the amount and quality of crops also decline. It is also seen that the lower lands become more polluted than the higher lands, as the effluents are ultimately deposited in the lower lands. Leaching is a process through which solid waste enters the porous soil and pollutes groundwater, contaminating the land (Keith, 2003, Saiful and Mahmood, 2014).

Heavy metals are considered one of the major sources of soil pollution. Heavy metal pollution of the soil is caused by various metals, especially Cu, Ni, Cd, Zn, Cr and Pb (Karaca *et.al.*, 2010) . Heavy metals exert toxic effects on soil microorganism hence results in the change of the diversity, population size and overall activity of the soil microbial communities (Ashraf and Ali, 2007). Soil contamination by heavy metals is of most important apprehension throughout the industrialized world (Hinojosa *et al.,* 2004). Heavy metal pollution not only results in adverse effects on various parameters relating to plant quality and yield but also causes changes in the size, composition and activity of the microbial community (Yao *et al.,* 2003). Therefore, heavy metals are considered as one of the major sources of soil pollution. Heavy metal pollution of the soil is caused by various metals especially Cu, Ni, Cd, Zn, Cr, and Pb (Hinojosa *et al.,* 2004) . The adverse effects of heavy metals on soil biological and biochemical properties are well documented. The soil properties i.e. organic matter, clay contents and pH have major influences on the extent of the effects of metals on biological and biochemical properties (Speira *et al.*, 1999).

2.7. Impacts of textile waste water use in agriculture

2.7.1. Public health

Textile industries also discharge with wastewater an array of hazardous organic and inorganic compounds/substances such as aromatic amines (benzidine and toluidine), heavy metals, ammonia, alkali salts, and toxic solids, as well as large amount of pigments and chlorine, a known carcinogen, which causes serious environmental and health problems (Kumari *et al.,* 2016). The untreated dyes cause chemical and biological changes in aquatic resources, which threaten fresh and other aquatic species. The presence of these compounds makes water unfit for other purposes also. The enormous amount of water required by textile production competes with the growing daily water requirements of approximately half a billion people that live in drought-prone regions of the world. By 2025, the number of inhabitants of drought-prone areas is projected to increase to almost one-third of the world’s population. If global consumption offresh water continues to double every 20 years, the polluted waters resulting from textile production will pose a greater threat to human lives (Mani and Bharagava, 2016).

The plant uptake of heavy metals from soils at high concentrations may result in a great health risk taking into consideration food-chain implications. Utilization of food crops contaminated with heavy metals is a major food chain route for human exposure. The food plants whose examination system is based on exhaustive and continuous cultivation have great capacity of extracting elements from soils. The cultivation of such plants in contaminated soil represents a potential risk since the vegetal tissues can accumulate heavy metals (Jordao *et al.*, 2006). Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues (Sobha *et al.,* 2007). Chronic level ingestion of toxic metals has undesirable impacts on humans and the associated harmful impacts become perceptible only after several years of exposure (Khan *et al.,* 2008).

Cadmium (Cd) is a well known heavy metal toxicant with a specific gravity 8.65 times greater than water. The target organs for Cd toxicity have been identified as liver, placenta, kidneys, lungs, brain and bones (Sobha *et al.,* 2007). Depending on the severity of exposure, the symptoms of effects include nausea, vomiting, abdominal cramps, dyspnea and muscular weakness. Severe exposure may result in pulmonary odema and death. Pulmonary effects (emphysema, bronchiolitis and alveolitis) and renal effects may occur following subchronic inhalation exposure to cadmium and its compounds (Duruibe *et al.,* 2007). The Itai-itai disease in Japan brought the dangers of environmental Cd to world attention. Cadmium has been associated to a lesser or greater extent with many clinical conditions including anosmia, cardiac failure, cancers, cerebrovascular infarction, emphysema, osteoporosis, proteinuria cataract formation in the eyes. Yet, it has been difficult to tie down obvious links of environmental exposures with morbidity and mortality (Lalor, 2008).

Zinc (Zn) is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction. The clinical signs of zinc toxicosis have been reported as vomiting, diarrhea, bloody urine, icterus (yellow mucus membrane), liver failure, kidney failure and anemia (Duruibe *et al.,* 2007)
.

Copper (Cu) is an essential element in mammalian nutrition as a component of metalloenzymes in which it acts as an electron donor or acceptor. Conversely, exposure to high levels of Cu can result in a number of adverse health effects. Exposure of humans to Cu occurs primarily from the consumption of food and drinking water. Acute Cu toxicity is generally associated with accidental ingestion; however, some members of the population may be more susceptible to the adverse effects of high Cu intake due to genetic predisposition or disease (Stern *et al.,* 2007).

Excessive human intake of Cu may leads to severe mucosal irritation and corrosion, widespread capillary damage, hepatic and renal damage and central nervous system irritation followed by depression. Severe gastrointestinal irritation and possible necrotic changes in the liver and kidney can also occur. The effects of Ni exposure vary from skin irritation to damage to the lungs, nervous system, and mucous membranes (Argun *et al.,* 2007).

Lead (Pb) is physiological and neurological toxic to humans. Acute Pb poisoning may results in a dysfunction in the kidney, reproduction system, liver and brain resulting in sickness and death (Odum, 2000). Lead heads the threats even at extremely low concentrations (Kazemipour *et al.,* 2008). A notably serious effect of lead toxicity is its teratogenic effect. Lead poisoning also causes inhibition of the synthesis of haemoglobin; cardiovascular system and acute and chronic damage to the central nervous system (CNS) and peripheral nervous system (PNS).

Other chronic effects include anemia, fatigue, gastrointestinal problems and anoxia. Lead can causes difficulties in pregnancy, high blood pressure, muscle and joint pain (Odum, 2000). Other effects include damage to the gastrointestinal tract (GIT) and urinary tract resulting in bloody urine, neurological disorder and can cause severe and permanent brain damage. While inorganic forms of lead, typically affect the CNS, PNS, GIT and other biosystems, organic forms predominantly affect the CNS. Lead affects children; particularly in the 2-3 years old range by leading to the poor development of the grey matter of the brain, thereby resulting in poor intelligence quotient (IQ). Its absorption in the body is enhanced by Ca and Zn deficiencies (Duruibe *et al.,* 2007).

Chromium (Cr) is the 10th abundant element in the earth's mantle and persists in the environment as either Cr (III) or Cr (VI). The Cr (VI) is toxic to plants and animals, being a strong oxidizing agent, corrosive, soluble in alkaline and mildly acidic water, toxic and potential carcinogens (Shaffer *et al.,* 2001; Jeyasingh and Philip, 2005; Huang *et al.*, 2009). The toxicity of Cr (VI) derives from its ability to diffuse through cell and oxidize biological molecules (Shaffer *et al.,* 2001) .

Mercury (Hg) is toxic and has no known function in human biochemistry and physiology. Inorganic forms of mercury cause spontaneous abortion, congenital malformation and gastrointestinal disorders (like corrosive esophagitis and hematochezia). Poisoning by its organic forms, which include monomethyl and dimethyl mecury presents with erethism (an abnormal irritation or sensitivity of an organ or body part to stimulation), acrodynia (Pink disease, which is characterized by rash and desquamation of the hands and feet), gingivitis, stomatitis, neurological disorders, total damage to the brain and CNS and are also associated with congenital malformation (Duruibe *et al.,* 2007).

Arsenic (As) toxicity symptoms depend on the chemical form of ingested. Arsenic acts to coagulate protein, forms complexes with coenzymes and inhibits the production of adenosine triphosphate (ATP) during respiration. It is possibly carcinogenic in compounds of all its oxidation states and high-level exposure can cause death. Arsenic toxicity also presents a disorder, which is similar to, and often confused with Guillain-Barre syndrome, an anti-immune disorder that occurs when the body's immune system mistakenly attacks part of the PNS, resulting in nerve inflammation that causes muscle weakness (Duruibe *et al.*, 2007).

2.7.2. Crops

A pot trial was conducted by Najam *et al.,* (2017) to evaluate the suitability of untreated textile waste water at different dilution levels (0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100%) for improving growth, physiology and yield of wheat (*Triticumae stivum L*.). Tap water (0 % dilution level) was applied as control treatment. Results showed that textile effluents negatively affected growth and yield of wheat. Maximum reduction in growth, yield, chemical and physiological parameters of wheat was recorded on application of textile wastewater (100%

waste water dilution level). However, on dilution, inhibitory effects of textile wastewater on all measured parameters of wheat were significantly reduced. In addition, effects of 10% and 20% diluted textile effluent on growth and yield of wheat was statistically at par with control. So, it can be concluded that although textile wastewater imparts negative effects on wheat but on dilution it can be used for irrigation of wheat in areas facing water scarcity.

A study was conducted by Shahjalal *et al.,* (2013) on Stem Amaranth irrigated by groundwater (control) and seven different types of textile dyeing wastewater to assess the suitability for further utilization in vegetables cultivation. The impact of textile wastewater was assessed regarding the growth, yield and nutritional qualities of Stem Amaranth. The growth and yield of Stem Amaranth were not strongly influenced by wastewater irrigation compared with groundwater. The yield (weight of plant) of Stem Amaranth observed in groundwater irrigated plant was 52.14 g, while the yield of the different wastewater irrigated plants were ranged from 25.27 to 49.49 g. Nutritional qualities of Stem Amaranth irrigated with wastewater was similar to those irrigated by groundwater. Chlorophyll a and chlorophyll b were higher in Stem Amaranth irrigated with wastewater than that of groundwater. The ß carotene in wastewater irrigated Stem Amaranth ranged from 0.49 to 0.82 mg per 100 g which was comparable with the ß carotene of ground water irrigated plant. The concentration of ascorbic acid in Stem Amaranth irrigated with wastewater was found almost identical with groundwater irrigated plants. From overall assessment, less polluted wastewater of a dyeing factory could be directly reutilized in irrigation purpose of vegetable cultivation.

An investigation was carried out by Varma and Sharma (2012) to assay the effects of effluents on seedling growth and plant growth of wheat (*Triticumae stivum L*). For that purpose textile effluent and dairy effluent were chosen. Concentrations used for both the effluents were 0, 25, 50, 75 and 100%. Minimum relative toxicity was in 25% concentration and increases gradually as the concentration increases.

Hamdi *et al.,* (2017) conducted an experiment on the impact of textile wastewater irrigation on the growth and development of apple plant. In this work, the effect of irrigation with textile wastewaters on the growth and development of "*Golden Delicious"* apple sapling was examined over a one-year period. Municipal water prepared as a control sample (T_0), 1/3 diluted (T_1), and undiluted (T_2) raw textile wastewater was used as the three different irrigation water samples. Two replications of each test were performed on three random samples each time. When examining the effects of T_0, T_1, and T_2 irrigation water on plant growth, it was found that T_1 irrigation water significantly increased the weight, the shoot length, and the diameter of the sapling. Despite increasing Ni and Cr metals in the apple saplings' leaves when irrigated with T_2 water, plant growth was restricted due to the lack of basic nutrients. When taking certain aspects into account, such as the proper treatment of wastewater, then 1/3 diluted textile wastewater can be used as agricultural irrigation water for the apple plants.

Rajeev and Singh (2015) conducted an experiment on the effect of treated textile (synthetic fiber) factory effluent irrigation on different productivity parameters of wheat crop (var. L. cv. HD-1553). Length of ear m-2, No. of grain ear-1 and yield (Q/ ha) were found higher in effluent irrigated crop in comparison to control.

An experiment was conducted by Begum *et al.,* (2011) at Mouchack textile industrial area of Gazipur for two consecutive years to study the effects of use of industrial waste water on the yield, nutrient content, and uptake of Boro rice. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The six treatments in this study were: T1: uncontaminated field + fresh water, T2: uncontaminated field + mixed water, T3: uncontaminated field + contaminated water for non-contaminated field, and T4: effluent contaminated field + fresh water, T5: effluent contaminated field + mixed water, T6: effluent contaminated field + contaminated water for contaminated field. Among the six treatments, uncontaminated field + fresh water (T1) showed the best positive effect on rice. The N, P. K, and S contents and uptake were higher in T1, but Zn, Mn, Fe, Cu, and Pb were higher in T6 treatment. The treatment T1, gave the highest grain yield (5.23 t/ha in 1999 and 5.40 t/ha in 2000), followed by mixed water (4.19 t/ha in 1999 and 4.24 t/ha in 2000) in both the growing seasons.

An experiment was conducted by Saravanamoorthy and Kumari (2007) to evaluate the use of textile waste water on morphophysiology and yield of two varieties of peanut, TMV-10, and JL-

24. Textile waste water application increased germination, chlorophyll a, b and total chlorophyll content, growth parameters, yield and yield contributing characters. Physico-chemical characteristics of textile waste water met the irrigation quality requirements and were within the permissible limits.

Garg and Kaushik (2007) conducted a study to evaluate the suitability of textile mill wastewater (treated and untreated) at different concentrations (0, 6.25, 12.5, 25, 50, 75, and 100%) for irrigation purposes. Effect of textile mill wastewater on germination, delay index, physiological growth parameters and plant pigments of two cultivars of sorghum was studied. The textile effluent did not show any inhibitory effect on seed germination at lower concentration (6.25%). The other reported plant parameters also followed the similar trend.

A field study was conducted by Singh *et al.,* (2001) at Arid Forest Research Institute to study the effect of textile industrial effluent on the growth of forest trees and associated soil properties. The effluent has high pH, electrical conductivity (EC), sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) whereas the bivalent cations were in traces. Eight months old seedlings of Acacia nilotica, Acacia tortilis, Albizia lebbeck, Azadirachta indica, Parkinsonia aculeata and Prosopis juliflora were planted. Various treatment regimes followed were; irrigation with effluent only (W1), effluent mixed with canal water in 1:1 ratio (W2), irrigation with gypsum treated effluent (W3), gypsum treated soil irrigated with effluent (W4) and wood ash treated soil irrigated with effluent (W5). Treatment regime W5 was found the best where plants attained (mean of six species) 173 cm height, 138 cm crown diameter and 9.2 cm collar girth at the age of 28 months. The poorest growth was observed under treatment regime of W3. The growth of the species varied significantly and the maximum growth was recorded for P. juliflora (188 cm height, 198 cm crown diameter and 10.0 cm collar girth). The minimum growth was recorded for A. lebbeck. Irrigation with effluent resulted increase the percent organic matter as well as in EC. In most of the cases there were no changes in soil pH except in W5 where it was due to the effect of wood ash. Addition of wood ash influenced plant growth. These results suggest that tree species studied (except A. lebbeck) can be established successfully using textile industrial wastewater in arid region.

Mohammad and Ahsan (1985) conducted an experiment to observe the effects of a textile factory effluent on soil and crop plants. The results revealed that the plants grown in different effluent concentrations were analysed for Na^+, K^+, Ca^{2+} and Mg^{2+}. Na^+ ion showed a constant and gradual increase with increase in the effluent concentration, whereas K^+, Ca^{2+} and Mg^{2+} concentrations were found to be highest in the plants grown in 50% effluent followed by 25, 75 and 100% effluent. Germination was inhibited and delayed by 100 and 75% effluent, whereas it was normal with other effluent concentrations as compared to water control. Undiluted and 75% effluent retarded the growth of plants whereas 50% effluent enhanced the growth.

Some heavy metals i.e. As, Cd, Hg, Pb or Se are not essential for plants growth, since they do not perform any known physiological function in plants. Others i.e. Co, Cu, Fe, Mn, Mo, Ni and Zn are essential elements required for normal growth and metabolism of plants, but these elements can easily lead to poisoning when their concentration is greater than optimal values (Garrido *et.al.,* 2002, Rascio and Izzo 2011). Heavy metal accumulation in plants depends upon plant species and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil to plant transfer factors of the metals (Khan *et al.,* 2008).

2.7.3. Soil resources

When agricultural fields are watered with effluents, the pores of the soil are clogged, which results in the loss of soil productivity and it also hardens the soil texture and thus prevents root penetration (Chandra *et al.,* 2009).

The study was conducted by Tusher *et al.,* (2017) to investigate the soil quality including heavy metal concentrations in agricultural lands around dyeing, glass and textile industries at Tangail district of Bangladesh. A total of nine samples, three samples from each industrial site, were collected at a depth of 0-15 cm with an interval of 10 m from each point of the agricultural lands adjacent to selected industries for analyzing the soil chemical properties such as pH, OM, total N, available P and S including heavy metals (Pb, Cd, Ni, Cu and Cr) concentrations. The study found soil pH of 6.4 and 6.1 around textile and glass industry, respectively, while comparatively lower pH (4.4) was observed around dyeing industry. Comparatively higher levels of OM, total

N, available P and S were found in soil around dyeing industry, whereas lower levels of OM and available S were observed around textile industry. The Cu, Pb and Cr were the dominant heavy metals around dyeing, glass and textile industry, respectively.

Heavy metals indirectly affect soil enzymatic activities by shifting the microbial community which synthesizes enzymes (Shun *et al.*, 2009). Heavy metals exhibit toxic effects towards soil biota by affecting key microbial processes and decrease the number and activity of soil microorganisms. Conversely, long-term heavy metal effects can increase bacterial community tolerance as well as the tolerance of fungi such as arbuscular mycorrhizal (AM) fungi, which can play an important role in the restoration of contaminated ecosystems (Mora *et al.,* 2005). Chen *et al.,* (2010) suggested that heavy metals caused a decrease in bacterial species richness and a relative increase in soil actinomycetes or even decreases in both the biomass and diversity of the bacterial communities in contaminated soils. Karaca *et al.,* (2010) reported that the enzyme activities are influenced in different ways by different metals due to the different chemical affinities of the enzymes in the soil system. Cadmium is the more toxic to enzymes than Pb because of its greater mobility and lower affinity for soil colloids. Copper inhibits b-glucosidase activity more than cellulose activity. Lead decreases the activities of urease, catalase, invertase and acid phosphatase significantly. Phosphatase and sulfatase are inhibit by As (V) but that urease was unaffected. Cadmium contamination has a negative effect on the activities of protease, urease, alkaline phosphatase and arylsulfatase but no significant effect on that of invertase. Each soil enzyme exhibits a different sensitivity to heavy metals. The order of inhibition of urease activity generally decreased according to the sequence Cr > Cd > Zn > Mn > Pb. Diversity and activity of soil microbes play significant roles in recycling of plant nutrients, maintenance of soil structure, detoxification of noxious chemicals and the control of plant pests and plant growth communities are important indices of soil quality. It is important to investigate the functioning of soil microorganisms in ecosystems exposed to long-term contamination by heavy metals (Wang *et. al.,* 2007). Chromium is commonly present in soils as Cr (III) and Cr (VI), which are characterized by distinct chemical properties and toxicities. Chromium (VI) is a strong oxidizing agent and is highly toxic, whereas Cr (III) is a micronutrient and a non-hazardous species, 10 to 100 times less toxic than Cr (VI) (Garnier *et al.,* 2006). Cr (VI) has been reported to cause shifts in the composition of soil microbial populations, and known to cause detrimental effects on microbial cell metabolism at high concentrations (Shun *et al.,* 2009). Ashraf and Ali (2007) also reported that the heavy metals exert toxic effects on soil microorganism hence results in the change of the diversity, population size and overall activity of the soil microbial communities and observed that the heavy metal (Cr, Zn and Cd) pollution influenced the metabolism of soil microbes in all cases. In general, an increase of metal concentration adversely affects soil microbial properties e.g. respiration rate, enzyme activity, which appears to be very useful indicators of soil pollutions. In case of soil contaminated with lead (Pb) slight change was observed in the soil microbial profile.

2.7.4. Ground water

Due to urbanization and expanding economic activities, about 13 % of the world's population do not have access to safe drinking water (WHO and UNICEF, 2010). With current trend of water demand, water shortage will become even more intense and approximately, half of the world's population will suffer from major water scarcity by the year 2030 (UNESCO-WWAP, 2009). Textile wastewater includes a large variety of dyes and chemical additions that pose an environmental challenge for textile industry not only as liquid waste but also due to its chemical composition. The shifting of irrigation water to fulfil the need of industrial use as well as water quality and lowering of water table around Tirupur textile hub has been reported in several studies. The surface as well as ground water quality induces environmental degradation over long period of time because of discharge of highly contaminated effluents accelerated by over exploitation of existing water resources (Dutta and Singh, 2014).

Dyeing and printing industrial wastes disposed both in liquid and solid forms in land and water bodies percolate into the ground water and get transported in the direction of ground water flow. The rate of percolation and transportation of pollutants in the groundwater flow direction increases in arid and semi-arid conditions due to high permeability of soil. As a result, different pollutants reach into the groundwater system and pose a threat to groundwater quality, which ultimately affects the socio-economic life of the people, who depend on groundwater for various purposes (Jacob *et al.,* 1999; Sharma *et al.,* 1999; Patel and Shrivastava, 1999; Sharma *et al.,* 2001; Hussain, 2001; Hussain *et al.,* 2001; 2003; 2004). The disposal of textile industrial waste on land and other surface water bodies, untreated/improperly treated effluents are also injected into the groundwater through nallas and wells in some locations. As a result, ground water resources of surrounding areas become unsuitable for drinking, domestic and industrial purposes (Mishra and Sahoo, 2003).

A study was conducted by Husain and Hussain (2012) on the Groundwater Pollution by Discharge of Dyeing and Printing Industrial Wastewater in Bandi River, Rajasthan, India. Chemical properties of groundwater sources situated near river Bandi in the downstream to Pali were studied to assess the environmental impact of the dyeing and printing industry. The wastewater of the printing and dyeing units of Pali had very high concentration of pollutants. It is characterized by very high TDS, chloride, sulphate, bicarbonate and sodium BOD and COD. The BOD is nearly six fold higher to COD. Chromium, copper and iron were also recorded in remarkable concentration. After treatment of wastewater in the combine effluent treatment plant (CETP) only BOD and COD were reduced while other parameters remain nearly the same. The concentration of iron increased after the treatment. The impact of the wastewater of the dyeing and printing units was clearly noticeable in the study area. The groundwater of the area became highly polluted and had TDS above 3000 mg/l. No source in the study area was found to be suitable for irrigation as well as drinking purposes.

A trial was conducted by Nangare *et al.*, (2008) on impact of textile industry on ground water quality with special reference to Ichalkaranji city, M.S.,(India). The analysis of groundwater (bore and well water) is to be carried out with parameters like hardness, alkalinity, fluoride, nitrates, chlorides, sulphates, TDS, chromium, iron etc. to get the information about the influence of pollutants on its quality of entire area. The result revealed that all the parameters are well within permissible limits but only, TDS and hardness showing higher values which indicate that the need for some kind of treatment for the removal of dissolved salts prior to its use for domestic purposes.

The research work by Dutta and Singh (2014) revealed that the groundwater samples of Pali, industrial area has shown alkaline nature and chemical parameters – COD, BOD, total dissolve solids electrical conductivity, chloride and Cr have exceeded the maximum discharge limits laid down by Bureau of Indian Standards , rendering wells in the area unfit for drinking and even for irrigation. The soil in this area has also become hard and infertile.

2.7.5. Ecological impact

Different textile and other industries used azo dyes, and parts of the dye used for coloring purposes are discharged into the environment in the form of waste waters, which causes serious human and ecological risks. The azo dye in its original form, as well as their biotransformation products, causes toxic effects, principally DNA damage. Azo dye consists of an important class of environmental mutagens and hence develops genotoxic dyes (Mani and Bharagava, 2018).

Heavy metals are highly persistent, toxic in trace amounts, and can potentially induce severe oxidative stress in aquatic organisms. Thus, these contaminants are highly significant in terms of ecotoxicology. Moreover, metals are not subject to bacterial degradation and hence remain permanently in the marine environment (Woo *et al.*, 2009) . Contamination of a river with heavy metals may cause devastating effects on the ecological balance of the aquatic environment, and the diversity of aquatic organisms becomes limited with the extent of contamination (Ayandiran *et al.*, 2009).

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Heavy metals released into aquatic systems are generally bound to particulate matter, which eventually settle down and become incorporated into sediments. Surface sediment therefore is the most important reservoir or sink of metals and other pollutants in aquatic environments. Sediment-bound pollutants can be taken up by rooted aquatic macrophytes and other aquatic organisms (Peng *et al.*, 2008). Because a major fraction of the trace metals introduced into the aquatic environment eventually become associated with the bottom sediments, environmental degradation by metals can occur in areas where water quality criteria are not exceeded, yet organisms in or near the sediments are adversely affected (Gurrieri, 1998). Diatom community structure can be affected by high levels of micro pollutants, and in particular by metals, which are often found in rivers (Morin *et al.*, 2007; Jongea *et al.*, 2009). Once heavy metals are accumulated by an aquatic organism, they can be transferred through the upper classes of the food chain. Carnivores at the top of the food chain including humans, obtain most of their heavy metal burden from the aquatic ecosystem by way of their food, especially where fish are present so there exist the potential for considerable biomagnifications (Ayandiran *et al.*, 2009) . Contaminants in aquatic systems, including heavy metals, stimulate the production of reactive oxygen species (ROS) that can damage fishes and other aquatic organisms (Woo *et al.,* 2009). Fish is a commodity of potential public health concern as it can be contaminated with a range of environmentally persistent chemicals, including heavy metals. The consumption of fish containing elevated levels of metals is a concern because chronic exposure to heavy metals can cause health problems (Soliman, 2006). Mercury (Hg) is one of the most important pollutants both because of its effect on marine organisms and it is potentially hazardous to humans. Methylmercury, which is formed in aquatic sediments through the bacterial methylation of organic mercury, is toxic chemical compound of mercury, in fact, nearly all of the mercury in fish muscles occurs as Methylmercury (Soliman, 2006). Transport of metals in fish occurs through the blood where the ions are usually bound to proteins. The metals are brought into contact with the organs and tissues of the fish and consequently accumulated to a different extent in different organs or tissues of the fish. There are five potential routes for a pollutant to enter a fish. These routes are through the food, non-food particles, gills, oral consumption of water and the skin. Once the pollutants are absorbed, they are transported by the blood to either a storage point (that is, bone) or to the liver for transformation and storage. If the pollutants are transformed by the liver, they may be stored there or excreted in the bile or passed back into the blood for possible excretion by the gills or kidneys, or stored in fat, which is an extra hepatic tissue (Ayandiran *et al.,* 2009).

Benthic macro invertebrate assemblages contain species with various sensitivities to contaminants and have been widely used to evaluate the ecological impacts of metal contamination in streams. They play vital roles in lotic food webs by forming a major link between primary producers and higher trophic levels and in lotic ecosystems by regulating organic matter decomposition and nutrient cycling. However, the impact of heavy metals on macro invertebrates has not been evaluated in terms of their food value for fish, even though invertebrates are an important food source for many moving-water fish species. It is of particular importance to evaluate the effects of heavy metal pollution on drift-prone macro invertebrates, on which most commercially or recreationally important salmonid species depend (Iwasaki *et al.,* 2002).

2.7.6. Socio-economic impact

Developing countries have limited capacities of cities to treat their wastewater that cause pollution of soils, water bodies and traditional irrigation water sources. Applying wastewater to land as irrigation limits the pollution of rivers, canals and other safe-water resources. This benefits the health of people downstream, who use these water resources for domestic and drinking-water needs.

Raja *et al.,* (2015) reported that water scarcity is one of the main constraints for agriculture sector in many countries. It pushes the farmers to use wastewater for irrigation as an available alternative, especially in peri-urban areas of developing countries. In areas where fresh water is scarce, wastewater allows low-income farmers to produce crops. Otherwise they would not able to grow crops. On the other hand, wastewater production is continuous, making it a reliable and demand- based source of water that is available to farmers whenever they need it (unlike canal irrigation). Being sure of their water supply, even in the dry season, farmers can grow high-value crops. They can also grow crops that are more sensitive to water stress (e.g. Vegetables).

Wastewater usage for irrigation has the benefits of conserving water and nutrients, reducing the pollution of rivers and canals, providing micronutrients, organic matter, all required nitrogen, and much of the required phosphorus and potassium for normal crop production (FAO, 1992; Murtaza *et al.,* 2010; Hanjra *et al.,* 2012). It is a great temptation for the poor farmers to use wastewater as it can reduce the crop production cost by 10–20% (Mapanda *et al.,* 2007; Murtaza *et al.,* 2010; Qadir *et al.,* 2010). The nutrients of that waste water contained are an additional benefit, saving farmers money (in terms of chemical fertilizers) and increasing crop yield. So, wastewater irrigation can also significantly contribute to urban food security and nutrition.

In an area of Pakistan, wastewater is frequently used without any prior treatment to irrigate vegetables and crops due to non-availability of fresh water (Murtaza *et al.,* 2010). Farmers are usually not well informed about the drawbacks of this practice, and have a different opinion (Zafar and Akhtar, 2003). About 26% of all vegetables grown in Pakistan are irrigated by untreated wastewater. As a result, locally produced vegetables are about 60% cheaper than imported vegetables, due to lower costs for fertilizer and transportation to market (Hanjra and Qureshi, 2010). Therefore waste water was preferred for its economic benefits.

CHAPTER - 3

MATERIALS AND METHODS

CHAPTER-3

MATERIALS AND METHODS

The materials and method is a vital component of any scientific research. Methods must be appropriate to fulfilling the overall aims of the study. It deserves a very careful consideration for conducting research. The basic materials for establishment of research are the unbiased information and facts. The methods section describes actions to be taken to investigate a research problem and the rationale for the application of specific procedures or techniques used to identify, select, process, and analyze information applied to understanding the problem, thereby, allowing the reader to critically evaluate a study's overall validity and reliability. The reliability of a scientific research depends on the proper and appropriate methodology for such research. It makes enable the researcher to collect reliable information to arrive at correct conclusion. There were selected two locations for conducting the study. The densely textile industrial area of Gazipur and Narayanganj district under Dhaka division, were chosen for collecting textile waste water under the study. For the conduction of field experiment the site was selected at central station, Bangladesh Jute Research Institute (BJRI), Dhaka. The detail research programme and methodology are presented in this chapter.

3.1. Global position and description of the study area

The selected site Narayanganj lies between $23^0$33' and $23^0$57' north latitudes and between $90^0$26' and $90^0$45' east longitudes (BBS 2011). The other site was at Gazipur located between $23^0$53' and $24^0$21' north latitudes and between $90^0$09' and $92^0$39' east longitudes (website 5). The central station of BJRI is located in $23^0$45'26" north latitude and $90^0$22'33" east longitude. The flood level is normal and drainage system was good. All the sites are under Dhaka division of Bangladesh.

3.2. Narayanganj

Narayanganj is a district in central Bangladesh, part of the Dhaka Division. The anicient city of Sonargaon is in Naryanganj. It is located in the bank of the Meghna and Shytolokha River.

The main centre of the disatrict is Naryanganj City. It is adjacent with capital city of Dhaka. Narayanganj is one of the oldest industrial district of Bangladesh. It is also a center of business and industry, especially the jute trade and processing plants, and the textile sector of the country. It is familiar as the “Dundee of Bangladesh” due to the presence of many jute mills. Dundee was the first industrialized "Juteopolis" in the world. Narayanganj is one of the high category districts for economy flow of Bangladesh. The area is about 684.37 Sq Km. and total population is 2948217 (web site 6). Narayanganj district is bounded on the north by Gazipur and Narsingdi districts, on the east by districts of Brahmanbaria and Comilla, on the south by Munshiganj and on the west by Dhaka (BBS, 2013). Narayanganj subdivision was established in 1882 and turned into a district in 1984. Narayanganj municipality was established in 1876. The area of the town is 18.7 sq. km. The district consists of 5 upazilas, 41 union, 619 mauza, 1204 village, 6 paurashava, 54 ward and 282 mahalla.The upazilas are Araihazar, Bandar, Narayanganj Sadar, Rupganj and Sonargaon(BBS, 2013). Annual Average Temperature and Rainfall: The annual average maximum and minimum temperature normally varies between 29.8^0 C and 17.6^0 C respectively. Annual average rainfall as recorded in 2011 was 2376 millimeters (BBS, 2013). Crops such as paddy, wheat, jute, cotton, tobacco, sugarcane, pulses, oil seeds, potato, vegetables and other seasonal crops are grown here (website 7).

3.3. Gazipur

Gazipur district is located at just north of capital city of Dhaka, Bangladesh. The previous name of the region was “**Joydebpur**”. Gazipur is bordered by the districts of Kishoreganj and a part of Mymensingh to the north, Dhaka and Narayanganj to the south, Kishoreganj and Narsingdi to the east, Dhaka and Tangail districts to the west. The area of current Gazipur district is 1806.36 Sq Km. It is a city corporation; 04 Municipalities in Gazipur named Tongi, Sreepur, Kaliganj and Kaliakuir. The number of Upazilla (sub- district) in Gazipur district is 05, named- Gazipur Sadar, Sreepur, Kaliakur, Kapashia and Kaligonj containing 44 Unions, 715 Mauzas and 1,114 Villages. The total population of Gazipur district is 34,03,912 (Male- 17,75,310 and Female- 16,28,602), sex ratio 109:100, population density 1884/Sq Km and annual growth rate is 5.21%. Major river of Gazipur are Lablong, Brahmaputra, Paruli, Turag, Suti, Goali, Banar, Balu, Chelai, Bangshi, Shitalakha etc. Annual average temperature of this district is maximum 36^{0}C and minimum 12.7^{0}C. Annual rainfall is 2376 mm. The crops potato, paddy, jute, oilseed, sugarcane, cotton, bamboo, jack fruit, Papaya etc. are grown here (website 8).

3.4. Description of the experimental soils and textile waste water

Pot and field experiments were carried out in Bangladesh Jute Research Institute, Central Station, Dhaka to evaluate the effect of textile waste water irrigation on growth- yield of jute vegetable. The waste water and soil samples were collected from district of Narayanganj (located between$23^0$33' and $23^0$57' north latitudes and between $90^0$26' and $90^0$45' east longitudes) and Gazipur (located between $23^0$53' and $24^0$21' north latitudes and between 90^0 09' and $92^0$39' east longitudes). These areas are belong to "tropical monsoon climate" and have three main seasons, namely: the monsoon or rainy season, the dry or winter season and the pre- monsoon or summer season.

3.5. Description of the experimental soils used in pot experiments

The soils used in the pot experiments representing plough layer depth from 0-15 cm. The collected soil sample was air dried, ground and screened to pass through a 2.0 mm sieve and then mixed thoroughly to make it a composite sample. Dry roots, grasses and other vegetative residual parts were removed from the soil. One kg of composite each sample was kept in the plastic container for chemical analysis. One litter of textile waste water also kept in a plastic bottle. The physical and chemical characteristics of the soils and water were determined by using the samples. Soil properties of the pot experiments are presented in Table 3.1.

3.6. Collection and preparation of soil before land preparation

The soil samples were collected before land preparation at a depth of 10-15 cm from 40 to 45 spots by using the steel made augur. The collected samples were mixed thoroughly and finally composite 500 gm soil was preserved for determining the initial soil nutrient status.

Table 3.1: Initial physical and chemical properties of experimental soils of pot experiments

Parameters	Observation			
	NCSN	CSN	NCSG	CSG
Sand (%)	39	24	18	15
Silt (%)	63	63	61	59
Clay (%)	8	13	21	26
Textural class	Silt Loam	Silt Loam	Silt Loam	Silt Loam
pH	6.8	6.9	5.9	6.6
EC (dS/m)	1.6	1.9	1.5	4.2
Organic matter (OM) %	1.77	3.82	1.78	2.69
Total Nitrogen (N) %	0.187	0.091	0.12	0.135
Potassium (K) meq/100g soil	0.18	0.10	0.62	0.49
Calcium (Ca) meq/100g soil	4.16	3.12	3.76	5.08
Magnesium (Mg) meq/100g soil	1.22	0.88	0.81	1.45
Phosphorus (P) ppm	6.20	17.16	4.24	5.21
Sulphur (S) ppm	16.73	11.22	14.03	33.25
Copper (Cu) ppm	0.24	0.56	0.82	0.22
Iron (Fe) ppm	52.07	234.00	50.12	118.70
Manganese (Mg) ppm	12.52	12.79	16.05	13.02
Zinc (Zn) ppm	1.46	5.67	0.9	19.38
Lead (Pb) ppm	11.67	17.62	10.21	27.02
Cadmium (Cd) ppm	0.098	0.123	0.054	0.133
Nickel (Ni) ppm	29.67	27.84	25.84	30.00
Chromium (Cr) ppm	34.80	33.37	32.42	37.72

Here to denote:

NCSN=Non contaminated soil of Narayanganj, CSN= Contaminated soil of Narayanganj,

NCSG=Non contaminated soil of Gazipur, CSN= Contaminated soil of Gazipur.

3.7. Description of the experimental fields

The field experiment was conducted at central station of Bangladesh Jute Research Institute (BJRI), Dhaka. The soil properties of the experimental field presented in Table 3.2.

Table 3.2: Initial physical and chemical properties of the experimental field soil

Parameters	Observation
Sand (%)	42
Silt (%)	45
Clay (%)	13
Textural class	Loam
pH	6.2
EC (dS/m)	1.3
Organic matter (OM) %	2.42
Total Nitrogen (N) %	0.121
Potassium (K) meq/100g soil	0.31
Calcium (Ca) meq/100g soil	3.27
Magnesium (Mg) meq/100g soil	0.93
Phosphorus (P) ppm	26.51
Sulphur (S) ppm	29.11
Copper (Cu) ppm	0.74
Iron (Fe) ppm	199.80
Manganese (Mg) ppm	2.42
Zinc (Zn) ppm	20.15
Lead (Pb) ppm	29.78
Cadmium (Cd) ppm	0.238
Nickel (Ni) ppm	23.48
Chromium (Cr) ppm	31.12

3.8. Collection of post harvest soil samples

The soil samples were collected after harvest the crops by using steel made augur. According to the treatments each sub plot was considered to collect the sample. It was kept in polythene bag and tagged treatment wise. The soil was air dried, ground and sieved through a 0.5 mm sieve for physical and chemical analysis.

3.9. Collection of textile waste water

Textile waste water was collected from Gazipur and Narayanganj district, located between Latitude $20^0 25^/$ to $23^0 02^/$ N and Longitude $88^0 35^/$ to $92^0 24^/$ E. The collected waste water samples were stocked in plastic container maintaining three main seasons, namely: the pre-monsoon or summer season, the monsoon or rainy season and the post-monsoon or winter season. Most of the textile mills of the country are situated in those locations. The amount of one litter of textile waste water sample was also kept in a plastic bottle for determination of physical and chemical properties. Analytical results of textile waste water of Natayangonj and Gazipur which were applied in the experiments as irrigation water are presented in Tables 3.3 and 3.4 respectively.

Table 3.3 : Analytical results of textile waste water of Narayangonj

Parameters	Pre-monsoon	monsoon	Post-monsoon
pH	7.5	8.6	7.7
EC (dS/m)	2.09	1.85	2.15
TDS (ppm)	752	730	1203
DO (ppm)	1.19	2.32	2.30
BOD (ppm)	15.39	23.75	11.14
Total Nitrogen (%)	0.07	0.05	0.06
Potassium (ppm)	0.52	0.65	2.32
Calcium (ppm)	0.58	0.75	3.75
Magnesium (ppm)	0.20	0.24	0.65
Phosphorus (ppm)	64.32	51.11	29.06
Sulphur (ppm)	113.72	108.25	194.78
Copper (ppm)	1.12	0.15	0.961
Iron (ppm)	1.34	0.51	0.92
Manganese (ppm)	0.097	0.028	0.069
Zinc (ppm)	0.08	0.12	0.086
Lead (ppm)	0.0001	0.0001	0.0001
Cadmium (ppm)	0.0095	0.0001	0.0039
Nickel (ppm)	0.482	0.567	0.210
Chromium (ppm)	0.100	0.115	0.231

Table 3.4: Analytical results of textile waste water of Gazipur

Parameters	Pre-monsoon	monsoon	Post-monsoon
pH	6.8	7.75	7.2
EC (dS/m)	3.17	2.11	2.43
TDS (ppm)	832	784	805
DO (ppm)	3.8	3.2	4.2
BOD (ppm)	26.21	37.2	13.4
Total Nitrogen (%)	0.5	0.5	0.6
Potassium (ppm)	0.52	0.48	0.61
Calcium (ppm)	0.58	0.60	0.73
Magnesium (ppm)	0.20	0.18	0.25
Phosphorus (ppm)	64.32	20.33	40.27
Sulphur (ppm)	113.72	32.60	70.48
Copper (ppm)	1.12	1.28	1.73
Iron (ppm)	1.34	0.58	1.11
Manganese (ppm)	0.097	0.032	0.069
Zinc (ppm)	0.08	0.11	0.10
Lead (ppm)	0.0001	0.0001	0.0001
Cadmium (ppm)	0.0095	0.0016	0.0032
Nickel (ppm)	0.482	0.210	0.351
Chromium (ppm)	0.151	0.112	0.152

3.10. Methods for soil analysis

3.10.1. Physical analysis

3.10.1.1. Moisture content

The percentage of moisture in soil was determined by drying a known amount of soil in an oven at 105^0 C for 24 hours until a constant weight was obtained and the moisture percentage was calculated from loss of moisture (Black, 1965).

3.10.1.2. Particle size analysis

The particle size distribution of soil was carried out by hydrometer method originally proposed by Bouyoucos (1962) and described by Piper (1966). Marshall's triangular co- ordination system as described by the United State Department of Agriculture was followed to determine the textural class.

3.10.2. Chemical analysis

3.10.2.1. pH

The glass electrode pH meter was used to determine pH of the soils and water samples. The ratio of the soil and water in the suspension was maintained at 1:2.50 (Hunter, 1984).

3.1..2.2. Electrical Conductivity (EC)

The EC (soil: water- 1:5) values were determined by EC meter (USSLS, 1954).

3.10.2.3. Soil organic carbon

Organic carbon in soil was determined by wet oxidation method as described by Walkley and Black (1934).

3.10.2.4. Organic matter

Organic matter was calculated by multiplying the organic carbon with the conventional van Bemmelen' s factor of 1.724 .

3.10.2.5. Total nitrogen

Total nitrogen of soil was determined by microkjeldahl method where soil was digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4 , $CuSO_4$, $5H_2O$: Selinium powder in the ratio 100:10:1). Nitrogen in the digest was estimated by distillation with 40% NaOH followed by titration of the distillation trapped in H_3BO_3 with 0.01 N H_2SO_4 (Jackson, 1973).

3.10.2.6. Available phosphorus

Available phosphorus was determined from soil extract, the extraction was made with Bray and Kurtz (1945) method. Spectrophotometer was used to measure the color intensity at the wave lengths of 880 nm following the ascorbic acid blue color method (Watanable and Olsen, 1965).

3.10.2.7. Exchangeable potassium

Exchangeable potassium was determined by neutral 1N NH_4OAc (pH 7.0 one normal ammonium acetate) extract of the soil by using flame photometer (Huq and Alam, 2005).

3.10.2.8. Available sulphur

Available sulphur was determined by extracting the soil sample with 0.15% $CaCl_2$ solution (Page *et al.*, 1982). The sulphur content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

3.10.2.9. Exchangeable calcium and magnesium

Exchangeable calcium and magnesium were extracted with neutral 1N NH_4OAc (one normal Ammonium acetate) as described by Jackson (1973). The calcium and magnesium were determined by atomic absorption spectrophotometer (AAS).

3.10.2.10. Heavy metal analysis

Flame atomic absorption spectrophotometer equipped with deuterium lamp background correction and hollow cathode lamps was used for the analysis of the heavy metals Fe, Zn, Mn, Cu, Co, Ni, Cd, Cr and Pb (Wodaje and Abebaw, 2017). Aqua regia (prepared from 3:1 ratio of 35–38% HCl and 65–68% HNO_3) and 30% H_2O_2 were used for sample digestion. Wet digestion method was used for digestion of the soil samples. The digested samples were determined for the concentrations of heavy metals (Fe, Zn Mn, Cu, Co, Ni, Cd, Cr and Pb) using flame atomic absorption spectrophotometer. Final concentrations of the metals in the soil samples were calculated using the following formula (Uwah *et al.*, 2012):

$$\text{Concentration (mg/kg)} = \frac{\text{Concentration (mg/L)} \times V}{W}$$

Where, *V* = Final volume (50 ml) of solution, and *M* = Initial weight (0.5 g) of sample measured.

3.11. Method of plant sample analysis

3.11.1. Plant sample collection

Plant samples were collected from individual experiment of pot and field (according to the treatments) for chemical analysis. Ten plants were randomly selected from each pot and plot. The plants were separated into leaves, roots and stem to obtain the chemical results of different parts of the jute, jute leaves vegetable (pat shak) and red amaranth plant. For rice, plant roots, straw and grain were separated to obtain the chemical properties. These plant samples were dried in the electrical oven at 70^0 C for 72 hours. After that the plant samples were ground in an electric grinding machine and stored for analysis.

3.11.2. Total nitrogen analysis

Plant samples were digested with sulphuric acid and digestion mixture (catalyst) and nitrogen was determined by alkali distillation of Kjeldahl digest (Jackson, 1973).

3.11.3. Total phosphorus, potassium and sulphur analysis

Total phosphorus, potassium and sulphur were determined by digestion with a mixture of conc. HNO_3 and $HClO_4$ (Jackson, 1973). Total phosphorus was determined by yellow color method (Jackson, 1973) and S was determined by turbidimetric method (Sakai, 1978) using spectrophotometer. Potassium was determined using flame photometer (Huq and Alam, 2005).

3.11.4. Total calcium and magnesium analysis

Total Ca and Mg were determined using atomic absorption spectroscopy (Huq and Alam, 2005).

3.11.5. Total heavy metal analysis

Aqua regia (prepared from 3:1 ratio of 35–38% HCl and 65–68% HNO_3) and 30% H_2O_2 were used for sample digestion. Wet digestion method was used for digestion of the soil samples. The digested samples were determined for the concentrations of heavy metals (Fe, Zn Mn, Cu, Co, Ni, Cd, Cr and Pb) using atomic absorption spectrophotometer (Wodaje and Abebaw, 2017).

3.12. Method of water sample analysis

The pH of collected water samples was measured with electric pH meter. The EC were determined by EC meter (USSLS,1954). Dissolved oxigen was determined by DO meter. Biological oxygen demand (BOD) was determined by BOD meter. Water sample was prepared as described the procedure by Huq and Alam (2005) to determine both DO and BOD. TDS was measured by the volume of solids in one litre of a sample that was settled on the bottom of a conical flask during the subsequent evaporation and drying in oven at specific temperature 103-105°C. For chemical analysis, samples were filtered (Whatman No. 42, England) to eliminate suspended solid particles. Nitrite-nitrogen was determined by modified Griess-Ilosvay method (Barnes and Folkard, 1951) while nitrate-nitrogen was determined colorimetrically (Joergensen and Brookes, 1990). Ammonium nitrogen was determined by phenate method. Phosphorus content was determined by ascorbic acid blue method (Murphy and Riley 1962). Potassium was determined by using flame photometer. Sulphur was measured by spectrophotometer. Several elements (Ca, Mg, Fe, Zn, Mn, Cu, Co, Ni, Cd, Cr and Pb) in water samples were determined using atomic absorption spectroscopy (Haswell, 1991).

3.13. Experimental set up

Two pot experiments and four field experiments were carried out under this Ph.D. research programme.

3.13.1. Pot experiment

i) Pot experiment No. 1: Influence of textile waste water on yield and heavy metal up take by jute leaves vegetable (pat shak)

ii) Pot experiment No. 2: Residual effect of textile waste water on yield and heavy metal up take by red amaranth

Each pot experiment has four different soil set:

A) Non contaminated soil of Narayanganj (NCSN),

B) Contaminated soil of Narayanganj (CSN),

C) Non contaminated soil of Gazipur (NCSG) and

D) Contaminated soil of Gazipur (CSG).

3.13.2. Field experiment

iii) Field experiment No. 1: Influence of textile waste water on yield and heavy metal up take by jute

iv)Field experiment No. 2: Influence of textile waste water on yield and heavy metal up take by rice

v) Field experiment No. 3: Influence of textile waste water on yield and heavy metal up take by jute leaves vegetable (pat shak) at field condition

vi) Field experiment No. 4: Influence of textile waste water on yield and heavy metal up take by red amaranth.

3.14. Treatments

3.14.1. Treatments for pot experiment No.-1 and field experiments

T_1 – Control

T_2- 100% RDF+ 0% TWW

T_3 – 50% RDF + 25% TWW

T_4 – 50% RDF + 50% TWW

T_5 – 50% RDF + 75% TWW

T_6 – 50% RDF + 100% TWW

Here, TWW= Textile waste water and RDF= Recommended dose of fertilizer

3.14.2. Treatments for pot experiment No.-2

T_1 – Control

T_2- 100% RDF+ RE of 0%TWW

T_3 – 50% RDF + RE of 25%TWW

T_4 – 50% RDF + RE of 50% TWW

T_5 – 50% RDF + RE of 75% TWW

T_6 – 50% RDF + RE of 100% TWW

Here, TWW= Textile waste water, RE= Residual effect and

RDF= Recommended dose of fertilizer

3.15. Variety

Pot experiment No.1: Jute leaves vegetable (pat shak) newly developed by BJRI deshi pat shak-1 variety was used in the experiment.

Pot experiment No.2: Red amaranth variety Lolita was used in the experiment.

Field experiment No.1: The high yielding jute variety Tossa (O -795) was used in the experiment.

Field experiment No.2: T. Aman rice Binashail variety was used in the experiment.

Field experiment No.3: Jute leaves vegetable newly developed by BJRI deshi pat shak-1 variety was used in the experiment.

Field experiment No.4: Red Amaranth variety Lolita was used in the experiment.

3.16. Experimental design

3.16.1. Design for pot experiment

Pot experiments were laid out in completely randomized design (CRD) with three replications. Earthen pot was used in the experiment. Each pot was filled up by 7 Kg of air dried well sieved soil. The two sets of experiments for non contaminated soils and contaminated soils were executed with six treatments.

Table 3.5: Treatments and layout of the pot experiment No. 1

	Control	100% RDF+ 0% TWW	50% RDF + 25% TWW	50% RDF + 50% TWW	50% RDF + 75% TWW	50% RDF + 100% TWW
Non contaminated Soil	R_1T_1	R_1T_2	R_1T_3	R_1T_4	R_1T_5	R_1T_6
	R_2T_1	R_2T_2	R_2T_3	R_2T_4	R_2T_5	R_2T_6
	R_3T_1	R_3T_2	R_3T_3	R_3T_4	R_3T_5	R_3T_6
Contaminated Soil	R_1T_1	R_1T_2	R_1T_3	R_1T_4	R_1T_5	R_1T_6
	R_2T_1	R_2T_2	R_2T_3	R_2T_4	R_2T_5	R_2T_6
	R_3T_1	R_3T_2	R_3T_3	R_3T_4	R_3T_5	R_3T_6

Table 3.6: Treatments and layout of the pot experiment No. 2

	Control	100%RDF + RE of 0%TWW	50% RDF + RE of 25%TWW	50% RDF + RE of 50%TWW	50% RDF + RE of 75%TWW	50% RDF + RE of 100%TWW
Non contaminated Soil	R_1T_1	R_1T_2	R_1T_3	R_1T_4	R_1T_5	R_1T_6
	R_2T_1	R_2T_2	R_2T_3	R_2T_4	R_2T_5	R_2T_6
	R_3T_1	R_3T_2	R_3T_3	R_3T_4	R_3T_5	R_3T_6
Contaminated Soil	R_1T_1	R_1T_2	R_1T_3	R_1T_4	R_1T_5	R_1T_6
	R_2T_1	R_2T_2	R_2T_3	R_2T_4	R_2T_5	R_2T_6
	R_3T_1	R_3T_2	R_3T_3	R_3T_4	R_3T_5	R_3T_6

3.16.2. Design for field experiment

The layout and design was followed randomized complete block design (RCBD) having three replications. The numbers of plots were 18 and dimension of each plot was 3m x 3m. The space between the plots, blocks and around the field was 1.0 meter.

Table 3.7: Treatments and layout of the field experiments

R_1	R_2	R_3
T_3	T_6	T_5
T_5	T_1	T_3
T_2	T_3	T_6
T_4	T_5	T_1
T_1	T_2	T_4
T_6	T_4	T_2

3.17. Land preparation

At the beginning of the experiment land was prepared finely with repeat plowing and cross plowing four times with power tiller followed by laddering. Weed and residue were cleaned properly. Drainage channel was made to remove the excess rain water from the plot. After completion of the first experiment the land was prepared without disturbing the layout of the previous experiment. The tillage was done by spade with very carefully giving the extra attention so that the layout remains intact. Weeds and roots of the previous crops were removed manually from the plots.

For rice the land was ploughed thoroughly and puddle with 3cm to 5cm of standing water in the field. Then the land was leveled after puddling to facilitate a uniform distribution of water and fertilizers.

3.18. Fertilizer application method

Inorganic fertilizers for the crops were calculated on the basis of soil chemical test as per Fertilizer Recommendation Guide (FRG, 2012) of Bangladesh Agricultural Research Council (BARC).

i) Jute

Half of N from urea and full dose of P as triple super phosphate (TSP), K as muriate of potash (MoP), S as gypsum were applied before sowing of seed. The rest half of amount of N was top dressed at 45 days of sowing after final thinning.

ii) Rice

Full dose of P as triple super phosphate (TSP), K as muriate of potash (MoP), S as gypsum and Z as zinc oxide were applied as a basal during final land preparation. Nitrogen as urea was applied in three equal splits, the first one as immediately after seedling establishment, the second one at early tillering stage and third one at 5-7 days before panicle initiation stage. It was applied as broadcast and mixed thoroughly with soil as soon as possible for better utilization.

iii) Jute leaves vegetable (pat shak)

Full dose of P as triple super phosphate (TSP), K as muriate of potash (MoP), S as gypsum were applied as a basal during final land preparation. Nitrogen as urea was applied as topdress in three equal splits, the first one-third during final land preparation, the second one-third at 20-25 days and the last one-third at 40-45 days.

iv) Red amaranthus

All of P as triple super phosphate (TSP), K as muriate of potash (MoP), S as gypsum and half of N from urea were applied as a basal during final land preparation. Remaining N was applied as topdress at 10-15 days after sowing under moist soil condition.

3.19. Sowing of seeds/ transplanting of seedlings

After final land preparation jute, jute leaves vegetable (pat shak) and red amaranth seeds were sown in line at a distance of 30 cm interval at depth of 2.5 cm. After sowing, seeds were covered with soil by hand. Jute leaves (pat shak) seeds were sown during first of January. Red amaranth seeds were sown at the first week of March. Jute seeds were sown during first week of April. Rice seedlings were transplanted in line at a distance of 30 cm interval at the second week of August.

3.20. Irrigation

Each plot was irrigated with fresh water or textile waste water when required as per treatment. During the initial period, paddy field required abundant water supply. Water supply was reduced periodically before harvesting the crop.

3.21. Intercultural practices

Recommended cultural practices for each crop were done as when necessary. Three weedings were done at the stage of 10, 25, and 40 days after sowing and two thinning were executed at the second and the third weeding. No pesticides were required during the growing period.

3.22. Harvesting

3.22.1. Jute

The jute plants were harvested at the early pod stage after total growth duration of 120 days. The plant population of each plot was counted at the time of harvest. A randomly selected 10 plants were uprooted from each plot and attached soil was removed carefully without damaging the root and root hair. Then plants were cut in ground level, the jute plants were made into small bundles and kept standing on ground for 4 days for shedding of leaves.

Retting of jute

After shedding of jute leaves, the bundles were steeped plot wise in pond water for retting. The retting process was completed in 21 days after steeping. In the retting process fibre in the bark get loosened and separated from the woody stalk.

Extracting (stripping), decortications, washing and drying

After proper retting the fibres were extracted by stripping and washed thoroughly in water. The extracted fibres were dried in sun plotwise on bamboo bars. After drying the fibres were weighed out to get the fibre yield. After stripping, the jute sticks were dried in the sun for several days and weighed out to record the yield of sticks.

3.22.2. Rice

Rice was harvested 36 to 40 days after flowering stage. It was harvested when the moisture content of the rice grain was 20 to 25%. Gradual drying was carried out for better recovery. A randomly selected ten hills were uprooted from each plot and attached soil was removed carefully without damaging the root and root hair. The plants were cut with about 100 cm of straw and are often dried in the field. They were piled into stacks with the panicles placed toward the centre to permit further drying of the grains.

Threshing and storage

Threshing is the removal or separation of grains from the panicles of the paddy stalks. Hand beating, ox treading, or a combination of both; and use of pedal threshers are the common methods of threshing. Small bundles were beaten on bare ground or other hard materials. Grains were then partially cleaned and removed from the threshing floor. Before storage, the grain were dried and cleaned. Grain were then stored in bags.

3.22.3. Jute leaves vegetable (pat shak)

The jute leaves vegetable plants were harvested at 45 days after germination of seeds. A randomly selected 10 plants were uprooted from each plot and attached soil was removed carefully without damaging the root and root hair.

3.22.4. Red Amaranth

Red amaranth plants were harvested before flowering. A randomly selected 10 plants were uprooted from each plot and attached soil was removed carefully without damaging the root and root hair.

3.23. Growth and yield component

3.23.1. Jute

Base diameter and plant height of ten randomly selected uprooted jute plants were taken with a slide calipers and meter scale respectively. Then the plant roots, shoots and leaves were separated and their green weight taken.

3.23.2. Rice

Plant height and tiller number of rice plant was recorded at 20 (early tillering stage: ETS), 40 (maximum tillering stage: MTS), 60 (panicle initiation stage: PIS) and 90 (maturity: Mat.) days after transplanting (DAT). Plant height of ten randomly selected uprooted hills were measured with a meter scale. Then the plant roots, straws and grains were separated and their green weight taken. Then number of tiller per hill, number of panicle, length of panicle, number of grain per panicle, percent of filled grain per panicle were counted.

3.23.3. Jute leaves vegetable (pat shak)

Plant height of ten randomly selected uprooted jute leaves plants were taken with a meter scale respectively. Then the plant roots, shoots and leaves were separated and their green weight taken. Then number of leaves were also counted.

3.23.4. Red amaranth

Base diameter and plant height of ten randomly selected uprooted jute plants were taken with a slide calipers and meter scale respectively. Then the plant roots, shoots and leaves were separated and their green weight taken.

3.24. Dry matter estimation

The separated plant parts were placed in an oven for 72 hours at 85^0 C and after constant weight. The plant samples were taken out of the oven and recorded their dry weight and determined moisture content in percentage.

3.25. Total dry matter production

Total dry matter production of each crop was calculated using the following formula:

$$\text{Total dry matter (t/ha)} = \frac{\text{Oven dry wt. of plant (gm) X No. of plant per plot X 0.01}}{\text{No. of plant dried in oven X Plot size (Sq.m)}}$$

3.26. Nutrient uptake

Nutrient uptake (Kg/ha) of different plant samples were calculated from the data of dry matter yield and nutrient content of different plant samples using the following formula:

$$\text{Nutrient uptake (Kg/ha)} = \frac{\text{Percent nutrient content X Total dry matter (kg/ha)}}{100}$$

3.27. Heavy metal uptake

Heavy metal uptake (gm/ha) of different plant samples were calculated from the data of dry matter yield and heavy metal content of different plant samples using the following formula:

$$\text{Heavy metal uptake (gm/ha)} = \frac{\text{Percent nutrient content X Total dry matter (gm/ha)}}{100}$$

3.28. Statistical analysis:

The data of respective variables of yield and yield contributing characteristics were analyzed by minitab 17.

CHAPTER - 4
RESULTS AND DISCUSSION

CHAPTER - 4

RESULTS AND DISCUSSION

Results of the different experiments are reported and discussed in this chapter.The collected soils for pot experiments the initial value of physical and chemical properties of non contaminated soil of Narayanganj (NCSN),contaminated soil of Narayanganj (CSN), non-contaminated soil of Gazipur (NCSG), contaminated soil of Gazipur (CSN) are shown in the Table 3.1. The textural class of all the sources of soils was silt loam. The values of pH of the soils were 6.8, 6.9, 5.9 and 6.6 in NCSN, CSN, NCSG and CSG, respectively. EC characters of soils were 1.6, 1.9, 1.5 and 4.2 dS/m in NCSN, CSN, NCSG and CSG, respectively. It is observed that organic matter content of both contaminated soils were comparatively higher than non contaminated soils, which were 3.82 and 2.69% in CSN and CSG, respectively. But the status of Zn at both contaminated soils were also high, which were 5.67 and 19.38 ppm in CSN and CSG, respectively.

The collected soils of experimental field were analyzed to observe the initial physical and chemical properties which are presented in Table 3.2. The textural class of the soil was loamy, pH value recorded 6.2 and EC of the soil obtained was 1.3 dS/m. The organic matter content of the soil was 2.42% and total nitrogen was 0.121 ppm.

Analytical results of textile waste water of Narayangonj which was applied in the experiment as irrigation water are shown in table 3.3. The pH of the textile waste water of Narayangonj in different periods were 7.5, 8.6 and 7.7 in pre-monsoon, monsoon and post-monsoon respectively. The EC values were 2.09, 1.85 and 2.15 dS/m in pre-monsoon, monsoon and post-monsoon respectively. Results showed that total nitrogen content was high in all the seasons, which values were 0.07, 0.05 and 0.06 % in pre-monsoon, monsoon and post- monsoon respectively. Analytical results of textile waste water of Gazipur which were applied in the experiment as irrigation water are shown in table 3.4. It was observed that pH of the textile waste water of Gazipur in different monsoon periods were 6.8, 7.75 and 7.2 in pre-monsoon, monsoon and post-monsoon respectively.The status of EC recorded were 3.17, 2.11 and 2.43 dS/m in pre-monsoon, monsoon and post-monsoon respectively. The total nitrogen content found was also high in all the seasons, which were 0.05, 0.05 and 0.06 % in pre-monsoon, monsoon and post-monsoon respectively.

Pot experiment No. 1

Pictorial view of pot experiment No. 1 - Jute leaves vegetable (Pat shak)

Pot Exp. 1: The pot experiment of jute leaves vegetable (Pat shak) was visited by co-supervisor.

4.1. Pot experiment No. 1

Influence of textile waste water on yield and heavy metal uptake by jute leaves vegetable (pat shak) in different soils

4.1. 1. Effect of textile waste water on growth and yield of jute leaves vegetable (pat shak) in different soils

Plant height, number of leaves, leaves weight, green plant weight, root weight are measured as yield contributing parameters.

4.1.2. Effect of textile waste water on plant height of jute leaves vegetable (pat shak) in different soils

The results of average plant height (cm) with different concentration of waste water is presented in Figures (4.1 to 4.4).

Plant height (cm) with different concentration of waste water irrigation in non contaminated soil of Narayanganj and non contaminated soil of Gazipur are presented in Figures 4.1 and 4.2

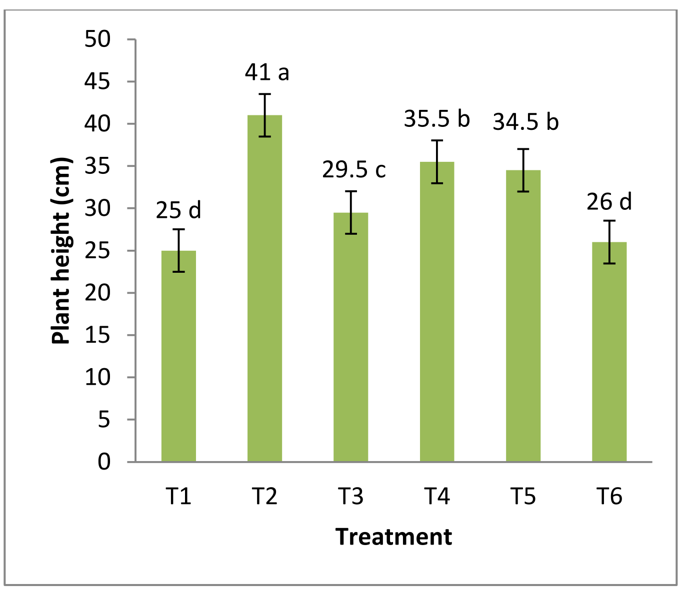

Fig. 4.1. Effect of textile waste water on plant height of jute leaves in non contaminated soil of Narayangonj

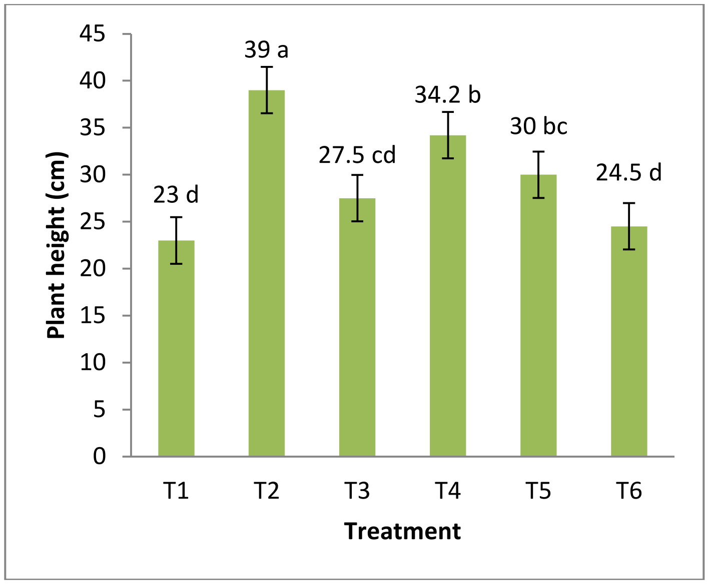

Fig. 4.2. Effect of textile waste water on plant height of jute leaves in non contaminated soil of Gazipur

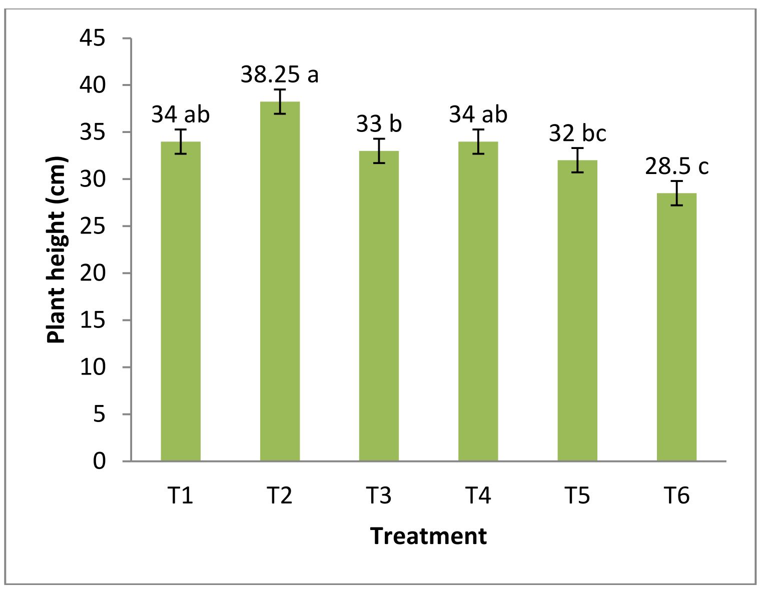

Fig. 4.3. Effect of textile waste water on plant height of jute leaves in contaminated soil of Narayangonj

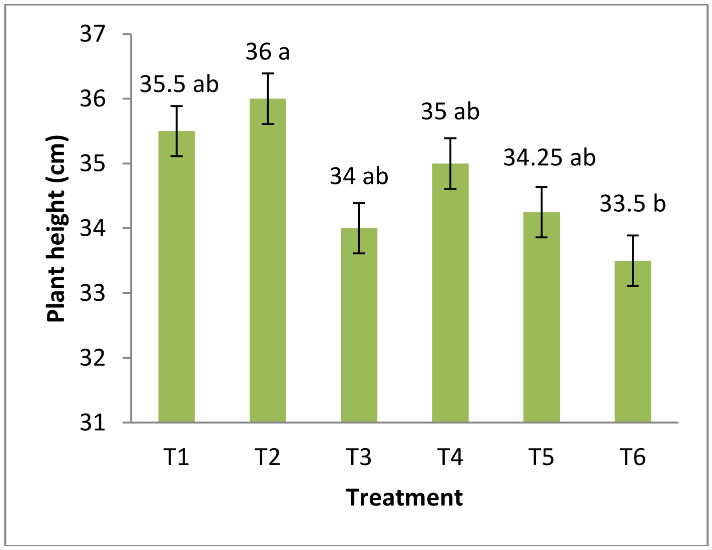

Fig. 4.4. Effect of textile waste water on plant height of jute leaves in contaminated soil of Gazipur

The result showed that textile waste water irrigation significantly ($P \leq 0.05$) increased the height of jute leaves vegetable plant (pat shak) as compared with control in both soils. The result also showed that plant height increased up to irrigation of 50% textile waste water then gradually decreased. The results revealed that T_2 (100% RDF + 0% TWW) showed the best positive effect on jute leaves plant height and T_4 (50% RDF + 50% TWW) possessed the second best positive effect on plant height in both soils. Here the tallest plant height 41 cm ,the second tallest plant height 35.5 cm were found with T_2 and T_4 respectively in non contaminated soil of Narayanganj. And in non contaminated soil of Gazipur the tallest plant height 39 cm ,the second tallest plant height 34.2 cm were found with the T_2 and T_4 respectively. The lowest plant height 25 cm and 23 cm was found with the treatment T_1 (control) in non contaminated soil of Narayanganj and non contaminated soil of Gazipur repectively. It was also found that all the treatments significantly ($P \leq 0.05$) varied with each other treatments, except T_4 and T_5 in non contaminated soil of Narayanganj. And in non contaminated soil of Gazipur treatment T_4 did not significantly vary with T_3 and T_5.

Plant height (cm) with different concentration of waste water irrigation in contaminated soil of Narayanganj and Gazipur are presented in Figure 4.3 and 4.4. The result showed that textile waste water irrigation decreased the plant height of jute leaves vegetable plant (pat shak) as compared with control in both soils. The result also showed that plant height gradually decreased more as concentration of irrigation textile waste water increased. The results revealed that T_2 (100% RDF + 0% TWW) showed the best positive effect on jute leaves plant height and T_1 (control) displayed the second best positive effect on plant height in both soils. Here the tallest plant 38.25 cm ,the second tallest plant height 34 cm were found with T_2 and T_1 respectively in non contaminated soil of Narayanganj. And in non contaminated soil of Gazipur the tallest plant 36 cm ,the second tallest plant 35.5 cm were found with the T_2 and T_1 respectively. The lowest plant height 28.5 cm and 33.5 cm was found with T_6 (50% RDF + 100% TWW) in contaminated soil of Narayanganj and contaminated soil of Gazipur respectively.

4.1.3. Effect of textile waste water on number leaves of jute leaves vegetable (pat shak) in different soils

The number of leaves per plant of jute leaves vegetable plant in different soils with different concentration of waste water irrigation are presented in Figures 4.5. to 4.8.

The result showed that 50% textile waste water irrigation in both Narayanganj and Gazipur non contaminated soils significantly ($P \leq 0.05$) increased the number of leaves per plant of jute leaves vegetable plant (pat shak) as compared with control (Fig. 4.5 and 4.6). The result also showed that number of leaves per plant decreased with 25%, 75% and 100% textile waste water irrigation, which did not significantly vary as compared with control. The results revealed that in both non contaminated soils treatment T_2 (100% RDF + 0% TWW) and T_4 (50% RDF + 50% TWW) showed the similar effect on number of leaves of jute leaves vegetable plant (pat shak), which have no significant difference between each other. The highest number of leaves per plant 10.5 and 11.3 ,the second highest 10.1 and 10.4 were found with T_2 and T_4 in non contaminated soil of Narayanganj and Gazipur respectively. And the lowest number of leaves per plant 8.6 and 9.1 were found with the treatment T_6 (50% RDF + 100% TWW) in non contaminated soil of Narayanganj and Gazipur respectively.

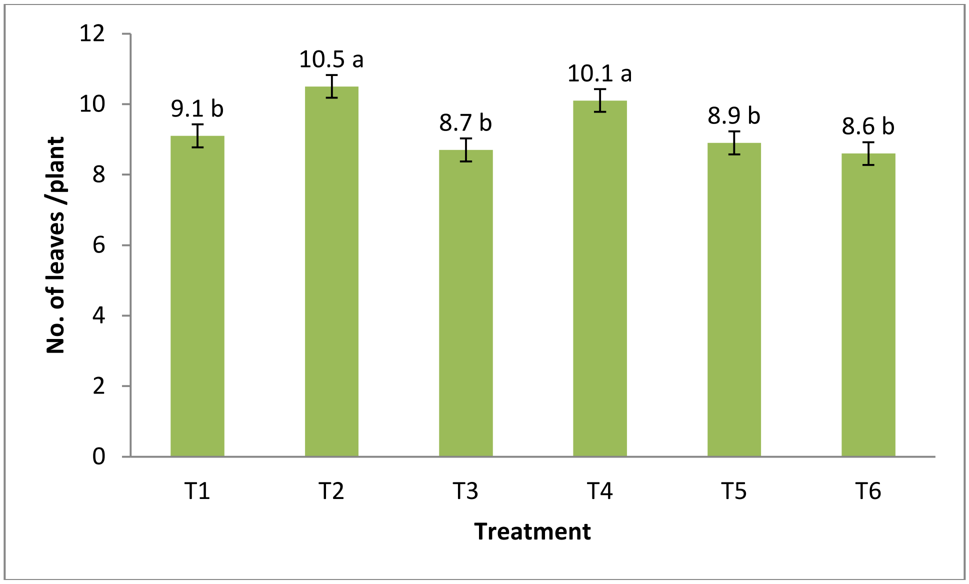

Fig. 4.5. Effect of textile waste water on number of leaves per plant of jute leaves vegetable in non contaminated soil of Narayanganj

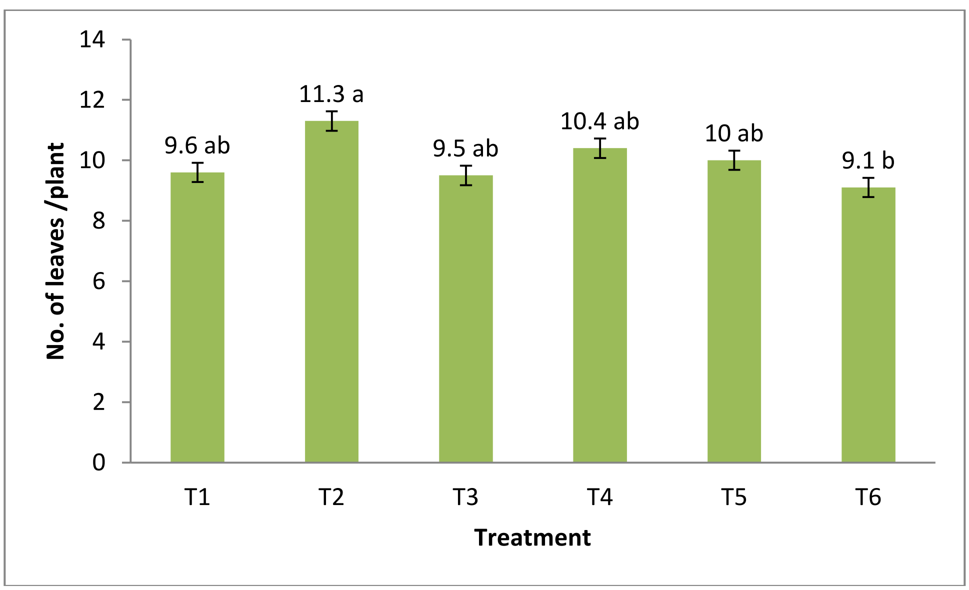

Fig. 4.6. Effect of textile waste water on number of leaves per plant of jute leaves vegetable in non contaminated soil of Gazipur

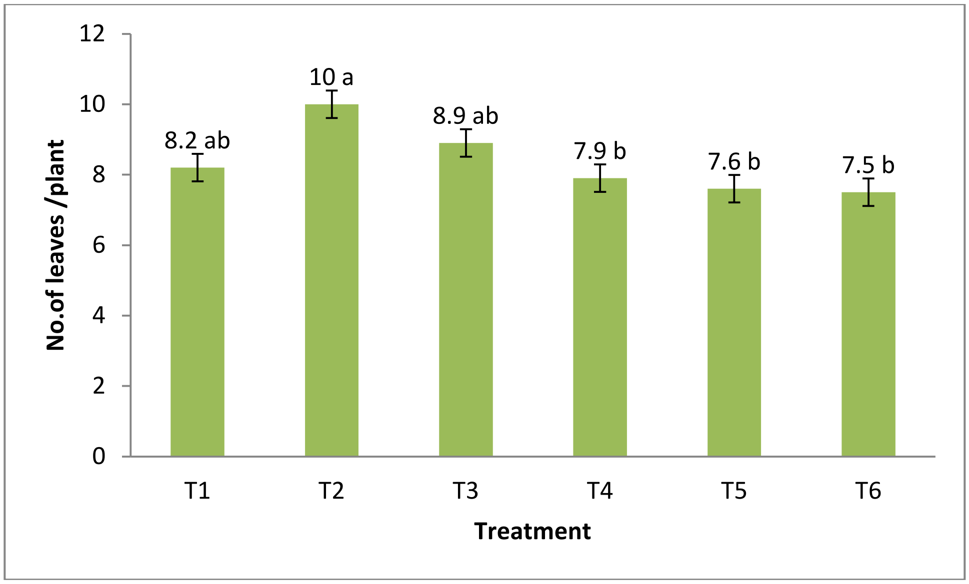

Fig. 4.7. Effect of textile waste water on number of leaves per plant of jute leaves vegetable in contaminated soil of Narayanganj

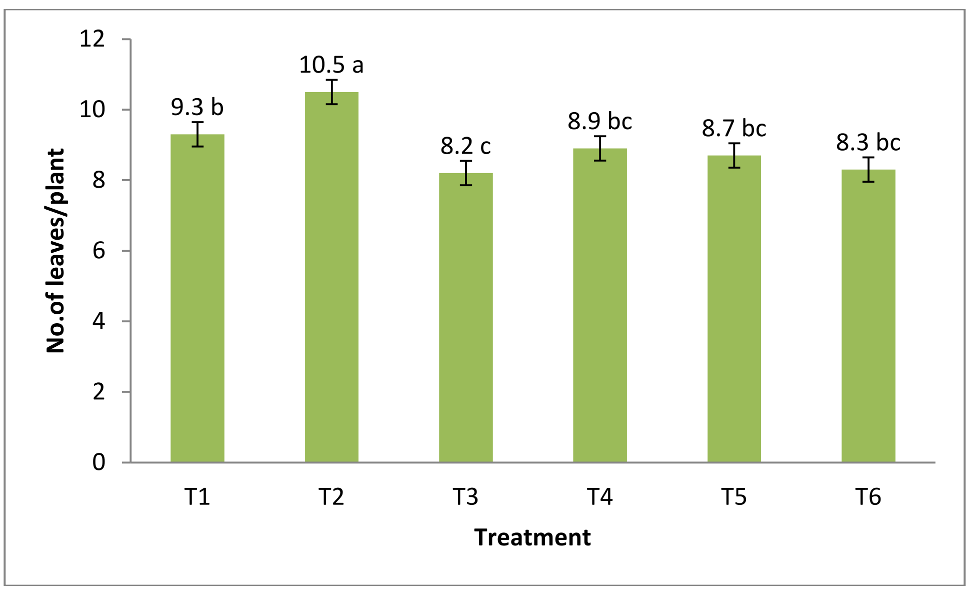

Fig. 4.8. Effect of textile waste water on number of leaves per plant of jute leaves vegetable in contaminated soil of Gazipur

The result showed that textile waste water irrigation in both Narayanganj and Gazipur contaminated soils decreased the number of leaves per plant of jute leaves vegetable plant (pat shak) as compared with control (Fig. 4.7 and 4.8). The result also showed that number of leaves per plant decreased with textile waste water irrigation, which did not significantly vary as compared with control . The findings revealed that in contaminated soil of Narayanganj and Gazipur the dose in T_2 (100% RDF + 0% TWW) contributed the highest number of leaves per plant, which were 10 and 10.5. The lowest number of leaves per plant 7.5 and 8.2 were found with T_6 (50% RDF + 100% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soil of Narayanganj and Gazipur respectively.

4.1.4. Effect of textile waste water on weight of leaves of jute leaves vegetable (pat shak) in different soils

Weight of leaves per plant of jute leaves vegetable (pat shak) in different soils with different concentration of waste water irrigation is presented in Figures 4.9. to 4.12.

The result showed that textile waste water irrigation significantly ($P \leq 0.05$) increased the weight of leaves per plant of jute leaves vegetable with T_4 and T_5 in non contaminated soil of Narayanganj and Gazipur as compared with control (Figures 4.9. and 4.10.). The result also displayed that weight of leaves per plant increased up to irrigation of 50% textile waste water then gradually decreased in both non contaminated soils. The results revealed that T_4 (50% RDF + 50% TWW) and T_5 (50% RDF + 75% TWW) have similar effect on the weight of leaves per plant in both soils, which had no significant difference between the treatments. Here the highest weight of leaves per plant 1.162 gm and 1.315 gm, and the second highest weight of leaves per plant 1.024 gm and 1.041 were found with the treatment T_2 and T_4 respectively in both soils. The lowest weight of leaves per plant 0.463 gm and 0.454 gm were observed with the T_6 (50% RDF + 100% TWW) in non contaminated soil of Narayanganj and Gazipur respectively. The results also revealed that jute leaves yield was increased 119.66% and 145.34% with T_2, and 93.57% and 94.22% with T_4 over control in non contaminated soil of Narayanganj and Gazipur respectively.

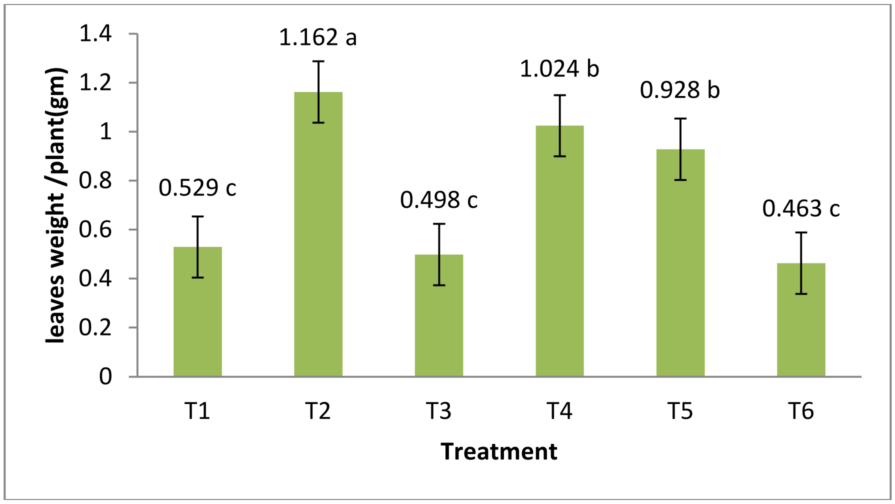

Fig. 4.9. Effect of textile waste water on leaves weight per plant of jute leaves vegetable in non contaminated soil of Narayanganj

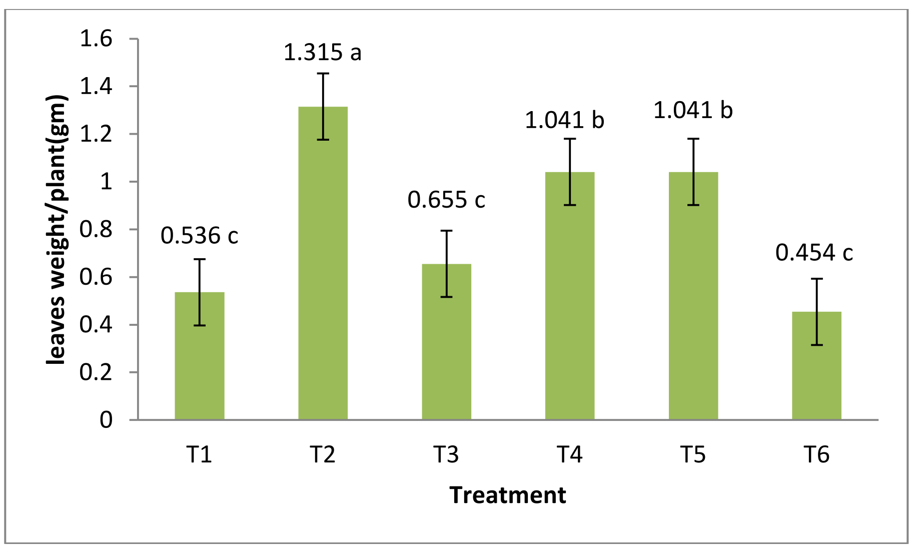

Fig. 4.10. Effect of textile waste water on leaves weight per plant of jute leaves vegetable in non contaminated soil of Gazipur

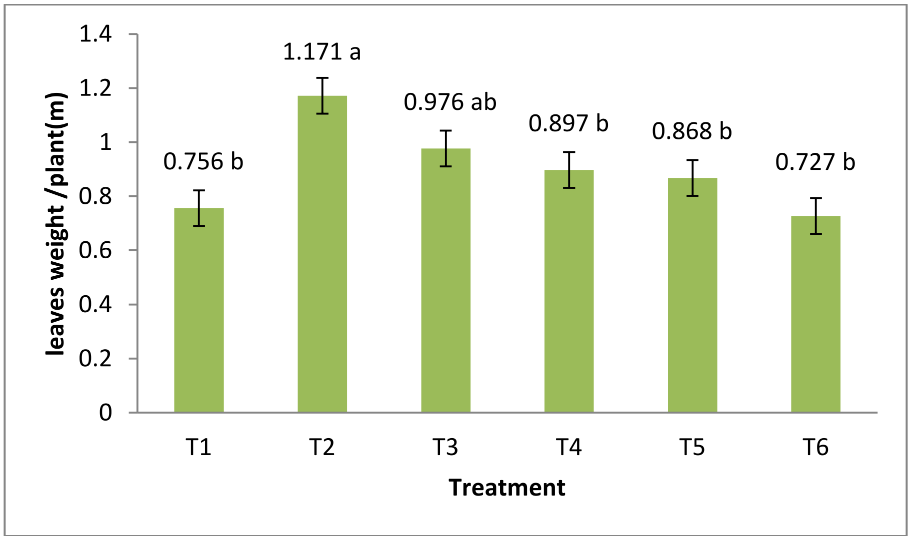

Fig. 4.11. Effect of textile waste water on leaves weight per plant of jute leaves vegetable in contaminated soil of Narayanganj

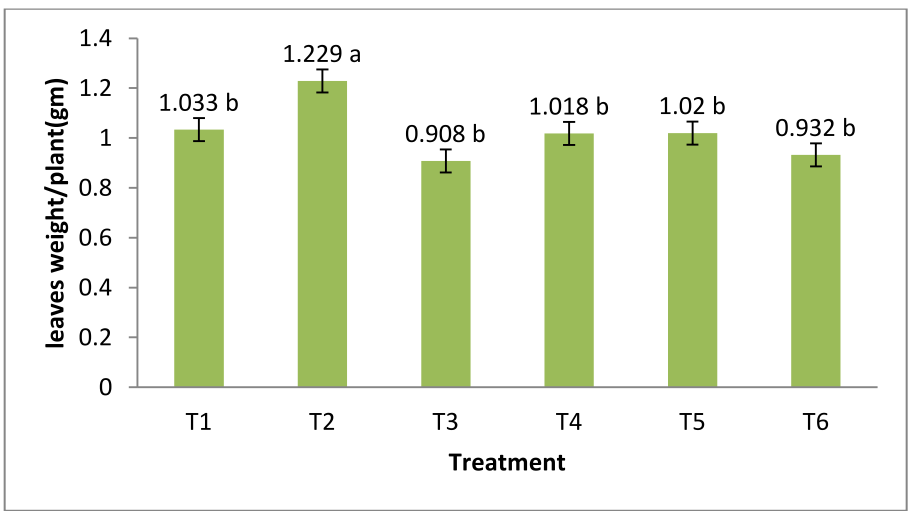

Fig. 4.12. Effect of textile waste water on leaves weight per plant of jute leaves vegetable in contaminated soil of Gazipur

In contaminated soil of Narayanganj the result showed that textile waste water irrigation increased the weight of leaves per plant of jute leaves vegetable (pat shak) with treatment as compared with control (except T_6) , but the increased rate did not significantly vary with each other treatment (Figures 4.11). The result also showed that weight of leaves per plant increased up to 75% irrigation of textile waste water then gradually decreased in non contaminated soil of

Narayanganj. The highest weight of leaves per plant 1.171 gm, and the second highest weight 0.976 gm were found with T_2 and T_4 respectively in non contaminated soil of Narayanganj. The lowest weight of leaves per plant 0.727 gm was found with T_6 (50% RDF + 100% TWW) in non contaminated soil of Narayanganj.

In contaminated soil of Gazipur the result showed that due to addition of textile waste water irrigation decreased slightly the weight of leaves per plant of jute leaves vegetable plant (pat shak) with treatment as compared with control. The rate of decreasing trends did not significantly varied among the treatments (Fig. 4.12). The highest weight of leaves per plant 1.229 gm, and the second highest weight of leaves per plant 1.033 gm was found with T_2 and T_1 respectively in non contaminated soil of Gazipur. The lowest weight of leaves per plant 0.908 gm was found with T_3 (50% RDF + 25% TWW) in non contaminated soil of Gazipur.

4.1.5. Effect of textile waste water on yield of jute leaves vegetable (pat shak) in different soils

Effect of textile waste water on yield of jute leaves vegetable plant (pat shak) in different soils are shown in Figures 4.13 to 4.16.

The results showed that irrigation of 25%, 50% and 75% of textile waste water in both non contaminated soil of Narayanganj and Gazipur significantly increased yield of jute leaves (pat shak) as compared with T_1(control)(Figures 4.13. and 4.14). But irrigation of 100% textile waste water in both non contaminated soils of Narayanganj and Gazipur significantly decreased jute leaves yield as compared with T_1(control). In non contaminated soil of Gazipur T_4 (50% RDF + 50% TWW) and T_5 (50% RDF + 75% TWW) had no significant difference in producing the yield of jute leaves. The results indicate that 50% and 75% textile waste water combined with 50% RDF gave similar yield. At both Narayanganj and Gazipur non contaminated soils, the highest yield of jute leaves 5.71 t/ha and 5.94 t/ha were found with T_2 (100% RDF + 0% TWW), and the second highest yield of jute leaves 4.89 t/ha and 5.46 t/ha were found with T_4 (50% RDF + 50% TWW). The lowest yield of jute leaves (pat shak) was 2.27 t/ha and 2.28 t/ha were found with T_6 (50% RDF + 75% TWW) and T_1 (control) in non contaminated soils of

Narayanganj and Gazipur respectively. The results also revealed that as concentration of textile waste water increased up to 75% the yield of jute leaves increased, after then decreased.

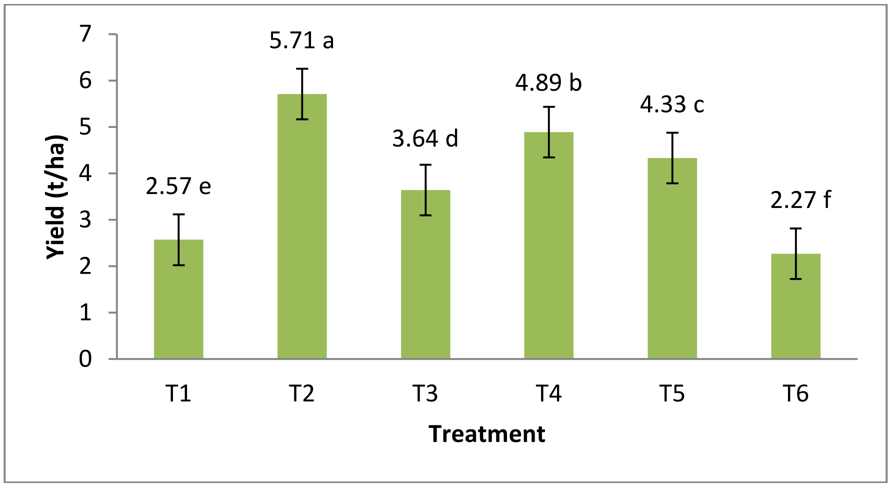

Fig. 4.13. Effect of textile waste water on yield of jute leaves in non contaminated soil of Narayanganj

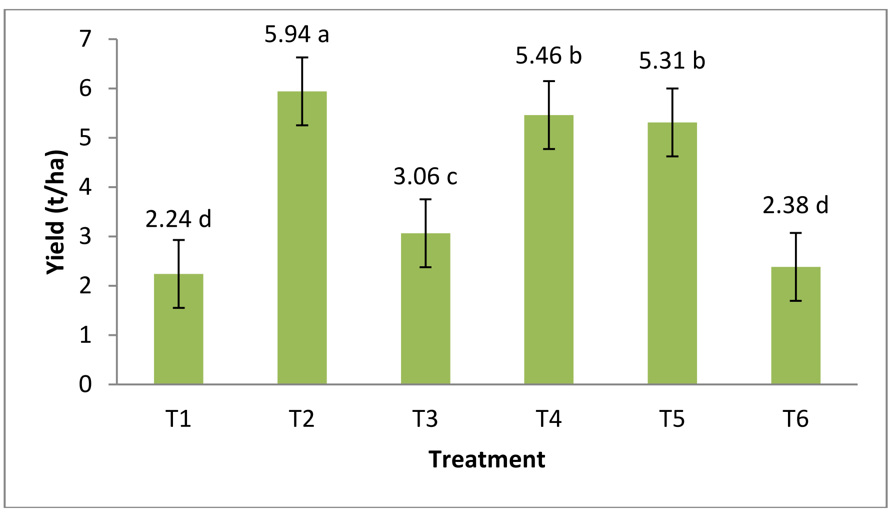

Fig. 4.14. Effect of textile waste water on yield of jute leaves in non contaminated soil of Gazipur

The results in contaminated soil of Narayanganj with the irrigation of 25%, 75% and 100% of textile waste water showed significantly decreased on jute leaves yield as compared with T_1(control)(Fig.4.15). With the irrigation of 50% textile waste water in contaminated soil of Narayanganj increased yield of jute leaves as compared with T_1(control), but it was statistically insignificant. In contaminated soil of Gazipur the applied rate of irrigation of 50% and 75% of textile waste water significantly increased jute leaves yield as compared with T_1(control)(Fig. 4.16). But the rate of irrigation of 25% and 100% textile waste water in contaminated soil of Gazipur significantly decreased jute leaves yield as compared with T_1(control).

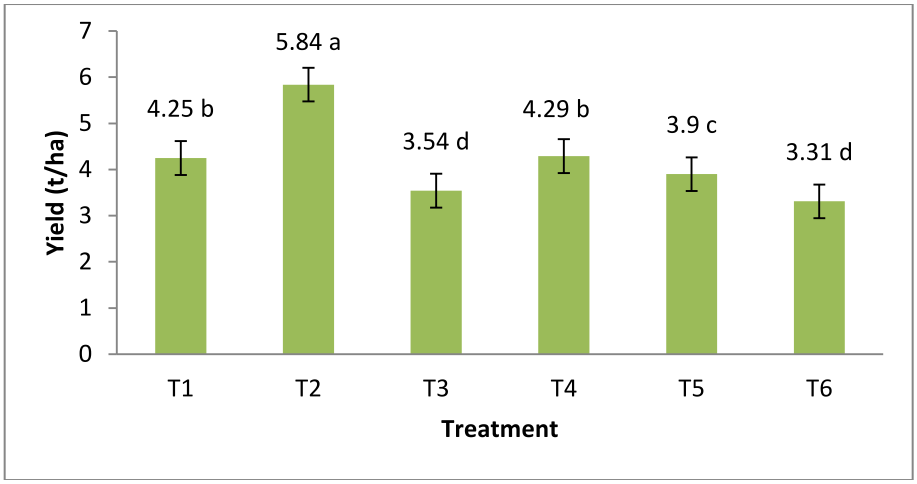

Fig. 4.15. Effect of textile waste water on yield of jute leaves in contaminated soil of Narayanganj

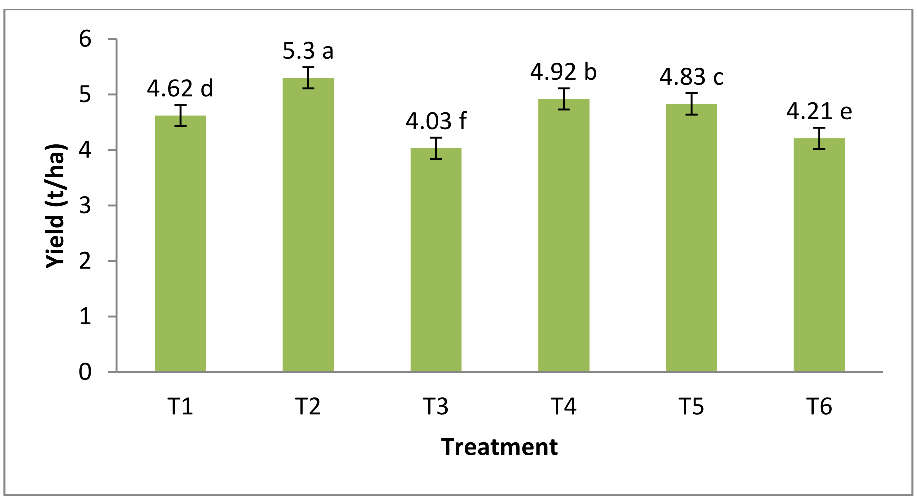

Fig. 4.16. Effect of textile waste water on yield of jute leaves in contaminated soil of Gazipur

In both contaminated soils of Narayanganj and Gazipur, the highest yield of jute leaves were 5.84 t/ha and 5.3 t/ha found with T_2 (100% RDF + 0% TWW), and yielded second highest 4.29 t/ha and 4.92 t/ha observed with T_4 (50% RDF + 50% TWW). The lowest yield of jute leaves were 3.31 t/ha and 4.03 t/ha found with T_6 (50% RDF + 75% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The results also revealed that as concentration of textile waste water increased up to 50% the yield of jute leaves increased, after then decreased. The study also pronounced that higher yield of jute leaves contributed by T_1 in both contaminated soils than T_3 and T_6.

4.1.6. Effect of textile waste water on dry matter production of jute leaves vegetable (pat shak) in different soils

Effect of textile waste water on dry matter production of jute leaves vegetable plant (pat shak) in different soils are presented in Tables 4.1. to 4.4.

Textile waste water irrigation in non contaminated soil of Narayanganj enhanced total dry matter yield significantly ($P \leq 0.05$) over control (Table 4.1). Highest dry matter yield was 1.81 t/ha, which was obtained with T_2 (100% RDF + 0% TWW). The second highest yield of dry matter yield was 1.55 t/ha, which was obtained with T_4 (50% RDF + 50% TWW). Lowest dry matter yield 0.81 t/ha was found with treatment T_1 (control). Dry matter yield was increased highest 123.46 % with T_2 and second highest 91.36 % with T_4 over control.

In non contaminated soil of Gazipur textile waste water irrigation increased total dry matter yield significantly ($P \leq 0.05$) over control, except T_6 (Table 4.2). Highest dry matter yield was 1.90 t/ha, which was obtained with the treatment T_2 (100% RDF + 0% TWW). The closest highest rate of dry matter yield was 1.77 t/ha, which was obtained with the treatment T_4 (50% RDF + 50% TWW). Lowest dry matter yield 0.66 t/ha was found with treatment T_6 (50% RDF + 100% TWW). Dry matter yield was increased highest 167.61% with T_2 and possessed second 149.30% with T_4 over control.

Table 4.1. Effect of textile waste water on dry matter production of jute leaves vegetable plant (pat shak) in non contaminated soil of Narayanganj

Treatment	Green weight of 10 plants /pot (gm)			Oven dry weight of 10 plants/pot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	5.29	6.50	2.48	1.72	2.18	0.63	0.31	0.39	0.11	0.81 f
T_2	11.62	15.19	4.08	3.75	5.05	1.03	0.69	0.93	0.19	1.81 a
T_3	4.98	6.67	2.60	1.62	2.23	0.66	0.30	0.41	0.12	0.83 e
T_4	10.24	12.58	3.74	3.34	4.21	0.95	0.61	0.77	0.17	1.55 b
T_5	9.28	10.99	3.14	3.03	3.68	0.80	0.56	0.68	0.15	1.39 c
T_6	4.63	5.48	2.29	2.41	1.83	0.59	0.44	0.33	0.11	0.88 d

Table 4.2. Effect of textile waste water on dry matter production of jute leaves vegetable plant (pat shak) in non contaminated soil of Gazipur

Treatment	Green weight of 10 plants /pot (gm)			Oven dry weight of 10 plants/pot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	5.36	4.86	1.89	1.74	1.62	0.48	0.32	0.30	0.09	0.71 e
T_2	13.16	14.86	3.73	4.28	4.94	0.95	0.80	0.92	0.18	1.90 a
T_3	6.55	7.56	2.5	2.11	2.51	0.63	0.39	0.46	0.12	0.97 d
T_4	10.41	16.08	3.04	3.36	5.35	0.78	0.62	1.00	0.15	1.77 b
T_5	10.48	15.7	2.35	3.38	5.22	0.6	0.63	0.97	0.11	1.71 c
T_6	4.54	4.6	2.24	1.46	1.53	0.57	0.27	0.28	0.11	0.66 f

Table 4.3. Effect of textile waste water on dry matter production of jute leaves vegetable plant (pat shak) in contaminated soil of Narayanganj

Treatment	Green weight of 10 plants /pot (gm)			Oven dry weight of 10 plants/pot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	7.55	11.69	3.62	2.45	3.87	0.92	0.46	0.72	0.17	1.35 b
T_2	11.71	15.17	4.34	3.81	5.08	1.09	0.71	0.95	0.20	1.86 a
T_3	9.76	7.14	2.14	3.18	2.36	0.54	0.59	0.44	0.10	1.13 d
T_4	8.97	11.17	3.06	2.84	3.71	0.78	0.53	0.69	0.14	1.36 b
T_5	8.69	9.04	3.12	2.82	3.03	0.79	0.53	0.57	0.15	1.25 c
T_6	7.27	7.73	2.62	2.34	2.58	0.66	0.44	0.49	0.12	1.05 e

Table 4.4. Effect of textile waste water on dry matter production of jute leaves vegetable plant (pat shak) in contaminated soil of Gazipur

Treatment	Green weight of 10 plants /pot (gm)			Oven dry weight of 10 plants/pot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	10.33	11.04	3.35	3.36	3.7	0.86	0.63	0.69	0.16	1.48 c
T_2	12.31	12.5	3.71	3.97	4.16	0.95	0.74	0.77	0.18	1.69 a
T_3	9.08	9.84	3	2.94	3.3	0.77	0.54	0.61	0.14	1.29 e
T_4	10.18	12.83	3.29	3.31	4.28	0.85	0.62	0.80	0.16	1.58 b
T_5	9.6	11.3	3.2	3.12	3.85	0.82	0.58	0.74	0.15	1.47 c
T_6	9.32	10.16	3.26	3.03	3.41	0.83	0.56	0.63	0.15	1.34 d

The applied irrigation of textile waste water in contaminated soil of Narayanganj decreased the total dry matter yield, significantly ($P \leq 0.05$) over control, except T_4 (table 4.3). Highest dry matter yield was 1.86 t/ha, which was obtained with T_2 (100% RDF + 0% TWW). The second highest value 1.36 t/ha, which was obtained with T_4 (50% RDF + 50% TWW). Lowest dry matter yield 1.05 t/ha was found with T_6 (50% RDF + 100% TWW). Dry matter yield was increased 37.78 % with T_2 and 0.74 % with T_4 over control. The results also revealed that treatment T_1 and T_4 gave similar dry matter yield, which have no significant different.

In contaminated soil of Gazipur due to apply of textile waste water as irrigation the total dry matter yield decreased significantly ($P \leq 0.05$) over control, except T_4 (table 4.4). Highest dry matter yield was 1.69 t/ha, which was obtained with T_2 (100% RDF + 0% TWW). The second highest dry matter yield was 1.58 t/ha, which obtained with T_4 (50% RDF + 50% TWW). Lowest dry matter yield 1.29 t/ha was found with T_3 (50% RDF + 25% TWW). Dry matter yield was increased 14.19 % with T_2 and 6.76 % with T_4 over control. The results also revealed that T_1 and T_5 gave similar dry matter yield, which have no significant difference.

4.1.7. Effect of textile waste water on nutrient content in different parts of jute leaves vegetable (pat shak) in different soils

Effect of textile waste water on nutrient content in different parts of jute leaves plants in different soils are presented in Tables 4.5. to 4.8. Average nutrient content of N, P, K, S, Ca and Mg in shoot was lower than leaves but higher than roots in all soils.

4.1.7.1. Effect of textile waste water on nutrient content in different parts of jute leaves vegetable plant in non contaminated soils

The N content of leaves of jute leaves vegetable plant varied between 1.53 % to 3.78 % and 1.65% to 3.28% in non contaminated soils of Narayanganj and Gazipur respectively (Tables 4.5 and 4.6). Highest N content in leaves 3.78 % and 3.28% was observed in T_2 (100% RDF + 0% TWW) in both Narayanganj and Gazipur soils. The lowest N content in leaves 1.53 % and 1.65% were observed with T_6 (50% RDF + 100% TWW) and T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. N content of shoot varied between 0.80% to 1.10% and 0.75% to 0.83% in non contaminated soils of Narayanganj and Gazipur respectively. Highest N content in shoot 1.10% (Narayanganj) and 0.83% (Gazipur) were observed in T_2 (100% RDF + 0% TWW). The lowest N content in shoot 0.80% and 0.75% were observed with T_3(50% RDF + 25% TWW) and T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. N content of root varied between 0.45% to 0.52% and 0.41% to 0.45% in non contaminated soil of Narayanganj and Gazipur respectively. Highest N content in root 0.52% and 0.45% were observed in T_2 (100% RDF + 0% TWW) in both soils. The lowest N content in root 0.45% was observed with T_3(50% RDF + 25% TWW) in non contaminated soil

Table 4.5. Effect of textile waste water on nutrient content in different parts of jute leaves vegetable plant (pat shak) in non contaminated soil of Narayanganj

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	1.57	0.18	1.74	0.028	0.126	0.143
	Shoot	1.00	0.10	0.70	0.015	0.040	0.050
	Root	0.50	0.20	0.45	0.016	0.015	0.019
T_2= 100% RDF + 0% TWW	Leaves	3.78	0.23	2.26	0.076	0.195	0.159
	Shoot	1.10	0.11	1.00	0.029	0.063	0.055
	Root	0.52	0.21	0.57	0.022	0.023	0.020
T_3=50% RDF + 25% TWW	Leaves	2.10	0.20	2.19	0.057	0.151	0.148
	Shoot	0.80	0.10	0.80	0.020	0.056	0.055
	Root	0.45	0.18	0.60	0.018	0.021	0.018
T_4=50%RDF + 50% TWW	Leaves	3.71	0.21	2.23	0.069	0.174	0.157
	Shoot	1.00	0.19	1.02	0.031	0.059	0.060
	Root	0.50	0.20	0.71	0.025	0.022	0.022
T_5=50%RDF + 75% TWW	Leaves	2.85	0.19	2.27	0.062	0.178	0.155
	Shoot	0.85	0.11	0.90	0.022	0.050	0.051
	Root	0.53	0.18	0.72	0.020	0.016	0.021
T_6=50%RDF + 100% TWW	Leaves	1.53	0.15	2.18	0.052	0.163	0.144
	Shoot	0.80	0.10	1.10	0.020	0.055	0.050
	Root	0.51	0.17	0.80	0.019	0.019	0.021

Table 4.6. Effect of textile waste water on nutrient content in different parts of jute leaves vegetable plant (pat shak) in non contaminated soil of Gazipur

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	1.65	0.11	2.99	0.032	0.187	0.152
	Shoot	0.75	0.10	0.85	0.012	0.061	0.063
	Root	0.41	0.13	0.55	0.011	0.022	0.021
T_2= 100% RDF + 0% TWW	Leaves	3.28	0.31	3.12	0.082	0.334	0.172
	Shoot	1.2	0.15	1.10	0.028	0.077	0.081
	Root	0.52	0.18	0.58	0.022	0.034	0.028
T_3=50% RDF + 25% TWW	Leaves	2.52	0.19	3.18	0.035	0.231	0.166
	Shoot	0.8	0.13	1.00	0.013	0.052	0.058
	Root	0.42	0.16	0.55	0.012	0.022	0.024
T_4=50%RDF + 50% TWW	Leaves	2.92	0.27	3.74	0.091	0.313	0.170
	Shoot	0.83	0.14	1.10	0.031	0.065	0.061
	Root	0.45	0.20	0.64	0.025	0.027	0.029
T_5=50%RDF + 75% TWW	Leaves	2.54	0.21	3.86	0.058	0.286	0.164
	Shoot	0.77	0.11	1.20	0.022	0.060	0.050
	Root	0.44	0.18	0.65	0.016	0.026	0.027
T_6=50%RDF + 100% TWW	Leaves	1.93	0.18	2.06	0.044	0.225	0.162
	Shoot	0.77	0.11	0.79	0.018	0.067	0.050
	Root	0.41	0.15	0.51	0.014	0.025	0.021

of Narayanganj and 0.41% was observed with T_6 and T_1 in non contaminated soil of Gazipur. The results revealed that N content of jute leaves vegetable plant (pat shak) increased with the increasing concentration of textile waste water up to 50%, then decreased in both non contaminated soils.

The P content of leaves of jute leaves vegetable varied between 0.15 % to 0.23 % and 0.11% to 0.31% in non contaminated soils of Narayanganj and Gazipur respectively (table 4.5 and 4.6).

Highest P content in leaves 0.23 % and 0.31% were observed in T_2 (100% RDF + 0% TWW) in both soils. The lowest P content in leaves 0.23 % and 0.11% were observed with the T_6 (50% RDF + 100% TWW) and T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. P content of shoot varied between 0.10% to 0.19% and 0.10% to 0.15% in non contaminated soil of Narayanganj and Gazipur respectively. Highest P content in shoot 0.21% and 0.14% were observed in T_2 (100% RDF + 0% TWW) in both soils. The lowest P content in shoot 0.10% was observed with T_1(control) in both soils. Phosphorus content of root varied between 0.17% to 0.21% and 0.13% to 0.18% in non contaminated soils of Narayanganj and Gazipur respectively. Highest P content in root 0.21% and 0.18% were observed in T_2 (100% RDF + 0% TWW) in both soils. The lowest P content in root 0.17% and 0.13% were observed with T_6(50% RDF + 100% TWW) and T_1(control) in non contaminated soils of Narayanganj and Gazipur, respectively. The results revealed that P content of jute leaves increased with the increasing concentration of textile waste water up to 50%, then decreased in both non contaminated soils.

The K content of leaves of jute leaves vegetable plant (pat shak) varied between 1.74 % to 2.27% and 2.99 % to 3.86% in non contaminated soils of Narayanganj and Gazipur respectively (Tables 4.5 and 4.6). Highest K content in leaves 2.27 % and 3.86% were observed in T_2 (100% RDF + 0% TWW) and T_5(50% RDF + 75% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The lowest K content in leaves 1.74 % and 2.99% was observed with the T_1(control) in both non contaminated soils. Potassium content of shoot varied between 0.70% to 1.10% and 0.79% to 1.20% in non contaminated soils of Narayanganj and Gazipur respectively. Highest K content in shoot 1.10% and 1.20% were observed in T_6 (50% RDF + 100% TWW) and T_5 (50% RDF + 75% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The lowest K content in shoot 0.70% and 0.79% were observed with T_1(control) and T_6 (50% RDF + 100% TWW) in non contaminated soil of Narayanganj and Gazipur respectively. Potassium content of root varied between 0.45% to 0.80% and 0.51% to 0.65% in non contaminated soils of Narayanganj and Gazipur respectively. Highest K content in root 0.80% and 0.65% were observed in T_6 (50% RDF + 100% TWW) and T_5 (50% RDF + 75% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively. The lowest K content in root 0.45% and 0.51% were observed with T_1(control) and T_6 in non contaminated soils of Narayanganj and Gazipur respectively. The results revealed that K content of jute leaves increased with the increasing concentration of textile waste water up to 75%, then decreased in both non contaminated soils.

The S content of leaves of jute leaves vegetable plant varied between 0.028 % to 0.076 % and 0.032 % to 0.091% in non contaminated soils of Narayanganj and Gazipur respectively (Tables 4.5 and 4.6). Highest S content in leaves 0.076 % and 0.091% were observed in T_2 (100% RDF + 0% TWW) and T_4(50% RDF + 50% TWW) in non contaminated soils of of Narayanganj and Gazipur respectively. The lowest S content in leaves 0.028 % and 0.032 % were observed with T_1(control) in both non contaminated soils. Sulphur content of shoot varied between 0.015% to 0.031% and 0.012% to 0.031% in non contaminated soils of Narayanganj and Gazipur respectively. Highest S content in shoot 0.031% was observed in T_4 (50% RDF + 50% TWW) and the lowest S content in shoot 0.015% and 0.012% were observed with T_1(control) in both non contaminated soils. S content of root varied between 0.016% to 0.025% and 0.011% to 0.025% in non contaminated soils of Narayanganj and Gazipur respectively. Highest S content in root 0.025% was observed in T_4 (50% RDF + 50% TWW) and the lowest S content in root 0.016% and 0.011% were with T_1(control) in both non contaminated soils. The results revealed that S content of jute leaves increased with the increasing concentration rate of textile waste water 25% and 50% in both non contaminated soils. Further higher rate of waste water of 75% and 100% irrigation causes the lower S content.

The Ca content of leaves of jute leaves varied between 0.126 % to 0.195 % and 0.187 % to 0.334% in non contaminated soils of Narayanganj and Gazipur respectively (Tables 4.5 and 4.6). Highest Ca content in leaves 0.195 % and 0.334% was observed in treatment T_2 (100% RDF + 0% TWW) in both non contaminated soils . The lowest Ca content in leaves 0.126 % and 0.187 % was observed with T_1(control) in both non contaminated soils. Calcium content of shoot varied between 0.040% to 0.063% and 0.052% to 0.077% in non contaminated soils of Narayanganj and Gazipur respectively. Highest Ca content in shoot 0.063% and 0.077% were recorded in T_2 (100% RDF + 0% TWW) in both soils. The lowest Ca content in shoot 0.040% and 0.052% were observed with T_1(control) and T_3 (50% RDF + 25% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. Ca content of root varied between 0.015% to 0.023% and 0.022% to 0.034% in non contaminated soil of Narayanganj and Gazipur respectively. Highest Ca content in root 0.023% and 0.034% were observed in T_2 (100% RDF + 0% TWW) and the lowest Ca content in root 0.015% and 0.022% were with T_1(control) in both non contaminated soils. The results revealed that Ca content of jute leaves increased with the increasing concentration of textile waste water up to 50% at Narayanganj and 75% at

Gazipur. There were reducing trends in content of Ca with 75% as well as 100% irrigation to the non contaminated soil of Narayanganj and same in soil of Gazipur with 100% waste water irrigation.

The Mg content of leaves of jute leaves varied between 0.143 % to 0.159 % and 0.152 % to 0.172% in non contaminated soils of Narayanganj and Gazipur respectively (Tables 4.5 and 4.6). Highest Mg content in leaves 0.159 % and 0.177% was observed in T_2 (100% RDF + 0% TWW) and the lowest Mg in leaves 0.143 % and 0.152 % with T_1(control) in both non contaminated soils. Mg content of shoot varied between 0.050% to 0.060% and 0.050% to 0.081% in non contaminated soil of Narayanganj and Gazipur respectively. Highest Mg content in shoot 0.060% and 0.081% were obtained in T_4 and T_2 in non contaminated soils of Narayanganj and Gazipur respectively. And the lowest Mg content in shoot 0.050% was observed with T_1(control) in non contaminated soil of Narayanganj and T_6 (50% RDF + 100% TWW) in both soils. Mg content of root varied between 0.018% to 0.022% and 0.021% to 0.029% in non contaminated soils of Narayanganj and Gazipur respectively. Highest Ca content in root 0.022% and 0.029% were observed in T_4 (50% RDF + 50% TWW). The lowest Ca content in root 0.018% was in T_3(50% RDF + 25% TWW) in non contaminated soil of Narayanganj and 0.021% was observed with T_1 and T_6 in non contaminated soil of Gazipur. The results revealed that Mg content of jute leaves vegetable plant increased with the increasing concentration of textile waste water up to 50% then decreased in both soils.

4.1.7.2. Effect of textile waste water on nutrient content in different parts of jute leaves vegetable plant in contaminated soils

The N content of leaves of jute leaves vegetable plant varied between 3.05 % to 3.97 % and 1.96% to 4.35% in contaminated soils of Narayanganj and Gazipur respectively (Tables 4.7 and 4.8). Highest N content in leaves 3.97 % and 4.35% was observed in T_2 (100% RDF + 0% TWW) in both soils. The lowest N content in leaves 3.05 % and 1.96% were observed with T_6(50% RDF + 100% TWW) and T_3(50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Nitrogen content of shoot varied between 0.83% to 1.20 % and 0.71% to 1.33% in contaminated soils of Narayanganj and Gazipur respectively. Highest N content in shoot 1.20% and 1.33% were observed in T_2 (100% RDF + 0% TWW) in both soils. The lowest N content in shoot 0.83% and 0.71% were observed with T_3(50% RDF + 25% TWW) and T_6(50% RDF + 100% TWW) in contaminated soils of Narayanganj and

Gazipur respectively. N content of root varied between 0.44% to 0.55% and 0.40% to 0.59 % in contaminated soils of Narayanganj and Gazipur respectively. Highest N content in root 0.55% and 0.59% were observed in treatment T_2 (100% RDF + 0% TWW) in both soils.

Table 4.7. Effect of textile waste water on nutrient content in different parts of jute leaves vegetable plant (pat shak) in contaminated soil of Narayanganj

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	3.36	0.25	2.27	0.057	0.156	0.155
	Shoot	1.12	0.12	0.80	0.018	0.050	0.072
	Root	0.47	0.18	0.58	0.014	0.021	0.020
T_2= 100% RDF + 0% TWW	Leaves	3.97	0.29	2.38	0.062	0.251	0.163
	Shoot	1.20	0.13	1.00	0.027	0.072	0.073
	Root	0.55	0.20	0.65	0.021	0.031	0.022
T_3=50% RDF + 25% TWW	Leaves	2.55	0.22	2.02	0.051	0.105	0.147
	Shoot	0.83	0.11	0.76	0.022	0.041	0.050
	Root	0.44	0.17	0.59	0.017	0.019	0.020
T_4=50%RDF + 50% TWW	Leaves	3.32	0.24	2.10	0.057	0.146	0.151
	Shoot	1.10	0.13	0.88	0.030	0.052	0.055
	Root	0.52	0.21	0.67	0.023	0.020	0.021
T_5=50%RDF + 75% TWW	Leaves	3.22	0.23	2.16	0.050	0.133	0.150
	Shoot	1.00	0.12	0.85	0.023	0.046	0.051
	Root	0.51	0.19	0.62	0.018	0.018	0.021
T_6=50%RDF + 100% TWW	Leaves	3.05	0.21	1.92	0.046	0.114	0.144
	Shoot	1.20	0.11	0.83	0.020	0.042	0.051
	Root	0.51	0.18	0.61	0.017	0.018	0.018

Table 4.8. Effect of textile waste water on nutrient content in different parts of jute leaves vegetable plant (pat shak) in contaminated soil of Gazipur

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	3.66	0.24	3.42	0.052	0.223	0.153
	Shoot	1.25	0.13	1.50	0.023	0.061	0.060
	Root	0.54	0.16	0.61	0.012	0.025	0.025
T_2= 100% RDF + 0% TWW	Leaves	4.35	0.27	3.45	0.061	0.239	0.159
	Shoot	1.33	0.14	1.53	0.024	0.063	0.065
	Root	0.59	0.17	0.66	0.014	0.031	0.028
T_3=50% RDF + 25% TWW	Leaves	1.96	0.15	2.77	0.046	0.217	0.148
	Shoot	0.72	0.11	1.12	0.020	0.060	0.052
	Root	0.41	0.12	0.51	0.011	0.027	0.022
T_4=50%RDF + 50% TWW	Leaves	2.73	0.19	3.48	0.055	0.222	0.151
	Shoot	0.80	0.13	1.45	0.021	0.054	0.065
	Root	0.47	0.15	0.65	0.012	0.028	0.030
T_5=50%RDF + 75% TWW	Leaves	2.09	0.17	3.02	0.054	0.219	0.150
	Shoot	0.75	0.12	1.11	0.026	0.053	0.047
	Root	0.41	0.14	0.60	0.013	0.029	0.023
T_6=50%RDF + 100% TWW	Leaves	2.02	0.16	2.53	0.051	0.218	0.149
	Shoot	0.71	0.10	0.85	0.022	0.055	0.050
	Root	0.40	0.13	0.50	0.012	0.030	0.023

The lowest nitrogen content in root 0.44% and 40% were observed with the treatment T_3 and T_6 in contaminated soils of Narayanganj and Gazipur. The results revealed that N content of jute leaves increased with the increasing concentration of textile waste water up to 50%, then decreased in both contaminated soils.

The P content of leaves of jute leaves varied between 0.21 % to 0.29 % and 0.15% to 0.27 % in contaminated soils of Narayanganj and Gazipur respectively (Tables 4.7 and 4.8). Highest P content in leaves 0.29 % and 0.27% was observed in T_2 (100% RDF + 0% TWW) in both soils. The lowest N content in leaves 0.21 % and 0.51% was observed with T_6 (50% RDF + 100% TWW) and T_3(50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. P content of shoot varied between 0.11% to 0.13% and 0.10% to 0.14% in contaminated soils of Narayanganj and Gazipur respectively. Highest P content in shoot 0.13% and 0.14% were observed in T_2 (100% RDF + 0% TWW) in both soils. The lowest P content in shoot 0.11% and 0.10% were observed with T_6(50% RDF + 100% TWW) in both soils . P content of root varied between 0.17% to 0.21% and 0.12% to 0.17 % in contaminated soils of Narayanganj and Gazipur respectively. Highest P content in root 0.21% and 0.17% were observed in T_4 and T_2 contaminated soils of Narayanganj and Gazipur respectively. The lowest P content in root 0.17% and 0.12% were observed with T_3(50% RDF + 25% TWW) in both soils. The results revealed that P content of jute leaves increased with the increasing concentration of textile waste water up to 50%, then decreased in both contaminated soils.

The K content of leaves of jute leaves vegetable plant varied between 1.92 % to 2.38 % and 2.53% to 3.45% in contaminated soil of Narayanganj and Gazipur respectively (table 4.7 and 4.8). Highest P content in leaves 2.38 % and 3.45% was observed in T_2 (100% RDF + 0% TWW) in both contaminated soils. The lowest K content in leaves 1.92 % and 2.53% was observed with T_6(50% RDF + 100% TWW) in both contaminated soils. K content of shoot varied between 0.76% to 1.00% and 0.85% to 1.53% in contaminated soil of Narayanganj and Gazipur respectively. Highest K content in shoot 1.00 % and 1.53% were observed in T_2 (100% RDF + 0% TWW) in both contaminated soils. The lowest K content in shoot 0.76% and 0.85% were observed with T_3(50% RDF + 25% TWW) and T_6 (50% RDF + 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. K content of root varied between 0.58% to 0.67% and 0.50% to 0.66% in contaminated soil of Narayanganj and Gazipur respectively. Highest K content in root 0.67% and 0.66% were observed in T_4 (50% RDF + 50% TWW) and T_2 (100% RDF + 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The lowest K content in root 0.58% and 0.50% were observed with T_1(control) and T_6 (50% RDF + 50% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The results revealed that K content of jute leaves increased with the increasing concentration of textile waste water up to 50%, then decreased in both contaminated soils.

The S content of leaves of jute leaves varied between 0.046 % to 0.062 % and 0.046 % to 0.061% in contaminated soils of Narayanganj and Gazipur respectively (Tables 4.7 and 4.8). Highest P content in leaves 0.062 % and 0.061% was observed in T_2 (100% RDF + 0% TWW) in both contaminated soils. The lowest S content in leaves 0.046 % was observed with T_6 and T_3 in non contaminated soils of Narayanganj and Gazopur respectively.. S content of shoot varied between 0.018% to 0.030 % and 0.020% to 0.026% in contaminated soil of Narayanganj and Gazipur respectively. Highest S content in shoot 0.030% and 0.026% were observed in T_4 (50% RDF + 50% TWW) and T_5 (50% RDF + 75% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The lowest S content in shoot 0.018% and 0.020% were observed with T_1(control) and T_3 (50% RDF + 25% TWW) in contaminated soil of Narayanganj and Gazipur respectively. S content of root varied between 0.014% to 0.023% and 0.011% to 0.014% in contaminated soils of Narayanganj and Gazipur respectively. Highest S content in root 0.023% and 0.014% was observed in T_4 (50% RDF + 50% TWW) and T_2 (100% RDF + 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The lowest S content in root 0.014% and 0.011% were observed with T_1(control) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The results revealed that S content of jute leaves increased with the increasing concentration of textile waste water up to 50%, then decreased in both contaminated soils.

The Ca content of leaves of jute leaves varied between 0.105 % to 0.251 % and 0.217 % to 0.239% in contaminated soils of Narayanganj and Gazipur respectively (Tables 4.7 and 4.8). Highest Ca content in leaves 0.251 % and 0.239% was observed in T_2 (100% RDF + 0% TWW) in both non contaminated soils. The lowest Ca content in leaves 0.105 % and 0.217 % was observed with T_3(50% RDF + 25% TWW) in both non contaminated soils. Ca content of shoot varied between 0.041% to 0.072% and 0.053% to 0.063% in non contaminated soils of Narayanganj and Gazipur respectively. Highest Ca content in shoot 0.072% and 0.063% were observed in T_2 (100% RDF + 0% TWW) in both soils. And the lowest Ca content in shoot 0.041% and 0.053% were observed with T_3(50% RDF + 25% TWW) and T_5 (50% RDF + 75% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. Ca content of root varied between 0.018% to 0.031% and 0.025% to 0.031% in contaminated soils of Narayanganj and Gazipur respectively. Highest Ca content in root 0.031% was observed in T_2 (50% RDF + 50% TWW) in both non contaminated soils. And the lowest Ca content in root 0.018% and 0.025% were observed with T_1(control) and with T_6 (50% RDF + 50% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The results revealed that Ca content of jute leaves increased with the increasing concentration of textile waste water up to 50%, then decreased in both soils.

The Mg content of leaves of jute leaves varied between 0.144 % to 0.163 % and 0.148 % to 0.159% in contaminated soils of Narayanganj and Gazipur respectively (Table 4.7 and 4.8). Highest Mg content in leaves 0.163 % and 0.159% was observed in T_2 (100% RDF + 0% TWW) in both soils. And the lowest Mg content in leaves 0.144 % and 0.148 % was observed with the T_6(50% RDF + 100% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Mg content of shoot varied between 0.050% to 0.073% and 0.047% to 0.065% in non contaminated soils of Narayanganj and Gazipur respectively. Highest Mg content in shoot 0.073% and 0.065% were observed in T_2 (100% RDF + 0% TWW) in both soils. And the lowest Mg content in shoot 0.050% and 0.047% were observed with T_3(50% RDF + 25% TWW) and T_5 (50% RDF + 75% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Mg content of root varied between 0.018% to 0.022% and 0.022% to 0.030% in non contaminated soils of Narayanganj and Gazipur respectively. Highest Ca content in root 0.022% and 0.030% were observed in T_2 and T_4 in contaminated soils of Narayanganj and Gazipur respectively. The lowest Ca content in root 0.018% was observed in T_6(50% RDF + 100% TWW) in non contaminated soils of Narayanganj and 0.022% was observed with T_3 (50% RDF + 25% TWW) in non contaminated soil of Gazipur. The results revealed that Mg content of jute leaves vegetable plant(pat shak) increased with the increasing concentration of textile waste water up to 50% , after then decreased in both soils.

4.1.8. Effect of textile waste water on nutrient uptake by jute leaves vegetable plant (pat shak) in different soils

Effect of textile waste water on nutrient uptake by jute leaves plant in different soils are presented in Tables 4.9. to 4.12 The results revealed that average nutrients uptake due to textile waste water irrigation increased significantly ($P \leq 0.05$) as compared with control in non contaminated soils, but in contaminated soils nutrient uptake decreased. Considerable amount of nutrients were taken up by all the treatments.

4.1.8.1. Effect of textile waste water on nutrient uptake by jute leaves vegetable plant in non contaminated soils

In non contaminated soils of Narayanganj and Gazipur N uptake by jute leaves increased significantly($P \leq 0.05$) by all treatments as compared with control (except T_6 in non contaminated soil of Gazipur)(Tables 4.9 and 4.10). The N uptake ranged between 9.72 to 37.3 kg/ha and 7.82 to 38.22 kg/ha in non contaminated soils of Narayanganj and Gazipur respectively. The highest uptake of N 37.3 and 38.22 kg/ha were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. And the second highest uptake of N 31.70 and 27.38 kg/ha were observed with T_4 (50% RDF + 50% TWW) in both non contaminated soils. The lowest uptake of N 9.72 and 7.82 kg/ha were found with the T_1 (control) and T_6 (50% RDF + 50% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The results revealed that irrigation of more than 50% concentration of textile waste water reduce the uptake of N by jute leaves in both non contaminated soils.

Phosphorus uptake by jute leaves vegetable plant in non contaminated soil of Narayanganj and Gazipur increased significantly ($P \leq 0.05$) by all treatments as compared with control (except T_3 and T_6 in non contaminated soil of Narayanganj) (Tables 4.9. and 4.10). The P uptake ranged between 1.19 to 3.14 kg/ha and 0.77 to 4.18 kg/ha in non contaminated soil of Narayanganj and Gazipur respectively. The highest uptake of P 3.14 and 4.18 kg/ha were observed with T_4 (50% RDF + 50% TWW) and T_2 (100% RDF + 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. And the second highest uptake of P 3.01 and 3.40 kg/ha were observed with T_2 (100% RDF + 0% TWW) and T_4 (50% RDF + 50% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of P 1.19 and 0.77 kg/ha were found with T_6 (50% RDF + 50% TWW) and T_1 (control) in non contaminated soils of Narayanganj and Gazipur respectively. The results revealed that irrigation of more than 50% concentration of textile waste water reduce the uptake of P by jute leaves in both non contaminated soils.

Potassium uptake by jute leaves in non contaminated soils of Narayanganj and Gazipur increased significantly ($P \leq 0.05$) by all treatments as compared with control (except T_6 in non contaminated soil of Gazipur))(Tables 4.9 and 4.10). The K uptake ranged between 8.98 to

Table 4.9. Effect of textile waste water on nutrient uptake by jute leaves vegetable plant (pat shak) in non contaminated soil of Narayanganj

Treatment	**Plant parts**	**Uptake of nutrient Kg/ha**					
		N	**P**	**K**	**S**	**Ca**	**Mg**
T_1= control	Leaves	5.02	0.58	5.57	0.09	0.40	0.46
	Shoot	4.10	0.41	2.87	0.06	0.16	0.21
	Root	0.60	0.24	0.54	0.02	0.02	0.02
	Total	**9.72 e**	**1.23 d**	**8.98 f**	**0.17f**	**0.58 f**	**0.69 e**
T_2=100% RDF + 0% TWW	Leaves	26.08	1.59	15.59	0.52	1.35	1.10
	Shoot	10.23	1.02	9.30	0.27	0.59	0.51
	Root	0.99	0.40	1.08	0.04	0.04	0.04
	Total	**37.30 a**	**3.01 b**	**25.97 a**	**0.83 a**	**1.98 a**	**1.65 a**
T_3=50%RDF +25% TWW	Leaves	6.30	0.60	6.57	0.17	0.45	0.44
	Shoot	3.28	0.41	3.28	0.08	0.23	0.23
	Root	0.54	0.22	0.72	0.02	0.03	0.02
	Total	**10.12 d**	**1.23 d**	**10.57 e**	**0.27 e**	**0.71 e**	**0.69 e**
T_4=50%RDF +%50 TWW	Leaves	23.00	1.30	13.83	0.43	1.08	0.97
	Shoot	7.80	1.48	7.96	0.24	0.46	0.47
	Root	0.90	0.36	1.28	0.05	0.04	0.04
	Total	**31.70 b**	**3.14 a**	**23.07 b**	**0.72 b**	**1.58 b**	**1.48 b**
T_5=50%RDF +75% TWW	Leaves	15.96	1.06	12.71	0.35	1.00	0.87
	Shoot	5.78	0.75	6.12	0.15	0.34	0.35
	Root	0.80	0.27	1.08	0.03	0.02	0.03
	Total	**22.54 c**	**2.08 c**	**19.91 c**	**0.53 c**	**1.36 c**	**1.25 c**
T_6=50%RDF +100% TWW	Leaves	6.73	0.66	9.59	0.23	0.72	0.63
	Shoot	2.72	0.34	3.74	0.07	0.19	0.17
	Root	0.56	0.19	0.88	0.02	0.02	0.02
	Total	**10.01 d**	**1.19 d**	**14.21 d**	**0.32 d**	**0.93 d**	**0.82 d**

Table 4.10. Effect of textile waste water on nutrient uptake by jute leaves vegetable plant (pat shak) in non contaminated soil of Gazipur

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	5.28	0.35	9.57	0.10	0.60	0.49
	Shoot	2.25	0.30	2.55	0.04	0.18	0.19
	Root	0.37	0.11	0.50	0.01	0.02	0.02
	Total	**7.90 e**	**0.77 f**	**12.62 e**	**0.15 f**	**0.80 e**	**0.70 c**
T_2=100% RDF + 0% TWW	Leaves	26.24	2.48	24.96	0.66	2.67	1.38
	Shoot	11.04	1.38	10.12	0.26	0.71	0.75
	Root	0.94	0.32	1.04	0.04	0.06	0.05
	Total	**38.22 a**	**4.18 a**	**36.12 b**	**0.96 a**	**3.44 a**	**2.18 a**
T_3=50%RDF +25% TWW	Leaves	9.83	0.74	12.40	0.14	0.90	0.65
	Shoot	3.68	0.60	4.60	0.06	0.24	0.27
	Root	0.71	0.27	0.94	0.02	0.04	0.04
	Total	**14.22 d**	**1.61 d**	**17.94 d**	**0.22 d**	**1.18 d**	**0.96 c**
T_4=50%RDF +%50 TWW	Leaves	18.40	1.70	23.56	0.57	1.97	1.07
	Shoot	8.30	1.40	11.00	0.31	0.65	0.61
	Root	0.68	0.30	0.96	0.04	0.04	0.04
	Total	**27.38 b**	**3.40 b**	**35.52 c**	**0.92 b**	**2.66 b**	**1.72 b**
T_5=50%RDF +75% TWW	Leaves	16.00	1.32	24.32	0.37	1.80	1.03
	Shoot	7.47	1.07	11.64	0.21	0.58	0.49
	Root	0.48	0.20	0.72	0.02	0.03	0.03
	Total	**23.95 c**	**2.59 c**	**36.68 a**	**0.60 c**	**2.41 c**	**1.5479 b**
T_6=50%RDF +100% TWW	Leaves	5.21	0.49	5.56	0.12	0.61	0.44
	Shoot	2.16	0.31	2.21	0.05	0.19	0.14
	Root	0.45	0.17	0.56	0.02	0.03	0.02
	Total	**7.82 e**	**0.95 e**	**8.33 f**	**0.19 e**	**0.83 e**	**0.60 c**

25.97 kg/ha and 8.33 to 36.68 kg/ha in non contaminated soils of Narayanganj and Gazipur espectively. The highest uptake of K 25.97 and 36.68 kg/ha were observed with T_2 (100% RDF + 0% TWW) and T_5 (50% RDF + 75% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively. And the second highest uptake of K 23.06 and 36.12 kg/ha were observed with T_4 (50% RDF + 50% TWW) and T_2 (100% RDF + 0% TWW) in non contaminated soils of

Narayanganj and Gazipur respectively. The lowest uptake of K 8.98 and 8.33 Kg/ha were found with T_1 (control) and T_6 (50% RDF + 50% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively. The results revealed that irrigation of more than 50% concentration of textile waste water reduce the uptake of K by jute leaves in non contaminated soil of Narayanganj. And irrigation of more than 75% concentration of textile waste water reduce the uptake of K by jute leaves in non contaminated soil of Gazipur.

Sulphur uptake by jute leaves vegetable plant in non contaminated soil of Narayanganj and Gazipur increased significantly ($P \leq 0.05$) by all treatments as compared with control (Tables 4.9 and 4.10). The S uptake ranged between 0.17 to 0.83 kg/ha and 0.15 to 0.96 kg/ha in non contaminated soils of Narayanganj and Gazipur, respectively. The highest uptake of S 0.83 and 0.96 kg/ha were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. And the second highest uptake of S 0.72 and 0.92 kg/ha were observed with T_4 (50% RDF + 50% TWW) in both non contaminated soils. The lowest uptake of S 0.17 and 0.15 Kg/ha were found with the T_1 (control) in both non contaminated soils. The results revealed that irrigation of more than 50% concentration of textile waste water reduce the uptake of S by jute leaves in both non contaminated soils.

As a result of textile waste water irrigation Ca uptake by jute leaves in non contaminated soils of Narayanganj and Gazipur increased significantly ($P \leq 0.05$) by all treatments as compared with control (Tables 4.9 and 4.10). The Ca uptake ranged between 0.58 to 1.98 kg/ha and 0.80 to 3.44 kg/ha in non contaminated soils of Narayanganj and Gazipur, respectively. The highest uptake of Ca 1.98 and 3.44 kg/ha were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. And the second highest uptake of Ca 1.58 and 2.66 kg/ha were observed with T_4 (50% RDF + 50% TWW) in both non contaminated soils. The lowest uptake of Ca 0.58 and 0.80 kg/ha were found with the T_1 (control) in both non contaminated soils. The results revealed that irrigation of more than 50% concentration of textile waste water decreased the uptake of Ca by jute leaves in both non contaminated soils.

Due to textile waste water irrigation Mg uptake by jute leaves in non contaminated soils of Narayanganj and Gazipur increased significantly ($P \leq 0.05$) by all treatments as compared with control (except T_6 in non contaminated soil of Gazipur) (Tables 4.9 and 4.10). The Mg uptake ranged between 0.69 to 1.65 kg/ha and 0.60 to 2.18 kg/ha in non contaminated soils of Narayanganj and Gazipur, respectively. The highest uptake of Mg 1.65 and 2.18 kg/ha were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. And the second highest uptake of Mg 1.48 and 1.72 kg/ha were observed with T_4 (50% RDF + 50% TWW) in both non contaminated soils. The lowest uptake of Mg 0.69 and 0.60 kg/ha were found with the T_1 (control) and T_6 (50% RDF + 50% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The results revealed that irrigation of more than 50% concentration of textile waste water decreased the uptake of Mg by jute leaves in non contaminated soils of Narayanganj and Gazipur.

4.1.8.2. Effect of textile waste water on nutrient uptake by jute leaves vegetable plant in contaminated soils

In contaminated soils of Narayanganj and Gazipur N uptake by jute leaves decreased significantly($P \leq 0.05$) by all treatments as compared with control (except T_4 in non contaminated soil of Narayanganj)(Tables 4.11 and 4.12.). The N uptake ranged between 19.14 to 40.69 kg/ha and 16.38 to 43.49 kg/ha in contaminated soils of Narayanganj and Gazipur, respectively. The highest uptake of N 40.69 and 43.493 kg/ha were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. And the second highest uptake of N 25.70 and 32.67 kg/ha were observed with T_4 (50% RDF + 50% TWW) and T_1(control) in contaminated soils of Narayanganj and Gazipur, respectively. The lowest uptake of N 19.14 and 16.38 Kg/ha were found with T_3 (50% RDF + 25% TWW) and T_6 (50% RDF + 50% TWW) in contaminated soils of Narayanganj and Gazipur, respectively. The results revealed that irrigation of textile waste water have negative effect on N uptake by jute in both contaminated soils. But 50% concentration of textile waste water slightly increased the uptake of N by jute leaves in both contaminated soils.

Textile waste water irrigation decreased P uptake significantly ($P \leq 0.05$)(Tables 4.11 and 4.12) by jute leaves plant in contaminated soils of Narayanganj and Gazipur as compared with control (except T_4 in both contaminated soils). The P uptake ranged between 1.68 to 3.70 kg/ha and 1.65 to 3.39 kg/ha in contaminated soils of Narayanganj and Gazipur, respectively. The highest uptake of P 3.70 and 3.39 kg/ha were observed with treatment T_2 (100% RDF + 0%.

Table 4.11. Effect of textile waste water on nutrient uptake by jute leaves vegetable plant (pat shak) in contaminated soil of Narayanganj

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	15.46	1.15	10.44	0.26	0.72	0.71
	Shoot	8.06	0.86	5.76	0.13	0.36	0.52
	Root	0.80	0.31	0.99	0.02	0.04	0.03
	Total	**24.32 c**	**2.32 c**	**17.19 c**	**0.41 c**	**1.12 c**	**1.26 b**
T_2=100% RDF + 0% TWW	Leaves	28.19	2.06	16.90	0.44	1.78	1.16
	Shoot	11.40	1.24	9.50	0.26	0.68	0.70
	Root	1.10	0.40	1.30	0.04	0.06	0.04
	Total	**40.69 a**	**3.70 a**	**27.70 a**	**0.74 a**	**2.52 a**	**1.90 a**
T_3=50%RDF +25% TWW	Leaves	15.05	1.30	11.92	0.30	0.62	0.87
	Shoot	3.65	0.48	3.34	0.10	0.18	0.22
	Root	0.44	0.17	0.59	0.02	0.02	0.02
	Total	**19.14 f**	**1.95 e**	**15.85 d**	**0.42 c**	**0.82 e**	**1.11 d**
T_4=50%RDF +%50 TWW	Leaves	17.60	1.27	11.13	0.30	0.77	0.80
	Shoot	7.37	0.87	5.70	0.20	0.35	0.37
	Root	0.73	0.29	0.94	0.03	0.03	0.03
	Total	**25.70 b**	**2.43 b**	**17.97 b**	**0.53 b**	**1.15 b**	**1.20 c**
T_5=50%RDF +75% TWW	Leaves	17.07	1.22	11.45	0.27	0.70	0.80
	Shoot	5.70	0.68	4.85	0.13	0.26	0.29
	Root	0.77	0.29	0.93	0.03	0.03	0.03
	Total	**23.54 d**	**2.19 d**	**17.23 c**	**0.43 c**	**0.99 d**	**1.12 d**
T_6=50%RDF +100% TWW	Leaves	13.42	0.92	8.45	0.20	0.50	0.63
	Shoot	5.88	0.54	4.07	0.10	0.21	0.25
	Root	0.61	0.22	0.73	0.02	0.02	0.02
	Total	**19.91 e**	**1.68 f**	**13.25 e**	**0.32 d**	**0.73 f**	**0.90 e**

Table 4.12. Effect of textile waste water on nutrient uptake by jute leaves vegetable plant (pat shak) in contaminated soil of Gazipur

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	23.06	1.51	21.55	0.33	1.40	0.96
	Shoot	8.75	0.91	10.50	0.16	0.43	0.42
	Root	0.86	0.26	0.98	0.02	0.04	0.04
	Total	**32.67 b**	**2.68 b**	**33.03 c**	**0.51 b**	**1.87 b**	**1.42 abc**
T_2=100% RDF + 0% TWW	Leaves	32.19	2.00	25.53	0.45	1.77	1.18
	Shoot	10.24	1.08	11.78	0.18	0.49	0.50
	Root	1.06	0.31	1.19	0.03	0.06	0.05
	Total	**43.49 a**	**3.39 a**	**38.50 a**	**0.66 a**	**2.32 a**	**1.73 a**
T_3=50%RDF +25% TWW	Leaves	10.58	0.81	14.96	0.25	1.17	0.80
	Shoot	4.39	0.67	6.83	0.12	0.37	0.32
	Root	0.57	0.17	0.71	0.02	0.04	0.03
	Total	**15.54 e**	**1.65 f**	**22.50 e**	**0.39 d**	**1.58 e**	**1.15 c**
T_4=50%RDF +%50 TWW	Leaves	16.93	1.18	21.58	0.34	1.38	0.94
	Shoot	6.40	1.04	11.60	0.17	0.43	0.52
	Root	0.75	0.24	1.04	0.02	0.04	0.05
	Total	**24.08 c**	**2.46 c**	**34.22 b**	**0.53 b**	**1.85 b**	**1.51 abc**
T_5=50%RDF +75% TWW	Leaves	12.12	0.99	17.52	0.31	1.27	0.87
	Shoot	5.55	0.89	8.21	0.19	0.39	0.35
	Root	0.62	0.21	0.90	0.02	0.04	0.03
	Total	**18.29 d**	**2.09 d**	**26.63 d**	**0.52 b**	**1.70 c**	**1.25 ab**
T_6=50%RDF +100% TWW	Leaves	11.31	0.90	14.17	0.29	1.22	0.83
	Shoot	4.47	0.63	5.36	0.14	0.35	0.32
	Root	0.60	0.20	0.75	0.02	0.05	0.03
	Total	**16.38 e**	**1.73 e**	**20.28 f**	**0.45 c**	**1.62 d**	**1.18 bc**

TWW) in both non contaminated soils. And the second highest uptake of P 2.43 and 2.68 kg/ha were observed with T_4 (50% RDF + 50% TWW) and T_1(control) in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of P 1.68 and 1.65 kg/ha were found with T_6 (50% RDF + 100% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The results revealed that irrigation of textile waste water have negative effect on P uptake by jute in both contaminated soils. But 50% concentration of textile waste water slightly increased the uptake of P by jute leaves in both contaminated soils.

Textile waste water irrigation decreased K uptake significantly ($P \leq 0.05$) by jute leaves in contaminated soils of Narayanganj and Gazipur as compared with control (except T_4 in both contaminated soils)(Tables 4.11 and 4.12). The K uptake ranged between 13.25 to 27.70 kg/ha and 20.28 to 38.50 kg/ha in contaminated soils of Narayanganj and Gazipur respectively. The highest uptake of K 27.70 and 38.50 kg/ha were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. And the second highest uptake of K 17.97 and 34.22 kg/ha were observed with T_4 (50% RDF + 50% TWW) in both contaminated soils. The lowest uptake of K 13.25 and 20.28 Kg/ha were found with T_6 (50% RDF + 100% TWW) in both contaminated soils. The results revealed that irrigation of textile waste water have negative effect on K uptake by jute in both contaminated soils. But 50% concentration of textile waste water slightly increased the uptake of K by jute leaves plant in both contaminated soils.

Textile waste water irrigation decreased S uptake (Tables 4.11 and 4.12) by jute leaves vegetable plant in contaminated soils of Narayanganj and Gazipur as compared with control (except T_4 in both contaminated soils). The S uptake ranged between 0.32 to 0.74 kg/ha and 0.39 to 0.66 kg/ha in contaminated soils of Narayanganj and Gazipur, respectively. The highest uptake of S 0.74 and 0.66 kg/ha were observed with T_2 (100% RDF + 0% TWW) in both contaminated soils. The second highest uptake of S 0.53 was observed with T_4 (50% RDF + 50% TWW) in both contaminated soils. The lowest uptake of S 0.32 and 0.39 Kg/ha were found with T_6 (50% RDF + 100% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur, respectively. The results revealed that irrigation of textile waste water have negative effect on S uptake by jute leaves vegetable plant in both contaminated soils. But 50% concentration of textile waste water slightly increased the uptake of S by jute leaves in both contaminated soils.

The textile waste water irrigation influenced the Ca uptake (Tables 4.11 and 4.12) by jute leaves vegetable plant in contaminated soils of Narayanganj and Gazipur decreased significantly ($P \leq 0.05$) by all treatments as compared with control (except T_4 in both non contaminated soils). The

Ca uptake ranged between 0.73 to 2.52 kg/ha and 1.58 to 2.32 kg/ha in contaminated soils of Narayanganj and Gazipur, respectively. The highest uptake of Ca 2.52 and 2.32 kg/ha were observed with T_2 (100% RDF + 0% TWW) in both contaminated soils. The second highest uptake of Ca 1.15 and 1.87 kg/ha were observed with T_4 (50% RDF + 50% TWW) and T_1 (control) in contaminated soils of Narayanganj and Gazipur, respectively. The lowest uptake of Ca 0.73 and 1.58 kg/ha were found with the T_6 (50% RDF + 50% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur, respectively. The results revealed that irrigation of textile waste water have negative effect on Ca uptake by jute leaves plant in both contaminated soils. But 50% concentration of textile waste water slightly increased the uptake of Ca by jute leaves in both contaminated soils.

Textile waste water irrigation decreased Mg uptake by jute leaves vegetable plant in contaminated soil of Narayanganj and Gazipur as compared with control (Tables 4.11 and 4.12). The Mg uptake ranged between 0.90 to 1.90 kg/ha and 1.15 to 1.73 kg/ha in contaminated soils of Narayanganj and Gazipur, respectively. The highest uptake of Mg 1.90 and 1.73 kg/ha were observed with T_2 (100% RDF + 0% TWW) in both contaminated soils. And the second highest uptake of Mg 1.26 and 1.51 kg/ha were observed with T_1 (control) and T_4 (50% RDF + 50% TWW) in contaminated soils of Narayanganj and Gazipur, respectively. The lowest uptake of Mg 0.90 and 1.15 kg/ha were found with the T_6 (50% RDF + 100% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur, respectively. The results revealed that irrigation of textile waste water had negative effect on Mg uptake by jute in both contaminated soils.

4.1.9. Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant (pat shak) in different soils

Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant in different soils are presented in Tables 4.13 to 4.16. The results revealed that heavy metal concentration in different parts of jute leaves vegetable plant increased with increased level of textile waste water irrigation in both non contaminated and contaminated soils.

4.1.9.1. Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant (pat shak) in non contaminated soils

Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.13 and 4.14. With the increasing of the concentration of textile waste water irrigation the concentration of heavy metals in jute leaves vegetable plant in both non contaminated soils were increased. It is noticeable that Ni was so trace that it could not possible to detect in non contaminated soil (both at Narayanganj and Gazipur) with T_1 and T_3.

Zinc concentration in leaves of jute leaves vegetable plant varied from 35.70 to 40.70 ppm and 43.70 to 48.70 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Zn in leaves 40.70 and 48.70 ppm were observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Zn in jute leaves 35.70 and 43.70 ppm were observed with T_1 (control) in both non contaminated soils. Zn concentration in shoot varied from 10.20 to 12.00 ppm and 13.50 ppm to 14.35 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Zn in shoot was 12.00 and 14.35 ppm were observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Zn in jute shoot 10.20 and 13.50 ppm were observed with T_1 (control) in both non contaminated soils. Zn concentration in root varied from 3.50 to 4.95 ppm and 4.90 to 5.60 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Zn in root was 4.95 and 5.60 ppm were observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Zn in jute root 3.50 and 4.90 ppm were observed with T_3 (50% RDF + 100% TWW) and T_1 (control) in non contaminated soils of Narayanganj and Gazipur, respectively. In non contaminated soil of Narayanganj the sequence of treatments for Zn concentration in leaves of jute leaves vegetable plant was $T_6 > T_5 > T_4 > T_2 > T_3 > T_1$,in shoot $T_6 > T_5 > T_4 > T_3 > T_2 > T_1$ and in root $T_6 > T_5 > T_4 > T_2 > T_1 > T_3$. And the sequence of treatments in non contaminated soil of Gazipur for Zn concentration in leaves of jute leaves was $T_6 > T_5 > T_4 > T_3 > T_2 > T_1$,in shoot $T_6 > T_5 > T_4 > T_3 > T_2 > T_1$ and in root $T_6 > T_5 > T_4 > T_3, T_2 > T_1$.

Copper concentration in leaves of jute leaves vegetable plant varied from 13.83 to 29.33 ppm and 15.35 to 24.43 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cu in jute leaves 29.33 and 24.43 ppm were observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Cu in jute leaves 13.83 and 15.35 ppm were observed with T_1 (control) in both non contaminated soils. Copper concentration in shoot of jute leaves varied from 4.20 to 8.75 ppm and 6.55 to 7.20 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Zn in jute shoot was 8.75 and 7.20 ppm were observed with the T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Cu in jute shoot 4.20 and 6.55 ppm were observed with T_1 (control) and T_3 (50% RDF + 25% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively. Cu concentration in root of jute leaves varied from 2.12 to 3.25 ppm and 2.85 to 3.40 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Cu in jute root was 3.25 and 3.40 ppm were observed with the T_6 (50% RDF + 100% TWW) and lowest concentration of Cu in jute root 2.12 and 2.85 ppm were observed with T_1 (control) in both non contaminated soils. The sequence of treatments in non contaminated soil of Narayanganj for Cu concentration in leaves of jute leaves vegetable was $T_6>T_5>T_4>T_2>T_3>T_1$,in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_2>T_1>T_3$. And the sequence of treatments in non contaminated soil of Gazipur for Cu concentration in leaves of jute leaves was $T_6>T_5>T_4>T_3>T_2>T_1$,in shoot $T_6>T_5>T_4>T_2>T_1>T_3$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$.

In both non contaminated soils Ni was not detected with T_1 (control) and T_3 (50% RDF + 25% TWW). Ni concentration in leaves of jute leaves vegetable plant varied from 0.02 to 0.09 ppm and 0.03 to 0.09 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Ni in jute leaves 0.09 ppm was observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Ni in jute leaves 0.02 and 0.03 ppm were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. Ni concentration in shoot of jute leaves varied from 0.007 to 0.015 ppm and 0.006 to 0.01 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Ni in jute shoot was 0.015 ppm and 0.01 ppm were observed with the T_6 (50% RDF + 100% TWW) in both non contaminated soils. The lowest concentration of Ni in jute shoot 0.007 and 0.006 ppm were observed with T_2 (100% RDF+ 0% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively. Ni concentration in root of jute leaves varied from 0.002 to 0.005 ppm and 0.003 to 0.004 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Ni in jute root was 0.005 and 0.004 ppm were observed with the T_6 (50% RDF + 100% TWW) and lowest concentration of Ni in jute root 0.002 and 0.003 ppm were observed with T_2 (100% RDF

+ 0% TWW) in both non contaminated soils. In non contaminated soil of Narayanganj the sequence of treatments for Ni concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_2$,in shoot $T_6>T_5>T_4>T_2$ and in root $T_6>T_5>T_4>T_2$. And the sequence of treatments in non contaminated soil of Gazipur for Ni concentration in leaves of jute leaves was $T_6>T_5>T_4>T_2$,in shoot $T_6>T_5>T_4>T_2$ and in root $T_6>T_5>T_4>T_2$.

Table 4.13. Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant in non contaminated soil of Narayanganj

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	**Cu**	**Ni**	**Fe**	**Cd**	**Cr**	**Pb**	**Mn**
T_1= (control)	Leaves	35.70	13.83	ND	444.04	0.006	1.20	0.060	50.22
	Shoot	10.20	4.20	ND	111.20	0.003	0.35	0.021	12.70
	Root	3.55	2.12	ND	53.70	0.001	0.12	0.006	4.22
T_2=100%RDF + 0% TWW	Leaves	37.70	25.48	0.020	453.86	0.005	1.21	0.020	57.50
	Shoot	10.54	10.62	0.007	148.30	0.002	0.36	0.004	12.20
	Root	4.05	3.14	0.002	113.22	0.001	0.13	0.001	4.70
T_3=50% RDF + 25% TWW	Leaves	36.70	24.15	ND	433.94	0.005	1.20	0.050	43.60
	Shoot	11.15	7.90	ND	152.70	0.003	0.36	0.020	10.72
	Root	3.50	3.10	ND	69.30	0.001	0.13	0.001	3.51
T_4=50%RDF + 50% TWW	Leaves	38.70	26.44	0.030	711.54	0.006	1.20	0.060	45.35
	Shoot	11.75	8.11	0.008	322.18	0.004	0.36	0.022	11.00
	Root	4.22	3.20	0.003	78.50	0.002	0.14	0.005	4.30
T_5=50%RDF + 75% TWW	Leaves	39.70	27.97	0.050	741.83	0.007	1.30	0.080	52.72
	Shoot	11.90	8.25	0.013	311.20	0.004	0.36	0.031	12.20
	Root	4.50	3.22	0.004	125.50	0.002	0.15	0.007	4.63
T_6=50%RDF + 100% TWW	Leaves	40.70	29.33	0.090	781.64	0.008	1.31	0.090	67.30
	Shoot	12.00	8.75	0.015	322.30	0.004	0.36	0.038	13.10
	Root	4.95	3.25	0.005	137.40	0.002	0.16	0.007	5.30

Table 4.14. Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant in non contaminated soil of Gazipur

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= (control)	Leaves	43.70	15.35	ND	1080.09	0.007	1.11	0.100	57.50
	Shoot	13.50	6.80	ND	457.50	0.003	0.41	0.035	12.90
	Root	4.90	2.85	ND	219.60	0.001	0.16	0.005	4.60
T_2=100%RDF + 0% TWW	Leaves	46.70	17.05	0.030	1184.09	0.006	1.70	0.050	61.20
	Shoot	14.50	7.00	0.006	423.70	0.002	0.45	0.021	12.10
	Root	5.10	3.20	0.003	223.90	0.001	0.17	0.002	4.90
T_3=50% RDF + 25% TWW	Leaves	44.70	20.64	ND	1165.92	0.006	1.10	0.110	45.50
	Shoot	13.60	6.55	ND	472.80	0.003	0.35	0.037	11.30
	Root	5.10	3.00	ND	225.20	0.001	0.13	0.006	4.70
T_4=50%RDF + 50% TWW	Leaves	44.90	22.83	0.040	1201.27	0.007	1.30	0.150	48.50
	Shoot	13.90	6.80	0.007	480.10	0.004	0.45	0.040	12.40
	Root	5.30	3.20	0.003	233.50	0.002	0.16	0.006	5.00
T_5=50%RDF + 75% TWW	Leaves	47.70	24.33	0.070	1300.78	0.008	1.50	0.170	55.70
	Shoot	14.20	7.10	0.008	502.70	0.004	0.50	0.050	13.90
	Root	5.35	3.33	0.003	247.20	0.002	0.18	0.006	5.50
T_6=50%RDF + 100% TWW	Leaves	48.70	24.43	0.090	1339.69	0.009	2.21	0.190	70.00
	Shoot	14.35	7.20	0.010	511.30	0.004	0.51	0.053	14.90
	Root	5.60	3.40	0.004	250.50	0.002	0.22	0.007	6.10

Concentration of Fe in leaves of jute leaves vegetable plant varied from 433.94 to 781.64 ppm and 1080.09 to 1339.69 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Fe in jute leaves 781.64 and 1339.69 ppm were observed with the T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Fe in jute leaves 433.94 and 1080.09 ppm were observed with T_3 (50% RDF + 100% TWW) and T_1 (control) in non contaminated soils of Narayanganj and Gazipur, respectively. Fe concentration in shoot of jute leaves varied from 111.20 to 322.30 ppm and 423.70 to 511.30 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Fe in jute shoot 322.30 and 511.30 ppm were observed with the T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Fe in jute shoot 111.20 and 423.70

ppm were observed with T_1 (control) and T_2 (100% RDF + 0% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively. Fe concentration in root of jute leaves varied from 53.70 to 137.40 ppm and 219.60 to 250.50 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Fe in jute root was 137.40 ppm and 250.50 ppm were observed with the T_6 (50% RDF + 100% TWW) and lowest concentration of Fe in jute root 53.70 and 219.60 ppm were found with T_1 (control) in both non contaminated soils. The sequence of treatments in non contaminated soil of Narayanganj for Fe concentration in leaves of jute leaves vegetable was $T_6>T_5>T_4>T_2>T_1>T_3$,in shoot $T_6>T_4>T_5>T_3>T_2>T_1$ and in root $T_6>T_5>T_2>T_4>T_3>T_1$. And the sequence of treatments in non contaminated soil of Gazipur for Fe concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_2>T_3>T_1$,in shoot $T_6>T_5>T_4>T_3>T_1>T_2$ and in root $T_6>T_5>T_4>T_3>T_2>T_1$.

Cadmium concentration in leaves of jute leaves vegetable plant varied from 0.005 to 0.008 ppm and 0.006 to 0.009 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Cd in jute leaves 0.008 and 0.009 ppm were observed with the T_6 (50% RDF + 100% TWW) in both non contaminated soils. The lowest concentration of Cd in jute leaves 0.005 and 0.006 ppm were observed with T_2 (50% RDF + 100% TWW) and T_3 (50% RDF + 100% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively. Cd concentration in shoot of jute leaves vegetable plant varied from 0.002 to 0.004 ppm in both non contaminated soils of Narayanganj and Gazipur. Highest concentration of Cd in jute shoot 0.004 ppm was observed with the T_4 (50% RDF + 500% TWW), T_5 (50% RDF + 75% TWW) and T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Cd in jute shoot 0.002 ppm was observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils of Narayanganj and Gazipur. Cadmium concentration in root of jute leaves vegetable plant varied from 0.001 to 0.002 ppm in both non contaminated soils of Narayanganj and Gazipur. Highest concentration of Cd in jute root was 0.002 ppm was observed with the T_4 (50% RDF + 500% TWW), T_5 (50% RDF + 75% TWW) and T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Cd in jute root 0.001 ppm was observed with T_1 (control), T_2 (100% RDF + 0% TWW) and T_3 (50% RDF + 25% TWW) in both non contaminated soils. The sequence of treatments in non contaminated soil of Narayanganj for Cd concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_1>T_3,T_2$,in shoot $T_6,T_5,T_4>T_3,T_1>T_2$ and in root $T_6,T_5,T_4>T_3,T_2,T_1$. And in non contaminated soil of Gazipur the sequence of treatments for Cd concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_1>T_3,T_2$,in shoot $T_6,T_5,T_4>T_3,T_1>T_2$ and in root $T_6,T_5,T_4>T_3,T_2,T_{1.}$

Cromium concentration in leaves of jute leaves vegetable plant varied from 1.20 to 1.31 ppm and 1.11 to 2.21 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Cr in jute leaves 1.31 and 2.21 ppm were observed with the T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Cr in jute leaves 1.20 and 1.11 ppm were observed with T_1 (control) in both non contaminated soils. Cr concentration in shoot of jute leaves varied from 0.35 to 0.36 ppm and 0.35 to 0.51 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Cr in jute shoot 0.36 and 0.51 ppm were observed with T_6 (50% RDF + 100% TWW) in both non contaminated soils. The lowest concentration of Cr in jute shoot 0.35 ppm was observed with T_1 (control) and T_3 (50% RDF + 25% TWW) in non contaminated soil of Narayanganj and Gazipur respectively. Cr concentration in root of jute leaves varied from 0.12 to 0.16 ppm and 0.13 to 0.22 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Cr in jute root was 0.16 and 0.22 ppm were observed with T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Cr in jute root 0.12 ppm and 0.13 ppm were observed with T_1 (control) and T_3 (50% RDF + 25% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively. The sequence of treatments in non contaminated soil of Narayanganj for Cr concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_2>T_3,T_1$,in shoot $T_6>T_5>T_4>T_1>T_2>T_3$ and in root $T_6>T_5>T_4>T_3>T_2>T_1$. And the sequence of treatments in non contaminated soil of Gazipur for Cr concentration in leaves of jute leaves vegetable plant was $T_6>T_2>T_5>T_4>T_1>T_3$,in shoot $T_6>T_2>T_5>T_4,T_1>T_3$ and in root $T_6>T_5>T_2>T_4>T_1>T_{3.}$

Lead concentration in leaves of jute leaves vegetable plant varied from 0.020 to 0.090 ppm and 0.050 to 0.190 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Pb in jute leaves 0.090 and 0.190 ppm were observed with the T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Pb in jute leaves and 0.050 ppm were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. Lead concentration in shoot of jute leaves varied from 0.004 to 0.038 ppm and0.021 to 0.053 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Pb in shoot 0.038 and 0.053 ppm were observed with T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Pb in shoot

0.004 and 0.021 ppm were observed with T_2 (100% RDF + 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. Pb concentration in root of jute leaves varied from 0.001 to 0.007 ppm and 0.002 to 0.007 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Pb in root 0.007 ppm was observed with T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Pb in jute root 0.001 and 0.002 ppm were observed with T_2 (100% RDF + 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. In non contaminated soil of Narayanganj the sequence of treatments for Pb concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_1>T_3,T_2$,in shoot $T_6>T_5>T_4>T_3>T_1>T_2$ and in root $T_6>T_5>T_1>T_4>T_3,T_2$. And in non contaminated soil of Gazipur the sequence of treatments for Pb concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_3>T_1>T_2$,in shoot $T_6>T_5>T_4>T_3>T_1>T_2$ and in root $T_6>T_5,T_4,T_3>T_1>T_2$.

Mn concentration in leaves of jute leaves vegetable plant varied from 43.60 to 67.30 ppm and 45.50 to 70.00 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Mn in jute leaves 67.30 and 70.00 ppm were observed with the T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Mn in leaves 43.60 and 45.50 ppm were observed with T_3 (50% RDF + 25% TWW) in both non contaminated soils. Mn concentration in shoot of jute leaves varied from 10.72 to 13.10 ppm and 11.30 to 14.90 ppm in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Mn in shoot 13.10 and 14.90 ppm were observed with T_6 (50% RDF + 100% TWW) in both non contaminated soils. And lowest concentration of Mn in shoot 10.72 and 11.30 ppm were observed with T_3 (50% RDF + 25% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. Mn concentration in root of jute leaves vegetable plant varied from 3.51 to 5.30 ppm and 4.70 to 6.10 ppm in non contaminated soil of Narayanganj and Gazipur respectively. Highest concentration of Mn in root 5.30 and 6.10 ppm were observed with T_6 (50% RDF + 100% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively. And lowest concentration of Mn in root 3.51 and 4.70 ppm were observed with T_3 (50% RDF + 25% TWW) and T_1 (control) in non contaminated soils of Narayanganj and Gazipur respectively.

The sequence of treatments in non contaminated soil of Narayanganj for Mn concentration in leaves of jute leaves was $T_6>T_2>T_5>T_4>T_1,T_3$,in shoot $T_6>T_2>T_5>T_4>T_1>T_3$ and in root $T_6>T_2>T_5>T_4>T_1>T_3$. And the sequence of treatments in non contaminated soil of Gazipur for Pb concentration in leaves of jute leaves was $T_6>T_2>T_1>T_5>T_4>T_3$,in shoot $T_6>T_5>T_1>T_4>T_2>T_3$ and in root $T_6>T_5,T_4,T_2>T_3>T_{1.}$

On the basis of heavy metal concentration in jute leaves vegetable plant in non contaminated soils, the order of concentration of heavy metal may be arranged as Fe>Mn>Zn>Cu>Cr>Pb>Ni>Cd.

4.1.9.2. Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant (pat shak) in contaminated soils

Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant in contaminated soils of Narayanganj and Gazipur are presented in Tables 4.15 and 4.16. With the increasing the concentration of textile waste water irrigation the concentration of heavy metals in jute leaves in both contaminated soils were increased.

Zinc concentration in leaves of jute leaves vegetable plant varied from 43.70 to 65.70 ppm and 60.70 to 81.70 ppm in contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Zn in jute leaves 65.70 and 81.70 ppm were observed with the T_6 (50% RDF + 100% TWW) and lowest concentration of Zn in jute leaves 43.70 and 60.70 ppm were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. Zn concentration in shoot varied from 12.50 to 17.62 ppm and 15.65 to 22.40 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Zn shoot in jute leaves vegetable plant was 17.62 and 22.40 ppm were observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Zn in shoot 12.50 and 15.65 ppm were observed with T_2 (100% RDF + 0% TWW) in both contaminated soils. Zn concentration in root varied from 5.25 to 8.20 ppm and 10.20 to 12.90 ppm in contaminated soil of Narayanganj and Gazipur respectively. Highest concentration of Zn in root 8.20 and 12.90 ppm were observed with the treatment T_6 (50% RDF + 100% TWW) and lowest concentration of Zn in jute leaves root 5.25 and 10.20 ppm were observed with T_2 (100% RDF + 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. In contaminated soil of Narayanganj the sequence of treatments for Zn concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_3>T_1>T_2$,in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_3>T_2>T_1$. And the sequence of treatments in contaminated soil of Gazipur for Zn concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_3>T_1>T_2$,in shoot $T_6>T_5>T_4>T_3>T_1>T_2$ and in root $T_6>T_5>T_4>T_1>T_3>T_2$.

Table 4.15. Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant in contaminated soil of Narayanganj

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= (control)	Leaves	50.70	28.56	ND	355.32	0.011	0.030	0.060	51.50
	Shoot	15.10	8.30	ND	105.20	0.005	0.007	0.020	12.90
	Root	6.22	3.20	ND	51.10	0.001	0.004	0.006	5.20
T_2=100%RDF + 0% TWW	Leaves	43.70	20.84	0.033	489.46	0.010	0.040	0.050	50.20
	Shoot	12.50	8.10	0.005	164.70	0.004	0.010	0.017	13.10
	Root	5.25	3.20	0.002	64.90	0.001	0.005	0.004	5.60
T_3=50% RDF + 25% TWW	Leaves	58.70	28.26	ND	756.96	0.011	0.043	0.060	45.70
	Shoot	16.80	8.30	ND	321.50	0.004	0.010	0.020	11.80
	Root	7.50	3.10	ND	89.90	0.001	0.006	0.004	4.20
T_4=50%RDF + 50% TWW	Leaves	62.70	29.16	0.050	814.69	0.011	0.046	0.080	48.30
	Shoot	16.90	8.35	0.005	342.70	0.004	0.012	0.022	12.50
	Root	7.70	3.20	0.002	91.30	0.001	0.006	0.005	5.60
T_5=50%RDF + 75% TWW	Leaves	64.70	30.16	0.050	890.40	0.012	0.048	0.100	55.10
	Shoot	17.10	8.50	0.006	355.20	0.005	0.014	0.030	13.90
	Root	8.00	3.20	0.003	117.40	0.002	0.006	0.006	5.70
T_6=50%RDF + 100% TWW	Leaves	65.70	34.45	0.070	909.65	0.012	0.051	0.150	70.50
	Shoot	17.62	8.90	0.008	362.80	0.005	0.015	0.032	14.20
	Root	8.20	3.45	0.005	151.20	0.002	0.007	0.006	6.50

Table 4.16. Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant in contaminated soil of Gazipur

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= (control)	Leaves	65.70	30.46	ND	991.17	0.011	0.038	0.060	50.10
	Shoot	16.50	8.50	ND	404.50	0.003	0.005	0.011	11.70
	Root	11.10	3.10	ND	201.30	0.001	0.002	0.005	5.00
T_2=100%RDF + 0% TWW	Leaves	60.70	28.66	0.030	976.03	0.010	0.045	0.047	51.90
	Shoot	15.65	8.70	0.004	400.20	0.003	0.007	0.010	12.80
	Root	10.20	3.00	0.002	201.40	0.001	0.004	0.004	5.50
T_3=50% RDF + 25% TWW	Leaves	67.70	27.17	0.060	913.47	0.011	0.040	0.050	43.50
	Shoot	17.90	8.00	0.006	372.80	0.003	0.006	0.010	10.90
	Root	10.50	3.00	0.003	171.50	0.001	0.003	0.004	4.10
T_4=50%RDF + 50% TWW	Leaves	68.70	32.84	0.060	972.11	0.012	0.047	0.060	46.30
	Shoot	18.00	8.90	0.006	410.50	0.003	0.007	0.011	12.10
	Root	11.20	3.30	0.002	201.10	0.002	0.003	0.004	5.40
T_5=50%RDF + 75% TWW	Leaves	77.70	34.64	0.070	1010.59	0.012	0.052	0.070	52.50
	Shoot	20.90	9.00	0.006	422.70	0.004	0.008	0.020	12.70
	Root	12.00	3.35	0.003	200.50	0.002	0.004	0.007	5.50
T_6=50%RDF + 100% TWW	Leaves	81.70	37.76	0.080	1165.93	0.013	0.055	0.110	65.90
	Shoot	22.40	9.30	0.007	435.80	0.004	0.010	0.030	13.60
	Root	12.90	3.40	0.004	231.90	0.002	0.007	0.007	6.20

Cu concentration in leaves of jute leaves vegetable plant varied from 20.84 to 34.45 ppm and 27.17 to 37.76 ppm in contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Zn in leaves 34.45 and 37.76 ppm were observed with the T_6 (50% RDF + 100% TWW). And lowest concentration of Cu in leaves 20.84 ppm and 27.17 ppm were observed with T_2 (100% RDF + 0% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur, respectively. Cu concentration in shoot varied from 8.10 to 8.90 ppm and 8.00 to 9.30 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cu in shoot of jute leaves vegetable plant was 8.90 and 9.30 ppm were observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Cu in jute shoot 8.10 and 8.00 ppm were observed with T_2 (100% RDF + 0% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Cu concentration in root varied from 3.10 to 3.45 ppm and 3.00 to 3.40 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cu in jute leaves root 3.45 ppm and 3.40 ppm were observed with the treatment T_6 (50% RDF + 100% TWW) and the lowest concentration of Cu in jute leaves root 3.10 ppm and 3.00 ppm were observed with T_3 (500% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The sequence of treatments in contaminated soil of Narayanganj Cu in leaves of jute leaves was $T_6>T_5>T_4>T_1>T_3>T_2$,in shoot $T_6>T_5>T_4>T_3>T_1>T_2$ and in root $T_6>T_5>T_4>T_2>T_1>T_3$. And the sequence of treatments in contaminated soil of Gazipur for Zn concentration in leaves of jute leaves was $T_6>T_5>T_4>T_1>T_2>T_3$,in shoot $T_6>T_5>T_4>T_2>T_1>T_3$ and in root $T_6>T_5>T_4>T_1>T_2>T_3$.

In contaminated soils of Narayanganj Ni was not detected with T_1 and T_3. And in contaminated soil of Gazipur Ni was not detected with T_1. Ni concentration in leaves of jute leaves vegetable plant varied from 0.033 to 0.070 ppm and 0.030 to 0.080 ppm in contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Ni in leaves 0.070 and 0.080 ppm were observed with the T_6 (50% RDF + 100% TWW) and lowest concentration of Ni in jute leaves 0.033 and 0.030 ppm were observed with T_2 (100% RDF + 0% TWW) in both contaminated soils. Ni concentration in shoot varied from 0.005 to 0.008 ppm and 0.004 ppm to 0.007 ppm in contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Ni in shoot of jute leaves vegetable plant 0.008 and 0.007 ppm were observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Ni in shoot 0.005 and 0.004 ppm were observed with T_2 (100% RDF + 0% TWW) in both contaminated soils. Ni concentration in root varied from 0.002 to 0.005 ppm and 0.002 to 0.004 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Ni in root 0.005 and 0.004 ppm were observed with the treatment T_6 (50% RDF + 100% TWW) and lowest concentration of Ni in jute leaves vegetable plant root 0.002 ppm was observed with T_2 (100% RDF + 0% TWW) in both contaminated soil of Narayanganj and Gazipur. The sequence of treatments in contaminated soil of Narayanganj for Ni concentration in leaves of jute leaves was $T_6>T_5,T_4>T_2$,in shoot $T_6>T_5>T_4,T_2$ and in root $T_6>T_5>T_4,T_2$. And the sequence of treatments in contaminated soil of

Gazipur for Ni concentration in leaves of jute leaves was $T_6>T_5>T_4,T_3>T_2$,in shoot $T_6>T_5,T_4,T_3>T_2$ and in root $T_6>T_5>T_3>T_4>T_2$.

Concentration of Fe in leaves of jute leaves vegetable plant varied from 355.32 to 909.65 ppm and 913.47 to 1165.93 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Fe in jute leaves 909.65 and 1165.93 ppm were observed with the T_6 (50% RDF + 100% TWW) in both contaminated soils. The lowest concentration of Fe in leaves 355.32 and 913.47 ppm were observed with T_1 (control) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Fe concentration in shoot varied from 105.20 to 362.80 ppm and 372.80 to 435.80 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Fe in shoot of jute leaves vegetable plant 362.80 and 435.80 ppm were observed with T_6 (50% RDF + 100% TWW) in both contaminated soils. The lowest concentration of Fe in shoot 105.20 and 372.80 ppm were observed with T_1(control) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Fe concentration in root varied from 51.10 to 151.20 ppm and 171.50 to 231.90 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Fe in jute leaves root 151.20 and 231.90 ppm were observed with T_6 (50% RDF + 100% TWW) in both contaminated soils . And lowest concentration of Fe in root 51.10 and 171.50 ppm were observed with T_1(control) and T_3 (50% RDF + 25% TWW) in contaminated soil of Narayanganj and Gazipur respectively. In contaminated soil of Narayanganj the sequence of treatments for Fe concentration in leaves of jute leaves vegetable was $T_6>T_5,T_4>T_3>T_2>T_1$,in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_3>T_2>T_1$. And the sequence of treatments in contaminated soil of Gazipur for Fe concentration in leaves of jute leaves vegetable was $T_6>T_5>T_4>T_1>T_2>T_3$,in shoot $T_6>T_5>T_4>T_1>T_2>T_3$ and in root $T_6>T_5>T_2>T_1>T_4>T_3$.

Cadmium concentration in leaves of jute leaves vegetable plant varied from 0.010 to 0.012 ppm and 0.010 to 0.013 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cd in leaves 0.012 and 0.013 ppm were observed with the T_6 (50% RDF + 100% TWW) in both contaminated soils. And lowest concentration of Cd in leaves 0.010 ppm was observed with T_2 (50% RDF + 25% TWW) in both contaminated soils. Cd concentration in shoot varied from 0.004 to 0.005 ppm and 0.003 to 0.004 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cd in shoot of jute leaves vegetable 0.005 and 0.004 ppm were observed with T_6 (50% RDF + 100% TWW) and T_5 (50% RDF + 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And lowest concentration of Cd in jute leaves shoot 0.004 and 0.003 ppm were observed with T_2 (100% RDF + 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Cd concentration in root varied from 0.001 to 0.002 ppm in both contaminated soils of Narayanganj and Gazipur. Highest concentration of Cd in root of jute leaves vegetable plant 0.002 ppm was observed with T_5 (50% RDF + 75% TWW) and T_6 (50% RDF + 100% TWW) in both contaminated soils . And lowest concentration of Cd in root 0.001 ppm was observed with T_1(control), T_2 (100% RDF + 0% TWW) and T_3 (50% RDF + 25% TWW) in both contaminated soil of Narayanganj and Gazipur. The sequence of treatments in contaminated soil of Narayanganj for Cd concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4,T_3,T_1>T_2$,in shoot $T_6>T_5>T_1>T_4,T_3>T_2$ and in root $T_6,T_5>T_4>T_3,T_1,T_2$. And in contaminated soil of Gazipur the sequence of treatments for Cd concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_3,T_1>T_2$,in shoot $T_6,T_5>T_4,T_3,T_2,T_1$ and in root $T_6,T_5,T_4>T_3,T_2,T_1$.

Cromium concentration in leaves of jute leaves vegetable plant varied from 0.030 to 0.051 ppm and 0.038 to 0.055 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cr in leaves 0.051 and 0.055 ppm were observed with the T_6 (50% RDF + 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And lowest concentration of Cd in leaves 0.030 and 0.038 ppm were observed with T_1(control) in contaminated soils of Narayanganj and Gazipur respectively. Cr concentration in shoot varied from 0.007 to 0.015 ppm and 0.005 to 0.010 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cr in shoot 0.015 and 0.010 ppm were observed with T_6 (50% RDF + 100% TWW) in contaminated soil of Narayanganj and Gazipur respectively. The lowest concentration of Cr in shoot 0.007 and 0.005 ppm were observed with T_1 (control) in contaminated soils of Narayanganj and Gazipur respectively. Cr concentration in root varied from 0.004 to 0.007 ppm and 0.002 to 0.007 in contaminated soil of Narayanganj and Gazipur respectively. Highest concentration of Cr in root 0.007 ppm was found with T_6 (50% RDF + 100% TWW) in both contaminated soils . And lowest concentration of Cr in root 0.004 and 0.002 ppm were observed with T_1(control) in contaminated soils of Narayanganj and Gazipur respectively. The sequence of treatments in contaminated soil of Narayanganj for Cr concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_4>T_3>T_2>T_1$,in shoot

T_6>T_5>T_4>T_3,T_2>T_1 and in root T_6>T_5>T_4,T_3>T_2>T_1 . And the sequence of treatments in contaminated soil of Gazipur for Cd concentration in leaves of jute leaves vegetable plant was T_6>T_5>T_4>T_2>T_3>T_1 ,in shoot T_6>T_5>T_2>T_4,T_3>T_1 and in root T_6>T_5>T_2>T_4,T_2>T_1.

Lead concentration in leaves of jute leaves vegetable plant varied from 0.050 to 0.150 ppm and 0.047 to 0.110 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Pb in leaves of jute leaves vegetable 0.050 and 0.047 ppm were observed with the T_6 (50% RDF + 100% TWW) in contaminated soil of Narayanganj and Gazipur respectively. And lowest concentration of Pb in leaves 0.050 and 0.047 ppm were observed with T_2(100% RDF + 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Pb concentration in shoot varied from 0.017 to 0.032 ppm and 0.010 to 0.030 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Pb in shoot of jute leaves vegetable 0.032 and 0.030 ppm were observed with T_6 (50% RDF + 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And the lowest concentration of Pb in shoot 0.017 and 0.010 ppm were observed with T_2 (100% RDF + 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Pb concentration in root varied from 0.004 ppm to 0.006 and 0.004 to 0.007 in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Pb in root 0.006 ppm and 0.007 ppm were observed with T_6 (50% RDF + 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And lowest concentration of Pb in root of jute leaves vegetable plant 0.004 ppm was observed with T_2 (100% RDF + 0% TWW) and T_3(50% RDF + 25% TWW) in both contaminated soil of Narayanganj and Gazipur. The sequence of treatments in contaminated soil of Narayanganj for Pb concentration in leaves of jute leaves vegetable plant was T_6>T_5>T_4>T_3>T_1>T_2 ,in shoot T_6>T_5>T_4>T_3>T_1>T_2 and in root T_6>T_5>T_1>T_4>T_3,T_2 . And the sequence of treatments in contaminated soil of Gazipur for Pb concentration in leaves of jute leaves vegetable plant was T_6>T_5>T_4>T_1>T_3>T_2 ,in shoot T_6>T_5>T_4>T_1>T_3,T_2 and in root T_6>T_5>T_1,T_4,T_3>T_2.

Manganese concentration in leaves of jute leaves vegetable plant varied from 45.70 to 70.50 ppm and 43.50 to 65.90 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Mn in leaves of jute leaves vegetable plant 70.50 and 65.90 ppm were observed with the T_6 (50% RDF + 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And lowest concentration of Mn in leaves 45.70 and 43.50 ppm were observed with T_3(50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Mn concentration in shoot varied from 11.80 to 14.20 ppm and 10.90 to 13.60 ppm in contaminated soil of Narayanganj and Gazipur respectively. Highest concentration of Mn in shoot of jute leaves vegetable plant 14.20 and 13.60 ppm were observed with T_6 (50% RDF + 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And lowest concentration of Mn in shoot 11.80 and 10.90 ppm were observed with T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. Mn concentration in root of jute leaves vegetable plant varied from 4.20 to 6.50 ppm and 4.10 to 6.20 ppm in contaminated soil of Narayanganj and Gazipur respectively. Highest concentration of Mn in root 6.50 and 6.20 ppm were observed with T_6 (50% RDF + 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And lowest concentration of Mn in root 4.20 and 4.10 ppm were observed with T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The sequence of treatments in contaminated soil of Narayanganj for Mn concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_2>T_4>T_1>T_3$,in shoot $T_6>T_5>T_2>T_1>T_4>T_3$ and in root $T_6>T_5>T_4>T_2>T_1>T_3$. And the sequence of treatments in contaminated soil of Gazipur for Pb concentration in leaves of jute leaves vegetable plant was $T_6>T_5>T_2>T_1>T_4>T_4$,in shoot $T_6>T_2>T_5>T_4>T_1,T_3$ and in root $T_6>T_5>T_2>T_1>T_4>T_3$.

On the basis of heavy metal concentration in jute leaves plant in contaminated soils, the order of concentration of heavy metal may be arranged as Fe>Zn>Mn>Cu>Pb>Ni>Cr>Cd.

4.1.10. Effect of textile waste water on heavy metal uptake by jute leaves vegetable plant in different soils

Effect of textile waste water on heavy metal uptake by different parts of jute leaves plant in different soils are presented in Tables 4.17 to 4.20.

4.1.10.1. Effect of textile waste water on heavy metal uptake by jute leaves vegetable plant in non contaminated soils

Effect of textile waste water on heavy metal uptake by different parts of jute leaves vegetable plant in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.17 and 4.18. Textile waste water irrigation significantly ($P \leq 0.05$) increased Zn uptake by jute leaves vegetable plant as compared with control in both non contaminated soils of Narayanganj and Gazipur. Zn uptake by each treatment also significantly ($P \leq 0.05$) varied with other treatments (except T_6 in non contaminated soil of Gazipur). The Zn uptake ranged between 15.44 to 36.58 gm/ha and 17.79 to 51.62 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Zn 15.44 and 17.78 gm/ha were found with the T_1 (control) and T_6 ((50% RDF + 100% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. And the highest uptake of Zn 36.58 and 51.62 gm/ha were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. On the basis of Zn uptake by jute leaves vegetable plant the treatments may be arranged in the order $T_2>T_5>T_4>T_6>T_3>T_1$ and $T_2>T_5>T_4>T_3>T_1>T_6$ in non contaminated soils of Narayanganj and Gazipur respectively.

Copper uptake increased significantly ($P \leq 0.05$) with textile waste water irrigation by jute leaves vegetable plant as compared with control in both non contaminated soils of Narayanganj and Gazipur. Copper uptake also significantly ($P \leq 0.05$) varied with other treatments. Uptake of Cu ranged between 6.16 to 28.06 gm/ha and 7.21 to 22.59 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Cu 6.16 and 7.21 gm/ha were found in non contaminated soils of Narayanganj and Gazipur respectively with the T_1 (control). And the highest uptake of Cu 28.06 and 22.59 gm/ha were observed with T_2 (100% RDF + 0% TWW) and T_5(50% RDF + 75% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. On the basis of Cu uptake by jute leaves plant the treatments may be arranged in the order of $T_2>T_5>T_4>T_6>T_3>T_1$ and $T_5>T_4>T_2>T_3>T_6>T_1$ for non contaminated soil of Narayanganj and Gazipur respectively.

In both non contaminated soils Ni was not up taken by T_1 (control) and T_3 (50% RDF + 25% TWW). Nickel uptake increased significantly ($P \leq 0.05$) with textile waste water irrigation by jute leaves vegetable plant as compared with control in both non contaminated soils of Narayanganj and Gazipur. Ni was also significantly ($P \leq 0.05$) varied with other treatments. Uptake of Ni ranged between 0.00 to 0.0452 gm/ha and 0.00 to 0.0472 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Ni found zero 0.00 gm/ha in non contaminated soil of Narayanganj and Gazipur with the T_1 (control) and T_3 (50% RDF + 25% TWW). And the highest uptake of Ni 0.0452 and 0.0472 gm/ha were observed with T_6 (50% RDF + 100% TWW) and T_5(50% RDF + 75% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. On the basis of Ni uptake by jute leaves plant the treatments may be arranged in the order of $T_6>T_5>T_4>T_2>T_3,T_1$ and $T_5>T_4>T_6>T_2>T_3,T_1$ for non contaminated soils of Narayanganj and Gazipur respectively.

Table 4.17. Effect of textile waste water on heavy metal uptake by jute leaves vegetable plant in non contaminated soil of Narayanganj

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1	Leaves	11.07	4.29	0	137.65	0.0019	0.37	0.0186	15.57
	Shoot	3.98	1.64	0	43.37	0.0012	0.14	0.0082	4.95
	Root	0.39	0.23	0	5.91	0.0001	0.01	0.0007	0.46
	Total	**15.44 f**	**6.16 f**	**0 e**	**186.93 f**	**0.0032 d**	**0.52 d**	**0.0275 c**	**20.98 e**
T_2	Leaves	26.01	17.58	0.0138	313.16	0.0035	0.83	0.0138	39.68
	Shoot	9.80	9.88	0.0065	137.92	0.0019	0.33	0.0037	11.35
	Root	0.77	0.60	0.0004	21.51	0.0002	0.02	0.0002	0.89
	Total	**36.58 a**	**28.06 a**	**0.0207 d**	**472.59 c**	**0.0056 b**	**1.18 a**	**0.0177 e**	**51.92 a**
T_3	Leaves	11.01	7.25	0	130.18	0.0015	0.36	0.0150	13.08
	Shoot	4.57	3.24	0	62.61	0.0012	0.15	0.0082	4.40
	Root	0.42	0.37	0	8.32	0.0001	0.02	0.0001	0.42
	Total	**16.00 e**	**10.86 e**	**0 e**	**201.11 e**	**0.0028 d**	**0.53 d**	**0.0233 d**	**17.90 f**
T_4	Leaves	23.61	16.13	0.0183	434.04	0.0037	0.73	0.0366	27.66
	Shoot	9.05	6.24	0.0062	248.08	0.0031	0.27	0.0169	8.47
	Root	0.72	0.54	0.0005	13.35	0.0003	0.02	0.0009	0.73
	Total	**33.38 b**	**22.91 b**	**0.0250 c**	**695.47 a**	**0.0071 a**	**1.02 b**	**0.0544 b**	**36.86 c**
T_5	Leaves	22.23	15.66	0.0280	415.42	0.0039	0.73	0.0448	29.52
	Shoot	8.09	5.61	0.0088	211.62	0.0027	0.24	0.0211	8.30
	Root	0.68	0.48	0.0006	18.83	0.0003	0.02	0.0011	0.69
	Total	**31.00 c**	**21.75 c**	**0.0374 b**	**645.87 b**	**0.0069 a**	**0.99 b**	**0.0670 a**	**38.51b**
T_6	Leaves	17.91	12.91	0.0396	343.92	0.0035	0.57	0.0396	29.61
	Shoot	3.96	2.89	0.0050	106.36	0.0013	0.12	0.0125	4.32
	Root	0.54	0.36	0.0006	15.11	0.0002	0.02	0.0008	0.58
	Total	**22.41 d**	**16.16 d**	**0.0452 a**	**465.39 d**	**0.0050 c**	**0.71082 c**	**0.0529 b**	**34.51 d**

Table 4.18. Effect of textile waste water on heavy metal uptake by jute leaves vegetable plant in non contaminated soil of Gszipur

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	**Cu**	**Ni**	**Fe**	**Cd**	**Cr**	**Pb**	**Mn**
T_1	Leaves	13.98	4.91	0	345.63	0.0035	0.35	0.0320	18.40
	Shoot	4.05	2.04	0	137.25	0.0009	0.12	0.0105	3.87
	Root	0.44	0.26	0	19.76	0.0001	0.01	0.0005	0.41
	Total	**18.47 e**	**7.21 f**	**0 e**	**502.64 f**	**0.0045 d**	**0.48 f**	**0.0430 e**	**22.68 d**
T_2	Leaves	37.36	13.64	0.0240	947.27	0.0080	1.36	0.0400	48.96
	Shoot	13.34	6.44	0.0055	389.80	0.0028	0.41	0.0193	11.13
	Root	0.92	0.58	0.0005	40.30	0.0002	0.03	0.0004	0.88
	Total	**51.62 a**	**20.66 c**	**0.0300 d**	**1377.37 a**	**0.0110 b**	**1.80 a**	**0.0597 d**	**60.97 a**
T_3	Leaves	17.43	8.05	0	454.71	0.0043	0.43	0.0429	17.75
	Shoot	6.26	3.01	0	217.49	0.0014	0.16	0.0170	5.20
	Root	0.61	0.36	0	27.02	0.0001	0.02	0.0007	0.56
	Total	**24.30 d**	**11.42 d**	**0 e**	**699.22 d**	**0.0058 c**	**0.61 e**	**0.0606 d**	**23.51 d**
T_4	Leaves	27.84	14.15	0.0372	744.79	0.0074	0.81	0.0930	30.07
	Shoot	13.90	6.80	0.0030	480.10	0.0030	0.45	0.0400	12.40
	Root	0.80	0.48	0.0003	35.03	0.0003	0.02	0.0009	0.75
	Total	**42.54 c**	**21.43 b**	**0.0405 b**	**1259.92 c**	**0.0107 b**	**1.28 c**	**0.1339 b**	**43.22 c**
T_5	Leaves	30.05	15.33	0.0441	819.49	0.0076	0.95	0.1071	35.09
	Shoot	13.77	6.89	0.0029	487.62	0.0039	0.49	0.0485	13.48
	Root	0.59	0.37	0.0002	27.19	0.0002	0.02	0.0007	0.61
	Total	**44.41 b**	**22.59 a**	**0.0472 a**	**1334.30 b**	**0.0117 a**	**1.46 b**	**0.1563 a**	**49.18 b**
T_6	Leaves	13.15	6.60	0.0243	361.72	0.0035	0.60	0.0513	18.90
	Shoot	4.02	2.02	0.0084	143.16	0.0011	0.14	0.0148	4.17
	Root	0.62	0.374	0.0017	27.56	0.0002	0.02	0.0008	0.67
	Total	**17.79 e**	**8.9861 e**	**0.0344 c**	**532.44 e**	**0.0048 d**	**0.76 d**	**0.0669 c**	**23.74 d**

Textile waste water irrigation significantly ($P \leq 0.05$) increased Fe uptake by jute leaves vegetable plant as compared with control in both non contaminated soils of Narayanganj and Gazipur. Fe uptake by each treatment also significantly ($P \leq 0.05$) vary with other treatments. The Fe uptake ranged between 186.93 to 695.47 gm/ha and 502.64 to 1377.37 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Fe 186.93 and

502.64 gm/ha were found with the T_1 (control) in non contaminated soils of Narayanganj and Gazipur respectively. And the highest uptake of Fe 695.47 and 1377.37 gm/ha were observed with T_4 (50% RDF + 50% TWW) and T_2 (100% RDF + 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. On the basis of Fe uptake by jute leaves plant the treatments may be arranged in the order of $T_4>T_5>T_2>T_6>T_3>T_1$ and $T_2>T_5>T_4>T_3>T_6>T_1$ for non contaminated soils of Narayanganj and Gazipur, respectively.

Cadmium uptake increased significantly ($P \leq 0.05$) with textile waste water irrigation by jute leaves vegetable plant as compared with control in both non contaminated soils of Narayanganj and Gazipur (except T_3 in non contaminated soil of Narayanganj, which did not significantly vary with treatment T_1). Uptake of Cd ranged between 0.0028 to 0.0071 gm/ha and 0.0045 to 0.0117 gm/ha in non contaminated soil of Narayanganj and Gazipur respectively. The lowest uptake of Cd 0.0028 and 0.0045 gm/ha were found with the T_3 (50% RDF + 25% TWW) and T_1 (control) in non contaminated soils of Narayanganj and Gazipur respectively. And the highest uptake of Cd 0.0071 and 0.0117 gm/ha were observed with T_4 (50% RDF + 50% TWW) and T_5(50% RDF+ 75% TWW) in non contaminated soil of Narayanganj and Gazipur respectively. On the basis of Cd uptake by jute leaves plant the treatments may be arranged in the order $T_4>T_5>T_2>T_6>T_1>T_3$ and $T_5>T_2>T_4>T_6>T_3>T_1$ in non contaminated soils of Narayanganj and Gazipur respectively.

Chromium uptake increased significantly ($P \leq 0.05$) with textile waste water irrigation by jute leaves vegetable plant as compared with control in both non contaminated soils of Narayanganj and Gazipur (except T_3 in non contaminated soil of Narayanganj, which did not significantly vary with treatment T_1). Uptake of Cr ranged between 0.52 to 1.18 gm/ha and 0.48 to 1.80 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Cr 0.52 and 0.48 gm/ha were found in non contaminated soil of Narayanganj and Gazipur respectively with the T_1 (control). And the highest uptake of Cr 1.18 and 1.80 gm/ha were observed with T_2 (100% RDF + 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. On the basis of Cr uptake by jute leaves plant the treatments may be arranged in the order of $T_2>T_4>T_5>T_6>T_3>T_1$ for both non contaminated soils.

Textile waste water irrigation significantly ($P \leq 0.05$) increased Pb uptake by jute leaves vegetable plant as compared with control in both non contaminated soils of Narayanganj and Gazipur. The Pb uptake ranged between 0.0177 to 0.0670 gm/ha and 0.0430 to 0.1563 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Pb 0.0177 and 0.0430 gm/ha were found with the T_2 ((100% RDF + 0% TWW) and T_1 (control) in non contaminated soils of Narayanganj and Gazipur respectively. And the highest uptake of Pb 0.0670 and 0.1563 gm/ha were observed with T_5 (50% RDF + 75% TWW) in both non contaminated soils. On the basis of Pb uptake by jute leaves plant the treatments may be arranged in the order of $T_5>T_4>T_6>T_1>T_3>T_2$ and $T_5>T_4>T_6>T_3>T_2>T_1$ for non contaminated soils of Narayanganj and Gazipur respectively.

Textile waste water irrigation significantly ($P \leq 0.05$) increased Mn uptake by jute leaves vegetable plant as compared with control in both non contaminated soils of Narayanganj and Gazipur (except T_3 in Non contaminated soil of Narayangang). Mn uptake ranged between 17.90 to 51.92 and 22.68 to 60.97 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Mn 17.90 and 22.68 gm/ha were found with the T_3 ((50% RDF + 25% TWW) and T_1 (control) in non contaminated soils of Narayanganj and Gazipur respectively. And the highest uptake of Mn 51.92 and 60.97 gm/ha were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. On the basis of Mn uptake by jute leaves plant the treatments may be arranged in the order to $T_2>T_5>T_4>T_6>T_1>T_3$ and $T_2>T_5>T_4>T_6>T_3>T_1$ for non contaminated soil of Narayanganj and Gazipur respectively.

4.1.10.2. Effect of textile waste water on heavy metal uptake by jute leaves vegetable plant in contaminated soils

Effect of textile waste water on heavy metal uptake by different parts of jute leaves vegetable plant in contaminated soil of Narayanganj and Gazipur are presented in Tables 4.19. and 4.20. Irrigation of textile waste water significantly ($P \leq 0.05$) increased Zn uptake by jute leaves plant as compared with control in both contaminated soils of Narayanganj and Gazipur. Zn uptake by each treatment also significantly ($P \leq 0.05$) varied with other treatments. The uptake capacity of T_4 and T_5 in contaminated soil Narayanganj and T_5 and T_6 in Gazipur did not show a great variation. The Zn uptake ranged between 35.26 to 45.97 gm/ha and 48.95 to 62.34 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Zn 35.26 and 48.95 gm/ha were found with the T_1 (control) and T_3 (50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively.The highest uptake of Zn 45.97 and 62.34 gm/ha were observed with T_4 (50% RDF + 50% TWW) and T_5 (50% RDF + 75% TWW) in contaminated soil of Narayanganj and Gazipur respectively. On the basis of Zn uptake by jute leaves plant the treatments may be arranged in the order to $T_4>T_5>T_2>T_3>T_6>T_1$ and $T_5>T_6>T_4>T_2>T_3>T_1$ for contaminated soils of Narayanganj and Gazipur respectively.

Table 4.19. Effect of textile waste water on heavy metal uptake by jute leaves vegetable plant in contaminated soil of Narayanganj

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	**Cu**	**Ni**	**Fe**	**Cd**	**Cr**	**Pb**	**Mn**
T_1	Leaves	23.32	13.14	0	163.45	0.0051	0.0138	0.0276	23.69
	Shoot	10.87	5.98	0	75.74	0.0036	0.0050	0.0144	9.29
	Root	1.057	0.54	0	8.69	0.0002	0.0007	0.0010	0.88
	Total	**35.26 e**	**19.66 d**	**0 c**	**247.88 e**	**0.0089 c**	**0.0195 f**	**0.0430 f**	**33.86 e**
T_2	Leaves	31.03	14.80	0.0234	347.52	0.0071	0.0284	0.0355	35.64
	Shoot	11.88	7.70	0.0048	156.47	0.0038	0.0095	0.0162	12.45
	Root	1.05	0.64	0.0004	12.98	0.0002	0.0010	0.0008	1.12
	Total	**43.96 b**	**23.14 a**	**0.0286 b**	**516.97 d**	**0.0111 a**	**0.0389 a**	**0.0525 d**	**49.21 a**
T_3	Leaves	34.63	16.67	0	446.61	0.0065	0.0254	0.0354	26.96
	Shoot	7.39	3.65	0	141.46	0.0018	0.0044	0.0088	5.19
	Root	0.75	0.31	0	8.99	0.0001	0.0006	0.0004	0.42
	Total	**42.77 c**	**20.63 c**	**0 c**	**597.06 c**	**0.0084 d**	**0.0304 e**	**0.0446 e**	**32.57 f**
T_4	Leaves	33.23	15.45	0.0265	431.79	0.0058	0.0243	0.0424	25.60
	Shoot	11.66	5.76	0.0035	236.46	0.0028	0.0083	0.0152	8.63
	Root	1.08	0.45	0.0003	12.78	0.0001	0.0008	0.0007	0.78
	Total	**45.97 a**	**21.66 b**	**0.0303 b**	**681.03 b**	**0.0087 c**	**0.0334 c**	**0.0583 c**	**35.01 d**
T_5	Leaves	34.29	15.98	0.0265	471.91	0.0064	0.0254	0.0530	29.20
	Shoot	9.75	4.85	0.0034	202.46	0.0029	0.0080	0.0171	7.92
	Root	1.20	0.48	0.0005	17.61	0.0003	0.0009	0.0009	0.86
	Total	**45.24 a**	**21.31 b**	**0.0304 b**	**691.98 a**	**0.0096 b**	**0.0343 b**	**0.071 b**	**37.98 c**
T_6	Leaves	28.91	15.16	0.0308	400.25	0.0053	0.0224	0.0660	31.02
	Shoot	8.63	4.36	0.0039	177.77	0.0025	0.0074	0.0157	6.96
	Root	0.98	0.41	0.0006	18.14	0.0002	0.0008	0.0007	0.78
	Total	**38.52 d**	**19.93 d**	**0.0353 a**	**596.16 c**	**0.0080 e**	**0.0306 d**	**0.0824 a**	**38.76 b**

Table 4.20. Effect of textile waste water on heavy metal uptake by jute leaves vegetable plant in contaminated soil of Gszipur

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	**Cu**	**Ni**	**Fe**	**Cd**	**Cr**	**Pb**	**Mn**
T_1	Leaves	41.39	19.19	0	624.44	0.0069	0.0239	0.0378	31.56
	Shoot	11.55	5.95	0	283.15	0.0021	0.0035	0.0077	8.19
	Root	1.78	0.50	0	32.21	0.0002	0.0003	0.0008	0.80
	Total	**54.72 c**	**25.64 c**	**0 f**	**939.80 c**	**0.0092 e**	**0.0277 e**	**0.0463 c**	**40.55 c**
T_2	Leaves	44.92	21.21	0.0222	722.26	0.0074	0.0333	0.0348	38.41
	Shoot	12.05	6.70	0.0030	308.15	0.0023	0.0054	0.0077	9.86
	Root	1.84	0.54	0.0004	36.25	0.0002	0.0007	0.0007	0.99
	Total	**58.81 b**	**28.45 a**	**0.0256 e**	**1066.66 a**	**0.0099 d**	**0.0394 a**	**0.0432 d**	**49.26 a**
T_3	Leaves	36.56	14.67	0.0324	493.27	0.0059	0.0216	0.0270	23.49
	Shoot	10.92	4.88	0.0037	227.41	0.0018	0.0037	0.0061	6.65
	Root	1.47	0.42	0.0004	24.01	0.0001	0.0004	0.0006	0.57
	Total	**48.95 d**	**19.97 d**	**0.0365 d**	**744.69 e**	**0.0078 f**	**0.0257 f**	**0.0337 e**	**30.71 e**
T_4	Leaves	42.59	20.36	0.0372	602.71	0.0074	0.0291	0.0372	28.71
	Shoot	14.40	7.12	0.0048	328.40	0.0024	0.0056	0.0088	9.68
	Root	1.79	0.53	0.0003	32.18	0.0003	0.0005	0.0006	0.86
	Total	**58.78 b**	**28.01 ab**	**0.0423 c**	**963.29 b**	**0.0101 b**	**0.0352 d**	**0.0466 c**	**39.25 d**
T_5	Leaves	45.07	20.09	0.0406	586.14	0.0070	0.0301	0.0406	30.45
	Shoot	15.47	6.66	0.0044	312.80	0.0030	0.0059	0.0148	9.40
	Root	1.80	0.50	0.0005	31.58	0.0003	0.0006	0.0011	0.83
	Total	**62.34 a**	**27.25 b**	**0.0455 b**	**930.52 d**	**0.0103 a**	**0.0366 c**	**0.0565 b**	**40.68 c**
T_6	Leaves	45.75	21.15	0.0448	652.92	0.0073	0.0308	0.0616	36.90
	Shoot	14.11	5.86	0.0044	274.55	0.0025	0.0063	0.0189	8.57
	Root	1.94	0.51	0.0006	34.79	0.0003	0.0011	0.0011	0.93
	Total	**61.80 a**	**27.52 b**	**0.0498 a**	**962.26 b**	**0.0101 c**	**0.0382 b**	**0.0816 a**	**46.40 b**

Copper uptake increased significantly ($P \leq 0.05$) with textile waste water irrigation by jute leaves vegetable plant as compared with control in both contaminated soils of Narayanganj and Gazipur (except T_3 in contaminated soil Gazipur). Cu uptake by each treatment also significantly ($P \leq$

0.05) varied with other treatments. Uptake of Cu ranged between 19.66 to 23.14 gm/ha and 19.97 to 28.45 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Cu 19.66 and 19.97 gm/ha were found with the T_1 (control) and T_3(50% RDF + 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The highest uptake of Cu 23.14 and 28.45 gm/ha were observed with T_2 (100% RDF + 0% TWW) in both contaminated soils of Narayanganj and Gazipur . On the basis of Cu uptake by jute leaves vegetable plant the treatments may be arranged in the order of $T_2>T_4>T_5>T_6>T_3>T_1$ and $T_2>T_4>T_6>T_5>T_1>T_3$ for contaminated soils of Narayanganj and Gazipur respectively.

Nickel was not taken up by jute leaves vegetable plant with $T_{1,}$ T_3 of Narayanganj and T_1 of Gazipur contaminated soil. Ni uptake increased significantly ($P \leq 0.05$) with textile waste water irrigation by jute leaves vegetable plant as compared with control in both contaminated soils. Uptake of Ni ranged between nil (zero) to 0.0353 gm/ha and nil (zero) to 0.0498 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Ni as nil was found with the T_1 (control) in contaminated soil of Narayanganj and Gazipur . And the highest uptake of Ni 0.0353 and 0.0498 gm/ha were observed with T_6 (50% RDF + 100% TWW) in both contaminated soil of Narayanganj and Gazipur. On the basis of Ni uptake by jute leaves plant the treatments may be arranged in the order of $T_6>T_5>T_4>T_2>T_3,T_1$ and $T_6>T_5>T_4>T_2>T_3,T_1$ for contaminated soils of Narayanganj and Gazipur respectively.

Textile waste water irrigation significantly ($P \leq 0.05$) increased Fe uptake by jute leaves vegetable plant as compared with control in both contaminated soils of Narayanganj and Gazipur (except T_3 and T_5 in contaminated soil of Gazipyr). Fe uptake by T_3 and T_6 contaminated soil of Narayanganj and T_4 and T_6 in contaminated soil of Gazipur did not significantly ($P \leq 0.05$) varied with other treatments. The Fe uptake ranged between 247.88 to 691.98 gm/ha and 744.69 to 1066.66 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Fe 247.88 and 744.69 gm/ha were found with the T_1 (control) and T_3 (50%RDF + 25% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. And the highest uptake of Fe 691.98 and 1066.66 gm/ha were observed with T_5 (50% RDF + 75% TWW) and T_2 (100% RDF + 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. On the basis of Fe uptake by jute leaves plant the treatments may be arranged in the order of $T_5>T_4>T_2>T_6>T_3>T_1$ and $T_2>T_4>T_6>T_5>T_1>T_3$ for contaminated soils of Narayanganj and Gazipur respectively.

In contaminated soil of Narayanganj Cd uptake significantly ($P \leq 0.05$) increased with textile waste water irrigation by jute leaves vegetable plant with T_5 as compared with control. But in contaminated soil of Gazipur Cd uptake significantly ($P \leq 0.05$) increased with textile waste water irrigation by jute leaves with all treatment as compared with control (except T_3) . Uptake of Cd ranged between 0.0080 to 0.0111 gm/ha and 0.0078 to 0.0103 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Cd 0.0080 and 0.0078 gm/ha were found with T_6 (50% RDF + 100% TWW) and T_3 (50% RDF + 25% TWW) in contaminated soil of Narayanganj and Gazipur respectively. The highest uptake of Cd 0.0111 and 0.0103 gm/ha were observed with T_5 (50% RDF + 75% TWW) and T_2(100% RDF + 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. On the basis of Cd uptake by jute leaves plant the treatments may be arranged in the order of $T_2>T_5>T_4>T_1>T_3>T_6$ and $T_5>T_4>T_6>T_2>T_1>T_3$ for contaminated soils of Narayanganj and Gazipur respectively.

Chromium uptake increased significantly ($P \leq 0.05$) with textile waste water irrigation by jute leaves vegetable plant as compared with control in both contaminated soils of Narayanganj and Gazipur (except T_3 in contaminated soil of Gazipur, which did not significantly vary with T_1). Uptake of Cr ranged between 0.0195 to 0.0389 gm/ha and 0.0257 to 0.0394 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Cr 0.0195 and 0.0257 gm/ha were found with the T_1 (control) and T_3(50% RDF +25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And the highest uptake of Cr 0.0389 and 0.0394 gm/ha were observed with T_2 (100% RDF + 0% TWW) in both contaminated soil of Narayanganj and Gazipur. On the basis of Cr uptake by jute leaves plant the treatments may be arranged in the order of $T_2>T_5>T_4>T_6>T_3>T_1$ and $T_2>T_6>T_5>T_4>T_1>T_3$ for contaminated soils of Narayanganj and Gazipur respectively.

Textile waste water irrigation significantly ($P \leq 0.05$) increased Pb uptake by jute leaves vegetable plant as compared with control in both contaminated soils of Narayanganj and Gazipur (except T_3 in contaminated soil of Gazipur). The Pb uptake ranged between 0.0430 to 0.0824 gm/ha and 0.0337 to 0.0816 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Pb 0.0430 and 0.0337 gm/ha were found with the T_1 (control) and T_3 ((50% RDF + 25% TWW) in contaminated soil of Narayanganj and Gazipur respectively. And the highest uptake of Pb 0.0824 and 0.0816 gm/ha were observed with T_6 (50% RDF + 100% TWW) in both contaminated soils. On the basis of Pb uptake by jute leaves plant the treatments may be arranged in the order of $T_6>T_5>T_4>T_2>T_3>T_1$ and $T_6>T_5>T_4>T_2>T_1>T_3$ for contaminated soils of Narayanganj and Gazipur respectively.

Textile waste water irrigation significantly ($P \leq 0.05$) increased Mn uptake by jute leaves vegetable plant as compared with control in contaminated soil of Narayanganj (except T_3 in non contaminated soil of Narayanganj). But in contaminated soil of Gazipur textile waste water irrigation significantly ($P \leq 0.05$) increased Mn uptake by jute leaves vegetable plant with T_6 as compared with control. Mn uptake ranged between 32.57 to 49.21 gm/ha and 30.71 to 49.26 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Mn 32.57 and 30.71 gm/ha were found with the T_3 ((50% RDF + 25% TWW) in both contaminated soils of Narayanganj and Gazipur. And the highest uptake of Mn 49.21 gm/ha and 49.26 gm/ha were observed with T_2 (100% RDF + 0% TWW) in both non contaminated soils. On the basis of Mn uptake by jute leaves plant the treatments may be arranged in the order of $T_2>T_6>T_5>T_4>T_1>T_3$ and $T_2>T_6>T_5>T_4>T_1>T_3$ for contaminated soils of Narayanganj and Gazipur respectively.

4.1.11. Effect of textile waste water on nutrient status of post harvest soil of jute leaves vegetable plant in different soils

Effect of textile waste water on nutrient status of post harvest soil for jute leaves vegetable plant cultivation in different soils are presented in Tables 4.21 to 4.24. Soil pH, organic matter, N, P, K, S, Ca and Mg were determined after harvest of the crops.

4.1.11.1. Effect of textile waste water on nutrient status of post harvest soil of jute leaves vegetable plant in non contaminated soils

Effect of textile waste water on nutrient status of post harvest soil for jute leaves vegetable plant cultivation in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.21. and 4.22. The results revealed that pH of the post harvest soil slightly increased with increasing the concentration of textile waste water irrigation in both non contaminated soils. The average pH of different treatments ranged between 6.84 to 6.89 and 5.92 to 5.96 in non contaminated soils of Narayanganj and Gazipur respectively. The highest value of pH 6.89 at Narayanganj and

5.96 at Gazipur were found with T_6 (50% RDF + 100% TWW) in non contaminated soils. And the lowest value of pH 6.84 and 5.92 were found with T_2 (100% RDF + 0% TWW) in both non contaminated soils.

Organic matter content of the post harvest non contaminated soils of Narayanganj and Gazipur significantly ($P \leq 0.05$) increased with the increasing the concentration of textile waste water irrigation as compared to control. Organic matter content of post harvest soil of different treatments ranged 1.76 to 1.89% and 1.77 to 1.89% in non contaminated soils of Narayanganj and Gazipur respectively. The highest organic matter content 1.89% was found with T_6 (50% RDF + 100% TWW) in non contaminated soils of both areas. And the lowest organic matter content 1.76 % and 1.77 % were found with T_1(control) in both non contaminated soils.

Table 4.21. Effect of textile waste water on nutrient status of post harvest soil for jute leaves vegetable plant cultivation in non contaminated soil of Narayanganj

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.85 bc	1.76 d	0.185 c	6.18 d	15.55 c	0.16 b	4.15 d	1.01 b
T_2=100%RDF + 0%TWW	6.84 c	1.77 d	0.252 a	6.83 c	16.39 a	0.18 ab	4.97 a	1.18 a
T_3=50%RDF + 25% TWW	6.87 ab	1.8 c	0.209 b	6.96 b	15.89 b	0.16 b	4.34 c	1.03 b
T_4=50%RDF + % 50 TWW	6.87 ab	1.86 b	0.215 b	6.97 b	15.9 b	0.16 b	4.42 c	1.03 b
T_5=50%RDF + 75% TWW	6.88 a	1.87 b	0.225 b	6.99 b	16.24 a	0.17 ab	4.49 bc	1.18 a
T_6=50%RDF + 100%TWW	6.89 a	1.89 a	0.267 a	7.06 a	16.43 a	0.19 a	4.53 ab	1.19 a

Table 4.22. Effect of textile waste water on nutrient status of post harvest soil for jute leaves vegetable plant cultivation in non contaminated soil of Gazipur

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	5.94 bc	1.77 d	0.115 c	4.20 d	14.01 d	0.51 c	3.54 e	0.75 c
T_2=100%RDF + 0%TWW	5.92 d	1.78 c	0.15 a	5.77 a	14.64 b	0.65 a	3.81 a	0.92 a
T_3=50%RDF + 25% TWW	5.93 cd	1.85 b	0.131 b	5.52 c	14.55 c	0.59 b	3.6 d	0.76 c
T_4=50%RDF + % 50 TWW	5.95 ab	1.86 ab	0.134 b	5.48 c	14.57 c	0.6 b	3.65 c	0.76 c
T_5=50%RDF + 75% TWW	5.95 ab	1.87 ab	0.145 a	5.61 b	14.62 b	0.65 a	3.69 b	0.77 c
T_6=50%RDF + 100%TWW	5.96 a	1.89 a	0.146 a	5.79 a	14.74 a	0.68 a	3.71 b	0.85 b

Nitrogen (N) content of the post harvest non contaminated soil of Narayanganj and Gazipur increased significantly ($P \leq 0.05$) with the increasing the concentration of textile waste water irrigation as compared with control. Post harvest soil N of different treatments ranged 0.185 to 0.267%. and 0.115 to 0.146% in non contaminated soils of Narayanganj and Gazipur respectively. In both non contaminated soils the highest nitrogen content 0.267%. and 0.146% were found with T_6 (50% RDF + 100% TWW), and the lowest N content 0.185% and 0.115% were found with T_1(control). In both soils post harvest soil N content with T_6 and T_2 were same, which did not significantly veried with each other treatment.

Post harvest soil P and S content increased significantly ($P \leq 0.05$) with increasing the concentration of textile waste water in both non contaminated soils as compared with control. P and S content of post harvest soil in all treatments also significantly varied with each other treatment (except T_3 and T_4 in both soils, which did not significantly very with each other). P content of post harvest soil of different treatments ranged between 6.18 to 7.06 ppm and 4.20 to 5.79 ppm in non contaminated soils of Narayanganj and Gazipur respectively. The S of post harvest soil of different treatments ranges between 15.55 to 16.43 ppm and 14.01 to 14.74

ppm in in non contaminated soils of Narayanganj and Gazipur respectively. The highest content of P 7.06 and 5.79 ppm, and the highest content of S 16.43 and 14.74 ppm were found with T_6 (50% RDF + 100% TWW) in both non contaminated soil of Narayanganj and Gazipur .The lowest content of P 6.18 ppm and 4.20 ppm, and lowest content of S 15.55 and 14.01 ppm were found with T_1(control) in both non contaminated soils of Narayanganj and Gazipur respectively.

Potassium content of post harvest soil increased significantly ($P \leq 0.05$) with textile waste water irrigation as compared with control in non contaminated soil of Gazipur. But in non contaminated soil of Narayanganj K content on post harvest soil significantly increased with T_6 as compared with control. The K of post harvest soil with different treatments ranged between 0.16 to 0.19 C mol/kg and 0.51 to 0.68 C mol/kg in non contaminated soils of Narayanganj and Gazipur respectively. The highest content of K 0.19 and 0.68 C mol/kg were found with T_6 (50% RDF + 100% TWW) in both soils. And the lowest content of K 0.16 and 0.51 C mol/kg were found with T_1(control) in both soils.

Calcium content of post harvest soil increased significantly ($P \leq 0.05$) with textile waste water irrigation as compared with control in both non contaminated soils. The Ca content of post harvest soil with different treatment ranged between 4.15 to 4.97 C mol/kg and 3.54 to 3.81 C mol/kg in non contaminated soils of Narayanganj and Gazipur respectively. The highest content of Ca 4.97 and 3.81 C mol/kg were found with T_2 (100% RDF + 0% TWW) in both soils. The lowest content of Ca 4.15 and 3.54 mol/kg were found with T_1(control) in both soils.

In post harvest soil Mg content increased significantly ($P \leq 0.05$) in T_5 and T_6 in non contaminated soil of Narayanganj, and in T_6 in non contaminated soil of Gazipur as compared with control. The Mg content of post harvest soil of different treatments ranged between 1.01 to 1.19 C mol/kg and 0.75 to 0.92 C mol/kg in non contaminated soils of Narayanganj and Gazipur respectively. The highest content of Mg 1.19 and 0.92 C mol/kg were observed with T_6 and T_2 respectively. The lowest content of Mg 1.01 and 0.75 C mol/kg were found with T_1(control) in both soils.

4.1.11.2. Effect of textile waste water on nutrient status of post harvest soil of jute leaves vegetable plant in contaminated soils

Effect of textile waste water on nutrient status of post harvest soil for jute leaves vegetable cultivation in contaminated soils of Narayanganj and Gazipur are presented in Tables 4.23. and 4.24. The results exibited that pH of the post harvest soil slightly increased with increasing the concentration of textile waste water irrigation in both contaminated soils. The average pH of different treatments ranged between 6.91 to 6.94 and 6.55 to 6.65 in contaminated soil of Narayanganj and Gazipur respectively. The highest value of pH 6.94 and 6.65 were found with T_6 (50% RDF + 100% TWW) in both contaminated soils. And the lowest value of pH 6.91 and 6.55 were found with T_2 (100% RDF + 0% TWW) in both contaminated soils.

Organic matter content of the post harvest contaminated soil of Narayanganj and Gazipur significantly ($P \leq 0.05$) increased with the increasing the concentration of textile waste water irrigation as compared with control. Organic matter content of post harvest soil of different treatments ranges between 3.78 to 3.88% and 2.90 to 3.01% in contaminated soils of Narayanganj and Gazipur respectively. The highest organic matter content 3.88% and 3.01% was found with T_6 (50% RDF + 100% TWW) in both contaminated soils. The lowest organic matter content 3.78 % and 2.90 % were found with T_1(control) in contaminated soils of Narayanganj and Gazipur respectively.

Nitrogen content of the post harvest contaminated soil of Narayanganj and Gazipur increased significantly ($P \leq 0.05$) with the increasing the concentration of textile waste water irrigation as compared with control. Post harvest soil N of different treatments ranged between 0.090 to 0.097%. and 0.121 to 0.177 % in contaminated soils of Narayanganj and Gazipur respectively. In both contaminated soils the highest nitrogen content 0.097%. and 0.177 % were found with T_6(50% RDF + 100% TWW), and the lowest nitrogen content 0.090 % and 0.121 % were found with T_1(control) in contaminated soils of Narayanganj and Gazipur respectively. In both post harvest soils N content with T_6 and T_2 were carried same value, which did not significantly varied with each other treatment.

Post harvest soil P and S content increased significantly ($P \leq 0.05$) with increasing the concentration of textile waste water in both contaminated soils as compared with control. P of post harvest soil of different treatments ranged between 16.05 to 16.97 ppm and 4.10 to 4.82

ppm in contaminated soils of Narayanganj and Gazipur respectively. The S of post harvest soil of different treatments ranged between 10.20 to 12.91 ppm and 30.12 to 30.95 ppm in contaminated soils of Narayanganj and Gazipur respectively. The highest content of P 16.97 ppm and 4.82 ppm, and the highest content of S 12.91 ppm and 30.95 ppm were found with T_6 (50% RDF + 100% TWW) in both contaminated soils of Narayanganj and Gazipur .The lowest content of P 16.05 ppm and 4.10 ppm, and lowest content of S 10.20 ppm and 30.12 ppm were found with T_1(control) in both contaminated soils of Narayanganj and Gazipur .

K content of post harvest soil increased significantly ($P \leq 0.05$) with textile waste water irrigation as compared with control in both contaminated soils of Narayanganj and Gazipur. The K of post harvest soil with different treatment ranged between 0.85 to 0.89 C mol/kg and 0.41 to 0.45 C mol/kg in contaminated soils of Narayanganj and Gazipur respectively. The highest content of K 0.89 and 0.45 C mol/kg were found with T_6(50% RDF+100% TWW) in both soils.

Table 4.23. Effect of textile waste water on nutrient status of post harvest soil for jute leaves vegetable plant cultivation in contaminated soil of Narayanganj

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.93 ab	3.78 ab	0.090 c	16.05 f	10.20 e	0.85 c	2.11 d	0.70 d
T_2=100%RDF + 0%TWW	6.91 b	3.80 ab	0.095 ab	17.73 a	12.32 b	0.92 a	2.85 a	0.86 a
T_3=50%RDF + 25% TWW	6.92 ab	3.85 ab	0.092 bc	16.09 e	10.86 d	0.87 bc	2.49 c	0.74 c
T_4=50%RDF + % 50 TWW	6.92 ab	3.87 b	0.093 abc	16.51 d	10.91 d	0.87 bc	2.56 b	0.75 c
T_5=50%RDF + 75% TWW	6.93 ab	3.87 a	0.094 abc	16.79 c	12.03 c	0.88 bc	2.81 a	0.77 bc
T_6=50%RDF + 100%TWW	6.94 a	3.88 a	0.097 a	16.97 b	12.91 a	0.89 ab	2.85 a	0.80 b

Table 4.24. Effect of textile waste water on nutrient status of post harvest soil for jute leaves vegetable plant cultivation in contaminated soil of Gazipur

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.63 ab	2.90 d	0.121 c	4.10 c	30.12 d	0.41 b	4.01 b	1.37 d
T_2=100%RDF + 0%TWW	6.55 c	2.93 c	0.175 a	4.75 ab	30.91 a	0.45 a	4.12 a	1.49 a
T_3=50%RDF + 25% TWW	6.61 b	2.97 b	0.163 b	4.69 b	30.55 c	0.43 ab	4.1 ab	1.4 cd
T_4=50%RDF + % 50 TWW	6.62 b	2.98 b	0.165 b	4.70 b	30.56 bc	0.44 ab	4.11 ab	1.42 bcd
T_5=50%RDF + 75% TWW	6.63 ab	2.98 b	0.167 b	4.71 b	30.61 b	0.44 ab	4.11 ab	1.45 abc
T_6=50%RDF + 100%TWW	6.65 a	3.01 a	0.177 a	4.82 a	30.95 a	0.45 a	4.13 a	1.46 ab

The lowest content of K 0.85 and 0.41 C mol/kg were found with T_1(control) in contaminated soils of Narayanganj and Gazipur respectively.

Calcium content of post harvest soil increased significantly ($P \leq 0.05$) with textile waste water irrigation as compared with control in both contaminated soils. The Ca of post harvest soil with different treatment ranged between 2.11 to 2.85 C mol/kg and 4.01 to 4.13 C mol/kg in contaminated soils of Narayanganj and Gazipur respectively. The highest content of Ca 2.85 and 4.13 C mol/kg were found with T_6 (50% RDF + 100% TWW), and the lowest content of Ca 2.11 and 4.01 mol/kg were found with T_1(control) in contaminated soils of Narayanganj and Gazipur respectively.

In post harvest soils Mg content increased with textile waste water irrigation significantly ($P \leq 0.05$) with all treatments in contaminated soil of Narayanganj, but with T_5 and T_6 explore in contaminated soil of Gazipur as compared with control. The Mg content of post harvest soil of different treatment ranged between 0.70 to 0.86 C mol/kg and 1.37 to 1.49 C mol/kg in contaminated soils of Narayanganj and Gazipur respectively. The highest content of Mg 0.86 and

1.49 C mol/kg were observed with T_2 and the lowest content of Mg 0.70 and 1.37 C mol/kg were found with T_1(control) in contaminated soils of Narayanganj and Gazipur respectively.

4.1.12. Effect of textile waste water on heavy metal concentration of post harvest soil of jute leaves vegetable plant in different soils

The heavy metal concentration of post harvest soil for jute leaves vegetable plant cultivation in different soils are presented in Tables 4.25 to 4.28. It was observed that as the concentration of textile waste water increased heavy metal concentration in post harvest soil also increased.

4.1.12.1. Effect of textile waste water on heavy metal concentration of post harvest soil of jute leaves vegetable plant in non contaminated soils

The heavy metal concentration of post harvest soil for jute leaves vegetable plant cultivation in non contaminated soil of Narayanganj and Gazipur are presented in Tables 4.25 and 4.26. The concentration of Zn in both non contaminated post harvest soil of jute leaves plants increased significantly ($P \leq 0.05$) in all treatment as compared with control. The Zn concentration of post harvest soil of different treatment ranged between 1.29 to 1.50 ppm and 0.66 to 0.92 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Zn in post harvest soils were 1.50 and 0.92 ppm in non contaminated soil of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Zn were 1.29 and 0.66 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which were found with the T_1(control).

In non contaminated soil of Narayanganj Cu concentration in post harvest soil of jute leaves plants increased significantly ($P \leq 0.05$) in all treatment as compared with control. But in con contaminated soil of Gazipur Cu concentration in post harvest soil of jute leaves plants increased significantly ($P \leq 0.05$) in T_6 as compared with control. The Cu concentration of post harvest soil of different treatment ranged between 0.18 to 0.29 ppm and 0.77 to 0.82 ppm in non contaminated sois of Narayanganj and Gazipur respectively. Highest concentration of Cu in post harvest soils were 0.29 and 0.82 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50%

RDF (T_6). Lowest concentration of Cu were 0.18 and 0.77 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which were found with the T_1(control).

Textile waste water irrigation increased the concentration of Ni in both non contaminated post harvest soil of jute leaves significantly ($P \leq 0.05$) in all treatment as compared with control (except T_3 in non contaminated soil of Narayanganj) . The Ni concentration of post harvest soil of different treatment ranged between 27.04 to 29.50 ppm and 20.33 to 26.22 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Ni in post harvest soils were 29.50 and 26.22 ppm, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6) and with 0% textile waste water irrigation along with 100% RDF (T_2) in non contaminated soils of Narayanganj and Gazipur respectively. Lowest concentration of Ni were 27.04 and 20.33 ppm which were found with the T_3 and T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively.

Table 4.25. Effect of textile waste water on heavy metal concentration of post harvest soil for jute leaves vegetable plant cultivation in non contaminated soil of Narayanganj

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1=control	1.29 d	0.18 c	27.31 d	45.33 f	0.092 b	30.24 e	10.02 e	10.50 e
T_2=100% RDF + 0%TWW	1.42 c	0.22 b	29.5 a	50.04 c	0.096 a	31.81 c	10.19 d	13.22 b
T_3=50% RDF + 25%TWW	1.44 bc	0.2 bc	27.04 d	46.55 e	0.097 a	30.23 e	10.14 d	12.72 d
T_4=50% RDF + 50%TWW	1.47 ab	0.22 b	28.85 bc	47.93 d	0.096 a	31.11 d	10.34 c	12.95 c
T_5=50% RDF + 75%TWW	1.49 a	0.27 a	28.7 c	53.61 b	0.098 a	33.67 b	11.57 b	13.05 c
T_6=50% RDF+ 100%TWW	1.50 a	0.29 a	29.22 ab	59.77 a	0.099 a	35.29 a	11.66 a	14.20 a

Table 4.26. Effect of textile waste water on heavy metal concentration of post harvest soil for jute leaves vegetable plant cultivation in non contaminated soil of Gazipur

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1=control	0.66 d	0.77 b	20.33 e	45.41 d	0.048 c	29.20 e	10.02 f	14.77 f
T_2=100% RDF + 0%TWW	0.75 c	0.80 ab	21.58 d	48.97 c	0.05 c	30.33 b	10.10 e	17.85 b
T_3=50% RDF + 25%TWW	0.7 d	0.71 c	24.46 c	51.1 b	0.063 b	29.78 d	10.30 d	16.29 e
T_4=50% RDF + 50%TWW	0.79 c	0.79 ab	25.09 b	51.7 a	0.065 ab	30.21 c	10.55 c	16.88 d
T_5=50% RDF + 75%TWW	0.84 b	0.80 ab	26.17 a	51.75 a	0.065 ab	33.20 a	11.04 b	17.52 c
T_6=50% RDF+ 100%TWW	0.92 a	0.82 a	26.22 a	51.91 a	0.067 a	33.24 a	11.39 a	17.95 a

Textile waste water irrigation increased the concentration of Fe in both non contaminated post harvest soil of jute leaves plants significantly ($P \leq 0.05$) in all treatment as compared with control . The Fe concentration of post harvest soil of different treatment ranged between 45.33 to 59.77 ppm and 45.41 to 51.91 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Fe in post harvest soils were 59.77 and 51.91 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Fe were 45.33 and 45.41 ppm which were found with T_3 and T_1 in non contaminated soils of Narayanganj and Gazipur respectively.

Textile waste water irrigation increased the concentration of Cd in both non contaminated post harvest soil of jute leaves plant significantly ($P \leq 0.05$) in all treatment as compared with control. The Cd concentration of post harvest soil of different treatment ranged between 0.092 to

0.099 ppm and 0.048 to 0.067 ppm in non contaminated soil of Narayanganj and Gazipur respectively. Highest concentration of Cd in post harvest soils were 0.099 and 0.067 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cd were 0.092 and 0.048 ppm which were found with the T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively

Textile waste water irrigation increased the concentration of Cr in both non contaminated post harvest soil of jute leaves vegetable plant significantly ($P \leq 0.05$) in all treatment as compared with control (except T_3 in non contaminated soil of Narayanganj) . The Cr concentration of post harvest soil of different treatment ranged between 30.23 to 35.29 ppm and 29.20 to 33.24 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cr in post harvest soils were 35.29 and 33.24 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cr were 30.23 and 29.20 ppm which were found with the T_3 (50% RDF + 25% TWW) and T_1 (control) in non contaminated soils of Narayanganj and Gazipur respectively.

Concentration of Pb in both non contaminated post harvest soil of jute leaves plant increased significantly ($P \leq 0.05$) in all treatment as compared with control. The Pb concentration of post harvest soil of different treatment ranged between 10.02 to 11.66 ppm and 10.02 to 11.39 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Pb in post harvest soils were 11.66 and 11.39 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Pb was 10.02 ppm in both non contaminated soil of Narayanganj and Gazipur, which was found with the T_1(control).

Concentration of Mn in both non contaminated post harvest soil of jute leaves vegetable plant increased significantly ($P \leq 0.05$) in all treatment as compared with control. The Mn concentration of post harvest soil of different treatment ranged between 10.50 to 14.20 ppm and 14.77 to 17.95 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Mn in post harvest soils were 14.20 and 17.95 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Mn were 10.50 and 14.77 ppm in non contaminated soil of Narayanganj and Gazipur respectively, which was found with the T_1(control).

4.1.12.2. Effect of textile waste water on heavy metal concentration of post harvest soil of jute leaves vegetable plant in contaminated soils

The heavy metal concentration of post harvest soil for jute leaves vegetable plant cultivation in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.27 and 4.28. Concentration of Zn in both contaminated post harvest soil of jute leaves increased significantly ($P \leq 0.05$) with textile waste water irrigation in all treatment as compared with control. The Zn concentration of post harvest soil of different treatment ranged between 4.45 to 5.94 ppm and 17.55 to 20.82 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest

Table 4.27. Effect of textile waste water on heavy metal concentration of post harvest soil for jute leaves vegetable plant cultivation in contaminated soil of Narayanganj

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1=control	4.45 e	0.47 c	24.25 d	215.39 f	0.112 b	32.00 f	16.73 d	11.10 f
T_2=100% RDF + 0%TWW	5.17 c	0.55 b	25.03 c	226.00 e	0.117 b	32.35 e	17.02 c	13.50 e
T_3=50% RDF + 25%TWW	4.91 d	0.49 c	25.11 c	245.77 d	0.120 b	32.78 d	17.79 b	13.78 d
T_4=50% RDF + 50%TWW	5.76 b	0.47 c	25.34 c	247.91 c	0.121 b	33.21 c	17.8 b	14.25 c
T_5=50% RDF + 75%TWW	5.8 b	0.58 b	28.35 b	260.25 b	0.133 b	35.18 b	17.85 a	14.83 b
T_6=50% RDF+ 100%TWW	5.94 a	0.63 a	29.11 a	267.76 a	0.135 a	35.91 a	17.88 a	15.03 a

Table 4.28. Effect of textile waste water on heavy metal concentration of post harvest soil for jute leaves vegetable plant cultivation in contaminated soil of Gazipur

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1=control	17.55 f	0.20 c	29.10 d	113.22 d	0.125 b	36.24 cd	26.11 f	11.25 f
T_2=100% RDF + 0%TWW	17.91 e	0.21 bc	29.25 d	115.70 c	0.130 ab	36.71 bcd	26.25 e	14.77 b
T_3=50% RDF + 25%TWW	19.99 d	0.24 ab	31.03 c	119.91 b	0.131 ab	38.12 d	28.43 d	13.3 e
T_4=50% RDF + 50%TWW	20.51 c	0.24 ab	31.05 c	120.00 ab	0.132 ab	38.96 abc	28.96 c	13.85 d
T_5=50% RDF + 75%TWW	20.75 b	0.25 a	32.75 b	120.43 ab	0.141 a	39.44 ab	29.61 b	14.62 c
T_6=50% RDF+ 100%TWW	20.82 a	0.26 a	32.99 a	120.51 a	0.144 a	39.75 a	29.75 a	15.11 a

concentration of Zn in post harvest soils were 5.94 and 20.82 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Zn were 4.45 and 17.55 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the T_1(control).

In contaminated soil of Gazipur Cu concentration in post harvest soil of jute leaves vegetable plant increased significantly ($P \leq 0.05$) in all treatment as compared with control. But in contaminated soil of Narayanganj Cu concentration in post harvest soil of jute leaves increased significantly ($P \leq 0.05$) in T_2, T_5 and T_6 as compared with control. The Cu concentration of post harvest soil of different treatment ranged between 0.47 to 0.63 ppm and 0.20 to 0.26 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cu in post harvest soils were 0.63 and 0.26 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cu were 0.47 and 0.20 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the T_1(control).

Textile waste water irrigation increased the concentration of Ni in both contaminated post harvest soil of jute leaves plant significantly ($P \leq 0.05$) in all treatment as compared with control . The Ni concentration of post harvest soil of different treatment ranged between 24.25 to 29.11 ppm and 29.10 to 32.99 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Ni in post harvest soils were 29.11 and 32.99 ppm, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6) in non contaminated soils of Narayanganj and Gazipur respectively. Lowest concentration of Ni were 24.25 and 29.10 ppm, which were found with the T_3 in contaminated soils of Narayanganj and Gazipur respectively.

Textile waste water irrigation increased the concentration of Fe in both contaminated post harvest soil of jute leaves vegetable plant significantly ($P \leq 0.05$) in all treatment as compared with control . The Fe concentration of post harvest soil of different treatment ranged between 215.39 to 267.76 ppm and 113.22 to 120.51 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Fe in post harvest soils were 267.76 and 120.51 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Fe were 215.39 and 113.22 ppm which were found with T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively.

Textile waste water irrigation increased the concentration of Cd in both contaminated post harvest soil of jute leaves plant significantly ($P \leq 0.05$) in all treatment as compared with control. The Cd concentration of post harvest soil of different treatment ranged between 0.112 to 0.135 ppm and 0.125 to 0.144 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cd in post harvest soils were 0.135 and 0.144 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cd were 0.112 and 0.125 ppm which were found with the T_1(control) in contaminated soils of Narayanganj and Gazipur respectively.

Textile waste water irrigation increased the concentration of Cr in both contaminated post harvest soil of jute leaves significantly ($P \leq 0.05$) in all treatment as compared with control. The Cr concentration of post harvest soil of different treatment ranged between 32.00 to 35.91 ppm and 36.24 to 39.75 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cr in post harvest soils were 35.91 and 39.75 ppm in contaminated soil of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cr were 32.00 and 36.24 ppm which were found with T_1 (control) in contaminated soils of Narayanganj and Gazipur respectively.

Concentration of Pb in both contaminated post harvest soil of jute leaves vegetable plant increased significantly ($P \leq 0.05$) for textile waste water irrigation in all treatment as compared with control. The Pb concentration of post harvest soil of different treatment ranged between 16.73 to 17.88 ppm and 26.11 to 29.75 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Pb in post harvest soils were 17.88 and 29.75 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Pb was 16.73 and 26.11 ppm in non contaminated soils of Narayanganj and Gazipur, which was found with the T_1(control).

Textile waste water irrigation increased the concentration of Mn in both contaminated in post harvest soil of jute leaves plant increased significantly ($P \leq 0.05$) in all treatment as compared with control. The Mn concentration of post harvest soil of different treatment ranged between 11.10 to 15.03 ppm and 11.25 to 15.11 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Mn in post harvest soils were 15.03 and 15.11 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Mn were 11.10 and 11.25 ppm in contaminated soils of Narayanganj and Gazipur respectively, which was found with the T_1(control).

Pot experiment no. 2

Pictorial view of pot experiment No. 2 (Red amaranth)

Pot Exp. 2: Laboratory experiment was doing on with co-supervisor and a scenario of red amaranth in pot experiment

4.2. Pot experiment No. 2

Residual effect of textile waste water on yield and heavy metal uptake by red amaranth in different soils

4.2.1. Residual effect of textile waste water on growth and yield of red amaranth

Plant height, number of leaves, weight of leaves, shoot and root of red amaranth were measured as yield contributing parameters.

4.2.2. Residual effect of textile waste water on plant height of red amaranth in different soils

There were residual effect of different combination of chemical fertilizer and textile waste water irrigation on plant height of red amaranth in different soils which are presented in Figures 4.17. to 4.20. The results revealed that higher concentration of textile waste water had higher positive effect on the plant height of red amaranth.

4.2.2.1. Residual effect of textile waste water on plant height of red amaranth in non contaminated soils

Residual effect of different combination of chemical fertilizer and textile waste water irrigation on plant height (cm) of red amaranth in non contaminated soils of Narayanganj and Gazipur are presented in Figures 4.17 and 4.18. The result showed that residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased the plant height of red amaranth as compared with control in non contaminated soils of both the places. The results displayed that due to the residual effect the tallest plant was found with T_2 (100% RDF + RE of 0% TWW) and T_6 (50% RDF + RE of 100% TWW) produced the second tallest plant height of red amaranth, where 100% textile waste water was irrigated in previous experiment. The result also revealed that residual effect of textile waste water irrigation was maximum for plant height with T_6 . Here the tallest plant height 20 and 22 cm , the second tallest plant height 16 and 19 cm were found with T_2 and T_6 respectively in both non contaminated soils of Narayanganj and Gazipur. The lowest plant height 4 and 9.25 cm were found with T_1 (control) in non contaminated soils of Narayanganj and Gazipur respectively.

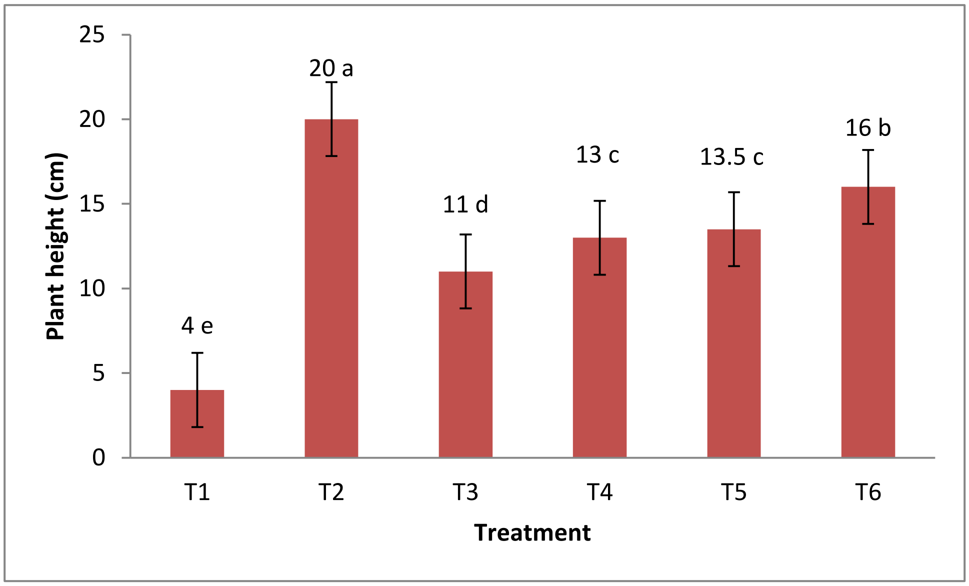

Fig. 4.17. Residual Effect of different concentration of textile waste water on plant height (cm) of red amaranth in NCSN

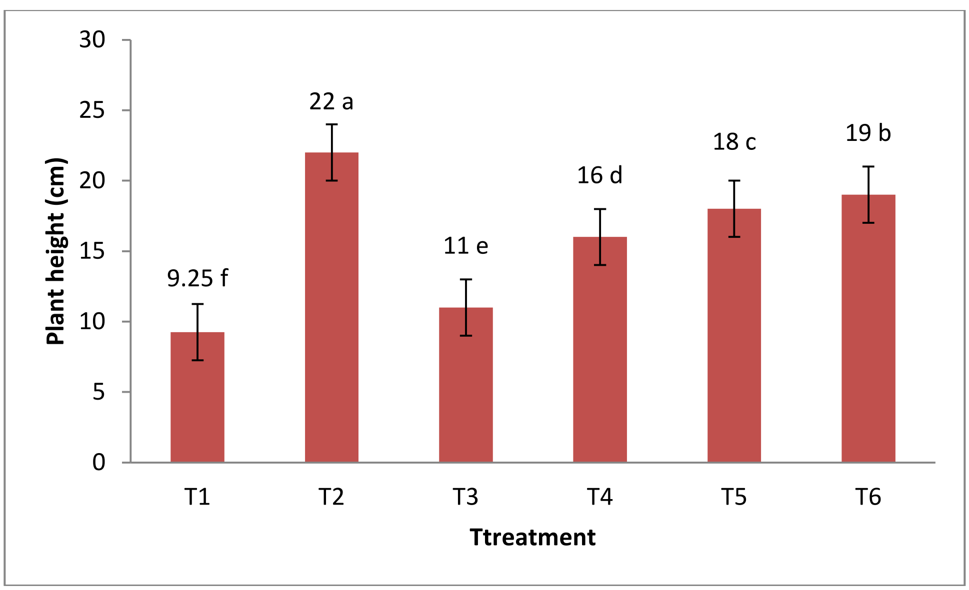

Fig. 4.18. Residual Effect of different concentration of textile waste water on plant height (cm) of red amaranth in NCSG

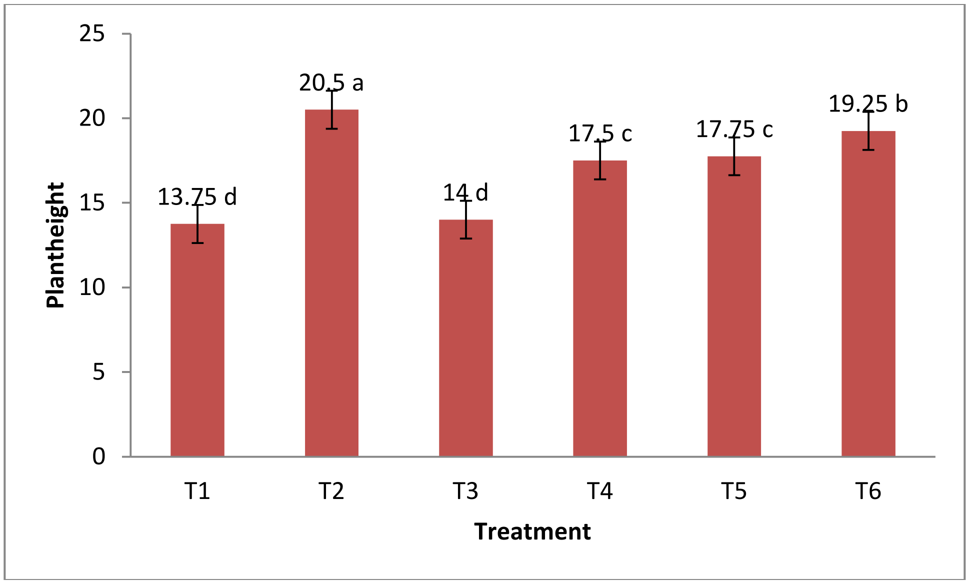

Fig. 4.19. Residual Effect of different concentration of textile waste water on plant height of red amaranth in CSN

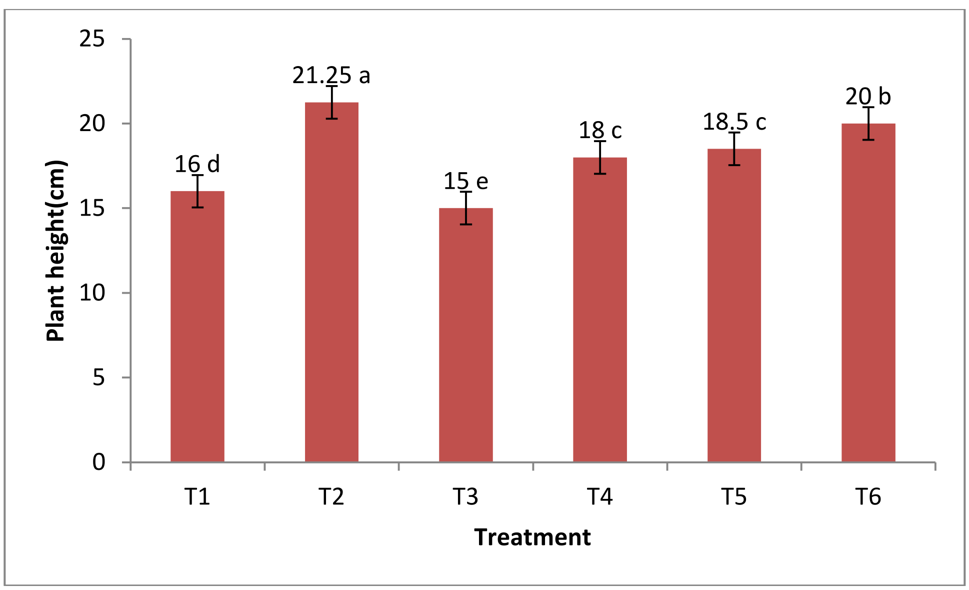

Fig. 4.20. Residual Effect of different concentration of textile waste water on plant height (cm) of red amaranth in CSG

4.2.2.2. Residual effect of textile waste water on plant height of red amaranth in contaminated soils

Residual effect of different combination of chemical fertilizer and textile waste water irrigation on plant height of red amaranth in contaminated soils of Narayanganj and Gazipur are presented in Figures 4.19 and 4.20. The result showed that on plant height of red amaranth textile waste water had positive residual effect in both the soils. The result revealed that residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased the plant height of red amaranth as compared with control in both contaminated soils (except T_3 in contaminated soil of Gazipur). The results revealed that the residual effect on T_2 (100% RDF + RE of 0% TWW) showed the highest plant height of red amaranth and T_6 (50% RDF + RE of 100% TWW) produce the second highest plant height, where 100% textile waste water was irrigated in previous experiment. The research indicated that actual residual effect of textile waste water irrigation on plant height was found maximum with T_6 . The tallest plant height 20.5 and 21.25 cm , the second tallest plant height 19.25 and 20 cm were found with T_2 and T_6 respectively in both non contaminated soils of Narayanganj and Gazipur, which was statistically similar. And the lowest plant height 13.75 and 15 cm were found with T_1 (control) and T_3 in contaminated soils of Narayanganj and Gazipur respectively.

4.2.3. Residual effects of textile waste water on number of leaves of red amaranth in different soils

Residual effect of different concentration of waste water irrigation on number of leaves per plant of red amaranth in different soils have been presented in Figures 4.21 to 4.24.

4.2.3. Residual effects of textile waste water on number of leaves of red amaranth in non contaminated soils

Residual effect of different concentration of waste water irrigation on number of leaves per plant of red amaranth in non contaminated soils are presented in Figures 4.21. and 4.22. The result showed that residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased the number of leaves per plant of red amaranth as compared with control. The result also showed that number of leaves per plant increased with the residual effect of higher concentration of textile waste water . The results revealed that T_4 (50% RDF + RE of 50% TWW) and T_5 (50%

RDF + RE of 75% TWW) showed the similar residual effect on number of leaves of red amaranth in both non contaminated soils, which had no significant difference between each other. The highest number of leaves per plant 14.2 and 14.7 ,the second highest number of leaves per plant 12.9 and 12.6 were found with T_2 and T_6 respectively in both non contaminated soils of Narayanganj and Gazipur. And the lowest number of leaves per plant 8.5 and 9.3 were found with T_1 (control) in both soils.

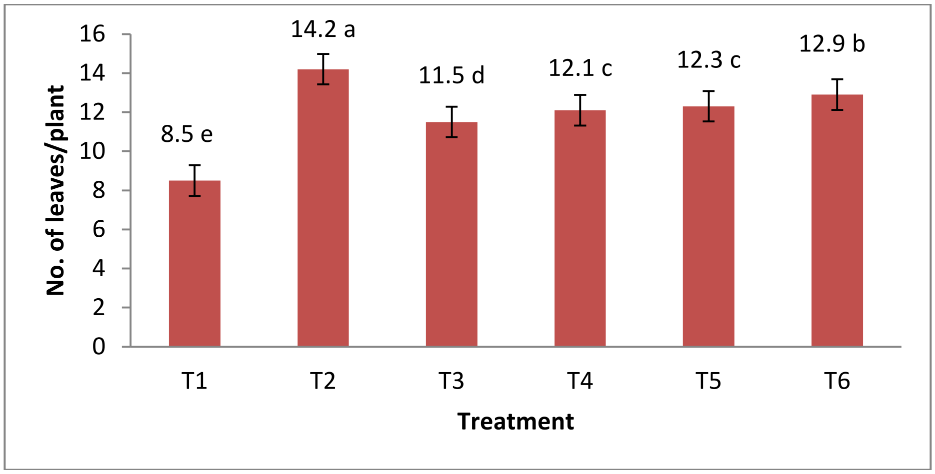

Fig. 4.21. Residual Effect of different concentration of textile waste water on number of leaves of red amaranth in NCSN

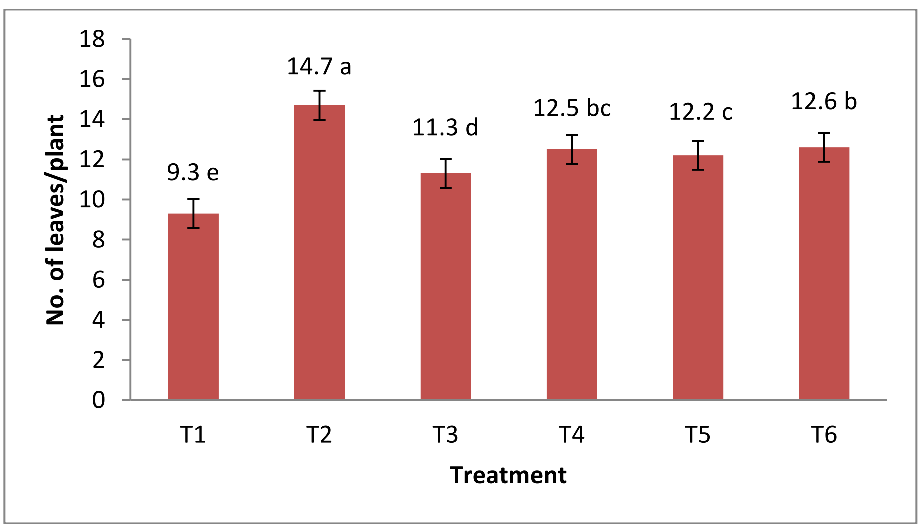

Fig. 4.22. Residual Effect of different concentration of textile waste water on number of leaves of red amaranth in NCSG

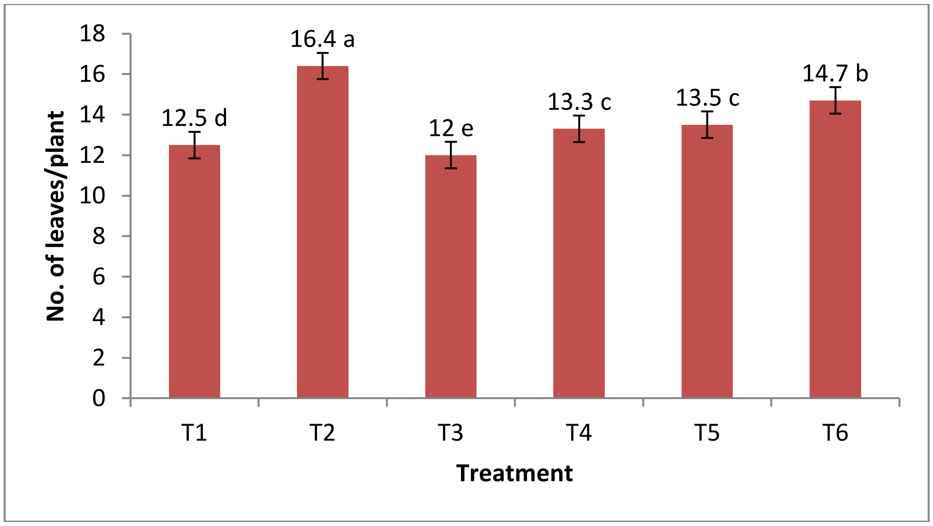

Fig. 4.23. Residual Effect of different concentration of textile waste water on number of leaves of red amaranth in CSN

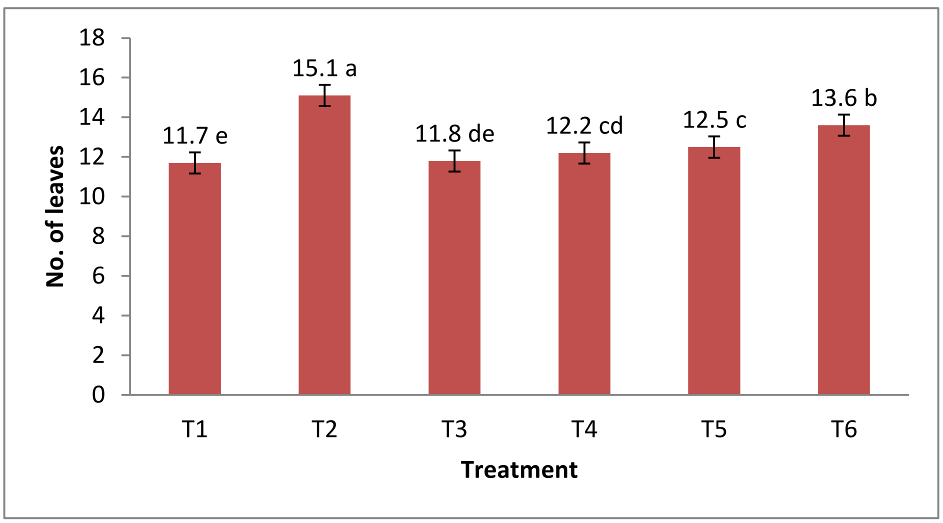

Fig. 4. 24. Residual Effect of different concentration of textile waste water on number of leaves of red amaranth in CSG

4.2.3.2. Residual effects of textile waste water on number of leaves of red amaranth in contaminated soils

Residual effect of different concentration of waste water irrigation on number of leaves per plant of red amaranth in contaminated soils are presented in Figures 4.23. and 4.24. The result showed that residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased the number of leaves per plant of red amaranth in contaminated soils of Narayanganj and Gazipur as compared with control (except T_3) . The result also showed that number of leaves per plant increased with the residual effect of 50%, 75% and 100% textile waste water . The results revealed that T_4 and T_5 showed the similar residual effect on producing number of leaves of red amaranth in both contaminated soils, which had no significant difference between each other. The highest number of leaves per plant 16.4 and 15.1, the second highest number of leaves per plant 14.7 and 13.6 were found with T_2 and T_6 respectively in both contaminated soils of Narayanganj and Gazipur. And the lowest number of leaves per plant 12 and 11.7 were found with T_3 and T_1 in contaminated soils of Narayanganj and Gazipur respectively.

4.2.4. Residual effect of textile waste water on yield of red amaranth in different soils

Residual effect of textile waste water on yield of red amaranth in different soils are shown in Figures 4.25. to 4.28.

4.2.4.1. Residual effect of textile waste water on yield of red amaranth in non contaminated soils

Residual effects of textile waste water on yield of red amaranth in non contaminated soil of Narayanganj and Gazipur are shown in Figures 4.25 and 4.26. The results showed that residual effect of irrigation of different dose of textile waste water significantly($P \leq 0.05$) increased red amaranth yield as compared with T_1(control) in both non contaminated soils. The results revealed that yield of red amaranth significantly increased with the increasing concentration of textile waste water irrigation. The highest yield of red amaranth were 13.01 and 11.9 t/ha, and the second highest yield recorded 11.44 and 10.13 t/ha with the treatment T2 and T6 in non contaminated soils of Narayanganj and Gazipur respectively. The lowest yield of red amaranth obtained 0.83 and 0.71 t/ha with T1 (control) in non contaminated soils of Narayanganj and Gazipurrespectively. The results also revealed that yield of red amaranth with all treatments significantly ($P \leq 0.05$) varied with each other treatment.

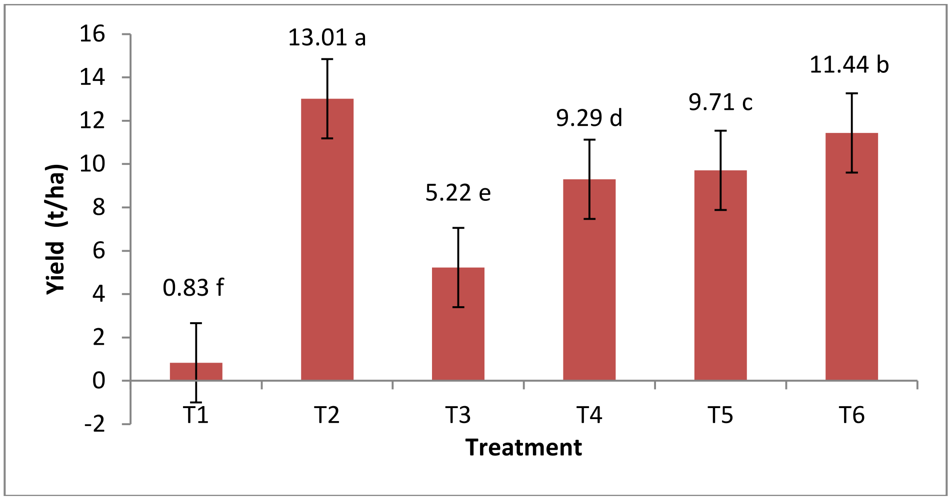

Fig. 4.25. Residual Effect of different concentration of textile waste water on yield of red amaranth in NCSN

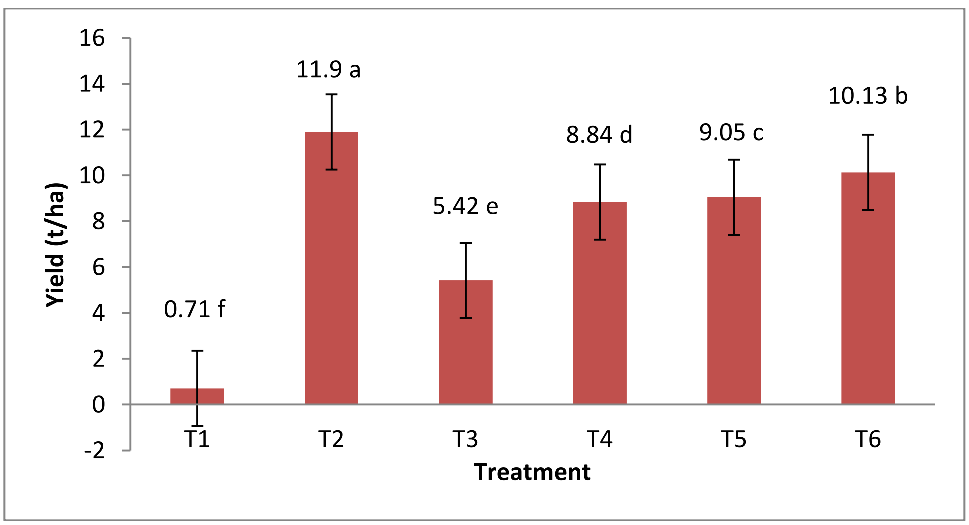

Fig. 4.26. Residual Effect of different concentration of textile waste water on yield of red amaranth in NCSG

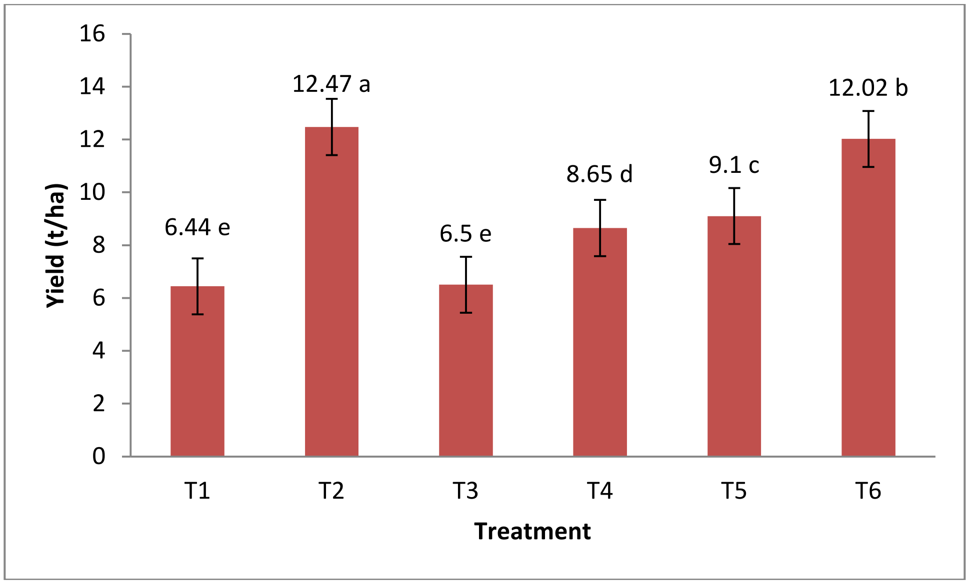

Fig. 4.27. Residual Effect of different concentration of textile waste water on yield of red amaranth in CSN

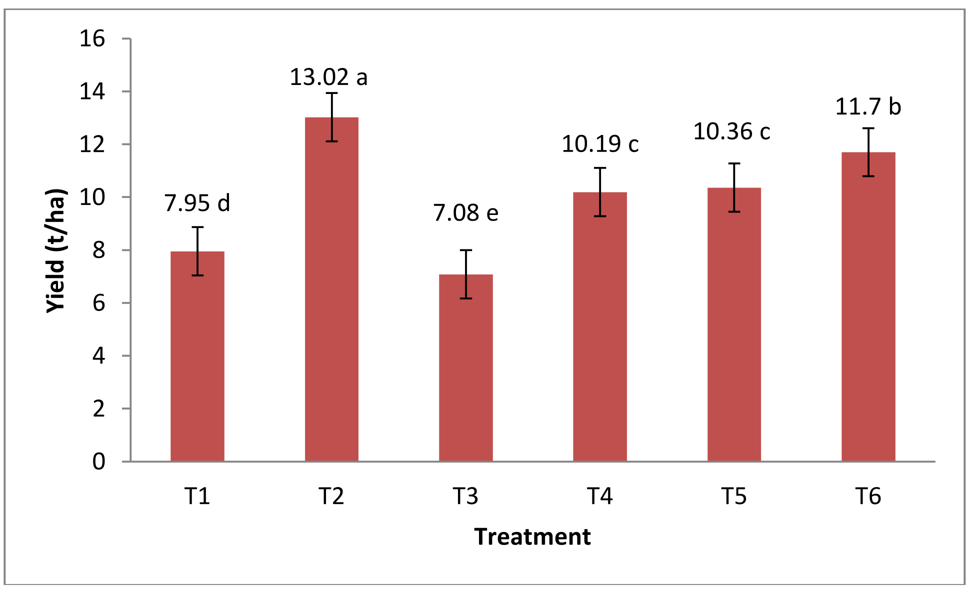

Fig. 4.28. Residual Effect of different concentration of textile waste water on yield of red amaranth in CSG

4.2.4.2. Residual effect of textile waste water on yield of red amaranth in contaminated soils

Residual effects of textile waste water on yield of red amaranth in contaminated soil of Narayanganj and Gazipur are shown in Figures 4.27 and 4.28. The results showed that residual effect of irrigation of 50%, 75% and 100% textile waste water significantly($P \leq 0.05$) increased yield as compared with T_1(control) in both contaminated soils. The results revealed that yield of red amaranth significantly increased with the increasing the concentration of textile waste water irrigation. The highest yield of red amaranth 12.47 and 13.02 t/ha, and the second highest yield of red amaranth 12.02 and 11.7 t/ha, were found with T_2 and T_6 in contaminated soil of Narayanganj and Gazipur respectively. The lowest yield of red amaranth were achieved 6.44 and 7.08 t/ha, with the treatment T_1 and T_3 in non contaminated soil of Narayanganj and Gazipur respectively. The results also revealed that yield of red amaranth with all treatments significantly ($P \leq 0.05$) varied among the treatments (except T_1 and T_3 in contaminated soil of Narayanganj, and T_4 and T_5 in contaminated soil of Gazipur).

4.2.5. Residual effect of textile waste water on dry matter production of red amaranth in different soils

Residual effect of textile waste water on dry matter production of red amaranth in different soils are presented in Tables 4.29 to 4.32

4.2.5.1. Residual effect of textile waste water on dry matter production of red amaranth in non contaminated soils

Residual effects of textile waste water on dry matter production of red amaranth in non contaminated soil of Narayanganj and Gazipur are presented in Tables 4.29. and 4.30. Residual effect of textile waste water enhanced total dry matter yield significantly ($P \leq 0.05$) over control in both non contaminated soils. Highest dry matter yield were 3.77 and 3.45 t/ha obtained with T2 in non contaminated soils of Narayanganj and Gazipur respectively. The second highest rate of dry matter yield 3.36 and 2.94 t/ha were obtained with T6 in both soils, where 100% textile waste water was irrigated in previous experiment. Lowest dry matter yield 0.25 and 0.21 t/ha were found with T1 (control) in non contaminated soils of Narayanganj and Gazipur respectively. The results also revealed that dry matter yield of red amaranth with all treatments significantly ($P \leq 0.05$) varied within the treatment.

Table 4.29. Residual effect of textile waste water on dry matter production of red amaranth in non contaminated soil of Narayanganj

Treat ment	Green weight of 20 plants /plot (gm)			Oven dry weight of 20 plants/plot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	2.20	4.30	1.00	0.25	0.65	0.23	0.06	0.14	0.05	0.25 f
T_2	47.5	90.00	7.00	5.94	13.41	1.62	1.07	2.41	0.29	3.77 a
T_3	15.8	35.20	4.50	1.93	5.25	1.04	0.36	0.99	0.20	1.55 e
T_4	22.8	72.20	6.00	2.76	10.76	1.39	0.51	1.98	0.26	2.75 d
T_5	25.5	73.00	6.50	3.11	10.95	1.51	0.58	2.03	0.28	2.89 c
T_6	29.9	88.10	7.00	3.62	13.13	1.62	0.66	2.40	0.30	3.36 b

Table 4.30. Residual effect of textile waste water on dry matter production of red amaranth in non contaminated soil of Gazipur

Treat ment	Green weight of 20 plants /plot (gm)			Oven dry weight of 20 plants/plot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	2.1	3.5	1	0.25	0.52	0.23	0.05	0.11	0.05	0.21 f
T_2	35.5	86.3	6.2	4.31	12.82	1.44	0.80	2.38	0.27	3.45 a
T_3	15.2	37.7	4.8	1.85	5.59	1.11	0.35	1.05	0.21	1.61 e
T_4	27.7	61.5	5.8	3.36	9.15	1.35	0.62	1.70	0.25	2.57 d
T_5	28	63.5	5.8	3.39	9.42	1.34	0.63	1.75	0.25	2.63 c
T_6	32.2	71.3	6	3.9	10.57	1.39	0.72	1.96	0.26	2.94 b

Table 4.31. Residual effect of textile waste water on dry matter production of red amaranth in contaminated soil of Narayanganj

Treat ment	Green weight of 20 plants /plot (gm)			Oven dry weight of 20 plants/plot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	23.2	41.9	4.5	2.81	6.24	1.04	0.52	1.15	0.19	1.86 e
T_2	45.9	88.1	8.5	5.58	13.08	1.97	0.98	2.29	0.34	3.61 a
T_3	21.6	45.4	4	2.62	6.73	0.93	0.48	1.23	0.17	1.88 e
T_4	23.6	66.4	5	2.86	9.85	1.16	0.52	1.79	0.21	2.52 d
T_5	25.1	68.9	6	3.04	10.2	1.39	0.55	1.86	0.25	2.66 c
T_6	33.5	92.3	7.7	4.06	13.68	1.79	0.73	2.46	0.32	3.51 b

Table 4.32. Residual effect of textile waste water on dry matter production of red amaranth in contaminated soil of Gazipur

Treat ment	Green weight of 20 plants /plot (gm)			Oven dry weight of 20 plants/plot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	24.7	55.1	5.2	2.99	8.17	1.21	0.56	1.53	0.23	2.32 d
T_2	40.5	91.4	8.1	4.91	13.55	1.88	0.91	2.52	0.35	3.78 a
T_3	21.9	50.6	4.5	2.66	7.5	1.04	0.49	1.38	0.19	2.06 e
T_4	31.5	71.5	6	3.82	10.61	1.39	0.71	1.98	0.26	2.96 c
T_5	32	73.8	6.2	3.88	10.95	1.45	0.72	2.03	0.27	3.02 c
T_6	35.1	85.1	6.3	4.25	12.64	1.46	0.79	2.34	0.27	3.40 b

4.2.5.2. Residual effect of textile waste water on dry matter production of red amaranth in contaminated soils

Residual effect of textile waste water on dry matter production of red amaranth in contaminated soils of Narayanganj and Gazipur are presented in Tables 4.31 and 4.32. Residual effect of 50%, 75% and 100% textile waste water enhanced total dry matter yield significantly ($P \leq 0.05$) over control in both contaminated soils. Highest dry matter yield 3.61 and 3.78 t/ha were obtained with T_2 in contaminated soils of Narayanganj and Gazipur respectively. The second highest dry matter yield 3.51 and 3.40 t/ha were obtained with T_6 in both soils, where 100% textile waste water was irrigated in previous experiment. Lowest dry matter yield 1.86 t/ha at Narayanganj and 2.06 t/ha at Gazipur found with T_1 and T_3 in contaminated soil. The results also revealed that dry matter yield of red amaranth with all treatments significantly ($P \leq 0.05$) varied with each other treatment (except T_1 and T_3 in contaminated soil of Narayanganj, and T_4 and T_5 in contaminated soil of Gazipur).

4.2.6. Residual effect of textile waste water on nutrient content in different parts of red amaranth in different soils

Residual effect of textile waste water on nutrient content in different parts of red amaranth in different soils are presented in Tables 4.33 to 4.36.

4.2.6.1. Residual effect of textile waste water on nutrient content in different parts of red amaranth in non contaminated soils

Residual effect of textile waste water on nutrient content in different parts of red amaranth in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.33 and 4.34. The results showed that nutrient content of N, P, K, S, Ca and Mg in shoot was lower than leaves but higher than roots of amaranth in both soils.

The N content of leaves of red amaranth varied between 2.71 to 3.75% and 2.62 to 4.78% in non contaminated soils of Narayanganj and Gazipur respectively. Highest nitrogen content in leaves 3.75 and 4.78% were observed in T_6 (50% RDF + RE of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively The lowest N content 2.71 and 2.62% were observed with T_3 (50% RDF + RE of 25% TWW) in both non contaminated soils. The N content of shoot varied between 0.80 to 1.10% at Narayanganj and 0.81 to 1.10% at Gazipur in non contaminated soils. Highest N content in shoot 1.10% was observed in T_2 (100% RDF + Re of 0% TWW) in both soils. And the lowest N content 0.80 and 0.81% were observed with T_3(50% RDF + RE of 25% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The N content of root varied 0.51 to 0.53% and 0.21 to 0.55% in the individual non contaminated soils of Narayanganj and Gazipur. Highest nitrogen content in root 0.53 and 0.55% were observed in T_5 (50% RDF + RE of 75% TWW) and

Table 4.33. Effect of textile waste water on nutrient content in different parts of red amaranth plant in non contaminated soil of Narayanganj

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	2.76	0.33	0.555	0.42	0.560	0.64
	Shoot	0.82	0.19	0.305	0.15	0.255	0.30
	Root	0.51	0.16	0.160	0.11	0.135	0.12
T_2= 100% RDF + RE of 0% TWW	Leaves	3.72	0.38	0.730	0.68	0.600	0.76
	Shoot	1.10	0.22	0.365	0.28	0.310	0.38
	Root	0.52	0.17	0.285	0.20	0.135	0.15
T_3=50% RDF + RE of 25% TWW	Leaves	2.71	0.32	0.565	0.43	0.570	0.60
	Shoot	0.80	0.20	0.330	0.16	0.300	0.27
	Root	0.47	0.15	0.260	0.13	0.125	0.12
T_4=50%RDF + RE of 50% TWW	Leaves	3.55	0.35	0.680	0.55	0.580	0.72
	Shoot	1.10	0.20	0.360	0.20	0.315	0.35
	Root	0.51	0.16	0.295	0.18	0.140	0.14
T_5=50%RDF + RE of 75% TWW	Leaves	3.63	0.36	0.685	0.61	0.590	0.74
	Shoot	1.00	0.20	0.375	0.22	0.320	0.37
	Root	0.53	0.17	0.310	0.17	0.140	0.16
T_6=50%RDF + RE of 100% TWW	Leaves	3.75	0.36	0.700	0.69	0.600	0.91
	Shoot	1.10	0.21	0.405	0.25	0.325	0.43
	Root	0.52	0.16	0.330	0.20	0.150	0.21

Table 4.34. Effect of textile waste water on nutrient content in different parts of red amaranth plant in non contaminated soil of Gazipur

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	2.88	0.34	0.540	0.23	0.890	0.70
	Shoot	0.85	0.16	0.240	0.14	0.240	0.41
	Root	0.43	0.13	0.105	0.11	0.105	0.18
T_2= 100% RDF + RE of 0% TWW	Leaves	4.78	0.39	0.605	0.47	1.475	0.89
	Shoot	1.10	0.18	0.260	0.31	0.385	0.53
	Root	0.55	0.15	0.150	0.17	0.160	0.22
T_3=50% RDF + RE of 25% TWW	Leaves	2.62	0.35	0.550	0.38	0.920	0.62
	Shoot	0.81	0.15	0.250	0.22	0.325	0.40
	Root	0.21	0.12	0.135	0.12	0.150	0.19
T_4=50%RDF + RE of 50% TWW	Leaves	3.00	0.36	0.590	0.41	1.00	0.77
	Shoot	0.84	0.17	0.275	0.27	0.420	0.45
	Root	0.44	0.12	0.125	0.15	0.180	0.21
T_5=50%RDF + RE of 75% TWW	Leaves	3.10	0.36	0.590	0.42	1.025	0.79
	Shoot	0.85	0.17	0.290	0.27	0.445	0.48
	Root	0.45	0.14	0.125	0.16	0.190	0.23
T_6=50%RDF + RE of 100% TWW	Leaves	3.75	0.39	0.600	0.43	1.050	0.86
	Shoot	0.89	0.18	0.305	0.28	0.450	0.54
	Root	0.47	0.15	0.145	0.17	0.210	0.23

T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The lowest nitrogen content in root 0.53% and 0.21% were observed with T_1(control) and T_3 in non contaminated soils of Narayanganj and Gazipur respectively . The results revealed that N content of red amaranth increased with the increasing of the residual effect of concentration of textile waste water irrigation.

The P content of leaves of red amaranth varied between 0.32 to 0.38% and 0.34 to 0.39% in non contaminated soils of Narayanganj and Gazipur respectively . Highest P content in leaves 0.38% and 0.39% were observed in T_2 (100% RDF + RE of 0% TWW) and T_6 (50% RDF + RE of 100% TWW) in Narayanganj and Gazipur non contaminated soils. And the lowest P content 0.32 and 0.34% were observed with T_1(control) and T_3 (50% RDF + RE of 25% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The P content of shoot varied 0.19 to 0.22% and 0.15 to 0.18% in Narayanganj and Gazipur non contaminated soils. Highest P content in shoot 0.22% and 0.18% were observed in T_2 (100% RDF + Re of 0% TWW) in both soils. And the lowest P content 0.19% and 0.15% were observed with T_1(control) and T_3(50% RDF + RE of 25% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The P content of root varied between 0.15 to 0.17% and 0.12 to 0.15% in non contaminated soil of Narayanganj and Gazipur. Highest P content in root 0.17% was observed in T_2 (100% RDF + RE of 0% TWW) and T_5 (50% RDF + RE of 75% TWW) in non cotaminated soil of Narayanganj and 0.15% was observed in T_2 (100% RDF + RE of 0% TWW) and T_6 (50% RDF + RE of 100% TWW) in non contaminated soil of Gazipur. The lowest P content in root 0.15% and 0.12% were observed with T_3(50% RDF + RE of 25% TWW) in both non contaminated soils of Narayanganj and Gazipur. The results revealed that P content of red amaranth increased with the increasing of the residual effect of concentration of textile waste water irrigation in both soils.

The K content of leaves of red amaranth varied between 0.555 to 0.730% and 0.540 to 0.605% in non contaminated soils followed Narayanganj and Gazipur. Highest K content in leaves 0.730% and 0.605% were observed in T_2 (100% RDF + RE of 0% TWW) in non contaminated soil of Narayanganj and Gazipur. And the lowest K content 0.555% and 0.540% were observed with T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. The K content of shoot varied between 0.305 to 0.405% and 0.240 to 0.305% in non contaminated soil followed Narayanganj and Gazipur. Highest K content in shoot 0.405 and 0.305% were observed in T_6(50% RDF + Re of 100% TWW) in both soils. And the lowest K content 0.305 and 0.240% were observed with T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. The K content of root varied between 0.160 to 0.330% and 0.105 to 0.150% in non contaminated soils of Narayanganj and Gazipur. Highest K content in root 0.330 and 0.150% was observed in T_6 (50% RDF + RE of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in non cotaminated soils of Narayanganj and Gazipur respectively. The lowest K content in root

0.160% and 0.105% were observed with T_1(control) in both non contaminated soil of Narayanganj and Gazipur. The results revealed that K content of red amaranth increased with the increasing of the residual effect of concentration of textile waste water irrigation in both soils.

The S content of leaves of red amaranth varied between 0.42 to 0.69% and 0.23 to 0.47% in non contaminated soils of Narayanganj and Gazipur. Highest S content in leaves found at Narayanganj 0.69% and in T_6 (50% RDF + Re of 100% TWW) and 0.47% at Gazipur soil in T_2 (100% RDF+ RE of 0% TWW). And the lowest S content 0.42% and 0.23% were observed with T_1(control) in non contaminated soils of Narayanganj and Gazipur. The S content of shoot varied between 0.15 to 0.25% and 0.14 to 0.31% in non contaminated soil of Narayanganj and Gazipur respectively. Highest S content in shoot 0.25 and 0.31% were observed in T_6 (50% RDF + Re of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in non contaminated soil of Narayanganj and Gazipur sequentially. And the lowest S content 0.15% and 0.14% were observed with T_1(control) in particular non contaminated soil of Narayanganj and Gazipur. The S content of root varied between 0.11 to 0.20% and 0.11 to 0.17% in non contaminated soils of Narayanganj and Gazipur respectively. Highest S content in root 0.20% and 0.17% was observed in T_6 (50% RDF + RE of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in both non cotaminated soils of Narayanganj and Gazipur. The lowest S content in root 0.11% was observed with T_1(control) in both non contaminated soils of Narayanganj and Gazipur. The results revealed that S content of red amaranth increased with the increasing of the residual effect of concentration of textile waste water irrigation in both soils.

The Ca content of leaves of red amaranth varied between 0.560 to 0.600% and 0.890 to 1.475% in singly non contaminated soil of Narayanganj and Gazipur. Highest Ca content in leaves 0.600% and 1.475% were observed in T_6 (50% RDF + Re of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in the independent non contaminated soil of Narayanganj and Gazipur. And the lowest Ca content 0.560 and 0.890% were observed with T_1(control) in non contaminated soil of Narayanganj and Gazipur respectively. The Ca content of shoot varied between 0.255 to 0.325% and 0.240 to 0.450% in non contaminated soils of Narayanganj and Gazipur sequentially. Highest Ca content in shoot 0.325 and 0.450% were observed in T_6 (50% RDF + Re of 100% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. And the lowest Ca content 0.255 and 0.240% were observed with T_1(control) in non contaminated soils of Narayanganj and Gazipur. The Ca content of root varied between 0.125 to 0.150% and 0.105 to 0.210% in discrete non contaminated soil of Narayanganj and Gazipur. Highest Ca content in root 0.150% and 0.210% was observed in T_6 (50% RDF + RE of 100% TWW) in both non cotaminated soils of Narayanganj and Gazipur. The lowest Ca content in root 0.125% and 0.105% were observed with T_3 (50% RDF + RE of 25% TWW) and T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. The results revealed that Ca content of red amaranth increased with the increasing of the residual effect of concentration of textile waste water irrigation in both soils.

The Mg content of leaves of red amaranth varied between 0.60 to 0.91% and 0.62 to 0.89% in separate non contaminated soil of Narayanganj and Gazipur. Highest Mg content in leaves 0.91 and 0.89% were observed in T_6 (50% RDF + Re of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The lowest Mg content 0.60% at Narayanganj and 0.62% at Gazipur were observed with T_3(50% RDF + Re of 25% TWW) in non contaminated soil. The Mg content of shoot varied between 0.27% to 0.43 % and 0.40% to 0.54% in non contaminated soils of Narayanganj and Gazipur respectively. Highest Mg content in shoot 0.43% and 0.54% were observed in T_6 (50% RDF + Re of 100% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. And the lowest Mg content 0.27% and 0.40% were observed with T_3(50% RDF + Re of 25% TWW) in non contaminated soil of Narayanganj and Gazipur respectively. The Mg content of root varied between 0.12% to 0.21% and 0.18% to 0.23% in non contaminated soils of Narayanganj and Gazipur respectively. Highest Mg content in root 0.21% and 0.23% was observed in T_6 (50% RDF + RE of 100% TWW) in both non cotaminated soil of Narayanganj and Gazipur. The lowest Mg content in root 0.12% and 0.18% were observed with T_3 (50% RDF + RE of 25% TWW) and T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. The results revealed that Mg content of red amaranth increased with the increasing of the residual effect of concentration of textile waste water irrigation in both soils.

4.2.6.2. Residual effect of textile waste water on nutrient content in different parts of red amaranth in contaminated soils

Residual effect of textile waste water on nutrient content in different parts of red amaranth in contaminated soils of Narayanganj and Gazipur are presented in Tables 4.35 and 4.36. The results showed that nutrient content of N, P, K, S, Ca and Mg in shoot found lower than leaves but higher than roots of amaranth in both contaminated soils.

Table 4.35. Effect of textile waste water on nutrient content in different parts of red amaranth plant in contaminated soil of Narayanganj

Treatment	**Plant parts**	**Nutrient %**					
		N	**P**	**K**	**S**	**Ca**	**Mg**
T_1= control	Leaves	3.17	0.33	0.650	0.27	0.190	0.410
	Shoot	1.11	0.15	0.255	0.18	0.060	0.170
	Root	0.45	0.11	0.110	0.12	0.024	0.061
T_2= 100% RDF + RE of 0% TWW	Leaves	3.50	0.34	0.945	0.37	0.560	0.930
	Shoot	1.20	0.15	0.330	0.23	0.120	0.260
	Root	0.53	0.12	0.145	0.15	0.040	0.085
T_3=50% RDF + RE of 25% TWW	Leaves	3.25	0.32	0.590	0.34	0.480	0.770
	Shoot	1.00	0.13	0.250	0.21	0.110	0.210
	Root	0.45	0.11	0.105	0.12	0.030	0.082
T_4=50%RDF + RE of 50% TWW	Leaves	3.28	0.32	0.760	0.35	0.550	0.880
	Shoot	1.10	0.14	0.265	0.23	0.120	0.230
	Root	0.50	0.12	0.130	0.14	0.040	0.085
T_5=50%RDF + RE of 75% TWW	Leaves	3.29	0.33	0.900	0.36	0.560	0.880
	Shoot	1.10	0.14	0.325	0.24	0.130	0.250
	Root	0.51	0.12	0.150	0.14	0.042	0.084
T_6=50%RDF + RE of 100% TWW	Leaves	3.50	0.34	0.980	0.36	0.580	0.900
	Shoot	1.20	0.15	0.335	0.25	0.130	0.270
	Root	0.52	0.12	0.155	0.15	0.042	0.087

Table 4.36. Effect of textile waste water on nutrient content in different parts of red amaranth plant in contaminated soil of Gazipur

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	2.88	0.30	0.725	0.230	0.78	0.800
	Shoot	0.95	0.13	0.425	0.085	0.21	0.092
	Root	0.52	0.10	0.180	0.033	0.13	0.055
T_2= 100% RDF + RE of 0% TWW	Leaves	4.45	0.33	0.860	0.310	0.98	0.980
	Shoot	1.25	0.15	0.455	0.091	0.25	0.120
	Root	0.78	0.11	0.220	0.045	0.16	0.096
T_3=50% RDF + RE of 25% TWW	Leaves	3.50	0.31	0.605	0.270	0.75	0.650
	Shoot	1.10	0.14	0.380	0.084	0.22	0.078
	Root	0.67	0.11	0.175	0.032	0.12	0.042
T_4=50%RDF + RE of 50% TWW	Leaves	3.66	0.31	0.730	0.200	0.77	0.720
	Shoot	1.23	0.14	0.415	0.085	0.23	0.085
	Root	0.70	0.10	0.175	0.035	0.14	0.051
T_5=50%RDF + RE of 75% TWW	Leaves	3.67	0.32	0.745	0.220	0.83	0.760
	Shoot	1.25	0.14	0.425	0.087	0.25	0.088
	Root	0.69	0.12	0.185	0.036	0.16	0.053
T_6=50%RDF + RE of 100% TWW	Leaves	3.79	0.32	0.785	0.320	0.90	0.820
	Shoot	1.35	0.15	0.440	0.099	0.28	0.096
	Root	0.77	0.13	0.200	0.041	0.19	0.067

The N content of leaves of red amaranth varied between 3.17 to 3.50% and 2.88 to 4.45% in contaminated soils of Narayanganj and Gazipur sequentially. Highest N content in leaves 3.50 and 4.45% were observed in T_6 (50% RDF + RE of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur. And the lowest nitrogen content 2.88 and 3.17% were observed with T_1 (control) in both contaminated soil of Narayanganj and Gazipur. The N content of shoot ranged 1.11 to 1.20% at Narayanganj and 0.95 to 1.35% at Gazipur contaminated soil. Highest N content in shoot 1.20 and 1.35% were observed in T_6(50% RDF + Re of 100% TWW) in both soils. And the lowest nitrogen content

1.11 and 0.95% were observed with T_1(control) in both contaminated soils of Narayanganj and Gazipur. The N content of root varies between 0.45 to 0.53% at Narayanganj and 0.52 to 0.78% at Gazipur contaminated soil. Highest N content in root 0.53 and 0.78% were observed in T_2 (100% RDF + RE of 0% TWW) in both contaminated soil of Narayanganj and Gazipur. The lowest N content in root 0.45 and 0.52% were observed with T_1(control) in contaminated soil of Narayanganj and Gazipur. The results revealed that N content of red amaranth increased with the increasing of the residual effect of concentration of textile waste water irrigation.

The P content of leaves of red amaranth varied between 0.32 to 0.34% and 0.30 to 0.33% in contaminated soils followed at Narayanganj and Gazipur. Highest P content in leaves 0.34% and 0.33% were observed in T_2 (100% RDF + RE of 0% TWW) and T_6 (50% RDF + RE of 100% TWW) in contaminated soils of Narayanganj and Gazipur. And the lowest P content 0.32% and 0.30% were observed with T_3 (50% RDF + RE of 25% TWW) and T_1(control) in contaminated soils of Narayanganj and Gazipur respectively. The P content of shoot varied between 0.13 to 0.15% and 0.13 to 0.15% in the particular contaminated soil of Narayanganj and Gazipur. Highest P content in shoot 0.15% was observed in T_2 (100% RDF + Re of 0% TWW) and T_6(50% RDF + RE of 100% TWW) in both soils. And the lowest P content 0.13% was observed with T_3(50% RDF + RE of 25% TWW) at Narayanganj and T_1(control) at Gazipur contaminated soil. The P content of root varied between 0.11 to 0.12% and 0.10 to 0.13% in contaminated soils of Narayanganj and Gazipur respectively. Highest P content in root 0.12% were observed in T_2 , T_4, T_5 and T_6 in cotaminated soil of Narayanganj and 0.13% was observed in T_6 in contaminated soil of Gazipur. The lowest P content in root 0.11 and 0.10% were observed with T_1(control) and T_3(50% RDF + RE of 25% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. The results revealed that P content of red amaranth increased with the increasing of the residual effect of concentration of textile waste water irrigation in both soils.

The K content of leaves of red amaranth varied between 0.590% to 0.980% and 0.605% to 0.860% in contaminated soils of Narayanganj and Gazipur successively. Highest K content in leaves 0.980% and 0.860% were observed in T_6 (50% RDF + RE of 100% TWW) and T_2(100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively . And the lowest K content 0.590% and 0.605% were observed with T_3(50% RDF + RE of 25% TWW) in contaminated soils of Narayanganj and Gazipur. The K content of shoot varied between 0.250 to 0.335% and 0.380 to 0.455% in contaminated soils of Narayanganj and

Gazipur respectively. Highest K content in shoot 0.335 and 0.455% were observed in T_6 (50% RDF + Re of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And the lowest K content 0.250 and 0.380% were observed with T_3(50% RDF + RE of 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The K content of root varied between 0.105 to 0.155% at Narayanganj and 0.175 to 0.220% at Gazipur contaminated soil. Highest K content in root 0.155 and 0.220% were observed in T_6 (50% RDF + RE of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in cotaminated soils of Narayanganj and Gazipur respectively. The lowest K content in root 0.105 and 0.175% were observed with T_1(50% RDF + RE of 25% TWW) in both contaminated soil of Narayanganj and Gazipur. The results revealed that K content of red amaranth increased with the increasing of the residual effect of concentration of textile waste water irrigation in both soils.

The S content of leaves of red amaranth varied between 0.27 to 0.37% and 0.230 to 0.320% in contaminated soil of Narayanganj and Gazipur respectively. Highest S content in leaves 0.37 and 0.320% were observed in T_2 (100% RDF + RE of 0% TWW) and T_6 (50% RDF + Re of 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively . And the lowest S content 0.27 and 0.230% were observed with T_1(control) respectively in contaminated soil of Narayanganj and Gazipur. The S content of shoot varied between 0.18 to 0.25% and 0.084 to 0.099% in contaminated soils of Narayanganj and Gazipur respectively. Highest S content in shoot 0.25 and 0.099% were observed in T_6 (50% RDF + Re of 100% TWW) in both contaminated soils of Narayanganj and Gazipur. And the lowest S content 0.18 and 0.084% were observed with T_1(control) and T_3 (50% RDF + Re of 25% TWW) in contaminated soil of Narayanganj and Gazipur respectively. The S content of root varied between 0.12 to 0.15% and 0.032 to 0.045% successively in contaminated soils of Narayanganj and Gazipur. Highest S content in root 0.15 and 0.045% was observed in T_2 (100% RDF + RE of 0% TWW) and T_6(50% RDF + RE of 100% TWW) in cotaminated soil of Narayanganj and Gazipur respectively. The lowest S content in root 0.12 and 0.032% were observed with T_1(control) and T_3(50% RDF + Re of 25% TWW) respectively in contaminated soil of Narayanganj and

Gazipur. The results revealed that S content of red amaranth increased with the higher residual effect of textile waste water irrigation in both soils.

The Ca content of leaves of red amaranth varied at Narayanganj 0.190 to 0.580% and 0.75 to 0.90% at Gazipur contaminated soil. Highest Ca content in leaves 0.580 and 0.90% were observed in T_6 (50% RDF + Re of 100% TWW) at Narayanganj and Gazipur contaminated soils. And the lowest Ca content 0.190 and 0.75% were obtained with T_1(control) and T_3(50% RDF + Re of 25% TWW) respectively in contaminated soils of Narayanganj and Gazipur. The Ca content of shoot varied between 0.060 to 0.130% at Narayanganj and 0.21 to 0.28% at Gazipur contaminated soil. Highest Ca content in shoot 0.130 and 0.28% were observed in T_6 (50% RDF+ Re of 100% TWW) in non contaminated soils of Narayanganj and Gazipur. And the lowest Ca content in shoot 0.060 and 0.12% were observed with T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. The Ca content of root varied between 0.024 to 0.042% at Narayanganj and 0.12 to 0.19% at Gazipur contaminated soil. Highest Ca content in root 0.042 and 0.19% was observed in T_6 (50% RDF + RE of 100% TWW) in both contaminated soils of Narayanganj and Gazipur. The lowest Ca content in root 0.024 and 0.12% were observed with T_1(control) and T_3 (50% RDF + RE of 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The findings indicated that the Ca increased in red amaranth due to residual effect of graded concentration of textile waste water.

The Mg content of leaves of red amaranth varied between 0.410 to 0.930% and 0.650 to 0.980% in contaminated soils of Narayanganj and Gazipur respectively. Highest Mg content in leaves 0.930 and 0.980% were observed in T_6 (50% RDF + Re of 100% TWW) in both contaminated soil of Narayanganj and Gazipur. And the lowest Mg content 0.410 and 0.650% were observed with T_1(control) and T_3 (50% RDF + RE of 25% TWW) in contaminated soil of Narayanganj and Gazipur successively. The Mg content of shoot varied between 0.170 to 0.270 % and 0.078 to 0.120% in contaminated soils of Narayanganj and Gazipur respectively. Highest Mg content in shoot 0.270 and 0.120% were observed in T_6 (50% RDF + Re of 100% TWW) and T_2 (100% RDF + Re of 0% TWW) respectively in contaminated soils of Narayanganj and Gazipur. And the lowest Mg content 0.170 and 0.120% were observed with T_1(control) and T_3(50% RDF + Re of 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The Mg content of root varied between 0.061 to 0.087% at contaminated soil of Narayanganj and 0.042 to 0.096% at contaminated soil of Gazipur. Highest Mg content in root 0.087 and 0.096% was observed in

T_6 (50% RDF + RE of 100% TWW) and T_2 (100% RDF + Re of 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The lowest Mg content in root 0.061 and 0.042% were observed with T_1(control) and T_3 (50% RDF + RE of 25% TWW) in contaminated soils of Narayanganj and Gazipur sequentially. The results explored that Mg content of red amaranth enhanced with the residual effect of higher concentration of textile waste water irrigation in both soils.

4.2.7. Residual effect of textile waste water on nutrient uptake by red amaranth in different soils

Residual effect of textile waste water on nutrient uptake in different parts of red amaranth in different soils are presented in Tables 4.37 to 4.40.

4.2.7.1. Residual effect of textile waste water on nutrient uptake by red amaranth in non contaminated soils

Residual effect of textile waste water on nutrient uptake in different parts of red amaranth in non contaminated soil of Narayanganj and Gazipur are presented in Tables 4.37 and 4.38. The results revealed that nutrients uptake due to residual effect of textile waste water irrigation increased significantly ($P \leq 0.05$) as compared with control in all the treatments. Considerable nutrients were taken up by all the treatments.

In both non contaminated soils N uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control. The N uptake ranged between 3.07 to 67.82 kg/ha and 2.60 to 65.91 kg/ha, which described successive result of non contaminated soils of Narayanganj and Gazipur. The highest uptake of N 67.82 and 65.91 kg/ha were observed with T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur. And the second highest uptake of N 52.71 kg/ha and 45.66 kg/ha were observed with T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of N 3.07 kg/ha and 2.60 kg/ha were found with T_1 (control) in non contaminated soils of Narayanganj and Gazipur. The results revealed that residual effect of irrigation of more concentration of textile waste water increased the uptake of N by red amaranth in both non contaminated soils.

In both non contaminated soils of Narayanganj and Gazipur P uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control. The P uptake ranged 0.55 to 9.86 kg/ha and 0.42 to 7.82 kg/ha in non contaminated soils of Narayanganj and Gazipur respectively. The highest uptake of P 9.86 kg/ha and 7.82 kg/ha were observed with T_2 (100% RDF + RE of 0% TWW) in non contaminated soil of Narayanganj and Gazipur. And the second highest uptake of P 7.90 and 6.73 kg/ha were observed with T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of P 0.55 and 0.42 kg/ha were found with T_1 (control) in non contaminated soils of Narayanganj and Gazipur. The results affirmed the uptake of P by red amaranth in both non contaminated soils were rising with residual effect of higher levels textile waste water.

In both non contaminated soil of Narayanganj and Gazipur K uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control. The K uptake ranged 0.84 to 17.44 kg/ha and 0.58 to 11.44 kg/ha respectively in non contaminated soils of Narayanganj and Gazipur. The highest uptake of K 17.44 and 11.44 kg/ha were observed with T_2 (100% RDF + RE of 0% TWW) in non contaminated soil of Narayanganj and Gazipur. And the second highest uptake of K 15.33 and 10.68 kg/ha were observed with the treatment T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of K 0.84 and 0.58 kg/ha were found with the treatment T_1(control) in non contaminated soils of Narayanganj and Gazipur. The results acknowledged that residual effect of irrigation of graded concentration of textile waste water increased the uptake of K by red amaranth in both non contaminated soils.

Sulphur uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control in both non contaminated soils of Narayanganj and Gazipur. The S uptake ranged 0.52 to 14.61 kg/ha in the soil of Narayanganj and it was 0.33 to 11.60 kg/ha at Gazipur non contaminated soil. The highest uptake of S 14.61 and 11.60 kg/ha were observed with T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. And the second highest uptake of S 11.15 and 9.03 kg/ha were observed with the T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of S found at Narayanganj 0.52 kg/ha and at Gazipur 0.33 kg/ha with the treatment T_1 (control) in non contaminated soil. The results revealed that residual effect various concentration of textile waste water increased the uptake of S by red amaranth in both non contaminated soils.

Ca uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control in both non contaminated soil of Narayanganj and Gazipur. The Ca uptake ranged between 0.77 to 14.28 kg/ha and 0.76 to 21.39 kg/ha in non contaminated soils of Narayanganj and Gazipur

Table 4.37. Residual effect of textile waste water on nutrient uptake in different parts of red amaranth in non contaminated soil of Narayanganj

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	1.66	0.20	0.33	0.25	0.34	0.38
	Shoot	1.15	0.27	0.43	0.21	0.36	0.42
	Root	0.26	0.08	0.08	0.06	0.07	0.06
	Total	**3.07 f**	**0.55 f**	**0.84 f**	**0.52 f**	**0.77 f**	**0.86 f**
T_2=100% RDF + RE of 0%TWW	Leaves	39.80	4.07	7.81	7.28	6.42	8.13
	Shoot	26.51	5.30	8.80	6.75	7.47	9.16
	Root	1.51	0.49	0.83	0.58	0.39	0.44
	Total	**67.82 a**	**9.86 a**	**17.44 a**	**14.61 a**	**14.28 a**	**17.73 a**
T_3=50%RDF + RE of 25% TWW	Leaves	9.76	1.15	2.03	1.55	2.05	2.16
	Shoot	7.92	1.98	3.27	1.58	2.97	2.67
	Root	0.94	0.30	0.52	0.26	0.25	0.24
	Total	**18.62e**	**3.43 e**	**5.82 e**	**3.39 e**	**5.27 e**	**5.07 e**
T_4=50%RDF + RE of %50 TWW	Leaves	18.11	1.79	3.47	2.81	2.96	3.67
	Shoot	21.78	3.96	7.13	3.96	6.24	6.93
	Root	1.33	0.42	0.77	0.47	0.36	0.36
	Total	**41.22 d**	**6.17 d**	**11.37 d**	**7.24 d**	**9.56 d**	**10.96 d**
T_5=50%RDF + RE of 75% TWW	Leaves	21.05	2.09	3.97	3.54	3.42	4.29
	Shoot	20.30	4.06	7.61	4.47	6.50	7.51
	Root	1.48	0.48	0.87	0.48	0.39	0.45
	Total	**42.83 c**	**6.63 c**	**12.45 c**	**8.49 c**	**10.31 c**	**12.25 c**
T_6=50%RDF + RE of 100% TWW	Leaves	24.75	2.38	4.62	4.55	3.96	6.01
	Shoot	26.40	5.04	9.72	6.00	7.80	10.32
	Root	1.56	0.48	0.99	0.60	0.45	0.63
	Total	**52.71 b**	**7.90 b**	**15.33 b**	**11.15 b**	**12.21 b**	**16.96 b**

Table 4.38. Residual effect of textile waste water on nutrient uptake in different parts of red amaranth in non contaminated soil of Gazipur

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	1.44	0.17	0.27	0.12	0.45	0.35
	Shoot	0.94	0.18	0.26	0.15	0.26	0.45
	Root	0.22	0.07	0.05	0.06	0.05	0.09
	Total	**2.60 f**	**0.42 f**	**0.58 f**	**0.33 f**	**0.76 f**	**0.89 f**
T_2=100% RDF + RE of 0%TWW	Leaves	38.24	3.12	4.84	3.76	11.80	7.12
	Shoot	26.18	4.29	6.19	7.38	9.16	12.61
	Root	1.49	0.41	0.41	0.46	0.43	0.59
	Total	**65.91 a**	**7.82 a**	**11.44 a**	**11.60 a**	**21.39 a**	**20.33 a**
T_3=50%RDF + RE of 25% TWW	Leaves	9.17	1.23	1.93	1.33	3.22	2.17
	Shoot	8.51	1.58	2.63	2.31	3.41	4.20
	Root	0.44	0.25	0.28	0.25	0.32	0.40
	Total	**18.12 e**	**3.06 e**	**4.84 e**	**3.89 e**	**6.95 e**	**6.77 e**
T_4=50%RDF + RE of %50 TWW	Leaves	18.60	2.23	3.66	2.54	6.20	4.77
	Shoot	14.28	2.89	4.68	4.59	7.14	7.65
	Root	1.10	0.30	0.31	0.38	0.45	0.53
	Total	**33.98 d**	**5.42 d**	**8.65 d**	**7.51 d**	**13.79 d**	**12.95 d**
T_5=50%RDF + RE of 75% TWW	Leaves	19.53	2.27	3.72	2.65	6.46	4.98
	Shoot	14.88	2.98	5.08	4.73	7.79	8.40
	Root	1.13	0.35	0.31	0.40	0.48	0.58
	Total	**35.54 c**	**5.60 c**	**9.11 c**	**7.78 c**	**14.73 c**	**13.96 c**
T_6=50%RDF + RE of 100% TWW	Leaves	27.00	2.81	4.32	3.10	7.56	6.19
	Shoot	17.44	3.53	5.98	5.49	8.82	10.58
	Root	1.22	0.39	0.38	0.44	0.55	0.60
	Total	**45.66 b**	**6.73 b**	**10.68 b**	**9.03 b**	**16.93 b**	**17.37 b**

respectively. The highest uptake of Ca 14.28 kg/ha and 21.39 kg/ha were observed with treatment T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. And the second highest uptake of Ca 12.21 kg/ha and 16.93 kg/ha were observed with the treatment T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of Ca 0.77 kg/ha and 0.76 kg/ha were found with the treatment T_1 (control) in non contaminated soils of Narayanganj and Gazipur respectively. The results revealed that the uptake of Ca by red amaranth enhanced with the rates of concentrated textile waste water.

The Mg uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control in both non contaminated soils of Narayanganj and Gazipur. The Mg uptake ranged between 0.86 to 17.73 kg/ha and 0.89 to 20.33 kg/ha in non contaminated soil of Narayanganj and Gazipur respectively. The highest uptake of Mg 17.73 kg/ha and 20.33 kg/ha were observed with T_2(100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. And the second highest uptake of Mg 16.96 kg/ha and 17.37 kg/ha were observed with T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of Ca 0.86 kg/ha and 0.89 kg/ha were found with T_1 (control) in non contaminated soils of Narayanganj and Gazipur. The study exposed that the Mg uptake also increased with the residual effect of different rates of textile waste water concentration.

4.2.7.2. Residual effect of textile waste water on nutrient uptake by red amaranth in contaminated soils

Residual effect of textile waste water on nutrient uptake in different parts of red amaranth in contaminated soil of Narayanganj and Gazipur are presented in Tables 4.39 and 4.40. The results revealed that nutrients uptake due to residual effect of textile waste water irrigation increased significantly ($P \leq 0.05$) as compared with control in all the treatments. Considerable nutrients were taken up by all the treatments.

Nitrogen uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control (except T_3 in contaminated soil of Narayanganj). The N uptake ranged between 28.67 to 63.58 kg/ha and 31.87 to 74.73 kg/ha in contaminated soils of Narayanganj and Gazipur respectively. The highest uptake of N 63.58 and 74.73 kg/ha were observed with T_2 (100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively .And the second highest uptake of N 56.73 and 63.61 kg/ha were observed with T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of N 28.67 and 31.87 kg/ha were found with the treatment T_3(50% RDF + RE 25% TWW) and T_1 (control) in contaminated soils of Narayanganj and Gazipur. The research achievement pointed out that N uptake was higher with the consequence of textile waste water residues.

In both contaminated soils of Narayanganj and Gazipur P uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control (except T_3 in both soils). Uptake of P found at Narayanganj 3.32 to 7.18 kg/ha and 3.66 to 7.17 kg/ha at Gazipur contaminated soil. The highest uptake of P 7.18 kg/ha and 7.17 kg/ha were observed with T_2 (100% RDF + RE of 0% TWW) in contaminated soil of Narayanganj and Gazipur. And the second highest uptake of P 6.55 kg/ha and 6.39 kg/ha were observed with T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of P 3.32 kg/ha and 3.66 kg/ha were found with the treatment T_3 (50% RDF + RE 25% TWW) in contaminated soils of Narayanganj and Gazipur. The results revealed that residual effect of irrigation of more concentration of textile waste water increased the uptake of P by red amaranth in both contaminated soils. The uptake of P increment in red amaranth due to outcome of increasing residues of textile waste water.

In both contaminated soils of Narayanganj and Gazipur K uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control (except T_3 in both soils). The K uptake in contaminated soil of Narayanganj 6.09 to 17.31 kg/ha and in Gazipur 8.53 to 20.07 kg/ha. The highest uptake of K 17.31 and 20.07 kg/ha were observed with T_2 (100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur. And the second highest uptake of K 15.89 and 17.04 kg/ha were observed with T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of K 6.09 kg/ha and 8.53 kg/ha were found with T_3 (50% RDF + RE 25% TWW) in sequential contaminated soils of Narayanganj and Gazipur. The results revealed that residual effect of irrigation of different rates of concentration of textile waste water caused increased uptake of K by red amaranth in both contaminated soils.

Sulphur uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control in both contaminated soils of Narayanganj and Gazipur (except T_3 in contaminated soil of Gazipur). The S uptake ranged between 3.70 to 9.41 kg/ha and 2.54 to 5.27 kg/ha in contaminated soils of Narayanganj and Gazipur respectively. The successive uptake of S 9.41 and 5.27 kg/ha were found highest with T_2 (100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur. And the second highest uptake of S 9.26 and 4.96 kg/ha were observed with T_6(50% RDF + RE 100% TWW) in both soils. The lowest uptake of S 3.70 kg/ha and 2.54 kg/ha were found with T_1 (control) and T_3 (50% RDF + RE 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The results revealed that residual effect of irrigation of more concentration of textile waste water increased the uptake of S by red amaranth in both contaminated soils.

Table 4.39. Residual effect of textile waste water on nutrient uptake in different parts of red amaranth in contaminated soil of Narayanganj

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	**P**	**K**	**S**	**Ca**	**Mg**
T_1= control	Leaves	16.48	1.72	3.38	1.40	0.99	2.13
	Shoot	12.77	1.73	2.93	2.07	0.69	1.96
	Root	0.86	0.21	0.21	0.23	0.05	0.12
	Total	**30.11 e**	**3.66 e**	**6.52 e**	**3.70 f**	**1.73 f**	**4.21 f**
T_2=100% RDF + RE of 0%TWW	Leaves	34.30	3.33	9.26	3.63	5.49	9.11
	Shoot	27.48	3.44	7.56	5.27	2.75	5.95
	Root	1.80	0.41	0.49	0.51	0.14	0.29
	Total	**63.58 a**	**7.18 a**	**17.31 a**	**9.41 a**	**8.38 a**	**15.35 a**
T_3=50%RDF + RE of 25% TWW	Leaves	15.60	1.54	2.83	1.63	2.30	3.70
	Shoot	12.30	1.60	3.08	2.58	1.35	2.58
	Root	0.77	0.18	0.18	0.20	0.05	0.14
	Total	**28.67 f**	**3.32 f**	**6.09f**	**4.42 e**	**3.70 e**	**6.42 e**
T_4=50%RDF + RE of %50 TWW	Leaves	17.06	1.66	3.95	1.82	2.86	4.58
	Shoot	19.69	2.51	4.74	4.12	2.15	4.12
	Root	1.05	0.25	0.27	0.29	0.08	0.18
	Total	**37.80 d**	**4.42 d**	**8.96 d**	**6.23 d**	**5.09 d**	**8.88 d**
T_5=50%RDF + RE of 75% TWW	Leaves	18.10	1.82	4.95	1.98	3.08	4.84
	Shoot	20.46	2.60	6.05	4.46	2.42	4.65
	Root	1.28	0.30	0.38	0.35	0.11	0.21
	Total	**39.84 c**	**4.72 c**	**11.38 c**	**6.79 c**	**5.61 c**	**9.70 c**
T_6=50%RDF + RE of 100% TWW	Leaves	25.55	2.48	7.15	2.63	4.23	6.57
	Shoot	29.52	3.69	8.24	6.15	3.20	6.64
	Root	1.66	0.38	0.50	0.48	0.13	0.28
	Total	**56.73 b**	**6.55 b**	**15.89 b**	**9.26 b**	**7.56 b**	**13.49 b**

Table 4.40. Residual effect of textile waste water on nutrient uptake in different parts of red amaranth in contaminated soil of Gazipur

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	16.13	1.68	4.06	1.29	4.37	4.48
	Shoot	14.54	1.99	6.50	1.30	3.21	1.41
	Root	1.20	0.23	0.41	0.08	0.30	0.13
	Total	**31.87 f**	**3.90 e**	**10.97 e**	**2.67 e**	**7.88 e**	**6.02 e**
T_2=100% RDF + RE of 0%TWW	Leaves	40.50	3.00	7.83	2.82	8.92	8.92
	Shoot	31.50	3.78	11.47	2.29	6.30	3.02
	Root	2.73	0.39	0.77	0.16	0.56	0.34
	Total	**74.73 a**	**7.17 a**	**20.07 a**	**5.27 a**	**15.78 a**	**12.28 a**
T_3=50%RDF + RE of 25% TWW	Leaves	17.15	1.52	2.96	1.32	3.68	3.19
	Shoot	15.18	1.93	5.24	1.16	3.04	1.08
	Root	1.27	0.21	0.33	0.06	0.23	0.08
	Total	**33.60 e**	**3.66 f**	**8.53 f**	**2.54 f**	**6.95 f**	**4.35 f**
T_4=50%RDF + RE of %50 TWW	Leaves	25.99	2.20	5.18	1.42	5.47	5.11
	Shoot	24.35	2.7	8.22	1.68	4.55	1.68
	Root	1.82	0.26	0.46	0.09	0.36	0.13
	Total	**52.16 d**	**5.23 d**	**13.86 d**	**3.19 d**	**10.38 d**	**6.92 d**
T_5=50%RDF + RE of 75% TWW	Leaves	26.42	2.30	5.36	1.58	5.98	5.47
	Shoot	25.38	2.84	8.63	1.77	5.08	1.79
	Root	1.86	0.32	0.50	0.10	0.43	0.14
	Total	**53.66 c**	**5.46 c**	**14.49 c**	**3.45 c**	**11.49 c**	**7.40 c**
T_6=50%RDF + RE of 100% TWW	Leaves	29.94	2.53	6.20	2.53	7.11	6.48
	Shoot	31.59	3.51	10.30	2.32	6.55	2.25
	Root	2.08	0.35	0.54	0.11	0.51	0.18
	Total	**63.61 b**	**6.39 b**	**17.04 b**	**4.96 b**	**14.17 b**	**8.91 b**

Calcium uptake significantly ($P \le 0.05$) increased with all treatments as compared with control in both contaminated soil of Narayanganj and Gazipur (except T_3 in contaminated soil of Gazipur). The Ca uptake ranged between 1.73 to 8.38 kg/ha and 6.95 to 15.78 kg/ha in contaminated soils of Narayanganj and Gazipur respectively. The highest uptake of Ca 8.38 kg/ha and 15.78 kg/ha were observed with T_2 (100% RDF + RE of 0% TWW) in contaminated soil of Narayanganj and Gazipur. And the second highest uptake of Ca 7.56 kg/ha and 14.17 kg/ha were observed with T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of Ca 1.73 kg/ha and 6.95 kg/ha were found with the treatment T_1 (control) and T_3 (50% RDF + RE 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The results revealed that residual effect of irrigation of more concentration of textile waste water increased the uptake of Ca by red amaranth in both contaminated soils.

Manganase uptake significantly ($P \leq 0.05$) increased with all treatments as compared with control in both non contaminated soils of Narayanganj and Gazipur (except T_3 in contaminated soil of Gazipur). The Mg uptake ranged between 4.21 to 15.35 kg/ha and 4.35 to 12.28 kg/ha in contaminated soils of Narayanganj and Gazipur respectively. The highest uptake of Mg 15.35 and 12.28 kg/ha were observed with T_2 (100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And the second highest uptake of Mg 13.49 and 8.91 kg/ha were observed with the treatment T_6 (50% RDF + RE 100% TWW) in both soils. The lowest uptake of Ca 4.21 and 4.35 kg/ha were found with T_1 (control) and T_3 (50% RDF + RE 25% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The results revealed that residual effect of irrigation of more concentration of textile waste water increased the uptake of Mg by red amaranth in both contaminated soils. It create an evidence, the nutrient uptake capacity of red amaranth was higher with the maximum residual effect exerted from the concentrated textile waste water utilization.

4.2.8. Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in different soils

Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in different soils are presented in Tables 4.41 to 4.44.

4.2.8.1. Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in non contaminated soils

Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.41 and

4.42. The results revealed that heavy metal concentration in leaves of red amaranth increased with residual effect of increased level of textile waste water irrigation.

Zinc concentration in leaves of red amaranth varied from 41.00 to 74.00 ppm and 68.00 to85.00 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Zn in leaves of amaranth 74.00 and 85.00 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in non contaminated soils of Narayanganj and Gazipur. And the lowest concentration of Zn in leaves of amaranth 41.00 and 68.00 ppm were observed with T_1 (control) in both non contaminated soils of Narayanganj and Gazipur. Zn concentration in shoot of amaranth varied

Table 4.41. Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in non contaminated soil of Narayanganj

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= (control)	Leaves	41.00	12.93	ND	296.93	ND	ND	ND	39.92
	Shoot	10.80	4.30	ND	101.70	ND	ND	ND	9.95
	Root	3.25	2.15	ND	52.10	ND	ND	ND	3.86
T_2=100%RDF + RE of 0% TWW	Leaves	56.00	17.61	ND	755.37	ND	ND	ND	64.92
	Shoot	11.50	5.00	ND	315.54	ND	ND	ND	11.10
	Root	4.40	2.70	ND	97.8	ND	ND	ND	3.30
T_3=50% RDF + RE of 25% TWW	Leaves	45.00	13.93	ND	921.07	ND	ND	ND	64.15
	Shoot	11.20	4.50	ND	375.50	ND	ND	ND	10.53
	Root	3.50	2.45	ND	122.30	ND	ND	ND	3.21
T_4=50%RDF + RE of 50% TWW	Leaves	52.00	14.64	ND	931.07	ND	ND	ND	65.14
	Shoot	11.77	4.93	ND	382.60	ND	ND	ND	10.77
	Root	4.10	2.78	ND	138.90	ND	ND	ND	3.58
T_5=50%RDF + RE of 75% TWW	Leaves	58.00	17.84	ND	942.84	ND	ND	ND	65.83
	Shoot	11.90	5.00	ND	395.50	ND	ND	ND	11.10
	Root	4.50	2.85	ND	142.60	ND	ND	ND	3.89
T_6=50%RDF + RE of 100% TWW	Leaves	74.00	18.15	ND	999.68	ND	ND	ND	86.95
	Shoot	12.20	5.20	ND	401.30	ND	ND	ND	15.72
	Root	4.99	3.00	ND	157.80	ND	ND	ND	5.55

Table 4.42. Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in non contaminated soil of Gazipur

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= (control)	Leaves	68.00	11.33	ND	432.28	ND	ND	ND	40.70
	Shoot	15.25	3.71	ND	202.50	ND	ND	ND	11.20
	Root	7.02	1.52	ND	112.20	ND	ND	ND	5.30
T_2=100%RDF + RE of 0% TWW	Leaves	73.00	14.52	ND	656.81	ND	ND	ND	52.13
	Shoot	15.65	6.10	ND	325.80	ND	ND	ND	12.50
	Root	7.11	2.85	ND	142.90	ND	ND	ND	6.90
T_3=50% RDF + RE of 25% TWW	Leaves	72.00	13.72	ND	650.43	ND	ND	ND	51.56
	Shoot	15.52	4.15	ND	306.90	ND	ND	ND	12.30
	Root	7.10	1.97	ND	129.60	ND	ND	ND	6.80
T_4=50%RDF + RE of 50% TWW	Leaves	75.00	14.02	ND	657.34	ND	ND	ND	52.92
	Shoot	15.80	5.11	ND	311.30	ND	ND	ND	13.10
	Root	7.91	2.45	ND	142.50	ND	ND	ND	6.90
T_5=50%RDF + RE of 75% TWW	Leaves	76.00	16.29	ND	655.96	ND	ND	ND	53.35
	Shoot	16.00	6.20	ND	328.40	ND	ND	ND	13.22
	Root	7.95	2.91	ND	152.10	ND	ND	ND	7.10
T_6=50%RDF + RE of 100% TWW	Leaves	85.00	18.63	ND	779.06	ND	ND	ND	78.89
	Shoot	16.82	6.25	ND	388.30	ND	ND	ND	15.20
	Root	8.64	2.91	ND	191.20	ND	ND	ND	7.34

from 10.80 to 12.20 ppm and 15.25 to 16.82 ppm respectively in non contaminated soils of Narayanganj and Gazipur. Highest concentration of Zn in shoot was 12.20 and 15.25 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in both non contaminated soils of Narayanganj and Gazipur. And lowest concentration of Zn in shoot 10.80 and 15.25 ppm were observed with T_1 (control) in non contaminated soils of Narayanganj and Gazipur successively. Zn concentration in root varied from 3.25 to 4.99 ppm and 7.02 to 8.64 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Zn in root 4.99 and 8.64 ppm were observed with T6 (50% RDF + RE of 100% TWW) and lowest concentration of Zn in root 3.25 and 7.02 ppm were observed with T1(control) in non contaminated soils of Narayanganj and Gazipur respectively. The sequence of treatments in non

contaminated soil of Narayanganj for Zn concentration in leaves of red amaranth was T6>T5>T2>T4>T3>T1 ,in shoot T6>T5>T4>T3>T2>T1 and in root T6>T5>T2>T4>T3>T1 And the sequence of treatments in non contaminated soil of Gazipur for Zn concentration in leaves of red amaranth was T6>T5>T4>T2>T3>T1 ,in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$.

Copper concentration in leaves of red amaranth varied from 12.93 to 18.15 ppm and 11.33 to 18.63 ppm in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cu in leaves of amaranth 18.15 and 18.63 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in non contaminated soils of Narayanganj and Gazipur. And the lowest concentration of Cu in leaves of amaranth 12.93 and 11.33 ppm were observed with T_1 (control) in both non contaminated soils of Narayanganj and Gazipur. Cu concentration in shoot of amaranth varied from 4.30 to 5.20 ppm and 3.71 to 6.25 ppm in non contaminated soil of Narayanganj and Gazipur respectively . Highest concentration of Cu in shoot 5.20 and 6.25 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in both non contaminated soils of Narayanganj and Gazipur. And lowest concentration of Cu in shoot 4.30 and 3.71 ppm were observed with T_1 (control) in non contaminated soil of Narayanganj and Gazipur respectively. Cu concentration in root of amaranth varied from 2.15 to 3.00 ppm and 1.52 to 2.91 ppm which consequent finding of non contaminated soils of Narayanganj and Gazipur. Highest concentration of Cu in root 43.00 and 2.91 ppm were observed with T_6 (50% RDF + RE of 100% TWW) and lowest concentration of Cu in root 2.15 and 2.91 ppm were observed with T_1(control) in non contaminated soils of Narayanganj and Gazipur. The sequence of treatments in non contaminated soil of Narayanganj for Cu concentration in leaves of red amaranth was $T_6>T_5>T_2>T_4>T_3>T_1$,in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$. The sequence of treatments in non contaminated soil of Gazipur for Cu concentration in leaves of red amaranth was $T_6>T_5>T_2>T_4>T_3>T_1$,in shoot $T_6>T_5>T_2>T_4>T_3>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$.

Concentration of Fe in leaves of red amaranth varied from 296.93 to 999.68 ppm and 432.28 to 779.06 ppm were sequential result of non contaminated soils of Narayanganj and Gazipur. Highest concentration of Fe in leaves of amaranth 999.68 and 779.06 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in non contaminated soil of Narayanganj and Gazipur respectively. And the lowest concentration of Fe in leaves of amaranth 296.93 and 432.28 ppm were observed with T_1 (control) in both non contaminated soils of Narayanganj and

Gazipur. Fe concentration in shoot of amaranth varied from 101.70 to 401.30 ppm at Narayanganj and 202.50 to 388.30 ppm at Gazipur non contaminated soil. Highest concentration of Fe in shoot 410.30 and 388.30 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in both non contaminated soils of Narayanganj and Gazipur. The lowest concentration of Fe in shoot 101.70 and 202.50 ppm were observed with treatment T_1 (control) in both non contaminated soils of Narayanganj and Gazipur. The variation of Fe content in root in non contaminated soil of Narayanganj ranged 52.10 to 157.80 ppm, while Gazipur was 112.20 to 191.20 ppm. Highest concentration of Fe in root 157.80 and 191.20 ppm were observed with T_6 (50% RDF + RE of 100% TWW) and lowest concentration of Fe in root 52.10 and 112.20 ppm were observed with T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. The sequence of treatments in non contaminated soil of Narayanganj for Fe concentration in leaves of red amaranth was $T_6>T_5>T_4>T_3>T_2>T_1$,in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_3>T_2>T_1$. And the sequence of treatments in non contaminated soil of Gazipur for Fe concentration in leaves of red amaranth was $T_6>T_5>T_4>T_2>T_3>T_1$,in shoot $T_6>T_5>T_2>T_4>T_3>T_1$ and in root $T_6>T_5>T_2>T_4>T_3>T_1$.

Mn concentration in leaves of red amaranth varied from 39.92 to 86.95 ppm and 40.70 to 78.89 ppm in respective non contaminated soil of Narayanganj and Gazipur. Highest concentration of Mn in leaves of amaranth 86.95 and 78.89 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in non contaminated soil of Narayanganj and Gazipur respectively. And the lowest concentration of Mn in leaves of amaranth 39.92 and 40.70 ppm were observed with T_1 (control) in both non contaminated soil of Narayanganj and Gazipur. Mn concentration in shoot of amaranth varied from 9.95 to 15.72 ppm and 11.20 to 15.20 ppm in non contaminated soil of Narayanganj and Gazipur respectively . Highest concentration of Mn in shoot was 15.72 and 15.20 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in both non contaminated soil of Narayanganj and Gazipur. And lowest concentration of Mn in shoot 9.95 and 11.20 ppm were observed with T_1 (control) in non contaminated soil of Narayanganj and Gazipur. Mn concentration in root of amaranth varied from 3.86 to 5.55 ppm in Narayanganj and 5.30 to 7.34 ppm in Gazipur non contaminated soil. Highest concentration of Mn in root 5.55 and 7.34 ppm were observed with T_6 (50% RDF + RE of 100% TWW) and lowest concentration of Mn in root 3.86 and 5.30 ppm were observed with T_1(control) in non contaminated soil of Narayanganj and Gazipur. The sequence of treatments in non contaminated soil of Narayanganj for Fe concentration in leaves of red amaranth was $T_6>T_5>T_4>T_2>T_3>T_1$,in shoot $T_6>T_5>T_2>T_4>T_3>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$. And the sequence of treatments in non contaminated soil of Gazipur for Fe concentration in leaves of red amaranth was $T_6>T_5>T_4>T_2>T_3>T_1$,in shoot $T_6>T_5>T_4>T_2>T_3>T_1$ and in root $T_6>T_5>T_4,T_2>T_3>T_1$.

On the basis of heavy metal concentration in red amaranth plant it may be arranged as Fe>Zn>Mn>Cu in both non contaminated soils. The heavy metal Ni, Cd, Cr and Pb were not detectable in the red amaranth plant in both non contaminated soils of Narayanganj and Gazipur.

4.2.8.2. Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in contaminated soils

Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.43 and 4.44. The results revealed that heavy metal concentration in leaves of red amaranth increased with residual effect of increased level of textile waste water irrigation in both soils.

Zinc concentration in leaves of red amaranth varied from 35.00 to 66.00 ppm and 36.00 to 67.00 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Zn in leaves of amaranth 66.00 and 67.00 ppm were observed with the T_6 (50% RDF + RE of 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And the lowest concentration of Zn in leaves of amaranth 35.00 and 36.00 ppm were observed with T_1 (control) in both contaminated soil of Narayanganj and Gazipur. Zn concentration in shoot of amaranth varied from 9.78 to 12.34 ppm and 10.20 to 15.80 ppm in contaminated soil of Narayanganj and Gazipur. Highest concentration of Zn in shoot was 12.34 and 15.80 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in both contaminated soil of Narayanganj and Gazipur. And lowest concentration of Zn in shoot 9.78 and 10.20 ppm were observed with T_1 (control) in both contaminated soils of Narayanganj and Gazipur. Zn concentration in root varied from 3.20 to 6.10 ppm and 4.31 to 8.95 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Zn in root 6.10 and 8.95 ppm were observed with

T_6 (50% RDF + RE of 100% TWW) and lowest concentration of Zn in root 3.20 and 4.31 ppm were observed with T_1(control) in contaminated soil of Narayanganj and Gazipur. The sequence of treatments in contaminated soil of Narayanganj for Zn concentration in leaves of red amaranth was $T_6>T_5>T_2>T_4>T_3>T_1$,in shoot $T_6>T_5>T_2>T_4>T_3>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$. And the sequence of treatments in contaminated soil of Gazipur for Zn concentration in leaves of red amaranth was $T_6>T_5>T_4>T_2>T_3>T_1$,in shoot $T_6>T_5>T_4>T_2>T_3>T_1$ and in root $T_6>T_5>T_2>T_4>T_3>T_1$.

Table 4.43. Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in contaminated soil of Narayanganj

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	**Cu**	**Ni**	**Fe**	**Cd**	**Cr**	**Pb**	**Mn**
T_1= (control)	Leaves	35.00	11.63	ND	391.02	ND	ND	ND	36.36
	Shoot	9.78	4.74	ND	103.23	ND	ND	ND	10.10
	Root	3.20	1.98	ND	50.10	ND	ND	ND	4.72
T_2=100%RDF + RE of 0% TWW	Leaves	53.50	14.13	ND	851.47	ND	ND	ND	67.99
	Shoot	12.00	5.82	ND	345.55	ND	ND	ND	14.75
	Root	5.75	2.77	ND	104.50	ND	ND	ND	5.34
T_3=50% RDF + RE of 25% TWW	Leaves	52.00	13.34	ND	566.37	ND	ND	ND	48.55
	Shoot	11.71	5.20	ND	145.71	ND	ND	ND	11.50
	Root	5.69	2.68	ND	79.25	ND	ND	ND	4.91
T_4=50%RDF + RE of 50% TWW	Leaves	53.00	14.16	ND	907.61	ND	ND	ND	68.54
	Shoot	11.98	6.12	ND	317.50	ND	ND	ND	14.75
	Root	5.81	3.11	ND	102.11	ND	ND	ND	6.14
T_5=50%RDF + RE of 75% TWW	Leaves	54.00	14.72	ND	883.38	ND	ND	ND	68.97
	Shoot	12.02	6.53	ND	352.75	ND	ND	ND	14.77
	Root	5.98	3.20	ND	125.90	ND	ND	ND	6.22
T_6=50%RDF + RE of 100% TWW	Leaves	66.00	16.03	ND	929.68	ND	ND	ND	71.67
	Shoot	12.34	6.79	ND	362.80	ND	ND	ND	14.98
	Root	6.10	3.25	ND	150.20	ND	ND	ND	6.50

(Here to denote- ND- Not detectable)

Table 4.44. Residual effect of textile waste water on heavy metal concentration in different parts of red amaranth in contaminated soil of Gazipur

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= (control)	Leaves	36.00	12.83	ND	411.35	ND	ND	ND	38.64
	Shoot	10.20	4.54	ND	252.30	ND	ND	ND	10.10
	Root	4.31	2.71	ND	176.80	ND	ND	ND	4.88
T_2=100%RDF + RE of 0% TWW	Leaves	53.00	14.32	ND	712.53	ND	ND	ND	53.45
	Shoot	13.10	5.39	ND	365.80	ND	ND	ND	14.80
	Root	6.44	2.90	ND	178.50	ND	ND	ND	6.05
T_3=50% RDF + RE of 25% TWW	Leaves	50.00	13.73	ND	502.57	ND	ND	ND	51.80
	Shoot	12.40	4.98	ND	281.20	ND	ND	ND	12.70
	Root	5.83	2.55	ND	199.80	ND	ND	ND	5.92
T_4=50%RDF + RE of 50% TWW	Leaves	54.00	14.22	ND	717.04	ND	ND	ND	56.60
	Shoot	13.10	5.10	ND	376.50	ND	ND	ND	14.88
	Root	6.22	2.81	ND	188.50	ND	ND	ND	5.95
T_5=50%RDF + RE of 75% TWW	Leaves	58.00	14.42	ND	743.07	ND	ND	ND	57.67
	Shoot	13.75	5.35	ND	355.60	ND	ND	ND	15.10
	Root	6.91	2.97	ND	185.30	ND	ND	ND	6.25
T_6=50%RDF + RE of 100% TWW	Leaves	67.00	14.43	ND	812.19	ND	ND	ND	65.87
	Shoot	15.80	5.50	ND	433.20	ND	ND	ND	15.89
	Root	8.95	3.00	ND	247.50	ND	ND	ND	6.73

(Here to denote- ND- Not detectable)

Copper concentration in leaves of red amaranth achieved at Narayanganj contaminated soil 11.63 to 16.03 ppm and 12.83 to 14.43 ppm in Gazipur. Highest concentration of Cu in leaves of amaranth 16.03 and 14.43 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in contaminated soils of Narayanganj and Gazipur. And the lowest concentration of Cu in leaves of amaranth 11.63 and 12.83 ppm were observed with T_1 (control) in both contaminated soils of Narayanganj and Gazipur. Copper concentration in shoot of amaranth varied from 4.74 to 6.79 ppm and 4.54 to 5.50 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cu in shoot 6.79 and 5.50 ppm were observed with the treatment T_6 (50% RDF + RE of 100% TWW) in both contaminated soils of Narayanganj and Gazipur. And lowest concentration of Cu in shoot 4.74 and 4.54 ppm were observed with treatment T_1

(control) in contaminated soil of Narayanganj and Gazipur respectively. Cu concentration in root of amaranth varied from 1.98 to 3.25 ppm and 2.71 to 3.00 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cu in root 3.25 and 3.00 ppm were observed with T_6 (50% RDF + RE of 100% TWW) and lowest concentration of Cu in root 1.98 and 2.71 ppm were observed with T_1(control) in contaminated soils of Narayanganj and Gazipur. The sequence of treatments in contaminated soil of Narayanganj for Cu concentration in leaves of red amaranth was $T_6>T_5>T_4>T_2>T_3>T_1$,in shoot $T_6>T_5>T_4>T_2>T_3>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$. And the sequence of treatments in contaminated soil of Gazipur for Cu concentration in leaves of red amaranth was $T_6>T_5>T_2>T_4>T_3>T_1$,in shoot $T_6>T_2>T_5>T_4>T_3>T_1$ and in root $T_6>T_5>T_2>T_4>T_3>T_1$.

Concentration of Fe in leaves of red amaranth varied from 391.02 to 929.68 ppm and 411.35 to 812.19 ppm respectively in contaminated soils of Narayanganj and Gazipur. Highest concentration of Fe in leaves of amaranth 929.68 and 812.19 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in contaminated soils of Narayanganj and Gazipur respectively. And the lowest concentration of Fe in leaves of amaranth 391.02 and 411.35 ppm were observed with T_1 (control) in both contaminated soils of Narayanganj and Gazipur. Fe concentration in shoot of amaranth varied from 103.23 to 362.80 ppm and 252.30 to 433.20 ppm in contaminated soils of Narayanganj and Gazipur respectively . Highest concentration of Fe in shoot 362.80 and 433.20 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in both contaminated soils of Narayanganj and Gazipur. And lowest concentration of Fe in shoot 103.23 and 252.30 ppm were observed with T_1 (control) in contaminated soils of Narayanganj and Gazipur. Fe concentration in root of amaranth resulted 50.10 to 150.20 ppm and 176.80 to 247.50 ppm in contaminated soil followed at Narayanganj and Gazipur. Highest concentration of Fe in root 150.20 and 247.50 ppm were observed with T_6 (50% RDF + RE of 100% TWW) and lowest concentration of Fe in root 50.10 and 176.80 ppm were observed with T_1(control) in contaminated soil of Narayanganj and Gazipur. The sequence of treatments in contaminated soil of Narayanganj for Fe concentration in leaves of red amaranth was $T_6>T_4>T_5>T_2>T_3>T_1$, in shoot $T_6>T_5>T_2>T_4>T_3>T_1$ and in root $T_6>T_5>T_2>T_4>T_3>T_1$. And the sequence of treatments in contaminated soil of Gazipur for Fe concentration in leaves of red amaranth was $T_6>T_5>T_4>T_2>T_3>T_1$, in shoot $T_6>T_4>T_5>T_2>T_3>T_1$ and in root $T_6>T_4>T_5>T_2>T_3>T_1$.

Manganese concentration in leaves of red amaranth varied from 36.36 to 71.67 ppm and 38.64 to 65.87 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Mn in leaves of amaranth 71.67 and 65.87 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in contaminated soils of Narayanganj and Gazipur. And the lowest concentration of Mn in leaves of amaranth 36.36 and 38.64 ppm were observed with T_1 (control) in both non contaminated soils of Narayanganj and Gazipur. Mn concentration in shoot at Narayanganj and Gazipur contaminated soil found 10.10 to 14.98 ppm and 10.10 to 15.89 ppm respectively. Highest concentration of Mn in shoot was 14.98 and 15.89 ppm were observed with T_6 (50% RDF + RE of 100% TWW) in both contaminated soils of Narayanganj and Gazipur. And lowest concentration of Mn in shoot 10.10 ppm was observed with T_1 (control) in both contaminated soil of Narayanganj and Gazipur. Mn concentration in root of amaranth varied from 4.72 to 6.50 ppm and 4.88 to 6.73 ppm in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Mn in root 6.50 and 6.73 ppm were observed with T_6 (50% RDF + RE of 100% TWW) and lowest concentration of Mn in root 4.72 and 4.88 ppm were observed with T_1(control) in contaminated soil of Narayanganj and Gazipur respectively. The sequence of treatments in contaminated soil of Narayanganj for Fe concentration in leaves of red amaranth was $T_6>T_5>T_4>T_2>T_3>T_1$,in shoot $T_6>T_5>T_4,T_2>T_3>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$. And the sequence of treatments in contaminated soil of Gazipur for Fe concentration in leaves of red amaranth was $T_6>T_5>T_4>T_2>T_3>T_1$, in shoot $T_6>T_5>T_4>T_2>T_3>T_1$ and in root $T_6>T_5>T_2>T_4>T_3>T_1$.

On the basis of heavy metal concentration in red amaranth plant, it may be arranged as Fe>Zn>Mn>Cu in both contaminated soils. Here the heavy metal Ni, Cd, Cr and Pb were not detected in the red amaranth plant in both contaminated soils of Narayanganj and Gazipur.

4.2.9. Residual effect of textile waste water on heavy metal uptake by red amaranth in different soils

Residual effect of textile waste water on heavy metal uptake by red amaranth in different soils are presented in Tables 4.45 to 4.48. The heavy metal Ni, Cd, Cr and Pb were found very trace which causing not detectable in red amaranth plant samples of non contaminated and contaminated soils of Narayanganj and Gazipur. So, these heavy metal such as Ni, Cd, Cr and Pb uptake by red amaranth were considered zero.

4.2.9.1.Residual effect of textile waste water on heavy metal uptake by red amaranth in non contaminated soils

Residual effect of textile waste water on heavy metal uptake by red amaranth in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.45 and 4.46.

Residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased Zn uptake by red amaranth as compared with control in both non contaminated soils. The Zn uptake by each treatment also significantly ($P \leq 0.05$) vary with other treatments. The Zn uptake ranged between 4.13 to 88.92 and 6.57 to 117.89 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The minimum uptake of Zn 4.13 gm/ha and 6.57 gm/ha were found with T_1 (control) and the maximum uptake of Zn 88.92 gm/ha and 117.89 gm/ha were observed with T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur. Considering Zn uptake by red amaranth the treatments can be arranged in the order of $T_2>T_6>T_5>T_4>T_3>T_1$ for both non contaminated soils.

Residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased Cu uptake by red amaranth as compared with control in both non contaminated soils. The Cu uptake by each treatment also found significantly ($P \leq 0.05$) vary with other treatments. The Cu uptake ranged between 1.49 to 31.67 gm/ha and 1.28 to 31.07 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Cu 1.49 gm/ha and 1.28 gm/ha were found with T_1 (control) and the highest uptake of Zn 31.67 gm/ha and 31.07 gm/ha were observed with T_2(100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur respectively. According to Cu uptake by red amaranth the treatments may be arranged in the order of $T_2>T_6>T_5>T_4>T_3>T_1$ for both non contaminated soils.

Residual effect of textile waste water irrigation was found significant ($P \leq 0.05$) in up taking of Fe by red amaranth compared to control in both non contaminated soils. The Fe uptake by each treatment also significantly ($P \leq 0.05$) varied with other treatments. The Fe uptake ranged between 34.67 to 1670.25 gm/ha and 59.90 to 1529.41 gm/ha in non contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Fe 34.67 gm/ha and 59.90 gm/ha were found with T_1 (control) in non contaminated soil of Narayanganj and Gazipur. And the highest uptake of Fe 1670.25 and 1529.41 gm/ha were observed with T_6 (50% RDF + RE of 100% TWW) and T_2 (100% RDF + RE of 0% TWW) in non contaminated soil of Narayanganj

Table 4.45. Effect of textile waste water on heavy metal uptake by red amaranth in non contaminated soil of Narayanganj

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= control	Leaves	2.46	0.78	0	17.82	0	0	0	2.40
	Shoot	1.51	0.60	0	14.24	0	0	0	1.39
	Root	0.16	0.11	0	2.61	0	0	0	0.19
	Total	**4.13 f**	**1.49 f**	**0**	**34.67 f**	**0**	**0**	**0**	**3.98 f**
T_2=100% RDF + RE of 0%TWW	Leaves	59.92	18.84	0	808.25	0	0	0	69.46
	Shoot	27.72	12.05	0	760.45	0	0	0	26.75
	Root	1.28	0.78	0	28.36	0	0	0	0.96
	Total	**88.92 a**	**31.67 a**	**0**	**1597.06 b**	**0**	**0**	**0**	**97.17 a**
T_3=50%RDF + RE of 25% TWW	Leaves	16.20	5.01	0	331.59	0	0	0	23.09
	Shoot	11.088	4.46	0	371.75	0	0	0	10.42
	Root	0.70	0.49	0	24.46	0	0	0	0.64
	Total	**27.98 e**	**9.96 e**	**0**	**727.80 e**	**0**	**0**	**0**	**34.15 e**
T_4=50%RDF + RE of %50 TWW	Leaves	26.52	7.47	0	474.85	0	0	0	33.22
	Shoot	23.30	9.76	0	757.55	0	0	0	21.32
	Root	1.07	0.72	0	36.11	0	0	0	0.93
	Total	**50.89 d**	**17.95 d**	**0**	**1268.51 d**	**0**	**0**	**0**	**55.47 d**
T_5=50%RDF + RE of 75% TWW	Leaves	33.64	10.35	0	546.85	0	0	0	38.18
	Shoot	24.16	10.15	0	802.87	0	0	0	22.53
	Root	1.26	0.80	0	39.93	0	0	0	1.09
	Total	**59.06 c**	**21.30 c**	**0**	**1389.65 c**	**0**	**0**	**0**	**61.80 c**
T_6=50%RDF + RE of 100% TWW	Leaves	48.84	11.98	0	659.79	0	0	0	57.39
	Shoot	29.28	12.48	0	963.12	0	0	0	37.73
	Root	1.50	0.90	0	47.34	0	0	0	1.67
	Total	**79.62 b**	**25.36 b**	**0**	**1670.25 a**	**0**	**0**	**0**	**96.79 b**

Table 4.46. Effect of textile waste water on heavy metal uptake by red amaranth in non contaminated soil of Gazipur

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= control	Leaves	4.08	0.68	0	25.94	0	0	0	2.44
	Shoot	2.14	0.52	0	28.35	0	0	0	1.57
	Root	0.35	0.08	0	5.61	0	0	0	0.27
	Total	**6.57 f**	**1.28 f**	**0**	**59.90 f**	**0**	**0**	**0**	**4.28 f**
T_2=100% RDF + RE of 0%TWW	Leaves	78.11	15.54	0	702.79	0	0	0	55.78
	Shoot	37.72	14.70	0	785.18	0	0	0	30.13
	Root	2.06	0.83	0	41.44	0	0	0	2.00
	Total	**117.89 a**	**31.07 a**	**0**	**1529.41 a**	**0**	**0**	**0**	**87.91 b**
T_3=50%RDF + RE of 25% TWW	Leaves	25.92	4.94	0	234.15	0	0	0	18.56
	Shoot	15.36	4.11	0	303.83	0	0	0	12.18
	Root	1.42	0.39	0	25.92	0	0	0	1.36
	Total	**42.70 e**	**9.44 e**	**0**	**563.90 e**	**0**	**0**	**0**	**32.10 e**
T_4=50%RDF + RE of %50 TWW	Leaves	38.25	7.15	0	335.24	0	0	0	26.99
	Shoot	31.28	10.12	0	616.37	0	0	0	25.94
	Root	2.06	0.64	0	37.05	0	0	0	1.79
	Total	**71.59 d**	**17.91 d**	**0**	**988.66 d**	**0**	**0**	**0**	**54.72 d**
T_5=50%RDF + RE of 75% TWW	Leaves	44.08	9.45	0	380.46	0	0	0	30.94
	Shoot	32.48	12.59	0	666.65	0	0	0	26.84
	Root	2.23	0.81	0	42.59	0	0	0	1.99
	Total	**78.79 c**	**22.85 c**	**0**	**1089.70c**	**0**	**0**	**0**	**59.77 c**
T_6=50%RDF + RE of 100% TWW	Leaves	56.10	12.30	0	514.18	0	0	0	52.07
	Shoot	40.37	15.00	0	931.92	0	0	0	36.48
	Root	2.59	0.87	0	57.36	0	0	0	2.20
	Total	**99.06 b**	**28.17 b**	**0**	**1503.46 b**	**0**	**0**	**0**	**90.75 a**

and Gazipur respectively. On the basis of Fe uptake by red amaranth the treatments may be arranged in the order of $T_6>T_2>T_5>T_4>T_3>T_1$ for Narayanganj and $T_2>T_6>T_5>T_4>T_3>T_1$ Gazipur non contaminated soil.

In both non contaminated soils residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased Mn uptake by red amaranth as compared with control. The Mn uptake by each treatment also significantly ($P \leq 0.05$) vary with other treatments. The Mn uptake ranged between 3.98 to 97.17 gm/ha and 4.28 to 90.75 gm/ha in non contaminated soil of Narayanganj and Gazipur respectively. The lowest uptake of Mn 3.98 and 4.28 gm/ha were found with T_1 (control) in both non contaminated soils of Narayanganj and Gazipur. And the highest uptake of Mn 97.17 and 90.75 gm/ha were observed with T_2 (100% RDF + RE of 0% TWW) and T_6 (50% RDF + RE of 100% TWW) respectively in non contaminated soils of Narayanganj and Gazipur. On the basis of Mn uptake by red amaranth the treatments may be arranged in the order of $T_2>T_6>T_5>T_4>T_3>T_1$ and $T_6>T_2>T_5>T_4>T_3>T_1$ for non contaminated soils of Narayanganj and Gazipur respectively.

4.2.9.2. Residual effect of textile waste water on heavy metal uptake by red amaranth in non contaminated soils

Residual effect of textile waste water on heavy metal uptake by red amaranth in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.47 and 4.48.

In both contaminated soils residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased Zn uptake by red amaranth as compared with control. The Zn uptake by each treatment also significantly ($P \leq 0.05$) varied with other treatments. The Zn uptake ranged between 3.63 to 87.84 gm/ha and 3.81 to 90.15 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Zn 3.63 and 3.81 gm/ha were found with the treatment T_1 (control) and the highest uptake of Zn 87.84 and 90.15 gm/ha were observed with treatment T_2(100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur. The findings of Zn uptake by red amaranth with the treatments may be arranged in the order of $T_2>T_6>T_5>T_4>T_3>T_1$ for both contaminated soils.

Residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased Cu uptake by red amaranth as compared with control in both contaminated soils. The Cu uptake by each treatment also significantly ($P \leq 0.05$) vary with other treatments. The Cu uptake ranged between 1.46 to 29.95 gm/ha and 1.55 to 29.15 gm/ha in contaminated soils of Narayanganj and Gazipur respectively. The lowest uptake of Cu 1.46 gm/ha and 1.55 gm/ha were found with the

T_1 (control) and the highest uptake of Zn 29.95 and 29.15 gm/ha were observed with T_2(100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. According to Cu uptake by red amaranth the treatments may be arranged in the order of $T_2>T_6>T_5>T_4>T_3>T_1$ for both contaminated soils.

Table 4.47. Effect of textile waste water on heavy metal uptake by red amaranth in contaminated soil of Narayanganj

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= control	Leaves	2.10	0.70	0	23.46	0	0	0	2.18
	Shoot	1.37	0.66	0	14.45	0	0	0	1.41
	Root	0.16	0.10	0	2.51	0	0	0	0.24
	Total	**3.63 f**	**1.46 f**	**0**	**40.42 f**	**0**	**0**	**0**	**3.83 f**
T_2=100% RDF + RE of 0%TWW	Leaves	57.25	15.12	0	911.07	0	0	0	72.75
	Shoot	28.92	14.03	0	832.78	0	0	0	35.55
	Root	1.67	0.80	0	30.31	0	0	0	1.55
	Total	**87.84 a**	**29.95 a**	**0**	**1774.15 a**	**0**	**0**	**0**	**109.85 a**
T_3=50%RDF + RE of 25% TWW	Leaves	18.72	4.80	0	203.89	0	0	0	17.48
	Shoot	11.59	5.15	0	144.25	0	0	0	11.39
	Root	1.14	0.54	0	15.85	0	0	0	0.98
	Total	**31.45 e**	**10.49 e**	**0**	**363.99 e**	**0**	**0**	**0**	**29.85 e**
T_4=50%RDF + RE of %50 TWW	Leaves	27.03	7.22	0	462.88	0	0	0	34.96
	Shoot	23.72	12.12	0	628.65	0	0	0	29.21
	Root	1.51	0.81	0	26.55	0	0	0	1.60
	Total	**52.26 d**	**20.15 d**	**0**	**1118.08 d**	**0**	**0**	**0**	**65.77 d**
T_5=50%RDF + RE of 75% TWW	Leaves	31.32	8.54	0	512.36	0	0	0	40.00
	Shoot	24.40	13.26	0	716.08	0	0	0	29.98
	Root	1.67	0.90	0	35.25	0	0	0	1.74
	Total	**57.39 c**	**22.70 c**	**0**	**1263.69 c**	**0**	**0**		**71.72 c**
T_6=50%RDF + RE of 100% TWW	Leaves	43.56	10.58	0	613.59	0	0	0	47.30
	Shoot	29.62	16.30	0	870.72	0	0	0	35.95
	Root	1.83	0.98	0	45.06	0	0	0	1.95
	Total	**75.01 b**	**27.86 b**	**0**	**1529.37 b**	**0**	**0**	**0**	**85.20 b**

Table 4.48. Effect of textile waste water on heavy metal uptake by red amaranth in contaminated soil of Gazipur

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= control	Leaves	2.16	0.77	0	24.68	0	0	0	2.32
	Shoot	1.43	0.64	0	35.32	0	0	0	1.41
	Root	0.22	0.14	0	8.84	0	0	0	0.24
	Total	**3.81 f**	**1.55 f**	**0**	**68.84 f**	**0**	**0**	**0**	**3.97 f**
T_2=100% RDF + RE of 0%TWW	Leaves	56.71	15.32	0	762.41	0	0	0	57.19
	Shoot	31.57	12.99	0	881.58	0	0	0	35.67
	Root	1.87	0.84	0	51.77	0	0	0	1.75
	Total	**90.15 a**	**29.15 a**	**0**	**1695.76 a**	**0**	**0**	**0**	**94.61 a**
T_3=50%RDF + RE of 25% TWW	Leaves	18.00	4.94	0	180.93	0	0	0	18.65
	Shoot	12.28	4.93	0	278.39	0	0	0	12.57
	Root	1.17	0.51	0	39.96	0	0	0	1.18
	Total	**31.45 e**	**10.38 e**	**0**	**499.28 e**	**0**	**0**	**0**	**32.40 e**
T_4=50%RDF + RE of %50 TWW	Leaves	27.54	7.25	0	365.69	0	0	0	28.87
	Shoot	25.94	10.10	0	745.47	0	0	0	29.46
	Root	1.62	0.73	0	49.01	0	0	0	1.55
	Total	**55.10 d**	**18.08 d**	**0**	**1160.17 d**	**0**	**0**	**0**	**59.88 d**
T_5=50%RDF + RE of 75% TWW	Leaves	33.64	8.36	0	430.98	0	0	0	33.45
	Shoot	27.91	10.86	0	721.87	0	0	0	30.65
	Root	1.93	0.83	0	51.88	0	0	0	1.75
	Total	**63.48 c**	**20.05 c**	**0**	**1204.73 c**	**0**	**0**	**0**	**65.85 c**
T_6=50%RDF + RE of 100% TWW	Leaves	44.22	9.52	0	536.05	0	0	0	43.47
	Shoot	37.92	13.20	0	1039.68	0	0	0	38.14
	Root	2.69	0.90	0	74.25	0	0	0	2.02
	Total	**84.83 b**	**23.62 b**	**0**	**1649.98 b**	**0**	**0**	**0**	**83.63 b**

Residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased Fe uptake by red amaranth as compared with control in both contaminated soils. The Fe uptake by each treatment also significantly ($P \leq 0.05$) vary with other treatments. The Fe uptake ranged between 40.42 to 1774.15 gm/ha and 68.84 to 1695.76 gm/ha in contaminated soils of Narayanganj and

Gazipur respectively. The minimum uptake of Fe 40.42 gm/ha and 68.84 gm/ha were found with the treatment T_1 (control) in contaminated soils of Narayanganj and Gazipur. And the maximum uptake of Fe 1774.15 and 1695.76 gm/ha were observed T_2 (100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur. On the basis of Fe uptake by red amaranth the treatments may be arranged in the order of $T_2>T_6>T_5>T_4>T_3>T_1$ for both contaminated soils of Narayanganj and Gazipur.

In both contaminated soils residual effect of textile waste water irrigation significantly ($P \leq 0.05$) increased Mn uptake by red amaranth as compared with control. The Mn uptake by each treatment also significantly ($P \leq 0.05$) vary with other treatments. The Mn uptake ranged at Narayanganj 3.83 to 109.85 gm/ha and 3.97 to 94.61 gm/ha at Gazipur contaminated soil. The lowest uptake of Mn 3.83 and 3.97 gm/ha were found with the T_1 (control) in both contaminated soil of Narayanganj and Gazipur. And the highest uptake of Mn 109.85 and 94.61 gm/ha were observed with T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur. Based on the uptake of Mn by red amaranth the treatments may be arranged in the order of $T_2>T_6>T_5>T_4>T_3>$ for both contaminated soils.

4.2.10. Residual effect of textile waste water on nutrient status of post harvest soil of red amaranth cultivation in different soils

Nutrient status due to residual effect of textile waste water of post harvest soil for red amaranth cultivation in different soils are presented in Tables 4.49 to 4.52. Soil pH, organic matter, N, P, K, S, Ca and Mg were determined after harvest of the amaranth.

4.2.10.1. Residual effect of textile waste water on nutrient status of post harvest soil of red amaranth cultivation in non contaminated soils

Nutrient status of post harvest soil of red amaranth due to residual effect of textile waste water in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.49 and 4.50. In both non contaminated soils the results revealed that pH of the post harvest soil for red amaranth cultivation significantly ($P \leq 0.05$) decreased with increasing the residual effect of concentration of textile waste water irrigation. The pH with different treatments ranged between 6.81 to 6.88 and 5.89 to 6.00 in non contaminated soils of Narayanganj and Gazipur respectively. The highest value of pH 6.88 and 6.00 were found with the T_3 (50% RDF + RE of 25% TWW) and T_1 (control) respectively in non contaminated soil of Narayanganj and Gazipur. And the lowest value of pH 6.81 and 5.89 were found with the T_2 (100% RDF + RE of 0% TWW) in both non contaminated soils of Narayanganj and Gazipur.

In both non contaminated soils when red amaranth cultivated organic matter content of the post harvest soil significantly ($P \leq 0.05$) increased with the residual effect of increasing the concentration of textile waste water irrigation. Organic matter content in all treatments also significantly increased as compared with control in both non contaminated soils. The organic matter content of post harvest soil of different treatments ranged between 2.77 to 2.85 % and 1.75 to 1.86% in non contaminated soils of Narayanganj and Gazipur respectively. The highest organic matter content 2.85 and 1.86% were found with T_6 (50% RDF + RE of 100% TWW), and the lowest organic matter content 2.77 and 1.75% were found with the T_1(control) in both non contaminated soils of Narayanganj and Gazipur.

Nitrogen content of the both post harvest non contaminated soils increased significantly ($P \leq 0.05$) with the increasing residual effect of the concentration of textile waste water irrigation. N content in post harvest soils of all the treatments significantly ($P \leq 0.05$) increased as compared with the control. The N of post harvest soil of different treatments ranged between 0.170 to 0.281 % and 0.120 to 0.162% in non contaminated soils of Narayanganj and Gazipur respectively. The highest nitrogen content 0.281 and 0.162 % were found with T_2(100% RDF + RE of 0% TWW), and the lowest nitrogen content 0.170 and 0.120 % were found with T_1(control) in both non contaminated soils of Narayanganj and Gazipur.

Phosphorus content of the both post harvest non contaminated soils increased significantly ($P \leq 0.05$) with the residual effect of textile waste water irrigation as compared with control. P of post harvest soil in all treatments also significantly varid with each other treatment in both non contaminated soils (except T_4 and T_5 in non contaminated soil of Narayanganj and T_3 and T_5 in non contaminated soil of Gazipur). The P of post harvest soil with different treatments ranged between 6.15 to 7.92 ppm. and 4.15 to 6.10 ppm in non contaminated soil of Narayanganj and Gazipur respectively. The highest content of P 7.92 and 6.10 ppm were found with T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur, respectively.

Table 4.49. Residual effect of textile waste water on nutrient status of post harvest soil for jute leaves cultivation in non contaminated soil of Narayanganj

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.87 ab	2.77 d	0.170 f	6.15 e	15.52 f	0.15 c	4.10 c	1.00 c
T_2=100%RDF + RE of 0%TWW	6.81 c	2.79 c	0.281 a	7.92 a	16.89 a	0.20 a	6.31 a	2.01 a
T_3=50%RDF + RE of 25% TWW	6.88 a	2.81 b	0.211 e	6.97 d	15.92 e	0.17 bc	5.80 b	1.07 ab
T_4=50%RDF + RE of % 50 TWW	6.86 b	2.84 a	0.218 d	7.00 cd	16.10 d	0.18 ab	5.83 b	1.12 ab
T_5=50%RDF + RE of 75% TWW	6.87 ab	2.85 a	0.23 c	7.12 c	16.38 c	0.18 ab	5.89 b	1.23 ab
T_6=50%RDF + RE of 100%TWW	6.87 b	2.85 a	0.275 b	7.26 b	16.67 b	0.19 ab	5.93 b	1.25 b

Table 4.50. Residual effect of textile waste water on nutrient status of post harvest soil for jute leaves cultivation in non contaminated soil of Gazipur

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.00 a	1.75 c	0.120 e	4.15 e	13.64 e	0.53 d	3.52 d	0.75 d
T_2=100%RDF + RE of 0%TWW	5.89 b	1.80 b	0.162 a	6.10 a	15.05 a	0.69 a	3.95 a	0.95 a
T_3=50%RDF + RE of 25% TWW	5.92 b	1.84 a	0.137 d	5.72 c	13.69 de	0.60 c	3.70 c	0.78 c
T_4=50%RDF + RE of % 50 TWW	5.93 b	1.84 a	0.141 c	5.55 d	13.73 d	0.62 c	3.66 c	0.78 c
T_5=50%RDF + RE of 75% TWW	5.93 b	1.85 a	0.149 b	5.70 c	14.22 c	0.66 b	3.70 c	0.79 c
T_6=50%RDF + RE of 100%TWW	5.93 b	1.86 a	0.15 b	5.88 b	14.51 b	0.68 ab	3.75 b	0.87 b

The lowest content of P 6.15 and 4.15 ppm were found with the T_1(control) in both non contaminated soils of Narayanganj and Gazipur.

Sulphur content of the post harvest soil increased significantly ($P \leq 0.05$) with the residual effect of textile waste water irrigation as compared with control in both non contaminated soils. S of post harvest soil in all treatments also significantly varied with each other treatment in both non contaminated soils (except T_3 and T_4 in non contaminated soil of Gazipur). The S of post harvest soil of with different treatments ranged between 15.52 to 16.89 ppm. and 13.64 to 15.05 ppm in non contaminated soils of Narayanganj and Gazipur respectively. The highest content of S 16.89 and 15.05 ppm were found with T_2 (100% RDF + RE of 0% TWW) in non contaminated soils of Narayanganj and Gazipur. The lowest content of S 15.52 and 13.64 ppm were found with T_1(control) in both non contaminated soils of Narayanganj and Gazipur.

In both non contaminated soils K content of post harvest soil increased significantly ($P \leq 0.05$) as compared with control due to residual effect of textile waste water irrigation. The K of post harvest soil with different treatment ranged between 0.15 to 0.20 C mol/kg and 0.53 to 0.69 C mol/kg were observed in non contaminated soils of Narayanganj and Gazipur respectively. The highest value of K 0.20 and 0.69 C mol/kg were found with T_2 (100% RDF + RE of 0% TWW) in both non contaminated soils of Narayanganj and Gazipur. The lowest content of K 0.15 and 0.53 C mol/kg were found with T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. The post harvest soil K content with treatment T_4, T_5 and T_6 in non contaminated soil of Narayanganj did not significantly vary with each other treatment. Similar trend observed in non contaminated soil of Gazipur in T_3 and T_4, which were insignificant.

In both non contaminated soils Ca content of post harvest soil increased significantly ($P \leq 0.05$) as compared with control due to residual effect of textile waste water irrigation. The Ca of post harvest soil with different treatment ranged between 4.10 to 6.31 C mol/kg and 3.52 to 3.95 C mol/kg were observed respectively in non contaminated soils of Narayanganj and Gazipur. The highest value of Ca 6.31 and 3.95 C mol/kg were found with T_2 (100% RDF + RE of 0% TWW) in both non contaminated soils of Narayanganj and Gazipur. The lowest value of Ca 4.10 and 3.52 C mol/kg were found with T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. In both non contaminated soils residual effect of different doses of textile waste water has no significant effect on concentration of Ca in post harvest soils (except T_6 in non contaminated soil of Gazipur).

In both non contaminated soils Mg content of post harvest soil increased significantly ($P \leq 0.05$) as compared with control due to residual effect of textile waste water irrigation. The Mg of post harvest soil with different treatment ranged between 1.00 to 2.01 C mol/kg and 0.75 to 0.95 C mol/kg were observed consequently in non contaminated soils of Narayanganj and Gazipur. The highest value of Mg 2.01 and 0.95 C mol/kg were found with T_2 (100% RDF + RE of 0% TWW) in both non contaminated soils of Narayanganj and Gazipur. The lowest value of Mg 1.00 and 0.75 C mol/kg were found with T_1(control) in non contaminated soils of Narayanganj and Gazipur respectively. In both non contaminated soils residual effect of 25%, 50% and 75% of textile waste water irrigation had no significant effect on concentration of Mg in post harvest soils.

4.2.10.2. Residual effect of textile waste water on nutrient status of post harvest soil of red amaranth cultivation in non contaminated soils

Residual effect of textile waste water on nutrient status of post harvest soil for red amaranth cultivation in contaminated soils of Narayanganj and Gazipur are presented in Tables 4.51 and 4.52. In both contaminated soils the results showed that pH value of the post harvest soil for red amaranth cultivation significantly ($P \leq 0.05$) decreased due to the residual effect of textile waste water irrigation. The pH of post harvest soil with different treatments ranged between 6.88 to 6.95 and 6.53 to 6.67 in contaminated soils of Narayanganj and Gazipur respectively. The highest value of pH 6.95 and 6.67 were found with T_1 (control) in non contaminated soil of Narayanganj and Gazipur. And the lowest value of pH 6.88 and 6.53 were found with the treatment T_2 (100% RDF + RE of 0% TWW) in both contaminated soils of Narayanganj and Gazipur.

Organic matter content of the post harvest soil slightly increased due to the residual effect of increasing the concentration of textile waste water irrigation. Organic matter content in all treatments significantly ($P \leq 0.05$) increased as compared with control in both contaminated soils. The organic matter content of post harvest soil of different treatments ranged between 2.78 to 2.86 % and 2.87 to 2.97 % in contaminated soils of Narayanganj and Gazipur respectively.

Table 4.51. Residual effect of textile waste water on nutrient status of post harvest soil for jute leaves cultivation in contaminated soil of Narayanganj

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.95 a	2.80 c	0.085 c	15.75 e	10.02 f	0.83 d	2.09 e	0.70 e
T_2=100%RDF + RE of 0%TWW	6.88 d	2.78 d	0.099 a	18.52 a	13.05 a	0.97 a	2.90 a	0.92 a
T_3=50%RDF + RE of 25% TWW	6.90 cd	2.82 b	0.094 b	15.17 f	10.92 e	0.88 c	2.51 d	0.75 d
T_4=50%RDF + RE of % 50 TWW	6.91 bc	2.85 a	0.094 b	15.93 d	11.01 d	0.88 c	2.60 c	0.77 cd
T_5=50%RDF + RE of 75% TWW	6.93 ab	2.85 a	0.095 b	16.87 c	12.12 c	0.89 bc	2.83 b	0.79 bc
T_6=50%RDF + RE of 100%TWW	6.93 ab	2.86 a	0.098 a	17.02 b	12.97 b	0.91 b	2.87 ab	0.82 b

Table 4.52. Residual effect of textile waste water on nutrient status of post harvest soil for jute leaves cultivation in contaminated soil of Gazipur

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.67 a	2.87 c	0.120 e	4.07 e	30.00 d	0.40 d	3.92 d	1.12 d
T_2=100%RDF + RE of 0%TWW	6.53 c	2.90 b	0.181 a	4.91 a	31.52 a	0.49 a	4.31 a	1.51 a
T_3=50%RDF + RE of 25% TWW	6.61 b	2.95 a	0.165 d	4.75 d	30.67 c	0.45 c	4.12 c	1.42 c
T_4=50%RDF + RE of % 50 TWW	6.61 b	2.95 a	0.167 cd	4.75 d	30.72 c	0.45 c	4.15 bc	1.45 b
T_5=50%RDF + RE of 75% TWW	6.62 b	2.96 a	0.168 c	4.77 c	30.80 b	0.46 bc	4.13 bc	1.46 b
T_6=50%RDF + RE of 100%TWW	6.62 b	2.97 a	0.173 b	4.84 b	30.84 b	0.47 b	4.16 b	1.47 b

The highest organic matter content 2.86 and 2.97 % were found with T_6 (50% RDF + RE of 100% TWW), and the lowest organic matter content 2.78 and 2.87 % were found with T_1 and T_2 in contaminated soils of Narayanganj and Gazipur, respectively.

Nitrogen content of the both post harvest contaminated soils increased significantly ($P \leq 0.05$) with the increasing residual effect of the concentration of textile waste water irrigation. N content in post harvest contaminated soils of all the treatments significantly ($P \leq 0.05$) increased as compared with the control. The N of post harvest soil of different treatments ranged between 0.085 to 0.099 % and 0.120 to 0.181% in contaminated soils of Narayanganj and Gazipur respectively. The highest N content 0.099 and 0.181 % were found with T_2(100% RDF + RE of 0% TWW), and the lowest nitrogen content 0.085 and 0.120 % were found with T_1(control) in both contaminated soils of Narayanganj and Gazipur.

Phosphorus content of the both post harvest contaminated soils increased significantly ($P \leq 0.05$) with the residual effect of textile waste water irrigation as compared with control. P of post harvest soil in all treatments also significantly varied with each other treatment in both non contaminated soils (except T_3 and T_4 in contaminated soil of Gazipur). The P of post harvest soil with different treatments ranged between 15.17 to 18.52 ppm. and 4.07 to 4.91 ppm in contaminated soils of Narayanganj and Gazipur, respectively. The maximum content of P 18.52 and 4.91 ppm were found with T_2 (100% RDF + RE of 0% TWW) in both contaminated soil of Narayanganj and Gazipur. The minimum content of P 15.17 and 4.07 ppm were found with T_3 (50% RDF + RE of 25% TWW) and T_1(control) respectively in non contaminated soils of Narayanganj and Gazipur.

Sulphur content of the both post harvest contaminated soils increased significantly ($P \leq 0.05$) with the residual effect of textile waste water irrigation as compared with control. S of post harvest soil in all treatments also significantly vary with the treatments in contaminated soil of Narayanganj. But in contaminated soil of Gazipur S content of post harvest soil in T_3 did not significantly varied with T_4, and T_5 did not significantly vary with T_6. The S of post harvest soil of with different treatments ranged between 10.02 to 12.97 ppm. and 30.00 to 31.52 ppm in contaminated soils of Narayanganj and Gazipur respectively. The highest content of S 12.97 and 31.52 ppm were found with T_2 (100% RDF + RE of 0% TWW) in contaminated soils of Narayanganj and Gazipur respectively. The lowest content of S 10.02 and 30.00 ppm were found with T_1(control) in both contaminated soils of Narayanganj and Gazipur.

In both contaminated post harvest soils K increased significantly ($P \leq 0.05$) as compared with control due to residual effect of textile waste water irrigation. The value of K in post harvest soil with different treatment ranged between 0.83 to 0.97 C mol/kg and 0.40 to 0.49 C mol/kg were observed in contaminated soils of Narayanganj and Gazipur respectively. The highest value of K 0.97 and 0.49 C mol/kg were found with T_2 (100% RDF + RE of 0% TWW) in both contaminated soils of Narayanganj and Gazipur. The lowest content of K 0.83 and 0.40 C mol/kg were found with T_1(control) in contaminated soils of Narayanganj and Gazipur respectively . Here post harvest soil K content with T_3 , T_4 and T_5 in both contaminated soils were not found significant.

In both contaminated soils, Ca content of post harvest soil increased significantly ($P \leq 0.05$) as compared with control due to residual effect of textile waste water irrigation. The Ca of post harvest soil with different treatment ranged between 2.09 to 2.90 C mol/kg and 3.92 to 4.31 C mol/kg were observed in contaminated soils of Narayanganj and Gazipur respectively. The highest value of Ca 2.90 and 4.31 C mol/kg were found with T_2 (100% RDF + RE of 0% TWW) in both contaminated soil of Narayanganj and Gazipur. The lowest value of Ca 2.09 and 3.92 C mol/kg were found with T_1(control) in contaminated soils of Narayanganj and Gazipur.It was observed from the result that Ca content in T_5 and T_6 statistically similar in post harvest sample of contaminated soil of Narayanganj. In contaminated post harvest soil of Gazipur the Ca content with T_3 , T_4 and T_5 did not significantly vary with these treatments.

Magnesium content of post harvest soil increased significantly ($P \leq 0.05$) as compared with control due to residual effect of textile waste water irrigation in both contaminated soils. The Mg of post harvest soil with different treatment ranged between 0.70 to 0.92 C mol/kg and 1.12 to 1.51 C mol/kg were observed in contaminated soils of Narayanganj and Gazipur respectively. The highest value of Mg 0.92 and 1.51 C mol/kg were found with T_2 (100% RDF + RE of 0% TWW) in both contaminated soils of Narayanganj and Gazipur. The lowest value of Mg 0.70 and 1.12 C mol/kg were found with T_1(control) in contaminated soils of Narayanganj and Gazipur. The residual effect of 75% and 100% of textile waste water irrigation had no significant effect on concentration of Mg in post harvest soils of Narayanganj. The similar result found in Gazipur contaminated soil where residual effect of 50%, 75% and 100% of textile waste water irrigation had no significant effect on concentration of Mg in post harvest soils.

4.2.11. Residual effect of textile waste water on heavy metal concentration in post harvest soil of red amaranth cultivation in different soils

Residual effect of textile waste water on heavy metal concentration of post harvest soil under red amaranth cultivation in different soils are presented in Tables 4.53 to 4.56. The result revealed that heavy metal concentration in post harvest soil decreased due to fresh water irrigation in control. In treated pots there were also decreased the heavy metal in post harvest soil due to fresh water irrigation but still the value were higher than control due to residual effect of textile waste water irrigation.

4.2.11.1.Residual effect of textile waste water on heavy metal concentration in post harvest soil of red amaranth cultivation in non contaminated soils

Residual effect of textile waste water on heavy metal concentration of post harvest soil for red amaranth cultivation in non contaminated soils of Narayanganj and Gazipur are presented in Tables 4.53 and 4.54.

Concentration of Zn in both post harvest non contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Zn of post harvest soil with different treatment ranged between 1.15 to 1.43 ppm and 0.58 to 0.83 ppm were observed in non contaminated soils of Narayanganj and Gazipur consequently. Highest concentration of Zn in post harvest soil were 1.43 and 0.83 ppm in non contaminated soil of Narayanganj and Gazipur, respectively, which were found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Zn were 1.15 and 0.58 ppm in non contaminated soils of Narayanganj and Gazipur, respectively, which were found with T_1(control). In post harvest non contaminated soil of Narayanganj the value of Zn in T_4, T_5 and T_6 did not significantly vary with each other treatment.

Table 4.53. Residual effect of textile waste water on heavy metal concentration of post harvest soil for red amaranth cultivation in non contaminated soil of Narayanganj

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1= control	1.15 d	0.13 e	26.27 f	43.75 f	0.080 c	25.33 f	8.05 f	9.20 d
T_2=100%RDF + RE of 0% TWW	1.27 c	0.15 d	28.30 a	47.22 c	0.084 b	28.50 c	8.65 d	13.02 b
T_3=50%RDF + RE of 25% TWW	1.36 b	0.16 d	26.59 e	44.10 e	0.088 a	27.21 e	8.50 e	12.47 c
T_4=50%RDF + RE of % 50 TWW	1.40 a	0.18 c	27.00 d	45.27 d	0.088 a	27.55 d	8.77 c	12.77 bc
T_5=50%RDF + RE of 75% TWW	1.41 a	0.20 b	27.32 c	50.55 b	0.089 a	30.33 b	9.20 b	12.92 b
T_6=50%RDF + RE of 100% TWW	1.43 a	0.22 a	28.12 b	55.21 a	0.090 a	32.10 a	10.10 a	13.96 a

Table 4.54. Residual effect of textile waste water on heavy metal concentration of post harvest soil for red amaranth cultivation in non contaminated soil of Gazipur

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1= control	0.58 e	0.64 d	19.17 e	40.31 d	0.041 e	25.40 c	8.44 e	14.36 c
T_2=100%RDF + RE of 0% TWW	0.67 d	0.70 c	19.64 de	42.12 c	0.044 d	26.55 c	8.51 e	17.58 a
T_3=50%RDF + RE of 25% TWW	0.65 d	0.67 cd	20.35 cd	42.50 bc	0.052 c	24.50 c	8.75 d	15.72 b
T_4=50%RDF + RE of % 50 TWW	0.70 c	0.72 bc	20.79 c	44.44 abc	0.053 bc	27.62 bc	9.00 c	16.51 ab
T_5=50%RDF + RE of 75% TWW	0.75 b	0.75 ab	22.50 b	45.70 ab	0.055 b	30.75 ab	9.22 b	17.14 ab
T_6=50%RDF + RE of 100% TWW	0.83 a	0.79 a	23.92 a	47.20 a	0.058 a	30.99 a	10.01 a	17.65 a

Concentration of Cu in both post harvest non contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Cu of post harvest soil with different treatment ranged between 0.13 to 0.22 ppm at Narayanganj and 0.64 to 0.79 ppm at Gazipur were observed in non contaminated soil. Highest concentration of Cu in post harvest soil were 0.22 and 0.79 ppm in non contaminated soils of Narayanganj and Gazipur, respectively, which were found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cu were 0.13 and 0.64 ppm in non contaminated soil of Narayanganj and Gazipur, which were found with T_1(control). In post harvest non contaminated soil of Gazipur the content of Cu in T_5 and T_6 did not significantly vary with each other treatment.

Concentration of Ni in both post harvest non contaminated soils of amaranth possessed significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Ni of post harvest soil with different treatment ranged between 26.27 to 28.30 ppm and 19.17 to 23.92 ppm were observed in non contaminated soils of Narayanganj and Gazipur consequently. Highest concentration of Ni in post harvest soil were 28.30 and 23.92 ppm in non contaminated soil of Narayanganj and Gazipur, found with T_2 (100% RDF + RE of 0% TWW) and T_6 (50% RDF + RE of 100% TWW) respectively. Lowest concentration of Ni were 26.27 and 19.17 ppm in non contaminated soil of Narayanganj and Gazipur respectively, found with T_1(control). In post harvest non contaminated soil of Gazipur the value of Ni in T_3 and T_4 did not significantly vary with each other treatment.

Concentration of Fe in both post harvest non contaminated soils of red amaranth possessed significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Fe of post harvest soil with different treatments ranged between 43.75 to 55.21 ppm and 40.31 to 47.20 ppm were observed in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Fe in post harvest soil were 55.21 and 47.20 ppm in non contaminated soil of Narayanganj and Gazipur, found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Fe were 43.75 and 40.31 ppm in non contaminated soils of Narayanganj and Gazipur, respectively found with the treatment T_1(control). In post harvest non contaminated soil of Gazipur the content of Fe in T_3 , T_4 and T_5 did not significantly vary with in these treatments.

Concentration of Cd in both post harvest non contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Cd of post harvest soil with different treatment ranged 0.080 to 0.090 ppm and 0.041 to 0.058 ppm were observed in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Cd in post harvest soil were 0.090 and 0.058 ppm in non contaminated soils of Narayanganj and Gazipur, which were found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cd were 0.080 and 0.058 ppm in non contaminated soils of Narayanganj and Gazipur respectively, found with T_1(control). In post harvest non contaminated soil of Narayanganj the value of Cd in T_3 , T_4 , T_5 and T_6 did not significantly vary with each other treatment. And in post harvest non contaminated soil of Gazipur the content of Cd in T_4 and T_5 did not significantly vary with each other treatment.

Concentration of Cr in both post harvest non contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Cr of post harvest soil with different treatment ranged between 25.33 to 32.10 ppm and 25.40 to 30.99 ppm were observed in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Cr in post harvest soil were 32.10 and 30.99 ppm in non contaminated soils of Narayanganj and Gazipur sequentially, found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cr were 25.33 and 25.40 ppm in non contaminated soil of Narayanganj and Gazipur respectively, found with T_1(control). In post harvest non contaminated soil of Narayanganj the value of Cr significantly vary with each other treatment. And in post harvest non contaminated soil of Gazipur the value of Cr in T_5 and T_6 statistically similar.

Concentration of Pb in both post harvest non contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Pb of post harvest soil with different treatment ranged between 8.05 to 10.10 ppm and 8.44 to 10.01 ppm were observed in non contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Pb in post harvest soil were 10.10 and 10.01 ppm in non contaminated soils of Narayanganj and Gazipur, respectively, which were found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Pb were 8.05 and 8.44 ppm in non contaminated soil of Narayanganj and Gazipur respectively, which were found with T_1(control). In post harvest non contaminated soil of Narayanganj the value of Pb significantly vary with each other treatment. And in post harvest non contaminated soil of Gazipur the value of Pb in T_1 and T_2 did not significantly varied.

Concentration of Mn in both post harvest non contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Mn of post harvest soil with different treatments ranged between 9.20 to 13.96 ppm and 14.36 to 17.65 ppm were observed in non contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Mn in post harvest soil were 13.96 and 17.65 ppm in non contaminated soils of Narayanganj and Gazipur, found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Mn were 9.20 and 14.36 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which were found with T_1(control). In post harvest non contaminated soil of Narayanganj the value of Mn in T_4 and T_5 did not significantly vary with each other treatment. And in post harvest non contaminated soil of Gazipur the value of Pb in T_3, T_4 and T_5 were not significantly varied among these with treatments.

4.2.11.2. Residual effect of textile waste water on heavy metal concentration in post harvest soil of red amaranth cultivation in contaminated soils

Residual effect of textile waste water on heavy metal concentration of post harvest soil for red amaranth cultivation in contaminated soils of Narayanganj and Gazipur are presented in Tables 4.55 and 4.56.

Concentration of Zn in both post harvest contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Zn of post harvest soil with different treatment ranged between 4.00 to 5.20 ppm and 15.11 to 20.10 ppm were observed in contaminated soils of Narayanganj and Gazipur, respectively. Highest concentration of Zn in post harvest soil were 5.20 and 20.10 ppm consequently in contaminated soils of Narayanganj and Gazipur, found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Zn were 4.00 and 15.11 ppm in non contaminated soils of Narayanganj and Gazipur respectively, which

Table 4.55. Residual effect of textile waste water on heavy metal concentration of post harvest soil for red amaranth cultivation in contaminated soil of Narayanganj

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1= control	4.00 e	0.34 e	22.10 f	214.34 f	0.110 d	30.20 d	15.60 d	10.35 f
T_2=100%RDF + RE of 0% TWW	4.20 d	0.40 c	22.31 e	218.55 e	0.114 c	30.57 d	15.65 d	13.15 e
T_3=50%RDF + RE of 25% TWW	4.22 d	0.37 d	22.72 d	239.33 d	0.117 bc	31.00 c	15.88 c	13.55 d
T_4=50%RDF + RE of % 50 TWW	4.77 c	0.41 c	22.90 c	242.50 c	0.117 bc	31.63 b	16.35 b	14.02 c
T_5=50%RDF + RE of 75% TWW	5.05 b	0.45 b	24.55 b	255.55 b	0.120 ab	31.80 b	16.90 a	14.23 b
T_6=50%RDF + RE of 100% TWW	5.20 a	0.48 a	25.20 a	260.12 a	0.125 a	32.55 a	17.00 a	14.47 a

Table 4.56. Residual effect of textile waste water on heavy metal concentration of post harvest soil for red amaranth cultivation in contaminated soil of Gazipur

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1= control	15.11 f	0.1 5 d	26.50 f	107.50 d	0.122 c	33.21 f	23.80 f	11.02 f
T_2=100%RDF + RE of 0% TWW	16.72 e	0.17 c	27.30 e	110.20 c	0.125 bc	34.28 e	24.05 e	12.81 e
T_3=50%RDF + RE of 25% TWW	17.35 d	0.17 c	27.55 d	111.33 c	0.125 bc	34.50 d	25.33 d	13.62 d
T_4=50%RDF + RE of % 50 TWW	18.25 c	0.19 b	28.77 c	115.50 b	0.126 b	35.10 c	25.79 c	14.10 c
T_5=50%RDF + RE of 75% TWW	19.70 b	0.20 b	30.10 b	117.20 a	0.130 a	35.88 b	26.53 b	14.54 b
T_6=50%RDF + RE of 100% TWW	20.10 a	0.22 a	31.21 a	118.11 a	0.132 a	36.25 a	27.20 a	14.89 a

were found with T_1(control). In post harvest non contaminated soil of Narayanganj the value of Zn in T_2 and T_3 did not significantly vary with each other treatment. And in post harvest contaminated soil of Gazipur the value of Zn significantly vary with each other treatment.

Concentration of Cu in both post harvest contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Cu of post harvest soil with different treatment ranged 0.34 to 0.48 ppm and 0.15 to 0.22 ppm were observed in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cu in post harvest soil were 0.48 and 0.22 ppm in contaminated soils of Narayanganj and Gazipur, found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cu were 0.34 and 0.15 ppm respectively in contaminated soils of Narayanganj and Gazipur, found with the treatment T_1(control). In post harvest contaminated soil of Narayanganj the value of Cu in T_2 and T_4 were found insignificant means similar. And in post harvest contaminated soil of Gazipur the value of Cu in T_4 and T_5 were not significantly varied among these treatments.

Concentration of Ni in both post harvest contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Ni of post harvest soil with different treatment ranged between 22.10 to 25.20 ppm and 26.50 to 31.21 ppm were observed in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Ni in post harvest soil were 25.20 and 31.21 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Ni were 22.10 and 26.50 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with T_1(control). In both post harvest contaminated soil of Narayanganj and Gazipur the value of Ni significantly vary with each other treatment.

Concentration of Fe in both post harvest contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Fe of post harvest soil with different treatments ranged between 214.34 to 260.12 ppm and 107.50 to 118.11 ppm were observed in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Fe in post harvest soil were 260.12 and 118.11 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Fe were 214.34 and 107.50 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with T_1(control). In post harvest contaminated soil of Gazipur the value of Fe in T_2 and T_3 did not significantly different. The content of Fe in T_5 and T_6 displayed almost similar in considering statistic value.

Concentration of Cd in both post harvest contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Cd of post harvest soil with different treatments ranged between 0.110 to 0.125 ppm and 0.122 to 0.132 ppm were observed in contaminated soil of Narayanganj and Gazipur respectively. Highest concentration of Cd in post harvest soil were 0.125 and 0.132 ppm in contaminated soils of Narayanganj and Gazipur, found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cd were 0.110 and 0.122 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the treatment T_1(control). In post harvest contaminated soil of Narayanganj the obtained value of Cd in T_3 , T_4 and T_5 insignificant among these three treatments. Similar result found in post harvest contaminated soil of Gazipur, the value of Cd in T_2, T_3 and T_4 did not significantly vary with each other treatment, beside this T_5 and T_6 also gave closed value which was not significant.

Concentration of Cr in both post harvest contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Cr of post harvest soil with different treatments ranged between 30.20 to 32.55 ppm and 33.21 to 36.25 ppm were found in contaminated soils of Narayanganj and Gazipur respectively. Highest concentration of Cr in post harvest soil were 32.55 and 36.25 ppm in contaminated soils of Narayanganj and Gazipur, found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Cr were 30.20 and 33.21 ppm in contaminated soils of Narayanganj and Gazipur respectively, found with T_1(control). In post harvest contaminated soil of Narayanganj the value of Cr in T_4 and T_5 did not significantly varied with this two treatments. And in post harvest non contaminated soil of Gazipur the value of Cr significantly vary with each other treatment.

Concentration of Pb in both post harvest contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Pb of post harvest soil with different treatments ranged between 15.60 to 17.00 ppm and 23.80 to 27.20 ppm were consequently observed in contaminated soils of Narayanganj and Gazipur. Highest concentration of Pb in post harvest soil were 17.00 and 27.20 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Pb were 15.60 and 23.80 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with T_1(control). In post harvest contaminated soil of Narayanganj the value of Pb in T_5 and T_6 did not significantly vary with each other treatment. And in post harvest non contaminated soil of Gazipur the value of Pb significantly vary with each other treatment.

Concentration of Mn in both post harvest contaminated soils of amaranth remained significantly ($P \leq 0.05$) higher due to the residual effect of textile waste water irrigation as compared with control. The Mn of post harvest soil with different treatments ranged between 10.35 to 14.47 ppm and 11.02 to 14.89 ppm were observed in contaminated soil of Narayanganj and Gazipur respectively. Highest concentration of Mn in post harvest soil were 14.47 and 14.89 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with the residual effect of 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Mn were 10.35 and 11.02 ppm in contaminated soils of Narayanganj and Gazipur respectively, which were found with T_1(control). In both post harvest contaminated soils of Narayanganj and Gazipur the value of Mn significantly varied with each other treatment.

<u>**Field experiment No. 1**</u>

Pictorial view of field experiment No. 1 (Jute)

Field Exp. 1: The field experiment of jute was visited by co-supervisor and supervisor

4.3. Field experiment No. 1:

Influence of textile waste water on yield and heavy metal uptake by jute

4.3.1. Effect of textile waste water on growth and yield of jute

Plant height, base diameter, weight of green plants, fiber and stick yield were measured as yield contributing parameters.

4.3.2. Effect of textile waste water on plant height

The result of plant height (m) with different concentration of waste water irrigation is presented in Figure 4.29. The result showed that T_2(100% RDF + 0% TWW) and T_4 (50% RDF + 50% TWW) performed positive effect on plant height of jute which were significantly ($P \leq 0.05$) varied with other treatments. The tallest plant height (3.7 m), the second tallest plant (3.50 m) were found with $T_2$and T_4 respectively. The lowest plant height (3.0 m)was obtained with T_1(control). It was also observed that application of different combinations of effluent showed a positive (+ve) effect on plant height of jute as compared with control.

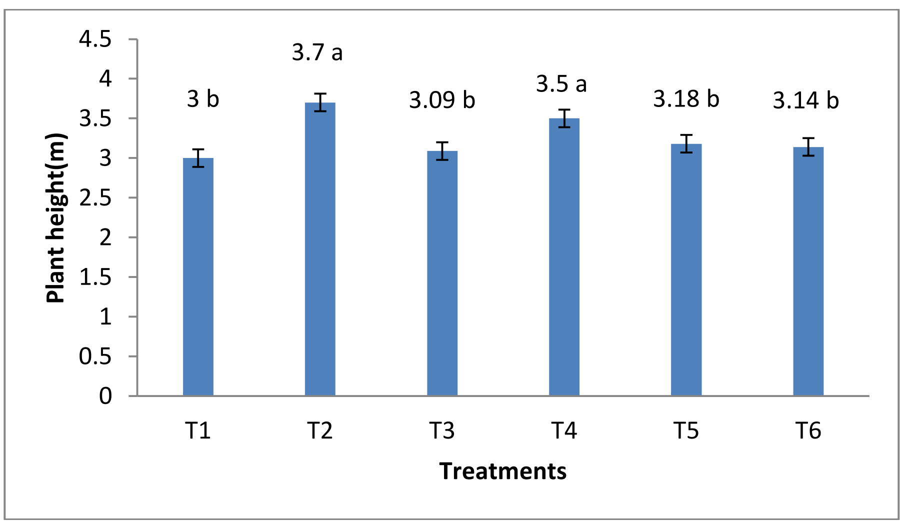

Fig. 4.29. Effect of textile waste water on plant height of jute

4.3.3. Effect of textile waste water on base diameter of jute plant

The base diameter of jute plant (mm) with different concentration of waste water irrigation is presented in Figure 4.30. The results showed that the maximum base diameter (16.17mm) was found with T_2(100% RDF + 0% TWW), which was also significantly ($P \leq 0.05$) varied with other treatments. Here the second highest base diameter of the jute plant (15.27mm) was found with T_4 (50% RDF + 50% TWW), which was also significantly ($P \leq 0.05$) varied with T_1 (control). And the lowest base diameter of the plant (13.47mm) was found with T_3(50% RDF + 25% TWW). The base diameter (14.15 mm) achieved with T_5 (50% RDF + 75% TWW), was also showed significantly varied with the T_1 (control). Application of different combinations of effluent significantly ($P \leq 0.05$) increased the base diameter of the jute plant as compared with control except T_3 (50% RDF + 25% TWW).

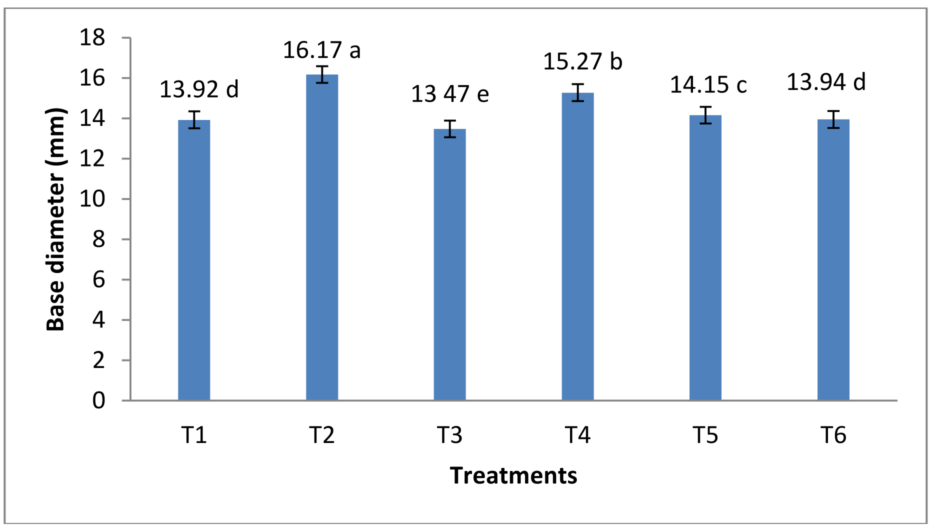

Fig. 4.30. Effect of textile waste water on base diameter of the jute plant

3.3.4. Effect of textile waste water ongreen plants yield with and without leaves

The results of green plants yield with and without leaves of jute with different concentration of waste water irrigation are presented in Figures 4.31 and 4.32. The highest green plants yield with leaves (58.65t/ha) and without leaves (37.46 t/ha) were found with T_4(50% RDF + 50% TWW) which significantly ($P \leq 0.05$) varied with other treatments. The lowest green plants yield with and without leaves were 35.5 and 21.95 t/ha respectively found with T_1 (control). The results of green plants yield with leaves in T_2(100% RDF + 0% TWW) significantly ($P \leq 0.05$) higher than T_1 ,T_3 and T_5. But the results showed that green plants yield without leaves in treatment T_2(100% RDF + 0% TWW) had no significant difference with the achievement of T_4 ,T_5 and T_6. The results also reflected that leaves yield significantly ($P \leq 0.05$) increased with different doses of textile waste water irrigation as compared with T_1 (control).

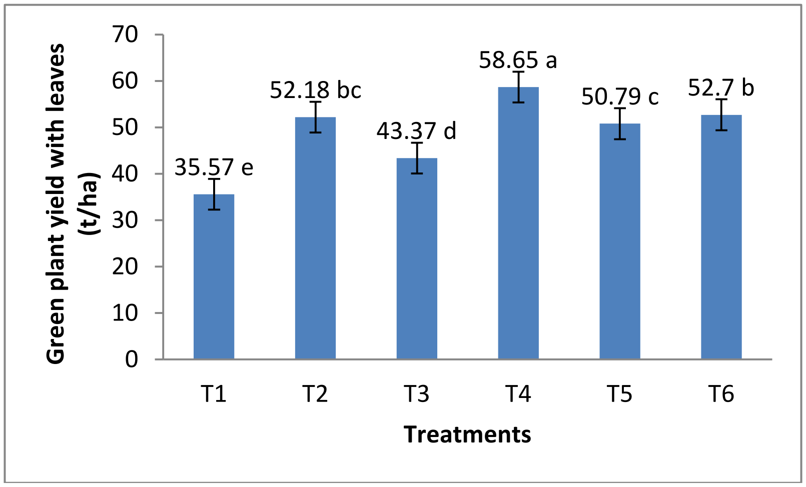

Fig. 4.31. Effect of textile waste water on green plant yield with leaves

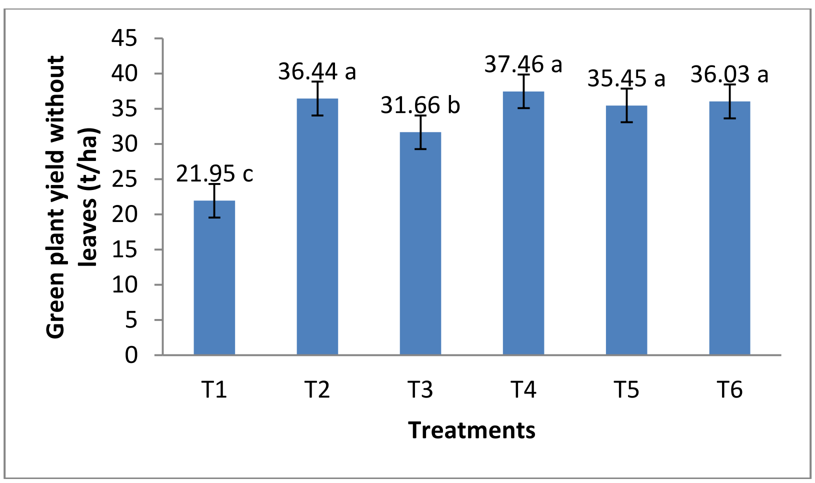

Fig. 4.32. Effect of textile waste water on green plant yield without leaves

4.3.5. Effect of textile waste water on fiber and stick yield

Effect of textile waste water on fiber and stick yield of jute are shown in Figures 4.33 and 4.34. It showed that irrigation of different doses of textile waste water, significantly increased both fiber and stick yield as compared with T_1 (control). In producing the yield of fiber there were no significant treatment difference between T_2(100% RDF + 0% TWW),T_4(50% RDF + 50% TWW) and T_5(50% RDF + 75% TWW).The results indicated that 50% and 75% textile waste water combined with 50% RDF may produce targeted yield which found with 100% RDF generally.

The highest yield of fiber was (2.87 t/ha) found with T_2(100% RDF + 0% TWW). And the second highest yield of fiber was (2.84 t/ha) found with T_4 (50% RDF + 50% TWW). The lowest yield of fiber was 2.02 t/ha, which was found with the treatment T_1 (control). Heihest stick yield 6.2 t/ha was recorded in T_2(100% RDF + 0% TWW) and significantly ($P \leq 0.05$) higher than other treatments. The second highest stick yield (5.94 t/ha) was found with T_4 (50% RDF + 50% TWW).The lowest yield of stick was (4.37 t/ha) found with T_1 (control).

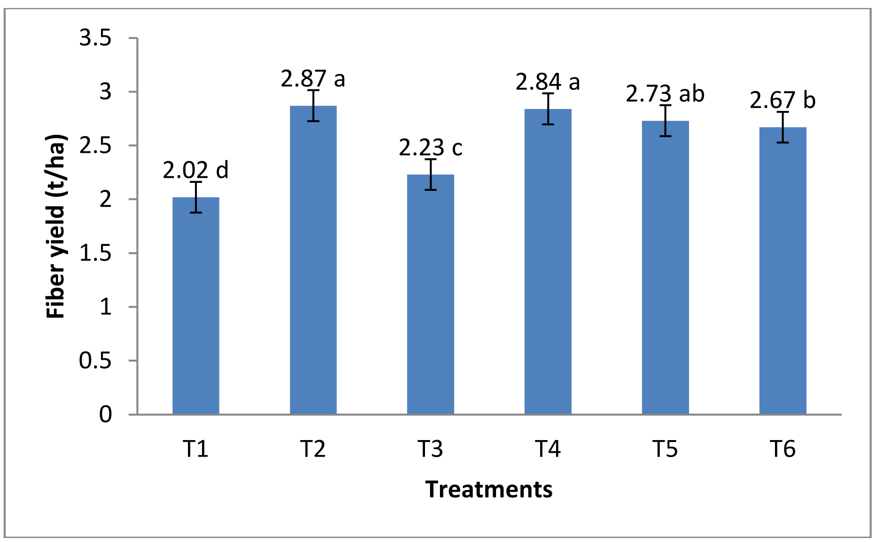

Fig. 4.33. Effect of textile waste water on fiber yield of jute

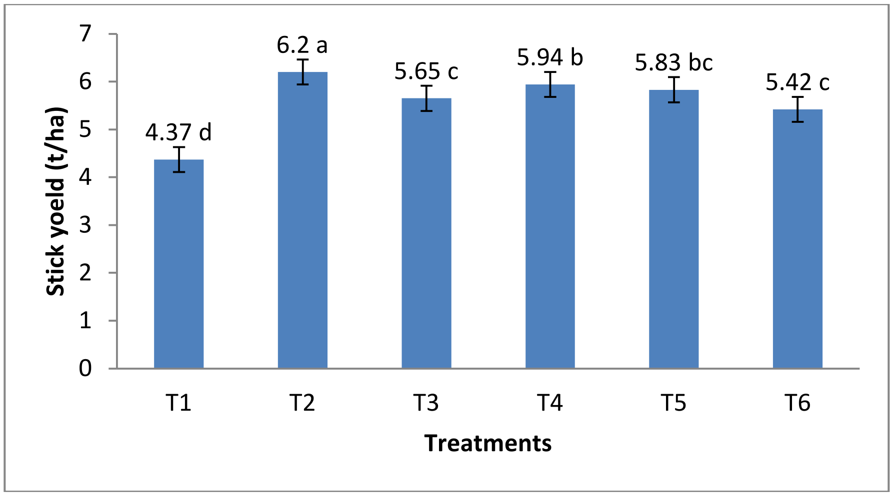

Fig. 4.34. Effect of textile waste water on stick yield of jute

4.3.6. Effect of textile waste water on dry matter production of jute

There were significant effect of textile waste water on dry matter production of jute (Table 4.57). The textile waste water enhanced total fresh yield as well as total dry matter yield significantly ($P \leq 0.05$) over control. Highest amount of total fresh (66.43 t/ha) and dry matter yield (12.95 t/ha) were obtained with T_2(100% RDF + 0% TWW). Considering the production of total fresh

Table 4.57. Effect of textile waste water on dry matter production of jute

Treatment	Green weight of 5 plants /plot (gm)			Oven dry weight of 5 plants/plot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)	Total fresh weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R	L+S+R
T_1	130.25	352.94	103.11	46.36	155.99	33.92	1.46	4.93	1.07	7.46 f	37.48 f
T_2	320.00	680.00	193.98	102.40	296.48	66.40	2.85	8.25	1.85	12.95 a	66.43 a
T_3	134.61	394.23	108.01	46.70	174.24	34.56	1.71	6.36	1.26	9.33 e	46.52 e
T_4	269.60	661.76	185.60	90.85	291.83	60.87	2.55	8.20	1.71	12.46 b	62.77 b
T_5	301.98	589.10	125.37	99.65	262.14	41.37	2.97	7.82	1.23	12.02 c	60.68 c
T_6	160.19	537.96	127.03	53.66	220.54	40.12	1.94	7.99	1.45	11.38 d	59.79 d

(62.77 t/ha) and total dry matter yield (12.46 t/ha) with T_4 (50% RDF + 50% TWW) could be ranked in second position. All the treatments showed the increased rate of fresh and dry matter yield than control. Total fresh yield (37.48 t/ha) and total dry matter yield (7.46 t/ha) were found lowest in T_1 (control). Dry matter yield was increased, maximum 73.59% with T_2 and second highest 67.02% found with T_4 over control.

4.3.7. Effect of textile waste water on nutrient content in different parts of jute

Effect of textile waste water on nutrient content in different parts of jute plant is presented in Table 4.58. Nutrient content of N, P, K, S, Ca and Mg found maximum in leaves, thereafter in shoots and minimum with roots (Table 4.58).The nutrient content of N of jute leaves varied between 2.09 to 2.47%. Highest N content in leaves 2.47% was observed in T_2(100% RDF + 0% TWW) and the lowest N 2.09% was observed with T_1(control). The nutrient content of N of shoot varies between 0.81 to 0.86%. Highest N content in shoot 0.86% was observed in T_2(100% RDF + 0% TWW) and the lowest 0.81% with T_1(control). The content of N of root varied 0.41 to 0.45%. Highest N content in root 0.45% was observed in T2(100% RDF + 0% TWW) and T6(50% RDF + 100% TWW), and the lowest 0.41% with T1(control).

The nutrient content P of jute leaves varied between 0.32 to 0.36%. Highest P content in leaves 0.36% was observed in T4(50% RDF + 50% TWW) and the lowest P content 0.32% was observed with T1(control). The nutrient content of P of shoot varied between 0.17 to 0.20%. Highest content of P in shoot 0.20% was observed in T6(50% RDF + 100% WW) and the lowest P content 0.17% with T1 (control) and T3 (50% RDF + 100% TWW). The nutrient content of P of root varied within 0.09 to 0.15%. Highest P content in root 0.15% was observed in T2(100% RDF + 0% TWW) and T4(50% RDF + 50% TWW). The lowest P content 0.09 % was observed with T1(control).

The nutrient content K in jute leaves varied ranges 2.49 to 2.91%. K content in leaves 2.91% was observed highest in T5(50% RDF + 75% TWW) and the lowest K content 2.49% with T3(50% RDF + 25% TWW). The nutrient content of K of shoot varied between 0.79% to 1.15%. Highest K content in shoot 1.15% was observed in T2(100% RDF + 0% TWW) and the lowest 0.17% with T1(control). The nutrient content of K of root varied between 0.56% to 0.72%. Highest K content in root 0.72% was observed in T_4(50% RDF + 50% TWW). The lowest K content 0.56% was observed with T_1 (control).

Table 4.58. Effect of textile waste water on nutrient content in different parts of jute plant

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	2.09	0.32	2.56	0.059	0.125	0.152
	Shoot	0.81	0.17	0.79	0.042	0.039	0.040
	Root	0.41	0.09	0.56	0.030	0.016	0.019
T_2= 100% RDF + 0% TWW	Leaves	2.47	0.35	2.66	0.070	0.127	0.157
	Shoot	0.86	0.18	1.15	0.051	0.041	0.041
	Root	0.45	0.15	0.63	0.035	0.016	0.020
T_3=50%RDF + 25% TWW	Leaves	2.12	0.33	2.49	0.061	0.124	0.153
	Shoot	0.83	0.17	0.91	0.044	0.036	0.039
	Root	0.42	0.12	0.70	0.032	0.015	0.017
T_4=50%RDF + 50% TWW	Leaves	2.34	0.36	2.61	0.067	0.128	0.155
	Shoot	0.86	0.19	1.08	0.061	0.037	0.040
	Root	0.43	0.15	0.72	0.037	0.017	0.02
T_5=50%RDF + 75% TWW	Leaves	2.17	0.34	2.91	0.076	0.127	0.154
	Shoot	0.84	0.18	1.31	0.053	0.038	0.04
	Root	0.44	0.13	0.75	0.037	0.014	0.02
T_6=50%RDF + 100% TWW	Leaves	2.14	0.34	2.47	0.065	0.123	0.153
	Shoot	0.85	0.20	1.00	0.041	0.040	0.042
	Root	0.45	0.13	0.71	0.035	0.015	0.021

The nutrient content of S in jute leaves varied between 0.059% to 0.076%. Highest S content in leaves 0.076% was observed in T_5(50% RDF + 75% TWW) and the lowest S content 0.059% with T_1(control). The nutrient content of S in shoot ranged 0.041 to 0.061%. Highest S content in shoot 0.061% was observed in T_4(50% RDF + 50% TWW) and the lowest Scontent 0.041% was with T_6(50% RDF + 100% TWW). The nutrient content of S of root varies between 0.03 to 0.037%. Highest S content in root 0.037% was observed in treatment T5(50% RDF + 75% TWW). The lowest S content 0.03 % was observed with T1 (control).

The Ca in jute leaves varied between 0.123 to 0.128%. Highest Ca content in leaves 0.128% was found with T_4(50% RDF + 50% TWW). The lowest Ca content 0.123% was observed with T_6(50% RDF + 100% TWW). Ca in shoot found ranged 0.036 to 0.041%. Highest Ca content in shoot 0.041% was observed in T_2(100% RDF + 0% TWW) and the lowest 0.036% with T_3(50% RDF + 25% TWW). Ca of root varied between 0.015 to 0.017%. Highest Ca content in root 0.017% was observed in T_4(50% RDF + 50% TWW). The lowest Ca content 0.015 % was with T_3(50% RDF + 25% TWW) and T_6(50% RDF + 100% TWW).

Mg in jute leaves varied between 0.152 to 0.157%. Highest Mg content in leaves 0.157% obtained in T_2(100% RDF + 0% TWW) and the lowest 0.152% with T_1(control). The nutrient content of Mg in shoot varies between 0.039 to 0.042%. Highest Mg content in shoot 0.042% was observed in T_6(50% RDF + 25% TWW). The lowest Mg content in shoot 0.039% was observed with T_3(50% RDF + 25% TWW). Mg in root varies between 0.017 to 0.021%. Highest Mg content in root 0.021% was observed in T_6(50% RDF + 75% TWW) and the lowest Mg 0.017% with T_3 (50% RDF + 25% TWW).

4.3.8. Effect of textile waste water on nutrient uptake by jute

Effect of textile waste water on nutrient uptake in different parts of jute plant is presented in table 4.59. The nutrients uptake due to textile waste water irrigation increased significantly ($P \leq$ 0.05)as compared to control. Considerable nutrients were taken up by the treatments. The N uptake by each treatment significantly varied. The N uptake ranged 150.95 to 335.65 kg/ha. The highest uptake of N (335.65 kg/ha) was observed with T_2(100% RDF + 0% TWW) and the second highest uptaken of N (308.47 kg/ha) with the T_4(50% RDF + 50% TWW). The lowest uptake of N (150.95 kg/ha) was found with T_1 (control).

The P uptake by each treatment also significantly ($P \leq$ 0.05) varied among the treatments. The P uptake ranges 28.26 to 61.90 kg/ha. The highest uptake of P (61.90 kg/ha) was observed with T_2(100% RDF + 0% TWW) and the next highest uptake of P (61.28 kg/ha) was with T_4(50% RDF + 50% TWW). The lowest uptake of P (28.26 kg/ha) found with T_1 (control).

Table 4.59 : Effect of textile waste water on nutrient uptake in different parts of jute plant

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	61.66	9.44	60.77	1.74	3.69	4.48
	Shoot	80.43	16.88	78.44	4.17	3.87	4.17
	Root	8.86	1.94	12.10	0.65	0.35	0.41
	Total	**150.95 f**	**28.26 f**	**151.31 f**	**6.56 f**	**7.91 b**	**9.06 e**
T_2=100% RDF + 0% TWW	Leaves	157.83	22.37	144.41	4.47	8.12	10.03
	Shoot	159.19	33.32	212.87	9.44	7.59	7.59
	Root	18.63	6.21	26.08	1.45	0.66	0.83
	Total	**335.65 a**	**61.90 a**	**383.36 b**	**15.36 b**	**16.37 a**	**18.45 a**
T_3=50%RDF +25% TWW	Leaves	62.54	9.74	73.46	1.80	3.66	4.51
	Shoot	91.30	18.70	100.10	4.84	3.96	4.29
	Root	9.16	2.62	15.26	0.70	0.33	0.37
	Total	**163.00 e**	**31.06 e**	**188.82 e**	**7.34 e**	**7.95 b**	**9.17 d**
T_4=50%RDF +%50 TWW	Leaves	133.85	20.59	132.13	3.83	7.32	8.87
	Shoot	158.15	34.94	198.61	11.22	6.80	7.36
	Root	16.47	5.75	27.58	1.42	0.65	0.77
	Total	**308.47 b**	**61.28 b**	**358.32 c**	**16.47 a**	**14.77 a**	**17.00 b**
T_5=50%RDF +75% TWW	Leaves	68.34	11.39	82.75	2.18	8.05	9.76
	Shoot	126.57	29.78	148.90	6.10	6.34	6.67
	Root	11.75	3.39	18.53	0.91	1.05	0.53
	Total	**206.66 c**	**44.56 d**	**250.18 d**	**9.19 c**	**15.44 a**	**16.96 b**
T_6=50%RDF +100% TWW	Leaves	137.58	21.56	184.49	4.82	4.12	5.13
	Shoot	140.11	30.02	218.51	8.84	5.96	6.25
	Root	11.57	3.42	19.73	0.97	0.39	0.55
	Total	**289.26 d**	**55.00 c**	**422.73 a**	**14.63 d**	**10.47 b**	**11.93 c**

The K uptake by each treatment significantly ($P \leq 0.05$) varied with the treatments. The K uptake ranges were 151.31 to 422.73 kg/ha. The highest uptake of K (422.73 kg/ha) was observed with treatment T_6(50% RDF + 100% TWW) and the second highest uptake of K (383.36 kg/ha) was observed with T_2(100% RDF + 0% TWW) and the lowest uptake of K (151.31 kg/ha) with T_1 (control).

The S uptake by each treatment significantly ($P \leq 0.05$) varied with the treatments. The S uptake ranges between 6.56 to 16.47 kg/ha. The highest uptake of K (16.47 kg/ha) was observed with T_4(50% RDF + 50% TWW) and T_2(100% RDF + 0% TWW) possessed second for uptake of S (15.36 kg/ha). The lowest uptake of S (6.56 kg/ha) was found with the treatment T_1 (control).

The Ca uptake by T_2 , T_4 and T_5 significantly ($P \leq 0.05$) differed with T_1 ,T_3 and T_6. The Ca uptake ranges were 7.91 to 16.37 kg/ha. The highest uptake of Ca (16.37 kg/ha) was observed with T_2(100% RDF + 0% TWW) and the second highest uptake position of Ca (15.44 kg/ha) was with T_5(50% RDF + 75% TWW). The lowest uptake of Ca (7.91 kg/ha) was found with T_1 (control).

The uptake of Mg increased significantly ($P \leq 0.05$) in all treatments as compared with control. The ranges were 9.06 to 18.45 kg/ha. The highest uptake of Mg (18.45 kg/ha) was with T_2(100% RDF + 0% TWW) and the second highest uptake of Mg(17.00 kg/ha) with T_4(50% RDF + 50% TWW) respectively. The lowest uptake of Mg (9.06 kg/ha) was found with T_1 (control).

4.3.9. Effect of textile waste water on heavy metal concentration in different parts of jute

Effect of textile waste water on heavy metal concentration in different parts of jute is presented in Table 4.60. Heavy metal concentration in jute plant increased with increased level of textile waste water irrigation. Zn concentration in leaves vary from 50.04 to 55.66 ppm. Highest concentration of Zn in jute leaves was (55.66 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest (50.04 ppm) with T_1 (control). Zn concentration in shoot vary from 14.1 to 16.32 ppm. Highest concentration of Zn in jute shoot was (16.32 ppm) observed with T_1(control) and lowest concentration of Zn in jute shoot (14.1 ppm) was observed with T_3 (50% RDF + 25% TWW). Zn concentration in root vary from 6.55 ppm to 7.05 ppm. Highest concentration of Zn in jute root was (7.05 ppm) observed with the treatment T_1(control) and lowest concentration of Zn in jute shoot (6.55 ppm) was observed with treatment T_2 (100% RDF + 0% TWW). Among the treatments sequence of Zn concentration in jute leaves was $T_6>T_5>T_4>T_2>T_1>T_3$,in shoot $T_1>T_4>T_2>T_6>T_5>T_3$ and in root $T_1>T_6>T_5>T_4>T_3>T_2$.

Increasing the concentration of textile waste water irrigation increased Cu content in leaves. Cu concentration in leaves was varied from 7.71 to 10.42 ppm. Highest concentration of Cu in jute leaves was (10.42 ppm) observed with T_6(50% RDF + 100% TWW) and lowest concentration of Cu (7.71 ppm) with T_3 (50% RDF + 25% TWW). The concentration of Cu in jute shoot varied from 2.27 to 4.11 ppm. Highest concentration of Cu in jute shoot (4.11 ppm) was observed with T_6(50% RDF + 100% TWW) and lowest concentration (2.27 ppm) with T_1 (control). In jute root Cu concentration found with range from 1.03 to 2.00 ppm. Highest concentration of Cu in root (2.00 ppm) was with T_6(50% RDF + 100% TWW) and lowest (1.03 ppm) with T_1(control).

Table 4.60: Effect of textile waste water on heavy metal concentration in different parts of jute

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= (control)	Leaves	50.04	7.81	0.101	304.87	ND	0.141	ND	25.35
	Shoot	16.32	2.27	0.043	117.37	ND	0.030	ND	8.77
	Root	7.05	1.03	0.011	62.11	ND	0.011	ND	4.02
T_2= 100% RDF + 0% TWW	Leaves	52.35	7.91	0.110	407.41	ND	0.143	ND	29.39
	Shoot	15.65	3.20	0.049	184.95	ND	0.031	ND	9.00
	Root	6.55	1.73	0.012	76.53	ND	0.010	ND	4.21
T_3=50%RDF + 25% TWW	Leaves	43.79	7.71	0.105	385.91	ND	0.140	ND	26.85
	Shoot	14.10	3.21	0.052	196.11	ND	0.032	ND	10.33
	Root	6.70	1.58	0.011	85.55	ND	0.010	ND	4.75
T_4=50%RDF +50% TWW	Leaves	53.36	10.22	0.121	645.26	ND	0.155	ND	30.75
	Shoot	16.23	4.07	0.055	221.30	ND	0.034	ND	12.42
	Root	6.72	1.94	0.014	97.35	ND	0.012	ND	5.22
T_5=50%RDF + 75% TWW	Leaves	54.52	8.93	0.120	676.3	ND	0.161	ND	29.04
	Shoot	15.02	3.04	0.053	256.25	ND	0.045	ND	12.01
	Root	6.91	1.85	0.011	100.00	ND	0.022	ND	5.86
T_6=50%RDF +100% TWW	Leaves	55.66	10.42	0.123	828.95	ND	0.164	ND	38.51
	Shoot	15.19	4.11	0.050	283.32	ND	0.050	ND	12.53
	Root	7.00	2.00	0.012	103.32	ND	0.023	ND	5.88

Among the treatments Cu concentration can be arranged in the sequence of (1) in jute leaves T_6>T_4>T_5>T_2>T_1>T_3, (2) in shoots T_6>T_4>T_3>T_2>T_5>T_1 and (3) in roots T_6>T_4>T_5>T_2>T_3>T.

Results showed (table 4.3.3) that there were found slight Ni content in leaves, shoots and roots of jute, through textile waste water applied as irrigation which remain below critical level.Ni concentration in leaves varied from 0.101 to 0.123 ppm. Highest concentration of Ni in jute leaves was (0.123 ppm) with T_6(50% RDF + 100% TWW) and lowest (0.101 ppm) with T_1(control). Ni concentration in jute shoot varied from 0.043 to 0.055 ppm. Highest concentration of Ni in jute shoot was (0.055 ppm) observed with T_4(50% RDF + 50% TWW) and lowest in jute shoot (0.043 ppm) found with T_1 (control). In jute root Ni concentration vary from 0.011 to 0.014 ppm. Highest concentration of Ni in jute root was (0.014 ppm) with T_4(50% RDF + 50% TWW) and lowest concentration of Ni (0.011ppm) was with T_1(control).Among the treatments sequence of Ni concentration in jute leaves was T_6>T_4>T_5>T_2>T_3>T_1 , in shoot T_4>T_5>T_3>T_6>T_2>T_1 and in root T_4>T_6 ,T_2>T_5,T_1 ,T_2respectively.

Fe content in jute leaves increased with the concentration of textile waste water irrigation increased. Fe concentration in leaves range from 304.87 ppm to 828.95 ppm. Highest concentration of Fe in jute leaves was (828.95 ppm) observed with T_6(50% RDF + 100% TWW) and lowest concentration of Fe in jute leaves (304.87 ppm) with T_1 (control). The range of Fe concentration in jute shoot found 117.37 to 283.32 ppm. Highest concentration of Fe in jute shoot was (283.32 ppm) observed with T_6(50% RDF + 100% TWW) and lowest concentration of Fe in jute shoot (117.37 ppm) was observed with T_1 (control). In jute root Fe concentration varied from 62.11 ppm to 103.32 ppm. Highest concentration of Fe in jute root was (103.32 ppm) observed with T_6(50% RDF + 100% TWW) and lowest concentration of Fe in jute root (62.11 ppm) with T_1(control). Among the treatments sequence of Fe concentration in jute leaves was T_6>T_5>T_4>T_2>T_3>T_1 , in shoot T_6>T_5>T_4>T_3>T_2>T_1 and in root T_6>T_5>T_4>T_3>T_2>T_1.

Cr content in jute leaves increased with the concentration of textile waste water irrigation increased. Cr concentration in leaves ranged from 0.141 ppm to 0.164 ppm. Highest concentration of Cr in jute leaves was (0.164 ppm) observed with T_6(50% RDF + 100% TWW) and lowest (0.141 ppm) with T_1 (control).The concentration of Cr in jute shoot found 0.03 to 0.05 ppm. Highest concentration of Cr in jute shoot was (0.05 ppm) observed with T_6(50% RDF + 100% TWW) and lowest concentration of Cr in jute shoot (0.03 ppm) with T_1 (control). In jute root Cr concentration varied from 0.010 to 0.023 ppm. Highest concentration of Cr in jute root was (0.023 ppm) observed with T_6(50% RDF + 100% TWW) and lowest concentration of Cr in jute root (0.010 ppm) was with T_2 (100% RDF + 0% TWW). The treatments sequence of Cr concentration can be arranged as in jute leaves $T_6>T_5>T_4>T_3>T_2>T_1$, in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_1>T_2$, T_3.

As the rate of textile waste water irrigation increased, the Mn concentration in jute leaves also increased. The range of Mn concentration in leaves from 25.35 to 38.51 ppm. Highest concentration of Mn in jute leaves was (38.51 ppm) observed with T_6(50% RDF + 100% TWW) and lowest concentration of Mn in jute leaves (25.35 ppm) was T_1 (control). Mn concentrations in jute shoot varied from 8.77 to 12.53 ppm. Highest concentration of Mn in jute shoot was (12.53 ppm) observed with T_6(50% RDF + 100% TWW) and lowest concentration of Mn in jute shoot (8.77 ppm) was with T_1 (control). In jute root Mn concentration vary from 4.02 to 5.88 ppm. Highest concentration of Mn in jute root was (5.88 ppm) observed with T_6(50% RDF + 100% TWW) and lowest concentration of Mn in jute root (4.02 ppm) was with T_1 (control). According to Mn concentration of the treatments can be arranged in the sequence such as : leaves $T_6>T_4>T_1>T_5>T_3>T_1$, in shoot $T_6>T_4>T_5>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_3>T_2>T_1$.

On the basis of heavy metal concentration in jute plant, it canbe arranged as follows Fe>Zn>Mn>Cu>Cr>Ni. The heavy metal Cd and Pb were not in detectable level in the jute plant.

4.3.10. Effect of textile waste water on heavy metal uptake by jute

Effect of textile waste water on heavy metal uptake by different parts of jute plant is presented in Table 4.61. Results showed that Cd and Pb were not up taken by jute plants.

The Zn uptake by each treatment significantly ($P \leq 0.05$) varied with the treatments. The Zn uptake ranges between 298.89 to 651.32 gm/ha. The lowest uptake of Zn (298.89 gm/ha) was found with T_3(50% RDF + 25% TWW) and the highest uptake of Zn (651.32 gm/ha) was observed with T_2(100% RDF + 0% TWW).

Table 4.61: Effect of textile waste water on heavy metal uptake in different parts of jute plant

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	**Cu**	**Ni**	**Fe**	**Cd**	**Cr**	**Pb**	**Mn**
T_1= control	Leaves	147.62	23.04	0.30	899.37	0	0.42	0	74.78
	Shoot	162.06	22.54	0.43	1165.48	0	0.30	0	87.09
	Root	15.23	2.22	0.02	134.16	0	0.02	0	8.68
	Total	**324.91 e**	**47.80 f**	**0.75 e**	**2199.00 e**	**0**	**0.74 d**	**0**	**170.55 f**
T_2=100%RDF + 0%TWW	Leaves	334.52	50.54	0.70	2603.35	0	0.91	0	187.80
	Shoot	289.68	59.23	0.91	3423.42	0	0.57	0	166.59
	Root	27.12	7.16	0.05	316.83	0	0.04	0	17.43
	Total	**651.32 a**	**116.93 c**	**1.66 b**	**6343.60 c**	**0**	**1.52 b**	**0**	**371.82 c**
T_3=50%RDF + 25% TWW	Leaves	129.18	22.74	0.31	1138.43	0	0.41	0	79.21
	Shoot	155.10	35.31	0.57	2157.21	0	0.35	0	113.63
	Root	14.61	3.44	0.02	186.50	0	0.02	0	10.36
	Total	**298.89 f**	**61.49 e**	**0.90 d**	**3482.14 d**	**0**	**0.78 d**	**0**	**203.20 e**
T_4=50%RDF + % 50 TWW	Leaves	305.22	58.46	0.69	3690.89	0	0.89	0	175.89
	Shoot	298.47	74.85	1.01	4069.71	0	0.63	0	228.40
	Root	25.74	7.43	0.05	372.85	0	0.05	0	19.99
	Total	**629.43 b**	**140.74 a**	**1.75 a**	**8133.45 b**	**0**	**1.57 b**	**0**	**424.28 b**
T_5=50%RDF + 75% TWW	Leaves	182.64	29.92	0.40	2265.61	0	0.54	0	97.28
	Shoot	223.65	45.27	0.79	3815.56	0	0.67	0	178.83
	Root	18.04	4.83	0.03	261.00	0	0.06	0	15.29
	Total	**424.33 d**	**80.02 d**	**1.22 c**	**6342.17 c**	**0**	**1.27 c**	**0**	**291.40 d**
T_6=50%RDF + 100%TWW	Leaves	352.88	66.06	0.78	5255.54	0	1.04	0	244.15
	Shoot	253.37	68.55	0.83	4725.78	0	0.83	0	209.00
	Root	18.41	5.26	0.03	271.73	0	0.06	0	15.46
	Total	**624.66 c**	**139.87 b**	**1.64 b**	**10253.05 a**	**0**	**1.93 a**	**0**	**468.61 a**

The uptake of Cu by each treatment significantly ($P \leq 0.05$) increased as compared with control. The Cu uptake ranges 47.80 to 140.74 gm/ha. The lowest uptake of Cu (47.80 gm/ha) was found with T_1 (control) and the highest uptake of Cu (140.74 gm/ha) was observed with T_4 (50% RDF + 50% TWW).

The Ni uptake by each treatment significantly ($P \leq 0.05$) increased as compared with control. The uptake ranges between 0.75 to 1.75 gm/ha. The lowest uptake of Ni (0.75 gm/ha) was found with T_1 (control) and the highest uptake of Ni (1.75 gm/ha) was observed with T_4 (50% RDF + 50% TWW).

The Fe uptake by each treatment significantly ($P \leq 0.05$) increased as compared with control. The Fe uptake ranges between 2199.00 to 10253.05 gm/ha. The lowest uptake of Fe (2199.008 gm/ha) was found with T_1 (control) and the highest uptake of Fe (10253.05 gm/ha) was observed with T_6 (50% RDF + 100% TWW).

The Cr uptake by each treatment significantly ($P \leq 0.05$) increased as compared with control except T_3 . The Cu uptake ranges between 0.74 to 1.93 gm/ha. The lowest uptake of Cu (0.74 gm/ha) was found with T_1 (control) and the highest uptake of Cu (1.93 gm/ha) was observed with T_6 (50% RDF + 100% TWW).

The Mn uptake by each treatment significantly ($P \leq 0.05$) increased as compared with control. The Mn uptake ranges between 170.55 to 468.61 gm/ha. The lowest uptake of Mn (170.55 gm/ha) was found with the T_1 (control) and the highest uptake of Mn (468.61 gm/ha) was observed with T_6 (50% RDF + 100% TWW).

4.3.11. Effect of textile waste water on nutrient status of post harvest soil of jute

Effect of textile waste water on average nutrient status of post harvest soil for jute cultivation is presented in Table 4.62. Soil pH, organic matter, N, P, K, S, Ca and Mg were determined after harvest of jute crops. The result revealed that pH of the soil slightly increased with the increasing the concentration of textile waste water irrigation, which did not significantly vary as compared with each other treatments.The average pHof different treatments ranges between 6.32 to 6.37. The highest value of pH 6.37 was found with the treatment T_6 (50% RDF + 100% TWW), and the lowest value of pH was found with T_2 (100% RDF + 0% TWW).

The organic matter content of post-harvest soil increased with the increasing rate of the textile waste water irrigation. The organic matter content of post harvest soil of different treatments ranges 2.42 to 2.68%. Results showed that organic matter obtained higher in post harvest soils with T_4(50% RDF + 50% TWW), T_5(50% RDF + 75% TWW) and T_6 (50% RDF + 100% TWW) significantly ($P \leq 0.05$) higher than T_1 (control).The highest organic matter (2.68%) was found with T_6 (50% RDF + 100% TWW), and the lowest (2.42%) was with T_1(control).

Table 4.62: Effect of textile waste water on nutrient status of post harvest soil of jute cultivation

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.33 a	2.42 d	0.120 d	24.03 f	29.10 e	0.31 c	3.29 d	0.94 b
T_2=100%RDF + 0%TWW	6.32 a	2.43 cd	0.202 b	25.80 d	29.77 c	0.42 a	3.35abc	0.97 a
T_3=50%RDF + 25% TWW	6.35 a	2.45 cd	0.124 d	25.11 e	29.51 d	0.35bc	3.30 cd	0.94 b
T_4=50%RDF + % 50 TWW	6.36 a	2.47 c	0.175 c	26.15 c	29.85bc	0.36bc	3.32bcd	0.96ab
T_5=50%RDF + 75% TWW	6.37 a	2.57 b	0.229 a	26.32 b	29.92 b	0.39ab	3.37ab	0.96ab
T_6=50%RDF + 100%TWW	6.37 a	2.68 a	0.233 a	26.93 a	30.53 a	0.44 a	3.40 a	0.98 a

The content of N of the post harvest soil increased with the increasing amount of textile waste water irrigation. The N of different treatments ranges 0.120 to 0.233%. N content in post harvest soils of all the treatments significantly ($P \leq 0.05$) increased as compared with the control except T_3 (50% RDF + 25% TWW). The highest N content (0.233 %) was found with T_6 (50% RDF + 100% TWW), and the lowest N (0.120 %) was with T_1(control).

The content of P and S of the post harvest soil increased significantly ($P \leq 0.05$) as compared with control. The P of different treatments ranges between 24.03 to 26.93 ppm and the S of different treatments ranges between 29.10 to 30.53 ppm. The highest content of P (26.93 ppm) and S (30.53 ppm) were found with T_6 (50% RDF + 100% TWW). The lowest content of P (24.03 ppm) and S (29.10 ppm) were found with T_1(control).

In treatment T_2 (100% RDF + 0% TWW), T_5 (50% RDF + 75% TWW) and T_6 (50% RDF + 100% TWW) K and Ca content of post harvest soil increased significantly ($P \leq 0.05$) as compared with control. The average K of different treatments ranged between 0.31 to 0.44 Cmol/kg and The Ca of different treatment ranged between 3.29 to 3.40 Cmol/kg .The highest content of K (0.44 C mol/kg) and Ca (3.40 C mol/kg) were found with T_6 (50% RDF + 100% TWW). The lowest content of K (0.31 C mol/kg) and Ca(3.29 C mol/kg) were found with T_1(control).

In post harvest soil Mg content of increased significantly ($P \leq 0.05$) in T_2 (100% RDF + 0% TWW) and T_6 (50% RDF + 1000% TWW) as compared with control. The Mg of different treatments ranged between 0.94 to 0.98 C mol/kg. The highest content of Mg (0.98 C mol/kg) and the lowest content of Mg (0.94 C mol/kg) was found with T_6 (50% RDF + 100% TWW) and T_1(control) respectively.

4.3.12. Effect of textile waste water on heavy metal concentration of post harvest soil

The heavy metal concentration of post harvest soil is presented in Table 4.63. It was observed from the table that as the concentration of textile waste water increased, heavy metal concentration in post harvest soil gradually increased.

The concentration of Zn and Cu in post harvest soil increased significantly ($P \leq 0.05$) in all treatment as compared with control. Highest concentration of Zn and Cu in post harvest soil were 30.31 and 0.93 ppm respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Zn and Cu were 20.10 and 0.70 ppm respectively, which were found with T_1 (control).

The concentration of Ni in post harvest soil increased significantly ($P \leq 0.05$) in T_2 (100% RDF + 0% TWW), T_5(50% RDF + 75% TWW) and T_6(50% RDF + 100% TWW) as compared with control. Highest concentration of Ni in post harvest soil 24.74 ppm was observed in T_6, where 100% textile waste water was irrigated. The lowest value of Ni 23.40 ppm in post harvest soil showed in T_1 (control).

The concentration of Fe in post harvest soil increased significantly ($P \leq 0.05$) in all treatments as compared with control, except T_3(50% RDF + 25% TWW). Highest concentration of Fe in post harvest soil 239.55 ppm was observed in T_6, where 100% textile waste water was irrigated. Lowest concentration of Fe in post harvest soil 195.59 ppm was observed in T_3 , where 25% textile waste water was irrigated.

Table 4.63: Effect of textile waste water on heavy metal concentration of post harvest soil for jute cultivation

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1=control	20.10 f	0.70 e	23.40 c	199.79 d	0.235 c	30.33 f	29.45 f	2.41 e
T_2=100% RDF + 0%TWW	26.25 c	0.81 c	24.11 b	202.32 c	0.250 a	30.79 e	30.22 d	2.55 d
T_3=50% RDF + 25%TWW	23.16 e	0.77 d	23.52 c	195.59 f	0.242 b	31.07 d	30.10 e	2.45 e
T_4=50% RDF + 50%TWW	25.18 d	0.82bc	23.60 c	199.38 e	0.244 b	33.21 c	31.37 c	2.63 c
T_5=50% RDF + 75%TWW	27.22 b	0.85 b	24.21 b	223.80 b	0.253 a	33.90 b	32.07 b	2.71 b
T_6=50% RDF+100%TWW	30.31 a	0.93 a	24.74 a	239.55 a	0.255 a	34.03 a	33.79 a	2.80 a

Significantly ($P \leq 0.05$) increased concentration of Cd, Cr and Pb in post harvest soil found in all the treatments as compared with control. Highest concentration of Cd, Cr and Pb in post harvest soil were 0.255, 34.03 and 33.79 ppm respectively, observed in T_6 (where 100% textile waste water was irrigated). Lowest concentration of Cd, Cr and Pb in post harvest soil were 0.235, 30.33 and 29.45 ppm respectively, were observed in T_1 (control).

The concentration of Mn in post harvest soil also increased significantly ($P \leq 0.05$) in all treatments as compared with control, except T_3 (50% RDF + 25% TWW). Highest concentration of Mn in post harvest soil 2.80 ppm was observed in T_6 (where 100% textile waste water was irrigated). Lowest concentration of Mn in post harvest soil 2.41 ppm was observed in T_1 (control).

Field experiment No. 2

Pictorial view of field experiment No. 2 (Rice)

Field Exp. 2: Rice transplantation and fertilization is going on

4.4. Field experiment No. 2

Influence of textile waste water on yield and heavy metal uptake by rice

4.4.1. Effect of textile waste water on growth and yield of rice

The plant height and tiller number of rice were recorded at 20 (early tillering stage: ETS), 40 (maximum tillering stage: MTS), 60 (panicle initiation stage: PIS) and 90 (maturity: Mat.) day after transplanting (DAT). The yield of straw and grain, yield contributing components of rice (panicle number/m^2, panicle length, number of grain per panicle, percentage of filled grain per panicle and 1000-grain weight) were recorded at the time of harvest.

4.4.2. Effect of textile waste water on plant height of rice

The results of plant height (cm) with different treatments at different growth stage of rice are presented in Figure 4.35. At early tillering stage (ETS) plant height significantly ($P \leq 0.05$) increased with textile waste water irrigation over the control (T_1). At this stage highest plant height (45.9 cm.) was recorded at the treatment 100% RDF along with 0% TWW irrigation (T_2), and second highest plant height (43.7 cm.) found with the treatment combination of 50% RDF along with 50% TWW irrigation (T_4). The lowest plant height at this stage (35.2 cm.) was found with T_1 (control). Considering the plant height of early tillering stage the treatments may be arranged in the order of $T_2 > T_4 > T_5 > T_3 > T_6 > T_1$.

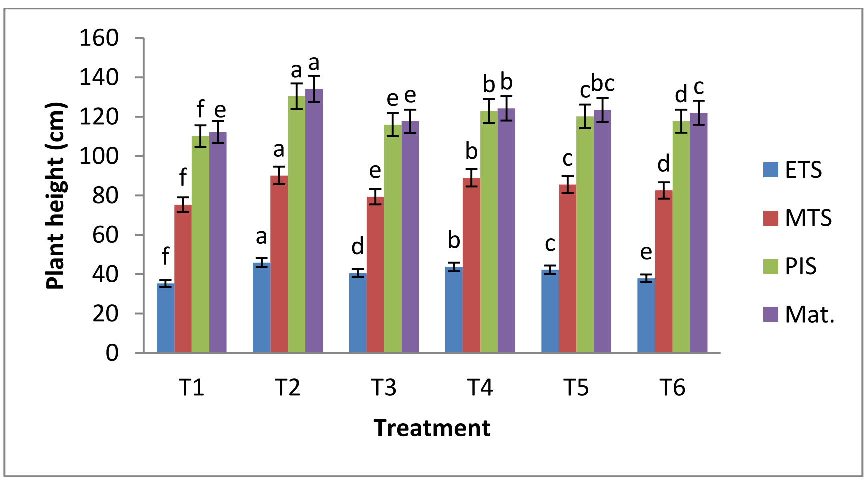

Fig. 4.35. Effect of textile waste water on plant height at different growth stages of rice

At maximum tillering stage (MTS) and panicle initiation stage (PIS) plant height significantly ($P \leq 0.05$) varied with each other treatments. Highest plant height 90.10 and 130.30 cm were recorded at MTS and PIS respectively in T_2(100% RDF with 0% TWW) where no applied of irrigation. Second highest plant height 88.9 and 122.8 cm. were recorded at MTS and PIS respectively, in the treatment combination of 50% RDF along with 50% TWW irrigation (T_4). The lowest plant height at this stage 75.3 and 100 cm. were found with T_1 (control). Considering the plant height of early tillering stage the treatments may be arranged in order of $T_2>T_4>T_5>T_3>T_6>T_1$. And considering the plant height of panicle initiation stage the treatments may be arranged in order of $T_2>T_4>T_5>T_6>T_3>T_1$.

At maturity stage (Mat.) plant height significantly ($P \leq 0.05$) increased with textile waste water irrigation as compared with control (T_1). At this stage highest plant height (134.1cm.) was measured at the treatment of sole inorganic fertilizer plot in T_2 (100% RDF along with 0% TWW irrigation), and second highest plant height (124.2 cm.) was found at the treatment combination of 50% RDF along with 50% TWW irrigation (T_4). At this stage plant height of T_4 (50% RDF + 50% TWW) and T_5 (50% RDF + 75% TWW) were found statistically similar. The lowest plant height at this stage (112.2 cm.) was found with T_1(control). Considering the plant height at maturity stage the treatments may be arranged in order of $T2>T_4>T_5>T_6>T_3>T_1$.

4.4.3. Effect of textile waste water on tiller number of rice

The results of tiller number with different treatments at different growth stages of rice are presented in Figure 4.36.

At early tillering stage (ETS) tiller number of rice increased in all the treatments significantly ($P \leq 0.05$) as compared with control. Highest tiller number (234/ m^2) was observed in T_2 ,where 100% RDF was applied with 0%TWW. And the lowest tiller number (217/m^2) was observed with T_1 (control). The results revealed that irrigation of different concentration of textile waste water had no significant difference between each other for the production of tiller number of rice at early tillering stage.

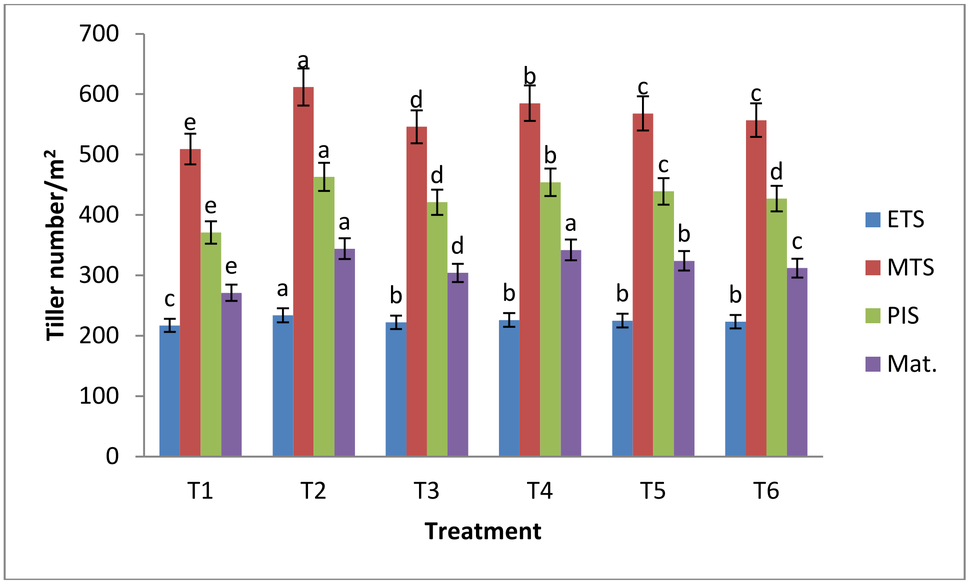

Fig. 4.36. Effect of textile waste water on tiller number of rice plant at different growth stage

The number of rice tiller at maximum tillering stage (MTS) increased in all the treatments significantly ($P \leq 0.05$) as compared with control. Highest tiller number (612/ m^2) was observed in T_2, where 100% RDF was applied without TWW(0%TWW). The second highest tiller number at this stage (585/m^2) was observed in T_4, where 50% RDF was applied along with 50% TWW. The lowest tiller number (509/m^2) was observed with T_1 (control). The results revealed that irrigation of textile waste water up to 50%concentration increased the tiller number of rice significantly ($P \leq 0.05$)at this stage. The incremental rate over 50%TWW causes decreased in number of tiller in this period of MTS.

At panicle initiation stage (PIS) the tiller number of rice also increased significantly ($P \leq 0.05$) in all treatments as compared with control (T_1). Highest tiller number (463/ m^2) was observed in T_2, where 100% RDF was applied without textile waste water (0%TWW). The second highest tiller number at this stage (454/m^2) was observed in T_4, where 50% RDF was applied along with 50% TWW. And the lowest tiller number (371/m^2) was observed with T_1 (control). The results revealed that irrigation of textile waste water up to 50% concentration also increased the tiller number of rice significantly ($P \leq 0.05$) at this stage after that further higher rate it decreased.

At maturitystage (Mat.) tiller number of rice also increased significantly ($P \leq$ 0.05) in all treatments as compared with control (T1). Highest tiller number (344/ m^2) was in T_2, where 100% RDF was applied without TWW (0%TWW). The second highest tiller number at this stage (342/m^2) was found in T_4, where 50% RDF was applied along with 50% TWW. And the lowest tiller number (271/m^2) was recorded with T_1(control). The results indicated that at this stage T_4(50% RDF + 50% TWW) had no significant difference with T_2 (100% RDF + 0% TWW) for the production of tiller. The results also showed that irrigation of textile waste water up to 50% concentration increased the tiller number of rice significantly ($P \leq$ 0.05) at this stage and then it decreased. Study revealed that no. of tiller increased with TWW up to 50% concentration and over this rate there was decreasing trend in all the stages.

4.4.4. Effect of textile waste water on straw and grain yield of rice

Effect of textile waste water on straw and grain yield of rice are presented in Figure 4.37. The straw yield significantly ($P \leq$ 0.05) increased with textile waste water irrigation as compared with control. The yield of straw ranged between 3.47 to 6.94 t/ha. Highest straw yield 6.94 t/ha was found with T_2, where 100% RDF was given**.** The second highest straw yield 6.05 t/ha was observed with T_5, where 50% RDF was incorporated along with 75% TWW. Straw yield increased up to irrigation of 75% TWW, and then gradually decreased. Straw yield with T_4(50% RDF + 50% TWW) and T_5(50% RDF + 75% TWW) did not significantly vary with each other. The lowest straw yield was found with T_1(control).

Results showed that grain yield in all the treatments also significantly ($P \leq$ 0.05) increased as compared with control. The range of grain yield was found between 1.9 to 4.25 t/ha. Highest straw yield 4.25 t/ha was found with T_2, where 100% RDF was applied without TWW (0% TWW). The second highest straw yield 3.97 t/ha was observed with T_4 , where 50% RDF was given along with 50% TWW. Grain yield increased up to irrigation of 50% TWW, then gradually decreased. Minimum grain yield was found with T_1 (control). Grain yield in all the treatments significantly varied with each other treatments.

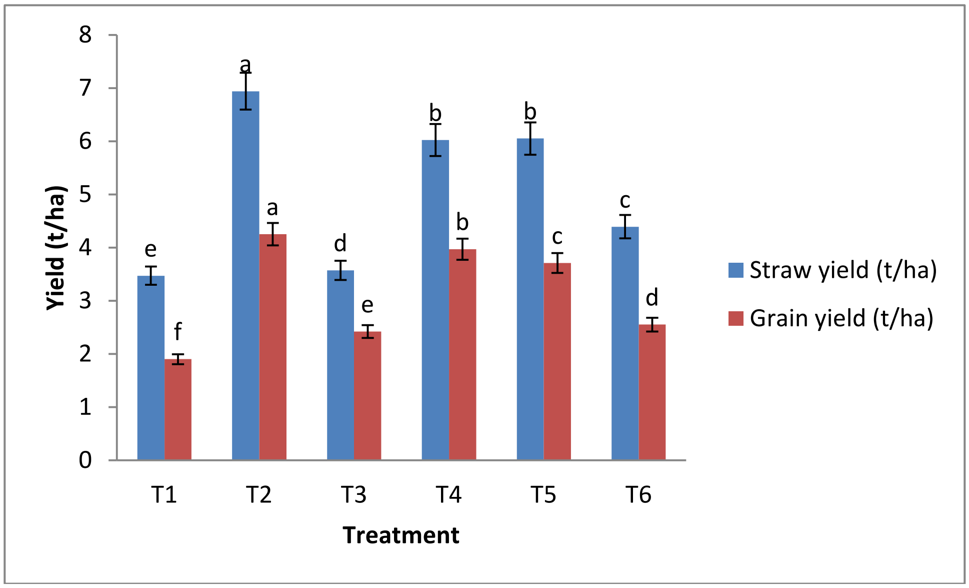

Fig. 4.37. Effect of textile waste water on straw and grain yield of rice

4.4.5. Effect of textile waste water on yield component of rice

The different yield component of rice such as panicle number per meter square ($/m^2$), panicle length, number of grain per panicle, percentage of filled grain per panicle and 1000-grain weight are presented in Figures 4.38 to 4.42. The panicle number/m^2 increased significantly ($P \leq 0.05$) in all treatments over the control (Figure 4.38). The ranges of panicle number of rice were 173 to 306/m^2. Application of 100% RDF, without TWW (0% TWW) contributed 306 panicle numbers per meter square, which was the highest number of panicle. The second highest panicle number per meter square 301 was found with T_4, where 50% RDF along with 50% TWW was applied.The lowest panicle number/m^2 173 was found with T_1 (control).

Irrigation of textile waste water enhanced panicle length of rice significantly ($P \leq 0.05$) as compared with control (Figure 4.39). As highest panicle length 24.57 cm. was found with T_2, where 100% RDF without irrigation of TWW (0% TWW). But the irrigated treatments with TWW also increased the panicle length and showed great variation compared to control (T_1). The result revealed that the increased of concentration of textile waste water irrigation up to 50% the panicle length of rice was increased, after that decreased. The second highest panicle length

24.12 cm. was observed with T_4, where 50% RDF along with 50% TWW was applied. Control (T_1) showed the lowest panicle length, which was 12.67 cm.

The number of grain per panicle increased significantly ($P \leq 0.05$) in all treatments as compared with control, except T_3, where 50% RDF along with 25% TWW was applied (Figure 4.40). Number of grain per panicle ranged between 113.75 to 118.5. Application of 100% RDF without TWW (0% TWW) showed 118.5 grain per panicle, which was the highest. The next highest number of grain per panicle 117.2 was found with T_4, where 50% RDF along with 50% TWW was applied. The lowest number of grain per panicle 113.75 was found with T_3, where 50% RDF along with 25% TWW was applied.

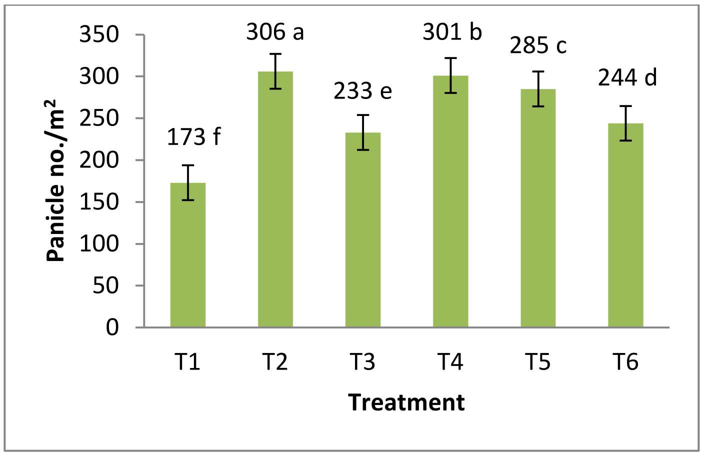

Fig. 4.38. Effect of textile waste water on panicle number of rice.

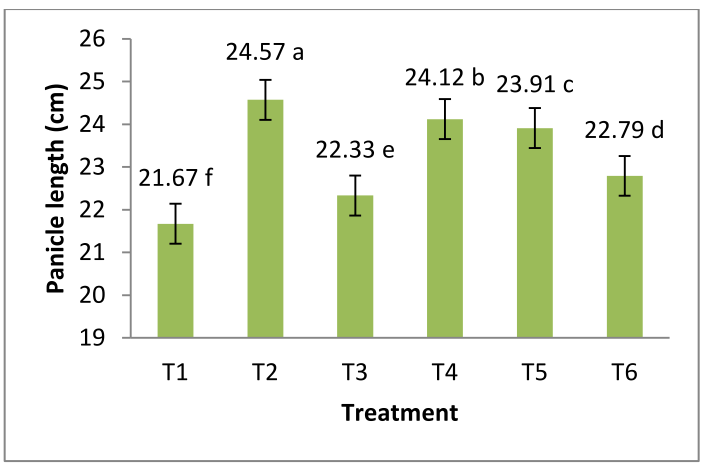

Fig. 4.39. Effect of textile waste water on panicle length of rice.

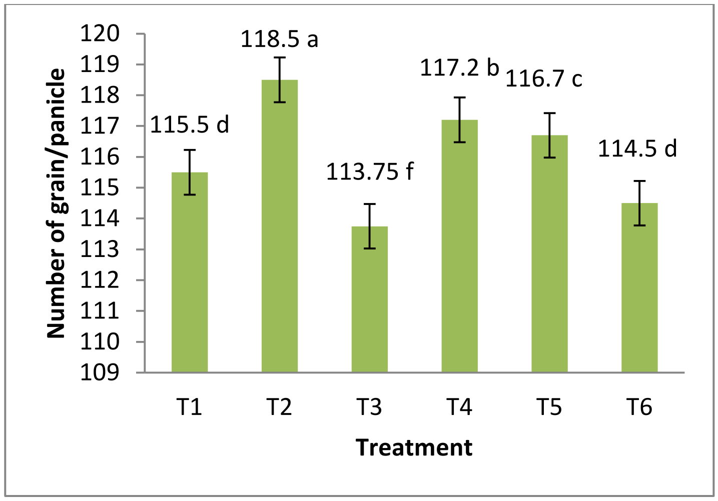

Fig. 4.40. Effect of textile waste water on number of grain per panicle

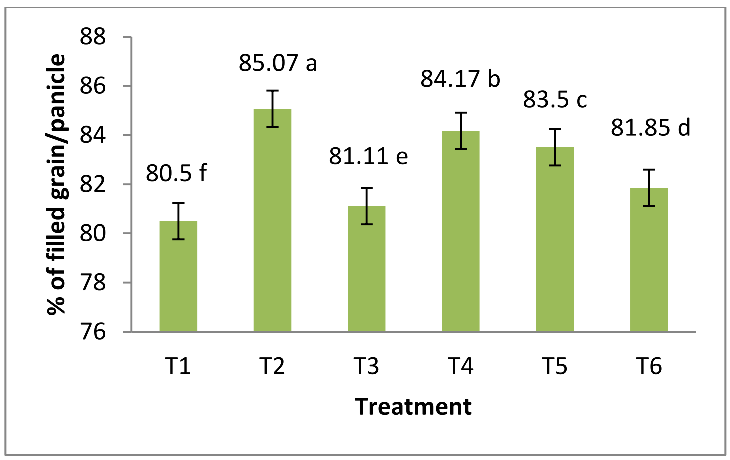

Fig. 4.41. Effect of textile waste water on percent of filled grain per panicle

Irrigation of textile waste water enhanced the percentage of filled grain per panicle significantly ($P \leq 0.05$) as compared with control (Figure 4.41). Highest percentage of filled grain per panicle (85.07) was found with T_2, where 100% RDF was applied without TWW (0% TWW). There were also increased the percentage of filled grain with the irrigated treatments of TWW over the control (T_1).The result revealed that with the increased of concentration of textile waste water irrigation up to 50%, the percentage of filled grain per panicle were increased, after then decreased. The second highest percentage of filled grain per panicle 84.17 was observed with T_4, where 50% RDF along with 50% TWW was applied. Control (T_1) showed the lowest percentage of filled grain.

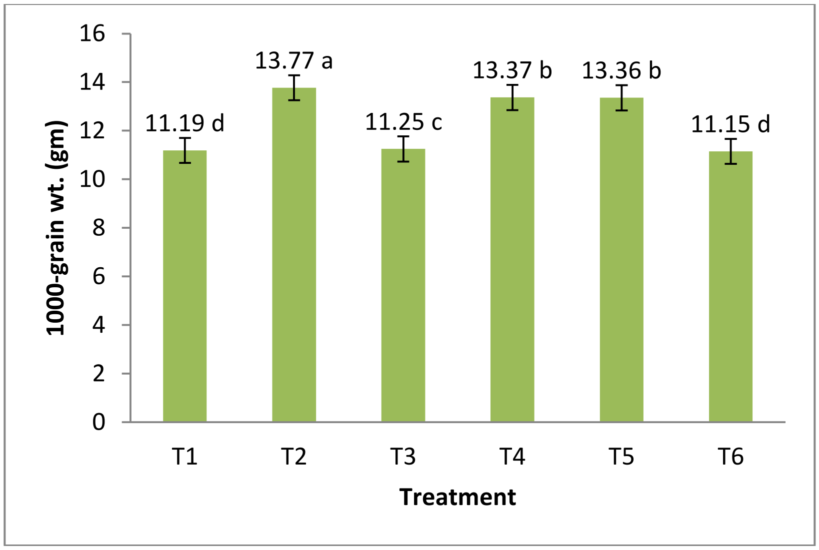

Fig. 4.42. Effect of textile waste water on 1000- grain weight of rice

The weight of 1000- grain increased significantly ($P \leq 0.05$) in all treatments as compared with control, except T_6 where 50% RDF along with 100% TWW was applied (Figure 4.42). 1000-grain weight range between 11.15 to 13.77 gm . Application of 100% RDF without TWW(0% TWW) in T_2 showed the highest 1000-grain weight, which was 13.77 gm. The second highest 1000- grain weight 13.37gm was found with T_4 , where 50% RDF along with 50% TWW was applied. The result revealed that 1000- grain weight with T_4 did not significantly vary with T_5. The lowest 1000-grain weight 11.15 was found with T_6 (where 50% RDF along with 100% TWW).

4.4.6. Effect of textile waste water on dry matter production of rice

Effect of textile waste water on dry matter production of rice is presented in Table 4.64. Textile waste water enhanced total fresh yield as well as total dry matter yield significantly ($P \leq 0.05$) over control. Total fresh and oven dry weight of rice with different treatments ranged 18.31 to 48.58 t/ha and 6.15 to 13.5 t/ha, respectively. Highest rate of total fresh yield (48.58 t/ha) and total dry matter yield (13.5 t/ha) were obtained with T_2(100% RDF + 0% TWW). The next total fresh yield (41.85 t/ha) and dry matter yield (11.77 t/ha), were achieved with T_4 (50% RDF + 50% TWW). Lowest total fresh yield (18.31 t/ha) and total dry matter yield (6.15 t/ha) were found in T_1 (control). Dry matter yield was increased 119.51% with T_2 and 91.38% with T_4 over control.

Table 4.64. Effect of textile waste water on dry matter production of rice

Treatment	Green weight of 5 hills /plot (g)			Oven dry weight of 5 hills /plot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)	Total fresh weight (t/ha)
	Grain	Straw	Root	Grain	Straw	Root	Grain	Straw	Root	G+S+R	G+S+R
T_1	64.05	313.33	80.35	47.5	86.67	19.69	1.9	3.47	0.79	6.15 f	18.31 f
T_2	126.35	846.67	220.5	104.42	170.5	56.67	4.25	6.94	2.31	13.5 a	48.58 a
T_3	75.51	380	101.3	62.15	91.67	25.12	2.42	3.57	0.98	6.97 e	21.68 e
T_4	119.51	730	192.5	98.85	150	44.29	3.97	6.02	1.78	11.77 b	41.85 b
T_5	118.43	680	180.8	97.07	158.3	42.85	3.71	6.05	1.64	11.4 c	37.43 c
T_6	79.37	630	172.2	65.49	113.33	41.67	2.54	4.39	1.62	8.55 d	34.17 d

4.4.7. Effect of textile waste water on nutrient content in different parts of rice

Effect of textile waste water on nutrient content in different parts of rice is presented in Table 4.65. Results showed there were considerable nutrient content in rice grain, straw and roots. The content of N in grain varied between 1.00 to 1.68%. HighestN in grain 1.68% was observed in T_2(100% RDF + 0% TWW) and the lowest 1.00% with T_6(50% RDF + 100% TWW). The nutrient content of N of straw varies between 0.54 to 0.68%. Highest N content in straw 0.68% was observed in T_2(100% RDF + 0% TWW) and the lowest 0.54% with T_1(control). The content of N in roots varied between 0.29 to 0.31%. Highest N content in rice root 0.31% was observed in T_5(50% RDF + 75% TWW) and the lowest 0.29% with T_1 (control) and T_6 (50% RDF + 100% TWW).

The content of P in rice grain varied between 0.016 to 0.029%. Highest P content in rice grain 0.029% was observed in T_2(100% RDF + 0% TWW) and T_4(50% RDF + 50% TWW). The lowest P found 0.16% with T_5(50% RDF + 50% TWW). The P content of straw varied between 0.012 to 0.031%. Highest P content in straw 0.031% was observed in T_3(50% RDF + 25% TWW) and the lowest P 0.012% with T_6(50% RDF + 100% TWW). The P content of root varied between 0.007 to 0.011%. Highest P content in rice root 0.011% was in T_3(50% RDF + 25% TWW). The lowest P in rice root 0.007% was withT1 (control).

Table 4.65. Effect of textile waste water on nutrient content in different parts of rice plant

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Grain	1.12	0.019	0.39	0.04	0.08	0.035
	Straw	0.54	0.013	3.528	0.041	0.28	0.22
	Root	0.29	0.007	0.91	0.01	0.15	0.022
T_2= 100% RDF + 0% TWW	Grain	1.68	0.023	0.525	0.047	0.1	0.085
	Straw	0.68	0.029	3.581	0.048	0.32	0.205
	Root	0.30	0.01	0.91	0.012	0.16	0.023
T_3=50% RDF + 25% TWW	Grain	1.12	0.019	0.519	0.04	0.09	0.04
	Straw	0.58	0.031	3.689	0.045	0.3	0.2
	Root	0.30	0.011	0.95	0.11	0.15	0.014
T_4=50%RDF + 50% TWW	Grain	1.62	0.029	0.447	0.045	0.1	0.05
	Straw	0.64	0.016	2.811	0.041	0.26	0.225
	Root	0.30	0.01	0.85	0.12	0.16	0.02
T_5=50%RDF + 75% TWW	Grain	1.05	0.016	0.321	0.041	0.12	0.085
	Straw	0.66	0.016	3.528	0.05	0.3	0.215
	Root	0.31	0.01	0.88	0.015	0.16	0.02
T_6=50%RDF + 100% TWW	Grain	1.00	0.019	0.43	0.044	0.11	0.095
	Straw	0.64	0.012	3.581	0.036	0.28	0.235
	Root	0.29	0.009	0.9	0.011	0.15	0.018

The content of K in rice grain varied between 0.321 to 0.525%. Highest K content in rice grain 0.525% was observed in T_2(100% RDF + 0% TWW) and the lowest 0.321% with the T_5(50% RDF + 75% TWW). The nutrient content of K in straw of rice varied between 2.811 to 3.689 %. Highest K content in straw 3.689% was observed in T_3(50% RDF + 25% TWW) and the lowest 2.811% with T_4 (50% RDF + 50% TWW). The nutrient content of K of roots varied between 0.85 to 0.95%. Highest K content in root 0.95% was observed in T_3(50% RDF + 25% TWW). The lowest K content 0.85 % was observed with T_4 (50% RDF + 50% TWW).

The S content of rice grain varied between 0.04 to 0.047%. Highest S content in rice grain 0.047% was observed in T_2(100% RDF + 0% TWW) and the lowest S content 0.04% was with

T_1(control) and with T_3. The nutrient content of S of straw varied between 0.036 to 0.048%. Highest S content in straw 0.048% was observed in T_2(100% RDF + 0% TWW) and the lowest 0.036% with T_6(50% RDF + 100% TWW). The content of S in root varied between 0.01 to 0.015%. Highest S content in rice root 0.015% was observed in T_5(50% RDF + 75% TWW). The lowest S content 0.01 % was observed with T1 (control).

The Ca content of rice grain varied between 0.08 to 0.12%. Highest Ca content in rice grain 0.12% was observed in T_5(50% RDF + 75% TWW) and the lowest 0.08% with T_1(control). The content of Ca in rice straw varied between 0.26 to 0.32%. Highest Ca content in rice straw 0.32% was observed in T_2(100% RDF + 0% TWW) and the lowest 0.26% with T_4(50% RDF + 50% TWW). The Ca content of root varied 0.15 to 0.16%. Maximum Ca content in root 0.16% was obtained in T_2(100% RDF + 0% TWW), T_4(50% RDF + 50% TWW) and T_5(50% RDF + 75% TWW). The minimum Ca content 0.15 % was observed with T_1(control), T_4 (50% RDF + 50% TWW) and T_6(50% RDF + 100% TWW). Results displayed there were no gulf of difference between the treatments in achieved in maximum (0.16%) and minimum (0.15%) Ca content, which was statistically similar.

The Mg content of rice grain varied within 0.035 to 0.095%. Highest Mg content in rice grain 0.095% was observed in T_6(50% RDF + 100% TWW) and the lowest Mg content 0.032% was with T_1(control). The Mg content of rice straw varied between 0.2 to 0.235%. Highest Mg content in rice straw 0.235% was observed in T_6(50% RDF + 100% TWW). The lowest Mg content in straw 0.2% was observed with T_3(50% RDF + 25% TWW). The Mg content of root varied between 0.014 to 0.023%. Highest Mg content in root 0.023% was observed in T_2(100% RDF + 0% TWW). The lowest Mg content 0.014% was observed with T_3(50% RDF + 25% TWW).

4.4.8. Effect of textile waste water on nutrient uptake by rice plant

The nutrient uptake capacity by rice plant influenced by textile waste water is presented in Table 4.66 The nutrients uptake due to textile waste water irrigation increased significantly ($P \leq 0.05$) as compared with control. Considerable nutrients were taken up by all the treatments. The up taken of N by each treatment significantly varied with other treatments, except T_4 and T_5. The N uptake ranges between 42.31 to 125.52 kg/ha. The highest uptake of N (125.52 kg/ha) was observed with T_2 (100% RDF + 0% TWW) and the next highest uptake of N (108.18 kg/ha) with T_4 (50% RDF + 50% TWW). The lowest uptake of N (42.31 kg/ha) was found with

T_1(control).

Table 4.66. Effect of textile waste water on nutrient uptake in different parts of rice plant

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	**P**	**K**	**S**	**Ca**	**Mg**
T_1= control	Grain	21.28	0.36	7.41	0.76	1.52	0.67
	Straw	18.74	0.45	122.42	1.42	9.72	7.63
	Root	2.29	0.06	7.19	0.08	1.19	0.17
	Total	**42.31 e**	**0.87 f**	**137.02 f**	**2.26 f**	**12.43 f**	**8.47 e**
T_2=100% RDF + 0% TWW	Grain	71.40	0.98	22.31	2.00	4.25	3.61
	Straw	47.19	2.01	248.52	3.33	22.21	14.23
	Root	6.93	0.23	21.02	0.28	3.70	0.53
	Total	**125.52 a**	**3.22 a**	**291.85 a**	**5.61 b**	**30.16 a**	**18.37 a**
T_3=50%RDF +25% TWW	Grain	27.10	0.46	12.56	0.97	2.18	0.97
	Straw	20.71	1.11	131.70	1.61	10.71	7.14
	Root	2.94	0.11	9.31	1.08	1.47	0.14
	Total	**50.75 d**	**1.68 d**	**153.57 e**	**3.66 d**	**14.36 e**	**8.25 f**
T_4=50%RDF +%50 TWW	Grain	64.31	0.75	20.60	1.59	3.57	1.99
	Straw	38.53	1.87	222.08	2.71	18.06	13.55
	Root	5.34	0.20	16.91	1.96	2.67	0.25
	Total	**108.18 b**	**2.82 b**	**259.59 b**	**6.26 a**	**24.30 c**	**15.79 c**
T_5=50%RDF +75% TWW	Grain	38.96	0.59	11.91	1.52	4.45	3.15
	Straw	39.93	0.97	213.44	3.03	18.15	13.01
	Root	5.08	0.16	14.43	0.25	2.62	0.33
	Total	**83.97 b**	**1.72 c**	**239.78 c**	**4.80 c**	**25.22 b**	**16.49 b**
T_6=50%RDF +100% TWW	Grain	25.40	0.48	10.92	1.12	2.79	2.41
	Straw	28.10	0.53	157.21	1.58	12.29	10.32
	Root	4.70	0.15	14.58	0.18	2.43	0.29
	Total	**58.20 c**	**1.16 e**	**182.71 d**	**2.88 e**	**17.51 d**	**13.02 d**

The uptake of P and K by different plant parts with the treatments also significantly ($P \leq 0.05$) varied. The total P uptake ranges by rice plants (grain+straw+roots) were 0.87 to 3.22 kg/ha and the K uptake ranged 137.02 to 291.85 kg/ha respectively. The highest uptake of P (3.22 kg/ha) and K (291.85 kg/ha) were found with T_2 (100% RDF + 0% TWW). The next highest uptake of P (2.82 kg/ha) and K (259.59 kg/ha) were recorded with T_4 (50% RDF + 50% TWW). And the lowest uptake of P (0.87 kg/ha) and K (137.02 kg/ha) were found with T_1 (control).

The S uptake by the treatments significantly ($P \leq 0.05$) varied. The S was uptaken by rice plants (grain+straw+roots) ranged between 2.26 to 6.26 kg/ha. The highest uptake of S (6.26 kg/ha) was obtained with T_4 (50% RDF + 50% TWW) and the next highest uptake of S (5.61 kg/ha) with T_2 (100% RDF + 0% TWW). The lowest uptake of S (2.26 kg/ha) was found with T_1 (control).

The total uptake of Ca and Mg by rice plants (grain+straw+roots) in all the treatments significantly ($P \leq 0.05$) varied with the treatments. The Ca uptake ranges between 12.43 to 30.16 kg/ha and the Mg uptake ranges 8.25 to 18.37 kg/ha The highest uptake of Ca (30.16 kg/ha) and Mg (18.37 kg/ha) were obtained with T_2 (100% RDF + 0% TWW). The second highest uptake of Ca (25.22 kg/ha) and Mg (16.49 kg/ha) were with T_5 (50% RDF + 75% TWW). The lowest uptake of Ca (12.43 kg/ha) and Mg (8.425 kg/ha) were found with T_1 (control) and T_3(50% RDF+ 25% TWW).

4.4.9. Effect of textile waste water on heavy metal concentration in different parts of rice

Effect of textile waste water on heavy metal concentration in different parts of rice is presented in Table 4.67. Heavy metal concentration in rice slightly increased with increased level of textile waste water irrigation which were in allowable limit. The concentration of Zn in grain varied from 36 to 50 ppm. Highest concentration of Zn in rice grain was (50 ppm) found with T_6(50% RDF + 100% TWW) and lowest concentration of Zn (36 ppm) was with T_3 (50% RDF + 25% TWW). Zn concentration in straw varied from 103 to 186 ppm. Highest concentration of Zn inrice straw was (186 ppm) with T_6(50% RDF + 100% TWW) and lowest (103 ppm) with T_1 (control). The content of Zn in rice root varied from 12 to 25 ppm. Highest concentration of Zn in rice root was (25ppm) observed with T_6(50% RDF + 100% TWW) and lowest (12 ppm) with

T_1 (control). According to the sequence of Zn concentration the treatments can be arranged in rice grain $T_6>T_5,T_2>T_4,T_1>T_3$, straw$T_6>T_2>T_5>T_4>T_3$ and root $T_6,T_5>T_4>T_3>T_2>T_1$.

The application of textile waste water irrigation with increasing rate, then Cu content in rice grain also increased very slightly. Cu concentration in rice grain varied 2.31 to 6.61 ppm. Highest concentration of Cu in rice grain (6.61 ppm) was with T_6(50% RDF + 100% TWW) and lowest (2.31 ppm) with T_2 (100% RDF + 0% TWW). The concentration of Cu in rice straw varied 8.52 to 8.97 ppm. Highest concentration of Cu in rice straw (8.97 ppm) was observed

Table 4.67. Effect of textile waste water on heavy metal concentration in different parts of rice

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	**Cu**	**Ni**	**Fe**	**Cd**	**Cr**	**Pb**	**Mn**
T_1= (control)	Grain	41	2.80	ND	109.81	ND	ND	ND	75.31
	Straw	103	9.71	ND	901.94	ND	ND	ND	408.75
	root	12	1.70	ND	41.31	ND	ND	ND	25.15
T_2= 100% RDF + 0% TWW	Grain	45	2.31	ND	119.48	ND	0.138	ND	79.32
	Straw	133	8.61	ND	806.33	ND	ND	ND	429.50
	root	15	2.00	ND	52.33	ND	ND	ND	30.10
T_3=50% RDF + 25% TWW	Grain	36	2.70	8.6	137.65	ND	ND	ND	76.50
	Straw	104	8.52	12.0	904.97	ND	0.169	ND	435.20
	root	16	1.40	0.01	70.10	ND	0.01	ND	33.50
T_4=50%RDF + 50% TWW	Grain	41	4.10	ND	147.42	ND	ND	ND	80.80
	Straw	117	8.91	ND	984.55	ND	ND	ND	450.25
	root	18	2.10	ND	79.80	ND	ND	ND	35.70
T_5=50%RDF + 75% TWW	Grain	45	5.61	7.9	158.97	ND	ND	ND	82.40
	Straw	126	8.91	10.0	1034.87	ND	ND	ND	457.90
	root	25	2.20	0.02	80.50	ND	ND	ND	35.90
T_6=50%RDF + 100% TWW	Grain	50	6.61	ND	161.00	ND	ND	ND	86.10
	Straw	186	8.97	ND	1273.76	ND	ND	ND	471.30
	root	25	2.30	ND	96.50	ND	ND	ND	36.20

with T_6(50% RDF + 100% TWW) and lowest (8.52 ppm) with T_3 (50% RDF + 25% TWW). Cu concentration in rice root varied from 1.40 ppm to 2.30 ppm. Highest concentration of Cu in rice root (2.30 ppm) observed with T6(50% RDF + 100% TWW) and lowest (1.40 ppm) with T3 (50% RDF + 25% TWW). Among the treatments sequence of Cu concentration in rice grain was T6>T5>T4>T1>T3>T2 , in straw T6>T5,T4>T1>T2>T3 and in root T6>T5>T4>T2>T1>T3 .

Results showed that there were not detectable of Ni in T1, T2, T4 and T6. But the content of Ni found in T3 and T5 progressively. The concentration Ni in different parts of rice plants were 8.6, 12.0 and 0.01 ppm were found respectively in rice grain, straw and root respectively with T3 (50% RDF + 25% TWW). Whereas T5 (50% RDF + 75% TWW) content lower rate of Ni viz. 7.9, 10.0 and 0.02 ppm in rice grain, straw and root respectively.

The content of Fe in rice grain increased with the increasing concentration of textile waste water irrigation. Fe concentration in rice grain ranged from 109.81 to 161.00 ppm. Highest of Fe content in rice grain (161.00 ppm) was with T6(50% RDF + 100% TWW) and lowest (109.81 ppm) with T1 (control). Fe concentration in rice straw varied from 806.33 to 1273.76 ppm. Highest concentration of Fe in rice straw (1273.76 ppm) was found with T6(50% RDF + 100% TWW) and lowest (806.33 ppm) with T2(100% RDF + 0% TWW). The concentration of Fe in rice root varied from 41.31 to 96.50 ppm. Highest concentration of Fe in rice root (96.50 ppm) was found with T6 (50% RDF + 100% TWW) and lowest (41.31 ppm) with T_1 (control). Among the treatments, the sequence of Fe concentrations were in rice grain $T_6>T_5>T_4>T_3>T_2>T_1$, in straw $T_6>T_5>T_4>T_3>T_1>T_2$and in root $T_6>T_5>T_4>T_3>T_2>T_1$.

Cd and Pb were not detectable in grain, straw and root of rice with the irrigation of different concentration of textile waste water. There was detected Cr (0.138ppm) in rice grain with T_2. Cr in straw (0.169ppm) and roots (0.01 ppm) with $T_{3.}$

With the application of increased rate of textile waste water irrigation enhanced the Mn content in rice grain. Mn concentration in rice grain ranged from 75.31 to 86.10 ppm. Highest concentration of Mn in rice grain (86.10 ppm) observed with T_6(50% RDF + 100% TWW) and lowest (75.31 ppm) was with T_1 (control). Mn concentration in rice straw varied from 408.75 to 471.30 ppm. Highest concentration of Mn in rice straw (471.30 ppm) was observed with T_6(50% RDF + 100% TWW) and lowest (408.75 ppm) with T_1 (control). Mn concentration roots of rice plant varied from 25.15 to 36.20 ppm. Highest concentration of Mn in root (36.20 ppm) was observed with T_6(50% RDF + 100% TWW) and lowest (25.15 ppm) was T_1 (control).Among the treatments, the sequence of Mn concentrations were in rice grain $T_6>T_5>T_4>T_2>T_3>T_1$, in straw $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_3>T_2>T_1$.

On the basis of heavy metal concentration in rice plant, it may be arranged in the order of Fe>Mn>Zn>Cu>Ni>Cr. Study showed that the heavy metal both Cd and Pb were not detected in the rice plant.

4.4.10. Effect of textile waste water on heavy metal uptake by rice

Effect of textile waste water on heavy metal uptake by different parts of rice plant is presented in Table 4.68. The average Zn uptake by each treatment significantly ($P \leq 0.05$) varied with other treatments. The Zn uptake ranges between 444.79 to 1148.77 gm/ha. The lowest uptake of Zn (444.79 gm/ha) was found with T_1 (control) and the highest uptake of Zn (1148.77 gm/ha) was with T_2 (100% RDF + 0% TWW).

The Cu uptake by rice with each treatment significantly ($P \leq 0.05$) increased as compared with control. The Cu uptake ranges between 38.32 to 78.33 gm/ha. The lowest uptake of Cu (38.32 gm/ha) was found with the treatment T_3 (50% RDF + 25% TWW) and the highest uptake of Cu (78.33 gm/ha) was with T_5 (50% RDF + 75% TWW).

The Ni uptake by rice was observed with T_3 and T_5, which were significantly ($P \leq 0.05$) varied with the treatments. The Ni uptake ranges between 0.0 (nil) to 89.84 gm/ha. The lowest uptake of Ni (0.0 gm/ha) was found with T_1 , T_2, T_4 and T_6 and the highest uptake of Ni (89.84 gm/ha) was with T_5 (50% RDF + 75% TWW). The uptake of Ni by different parts of rice plant were below critical limit.

The Fe uptake by rice with each treatment significantly ($P \leq 0.05$) increased as compared with control. The Fe uptake ranges between 3371.00 to 6982.76 gm/ha. The lowest uptake of Fe (3371.00 gm/ha) was found with the treatment T_1 (control) and the highest uptake of Fe (6982.76 gm/ha) was observed with treatment T_5 (50% RDF + 75% TWW).

Table 4.68. Effect of textile waste water on heavy metal uptake by different parts of rice plant

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= control	Grain	77.90	5.32	0	208.64	0	0	0	143.09
	Straw	357.41	33.69	0	3129.73	0	0	0	1418.36
	Root	9.48	1.34	0	32.63	0	0	0	19.87
	Total	**444.79 f**	**40.35 d**	**0 c**	**3371.00 f**	**0**	**0 b**	**0**	**1581.32 f**
T_2=100%RDF + 0%TWW	Grain	191.25	9.82	0	507.79	0	0.59	0	337.11
	Straw	923.02	59.75	0	5595.93	0	0	0	2980.73
	Root	34.50	4.60	0	120.36	0	0	0	69.23
	Total	**1148.77 a**	**74.17 b**	**0 c**	**6224.08 c**	**0**	**0.59 a**	**0**	**3387.07 a**
T_3=50%RDF + 25% TWW	Grain	87.12	6.53	20.81	333.11	0	0	0	185.13
	Straw	371.28	30.42	42.84	3230.74	0	0.60	0	1553.66
	Root	15.68	1.37	0.01	68.70	0	0.01	0	32.83
	Total	**474.08 e**	**38.32 e**	**63.66 b**	**3632.55 e**	**0**	**0.61 a**	**0**	**1771.62 e**
T_4=50%RDF + 50% TWW	Grain	162.77	16.28	0	585.26	0	0	0	320.78
	Straw	704.34	53.64	0	5926.99	0	0	0	2710.51
	Root	31.86	3.72	0	141.25	0	0	0	63.19
	Total	**898.97 d**	**73.64 b**	**0 c**	**6653.50 b**	**0**	**0 b**	**0**	**3094.48 c**
T_5=50%RDF + 75% TWW	Grain	166.95	20.81	29.31	589.78	0	0	0	305.70
	Straw	762.30	53.91	60.50	6260.96	0	0	0	2770.30
	Root	41.00	3.61	0.03	132.02	0	0	0	58.88
	Total	**970.25 c**	**78.33 a**	**89.84 a**	**6982.76 a**	**0**	**0 b**	**0**	**3134.88 b**
T_6=50%RDF + 100%TWW	Grain	127.50	16.86	0	410.55	0	0	0	219.56
	Straw	816.54	39.38	0	5591.81	0	0	0	2069.01
	Root	40.50	3.73	0	156.33	0	0	0	58.64
	Total	**984.54 b**	**59.97 c**	**0 c**	**6158.69 d**	**0**	**0 b**	**0**	**2347.21 d**

The Cr uptake by rice was observed with treatment T_2 and T_3, which were not significantly $P \leq$ 0.05) varied with the treatments. The Cr uptake ranges between 0.0 (nil) to 0.61 gm/ha. The lowest uptake of Cr (0 gm/ha) was found with the T_1 , T_4, T_5 and T_6 and the highest uptake of Cr (0.613 gm/ha) was with T_3 (50% RDF + 25% TWW).

The Mn uptake by rice with each treatment significantly ($P \leq 0.05$) increased as compared with control. The treatments also significantly varied with each other. The Mn uptake ranges between 1581.32 gm/ha to 3387.07 gm/ha. The lowest uptake of Mn (1581.32 gm/ha) was found with T_1(control) and the highest uptake of Mn (3387.07 gm/ha) was with T_2 (100% RDF + 0% TWW).

4.4.11. Effect of textile waste water on nutrient status of post harvest soil of rice cultivation

Effect of textile waste water on nutrient status of post harvest soil of rice cultivation is presented in Table 4.69. Soil pH, organic matter, N, P, K, S, Ca and Mg were determined after harvest of the crops. The result showed that pH of the soil slightly increased with the increasing the concentration of textile waste water irrigation, which also significant difference among the

Table 4.69. Effect of textile waste water on nutrient status of post harvest soil for rice cultivation

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.35 e	2.45 d	0.118 e	24.00 f	29.00 f	0.30 f	3.22 e	0.87 e
T_2=100%RDF + 0%TWW	6.37 d	2.49 cd	0.232 b	26.35 d	30.51 d	0.51 b	3.75 b	1.02 d
T_3=50%RDF + 25% TWW	6.37 d	2.52 c	0.154 d	25.58 e	30.05 e	0.40 e	3.59 d	0.99 d
T_4=50%RDF + 50% TWW	6.39 c	2.58 b	0.186 c	27.83 c	32.44 c	0.43 d	3.64 c	1.24 c
T_5=50%RDF + 75% TWW	6.41 b	2.61 b	0.233 b	28.55 b	35.65 b	0.47 c	3.79 b	1.30 b
T_6=50%RDF + 100%TWW	6.44 a	2.75 a	0.245 a	29.20 a	35.93 a	0.54 a	4.05 a	1.39 a

treatments. The pH of different treatments ranged between 6.35 to 6.44. The highest value of pH 6.44 was found with T_6 (50% RDF + 100% TWW), and the lowest (6.35) with T_1 (control).

Organic matter (OM) content of the post harvest soil of rice increased with the increasing rate of textile waste water irrigation. The OM content of post harvest soil of different treatments ranged between 2.45 to 2.75%. The OM content in post harvest soil of T_3 (50% RDF + 25% TWW), T_4 (50% RDF + 50% TWW), T_5 (50% RDF + 75% TWW) and T_6(50% RDF + 100% TWW) significantly ($P \leq 0.05$) varied as compared with T_1 (control). The highest organic matter content (2.75%) was found with T_6 (50% RDF + 100% TWW), and the lowest (2.45%) with T_1(control).

Nitrogen content of the post harvest soil of rice field increased with the increasing of textile waste water irrigation. The ranges of N in the treatments between 0.118 to 0.245%. N content in post harvest soil of all the treatments significantly ($P \leq 0.05$) increased as compared with the control (T_1). The highest N content (0.245%) was found with T_6 (50% RDF + 100% TWW), and the lowest (0.118 %) with T_1 (control).

The content of P and S of the post harvest soil of rice field increased significantly ($P \leq 0.05$) as compared with control. The ranges of P of post harvest soil of rice with different treatments were 24.00 to 29.20 ppm and S varied 29.00 to 35.93 ppm. The highest content of P (29.20 ppm) and S (35.93 ppm) were found with T_6 (50% RDF + 100% TWW). The lowest content of P (24.00 ppm) and S (29.00 ppm) were found with T_1 (control).

The content of K, Ca and Mg of post-harvest soil of rice increased in all the treatments significantly ($P \leq 0.05$) as compared with control. The K content in different treatments ranged between 0.30 to 0.54 C mol/kg. The Ca in different treatments ranged between 3.22 to 4.05 C mol/kg. Mg content with the treatments ranged between 0.87 to 1.39 C mol/kg. The highest concentration of K(0.54 C mol/kg), Ca(4.05 C mol/kg) and Mg (1.39 C mol/kg) were found with T_6 (50% RDF + 100% TWW). The lowest concentration of K (0.30 C mol/kg), Ca(3.22 C mol/kg) and Mg (0.87 C mol/kg) were found with T_1(control).

4.4.12. Effect of textile waste water on heavy metal concentration of post harvest soil of rice

The concentration of heavy metal in post harvest soil of rice field is presented in Table 4.70. It was observed that when the concentration of textile waste water increased, heavy metal increment was not found as much as higher in post harvest soil.

The concentration of Zn and Cu in post-harvest soil of rice field increased slightly in all treatment as compared with control. Zn and Cu concentration ranged 18.22 to 33.59 ppm and 0.63 to 0.98 ppm respectively were found in post harvest soil. Results showed Cu concentration in T_2 and T_4 carried statically same value. Highest concentration of Zn and Cu in post harvest soil were 33.59 and 0.98 ppm respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Zn and Cu were 18.22 and 0.63 ppm respectively, found with T_1 (control).

Table 4.70. Effect of textile waste water on heavy metal concentration of post harvest soil for rice cultivation

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1=control	18.22 f	0.63 e	22.59 e	202.11 e	0.224 d	30.10 f	29.30 f	2.30 c
T_2=100% RDF + 0%TWW	29.35 c	0.87 c	26.77 d	207.57 c	0.262 a	30.90 e	30.70 e	3.07 b
T_3=50% RDF + 25%TWW	26.74 e	0.80 d	26.77 d	203.75 d	0.247 c	31.22 d	30.92d	2.79bc
T_4=50% RDF + 50%TWW	29.20 d	0.85 c	27.05 c	207.50 c	0.251 c	33.89 c	31.75 c	2.91bc
T_5=50% RDF + 75%TWW	30.35 b	0.91 b	27.23 b	230.78 b	0.257 b	34.25 b	32.44 b	3.11ab
T_6=50% RDF+ 100%TWW	33.59 a	0.98 a	27.50 a	245.03 a	0.262 a	35.90 a	34.27 a	3.50 a

The concentration of Ni in post harvest soil of rice field increased significantly ($P \leq 0.05$) in all the treatments as compared with control. Highest concentration of Ni in post harvest soil 27.50 ppm was observed in T_6 , where 100% textile waste water was irrigated. It showed the lowest value of Ni (22.59 ppm) in post harvest soil with T_1 (control).The concentration of Ni in post harvest soil carried same value (26.77ppm) in T_2 and $T_{3.}$ In all the treatments displayed slightly increment of Ni over control.

Content of Fe in post harvest soil of rice increased significantly ($P \leq 0.05$) in all treatments as compared with control. Fe concentration in post harvest soil varied 202.11 to 245.03 ppm among the treatments. Highest concentration of Fe in post harvest soil 245.03 ppm was observed in T_6, where 100% textile waste water was irrigated. Lowest concentration of Fe in post harvest soil 202.11 ppm found in T_1 , where no fertilizer and textile waste water were used. The statically similar content Fe were found with T_2 and T_4 .

The concentration of Cd, Cr and Pb in post harvest soil of rice field were increased slightly in all the treatments (table 4.4.6). Results showed that there were no great variation in increasing Cd, Cr and Pb among the treatments T_1, T_2, T_3,T_4,T_5 and T_6. Highest concentration of Cd, Cr and Pb in post harvest soil were 0.262, 35.90 and 34.27 ppm respectively, found in T_6 , where 100% textile waste water was irrigated. Lowest concentration of Cd, Cr and Pb in post harvest soil were 0.224, 30.10 and 29.30 ppm respectively were found in T_1 (control). The findings also showed that Cd, Cr and Pb concentration in post harvest soil of treated plots with TWW slightly increased than T_1.

The content Mn in post harvest soil of rice field increased significantly ($P \leq 0.05$) in all the treatments as compared with control. Highest concentration (3.50 ppm) of Mn in post harvest soil was found in T_6, where 100% textile waste water was irrigated with 50%RDF. Mn found lowest (2.30 ppm) in post harvest soil in T_1 (control). There were no significant variation considering post-harvest soil Mn with T_2, T_3, T_4 and $T_{5.}$

Field experiment No. 3

Pictorial view of field experiment No. 3- Jute leaves vegetable (Pat shak))

Field Exp. 3: Jute leaves vegetable (Pat shak) at field condition

4.5. Field experiment No. 3

Influence of textile waste water on yield and heavy metal uptake by jute leaves (pat shak) at field condition

4.5.1. Effect of textile waste water on growth and yield of jute leaves vegetable plant (pat shak) at field condition

Plant height, number of leaves, weight of leaves, green plant and root were measured as yield contributing parameters.

4.5.2. Effect of textile waste water on plant height of jute leaves vegetable plant (pat shak) at field condition

Plant height (cm) with different concentration of waste water irrigation are presented in Figure 4.43. The result showed that textile waste water irrigation significantly ($P \leq 0.05$) increased the plant height of jute leaves vegetable plant at field condition as compared with control. The result also showed that plant height increased up to irrigation of 50% textile waste water. The extend irrigation of 50% textile waste water gradually decreased plant height. The results revealed that T_2(100% RDF + 0% TWW) acted the best positive effect on height of jute leaves plant and T_4 (50% RDF + 50% TWW) showed the second best positive effect on plant height at field condition. The tallest plant (60.73 cm) and the second tallest plant (56.47 cm) were found with

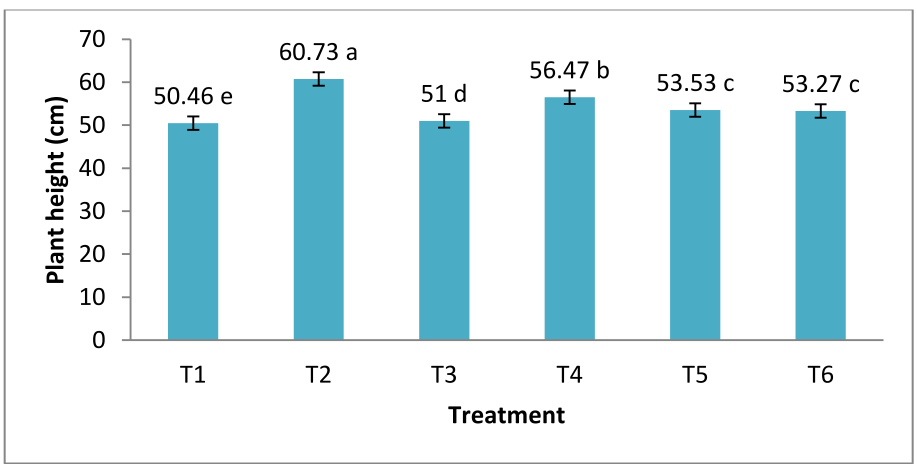

Fig. 4.43. Effect of textile waste water on plant height of jute leaves vegetable plant at field condition

T_2 and T_4 respectively. And the lowest plant height 50.46 cm was found with T_1(control). It was also found that all the treatments significantly ($P \leq 0.05$) varied with each other treatments, except T_5 and T_6 .

4.5.3. Effect of textile waste water on number leaves of jute leaves vegetable plant (pat shak) at field condition

Results of number of leaves per plant of jute leaves plant at field condition with different concentration of waste water irrigation are presented in Figure 4.44. The result showed that textile waste water irrigation significantly ($P \leq 0.05$) increased the number of leaves per plant of jute leaves plant at as compared with control, except T_3. The result also showed that number of leaves per plant increased up to irrigation of 75% textile waste water then gradually decreased. The results were displayed that T_2 (100% RDF + 0% TWW), T_4 (50% RDF + 50% TWW) and T_5 (50% RDF + 75% TWW) similar effect on producing number of leaves of jute leaves plant, which had no significant difference. The highest number of leaves per plant 12.6, the next highest number of leaves per plant 12.33 were found with T_2 and T_5 respectively. The lowest number of leaves per plant 9.4 was found with T_3 (50% RDF + 25% TWW).

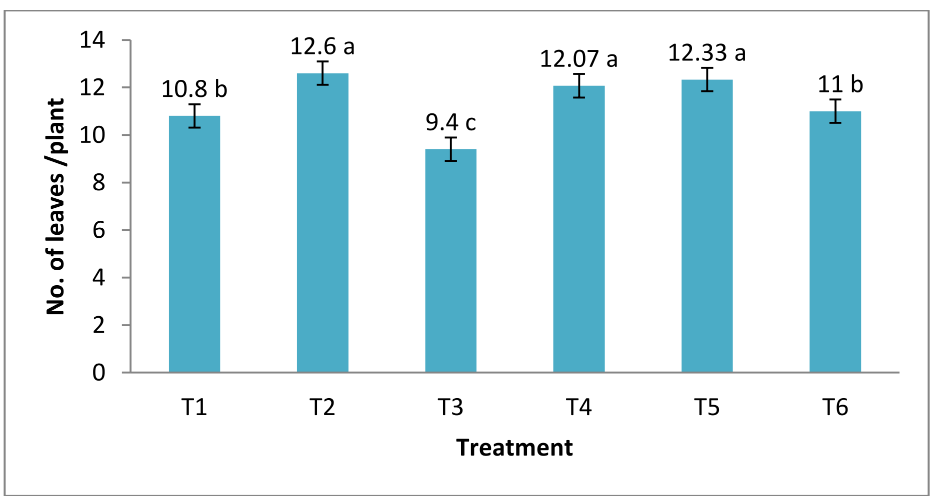

Fig. 4.44. Effect of textile waste water on number of leaves per plant of jute leaves vegetable plant at field condition

4.5.4. Effect of textile waste water on weight of leaves of jute leaves vegetable plant (pat shak) at field condition

The weight of leaves per plant of jute leaves plant at field condition with different concentration of waste water irrigation are presented in Figure 4.45. From the result it showed that textile waste water irrigation significantly ($P \leq 0.05$) increased the weight of leaves per plant in treated plots as compared with control, except T_3. The result also showed that weight of leaves per plant increased up to irrigation of 75% textile waste water but 100% rate of irrigation gradually decreased. The similar results found with T_4 (50% RDF + 50% TWW) and T_5 (50% RDF + 75% TWW) on the weight of leaves per plant, and no significant difference between the two treatments. The highest weight of leaves per plant was obtained (3.36 gm) in T_2. The second highest weight of leaves per plant (3.01 gm) were found with the treatment T_5. The lowest weight of leaves per plant (2.27 gm.) was found with T_3 (50% RDF + 25% TWW). The results also revealed that jute leaves yield was increased highest 29.23% with T_2 and next highest percent increment 15.77% with treatment T_5 over control.

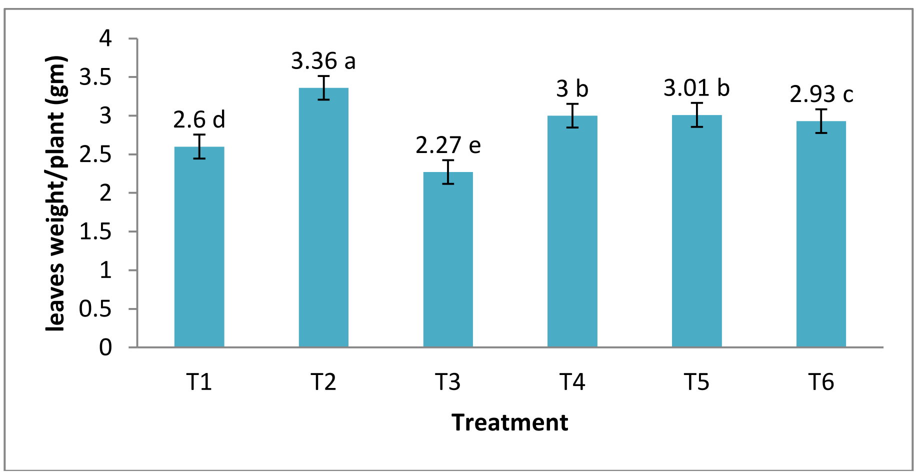

Fig. 4.45. Effect of textile waste water on leaves weight per plant of jute leaves vegetable plant at field condition

4.5.5. Effect of textile waste water on yield of jute leaves vegetable plant (pat shak) at field condition

Effect of textile waste water on the yield of jute leaves vegetable at field condition are shown in Figure 4.46. The irrigation of different doses of textile waste water significantly increased jute leaves yield as compared with T_1(control). There were no significant difference in T_4 (50% RDF + 50% TWW) and T_5 (50% RDF + 75% TWW) on the yield of jute leaves. The results indicated that 50% and 75% textile waste water combined with 50% RDF can gave similar yield production. The highest yield of jute leaves was 5.44 t/ha, which was found with T_2 (100%

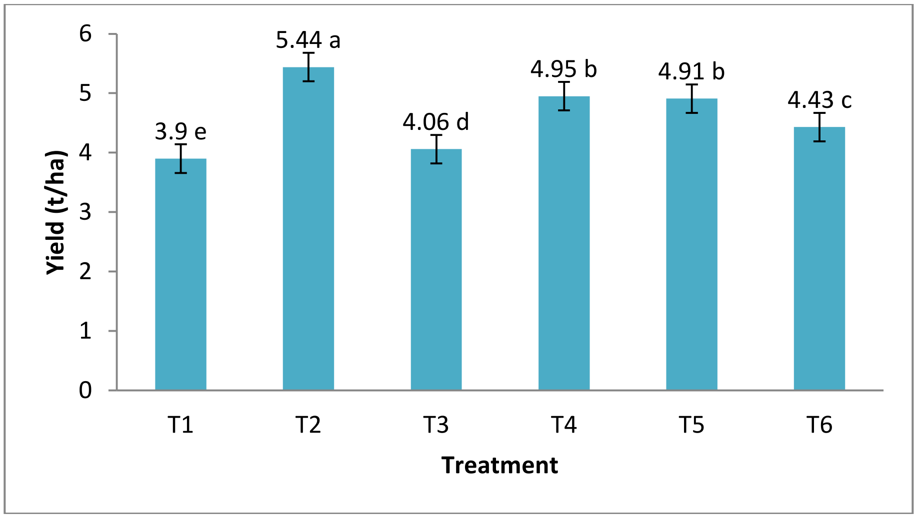

Fig. 4.46. Effect of textile waste water on yield of jute leaves vegetable plant at field condition

RDF + 0% TWW). The second highest yield of jute leaves was 4.95 t/ha achieved with the T_4(50% RDF + 50% TWW). It was yielded lowest 3.9 t/ha jute leaves vegetable with T_1(control). The results also showed that yield of jute leaves enhanced up to irrigation of 75%, beyond this decreased the yield.

4.5.6. Effect of textile waste water on dry matter production of jute leaves vegetable plant (pat shak) at field condition

The result of effect of textile waste water on dry matter production of jute leaves is presented in Table 4.71. Textile waste water enhanced total dry matter yield significantly ($P \leq 0.05$) over control. Highest dry matter yield was 1.77 t/ha, obtained with T_2 (100% RDF + 0% TWW). The dry matter yield was 1.57 t/ha, which was obtained with T_4 (50% RDF + 50% TWW) ranked as second highest. Lowest dry matter yield 1.24 t/ha was found with T_1 (control). The results also

Table 4.71. Effect of textile waste water on dry matter production of jute leaves vegetable plant (pat shak)

Treatment	Green weight of 5 plants /plot (gm)			Oven dry weight of 5 plants/plot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	13.00	40.00	7.67	4.16	13.2	1.92	0.27	0.85	0.12	1.24 d
T_2	16.80	55.67	8.67	5.46	18.65	2.17	0.37	1.25	0.15	1.77 a
T_3	11.33	44.00	7.67	3.69	14.3	1.89	0.24	0.92	0.12	1.28 d
T_4	15.00	53.33	8.33	4.85	17.44	2.07	0.31	1.13	0.13	1.57 b
T_5	15.05	51.33	9.10	4.91	16.68	2.25	0.32	1.08	0.15	1.55 b
T_6	14.67	45.00	9.00	4.84	14.76	2.23	0.31	0.95	0.14	1.40 c

revealed that T_4 and T_5 contributed similar dry matter yield, which was insignificant. Dry matter yield was increased in highest percentage (42.74%) with T_2 and next (26.61%) with T_4 over control.

4.5.7. Effect of textile waste water on nutrient content in different parts of jute leaves vegetable plant (pat shak) at field condition

Effect of textile waste water on nutrient content in different parts of jute leaves plant are presented in Table 4.72. Nutrient content of N, P, K, S, Ca and Mg in shoot was lower than leaves but higher than roots. The nutrient content of N of leaves of jute leaves plant found between 2.44 to 2.60%. Highest N content in leaves 2.60% was observed in T_2(100% RDF + 0% TWW) and the lowest 2.44% with T_6 (50% RDF + 100% TWW). The content of N in shoot obtained 0.82 to 1.20%. N content in shoot 1.20% was observed highest in T_2(100% RDF + 0% TWW) and the lowest N content 0.82% with T_5(50% RDF + 75% TWW). The content of N of root varied between 0.47 to 0.55%. Highest N content in root 0.45% was observed in T_2 (100% RDF + 0% TWW) and in T_6 (50% RDF + 100% TWW). The lowest N content in root 0.47% was recorded with T_3(50% RDF + 25% TWW). The results also showed that the N content of

Table 4.72. Effect of textile waste water on nutrient content in different parts of jute leaves vegetable plant (pat shak)

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	2.48	0.37	2.44	0.042	0.155	0.130
	Shoot	1.00	0.20	0.80	0.025	0.050	0.040
	Root	0.52	0.22	0.50	0.020	0.020	0.015
T_2= 100% RDF + 0% TWW	Leaves	2.60	0.40	2.55	0.045	0.162	0.150
	Shoot	1.20	0.25	1.00	0.027	0.060	0.050
	Root	0.55	0.30	0.60	0.021	0.022	0.020
T_3=50% RDF + 25% TWW	Leaves	2.49	0.34	2.48	0.041	0.159	0.135
	Shoot	0.90	0.18	0.90	0.025	0.055	0.047
	Root	0.47	0.20	0.62	0.019	0.020	0.017
T_4=50%RDF + 50% TWW	Leaves	2.57	0.38	2.66	0.039	0.160	0.144
	Shoot	1.00	0.24	1.05	0.023	0.057	0.050
	Root	0.52	0.30	0.75	0.020	0.020	0.020
T_5=50%RDF + 75% TWW	Leaves	2.52	0.35	2.80	0.041	0.160	0.140
	Shoot	0.82	0.21	1.30	0.022	0.055	0.050
	Root	0.50	0.26	0.90	0.020	0.018	0.020
T_6=50%RDF + 100% TWW	Leaves	2.44	0.33	2.50	0.043	0.160	0.138
	Shoot	0.86	0.25	1.00	0.020	0.060	0.049
	Root	0.55	0.27	0.77	0.018	0.017	0.021

jute leaves increased with 25% and 50% of textile waste water. The higher rate of textile waste water such as 75% and 100% reduced the N content.

The P content of leaves of jute leaves vegetable plant observed within the range of 0.33 to 0.40%. Highest P content in leaves 0.40% was observed in T_2 (100% RDF + 0% TWW) and the lowest P content 0.33% was with T_6 (50% RDF + 100% TWW). The P content of shoot varied 0.18 to 0.25%. Highest P content in shoot 0.25% was observed in T_2 (100% RDF + 0% TWW) and T_6 (50% RDF + 1000% TWW). The lowest P content 0.18% was with T_3 (50% RDF + 100% TWW) . The P content of root variation observed 0.20 to 0.30%. P content in root 0.30% was observed highest in T_2 (100% RDF + 0% TWW) and T_4 (50% RDF + 50% TWW). The lowest P content 0.20 % was observed with T_3(50% RDF + 25% TWW). The results revealed that P content of jute leaves vegetable plant increased with the concentration of textile waste water increased up to 50%, but higher rates of 75% and 100% reduced the P content.

The nutrient content of K in leaves of jute vegetable plant varied between 2.44 to 2.80%. Highest K in leaves 2.80% was in T_5 (50% RDF + 75% TWW) and the lowest K content 2.44% was observed with T_1(control). The nutrient content of K of shoot found in between 0.90 to 1.05%. Highest K content in shoot 1.05% was observed in T_5 (50% RDF + 75% TWW) and the lowest K content 0.90% with T_3(50% RDF + 25% TWW). The K content of root varied between 0.50 to 0.90%. Highest K content in root 0.90% was observed in T_5(50% RDF + 75% TWW). The K content 0.50 % was found lowest with T_1(control). The results showed that K content of jute leaves increased with the irrigation of textile waste water increased up to 75%, after then decreased.

The S content of leaves of jute leaves vegetable varied between 0.039 to 0.045%. Highest S content in leaves 0.045% was observed in T_2 (100% RDF + 0% TWW) and the lowest S 0.039% was with T_4 (50% RDF + 50% TWW). The S content of shoot varied between 0.020 to 0.027%. Highest S content in shoot 0.027% was observed in T_2 (100% RDF + 0% TWW) and the lowest S content 0.020% was with T_6(50% RDF + 100% TWW). The S content of root varied 0.018 to 0.021%. Highest S content in root 0.021% was observed in T_2 (100% RDF + 0% TWW). The lowest S content 0.018 % was observed with T_6((50% RDF + 100% TWW). The results showed that S content of jute leaves increased with all the treatments of textile waste water. The study also showed that the supreme dose 100% textile waste water also increased S content in leaves.

The Ca content of leaves of jute vegetable plant varied between 0.155 to 0.162%. Highest Ca content in leaves 0.162% was observed in T_2 (100% RDF + 0% TWW) and the lowest Ca content 0.155% was observed with T_1(control). The Ca content of shoot varied 0.050 to 0.060%. Highest Ca content in shoot 0.060% was observed in T_2 (100% RDF + 0% TWW) and T_6 (50% RDF + 100% TWW). The lowest Ca content in shoot 0.050% was found with T_1(control). The Ca content of root varied between 0.017 to 0.022%. Highest Ca content in root 0.022% was observed in T_2(100% RDF + 0% TWW). The lowest Ca content 0.017 % was observed with T_6(50% RDF + 100% TWW). Ca content of jute leaves increased with all the treatments of textile waste water than control (T_1).

The Mg content of leaves of jute leaves vegetable plant varied between 0.130 to 0.150%. Highest Mg content in leaves 0.150% was observed in T_2 (100% RDF + 0% TWW) and the lowest Mg content 0.130% was observed with T_1 (control). The Mg content of shoot varied between 0.040 to 0.050%. Highest Mg content in shoot 0.050% was observed in T_2 (100% RDF + 0% TWW), T_4 (50% RDF + 50% TWW) and in T_5 (50% RDF + 75% TWW). The lowest Mg content in shoot 0.040% was observed with T_1 (control). The Mg content of root varied between 0.015% to 0.021%. Highest Mg content in root 0.021% was observed in T_6 (50% RDF + 75% TWW). The lowest Mg content 0.015% was observed with T_1 (control). The results revealed that Mg content of jute leaves increased due to irrigation of textile waste water up to 50%, beyond this rates found decreasing trends.

4.5.8. Effect of textile waste water on nutrient uptake by jute leaves vegetable plant (pat shak) at field condition

Effect of textile waste water on nutrient uptake in different parts of jute leaves vegetable plant is presented in Table 4.73. The nutrients uptake with textile waste water irrigation increased significantly ($P \leq 0.05$) as compared with control in all the treatments (except N and P uptake by T_3). Considerable nutrients were taken up by all the treatments.

The total N uptake by each treatment significantly varied within the treatments. Total N uptake by jute leaves plants (leaves + shoots + roots) ranged between 14.82 to 25.45 kg/ha. The highest uptake of N (25.45 kg/ha) was observed with T_2 (100% RDF + 0% TWW) and the second highest uptake of N (19.95 kg/ha) was observed with T_4 (50% RDF + 50% TWW). The lowest uptake of N (14.82 kg/ha) was found with T_3 (50% RDF + 25% TWW). The results revealed that irrigation of more than 50% concentration of textile waste water reduce the total uptake of N by jute leaves plants.

Table 4.73. Effect of textile waste water on nutrient uptake in different parts of jute leaves vegetable plant (pat shak)

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	6.70	1.00	6.59	0.11	0.42	0.35
	Shoot	8.50	1.70	6.80	0.21	0.43	0.34
	Root	0.62	0.26	0.60	0.02	0.02	0.02
	Total	**15.82 e**	**2.96 d**	**13.99 f**	**0.34 c**	**0.87 f**	**0.71 e**
T_2=100% RDF + 0% TWW	Leaves	9.62	1.48	9.44	0.17	0.60	0.56
	Shoot	15.00	3.13	12.50	0.34	0.75	0.63
	Root	0.83	0.45	0.90	0.03	0.03	0.03
	Total	**25.45 a**	**5.06 a**	**22.84 b**	**0.54 a**	**1.38 a**	**1.22 a**
T_3=50%RDF +25% TWW	Leaves	5.98	0.82	5.95	0.10	0.38	0.32
	Shoot	8.28	1.66	8.28	0.23	0.51	0.43
	Root	0.56	0.24	0.74	0.02	0.02	0.02
	Total	**14.82 f**	**2.72 e**	**14.97 e**	**0.35 c**	**0.91 e**	**0.77 d**
T_4=50%RDF +%50 TWW	Leaves	7.97	1.18	8.25	0.12	0.50	0.45
	Shoot	11.30	2.71	11.87	0.26	0.64	0.57
	Root	0.68	0.39	0.98	0.03	0.03	0.03
	Total	**19.95 b**	**4.28 b**	**21.10 c**	**0.41 b**	**1.17 b**	**1.05 b**
T_5=50%RDF +75% TWW	Leaves	8.06	1.12	8.96	0.13	0.51	0.45
	Shoot	8.86	2.27	14.04	0.24	0.59	0.54
	Root	0.75	0.39	1.35	0.03	0.03	0.03
	Total	**17.67 c**	**3.78 c**	**24.35 a**	**0.40 bc**	**1.13 c**	**1.02 b**
T_6=50%RDF +100% TWW	Leaves	7.56	1.02	7.75	0.13	0.50	0.43
	Shoot	8.17	2.38	9.50	0.19	0.57	0.47
	Root	0.77	0.38	1.08	0.03	0.02	0.03
	Total	**16.50 d**	**3.78 c**	**18.33 d**	**0.35 c**	**1.09 d**	**0.93 c**

The total P uptake by the treatments also found significant ($P \leq 0.05$). The total P uptake of jute leaves plants (leaves + shoots + roots) ranged between 2.72 to 5.06 kg/ha. The highest of P (5.06 kg/ha) was observed highest with T_2 (100% RDF + 0% TWW) and the next highest uptake of P

(4.28 kg/ha) with T_4 (50% RDF + 50% TWW). The lowest uptake of P (2.72 kg/ha) was found with T_3(50% RDF + 25% TWW). The results revealed that irrigation of more than 50% concentration of textile waste water showed negative effect on the uptake of P by jute leaves plants.

The total K uptake by jute leaves vegetable plant in different treatments significantly ($P \leq 0.05$) increased. Each treatment also significantly ($P \leq 0.05$) varied with other treatments. The total K uptake of jute leaves plants (leaves + shoots + roots) ranged between 13.99 to 24.35 kg/ha. The highest uptake of K (24.35 kg/ha) was recorded with T_5 (50% RDF + 75% TWW) and the second highest uptake of K (22.84 kg/ha) was with T_2 (100% RDF + 0% TWW). The uptake of K (13.99 kg/ha) was found lowest with T_1 (control). The results point out that irrigation of more than 75% concentration of textile waste water reduced the uptake of K by jute leaves plants.

Total S uptake by jute leaves plants in T_2 and T_4 significantly ($P \leq 0.05$) increased as compared with T_1 (control). The S uptake by the treatments T_1, T_3, T_5 and T_6 were not significantly ($P \leq 0.05$) varied. The total S uptake of jute leaves plants (leaves + shoots + roots) ranged between 0.35 kg/ha to 0.54 kg/ha. The highest uptake of K (0.54 kg/ha) was observed with T_2 (100% RDF + 0% TWW) and the second highest uptake of S (0.41 kg/ha) was with T_4 (50% RDF + 50% TWW). The lowest uptake of S (0.35 kg/ha) was found with T_6 (50% RDF + 100% TWW). The results displayed that irrigation of more than 50% concentration of textile waste water had lower uptake rate of S by jute leaves plants.

Total Ca uptake by jute leaves vegetable plant with all the treatments significantly ($P \leq 0.05$) increased as compared with control. The total Ca uptake of jute leaves plants (leaves + shoots + roots) were ranged within 0.87 to 1.38 kg/ha. The highest uptake of Ca (1.38 kg/ha) was observed with T_2(100% RDF + 0% TWW) and hold the second place of uptake of Ca (1.17 kg/ha) was the T_4(50% RDF + 50% TWW). The lowest uptake of Ca (0.87 kg/ha) was found with T_1 (control).

Total Mg uptake by jute leaves plant increased significantly ($P \leq 0.05$) in all treatments as compared with control. The total Mg uptake of jute leaves plants (leaves + shoots + roots) ranged 0.71 to 1.22 kg/ha. The maximum uptake of Mg (1.22 kg/ha) was observed with T_2 (100% RDF + 0% TWW) and the second best uptake of Mg (1.05 kg/ha) was with T_4 (50%

RDF + 50% TWW). The minimum uptake of Mg (0.71 kg/ha) was found with the treatment T_1 (control).

4.5.9. Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant (pat shak) at field condition

Effect of textile waste water on heavy metal concentration in different parts of jute leaves at field condition is presented in Table 4.74. The data comprising that heavy metal accumulation in jute leaves plant had no large variation due to effect of textile waste water irrigation.

Table 4.74. Effect of textile waste water on heavy metal concentration in different parts of jute leaves vegetable plant (pat shak)

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= (control)	Leaves	49.50	8.75	ND	965.01	ND	ND	ND	55.90
	Shoot	15.25	3.20	ND	302.01	ND	ND	ND	10.03
	Root	5.10	1.00	ND	99.11	ND	ND	ND	3.51
T_2=100%RDF + 0% TWW	Leaves	51.5	12.70	7.05	1130.34	ND	0.125	ND	61.21
	Shoot	22.00	4.10	3.00	312.00	ND	0.102	ND	12.10
	Root	6.00	1.50	1.20	100.55	ND	0.031	ND	3.75
T_3=50% RDF + 25% TWW	Leaves	50.50	14.33	8.10	1012.56	ND	0.122	ND	51.74
	Shoot	20.00	5.11	3.20	310.53	ND	0.040	ND	10.33
	Root	5.50	1.60	1.30	100.00	ND	0.010	ND	4.75
T_4=50%RDF + 50% TWW	Leaves	52.50	15.89	8.30	1085.76	ND	0.127	ND	56.12
	Shoot	21.00	5.55	3.50	314.11	ND	0.050	ND	12.20
	Root	7.00	1.70	1.30	102.35	ND	0.010	ND	4.21
T_5=50%RDF + 75% TWW	Leaves	53.00	16.90	8.50	1274.55	ND	0.133	ND	74.25
	Shoot	22.00	6.00	3.70	357.03	ND	0.054	ND	15.02
	Root	7.00	2.10	1.50	105.12	ND	0.013	ND	4.52
T_6=50%RDF + 100% TWW	Leaves	53.50	18.93	9.60	1404.21	ND	0.139	ND	77.62
	Shoot	22.50	6.50	4.00	373.22	ND	0.061	ND	15.74
	Root	7.50	2.20	2.01	105.58	ND	0.015	ND	5.00

Zinc concentration in leaves of jute leaves vegetable plant varied from 49.50 to 53.50 ppm. Highest concentration of Zn in leaves was (53.50 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest (49.50 ppm) with T_1 (control). Zn concentration in shoot varied from 15.25 to

22.50 ppm. Highest concentration of Zn in shoot was (22.50 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest (15.25 ppm) was with T_1 (control). Zn concentration in root varied from 5.10 to 7.50 ppm. Highest concentration of Zn in root was (7.50 ppm) observed with the treatment T_6 (50% RDF + 100% TWW) and lowest Zn in shoot (5.10 ppm) with T_1 (control). The sequence of treatments for Zn concentration in leaves of jute leaves plant was $T_6>T_5>T_4>T_2>T_3>T_1$, in shoot $T_6>T_5,T_2>T_4>T_3>T_1$ and in root $T_6>T_5,T_4>T_2>T_3>T_1$.

Copper concentration in leaves of jute leaves vegetable plant varied from 8.75 to 18.93 ppm. Highest concentration of Cu in jute leaves was (18.93 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest (8.75 ppm) with T_1(control). Cu concentration in shoot varied from 3.20 ppm to 6.50 ppm. Highest concentration of Cu in shoot (6.50 ppm) was observed with T_6 (50% RDF + 100% TWW) and lowest of Cu (3.20 ppm) was with T_1 (control). In root Cu concentration varied from 1.00 to 2.20 ppm. Highest concentration of Cu in root (2.20 ppm) was observed with T_6 (50% RDF + 100% TWW) and lowest (1.00 ppm) with T_1 (control). The sequence of treatments for Cu concentration was in leaves $T_6>T_5>T_4>T_3>T_2>T_1$, in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_3>T_2>T_1$.

Nickel was not detectable in any part of jute leaves vegetable plant in T_1. Ni concentration in leaves varied from 7.05 to 9.60 ppm. Highest concentration of Ni in leaves was (9.60 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest (7.05 ppm) with T_2 (100% RDF + 0% TWW). Ni concentration in jute leaves vegetable shoot varied from 3.00 to 4.00 ppm. Highest concentration of Ni in shoot was (4.00 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Ni in shoot (3.00 ppm) was observed with T_2 (100% RDF + 0% TWW). In jute leaves vegetable root Ni concentration varied from 1.20 to 2.01 ppm. Highest concentration of Ni in root was (2.01 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Ni in root (1.20 ppm) was observed with T_2 (100% RDF + 0% TWW). The sequence of treatments for Ni concentration in jute vegetable leaves was $T_6>T_5>T_4>T_3>T_2>T_1$, in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_3>T_2>T_1$.

Content of Fe in jute leaves vegetable plant increased with the increasing concentration of textile waste water irrigation. Fe concentration in leaves of jute leaves ranged from 965.01 to 1404.21 ppm. Highest concentration of Fe in leaves was (1404.21 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Fe (965.01 ppm) was with T_1 (control). Fe concentration in shoot varied from 302.01 to 373.22 ppm. Highest concentration of Fe in shoot was (373.22 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest (302.01 ppm) with T_1 (control). In root the Fe concentration varied from 99.11 to 105.58 ppm. Highest concentration of Fe in root was (105.58 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest (99.11ppm) with T_1(control). The sequence of treatments for Fe concentration in jute vegetable leaves was $T_6>T_5>T_4>T_2>T_3>T_1$, in shoot $T_6>T_5>T_4>T_3>T_2>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$.

The data showed that the Cr was not found detectable level in T_1 (control). In the other treatments the Cr concentration in leaves ranged from 0.122 to 0.139 ppm. Highest concentration of Cr in leaves of jute leaves vegetable was (0.139 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Cr (0.122 ppm) was with T_3 (50% RDF + 25% TWW). Cr concentration in jute leaves shoot varied from 0.040 to 0.102 ppm. Highest concentration of Cr in shoot was (0.102 ppm) observed with T_2 (100% RDF + 0% TWW) and lowest concentration of Cr in shoot (0.040 ppm) was observed with T_3 (50% RDF + 25% TWW). In jute leaves root Cr concentration varied from 0.010 ppm to 0.031 ppm. Highest concentration of Cr in jute root was (0.031 ppm) observed with T_2 (100% RDF + 0% TWW) and lowest concentration of Cr in root (0.010 ppm) was observed with T_3 (50% RDF + 25% TWW) and T_4 (50% RDF + 50% TWW). The sequence of treatments for Cr concentration in leaves was $T_2>T_6>T_5>T_4>T_3>T_1$, in shoot $T_2>T_6>T_5>T_4>T_3>T_1$ and in root $T_2>T_6>T_5>T_4,T_3> T_1$.

As the concentration of textile waste water irrigation increased the Mn concentration in leaves of jute leaves plant increased. Mn concentration in leaves ranged from 51.74 to 77.62 ppm. Highest concentration of Mn in leaves was (77.62 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Mn (51.74 ppm) with T_3 (50% RDF + 25% TWW). Mn concentration in jute leaves shoot varied from 10.03 ppm to 15.74 ppm. Highest concentration of Mn in shoot was (15.74 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Mn in shoot (10.03 ppm) was observed with T_1 (control). In jute leaves root Mn concentration varied from 3.51 ppm to 5.00 ppm. Highest concentration of Mn in root was (5.00 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Mn in root (3.51 ppm) with T_1 (control). The sequence of treatments for Mn concentration in leaves was $T_6>T_5>T_2>T_4>T_1>T_3$, in shoot $T_6>T_5>T_4>T_2>T_3>T_1$ and in root $T_6>T_2>T_5>T_4>T_3>T_1$.

In accordance of heavy metal accumulation in jute leaves plant, it may be arranged as Fe>Mn>Zn>Cu>Ni>Cr. The heavy metal Cd and Pb were not detectable level in the jute leaves vegetable plant.

4.5.10. Effect of textile waste water on heavy metal uptake by jute leaves vegetable plant (pat shak) at field condition

Influence of textile waste water on heavy metal uptake by different parts of jute leaves plant is presented in Table 4.75. The result noticed that the heavy metal Pb and Cd were not up taken by jute leaves vegetable plant.

Textile waste water irrigation significantly ($P \leq 0.05$) increased Zn uptake by jute leaves vegetable as compared with control. The statistical analysis showed that uptake of Zn in T_5 and T_6 were similar. The Zn uptake ranged 26.94 to 47.46 gm/ha. The lowest uptake of Zn (26.94 gm/ha) was found with T_1 (control) and the highest uptake of Zn (47.46 gm/ha) was with T_2(100% RDF + 0% TWW). On the basis of Zn uptake by jute leaves vegetable plant the treatments may be arranged in the order of $T_2>T_5>T_4>T_6>T_3>T_1$.

The Cu uptake by jute leaves with all treatments significantly ($P \leq 0.05$) increased as compared with control. The statistical analysis showed that the uptake of Cu in T_5 and T_6 were similar. The Cu uptake ranged between 5.20 to 12.36 gm/ha. The lowest uptake of Cu (5.20 gm/ha) was found with T_1 (control) and the highest uptake of Cu (12.36 gm/ha) was with T_6 (50% RDF + 100% TWW). The findings of Cu uptake by jute leaves vegetable plant may be arranged in the order of $T_6>T_5>T_4>T_2>T_3>T_1$.

In jute leaves vegetable the Ni uptake by the treatment T_1(control) was found zero. Ni uptake by each treatment significantly ($P \leq 0.05$) varied with other treatments. The Ni uptake ranges between 0.0 (nil) to 7.06 gm/ha. The lowest uptake of Ni (0.0 gm/ha) was found with T_1 (control) and the highest uptake of Ni (7.06 gm/ha) was with T_6 (50% RDF + 100% TWW). On the basis of Ni uptake by jute leaves vegetable plant the treatments may be arranged in the order of $T_6>T_5>T_4>T_2>T_3>T_1$.

Table 4.75. Effect of textile waste water on heavy metal uptake by jute leaves vegetable plant (pat shak)

Treatment	Plant parts	Uptake of heavy metal (gm/ha)						
		Zn	**Cu**	**Ni**	**Fe**	**Cd**	**Cr**	**Pb**	**Mn**
T_1= control	Leaves	13.37	2.36	0	260.55	0	0	0	15.09
	Shoot	12.96	2.72	0	256.71	0	0	0	8.53
	Root	0.61	0.12	0	11.89	0	0	0	0.42
	Total	**26.94 e**	**5.20 e**	**0 f**	**529.15 e**	**0**	**0 d**	**0**	**24.04 c**
T_2=100%RDF + 0%TWW	Leaves	19.06	4.70	2.61	418.22	0	0.120	0	22.65
	Shoot	27.50	5.13	3.75	390.00	0	0.128	0	15.13
	Root	0.90	0.23	0.18	15.08	0	0.005	0	0.56
	Total	**47.46 a**	**10.06 c**	**6.54 d**	**823.30 a**	**0**	**0.253 a**	**0**	**38.34 a**
T_3=50%RDF + 25% TWW	Leaves	12.12	3.44	1.94	243.02	0	0.029	0	12.42
	Shoot	18.40	4.70	2.94	285.69	0	0.037	0	9.50
	Root	0.66	0.19	0.16	12.00	0	0.001	0	0.57
	Total	**31.18 d**	**8.34 d**	**5.04 e**	**540.71 d**	**0**	**0.067 c**	**0**	**22.49 c**
T_4=50%RDF + % 50 TWW	Leaves	16.28	4.93	2.57	336.58	0	0.039	0	17.40
	Shoot	23.73	6.27	3.96	354.94	0	0.057	0	13.79
	Root	0.91	0.22	0.17	13.30	0	0.001	0	0.55
	Total	**40.92 bc**	**11.42 b**	**6.70 c**	**704.82 c**	**0**	**0.097 b**	**0**	**31.74 b**
T_5=50%RDF + 75% TWW	Leaves	16.96	5.41	2.72	407.86	0	0.043	0	23.76
	Shoot	23.76	6.48	4.00	385.59	0	0.058	0	16.22
	Root	1.05	0.32	0.23	15.77	0	0.002	0	0.68
	Total	**41.77 b**	**12.21 a**	**6.95 b**	**809.22 b**	**0**	**0.103 b**	**0**	**40.66 a**
T_6=50%RDF + 100%TWW	Leaves	16.59	5.87	2.98	435.31	0	0.043	0	24.06
	Shoot	21.38	6.18	3.80	354.56	0	0.058	0	14.95
	Root	1.05	0.31	0.28	14.78	0	0.002	0	0.700
	Total	**39.02 c**	**12.36 a**	**7.06 a**	**804.65 b**	**0**	**0.103 b**	**0**	**39.71 a**

The Fe uptake by all the treatments significantly ($P \leq 0.05$) increased as compared with control. The Fe uptake ranges between 529.15 to 823.30 gm/ha. The lowest uptake of Fe (529.15 gm/ha) was found with T_1 (control) and the highest uptake of Fe (823.30 gm/ha) was with T_2 (100% RDF + 0% TWW). Fe uptake by jute leaves vegetable plant was found all most similar in T_5 and

T_6. The data indicated that the Fe uptake by jute leaves plant with the treatments may be arranged in the order of $T_2>T_5>T_6>T_4>T_3>T_1$.

The Cr uptake with T_1 was (zero) not detectable range. The Cr uptake was different scares level with the increasing concentration of textile waste water. The Cu uptake ranged between 0.0 (nil) to 0.253 gm/ha. The lowest uptake of Cu (0.0 gm/ha) was found with T_1 (control). The highest uptake of Cu (0.253 gm/ha) was observed with T_2 (100% RDF + 0% TWW). Cr uptake by jute leaves vegetable plant in the treatments may be arranged in the order of $T_2>T_6>T_5>T_4>T_3>T_1$.

The Mn uptake by jute leaves plant in the treatments significantly ($P \leq 0.05$) increased. The Mn uptake by jute leaves plant ranged between 22.49 to 40.66 gm/ha. The lowest uptake of Mn (22.49 gm/ha) was found with T_3 (50% RDF + 25% TWW) and the highest uptake of Mn (40.66 gm/ha) was observed with T_5 (50% RDF + 75% TWW). From the study it was observed that the Mn uptake value was nearer in T_5 and T_6. Findings of Mn uptake by jute leaves vegetable plant, the treatments may be arranged in the order of $T_5>T_6>T_2>T_4>T_1>T_3$.

4.5.11. Effect of textile waste water on nutrient status of post harvest soil of jute leaves vegetable plant (pat shak) at field condition

Effect of textile waste water on average nutrient status of post harvest soil for jute leaves vegetable plant cultivation is presented in Table 4.76. Soil pH, organic matter, N, P, K, S, Ca and Mg were influenced by the textile waste water irrigation.

The pH of the post harvest soil increased at 5% level, but was not showed gulf of difference among treatments. The pH of treatments ranges between 6.35 to 6.48. The highest value of pH (6.48) was found with T_6 (50% RDF + 100% TWW), and the lowest pH (6.35) was with T_2 (100% RDF + 0% TWW). The obtained value of pH in different treatment were carried almost same.

Organic matter content of the post harvest soil significantly ($P \leq 0.05$) increased due to irrigation of textile waste water in comparison with control. The organic matter content of post harvest soil of different treatments were ranged between 2.44 to 2.82%. The highest organic matter content (2.82%) was found with T_6 (50% RDF + 100% TWW), and the lowest organic matter content (2.44%) was found with the treatment T_1(control).

Table 4.76. Effect of textile waste water on nutrient status of post harvest soil for jute leaves vegetable plant (pat shak) cultivation

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.39 d	2.44 e	0.115 e	23.57 f	25.72 f	0.27 d	3.05 f	0.80 e
T_2=100%RDF + 0%TWW	6.35 e	2.50 d	0.257 a	27.92 d	32.12 d	0.55 a	4.07 c	1.52 c
T_3=50%RDF + 25% TWW	6.40 d	2.55 c	0.168 d	26.43 e	30.55 e	0.42 c	3.77 e	1.11 d
T_4=50%RDF + % 50 TWW	6.42 c	2.67 b	0.190 c	29.22 c	33.20 c	0.44 c	3.90 d	1.54 c
T_5=50%RDF + 75% TWW	6.45 b	2.69 b	0.241 b	30.15 b	36.11 b	0.48 b	4.21 b	1.72 b
T_6=50%RDF + 100%TWW	6.48 a	2.82 a	0.259 a	32.29 a	36.90 a	0.56 a	4.59 a	1.81 a

Nitrogen content of the post harvest soil increased significantly ($P \leq 0.05$) with the increasing the concentration of textile waste water irrigation. The N of different treatments ranges between 0.115 to 0.259 %. The highest nitrogen content (0.259 %) was found with T_6 (50% RDF + 100% TWW), and the lowest nitrogen content (0.115 %) was with T_1(control). The results also showed that content of N in T_4 and T_5 was similar.

Phosphorus and Sulphur content of the post harvest soil increased significantly ($P \leq 0.05$) as compared with control. The P of post harvest soil of different treatments ranged between 23.57 to 32.29 ppm. and the S ranged 25.72 to 36.90 ppm. The highest content of P (32.29 ppm) and S (36.90 ppm) were found with T_6 (50% RDF + 100% TWW). The lowest content of P (23.57 ppm) and S (25.72 ppm) were found with T_1(control). The achievement indicated that adequate amount of P and S were retained in soil.

Potassium and Calcium content of post harvest soil increased significantly ($P \leq 0.05$) as compared with control. The K of different treatment ranged between 0.27 to 0.56 C mol/kg and the Ca ranged 3.05 to 4.59 C mol/kg .The highest content of K (0.56 C mol/kg) and Ca(4.59 C mol/kg) were found with T_6 (50% RDF + 100% TWW). The lowest content of K (0.27 C mol/kg) and Ca(3.05 C mol/kg) were found with T_1(control). Here post harvest soil K content with treatment T_3 and T_4 possessed almost similar value. The result exposed similar trend with T_2 and T_6 in containing K.

Magnesium content increased significantly ($P \leq 0.05$) in all treatment as compared with control. The Mg content of post harvest soil of different treatments ranged between 0.80 to 1.81 C mol/kg. The highest content of Mg (1.81 C mol/kg) was observed with T_6 and the lowest content of Mg (0.80 C mol/kg) was found with T_1(control). The post harvest soil Mg content in T_2 and T_4 statistically found similar.

4.5.12. Effect of textile waste water on heavy metal concentration of post harvest soil of jute leaves a vegetable plant (pat shak) field condition

The heavy metal concentration of post harvest soil for jute leaves vegetable cultivation is presented in Table 4.77. It was observed that as the concentration of textile waste water increased, heavy metal concentration in post harvest soil were not found very high rate with the treatments.

Concentration of Zn and Cu in post harvest soil of jute leaves vegetable plant increased significantly ($P \leq 0.05$) in all treatments as compared with control. Highest concentration of Zn and Cu in post harvest soil were 35.21 and 1.01 ppm respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Zn and Cu were 17.50 ppm and 0.57 ppm, which were found with T_1(control). The results exploring that Zn content in T_2 and T_5 were carried very closer value. The content of Cu found similar in T_2 and T_4.

Concentration of Ni in post harvest soil was found little variation ($P \leq 0.05$) among the treatments. Highest concentration of Ni in post harvest soil 32.11 ppm was observed in T_6, where 100% textile waste water was irrigated. The lowest value of Ni (21.50 ppm) in post harvest soil found with T_1. Ni content of post harvest soil with T_2, T_3 and T_4 was found similar and showed lower value with compare to other treatments.

Table 4.77. Effect of textile waste water on heavy metal concentration of post harvest soil for jute leaves vegetable plant (pat shak) cultivation

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1=control	17.50 e	0.57 d	21.50 d	200.77 e	0.200 b	27.55 d	27.33 f	2.22 d
T_2=100% RDF + 0%TWW	32.52 b	0.93 b	28.95 c	250.10 b	0.266 a	32.75 c	32.42 e	3.89 ab
T_3=50% RDF + 25%TWW	29.22 d	0.85 c	27.75 c	237.33 d	0.250 a	32.08 c	33.08 d	2.97 c
T_4=50% RDF + 50%TWW	31.70 c	0.92 b	29.22 bc	243.50 c	0.258 a	34.11 b	34.93 c	3.44 bc
T_5=50% RDF + 75%TWW	32.72 b	0.86 c	30.07 b	251.90 b	0.266 a	36.05 a	35.11 b	3.90 ab
T_6=50% RDF+ 100%TWW	35.21 a	1.01 a	32.11 a	260.21 a	0.275 a	37.11 a	35.90 a	4.07 a

Concentration of Fe in post harvest soil increased significantly ($P \leq 0.05$) in all treatments as compared with control. Highest concentration of Fe in post harvest soil 260.21 ppm was observed in T_6 , where 100% textile waste water was irrigated. Lowest concentration of Fe in post harvest soil 200.77 ppm was observed in T_1 (control). The Fe content in post harvest soil with T_2 and T_5 statistically similar.

Concentration of Cd in post harvest soil slightly increased in all the treatments as compared with control. Highest concentration of Cd in post harvest soil 0.275 ppm was observed in treatment T_6, where 100% textile waste water was irrigated. Lowest concentration of Cd in post harvest soil was 0.200 ppm observed in T_1 (control). The findings clearly showed that Cd content of post harvest soil with T_2, T_3 , T_4 , T_5 and T_6 did not significantly vary with each other treatment. It is also observed that Cd content found almost similar with all the treated plots compared to initial soil value. Rather it was decreased in T_1 considering the Cd presented in initial soil.

Concentration of Cr and Pb in post harvest soil increased in all treatments as compared with control. Highest concentration of Cr and Pb in post harvest soil were 37.11 and 35.90 ppm respectively, observed in T_6, where 100% textile waste water was irrigated. Lowest concentration of Cr and Pb in post harvest soil were 27.55 and 27.33 ppm respectively, observed in T_1 (control). The post harvest soil Cr content with T_2 did not significantly varied with T_3. It was also found that Cr content had similar value in T_5 and T_6. The variation was not found larger in compare to initial soil value containing the Cr and Pb in post harvest soil among the treated plats. Findings also indicated that Cr and Pb was lower in T_1 compare to initial soil value.

Concentration of Mn in post harvest soil increased significantly ($P \leq 0.05$) in all the treatments as compared with control. Highest concentration of Mn in post harvest soil 4.07 ppm was observed in T_6 with 100% textile waste water irrigation. Lowest concentration of Mn in post harvest soil 2.22 ppm was observed in T_1 (control). Mn content of post harvest soil with treatment T_2, T_5 and T_6 carried similar value which statistically found insignificant. This findings also showed a larger variation in compare to other treatments T_4, T_3 and T_1.

Field experiment No. 4

Pictorial view of field experiment No. 4 (Red amaranth)

Field Exp. 4: Textile waste water was applying in the experimental plots

4.6. Field experiment No. 4

Influence of textile waste water on yield and heavy metal uptake by red amaranth

4.6.1. Effect of textile waste water on growth and yield of red amaranth

Plant height, base diameter, number of leaves, weight of leaves, shoot and root are measured as yield contributing parameters.

4.6.2. Effect of textile waste water on plant height of red amaranth

Plant height (cm) of red amaranth with different concentration of textile waste water irrigation has been presented in Figure 4.47.

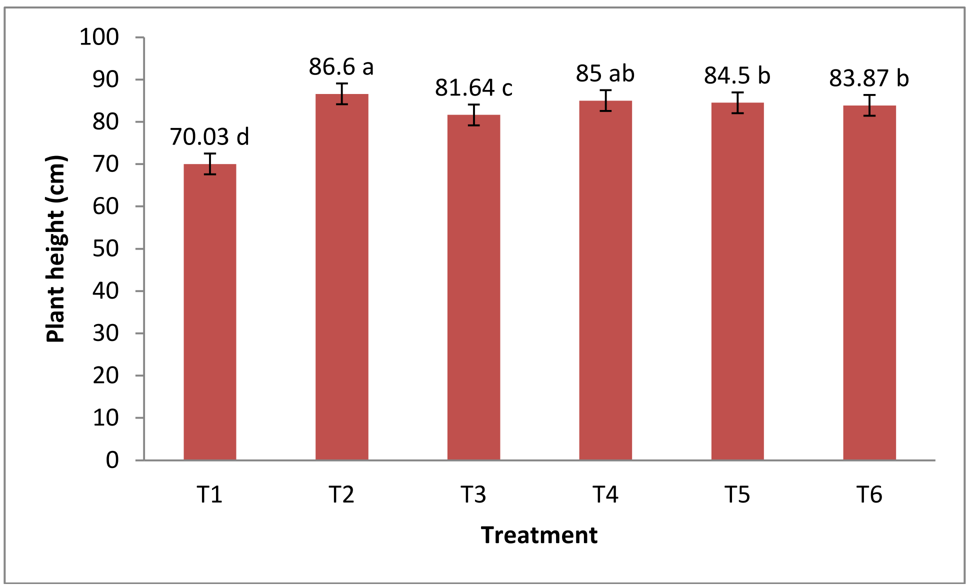

Fig. 4.47. Effect of textile waste water on plant height of red amaranth

The result showed that due to textile waste water irrigation there was significantly ($P \leq 0.05$) increased the plant height of red amaranth as compared with control. The result also showed that plant height increased up to irrigation of 50% textile waste water then gradually decreased. The results revealed that T_2 (100% RDF + 0% TWW) showed the best positive effect on red amaranth plant height and T_4 (50% RDF + 50% TWW) showed the second best positive effect on plant height. The tallest plant 86.6 cm ,the second tallest plant 85 cm were found with the T_2 and T_4 respectively. And the lowest plant height 70.03 cm was found with T_1 (control). The value of plant height with T_4, T_5 and T_6 were statistically similar.

4.6.3. Effect of textile waste water on base diameter of amaranth plant

The results of base diameter of red amaranth plant (mm) with different concentration of waste water irrigation has been presented in Figure 4.48. Application of different combinations of effluent significantly ($P \le 0.05$) increased the base diameter of the red amaranth plant as compared with control. The highest base diameter 18.2 mm was found with T_2 (100% RDF + 0% TWW), which was also significantly ($P \le 0.05$) varied with other treatments. Here the second highest base diameter of the red amaranth plant 16 mm was found with T_4(50% RDF + 50% TWW), which was also significantly ($P \le 0.05$) varied with T_5, T_6 and T_1. The lowest base diameter of the plant 12.1 mm was found with T_1 (control). Base diameter increased up to 50% textile waste water irrigation after that it was decreasing trends.

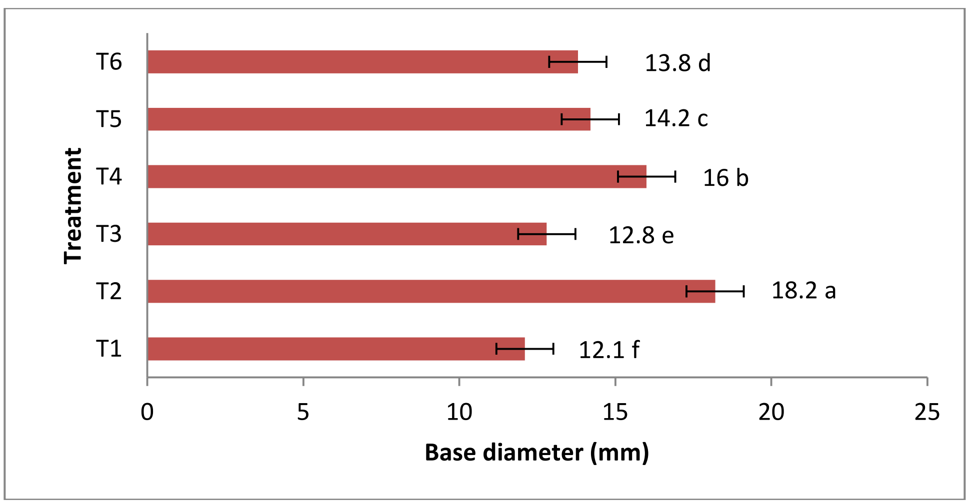

Fig. 4.48. Effect of textile waste water on base diameter of red amaranth

4.6.4. Effect of textile waste water on number leaves of red amaranth

Results of number of leaves per plant of red amaranth with different concentration of waste water irrigation has been presented in Figure 4.49. The result showed that textile waste water irrigation significantly ($P \le 0.05$) increased the number of leaves per plant of red amaranth as compared with control. The result also showed that number of leaves per plant increased up to irrigation of 25% textile waste water then gradually decreased.

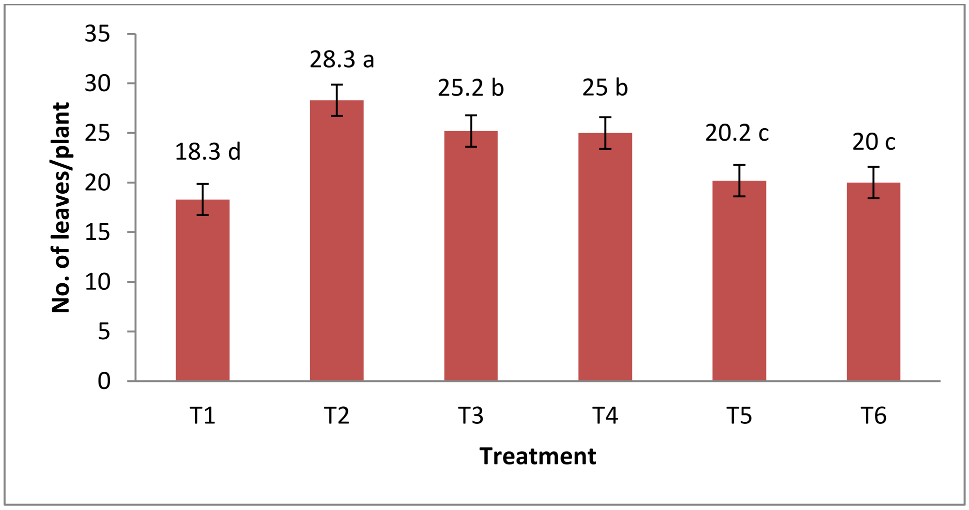

Fig. 4.49. Effect of textile waste water on number of leaves per plant of red amaranth

The results revealed that T_3 (50% RDF + 25% TWW) and T_4 (50% RDF + 50% TWW) showed the similar effect on number of leaves of red amaranth, and no significant difference between each other . Same trend of result found with T_5 (50% RDF + 75% TWW) and T_6 (50% RDF + 100% TWW) on producing number of leaves without significant difference between each other. The highest number of leaves per plant 28.3, the next highest number of leaves per plant 25.2 were found with T_2 and T_4 respectively. And the lowest number of leaves per plant 18.3 was found with T_1 (control).

4.6.5. Effect of textile waste water on yield of red amaranth

Effect of textile waste water on yield of red amaranth are shown in Figure 4.50. The results showed that irrigation of different dose of textile waste water significantly ($P \leq 0.05$) enhanced yield of red amaranth as compared with T_1(control). The yield of red amaranth increased with the concentration of textile waste water up to 50%, beyond that dose it was decreased. The highest yield of red amaranth 38.18 t/ha was found with T_2 (100% RDF + 0% TWW). And the second highest yield of red amaranth 36.78 t/ha was found with T_4 (50% RDF + 50% TWW). The lowest yield of red amaranth 23.75 t/ha was found with T_1 (control). The results also revealed that yield of red amaranth with all treatments significantly ($P \leq 0.05$) varied with the treatments. In this experiment, yield was increased 60.76% with T_2 and 54.86% with T_4 over control.

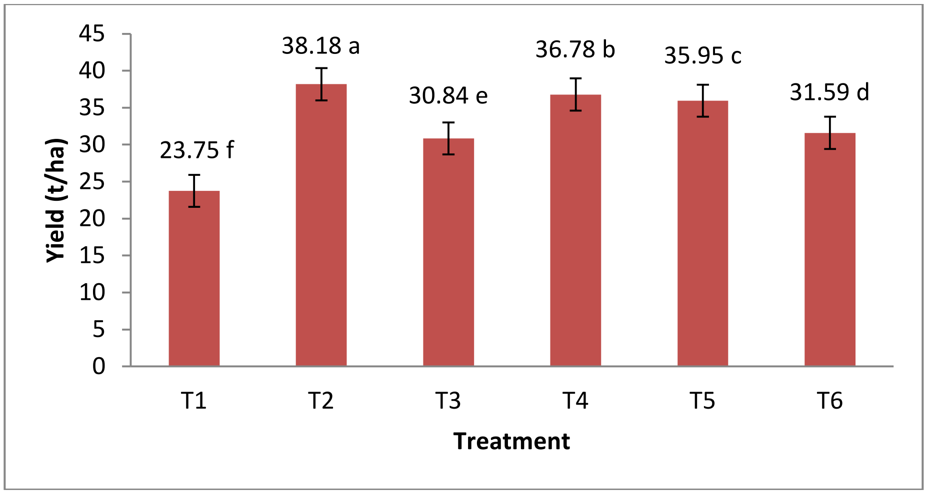

Fig. 4.50. Effect of textile waste water on yield of red amaranth

4.6.6. Effect of textile waste water on dry matter production of red amaranth

Effect of textile waste water on dry matter production of red amaranth is presented in Table 4.78. Textile waste water enhanced total dry matter yield significantly ($P \leq 0.05$) over control. The maximum dry matter yield (6.01 t/ha) was obtained with T_2 (100% RDF + 0% TWW). The

Table 4.78. Effect of textile waste water on dry matter production of red amaranth

Treatment	Green weight of 5 plants /plot (gm)			Oven dry weight of 5 plants/plot (gm)			Oven dry weight (t/ha)			Total dry weight (t/ha)
	Leaves	Shoot	Root	Leaves	Shoot	Root	Leaves	Shoot	Root	L+S+R
T_1	95.5	236.17	43.33	11.56	34.95	10.05	0.73	2.21	0.64	3.58 e
T_2	201.7	331.97	58.33	32.01	48.13	13.17	2.06	3.10	0.85	6.01 a
T_3	162.0	253.20	40.20	19.29	37.98	9.40	1.31	2.57	0.64	4.52 d
T_4	169.0	317.67	56.67	21.28	45.12	12.86	1.44	3.05	0.87	5.36 b
T_5	155.7	304.30	55.67	18.08	44.87	12.77	1.26	3.12	0.89	5.27 c
T_6	151.5	265.50	53.33	17.56	38.76	12.11	1.18	2.6	0.81	4.59 d

second major rate of dry matter yield (5.36 t/ha) was obtained with T_4 (50% RDF + 50% TWW). Lowest dry matter yield (3.58 t/ha) was found with T_1 (control). The results also revealed that T_3 and T_6 gave similar dry matter yield, which had no significant different. Dry matter yield was increased 67.88% with T_2 and 49.72% with T_4 over control.

4.6.7. Effect of textile waste water on nutrient content in different parts of red amaranth

Effect of textile waste water on nutrient content in different parts of red amaranth is presented in Table 4.79. Nutrient content of N, P, K, S, Ca and Mg in shoot was lower than leaves but higher than roots. The nutrient content of N in leaves of red amaranth varied between 3.10 to 3.70%. Highest N content in leaves 3.70% was observed in T_2 (100% RDF + 0% TWW) and the lowest 3.10% was with T_1 (control). The nutrient content of N of shoot varied between 0.94 to 1.04%. Highest N content in shoot 1.04% was observed in treatment T_5 (50% RDF + 75% TWW) and the lowest 0.94% was observed with T_1(control). The nutrient content of N of root varied 0.60 to 0.69%. Highest N content in root 0.69% was observed in T_5 (50% RDF + 75% TWW). The lowest N content in root 0.60% was observed with T_1(control). The results revealed that N content of red amaranth increased with the concentration of textile waste water increased up to 75%, it decreased with highest irrigation (100%) dose.

The P content of leaves of red amaranth was within 0.34 to 0.41%. P content found highest in amaranth leaves 0.41% in T_2 (100% RDF + 0% TWW) and the lowest P content 0.34% with T_1(control). The P content of shoot varied 0.12 to 0.15%. Highest P content in shoot 0.15% was found in T_2(100% RDF + 0% TWW) and T_5(50% RDF + 75% TWW). The lowest P content 0.12% was observed with T_1 (control). The P content of root varied between 0.07 to 0.11%. P content in root 0.11% was highest observed in T_4(50% RDF + 50% TWW). The lowest P content 0.07 % was observed with T_3(50% RDF + 25% TWW). The results revealed that P content of red amaranth influenced by the concentration of textile waste water irrigation up to 75%, then decreased.

Table 4.79. Effect of textile waste water on nutrient content in different parts of red amaranth plant

Treatment	Plant parts	Nutrient %					
		N	P	K	S	Ca	Mg
T_1= control	Leaves	3.10	0.34	0.46	0.67	0.730	0.75
	Shoot	0.94	0.12	0.25	0.32	0.225	0.30
	Root	0.60	0.08	0.16	0.20	0.110	0.13
T_2= 100% RDF + 0% TWW	Leaves	3.70	0.41	0.49	0.85	0.895	0.84
	Shoot	1.02	0.15	0.26	0.41	0.290	0.35
	Root	0.65	0.10	0.18	0.30	0.150	0.20
T_3=50% RDF + 25% TWW	Leaves	3.21	0.36	0.45	0.78	0.775	0.77
	Shoot	0.96	0.13	0.23	0.35	0.235	0.31
	Root	0.63	0.07	0.18	0.22	0.125	0.14
T_4=50%RDF + 50% TWW	Leaves	3.52	0.37	0.48	0.82	0.810	0.82
	Shoot	1.02	0.14	0.27	0.40	0.255	0.40
	Root	0.66	0.11	0.17	0.31	0.155	0.20
T_5=50%RDF + 75% TWW	Leaves	3.61	0.38	0.47	0.81	0.850	0.80
	Shoot	1.04	0.15	0.26	0.38	0.265	0.37
	Root	0.69	0.10	0.17	0.20	0.150	0.16
T_6=50%RDF + 100% TWW	Leaves	3.37	0.36	0.46	0.80	0.800	0.75
	Shoot	0.97	0.14	0.23	0.36	0.245	0.33
	Root	0.66	0.09	0.15	0.25	0.135	0.16

The K content of leaves of red amaranth varied between 0.45 to 0.49%. Highest K content in leaves 0.49% was achieved in T_2 (100% RDF + 0% TWW) and the lowest K content 0.45% was with T_3 (50% RDF + 25% TWW). The K content of shoot varied 0.23 to 0.27%. Highest K content in shoot 0.27% was contributed by T_4 (50% RDF + 50% TWW) and the lowest K content 0.23% with T_3(50% RDF + 50% TWW) and T_6(50% RDF + 100% TWW). The K content of root varied between 0.15 to 0.18%. Highest K content in root 0.18% was observed in T_3 (50% RDF + 25% TWW). The lowest K content 0.15 % was observed with T_6(50% RDF +

100% TWW). The results revealed that K content of red amaranth increased with the concentration of textile waste water increased up to 50%, after then it was decreased.

Sulphur content of leaves of red amaranth varied between 0.67 to 0.85%. Highest S content in leaves 0.85% was observed in T_2 (100% RDF + 0% TWW) and the lowest S content 0.67% was with T_1(control). The S content of shoot varied between 0.32 to 0.41%. Highest S content in shoot 0.41% was observed in T_2 (100% RDF + 0% TWW) and the lowest S content 0.32% was with T_1(control). The S content of root varied between 0.20% to 0.31%. Highest S content in root 0.31% was observed in T_4 (50% RDF + 50% TWW). The lowest S content 0.20% was observed with T_1 (control) and T_5((50% RDF + 75% TWW). S content of red amaranth increased with the irrigation of textile waste water up to 50%. The over rates of irrigation viz. 75% and 100% reduced the S content.

Calcium content of leaves of red amaranth varied between 0.730 to 0.895%. Highest Ca content in leaves 0.895% was monitored in T_2 (100% RDF + 0% TWW) and the lowest Ca content 0.730% was detected with T_1(control). The Ca content of shoot varied between 0.225 to 0.290%. Highest Ca content in shoot 0.290% was observed in T_2 (100% RDF + 0% TWW) and the lowest Ca content in shoot 0.225% was with T_1(control). The Ca content of root varied between 0.110 to 0.155%. Highest Ca content in root 0.155% was achieved in T_4 (50% RDF + 50% TWW). The lowest Ca content 0.110 % was found with T_1(control). The study revealed that highest dose of irrigation (100% TWW) declined the content of Ca.

The Mg content of leaves of red amaranth varied between 0.75 to 0.84%. Highest Mg content in amaranth leaves 0.84% was obtained in T_2 (100% RDF + 0% TWW) and the lowest Mg content 0.75% was with T_1 (control). The Mg content of shoot varied between 0.30 to 0.40%. Highest Mg content in shoot 0.40% was observed in T_4 (50% RDF + 50% TWW). The lowest Mg content in shoot 0.30% was found with T_1 (control). The Mg content of root varied between 0.13 to 0.20%. Highest Mg content in root 0.20% was observed in T_2 (100% RDF + 0% TWW) and T_4 (50% RDF + 50% TWW). The lowest Mg content 0.13% was observed with T_1(control). Mg content achieved in higher rate up to 50% textile waste water irrigation, beyond this dose it was decreased.

4.6.8. Effect of textile waste water on nutrient uptake by red amaranth

Effect of textile waste water on nutrient uptake in different parts of red amaranth is presented in Table 4.80. The results revealed that nutrients uptake due to textile waste water irrigation increased significantly ($P \leq 0.05$) as compared with control in all the treatments. Considerable nutrients were taken up by all the treatments.

Total N uptake by red amaranth significantly ($P \leq 0.05$) increased with all treatments as compared with control. The total N uptake of red amaranth plant (leaves + shoot + root) ranged between 47.24 to 113.37 kg/ha. The highest uptake of N (113.37 kg/ha) was observed with T_2(100% RDF + 0% TWW) and the next highest uptake of N (87.54 kg/ha) was observed with T_4(50% RDF + 50% TWW). The lowest uptake of N (47.24 kg/ha) was found with the T_1(control). The results revealed that irrigation of more than 50% concentration of textile waste water reduced the uptake of N by red amaranth.

Total P uptake significantly ($P \leq 0.05$) increased with all treatments over control by red amaranth. P uptake by each treatment also significantly pronounced with other treatments. The P uptake of red amaranth plant (leaves + shoot + root) ranged between 5.64 to 13.95 kg/ha. The highest uptake of P (13.95 kg/ha) was observed with T_2 (100% RDF + 0% TWW) and the second highest uptake of P (10.56 kg/ha) was observed with T_4 (50% RDF + 50% TWW). The lowest uptake of P (5.64 kg/ha) was found with T_1 (control). The results revealed that irrigation of more than 50% concentration of textile waste water had lower amount uptake of P by red amaranth.

The total K uptake by red amaranth exhibited significant treatment difference ($P \leq 0.05$). The total K uptake by red amaranth plant (leaves + shoot + root) found ranged 9.91 to 19.68 kg/ha. The highest uptake of K (19.684 kg/ha) was observed with T_2 (100% RDF + 0% TWW) and the next highest uptake of K (16.63 kg/ha) was observed with T_4 (50% RDF + 50% TWW). The lowest uptake of K (9.91 kg/ha) was found with T_1 (control). The results revealed that irrigation of more than 50% concentration of textile waste water reduce the uptake of K by red amaranth.

Table 4.80. Effect of textile waste water on nutrient uptake in different parts of red amaranth

Treatment	Plant parts	Uptake of nutrient Kg/ha					
		N	**P**	**K**	**S**	**Ca**	**Mg**
T_1= control	Leaves	22.63	2.48	3.36	4.89	5.33	5.48
	Shoot	20.77	2.65	5.53	7.07	4.97	6.63
	Root	3.84	0.51	1.02	1.28	0.70	0.83
	Total	**47.24 d**	**5.64 f**	**9.91 f**	**13.24 f**	**11.00 f**	**12.94 f**
T_2=100% RDF + 0% TWW	Leaves	76.22	8.45	10.09	17.51	18.44	17.30
	Shoot	31.62	4.65	8.06	12.71	8.99	10.85
	Root	5.53	0.85	1.53	2.55	1.28	1.70
	Total	**113.37 a**	**13.95 a**	**19.68 a**	**32.77 a**	**28.71 a**	**29.85 a**
T_3=50%RDF +25% TWW	Leaves	42.05	4.72	5.90	10.22	10.15	10.09
	Shoot	24.67	3.34	5.91	9.00	6.04	7.97
	Root	4.03	0.45	1.15	1.41	0.80	0.90
	Total	**70.76 c**	**8.51 e**	**12.96 d**	**20.63 e**	**16.99 d**	**18.96 d**
T_4=50%RDF +%50 TWW	Leaves	50.69	5.33	6.91	11.81	11.66	11.81
	Shoot	31.11	4.27	8.24	12.20	7.78	12.20
	Root	5.74	0.96	1.48	2.70	1.35	1.74
	Total	**87.54 b**	**10.56 b**	**16.63 b**	**26.71 b**	**20.79 b**	**25.75 b**
T_5=50%RDF +75% TWW	Leaves	45.49	4.79	5.92	10.21	10.71	10.08
	Shoot	32.45	4.68	8.11	11.86	8.27	11.54
	Root	6.14	0.89	1.51	1.78	1.34	1.42
	Total	**84.08 b**	**10.36 c**	**15.54 c**	**23.85 c**	**20.32 c**	**23.04 c**
T_6=50%RDF +100% TWW	Leaves	39.77	4.25	5.43	9.44	9.44	8.85
	Shoot	25.22	3.64	5.98	9.36	6.37	8.58
	Root	5.35	0.73	1.22	2.03	1.09	1.30
	Total	**70.33 c**	**8.62 d**	**12.63 e**	**20.83 d**	**16.90 e**	**18.73 e**

Total S uptake by red amaranth with each treatment significantly ($P \leq 0.05$) increased as compared with control. The total S uptake ranged between 13.24 to 32.77 kg/ha. The highest uptake of K (32.77 kg/ha) was observed with T_2 (100% RDF + 0% TWW) and the second highest uptake of S (26.71 kg/ha) was observed with T_4 (50% RDF + 50% TWW). The lowest uptake of S (13.24 kg/ha) was found with T_1 (control). The results revealed that irrigation of more than 50% concentration of textile waste water have negative effect on the uptake of S by red amaranth.

Calcium uptake by red amaranth with all the treatments significantly ($P \leq 0.05$) increased. The Ca uptake ranged 11.00 to 28.71 kg/ha. The highest uptake of Ca (28.71 kg/ha) was observed with T_2(100% RDF + 0% TWW). The Ca uptake ranked in second largest (20.79 kg/ha) was observed with T_4 (50% RDF + 50% TWW). The lowest uptake of Ca (11.00 kg/ha) was found with T_1(control). The results showed that irrigation of more than 50% concentration of textile waste water reduce the uptake of Ca by red amaranth.

Total Mg uptake by red amaranth increased significantly ($P \leq 0.05$) in all treatments as compared with control. The Mg uptake ranges between 12.94 to 29.85 kg/ha. The highest uptake of Mg (29.85 kg/ha) was observed with T_2 (100% RDF + 0% TWW) and the second major uptake of Mg (25.75 kg/ha) was observed with T_4 (50% RDF + 50% TWW). The lowest uptake of Mg (12.93 kg/ha) was found with T_1 (control). The results also showed that irrigation of more than 50% concentration of textile waste water reduce the uptake of Mg by red amaranth. Maximum uptake of nutrients found up to 50% irrigation of textile waste water further doses decreasing trend.

4.6.9. Effect of textile waste water on heavy metal concentration in different parts of red amaranth

Effect of textile waste water on heavy metal concentration in different parts of red amaranth is presented in Table 4.81. The results revealed that heavy metal concentration in leaves of red amaranth increased with increased level of textile waste water irrigation.

Zinc concentration in leaves of red amaranth varied from 29.53 ppm to 60.06 ppm. Highest concentration of Zn in leaves of amaranth was (60.06 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Zn in leaves of amaranth (29.53 ppm) was observed with T_1(control). Zn concentration in shoot varied from 10.00 ppm to 21.11 ppm. Highest concentration of Zn in shoot of amaranth was (21.11 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Zn in shoot of amaranth (10.00 ppm) was observed with

T_1(control). Zn concentration in root varied from 5.50 ppm to 9.70 ppm. Highest concentration of Zn in root of amaranth was (9.70 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Zn in root of amaranth (5.50 ppm) was observed with T_3 (50% RDF + 25%TWW). The sequence of treatments for Zn concentration in red amaranth leaves was $T_6>T_5>T_4>T_2>T_3>T_1$, in shoot $T_6>T_5,T_4>T_2>T_3>T_1$ and in root $T_6>T_5,T_4>T_1>T_2>T_3$.

With the increasing of the concentration of textile waste water irrigation increased Cu content in leaves of red amaranth. Cu concentration in leaves varied from 3.12 to 11.22 ppm. Highest concentration of Cu in leaves was (11.22 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Cu in leaves (3.12 ppm) was observed with T_3 (50% RDF + 25%TWW).

Table 4.81. Effect of textile waste water on heavy metal concentration in different parts of red amaranth

Treatment	Plant parts	Heavy metal concentration (ppm)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= (control)	Leaves	29.53	5.11	ND	331.67	ND	ND	ND	13.91
	Shoot	10.00	2.05	ND	105.90	ND	ND	ND	5.30
	Root	7.10	1.10	ND	47.30	ND	ND	ND	1.75
T_2=100%RDF + 0% TWW	Leaves	48.48	7.52	ND	483.38	ND	ND	ND	20.41
	Shoot	15.12	3.10	ND	155.20	ND	ND	ND	9.22
	Root	6.72	1.40	ND	68.30	ND	ND	ND	4.01
T_3=50% RDF + 25% TWW	Leaves	33.54	3.12	ND	543.07	ND	ND	ND	14.41
	Shoot	13.75	1.04	ND	125.60	ND	ND	ND	6.43
	Root	5.50	0.62	ND	67.20	ND	ND	ND	3.11
T_4=50%RDF + 50% TWW	Leaves	51.65	10.72	ND	858.13	ND	ND	ND	25.80
	Shoot	20.00	4.21	ND	301.00	ND	ND	ND	11.55
	Root	9.54	1.63	ND	79.50	ND	ND	ND	5.32
T_5=50%RDF + 75% TWW	Leaves	56.22	10.72	ND	1302.67	ND	ND	ND	31.90
	Shoot	20.90	4.10	ND	454.50	ND	ND	ND	13.33
	Root	9.60	1.56	ND	107.70	ND	ND	ND	6.02
T_6=50%RDF + 100% TWW	Leaves	60.06	11.22	ND	1545.77	ND	ND	ND	34.78
	Shoot	21.11	4.23	ND	525.10	ND	ND	ND	13.53
	Root	9.70	1.55	ND	119.60	ND	ND	ND	6.92

Copper concentration in shoot of amaranth varied from 1.04 to 4.23 ppm. Highest concentration of Cu in amaranth shoot (4.23 ppm) was observed with T_6(50% RDF + 100% TWW) and lowest concentration of Cu in shoot (1.04 ppm) was observed with T_3(50% RDF + 25%TWW). Cu concentration in root varied from 0.62 ppm to 1.63 ppm. Highest concentration of Cu in root (1.63 ppm) was observed with T_4 (50% RDF + 50% TWW) and lowest concentration of Cu in root (0.62 ppm) was with T_3 (50% RDF + 25%TWW). The sequence of treatments for Cu concentration in red amaranth leaves was $T_6>T_5,T_4>T_2>T_1>T_3$, in shoot $T_6>T_4>T_5>T_2>T_1>T_3$ and in root $T_4>T_5>T_6>T_2>T_1>T_3$.

Fe content in red amaranth increased with the increasing rate of textile waste water irrigation. Fe concentration in leaves of red amaranth ranged from 331.67 to 1545.77 ppm. Highest concentration of Fe in red amaranth leaves was (1545.77 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Fe (331.67 ppm) was with T_1(control). Fe concentration in red amaranth shoot varied from 105.90 to 525.10 ppm. Highest concentration of Fe in red amaranth shoot was (525.10 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Fe in shoot (105.90 ppm) was with T_1(control). In red amaranth root Fe concentration varied from 47.30 to 119.60 ppm. Highest concentration of Fe in red amaranth root was (119.60 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Fe (47.30 ppm) was with T_1(control). The sequence of treatments for Fe concentration in red amaranth leaves was $T_6>T_5>T_4>T_3>T_2>T_1$, in shoot $T_6>T_5>T_4>T_2>T_3>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$.

As the concentration of textile waste water irrigation increased the Mn concentration in leaves of red amaranth also increased. Mn concentration in leaves ranged from 13.91 to 34.78 ppm. Highest concentration of Mn in leaves of amaranth (34.78 ppm) was observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Mn in leaves (13.91 ppm) was observed with T_1(control). Mn concentration in red amaranth shoot varied from 5.30 to 13.53 ppm. Highest concentration of Mn in shoot was (13.53 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Mn in shoot (5.30 ppm) was observed with T_1 (control). In red amaranth root Mn concentration varied from 1.75 ppm to 6.92 ppm. Highest concentration of Mn in root was (6.92 ppm) observed with T_6 (50% RDF + 100% TWW) and lowest concentration of Mn in root (1.75 ppm) was observed with T_1 (control). The sequence of treatments for Mn concentration in red amaranth leaves was $T_6>T_5>T_4>T_2>T_3>T_1$, in shoot $T_6>T_5>T_4>T_2>T_3>T_1$ and in root $T_6>T_5>T_4>T_2>T_3>T_1$.

On the basis of heavy metal concentration in red amaranth plant, it may be arranged as Fe>Zn>Mn>Cu. The heavy metal such as Ni, Cd, Cr and Pb in red amaranth were not detectable limit.

4.6.10. Effect of textile waste water on heavy metal uptake by red amaranth

Effect of textile waste water on heavy metal uptake by red amaranth is presented in Table 4.82. Ni, Cd, Cr and Pb were not taken up by red amaranth plant. So, Ni, Cd, Cr and Pb uptake by red amaranth were zero.

The uptake of Zn by red amaranth was significantly affected ($P \le 0.05$) due to irrigation of textile waste water. The Zn uptake by each treatment also significantly ($P \le 0.05$) varied with treatments over control. The Zn uptake ranged between 48.20 to 152.45 gm/ha. The lowest uptake of Zn (48.20 gm/ha) was found with T_1 (control) and the highest uptake of Zn (152.45 gm/ha) was with T_2 (100% RDF + 0% TWW). As based on the Zn uptake by red amaranth the treatments may be arranged in the order of $T_2>T_5>T_4>T_6>T_3>T_1$.

The Cu uptake by red amaranth with all the treatments significantly ($P \le 0.05$) increased as compared with control (except T_3). The Cu uptake by T_2, T_5 and T_6 found statistically similar value. The Cu uptake ranged between 7.16 to 29.70 gm/ha. The lowest uptake of Cu (7.16 gm/ha) was found with T_3 (50% RDF + 25% TWW) and the highest uptake of Cu (29.70 gm/ha) was observed with T_4 (50% RDF + 50% TWW). On the basis of Cu uptake by red amaranth the treatments may be arranged in the order of $T_4>T_5>T_2>T_6>T_1>T_3$.

The Fe uptake by red amaranth with all the treatments significantly ($P \le 0.05$) increased than the control. The Fe uptake ranged between 506.43 to 3286.15 gm/ha. The lowest uptake of Fe (506.43 gm/ha) was found with T_1 (control) and the highest uptake of Fe (3286.15 gm/ha) was observed with T_6 (50% RDF + 100% TWW). On the basis of findings of Fe uptake by red amaranth the treatments may be arranged in the order of $T_6>T_5>T_4>T_2>T_1>T_3$.

Table 4.82. Effect of textile waste water on heavy metal uptake by red amaranth

Treatment	Plant parts	Uptake of heavy metal (gm/ha)							
		Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
T_1= control	Leaves	21.56	3.73	0	242.12	0	0	0	10.15
	Shoot	22.10	4.53	0	234.04	0	0	0	11.71
	Root	4.54	0.70	0	30.27	0	0	0	1.12
	Total	**48.20 e**	**8.96 d**	**0**	**506.43 f**	**0**	**0**	**0**	**22.98 f**
T_2=100%RDF + 0%TWW	Leaves	99.87	15.49	0	995.76	0	0	0	42.04
	Shoot	46.87	9.61	0	481.12	0	0	0	28.58
	Root	5.71	1.19	0	58.06	0	0	0	3.41
	Total	**152.45 a**	**26.29 bc**	**0**	**1534.94 d**	**0**	**0**	**0**	**74.03 d**
T_3=50%RDF + 25% TWW	Leaves	43.94	4.09	0	711.42	0	0	0	18.88
	Shoot	35.34	2.67	0	322.79	0	0	0	16.53
	Root	3.52	0.40	0	43.01	0	0	0	1.99
	Total	**82.80 d**	**7.16 e**	**0**	**1077.22 e**	**0**	**0**	**0**	**37.40 e**
T_4=50%RDF + 50% TWW	Leaves	74.38	15.44	0	1235.71	0	0	0	37.15
	Shoot	61.00	12.84	0	918.05	0	0	0	35.23
	Root	8.30	1.42	0	69.17	0	0	0	4.63
	Total	**143.68 b**	**29.70 a**	**0**	**2222.93 c**	**0**	**0**	**0**	**77.01 c**
T_5=50%RDF + 75% TWW	Leaves	70.84	13.51	0	1641.36	0	0	0	40.19
	Shoot	65.21	12.80	0	1418.04	0	0	0	41.59
	Root	8.54	1.39	0	95.85	0	0	0	5.36
	Total	**144.59 b**	**27.70 b**	**0**	**3155.25 b**	**0**	**0**	**0**	**87.14 a**
T_6=50%RDF + 100%TWW	Leaves	70.87	13.24	0	1824.01	0	0	0	41.04
	Shoot	54.89	11.00	0	1365.26	0	0	0	35.18
	Root	7.86	1.26	0	96.88	0	0	0	5.61
	Total	**133.62 c**	**25.50 c**	**0**	**3286.15 a**	**0**	**0**	**0**	**81.83 b**

There were significant treatments difference ($P \leq 0.05$) monitored on the Mn uptake by red amaranth. The Mn uptake by red amaranth ranged between 22.98 to 87.14 gm/ha. The lowest uptake of Mn (22.98 gm/ha) was found with T_1 (control) and the highest uptake of Mn (87.14 gm/ha) was observed with T_5 (50% RDF + 75% TWW). On the basis of Mn uptake by red amaranth the treatments may be arranged in the order of $T_5>T_6>T_4>T_3>T_2>T_1$.

4.6.11. Effect of textile waste water on nutrient status of post harvest soil of red amaranth

Effect of textile waste water on average nutrient status of post harvest soil for red amaranth is presented in Table 4.83. Soil pH, organic matter, N, P, K, S, Ca and Mg were changed in different treatments.

The results revealed that pH of the post harvest soil of red amaranth were found in neutral range. The pH of different treatments ranged between 6.33 to 6.51. The highest value of pH (6.51) was found with the T_6 (50% RDF + 100% TWW), and the lowest value of pH (6.33) was found with T_2 (100% RDF + 0% TWW). Study indicated that soil pH had no abrupt increase due to graded textile waste water irrigation, which is good for soil.

Table 4.83. Effect of textile waste water on nutrient status of post harvest soil for jute leaves cultivation

Treatment	pH	OM	N	P	S	K	Ca	Mg
		(%)		(ppm)		C mol/kg		
T_1= control	6.42 d	2.42 f	0.107 f	20.90 f	20.32 f	0.20 e	2.90 e	0.67 f
T_2=100%RDF + 0%TWW	6.33 e	2.48 e	0.279 b	29.85 d	35.70 c	0.59 b	4.78 c	1.97 b
T_3=50%RDF + 25% TWW	6.42 d	2.59 d	0.180 e	27.02 e	33.02 e	0.49 d	3.99 d	1.55 e
T_4=50%RDF + 50% TWW	6.45 c	2.71 c	0.224 d	30.55 c	35.54 d	0.51 d	4.67 c	1.77 d
T_5=50%RDF + 75% TWW	6.48 b	2.78 b	0.267 c	32.52 b	38.78 b	0.54 c	5.22 b	1.90 c
T_6=50%RDF + 100%TWW	6.51 a	3.23 a	0.285 a	35.77 a	39.22 a	0.67 a	5.70 a	2.07 a

Due to use of textile waste water irrigation on the cultivation of red amaranth organic matter content of the post harvest soil significantly ($P \leq 0.05$) increased in the treated plots. The organic matter content of post harvest soil of different treatments ranged between 2.42 to 3.23% . The highest organic matter content (3.23%) was found with T_6 (50% RDF + 100% TWW), and the lowest organic matter content (2.42%) was found with T_1(control).

Nitrogen content of the post harvest soil increased significantly ($P \leq 0.05$) with the increasing the concentration of textile waste water irrigation. The N of different treatments ranges between 0.107 to 0.285 %. N content in post harvest soils of all the treatments significantly ($P \leq 0.05$) increased as compared with the control. The highest nitrogen content (0.285%) was found with T_6 (50% RDF + 100% TWW), and the lowest N content (0.107 %) was with T_1(control).

Phosphorus and Sulphur content of the post harvest soil increased significantly ($P \leq 0.05$) with textile waste water irrigation. P and S of post harvest soil in all treatments also significantly vary with each other treatment. The P of post harvest soil of different treatments ranged between 20.90 to 35.77 ppm. The S of post harvest soil of different treatments ranged between 20.32 to 39.22 ppm. The highest content of P (35.77 ppm) and S (39.22 ppm) were found with T_6 (50% RDF + 100% TWW). The lowest content of P (20.90 ppm) and S (20.32 ppm) were found with T_1(control).

Potassium and Calcium content of post harvest soil increased significantly ($P \leq 0.05$) with the textile waste water irrigation. The K of different treatment ranged between 0.20 to 0.67 C mol/kg and the Ca ranged between 2.90 to 5.70 C mol/kg .The highest content of K (0.67 mol/kg) and Ca(5.70 C mol/kg) were found with T_6 (50% RDF + 100% TWW). The lowest content of K (0.20 C mol/kg) and Ca(2.90 C mol/kg) were found with T_1(control). The post harvest soil K content with treatment T_3 and T_4 exerted similar value. Considering the Ca content of post harvest soil in T_2 and T_4 carried all most similar value.

With the increasing of textile waste water concentration the post harvest soil Mg content increased significantly ($P \leq 0.05$) in all the treatment as compared with control. The Mg content of post harvest soil of different treatment ranged between 0.67 to 2.07 C mol/kg. The highest content of Mg (2.07 C mol/kg) was observed with T_6 and the lowest content of Mg (0.67 C mol/kg) was with T_1(control).

4.6.12. Effect of textile waste water on heavy metal concentration of post harvest soil of red amaranth

Effect of textile waste water on heavy metal concentration of post harvest soil for red amaranth is presented in Table 4.84. The result revealed that heavy metal concentration in post harvest soil were not increased as much as due to increasing the concentration of textile waste water irrigation.

Table 4.84. Effect of textile waste water on heavy metal concentration of post harvest soil for red amaranth cultivation

Treatment	Zn	Cu	Ni	Fe	Cd	Cr	Pb	Mn
	(ppm)							
T_1=control	15.90 e	0.51 f	20.55 f	200.02 f	0.191 e	25.10 f	26.00 f	2.01 f
T_2=100% RDF + 0%TWW	34.88 b	1.22 c	30.50 d	277.90 c	0.290 c	37.37 c	38.02 c	4.05 d
T_3=50% RDF + 25%TWW	30.50 d	0.97 e	29.11 e	250.45 e	0.273 d	33.22 e	35.54 e	3.27 e
T_4=50% RDF + 50%TWW	32.79 c	1.08 d	30.90 c	271.43 d	0.295 c	36.80 d	37.30 d	4.45 c
T_5=50% RDF + 75%TWW	34.90 b	1.47 b	33.51 b	292.50 b	0.311 b	39.45 b	39.50 b	5.02 b
T_6=50% RDF+ 100%TWW	38.20 a	1.79 a	36.22 a	303.70 a	0.345 a	41.15 a	40.22 a	6.00 a

Concentration of Zn and Cu in post harvest soil of amaranth increased significantly ($P \leq 0.05$) with the concentration of textile waste water in all treatments as compared with control. But among the irrigated treatments there were no great difference of Zn and Cu containing. Highest concentration of Zn and Cu in post harvest soil were 38.20 and 1.79 ppm respectively, which were found with the 100% textile waste water irrigation along with 50% RDF (T_6). Lowest concentration of Zn and Cu were 15.90 and 0.51 ppm respectively were found with T_1(control). The content of Zn found in T_2 and T_5 was statistically similar.

Ni in post harvest soil increased significantly ($P \leq 0.05$) in all treatments as compared with control. Study showed that Ni content in irrigated treatments having all most similar values. Highest concentration of Ni in post harvest soil 36.22 ppm was observed in T_6 , where 100% textile waste water was irrigated. It showed that the lowest value of Ni in post harvest soil was 20.55 ppm with T_1.

Textile waste water irrigation significantly ($P \leq 0.05$) increased Fe concentration in post harvest soil of red amaranth. Concentration of Fe in post harvest soil increased significantly ($P \leq 0.05$) in all treatments as compared with control. Highest concentration of Fe in post harvest soil 303.70 ppm was observed in T_6 , where 100% textile waste water was irrigated. Lowest concentration of Fe in post harvest soil 200.02 ppm was observed in T_1 (control).

Textile waste water irrigation increased Cd concentration in post harvest soil of red amaranth. Concentration of Cd in post harvest soil increased significantly ($P \leq 0.05$) in all the treatments as compared with control. Highest concentration of Cd in post harvest soil 0.345 ppm was observed in treatment T_6 , where 100% textile waste water was irrigated. Lowest concentration of Cd in post harvest soil were 0.191 ppm was observed in T_1 (control). Cd content of post harvest soil with T_2 and T_4 were not significantly varied with each other treatments.

Due to the concentration of textile waste water irrigation it was increased the Cr and Pb concentration in post harvest soil of red amaranth. Concentration of Cr and Pb in post harvest soil increased significantly ($P \leq 0.05$) in all treatments as compared with control. Highest concentration of Cr and Pb in post harvest soil were 41.15 and 40.22 ppm respectively, observed in T_6 , where 100% textile waste water was irrigated. Lowest concentration of Cr and Pb in post harvest soil were 25.10 and 26.00 ppm respectively found with T_1 (control).

Increasing the concentration of textile waste water irrigation significantly ($P \leq 0.05$) also increased the Mn concentration in post harvest soil of red amaranth. Concentration of Mn in post harvest soil increased significantly ($P \leq 0.05$) in all the treatments as compared with control. Highest concentration of Mn in post harvest soil 6.00 ppm was observed in T_6. Lowest concentration of Mn in post harvest soil 2.01 ppm was observed in T_1 (control).

CHAPTER - 5
GENERAL DISCUSSION

CHAPTER -5

GENERAL DISCUSSION

Effect of textile waste water on growth and yield of jute leaves vegetable plant in pot culture 1

The plant height, number of leaves, weight of leaves and yield of leaves in jute vegetable plant are shown in parenthesis denoted the results of Narayanganj and Gazipur soils, respectively (both non-contaminated and contaminated soil)

Pot experiment 1, in non-contaminated soil

In pot experiment 1, in non-contaminated soils it appeared (Figure- 4.1, 4.2, 4.5, 4.6, 4.9, 4.10, 4.13 and 4.14) that the tallest plant (41 cm and 39cm), maximum number of leaves per plant (10.5 and 11.3), highest leaves weight per plant (1.162 and 1.315 gm) and highest yield (5.71 and 5.94 t/ha) were obtained with T_2 (100% RDF+ 0%TWW). The second tallest plant (35.5 and 34.2 cm), next maximum number of leaves per plant (10.1 and 10.4), close highest leaves weight per plant (1.024 and 1.041 gm) and nearest highest yield (4.89 and 5.46 t/ha) were obtained with the integrated treatments T_4 (50% RDF + 50% TWW). Among the textile waste water treated pots T_4 (50% RDF + 50% TWW) ranked first in producing the maximum plant height, number of leaves, weight of leaves and yield of leaves in jute vegetable plant. Basically similar results found inT_2 and $T_{4.}$

Lowest plant height (25 and 23 cm) obtained with T_1.The lowest number of leaves (8.6 and 9.1) and leaves weight per plant (0.463 and 0.454) found with T_6. The lowest yield (2.27 and 2.24 t/ha) obtained with T_6 and T_1 at Narayanganj and Gazipur soil respectively.

Pot experiment 1, in contaminated soil

In contaminated soils it come into view (Figure, 4.3, 4.4, 4.7, 4.8, 4.11, 4.12 , 4.15 and 4.16) that the tallest plant (38.25 and 36 cm), maximum number of leaves (10 and 10.5), leaves weight per plant (1.171 and 1.229 gm) and maximum yield (5.84 and 5.3 t/ha) were achieved with T_2 (100% RDF + 0% TWW).The second tallest plant (34 and 35.5 cm) were observed in T_1 (control), nearest maximum number of leaves per plant (8.9 and 9.3), closest highest leaves weight per plant (0.976 and 1.033 gm) were achieved in T_3 (50% RDF + 25% TWW) and T_1 (control). And nearest highest yield (4.29 and 4.92 t/ha) were obtain with the integrated treatments T_4 (50% RDF + 50% TWW). Lowest plant height (28.5 and 33.5 cm) obtained with T_6, lowest number of leaves (7.5 and 8.2) observed with T_6 and T_3, lowest leaves weight per plant (0.727 and 0.908) found with T_6 and T_3, lowest yield (3.31 and 4.03 t/ha) obtained with T_6 and T_3 (T_6 at Narayanganj and and T_3 at Gazipur soil).

Findings indicate that closest yield was obtained between T_2 and T_4. There was no statistically difference between T_2(100% RDF) and T_4(50% RDF + 50% TWW). The textile waste water in T_4 distinctly produced the yield and growth parameters among the treated pot. The highest dose of textile waste water T_6 (50% RDF + 100% TWW) showed a decreasing rate of plant height, number of leaves per plant, leaves weight per plant and yield of jute leaves. For non contaminated soils the treatments may be arranged in the order of $T_2>T_4>T_5>T_3>T_6>T_1$ for plant height, $T_2>T_4>T_1>T_5>T_3>T_6$ for number of leaves, $T_2>T_4>T_5>T_1>T_3>T_6$ for leaves weight per plant, $T_2>T_4>T_5>T_3>T_1>T_6$ or $T_2>T_4>T_5>T_3>T_6>T_1$ for yield. But for contaminated soils the treatment may be arranged in the order of $T_2>T_1,T_4>T_3>T_5>T_6$ for plant height, $T_2>T_3>T_1>T_4>T_5>T_6$ for number of leaves, $T_2>T_3>T_4>T_5>T_1>T_6$ for leaves weight per plant, $T_2>T_4>T_1>T_5>T_3>T_6$ or $T_2>T_4>T_5>T_1>T_3>T_6$ for yield. Findings indicate that among the treatments of textile waste water with 50% RDF, T_4 gave the best yield of jute leaves over control in both non contaminated and contaminated soils.

Field experiments

In field experiment 1, 2, 3 and 4 more or less similar results were observed.

Field experiment 1

Effect of textile waste water on growth and yield of jute

It was showed up (Fig. 4.29, 4.30, 4.33 and 4.34) that he highest plant (3.7m) , base diameter (16.17 mm), fiber (2.87 t/ha) and sticks yield 6.2 t/ha (Fig. 4.34) were found with T_2 (100% RDF + 0% TWW). The next tallest plant 3.5 m(Fig. 4.29), maximum basal diameter 15.27 mm (Fig. 4.30) fiber 2.48 t/ha (Fig. 4.33) and stick yield 5.94 t/ha (Fig. 4.34) were achieved with T_4 (50% RDF + 50% TWW).

The lowest performance in plant height 3.0 m (Fig. 4.29), base diameter 13.47 mm (Fig. 4.30) fiber yield 2.02 t/ha (Fig. 4.33) and sticks yield 4.37 t/ha (Fig. 4.34) were obtained withT_1- (control). Considering the performance on the fibre yield of jute, the treatments may be arranged in the order of $T_2 > T_4 > T_5 > T_6 > T_3 > T_1$

Field experiment 2

Effect of textile waste water on growth and yield of rice

The supreme achievement found in T_2(100% RDF + 0% TWW) that highest plant of rice 134.1 cm (Fig. 4.35), tiller number per meter square 612 (Fig. 4.36), straw and grain yield 6.94 t/ha and 4.25 t/ha (Fig. 4.37). Among the treatments of TWW , it was found maximum height of rice plant 124.2 cm for rice (Fig.4.35), tiller number per meter square 585 (Fig. 4.36), straw and grain yield 6.05 t/ha and 3.97 t/ha (Fig. 4.37) in T_5 (50% RDF + 75% TWW) and T_4 (50% RDF + 50% TWW). The minimum growth and yield were in T_1 where nothing was applied. On the basis of grain yield of rice the treatments sequence can be showed as $T_2 > T_4 > T_5 > T_6 > T_3 > T_{1.}$

Field experiment 3

Effect of textile waste water on growth and yield of jute leaves vegetable plant

The top most height of jute leaves vegetable plant 60.73 cm (Fig. 4.43), number of leaves 12.6 per plant(Fig. 4.44), leaves weight per plant 3.36 gm (Fig. 4.45), yield of jute leaves 5.44 t/ha (Fig. 4.46) were obtained with T_2 (100% RDF + 0% TWW).

The next highest 56.47 cm for jute leaves plant (Fig. 4.43), highest number of leaves per jute vegetable plant 12.33 (Fig. 4.44) were observed in T_4(50% RDF + 50% TWW) and T_5 (50% RDF + 75% TWW). Next maximum yield of jute leaves 4.95 t/ha (Fig. 4.46) were achieved by T_4 (50% RDF + 50% TWW). Statistically findings of T_5 and T_4 were similar with T_2. Minimum results found with T_1.With advantages of yield of vegetable leaves, the treatments may arranged in the sequence of $T_2 > T_4 > T_5 > T_6 > T_3 > T_1$ accordingly.

Field experiment 4

Effect of textile waste water on growth and yield on red amaranth

It was resulted that extreme height of red amaranth plant 86.6 cm (Fig.4.47), base diameter 18.2 mm (Fig. 4.48) number of leaves 28.3 per plant (Fig. 4.49), yield 38.18 t/ha (Fig. 4.50) were observed with T_2 (100% RDF + 0% TWW). Lowest height 70.03 cm for red amaranth (Fig. 4.47), number of leaves 18.3 per plant (Fig. 4.49), minimum yield of red amaranth 23.75 t/ha (Fig 4.50) were observed with T_1 (control).

Among the textile waste water treated plots tallest plant 85 cm (Fig 4.47), maximum base diameter 16 mm (Fig. 4.48), number of leaves 25.2 per plant (Fig. 4.49) were observed in T_4(50% RDF + 50% TWW) and T_3 (50% RDF + 25% TWW). Highest yield of red amaranth 36.78 t/ha (Fig. 4.50) was achieved with red amaranth by the integrated dose of T_4 (50% RDF + 50% TWW).

Due to addition of textile waste water as irrigation growth and yield also increased in jute, rice, jute leaves vegetables and red amaranth. Highest increment of growth and yield were with T_4 (50% RDF + 50% TWW) and found efficient treatment. The T_4 was ranked first among the treated plots with TWW in concerning growth and yield. The treatment T_4 stood second position compare to T_2 showed all most similar result.

Begum *et al*., (2018) found that application of different combination of textile waste water showed positive effect on plant height, number of leaves and the total leaves weight of jute leaves. Their findings supported and consented the achievements of this research study. They further reported, the yield decreased significantly in polluted soil irrigated with polluted water.

Kumar *et al.*, (2018) reported that the application of inorganic fertilizer in the presence of distillery effluent was highly beneficial to rice and wheat crop. Pre-sowing irrigation with (spent wash methanated) distillery effluent along with inorganic fertilizers proved most effective in increasing the grain and straw yields of rice and wheat crop. The findings of this experiment agreed with the results reported earlier by Kumar et al., (2018) for the soil irrigated with textile waste water.

Yaseen et al., (2017) observed that application 50:50% of waste and canal water improved plant height, number of pod plant(-1), pod length of field mustard. They suggested that wastewater utilization along with canal water mixing might be an effective approach for enhancing growth and yield of field mustard.

Hamdi *et al.*,(2017) stated that1/3 diluted textile wastewater can be used as agricultural irrigation water for the apple plants growth.

Yaseen *et al.*,(2016) found that. the application of liquid NPK fertilizer with end drain textile waste water increased plant height, spike length, flag leaf length, root length, number of tillers (m^{-2}), number of fertile tillers (m^{-2}), 1000 grain weight, grain yield and straw yield of wheat.

Khan *et al.,* (2011) suggested that waste water from textile factory could be utilized for irrigation purposes after proper dilution and may contribute, at least in part towards solving the problem of textile effluent disposal.

Saravanamoorthy and Kumari (2007) found that textile waste water application increased germination, chlorophyll a, b and total chlorophyll content, growth parameters, yield and yield contributing characters. Physico-chemical characteristics of textile waste water met the irrigation quality requirements and were within the permissible limits.

Kanan *et al.,* (2005) and Khan *et al.,* (2003) applied the textile waste water to agricultural field instead of disposing off in lakes and rivers and found crops grown better due to presence of various nutrients like N, P, Ca, Mg etc like the achievement of the study.

Ramana *et al.,* (2002) found that they were beneficial with the irrigation waste water on various crops including vegetables.

Mycin (2016) suggest that the textile mill effluent is toxic to crop and it can be used for irrigation purpose after a proper treatment with appropriate dilution.

Muhammad *et al.,* (2013) found that vegetative growth of Sorghum assessment showed that plant height was better in control (0% TWW) and T4(100% TWW) had the least height among all treatments.

Najam *et al.,* (2015) found that the effect of textile wastewater on dilution level 10, 20 and 30% on growth parameters of wheat was statistically at par with control. Maximum reduction in growth parameters of wheat was observed on application of concentrated textile effluent (100% dilution level) as plant height, spike length, root mass and root length of wheat was decreased by up to 17, 22, 68 and 24%, respectively, as compared to control (tap water).

Rajkishore and Vignesh (2012) recorded higher grain yields and increased soil nutrients at 50/75 times dilution of distillery effluent in irrigated rice. Pandey and Singh (2015) suggested that the high values of yield parameters of textile wastewater irrigated wheat crop productivity indicate the positive impact of textile wastewater irrigation on wheat crop productivity.

Khandaker *et al.,* (2013) found that growth and yield performance of Stem Amaranth irrigated with different less polluted textile waste water increased the number of leaves, leaf length and leaf width, steam diameter, plant weight, and also plant height.

Yagdi *et al.,* (2000) observed that toxicity of heavy metals (As, Cu, Hg, Zn, Cd, Cr, Pb, Mo, Ni, and Se) decreased plant growth and development. The work also showed that plant growth and yield stunted with T_6 where maximum toxic element observed.

Yasmin *et al.,* (2011) Waste water showed increasing inhibitory effects with increasing concentrations while concentrations below 50% showed positive effects on germination and growth of lentil seedlings. Nagajyothi *et al.,* (2009) and Nath *et al.,* (2009) reported that textile waste water irrigation improve crop growth and yield.

All these findings and statements are similar and also co related with the achievements of this study.

Effect of textile waste water on total dry matter production

In pot experiment in contaminated and non contaminated soils up to 50% textile waste water treated pots combined with 50% RDF enhanced the dry matter yield of jute leaves and lowest with control (T_1) and with T_6 (50%RDF + 100% TWW). Total dry matter was significantly superior with T_2 (100% RDF + 0% TWW) and among the textile waste water treated pots T_4 (50% RDF + 50% TWW) gave second highest value of total dry matter. Lowest dry matter was found with T_1 (control) and T_6 (50% RDF + 50% TWW). In contaminated soils highest total dry matter was achieved with T_2 (100% RDF + 0% TWW), and closest highest dry matter was found with T_4(50% RDF + 50% TWW) and lowest dry matter was found with T_6(50%RDF + 100% TWW).

In field experiments 1, 2, 3 and 4 more or less similar results were observed. It showed that different doses of textile waste water treated plots combined with 50% RDF enhanced dry matter yield of jute, rice, jute leaves and red amaranth and lowest with control (Tables 4.57, 4.64, 4.71, 4.78). Total dry matter yield was higher with T_2 (100% RD +0% TWW) and among the textile waste water treated plots T_4 (50% RDF + 50% TWW) showed the highest value of total dry matter of jute, rice, jute leaves and red amaranth. The treatments may be arranged in the order of $T_2>T_4>T_5>T_6>T_3>T_1$ for total dry matter of jute, rice, jute leaves and red amaranth. The results which found with T_2 and T_4 statistically similar.

The above results are consistent with the findings of Yaseen *et. al.,* (2017) who suggest that application of 50:50% textile waste and canal water improved plant root dry weight and shoot dry weight of field mustard 15% and 56% respectively, over positive control treatment.

Similar type of results found by Yaseen *et. al.,* (2015) in rice cultivation. They reported that the application liquid NPK fertilizer with end drain textile waste water increased plant height, spike length, flag leaf length, root length, number of tillers (m(-2)), number of fertile tillers (m(-2)), 1000 grain weight, grain yield, straw yield and biological yield of rice up to 21, 20, 20, 44, 17, 20, 14, 44, 40 and 41%, respectively compared to canal water (control).

Muhammad *et al.,* (2013) reported that T0(0 % TWW) had greater fresh and dry weight of Sorghum. Hassan *et al.,* (2013) found significant difference in shoot length, fresh weight and dry weight of individual seedling of country bean with textile waste water irrigation whereas the rest of characteristics were shown statistically insignificant results.

The findings of the present study was homologous with the findings reported by Saravanamoorthy and Kumari (2007). They found that the increase in shoot and root dry weight were observed at 25% effluent treatment in textile effluent treatment could increase the yield of the plants at 25% and 50% treatments. However, the yield decreased in 100% concentration treatment.

The results found in the different crops with graded textile water was equivalent to the observation of Garg and Kaushik (2007) with untreated effluent. In their report it was more pronounced at 75 and 100% concentrations for shoot dry weight, whereas effect was more pronounced at 50, 75 and 100% concentrations for root dry weights. The root and shoot dry weight of *Desijowar* in 75% untreated effluent concentration were lower than control .

Effect of textile waste water on nutrient content of various parts of plant

In pot experiment 1, results showed that different combinations of textile waste water with 50% RDF caused significant changes in nutrient contents of jute leaves plants. In non-contaminated soils all the treatments showed higher nutrient content over control. In these soils nutrient content increased with the increasing concentration of textile waste water up to 50% then decreased. But in contaminated soils, all the textile waste water treated pots showed lower nutrient content over control. Which indicate that textile waste water has negative effect on nutrient content of jute in contaminated soils. Effect of textile waste water on nutrient content in different parts of jute leaves was pronounced.

In non contaminated soil of Narayanganj the nutrients N, P, K, S, Ca and Mg of leaves of jute leaves varied between 1.53 to 3.78 %, 0.15 to 0.23 %, 1.74 to 2.27 %, 0.028 to 0.076 %, 0.126 to 0.195 % and 0.143 to 0.159 %. In shoot nutrient content was lower than leaves but higher than that in root. The range of N, P, K, S, Ca and Mg in shoot were 0.80 to 1.10 %, 0.10 to 0.19 %, 0.70 to 1.10 %, 0.015 to 0.031 %, 0.040 to 0.063% and 0.050 to 0.060%. In root N, P, K, S, Ca and Mg varied between 0.45 to 0.52 %, 0.17 to 0.21%, 0.45 to 0.80%, 0.016 to 0.025%, 0.015 to 0.023 % and 0.018 to 0.022 % with different treatments. Highest N (3.78%), P (0.23%), K(2.27%), S(0.076%), Ca (0.195%) and Mg(0.159%) were found in jute leaves with T_2(100% RDF + 0% TWW).

In non contaminated soil of Gazipur the nutrients N, P, K, S, Ca and Mg of leaves of jute leaves varied between 1.65 to 3.28 %, 0.11 to 0.31 %, 2.99 to 3.86 %, 0.032 to 0.091 %, 0.187 to 0.334 % and 0.152 to 0.172 %. In shoot nutrient content was lower than leaves but higher than that in root. The range of N, P, K, S, Ca and Mg in shoot were 0.75 to 0.83 %, 0.10 to 0.15 %, 0.79 to 1.20 %, 0.012 to 0.031 %, 0.052 to 0.077% and 0.050 to 0.081%. In root N, P, K, S, Ca and Mg varied between 0.41 to 0.45 %, 0.13 to 0.18%, 0.51 to 0.65%, 0.011 to 0.025%, 0.022 to 0.034 % and 0.021 to 0.029 % with different treatments. Highest N (3.28%), P (0.31%), K(3.86%), S(0.091%), Ca (0.334%) and Mg(0.172%) were found in lute leaves with T_2(100% RDF + 0%

TWW). The range indicated that non contaminated soil of Gazipur is more fertile than the non contaminated soil of Narayanganj.

In contaminated soil of Narayanganj the nutrients N, P, K, S, Ca and Mg of leaves of jute leaves varied between 3.05 to 3.97 %, 0.21 to 0.29 %, 1.92 to 2.38 %, 0.046 to 0.062 %, 0.105 to 0.251 % and 0.144 to 0.163 %. In shoot nutrient content was lower than leaves but higher than that in root. The range of N, P, K, S, Ca and Mg in shoot were 0.83 to 1.20 %, 0.11 to 0.13 %, 0.76 to 1.00 %, 0.018 to 0.030 %, 0.041 to 0.072% and 0.050 to 0.073%. In root N, P, K, S, Ca and Mg varied between 0.44 to 0.55 %, 0.17 to 0.21%, 0.58 to 0.67%, 0.014 to 0.023%, 0.018 to 0.031% and 0.018 to 0.022 % with different treatments. Highest N (3.97%), P (0.29%), K(2.38%), S(0.062%), Ca (0.251%) and Mg(0.163%) were found in lute leaves with T_2(100% RDF + 0% TWW).

In contaminated soil of Gazipur the nutrients N, P, K, S, Ca and Mg of leaves of jute leaves ranged varied between 1.96 to 4.35 %, 0.15 to 0.27 %, 2.53 to 3.45 %, 0.046 to 0.061 %, 0.217 to 0.239 % and 0.148 to 0.159 %. In shoot nutrient content was lower than leaves but higher than that in root. The range of N, P, K, S, Ca and Mg in shoot were 0.71 to 1.33 %, 0.10 to 0.14 %, 0.85 to 1.53 %, 0.020 to 0.026 %, 0.053 to 0.063% and 0.047 to 0.065%. In root N, P, K, S, Ca and Mg varied between 0.40 to 0.59 %, 0.12 to 0.17%, 0.50 to 0.66%, 0.011 to 0.014%, 0.025 to 0.031 % and 0.022 to 0.030 % with different treatments. Highest N (4.35%), P (0.27%), K(3.45%), S(0.061%), Ca (0.239%) and Mg(0.159%) were found in lute leaves with T_2(100% RDF + 0% TWW). The range indicate that contaminated soil of Gazipur is more fertile than the contaminated soil of Narayanganj.

In field experiments 1, 2, 3 and 4 more or less similar results were observed. In field it appeared that the N, P, K, S, Ca and Mg of leaves of jute varied between 2.04 to 2.47%, 0.32 to 0.36%, 2.49 to 2.91%, 0.059 to 0.076 %, 0.123 to 0.128% and 0.152 to 0.157%. In shoot it ranged between 0.81 to 0.86%, 0.17 to 0.20 %, 0.79 to 1.15%, 0.041 to 0.061 %, 0.036 to 0.041% and 0.039 to 0.042%. In root it ranged between 0.41 to 0.45%, 0.09 to 0.15%, 0.56 to 0.72%, 0.030 to 0.037%, 0.015 to 0.017 and 0.017 to 0.021% with different treatments. Highest N (2.47%) and Mg (0.157%) were observed with T_2(100% RDF + 0% TWW), highest P (0.36%) and Ca (0.128%) with T_4(50% RDF + 50% TWW), and highest K(2.91%) and S(0.076%) with T_5(50% RDF + 75% TWW).

The concentration of the N, P, K, S, Ca and Mg of grain of rice varied between 1.00 to 1.68%, 0.016 to 0.029%, 0.321 to 0.525%, 0.040 to 0.047%, 0.08 to 0.12% and 0.035 to 0.095%. In straw it ranged between 0.54 to 0.68%, 0.012 to 0.031%, 2.811 to 3.689%, 0.036 to 0.048%, 0.26 to 0.32% and 0.2 to 0.235% . And in root it ranged between 0.29 to 0.31%, 0.007 to 0.011%, 0.85 to 0.95%, 0.01 to 0.015%, 0.15 to 0.16% and 0.014 to 0.023% with different treatments. Highest N (1.68%), K(0.525%) and S(0.047%) were found with T_2(100% RDF + 0% TWW). Highest P(0.029%), Ca (0.12%) and Mg(0.095%) were found in rice grain with T_4(50% RDF +50% TWW), T_5(50% RDF + 75% TWW), T_6(50% RDF + 100% TWW) respectively.

In field N, P, K, S, Ca and Mg concentration of leaves of jute leaves varied between 2.44 to 2.60%, 0.33 to 0.40%, 2.44 to 2.80%, 0.039 to 0.045%, 0.155 to 0.162% and 0.130 to 0.150%. In shoot it ranged between 0.82 to 1.20%, 0.18 to 0.25%, 0.75 to 1.05%, 0.020 to 0.027%, 0.050 to 0.060% and 0.040 to 0.050% . And in root it ranged between 0.47 to 0.55%, 0.20 to 0.30%, 0.50 to 0.90%, 0.018 to 0.021%, 0.017 to 0.022% and 0.015 to 0.021% with different treatments. Highest N (2.60%), P (0.40%), S(0.045%), Ca (0.162%) and Mg(0.150%) were found in leaves of jute leaves with T_2(100% RDF + 0% TWW), and highest K(2.80%) was found with T_5(50% RDF + 75% TWW).

The concentration of the N, P, K, S, Ca and Mg of leaves of red amaranth varied between 3.10 to 3.70%, 0.34 to 0.41%, 0.45 to 0.49%, 0.67 to 0.85%, 0.730 to 0.895% and 0.75 to 0.84%. In shoot it ranged between 0.94 to 1.04%, 0.12 to 0.15%, 0.23 to 0.27%, 0.32 to 0.41%, 0.225 to 0.290% and 0.30 to 0.40% . And in root it ranged between 0.06 to 0.69%, 0.07 to 0.11%, 0.15 to 0.18%, 0.20 to 0.31%, 0.110 to 0.155% and 0.13 to 0.20% with different treatments. Highest N (3.70%), P (0.41%), K(0.49%), S(0.85%), Ca (0.895%) and Mg(0.84%) were found in leaves of red amaranth with T_2(100% RDF + 0% TWW). In field the findings indicated that all the treatments contented higher nutrient over control. Nutrient content increased with the increasing concentration of textile waste water up to 50% to 75% over then decreased. Nutrient content were significantly higher with T_2 (100% RD + 0% TWW) and lowest value was observed in T_1(control). These observations are in agreement with the findings of the following scientist:

Similar result was reported by Begum *et al.*, (2011) from a trial, that the N, P. K, and S contents were higher in uncontaminated field + fresh water irrigation, which gave the highest grain yield of rice.

Yaseen *et al.*,(2017) also described that application 50:50% of textile waste water and canal water improved nitrogen, phosphorus and potassium concentration in grain and straw up to 20, 44 and 42%, respectively, over positive control treatment.

The present findings correlates with the findings of Preeti *et al.*, (2008) who found that an increase in the level of textile waste effluent irrigation it significantly increased the content of N (by 21%), K (11%), S (10%), Zn (9%), Cu (21%) and Mo (8%), but decreased that of P (16%) and Mg (19%) in rice grain. In the case of rice straw, an increase in K (28%), S (32%), Cu (65%) and Mo (45%) content was recorded. Effluent application, inorganic fertilizers and their interactions had a significant effect on both the grain and straw yields and on the nutrient concentration in plants.

Sahar et al., (2017) as evident by their results, they found that the application of 100% textile wastewater reduced nitrogen and phosphorous contents in grains by 27 and 18%, respectively, compared to control (tap water). On increasing dilution level, inhibitory effects of textile effluents were linearly reduced. In addition, application of 10% and 20% diluted textile wastewater significantly increased N and P contents in grains compared to control.

Munir *et al.*, (2007) also observed that plant growth, soil fertility and productivity can be enhanced with wastewater irrigation management system, which will increase levels of plant nutrients and soil organic matter essential for plant growth and development.

Jaishree and Khan (2013) reported the similar trend of result. In cow pea there was a reduction in plant growth and nitrogen content with the increasing concentration of heavy metals in textile waste water.

Effect of textile waste water on nutrient uptake by plant

In pot experiment 1, the results showed that nutrient uptake increased due to different textile waste water irrigation over control in non-contaminated soils. But in contaminated soils it showed negative effects. In non-contaminated soil of Narayanganj the total uptake of N, P, K, S, Ca and Mg of jute leaves plants (leaves + shoots + roots) varied between 9.72 to 37.3 kg/ha, 1.19 to 3.14 kg/ha, 8.98 to 25.97 kg/ha, 0.17 to 0.83 kg/ha, 0.58 to 1.98 kg/ha and 0.69 to 1.65 kg/ha. And in non-contaminated soil of Gazipur it varied between 7.82 to 38.22 kg/ha, 0.77 to 4.18 kg/ha, 8.33 to 36.68 kg/ha, 0.15 to 0.96 kg/ha, 0.80 to 3.44 kg/ha and 0.60 to 2.18 kg /ha. In contaminated soil of Narayanganj it ranged between 19.14 to 40.69 kg/ha, 1.68 to 3.70 kg/ha, 13.25 to 27.70 kg/ha, 0.32 to 0.74 kg/ha, 0.73 to 2.52 kg/ha and 0.90 to 1.90 kg/ha. And in contaminated soil of Gazipur it ranged between 16.38 to 43.49 kg/ha, 1.65 to 3.39 kg/ha, 20.28 to 38.50 kg/ha, 0.39 to o.66 kg/ha, 1.58 to 2.32 kg/ha and 1.15 to1.73 kg/ha. In all soils highest uptake of N, P, K, S, Ca and Mg were achieved with T_2(100% RDF + 0% TWW). And the closest highest uptake of N, P, K, S, Ca and Mg were achieved with T_4(50% RDF +50% TWW). In non-contaminatedsoils lowest uptake of N, P, K, S, Ca and Mg were found with T_1(control). But in contaminated soils lowest uptake of N, P, K, S, Ca and Mg were found with T_6 (50% RDF+ 100% TWW) or T_3(50% RDF +25% TWW).

In field experiments 1, 2, 3 and 4 almost similar results were found. For jute total nutrient uptake of N, P, K, S, Ca and Mg of juteplants (leaves + shoot + roots) varied between 150.95 to 335.65 kg/ha, 28.26 to 61.90 kg/ha, 151.31 to 422.73 kg/ha, 6.56 to 16.47 kg/ha, 7.91 to 16.37 kg/ha and 9.06 to 18.45 kg/ha. Highest uptake of N, P, Ca and Mg were achieved with T_2(100% RDF + 0% TWW). And highest K and S uptake were achieved with T_6(50% RDF + 100% TWW) and T_4(50% RDF +50% TWW) respectively. The closest highest uptake of N, P, Ca and Mg were achieved with T_4(50% RDF +50% TWW). And nearest highest K and S uptake were achieved with T_2 (100% RDF + 0% TWW) . Lowest uptake of N, P, K, S, Ca and Mg were found with T_1(control).

The total uptake of N, P, K, S, Ca and Mg of rice plants (grain + straw + roots) varied between 42.31 to 125.52 kg/ha, 0.87 to 3.22 kg/ha, 137.02 to 291.85 kg/ha, 2.26 to 6.26 kg/ha, 12.43 to 30.16 kg/ha and 8.25 to 18.37 kg/ha. Highest uptake of N, P, K, Ca and Mg were achieved with T_2(100% RDF + 0% TWW). And highest S uptake were achieved with T_4 (50% RDF + 50%

TWW). The closest highest uptake of N, P and K were achieved with T_4(50% RDF +50% TWW). And nearest highest S and Ca uptake were achieved with T_5 (50% RDF + 75% TWW) . Lowest uptake of N, P, K, S, Ca and Mg were found with T_1(control).

The total uptake of N, P, K, S, Ca and Mg of jute leaves plants (leaves + shoot + roots) in field condition varied between 14.82 to 25.45 kg/ha, 2.72 to 5.06 t/ha, 13.99 to 24.35 t/ha, 0.35 to 0.54 t/ha, 0.87 to 1.38 t/ha and 0.71 to 1.22 t/ha. Highest uptake of N, P, S, Ca and Mg were achieved with T_2(100% RDF + 0% TWW). And highest K uptake were achieved with T_5 (50% RDF + 75% TWW). The closest highest uptake of N, P, S, Ca and Mg were showed with T_4 (50% RDF + 50% TWW). And the closest total K uptake was found with T_2(100% RDF + 0% TWW). Lowest uptake of N, K, Ca and Mg were found with T_1 (control). and lowest uptake of P and S were found with T_3 (50% RDF + 25% TWW) and T_6 (50% RDF + 100% TWW).

Total uptake of N, P, K, S, Ca and Mg of red amaranth plants (leaves + shoot + roots) varied between 47.24 to 113.37 kg/ha, 5.64 to 13.95 kg/ha, 9.91 to 19.68 kg/ha, 13.24 to 32.77 kg/ha, 11.00 to 28.71 kg/ha and 12.94 to 29.85 kg/ha. Highest uptake of N, P, K, S, Ca and Mg of red amaranth were achieved with T_2(100% RDF + 0% TWW). And the closest highest uptake of N, P, K, S, Ca and Mg of red amaranth were achieved with T_4(50% RDF + 50% TWW). Lowest uptake of N, P, K, S, Ca and Mg of red amaranth were found with T_1(control). Findings indicate that highest nutrient uptake was achieved with 100% RDF along with 0% textile waste water irrigation. Nutrient uptake increased with 50% RDF along with textile waste water irrigation up to 50% concentration then decreased. The findings are in consent with the following research workers:

Yaseen *et al.,* (2017) found that application 50:50% of textile waste water and canal water improved nutrients uptakes and agronomic efficiency of fertilizers compared to positive control treatment.

The findings are agreed with the findings of Yaseen *et al.,* (2015) they reported that the NPK uptake in grain was increased up to 15, 30 and 28%, respectively by liquid fertilizer treated textile end drain water as compare to canal water with liquid fertilizer. The result may imply that waste water application along with liquid-NPK could be a novel approach for improving growth and yield of wheat in saline sodic soils.

Begum *et al.,* (2011) reported that the N, P. K, and S uptake were higher in uncontaminated field + fresh water irrigation, which gave the highest grain yield of rice. And heavy metal had antagonistic effects on essential plant nutrient uptake. Plant did not uptake adequate amount of nutrients from waste water. These findings was similar with the achievements of present study.

Study of Carlos *et al.,* (2018) showed that nutrients uptake were increased with the graded irrigation of textile waste water in crops. They observed that increased in concentrations of N, P, K, S in tissue of maize under irrigation with industrial wastewater of different rate.

Yagdi *et al.,* (2000) reported that uptake of N, P, and K were decreased with increasing concentration of polluted water.

Effect of textile waste water on heavy metal concentration of various parts of plant in pot culture

In pot experiment 1, the results showed that heavy metal concentration in different parts of jute leaves plants increased with the increasing level of textile waste water irrigation. In non-contaminated soil of Narayanganj the concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn of leaves of jute leaves varied between 35.70 to 40.70 ppm, 13.83 to 29.33 ppm, 0.02 to 0.09 ppm, 433.94 to 781.64 ppm, 0.005 to 0.008 ppm, 1.20 to 1.31 ppm, 0.020 to 0.090 ppm and 43.60 to 67.30 ppm. In shoot it ranged between 10.20 to 12.00 ppm, 4.20 to 8.75 ppm, 0.007 to 0.015 ppm, 111.20 to 322.30 ppm, 0.002 to 0.004 ppm, 0.35 to 0.36 ppm, 0.004 to 0.038 ppm and 10.72 to 13.10 ppm. In root it ranged between 3.50 to 4.95 ppm, 2.12 to 3.25 ppm, 0.002 to 0.005 ppm, 53.70 to 137.40 ppm, 0.001 to 0.002 ppm, 0.12 to 0.16 ppm, 0.001 to 0.007 ppm and 3.51 to 5.30 ppm. In non-contaminated soil of Gazipur the concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn of leaves of jute leaves varied between 43.70 to 48.70 ppm, 15.35 to 24.43 ppm, 0.03 to 0.09 ppm, 1080.09 ppm to 1339.69 ppm, 0.006 to 0.009 ppm, 1.11 to 2.21 ppm, 0.050 to 0.190 ppm and 45.50 to 70.00 ppm. In shoot it varied between 13.50 to 14.35 ppm, 6.55 to 7.20 ppm, 0.006 to 0.01 ppm, 423.70 to 511.30 ppm, 0.002 to 0.004 ppm, 0.35 to 0.51 ppm, 0.021 to 0.053 ppm, and 11.30 to 14.90 ppm. In root it ranged between 4.90 to 5.60 ppm, 2.85 to 3.40

ppm, 0.003 to 0.004 ppm, 219.60 to 250.50 ppm, 0.001 to 0.002 ppm,0. 13 to 0.22 ppm, 0.002 to 0.007 ppm and 4.60 to 6.10 ppm.

In contaminated soil of Narayanganj the concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn of leaves of jute leaves ranged between 43.70 to 65.70 ppm, 20.84 to 34.45 ppm, 0.033 to 0.070 ppm, 355.32 to 909.65 ppm, 0.010 to 0.012 ppm, 0.030 to 0.051 ppm, 0.050 to 0.150 ppm and 45.70 to 70.50 ppm. In shoot it ranged between 12.50 to 17.62 ppm, 8.10 to 8.90 ppm, 0.005 to 0.008 ppm, 105.20 to 362.80 ppm, 0.004 to 0.005 ppm, 0.007 to 0.015 ppm,0.017 to 0.032 ppm and 11.80 to 14.20 ppm. In root it ranged varied between 5.25 to 8.20 ppm, 3.10 to 3.45 ppm, 0.002 to 0.005 ppm, 51.10 to 151.20, 0.001 to 0.002 ppm, 0.004 to 0.007 ppm, 0.004 to 0.006 ppm and 4.20 to 6.50 ppm. In contaminated soil of Gazipur the concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn of leaves of jute leaves ranged between 60.70 to 81.70 ppm, 27.17 to 37.76 ppm, 0.030 to 0.080 ppm, 913.47 to 1165.93 ppm, 0.010 to 0.013 ppm, 0.038 to 0.055 ppm, 0.047 to 0.110 ppm and 43.50 to 65.90 ppm. In shoot it varied between 15.65 to 22.40 ppm, 8.00 to 9.30 ppm, 0.004 to 0.007 ppm, 372.80 to 435.80 ppm, 0.003 to 0.004 ppm, 0.005 to 0.010 ppm, 0.010 to 0.030 ppm and 10.90 to 13.60 ppm. I root it ranged between 10.20 to 12.90 ppm, 3.00 to 3.40 ppm, 0.002 to 0.004 ppm, 171.50 to 231.90 ppm, 0.001 to 0.002 ppm, 0.002 to 0.007 ppm, 0.004 to 0.007 ppm and 4.10 to 6.20 ppm. In both soils the highest concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn in all the parts of jute leaves plant were found with T_6, where 100% textile waste water was irrigated. The order of accumulation of heavy metal may be arranged as Fe>Mn>Zn>Cu>Cr>Pb>Ni>Cd for jute leaves in both non contaminated and contaminated soils.

Effect of textile waste water on heavy metal concentration of various parts of plant in field experiments

In field experiments 1, 2, 3 and 4 due to textile waste water irrigation almost similar results were observed. In field the heavy metal Cd and Pb were not detected in the jute plant. The concentration of Zn, Cu, Ni, Fe, Cr and Mn of leaves of jute ranged between 50.04 to 55.66 ppm, 7.71 to 10.42 ppm, 0.101 to 0.123 ppm, 304.87 to 828.95 ppm, 0.141 to 0.164 ppm and 25.35 to 38.51 ppm. In shoot it ranged between 14.10 to 16.32 ppm, 4.11 to 2.27 ppm, 0.043 to 0.055 ppm, 117.37 to 283.32 ppm, 0.03 to 0.05 ppm and 8.77 to 12.53 ppm. And in root it varied between 6.55 to 7.05 ppm, 1.03 to 2.00 ppm, 0.011 to 0.014 ppm, 62.11 to 103.32 ppm, 0.010 to

0.023 ppm and 4.02 to 5.88 ppm. On the basis of heavy metal concentration in jute plant, the heavy metal may be arranged in the order of Fe>Zn>Mn>Cu>Cr>Ni.

In rice plant heavy metal Cd and Pb were not detected. Chromium 0.138 ppm was found in rice grain with the treatment T_2 (100% RDF + 0% TWW), and 0.169 and 0.01 ppm were found in rice straw and root with treatment T_3 (50% RDF + 25% TWW). The concentration of Zn, Cu, Ni, Fe and Mn in rice grain ranged between 36 to 50 ppm, 2.31 to 6.61 ppm, 7.9 to 8.6 ppm, 109.81 to 161.00 ppm, and 76.31 to 86.10 ppm. In straw of rice the concentration of of Zn, Cu, Ni, Fe and Mn ranged between 103 to 186 ppm, 8.52 to 8.97 ppm, 10.0 to 12.0 ppm, 806.33 to 1273.76 ppm and 508.75 to 471.30 ppm. In root of rice it ranged between 12 to 25 ppm, 1.40 to 2.30 ppm, 0.01 to 0.02 ppm, 41.31 to 96.50 ppm and 25.15 to 36.20 ppm. On the basis of heavy metal concentration in rice plant, it may be arranged in order of Fe>Mn>Zn>Cu>Ni>Cr.

In field the heavy metal Cd and Pb were not detected in the jute leaves plant. The concentration of Zn, Cu, Ni, Fe, Cr and Mn of leaves of jute leaves ranged between 49.50 to 53.50 ppm, 8.75 to 18.93 ppm, 7.05 to 9.60 ppm, 965.00 to 1404.21 ppm, 0.122 to 0.139 ppm and 51.74 to 77.62 ppm. In shoot it ranged between 15.25 to 22.50 ppm, 3.20 to 6.50 ppm, 3.00 to 4.00 ppm, 302.01 to 373.22 ppm, 0.040 to 0.102 ppm and 10.03 to 15.74 ppm. In root it ranged between 5.10 to 7.50 ppm, 1.00 to 2.20 ppm, 1.20 to 2.01 ppm, 99.11 to 105.58 ppm, 0.010 to 0.031 ppm and 3.51 to 5.00 ppm. On the basis of heavy metal concentration in jute leaves plant, the order of concentration of heavy metal may be arranged as Fe>Mn>Zn>Cu>Ni>Cr.

In red amaranth plant heavy metal Ni, Cd, Cr andPb were not detected. The concentration of Zn, Cu, Fe, Cr and Mn of leaves red amaranth ranged between 29.53 to 60.06 ppm, 3.12 to 11.22 ppm, 331.67 to 1545.77 ppm and 13.91 to 34.78 ppm. In shoot it ranged between 10.00 to 21.11 ppm, 1.04 to 4.23 ppm, 105.90 ppm to 525.10 ppm and 5.30 to 13.53 ppm. In root it varied between 5.50 to 9.70 ppm, 0.62 to 1.63 ppm, 47.30 to 119.60 ppm and 1.75 to 6.92 ppm. On the basis of heavy metal concentration in red amaranth plant, the order of concentration of heavy metal may be arranged as Fe>Zn>Mn>Cu. The findings are in consent with the following research workers:

Elhameh *et al .,* (2018) found that the trend of heavy metals concentration in vegetables was in the following order: Mn □ Zn □ Cu □ Pb □ Cr □ Cd.

Hamdi *et al .,* (2017)found the high concentration of heavy metals in textile wastewater irrigated saplings, which indicate that the accumulation of heavy metals in apple saplings due to presents of higher Cr, Mn and Zn concentrations.

Begum *et al.,* (2011) reported that Zn, Mn, Fe, Cu, and Pb were higher in rice plant with T_6 treatment, where effluent was irrigated to the contaminated field.

Khan *et al.,* (2005, 2003) and Khan *et al.,* (2001) reported high concentration of heavy metal in vegetables grown in agricultural fields receiving textile waste water.

Yaseen *et al.,* (2017) found that concentration of heavy metals predominantly Cr, Cu, Cd and Pb was reduced in grains by application of 50% canal water and 50% textile wastewater.

Carlos *et al.,* (2018) found increases in concentrations of Mn, Na, Cu, and Zn in tissue of maize under irrigation with industrial wastewater.

Effect of textile waste water on heavy metal uptake by plant

In pot experiment 1, the results showed that heavy metal uptake increased due to different textile waste water irrigation over control. In non-contaminated soil of Narayanganj the total uptake of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn of jute leaves plants (leaves + shoots + roots) varied between 15.44 to 36.58 gm/ha, 6.16 to 28.06 gm/ha, 0.0 (nil) to 0.0452 gm/ha, 186.93 to 695.47 gm/ha, 0.0028 to 0.0072 kg/ha, 0.52 to 1.18 kg/ha, 0.0177 to 0.0670 gm/ha and 17.90 to 51.92 kg/ha. In non contaminated soil of Gazipur the total uptake of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn of jute leaves plants (leaves + shoots + roots) ranged between 17.79 to 51.62 gm/ha, 7.21 to 22.59 gm/ha, 0.0 (nil) to 0.0472 gm/ha, 502.64 to 1377.37 gm/ha, 0.0045 to 0.0117 gm/ha, 0.48 to 1.80 gm/ha, 0.0430 to 0.1563 gm/ha and 22.68 to 60.97 gm/ha. In contaminated soil of Narayanganj the total uptake of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn of jute leaves plants (leaves + shoots + roots) varied between 35.26 to 45.79 gm/ha, 19.66 to 23.14 gm/ha, 0.0 (nil) to 0.0353 kg/ha, 247.88 to 691.98 kg/ha, 0.0080 to 0.0111 kg/ha, 0.0195 to 0.0389 kg/ha, 0.0430 to 0.0824 kg/ha and 32.57 to 49.21 kg/ha. In contaminated soil of Gazipur the total uptake of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn of jute leaves plants (leaves + shoots + roots) ranged between 48.95 to

62.34 kg/ha, 19.97 to 28.45 kg/ha, 0.0 (nil) to 0.0498 kg/ha, 744.69 to 1066.66 gg/ha, 0.0078 to 0.0103 kg/ha, 0.0257 to 0.0394 kg/ha, 0.0337 to 0.0816 kg/ha and 30.71 to 49.26 kg/ha.

In Field experiments 1, 2, 3 and 4 almost similar results were observed. Textile waste water irrigation increased the heavy metal uptake by plant as compared with control. In field Cd and Pb were not taken up by jute plant. The total uptake of Zn, Cu, Ni, Fe, Cr and Mn of jute plants (leaves + shoots + roots) varied between 298.89 to 651.32 gm/ha, 47.80 to 140.74 gm/ha, 0.75 to 1.75 gm/ha, 2199.00 to 10253.05 gm/ha, 0.74 to 1.93 gm/ha and 170.55 to 468.61 gm/ha. In field Cd and Pb were not taken up by rice plant. The total uptake of Zn, Cu, Ni, Fe, Cr and Mn of rice plants (leaves + shoots + roots) varied between 444.79 to 1148.77 gm/ha, 38.32 to 78.33 gm/ha, 0.0 (nil) to 89.84 gm/ha, 3371.00 to 6982.76 gm/ha, 0.0 (nil) to 0.61gm/ha and 1581.32 to 3387.07 gm/ha. In field Cd and Pb were not taken up by jute leaves plant. The total uptake of Zn, Cu, Ni, Fe, Cr and Mn of jute leavrs plants (leaves + shoots + roots) varied between 26.94 to 47.46 gm/ha, 5.20 to 12.36 gm/ha, 0.0 (nil) to 7.06 gm/ha, 529.15 to 823.30 gm/ha, 0.0 (nil) to 0.253 gm/ha and 22.49 to 40.66 gm/ha. In field Ni, Cd, Cr and Pb were not taken up by red amaranth plant. The total uptake of Zn, Cu, Fe and Mn of red amaranth plants (leaves + shoots + roots) varied between 48.20 to 152.45 gm/ha, 7.16 to 29.70 gm/ha, 506.43 to 3286.15 gm/ha and 22.98 to 87.14 gm/ha. The findings indicate that ability of uptake of heavy metal by different plant are different. High concentration of heavy metal reduced plant growth as a result total heavy metal uptake reduced. These observations are supported with the findings of the following workers:

Bieby *et al.,* (2011) reported that high concentrations of contaminants may inhibit plant growth and, thus, may limit total uptake of heavy metals by plants.

Qing *et al.,* (2003) found that the abilities of various plant species to uptake and accumulate the metals from the soil are different.

Marisa and John (2006) observed that individual plant types greatly differ in their metal uptake and bioavailability varied widely from element to element and according to different plant types.

Kaur and Sharma (2015) found that crop species exercise differently in accumulating heavy metals of effluents irrigated soils in their tissue. Uptake of heavy metals by plants may be an indicator of efficiency of metal absorption of various crop species grown on metal contaminated soils.

Jiwan and Kalamdhad (2011) found that the heavy metals uptake by plants from the soil reduces the crop productivity by inhibiting physiological metabolism.

Effect of textile waste water on nutrient status of post harvest soils

In pot experiment 1, the results showed that the pH of the post harvest soil slightly increased with increasing the concentration of textile waste water irrigation in all soils. The highest value of pH were found with the treatment T_6 ,where 100% textile waste water was irrigated. And the lowest value of pH were found with the treatment T_2 , where 100% RDF were applied. The highest content of organic matter, N, P, S, K, Ca and Mg were found with the treatment T_6 (50% RDF + 100% TWW) in all post harvest soils. And lowest content of organic matter, N, P, S, K, Ca and Mg were found with the treatment T_1 (control) in all post harvest soils.

In field experiments 1, 2, 3 and 4 almost similar results were observed. The pH of post harvest soil of jute, rice, jute leaves and red amaranth increased with increasing the concentration of textile waste water irrigation. The maximum value of pH were found with 100% textile waste water irrigation (T_6) and minimum pH were found with 100% RDF application (T_2) in post harvest soil of all crops. The highest content of organic matter, N, P, S, K, Ca and Mg were found with the treatment T_6 (50% RDF + 100% TWW) in all crops post harvest soils. And lowest content of organic matter, N, P, S, K, Ca and Mg were found with the treatment T_1 (control) in all crops post harvest soils. These observations are in agreement with the findings of the following scientist:

Malik (2017) reported that the pH of all the soil samples was highly alkaline (pH range 7.72-9.6) indicating the flow of alkaline effluents from the textile mill and the pH is also higher than the control value (6.13-6.42). High value of organic carbon was found around the industry indicating the accumulation of light organic matter in the soil.

Lekshmi and Rajani (2017) found that the effluent application is capable to cause noticeable changes in the soil parameters. Except the pH, all the parameters got increased with the increase in treatment concentrations.

Faryal et al., (2007) suggest that irrigation with local textile wastewater not only alters the soil chemistry, but also changes bacterial and VAM population in addition to enhancing the intrinsic endurance of these microbes to different metal ions present in their microenvironment.

Singh *et al.,* (2012) reported that waste water irrigation increased total N, P, K and organic carbon content of soil.

Kiziloglu *et al.,* (2007) observed that textile waste water irrigation can improve physical properties, nutrient contents of soils.

Chhonkar *et al.,* (2000) reported that the addition of textile effluent to soil on short-term basis results into increase in water soluble salts, organic matter, Na, Ca, Mg, K, NH_4-N, P content of soil as compared to normal water irrigated soil.

Effect of textile waste water on heavy metal concentration of post harvest soils

In pot experiment 1, the results showed that in both non contaminated and contaminated soils heavy metal concentration in post harvest soil increased with the increasing concentration of textile waste water irrigation. Both in non contaminated and contaminated soils the maximum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found in treatment T_6, where 100% textile waste water was irrigated. And the minimum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found in treatment T_1(control) in all soils.

In field experiment 1, 2, 3 and 4 almost similar results were observed. In post harvest soil of jute, rice, jute leaves and red amaranth the heavy metal concentration increased with the higher concentration of textile waste water irrigation. In post harvest soil of jute, rice, jute leaves and red amaranth the maximum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found in treatment T_6, where 100% textile waste water was irrigated. And the minimum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found in treatment T_1(control) in all crops post harvest soils. The results are consistent with the findings of the following scientist:

Lekshmi and Rajani (2017) observed that the regular and periodic addition of industrial effluent makes undesirable changes to the soil parameters. Even a small concentration for a short period of time is capable to cause a great change from the normal parameter value, which indicates the toxicity of the effluent.

Shammi *et al.,* (2016) reported that irrigation with wastewater increased the level of salinity and heavy metals accumulate on the agriculture land.

Najam *et al.,* (2015) The long-term usage of industrial wastewater makes heavy metals to accumulate in soil.

Alrawiq *et al.,* (2014) observed that the average concentrations of heavy metals, except for Cd, were higher in the soil irrigated with recycled water than in the soil irrigated with non-recycled water.

Bhatti *et al.,* (2016) reported that use of NPK fertilizers and other agrochemicals further contaminate the soil with heavy metals. Various NPK fertilizers act as source of heavy metals such as Cd, As, Pb, Cr, Ni, Cu etc.

Yaseen *et al.,* (2015) observed that textile waste water contains relatively high amount of sodium and heavy metals including Zn, Cu, Pb, Ni, Cr, Cd, depending upon the type of activities it is associated with, which can be accumulated in the soil during irrigation with this waste water and display toxic effects on the plants.

Residual effect of textile waste water on growth and yield

In pot experiment 2, it appeared that in both non contaminated and contaminated the tallest plant, maximum number of leaves per plant and highest yield were obtain with the integrated treatments T_2 (100% RDF + RE of 0% TWW). And among the previously textile waste water treated pots the second tallest plant, nearest maximum number of leaves per plant and nearest highest yield were obtain with the integrated treatments T_6 (50% RDF + Re of 100% TWW) in both non contaminated and contaminated soils. It might be due to residual effect of higher concentration of textile waste water, which increased soil organic matter and nutrients. In non contaminated soils lowest plant height, minimum number of leaves per plant and lowest yield were observed with control (T_1). In contaminated soil of Narayanganj lowest plant height was found with control (T_1) but lowest number of leaves and lowest yield was found with T_3(50% RDF + Re of 25% TWW). In contaminated soil of Gazipur lowest plant height and lowest yield was observed with T_3(50% RDF + Re of 25% TWW) but lowest number of leaves was found with control (T_1). These observations are in agreement with the findings of the following worker in different aspect:

Chandini *et al.,* (2019) reported that the some of the chemical fertilizers have residual effect which increases the plant growth during succeeding crop production.

Ziemacki *et al.,* (2018) found that both fertilizer application on soils have positive long-term effects on soil nutrient content and crop yield even in the season after the fertilizer application due to its residual effect.

Due to residual effect of TWW irrigation with chemical fertilizers of preceding crop, it thrives well the succeeding crop was marked in this study. Saravanamoorthy and Kumari (2007) found that textile waste water acts as a supplement to the soil fertility, humus content, organic matter and mobile compounds and prevail nutrients in soil, which increased plant growth and yield.

Savci (2012) reported that the amount of nutrients in the soil effects the quantity of yield which was relevant with this study.

Sarfaraz (2017) reported that chemical fertilizers improve the growth of plants and increase the yields of fruits and vegetables in a relatively short period of time. Raja (2001) reported that increasing the nitrogen levels in soil significantly increased the number of primes, yield attributes, green era and kernel yield.

Leghari *et al.,* (2016) found that nitrogen play a key role in agriculture by increasing the crop yield. Emily *et al.,* (2017) suggest that native soil organic matter can support productivity levels.

Schjonning *et al.,* (2018) observed that positive effect of soil organic matter in terms of a reduction of mineral N needed to obtain the potential crop yield. Johnny (2011) reported that N and P interactions with soil organic matter and its support of high crop yields. Morgan and Connolly (2013) found that plant growth and development largely depend on the combination and concentration of mineral nutrients available in the soil.

Residual effect of textile waste water on dry matter production

Residual effect of textile waste water enhanced total dry matter yield over control in both non contaminated and contaminated soils. Highest dry matter yield were obtained with the treatment T_2(100% RDF + RE of 0% TWW) in both soils. The second highest rate of dry matter were obtained with the T_6 (50% RDF + Re of 100% TWW), where 100% textile waste water was irrigated in previous experiment. It might be due to residual effect of 100% TWW, which increased soil organic matter and soil nutrient content. Lowest dry matter yield were found with treatment T1 (control) in both non contaminated soils and contaminated soil of Narayanganj. But in contaminated soil of Gazipur the lowest yield was obtained with T3(50% RDF + Re of 25% TWW). These observations are in agreement with the findings of the following scientists:

Rafiq *et al.*, (2010) reported that nitrogen enhances the yield and also enhances leaf area and total leaf biomass of plants ultimately dry matter yield.

Bauer and Black (1994) reported that on an annual basis, highest total aerial dry matter and grain yields were associated with highest organic matter contents of soil.

Residual effect of textile waste water on nutrient content

In pot experiment 2, the results showed that nutrient content in red amaranth increased with the higher concentration of textile waste water residual effect. Which indicate that residual effects of textile waste water has positive effect on nutrient content. It might be due to higher organic matter and nutrient accumulation in soil with irrigation of higher concentration of textile waste water.

In non contaminated soil of Narayanganj the nutrient content of N, P, K, S, Ca and Mg of leaves of amaranth varied between 2.71% to 3.75%, 0.32% to 0.38%, 0.555% to 0.730%, 0.42% to 0.69%, 0.560% to 0.600% and 0.60% to 0.91%. In shoot the nutrient content of N, P, K, S, Ca and Mg varied between 0.80% to 1.10%, 0.19% to 0.22%, 0.305% to 0.405%, 0.15% to 0.25%, 0.255% to 0.325% and 0.27% to 0.43 %. In root the nutrient content of N, P, K, S, Ca and Mg varied between 0.51% to 0.53%, 0.15% to 0.17%, 0.160% to 0.330%, 0.11% to 0.20%, 0.125% to 0.150% and 0.12% to 0.21% with different treatments. Highest N(3.75%), S(0.69%), Ca(0.600%) and Mg (0.91%) in amaranth leaves were found with T_6, and highest P(0.38%), K(0.730%) were observed in T_2. In non contaminated soil of Gazipur the nutrient content of N, P, K, S, Ca and Mg of leaves of amaranth varied between 2.62% to 4.78%, 0.34% to 0.39%, 0.540% to 0.605%, 0.23% to 0.47%, 0.890% to 1.475% and 0.62% to 0.89% .In shoot the nutrient content of N, P, K, S, Ca and Mg varied between 0.81% to 1.10%, 0.15% to 0.18%, 0.240% to 0.305%, 0.14% to 0.31% , 0.240% to 0.450% and 0.40% to 0.54%. In root the nutrient content of N, P, K, S, Ca and Mg varied between 0.21% to0.55%, 0.12% to0.15%, 0.105% to0.150%, 0.11% to0.17%, 0.105% to 0.210% and 0.18% to 0.23% with different treatment. Highest N(4.78%), P(0.39%), K(0.605%), S(0.47%), Ca(1.475%) and Mg(0.89%) in leaves of amaranth were found in T_2.

In contaminated soil of Narayanganj the nutrient content of N, P, K, S, Ca and Mg of leaves of amaranth varied between 3.17% to 3.50%, 0.32% to 0.34%, 0.590% to 0.980%, 0.27% to 0.37%, 0.190% to 0.580% and 0.410% to 0.930%. In shoot the nutrient content of N, P, K, S, Ca and Mg varied between 1.11% to 1.20%, 0.13% to 0.15%, 0.250% to 0.335%, 0.18% to 0.25%, 0.060% to 0.130% and 0.170% to 0.270%. In root the nutrient content of N, P, K, S, Ca and Mg varied between 0.45% to 0.53%, 0.11% to 0.12%, 0.105% to 0.155%, 0.12% to 0.15%, 0.024% to 0.042% and 0.061% to 0.087% with different treatment. Highest N(3.50%), P(0.34%), K(0.980%), Ca(580%) in leaves of amaranth were observed with T_6. But Highest S(0.37%) and Mg(0.930%) were found in T_2. In contaminated soil of Gazipur the nutrient content of N, P, K, S, Ca and Mg of leaves of amaranth varied between 2.88% to 4.45%, 0.30% to 0.33%, 0.605% to 0.860%, 0.230% to 0.320%, 0.75% to 0.90% and 0.650% to 0.980%. In shoot the nutrient content of N, P, K, S, Ca and Mg varied between 0.95% to 1.35%, 0.13% to 0.15%, 0.380% to 0.455%, 0.084% to 0.099%, 0.21% to 0.28% and 0.078% to 0.120%. In root the nutrient content of N, P, K, S, Ca and Mg varied between 0.52% to0.78%, 0.10% to0.13%, 0.175% to0.220%, 0.032% to0.045%, 0.12% to 0.19% and 0.042% to 0.096% with different treatments. Highest N(4.45%), P(0.33%), K(0.860%), Ca(0.98%) and Mg(0.980%) were observed with T_2. But highest S(0.320%) was found with T_6. These observations are correlated with the findings of the following worker:

Brady and Weil (2007) reported that soil organic matter increases aeration and water holding capacity, provide habitat for soil organisms that fuel nutrient cycling, and retains and provides nutrients critical to productivity.

Fred (2012) reported that mineralization of N, P and S from organic matter is an important source of these nutrients for plants and organic matter also helps to hold on positively charged potassium (K^+), calcium (Ca^{++}), and magnesium (Mg^{++}) ions.

Menshik *et al.*, (2019) reported that soil organic matter serves as a reservoir of nutrients, most notably, N, P and S for plants and the soil biota.

Residual effect of textile waste water on nutrient uptake

The results revealed that nutrients uptake due to residual effect of textile waste water irrigation increased significantly as compared with control in all the treatments.

In non contaminated soil of Narayanganj the total uptake of N, P, K, S, Ca and Mg of red amaranth plants (leaves + shoots + roots) varied between 3.07 to 67.82 kg/ha, 0.55 to 9.86 kg/ha, 0.84 to 17.44 kg/ha, 0.52 to 14.61 kg/ha, 0.77 to 14.28 kg/ha and 0.86 to 17.73 kg/ha. And in non contaminated soil of Gazipurthe total uptake of N, P, K, S, Ca and Mg of red amaranth plants (leaves + shoots + roots) varied between 2.60 to 65.91 kg/ha, 0.42 to 7.82 kg/ha, 0.58 to 11.44 kg/ha, 0.33 to 11.60 kg/ha, 0.76 to 21.39 kg/ha and 0.89 to 20.33 kg/ha. In contaminated soil of Narayanganjthe total uptake of N, P, K, S, Ca and Mg of red amaranth plants (leaves + shoots + roots) ranged between 28.67 to 63.58 kg/ha, 3.32 to 7.18 kg/ha, 6.09 to 17.31 kg/ha, 3.70 to 9.41 kg/ha, 1.73 to 8.38 kg/ha and 4.21 to 15.35 kg/ha. In contaminated soil of Gazipurthe total uptake of N, P, K, S, Ca and Mg of red amaranth plants (leaves + shoots + roots) varied between 31.87 to 74.73 kg/ha, 3.66 to 7.17 kg/ha, 8.53 to 20.07 kg/ha, 2.54 to 5.27 kg/ha, 6.95 to 15.78 kg/ha and 4.35 to 12.28 kg/ha. In all soils highest uptake of N, P, K, S, Ca and Mg were achieved with T_2(100% RDF + RE of 0% TWW). And the closest highest uptake of N, P, K, S, Ca and Mg were achieved withT_6 (50% RDF + Re of 100% TWW). In both non contaminated soils lowest uptake of N, P, K, S, Ca and Mg were found with T_1(control). In contaminated soil of Narayanganj lowest uptake of N, P, K were observed with T_3(50% RDF + Re of 25% TWW) and lowest uptake of S, Ca and Mg were observed with T_1(control). In contaminated soil of Gazipur the lowest uptake of N was observed with T_1(control) and lowest uptake of P, K, S, Ca and Mg were observed with T_3(50% RDF + Re of 25% TWW). These observations are in agreement with the findings of the following scientist:

Peter *et al.,* (2019) reported that manure N uptake was notably lower compared to the uptake from inorganic N sources as it is, in most cases, not readily available for immediate crop uptake.

Ma *et al.,* (1999) reported that a significantly lower manure N uptake efficiency compared to inorganic N uptake efficiency even when grain yield levels were comparable for the two input sources.

Qian *et al.,* (2006) reported that dual N sources enhanced the growth and N uptake of rice crop.

Residual effect of textile waste water on heavy metal concentration in plants

The results showed that heavy metal concentration in red amaranth increased with residual effect of increased level of textile waste water irrigation. Ni, Cd, Cr and Pb were nil in the red amaranth plant in both non contaminated and contaminated soils of Narayanganj and Gazipur. Maximum concentration of Zn, Cu, Fe and Mn were found in treatment T_6, where 100% textile waste water was irrigated previously. And the minimum concentration of Zn, Cu, Fe and Mn were found in treatment T_1(control) in all soils.

In non contaminated soil of Narayanganj the concentration of Zn, Cu, Fe and Mn of leaves of red amaranth plants varied between 41.00 to 74.00 ppm, 12.93 to 18.15 ppm, 296.93 to 999.68 ppm and 39.92 to 86.95 ppm. The concentration of Zn, Cu, Fe and Mn of shoot of red amaranth varied between 10.80 to 12.20 ppm, 4.30 to 5.20 ppm, 101.70 to 401.30 ppm and 9.95 to 15.72 ppm. The concentration of Zn, Cu, Fe and Mn of root of red amaranth varied between 3.25 to 4.99 ppm, 2.15 to 3.00 ppm, 52.10 to 157.80 ppm and 3.86 to 5.55 ppm.

In non contaminated soil of Gazipurthe concentration of Zn, Cu, Fe and Mn of leaves of red amaranth plants ranged between 68.00 to 85.00 ppm, 11.33 to 18.63 ppm, 432.28 to 779.06 ppm and 40.70 to 78.89 ppm.The concentration of Zn, Cu, Fe and Mn of shoot of red amaranth plants ranged between 15.25 to 16.82 ppm, 3.71 to 6.25 ppm, 202.50 to 388.30 ppm and 11.20 to 15.20 ppm. The concentration of Zn, Cu, Fe and Mn of root of red amaranth plants ranged between 7.02 to 8.64 ppm, 1.52 to 2.91 ppm, 112.20 to 191.20 ppm and 5.30 to 7.34 ppm.

In contaminated soil of Narayanganj the concentration of Zn, Cu, Fe and Mn of leaves of red amaranth plants varied between 35.00 to 66.00 ppm, 11.63 to 16.03 ppm, 391.02 to 929.68 ppm and 36.36 to 71.67 ppm. The concentration of Zn, Cu, Fe and Mn of shoot of red amaranth varied between 9.78 to 12.34 ppm, 4.74 to 6.79 ppm, 103.23 to 362.80 ppm and 10.10 to 14.98 ppm. The concentration of Zn, Cu, Fe and Mn of root of red amaranth varied between 3.20 to 6.10 ppm, 1.98 to 3.25 ppm, 50.10 to 150.20 ppm and 4.72 to 6.50 ppm.

In contaminated soil of Gazipurthe concentration of Zn, Cu, Fe and Mn of leaves of red amaranth plants ranged between 36.00 to 67.00 ppm, 12.83 to 14.43 ppm, 411.35 to 812.19 ppm and 38.64 to 65.87 ppm. The concentration of Zn, Cu, Fe and Mn of shoot of red amaranth varied between 10.20 to 15.80 ppm, 4.54 to 5.50 ppm, 252.30 to 433.20 ppm and 10.10 to 15.89 ppm. The concentration of Zn, Cu, Fe and Mn of root of red amaranth varied between 4.31 to 8.95 ppm, 2.71 to 3.00 ppm, 176.80 to 247.50 ppm and 4.88 to 6.73ppm. These observations are in agreement with the findings of the following scientist:

Cho-ruk *et al.,* (2006) reported that many species of plants have been successful in absorbing contaminants such as lead, cadmium, chromium, arsenic, and various radionuclides from soils. One of phytoremediation categories, phytoextraction, can be used to remove heavy metals from soil using its ability to uptake metals which are essential for plant growth (Fe, Mn, Zn, Cu, Mg, Mo, and Ni). Some metals with unknown biological function (Cd, Cr, Pb, Co, Ag, Se, Hg) can also be accumulated .

Residual effect of textile waste water on heavy metal uptake

Heavy metal uptake increased with the increasing residual effect of textile waste water irrigation by red amaranth as compared with control in both non contaminated and contaminated soils. In non contaminated soil of Narayanganj total heavy metal Zn, Cu, Fe and Mn uptake by red amaranth plants (leaves + shoots + roots) ranged between 4.13 to 88.92 gm/ha, 1.49 to 31.67 gm/ha, 34.67 to 1670.25 gm/ha and 3.98 to 97.17 gm/ha. In non contaminated soil of Gazipur total heavy metal Zn, Cu, Fe and Mn uptake by red amaranth plants (leaves + shoots + roots) ranged between 6.57 to 117.89 gm/ha, 1.28 to 31.07 gm/ha, 59.90 to 1529.41 gm/ha and 4.28 to 90.75 gm/ha.

In contaminated soil of Narayanganj total heavy metal Zn, Cu, Fe and Mn uptake by red amaranth plants (leaves + shoots + roots) ranged between 3.63 to 87.84 gm/ha, 1.46 to 29.95 gm/ha, 40.42 to 1774.15 gm/ha and 3.83 to 109.85 gm/ha. In contaminated soil of Gazipur total heavy metal Zn, Cu, Fe and Mn uptake by red amaranth plants (leaves + shoots + roots) ranged between 3.81 to 90.15 gm/ha, 1.55 to 29.15 gm/ha, 68.84 to 1695.76 gm/ha and 3.97 to 94.61 gm/ha. These observations are in agreement with the findings of the following scientist:

Jaishree and Khan (2013) reported that heavy metal uptake by grains was directly related to the applied heavy metal with greater concentrations, where metals were added separately rather than in combinations.

Residual effect of textile waste water on nutrient status of post harvest soils

In pot experiment 2, the results showed that the pH of the post harvest soil slightly decreased due to irrigation with fresh water, which were previously irrigated with textile waste water. The highest content of organic matter (2.28, 1.86, 2.86 and 2.97%) were remain in T_6, where 100% textile waste water was irrigated previously. The highest content of N, P, S, K, Ca and Mg were found with the treatment T_2 (100% RDF + RE of 0% TWW) in all post harvest soils. And lowest content of organic matter, N, P, S, K, Ca and Mg were found with the treatment T_1 (control) in all post harvest soils. These observations are in agreement with the findings of the following scientist:

Baishya *et al.,* (2017) reported that the recommended dose of NPK fertilizers enhances the post harvest fertility status of soil.

Sultana *et al.,* (2012) observed that soil with high organic matter showed highest concentrations for almost all nutrients due to poor uptake whereas the soil with no fertilization showed the lowest values in post harvest soil.

Residual effect of textile waste water on heavy metal concentration of post harvest soils

In pot experiment 2, the result showed that in both non contaminated and contaminated soils heavy metal accumulation decreased due to fresh water irrigation and uptake by plants, but still the value were higher than control due to residual effect of textile waste water irrigation. Both in non contaminated and contaminated soils the maximum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found in treatment T_6, where 100% textile waste water was irrigated previously.

And the minimum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found in treatment T_1(control) in all soils. These observations are in agreement with the findings of the following scientist:

Wang and Greger (2006) reported that phytoextraction is considered as an environmental friendly method to remove metals from contaminated soils in situ. This method can be used in much larger-scale clean-up operations and has been applied for other heavy metals .

Mwegoha (2008) found that phytoremediation can be a time-consuming process, and it may take at least several growing seasons to clean up a site.

CHAPTER - 6

SUMMARY, CONCLUSION AND RECOMMENDATION

CHAPTER - 6

SUMMARY AND CONCLUSION

Textile industry is one of the most important and rapidly developing industrial sectors in Bangladesh. It is the most important sector of Bangladesh's economy. The country has its limited capacities to treat textile wastewater, which cause pollution of soils, water bodies and traditional irrigation water sources. The textile waste water uses to land as irrigation limits the pollution of rivers, canals and other safe-water resources. This benefits the health of people downstream, who use these water resources for domestic purpose and drinking-water needs. In areas where fresh water is scarce, textile waste water allows low-income farmers to produce crops. They would otherwise not to be able to grow. Textile waste water contains nutrients and organic matter which can be used for irrigation to improve the nutrient and organic matter content of soil. Use of textile wastewater irrigation can also result in serious environmental problems, contaminating soil and ground water with chemical pollutants including heavy metals. Under such situation, an attempt has been made to supplement the irrigation water and nutrient through textile waste water which would maximized benefits and minimized risks.

The densely textile industrial areas of Gazipur and Narayanganj district under Dhaka division of Bangladesh, were chosen for collecting soil and textile waste water under the study. The pot and field experiments were conducted at Bangladesh Jute Research Institute, Central Station, Dhaka. Treatments for pot experiment no.-1 and field experiments were- T_1 – Control, T_2- 100% RDF+ 0% TWW, T_3 – 50% RDF + 25% TWW, T_4 – 50% RDF + 50% TWW, T_5 – 50% RDF + 75% TWW, T_6 – 50% RDF + 100% TWW. And Treatments for pot experiment no.-2 were - T_1 – Control, T_2- 100% RDF+ RE of 0%TWW, T_3 – 50% RDF + RE of 25%TWW, T_4 – 50% RDF + RE of 50% TWW, T_5 – 50% RDF + RE of 75% TWW, T_6 – 50% RDF + RE of 100% TWW (Here, TWW= Textile waste water, RE= Residual effect and RDF= Recommended dose of fertilizer). The objectives of the research work were: (1) To study the effects of textile waste water on the growth and yield of crops. (2) To observe the effects of textile waste water irrigation on the properties of soil. (3) To determine macronutrient and heavy metal uptake by jute, rice and vegetable crops. (4) To observe the residual effects of textile waste water irrigation on soil and crop. (5) To make a suitable integrated dose for the cropping pattern.

Pot experiments were laid out in completely randomized design (CRD) with three replications. The field experiments were followed randomized complete block design (RCBD) having three replications. Inorganic fertilizers for the crops were calculated on the basis of soil chemical test as per Fertilizer Recommendation Guide (FRG, 2012) of Bangladesh Agricultural Research Council (BARC). Irrigation and fertilizer were applied to the soil according to treatment design. During the study recommended intercultural practices for each crop were done as when necessary. The jute plants were harvested at the early pod stage after total growth duration of 120 days. Rice was harvested 36 to 40 days after flowering stage. The jute leaves plants were harvested at 45 days after germination of seeds. Red amaranth plants were harvested before flowering.

The initial and post-harvest soil samples were collected and processed for chemical analysis. The plant samples were taken for determining the dry matter, nutrient content and heavy metal concentration in different parts of the plants, and nutrient and heavy metal uptake capacity. The findings showed that irrigation of concentration of textile waste water up to 50% increased the different growth parameters significantly then decreased. Highest yield was achieved with T_2 (100% RDF+0% TWW). Among the different treatments of textile waste water the combinations of 50% chemical fertilizer and 50% textile waste water (T_4) gave the second highest yield and found statistically similar result compare to T_2 (100% RDF+0% TWW).

Growth and yield performance of jute vegetable plant, jute fiber crop, rice and red amaranth with textile waste water

Results from the pot experiment 1 and field experiments the maximum height of plant, number of leaves, weight of leaves per plant, base diameter, yield of fiber, stick, rice, straw, jute leaves and red amaranth were obtained with T_2 (100% RDF + 0% TWW). The next tallest plant, second highest number of leaves, yield of fiber was found with T_4. But there was no significant treatment difference between T_2 and T_4.

The results indicated that among the treated plots, the 50% textile waste water combined with 50% RDF(T_4) produced optimum growth and yield which was all most same with100% RDF(T_2). The lowest plant height, number of leaves, leaves weight per plant, base diameter, yield of fiber, stick, rice, straw, jute leaves and red amaranth were found with T_1(control). Form the findings the treatment may be arranged in the order of $T_2>T_4>T_5>T_3>T_1>T_6$ and $T_2>T_4>T_5>T_3>T_6>T_1$ for jute leaves yield in non contaminated soil of Narayanganj and Gazipur respectively. The treatments may be arranged in the order of $T_2>T_4>T_1>T_5>T_3>T_6$ and $T_2>T_4>T_5>T_1>T_6>T_3$ for jute leaves yield in contaminated soils of Narayanganj and Gazipur respectively. The treatments may be arranged in the order of $T_2>T_4>T_5>T_6>T_3>T_1$ for fiber yield of jute, $T_2>T_4>T_5>T_3>T_6>T_1$ for stick yield of jute, $T_2>T_5>T_4>T_6>T_3>T_1$ for straw yield of rice, $T_2>T_4>T_5>T_6>T_3>T_1$ for grain yield of rice, $T_2>T_4>T_5>T_6>T_3>T_1$ for yield of jute lives and $T_2>T_4>T_5>T_6>T_3>T_1$ for yield of red amaranth in field.

In pot experiment 2, due to residual effects of textile waste in both non contaminated and contaminated soils the tallest plant, maximum number of leaves per plant and highest yield were obtained with T_2(100% RDF + RE of 0% TWW). The next maximum plant height, number of leaves per plant and yield were obtained with the integrated treatments T_6 (50% RDF + Re of 100% TWW). The lowest yield components were found with T_1(control) and T_3 (50% RDF + Re of 25% TWW).

In both the pot and field experiments it was found that the total dry matter production of crops was influenced significantly by different levels of textile waste water irrigation. The leave, shoot, root, straw and grain were considered as different parts of crops to estimate the total dry matter. In both pot and field experiments maximum dry matter production was observed with T_2 (100% RDF). In pot experiment 1 and field experiments dry matter yield was increased up to 50% textile waste water treated pots combined with 50% RDF improved dry matter yield after then decreased. The lowest dry matter was found with control (T_1) and T_6(50%RDF + 100% TWW). The dry matter production (in pot expt.2) of red amaranth was gradually increased with the increasing rate of residual effect of textile waste water up to 100% dose. Lowest yield of dry matter was found with control (T_1) .

Influence of textile waste water in nutrient content of different plant parts of crops

Effect of textile waste water on nutrient content in different plant parts of crops including vegetables jute plant were found pronounced. Highest N, P, K, S, Ca and Mg content were found in leaves than shoot and root in the all treatments. In pot experiment 1 and field experiments there were increased the nutrient content with the irrigated textile waste water up to 50% after that the over dose decreased.

Nutrient content in plant parts of crops under pot experiments 1

Under the pot experiment 1, in both non contaminated and contaminated soils the nutrient content of N, P, S, Ca and Mg were found distinct with T_2(100% RDF + 0% TWW) in jute vegetables plant.The highest K content was found with T_5 (50% RDF + 75% TWW). Lowest nutrient content was found with T_1(control) and T_6 (50% RDF + 100% TWW). In non contaminated soil of Narayanganj in leaves of jute leaves highest N (3.78%), P (0.23%), K(2.27%), S(0.076%), Ca (0.195%) and Mg(0.159%) were found. In non contaminated soil of Gazipur in leaves of jute leaves optimum N (3.28%), P (0.31%), K(3.86%), S(0.091%), Ca (0.334%) and Mg(0.172%) were observed. In contaminated soil of Narayanganj in leaves of jute leaves highest N (3.97%), P (0.29%), K(2.38%), S(0.062%), Ca (0.251%) and Mg(0.163%) were found. And in contaminated soil of Gazipur highest N (4.35%), P (0.27%), K(3.48%), S(0.061%), Ca (0.239%) and Mg(0.159%) were found in leaves of jute leaves.

Nutrient content in plant parts of crops under field experiments

In field experiment 1, the jute crop content highest N (2.47%) and Mg (0.157%) with T_2(100% RDF + 0% TWW). The highest P (0.36%) and Ca (0.128%) was found with T_4(50% RDF + 50% TWW), and K(2.91%) and S(0.076%) was observed with T_5(50% RDF + 75% TWW) in jute leaves. Nitrogen content of shoot found highest (0.86%) in T_2 and T_4. Maximum P(0.20%), K(1.31), Ca(0.41%), Mg(0.42%) in jute shoot found with the textile waste water irrigation. Jute root contained highest N(0.45%) with $T_{6.}$.The P, K, S, Ca and Mg in roots also increased with textile waste water treatments.

In field experiment 2, rice was grown where the concentrations of the N, P, K, S, Ca and Mg in grain of rice varied between 1.00 to 1.68%, 0.016 to 0.029%, 0.321 to 0.525%, 0.040 to 0.047%, 0.08 to 0.12% and 0.035 to 0.095%. In rice grain, the highest N (1.68%), K(0.525%) and S(0.047%) were found with T_2. The highest P(0.029%) content in grain with T_4, Ca (0.12%) in T_5 and Mg(0.095%) in T_6. In straw the N ranged between 0.54 to 0.68%, P 0.012 to 0.031%, K 2.811 to 3.689%, S 0.036 to 0.048%, Ca 0.26 to 0.32% and Mg 0.2 to 0.235%. In the root of rice

N ranged 0.29 to 0.31%, P 0.007 to 0.011%,K 0.85 to 0.95%, S 0.01 to 0.015%,Ca 0.15 to 0.16% and Mg 0.014 to 0.023% with different treatments.

In field experiment 3, jute leaves vegetable plant (pat shak) was cultivated where highest N (2.60%), P (0.40%), S(0.045%), Ca (0.162%) and Mg(0.150%) were found in leaves of jute vegetable plant with T_2(100% RDF + 0% TWW), and highest K(2.80%) was found with T_5. In shoot the nutrients N, P, K, S, Ca and Mg ranged between 0.82 to 1.20%, 0.18 to 0.25%, 0.75 to 1.05%, 0.020 to 0.027%, 0.050 to 0.060% and 0.040 to 0.050%. And in root it ranged between 0.47 to 0.55%, 0.20 to 0.30%, 0.50 to 0.90%, 0.018 to 0.021%, 0.017 to 0.022% and 0.015 to 0.021% with different treatments.

In field experiment 4, the tested crop was red amaranths, where highest N (3.70%), P (0.41%), K(0.49%), S(0.85%), Ca (0.895%) and Mg(0.84%) were found in leaves with T_2. In shoot it ranged between 0.94 to 1.04%, 0.12 to 0.15%, 0.23 to 0.27%, 0.32 to 0.41%, 0.225 to 0.290% and 0.30 to 0.40% . And in root ranges of N, P, K, S, Ca and Mg were ranged between 0.06 to 0.69%, 0.07 to 0.11%, 0.15 to 0.18%, 0.20 to 0.31%, 0.110 to 0.155% and 0.13 to 0.20% with different treatments.

Nutrient content in plant parts of crops under pot experiments 2

In pot experiment 2, it was observed the residual effects of textile waste water has positive effects on nutrient content of red amaranth. Nutrient content in red amaranth increased with the of higher residual action of textile waste water.

In non-contaminated soil of Narayanganj in leaves of red amaranth highest N(3.75%), S(0.69%), Ca(0.600%) and Mg (0.91%) were found with T_6 (50% RDF + RE of 100% TWW), and highest P(0.38%), K(0.730%) were observed in T_2 (100% RDF + RE of 0% TWW). In non contaminated soil of Gazipur in leaves of red amaranth highest N(4.78%), P(0.39%), K(0.605%), S(0.47%), Ca(1.475%) and Mg(0.89%) were found in T_2 (100% RDF + RE of 0% TWW). In contaminated soil of Narayanganj in leaves of red amaranth highest N(3.50%), P(0.34%), K(0.980%), Ca(580%) were observed with T_6 (50% RDF + RE of 100% TWW), but highest S(0.37%) and Mg(0.930%) were found in T_2 (100% RDF + RE of 0% TWW). In contaminated soil of Gazipur in leaves of red amaranth highest N(4.45%), P(0.33%), K(0.860%), Ca(0.98%)

and Mg(0.980%) were observed with T_2 (100% RDF + RE of 0% TWW), but highest S(0.320%) was found with T_6 (50% RDF + RE of 100% TWW).

Nutrient uptake by jute vegetable leaves plant (Pat shak) in pot expt.1

In pot experiment 1, the results revealed that in non-contaminated soils different concentration of textile waste water irrigation had positive effects on nutrient uptake capacity, but in contaminated soils it showed lower trends of nutrient uptake over control(T_1). In both non contaminated and contaminated soils highest uptake of N, P, K, S, Ca and Mg were achieved with T_2(100% RDF + 0% TWW). And the next highest uptake of N, P, K, S, Ca and Mg were achieved with T_4(50% RDF +50% TWW). In non-contaminated soils lowest uptake of N, P, K, S, Ca and Mg were found with T_1(control). But in contaminated soils lowest uptake of N, P, K, S, Ca and Mg were found with T_6 (50% RDF+ 100% TWW) or T_3(50% RDF +25% TWW).

Nutrient uptake by jute crop under field expt.1

In field experiment 1, the jute was uptaken highest N, P, Ca and Mg with T_2(100% RDF + 0% TWW), and highest K and S uptake were with T_6 (50% RDF + 100% TWW) and T_4(50% RDF +50% TWW) respectively. Lowest uptake of N, P, K, S, Ca and Mg were found with T_1(control).

Nutrient uptake by rice crop under field expt.2

In field experiment 2, rice plant uptake highest N, P, K, Ca and Mg with T_2(100% RDF + 0% TWW), and highest S uptake were with T_4 (50% RDF + 50% TWW). Lowest uptake of N, P, K, S, Ca and Mg were found with T_1(control).

Nutrient uptake by jute leaves vegetable plant (Pat shak) under field expt.3

In field experiment 3, highest uptake of N, P, S, Ca and Mg by jute leaves vegetable plant (Pat shak) were obtained with T_2(100% RDF + 0% TWW), and highest K uptake were obtained with T_5 (50% RDF + 75% TWW). Lowest uptake of N, K, Ca and Mg were found with T_1 (control), and lowest uptake of P and S were found with T_3(50% RDF + 25% TWW) and T_6 (50% RDF + 100% TWW).

Nutrient uptake by red amaranth under field expt.4

In field experiment 4, highest uptake of N, P, K, S, Ca and Mg of red amaranth were obtained with T_2(100% RDF + 0% TWW). Lowest uptake of N, P, K, S, Ca and Mg of red amaranth were found with T_1(control).

Nutrient uptake by red amaranth under pot expt.2

In pot experiment 2, the results revealed that nutrients uptake increased significantly due to residual effect of concentration of textile waste water irrigation. In both non contaminated and contaminated soils highest uptake of N, P, K, S, Ca and Mg were achieved with T_2(100% RDF + RE of 0% TWW), and the closest highest uptake of N, P, K, S, Ca and Mg were obtained with T_6 (50% RDF + Re of 100% TWW). In both non contaminated soils lowest uptake of N, P, K, S, Ca and Mg were found with T_1(control). But in contaminated soil of Narayanganj lowest uptake of N, P, K were observed with T_3(50% RDF + Re of 25% TWW) and lowest uptake of S, Ca and Mg were observed with T_1(control). And in contaminated soil of Gazipur the lowest uptake of N was observed with T_1(control) and lowest uptake of P, K, S, Ca and Mg were observed with T_3(50% RDF + Re of 25% TWW).

Heavy metal concentration in crops under pot and field experiments

In pot experiment 1 and field experiments the results showed that heavy metal concentration in different parts of jute leaves plants increased with the increasing level of textile waste water irrigation. In both non contaminated and contaminated soils the highest concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn in all the parts of jute leaves plant were found with T_6, where 100% textile waste water was irrigated. The order of accumulation of heavy metal may be arranged as Fe>Mn>Zn>Cu>Cr>Pb>Ni>Cd for jute leaves in both non contaminated and contaminated soils.

In field experiment 1, 2, 3 and 4 almost similar results were observed due to textile waste water irrigation. In field the heavy metal Cd and Pb were not detected in the jute, rice and jute leaves plant. And in red amaranth plant heavy metal Ni, Cd, Cr and Pb were not detected. On the basis of heavy metal concentration the heavy metal may be arranged in the order of

Fe>Zn>Mn>Cu>Cr>Ni for jute plant, Fe>Mn>Zn>Cu>Ni>Cr for rice plant, Fe>Mn>Zn>Cu>Ni>Cr for jute leaves plant, Fe>Zn>Mn>Cu for red amaranth plats.

In pot experiment 2, the results revealed that heavy metal concentration in red amaranth increased with residual effect of increased level of textile waste water irrigation. Nickel, Cd, Cr and Pb were not taken up by the red amaranth plant in both non contaminated and contaminated soils. Highest concentration of Zn, Cu, Fe and Mn were found in treatment T_6 (50% RDF + RE of 100% TWW), and the lowest concentration of Zn, Cu, Fe and Mn were found in treatment T_1(control) in all soils. On the basis of heavy metal concentration in red amaranth plant, the order of concentration of heavy metal may be arranged as Fe>Zn>Mn>Cu in both non contaminated and contaminated soils.

Heavy metal uptake by crops under pot and field experiments

Heavy metal uptake increased due to different concentration of textile waste water irrigation over control. The findings also indicate that ability of uptake of heavy metal by different plant are different. High concentration of heavy metal reduced plant growth, as a result amount of total heavy metal uptake reduced. In field Cd and Pb were not taken up by jute, rice and jute leaves plants. And Ni, Cd, Cr and Pb were not taken up by red amaranth plant. Due to the increasing residual effect of textile waste water irrigation heavy metal uptake increased by red amaranth as compared with control in both non contaminated and contaminated soils. In this experiment Ni, Cd, Cr and Pb were not taken up by red amaranth.

Nutrient content in post harvest soils

Due to higher concentration of textile waste water irrigation nutrient content in post harvest soil increased significantly. In all post harvest soils the highest accumulation of organic matter, N, P, S, K, Ca and Mg were observed with the treatment T_6, where 100% textile waste water was irrigated. And lowest content of organic matter, N, P, S, K, Ca and Mg were found with the treatment T_1 (control). Due to residual effect of textile waste the highest content of organic matter was found in T_6, where 100% textile waste water was irrigated previously. And the maximum content of N, P, S, K, Ca and Mg in post harvest soil were found with the treatment T_2 (100% RDF + RE of 0% TWW) . And lowest content of organic matter, N, P, S, K, Ca and Mg were found with the treatment T_1 (control) in all post harvest soils.

Heavy metal concentration in post harvest soils

Heavy metal concentration in post harvest soil increased significantly due to higher concentration of textile waste water irrigation. In post harvest soil of jute, rice, jute leaves and red amaranth the maximum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found with 100% textile waste water was irrigation (T_6) . And the minimum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found in treatment T_1(control). Due to residual effect of textile waste water irrigation the maximum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found in treatment T_6, where 100% textile waste water was irrigated previously. And the minimum concentration of Zn, Cu, Ni, Fe, Cd, Cr, Pb and Mn were found in treatment T_1(control) in all soils.

Suggestions

It could be suggested from the experiments that where fresh water irrigation is scarce, textile waste water should be given priority to be used in jute, rice and vegetables cultivation, which will also provide plant nutrients and reduce soil, water and environmental pollution. However, further field trials are needed to assess the soil condition in case of continuous use of textile waste water and the residual effects of it.

Conclusions

From the above findings the following conclusion can be drawn:

- 50% textile waste water mixed with 50% fresh water along with 50% RDF (T_4) was found statistically suitable dose which improve jute, rice and vegetables yield and some soil properties.
- Fresh water irrigation with 100% RDF (T_2) could not produce distinct yield compare to $T_{4.}$ Considering the nutrient cost and uptake by T_2, the contribution all most similar to T_4.
- In some cases T_4 gave highest yield and most of the cases there was no significant difference between T_2 and T_4.
- Irrigation of mixed water T_4(50% RDF + 50% TWW) can save up 50% chemical fertilizer.
- In contaminated soil fresh water irrigation showed positive effect and textile waste water irrigation showed negative effect on growth and yield of crops.
- Heavy metal concentration in plant and post harvest soil was little bit higher with increasing concentration of textile waste water irrigation which found within critical limit.
- In residual effect of textile waste water irrigation heavy metal concentration in post harvest soil is under permissible value of WHO (1996).

Recommendation

In spite of fresh water irrigation scarcity, no systematic activities have so far been undertaken to improve the process of textile waste water irrigation in our country. In order to bring a positive change in the production of jute, rice and vegetables and to reduce the environmental pollution, the following recommendations are made on the basis of the findings of current study:

1) Among the treatments of textile waste water T_4(50% RDF+ 50% TWW) may be recommended for improving the yield of jute, rice and vegetables crop yield, which will also save 50% fertilizer cost.
2) Before application of the textile waste water it needs to chemical analysis.
3) Efforts may be given to make the farmers aware of the appropriate textile waste water management practices for jute, rice and vegetables cultivation and to provide them necessary training and other technical assistance for this purpose.
4) Further research activity may be undertaken to develop fertilizer dose, method and time of fertilizer application and selection of fertilizer including other intercultural operations to increase yield per unit area.
5) Further research needed to assess the soil condition in case of long term use of textile waste water.
6) Further field trials needed to assess the residual effects of textile waste water irrigation in crops and soil.

CHAPTER - 7

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Appendices

Appendix Table 1: WHO permissible limits for heavy metals in plant and soil.

Elements	*Target value of soil (mg/kg)	***Permissible value of plant (mg/kg)
Cd	0.8	0.02
Zn	50	0.60
Cu	36	10
Cr	100	1.30
Pb	85	2
Ni	35	10

*Target values are specified to indicate desirable maximum levels of elements in unpolluted soils
Source: Denneman and Robberse 1990; Ministry of Housing, Netherlands 1994
***Source: WHO (1996)

Appendix Table 2. Permissible limit of heavy metals in agricultural soil.

Heavy metals (mg kg^{-1})	Indian standards (Awasthi, 1998)	European union standards (EU, 2002)
Cr	-	150
Mn	-	-
Cu	135-270	140
Zn	300-600	300
Ni	75-150	75
Cd	3-6	3
Pb	250-500	300

Source: https://doi.org/10.3389/fenvs.2017.00064

Appendix Table 3: RECOMMENDED MAXIMUM CONCENTRATIONS OF TRACE ELEMENTS IN IRRIGATION WATER[1]

Element	Recommended Maximum Concentration[2] (mg/l)	Remarks
Al(aluminium)	5.0	Can cause non-productivity in acid soils (pH < 5.5), but more alkaline soils at pH > 7.0 will precipitate the ion and eliminate any toxicity.
As (arsenic)	0.10	Toxicity to plants varies widely, ranging from 12 mg/l for Sudan grass to less than 0.05 mg/l for rice.
Be (beryllium)	0.10	Toxicity to plants varies widely, ranging from 5 mg/l for kale to 0.5 mg/l for bush beans.
Cd (cadmium)	0.01	Toxic to beans, beets and turnips at concentrations as low as 0.1 mg/l in nutrient solutions. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Co (cobalt)	0.05	Toxic to tomato plants at 0.1 mg/l in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Cr (chromium)	0.10	Not generally recognized as an essential growth element. Con-servative limits recommended due to lack of knowledge on its toxicity to plants.
Cu (copper)	0.20	Toxic to a number of plants at 0.1 to 1.0 mg/l in nutrient solutions.
F (fluoride)	1.0	Inactivated by neutral and alkaline soils.
Fe (iron)	5.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Overhead sprinkling may result in unsightly deposits on plants, equipment and buildings.
Li (lithium)	2.5	Tolerated by most crops up to 5 mg/l; mobile in soil. Toxic to citrus at low concentrations (<0.075 mg/l). Acts similarly to boron.
Mn (manganese)	0.20	Toxic to a number of crops at a few-tenths to a few mg/l, but usually only in acid soils.
Mo (molybdenum)	0.01	Not toxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high concentrations of available molybdenum.
Ni (nickel)	0.20	Toxic to a number of plants at 0.5 mg/l to 1.0 mg/l; reduced toxicity at neutral or alkaline pH.
Pd (lead)	5.0	Can inhibit plant cell growth at very high concentrations.
Se (selenium)	0.02	Toxic to plants at concentrations as low as 0.025 mg/l and toxic to livestock if forage is grown in soils with relatively high levels of added selenium. An essential element to animals but in very low concentrations.
Sn (tin)		
Ti (titanium)	----	Effectively excluded by plants; specific tolerance unknown.
W (tungsten)		

V (vanadium)	0.10	Toxic to many plants at relatively low concentrations.
Zn (zinc)	2.0	Toxic to many plants at widely varying concentrations; reduced toxicity at pH > 6.0 and in fine textured or organic soils.

[1] Adapted from National Academy of Sciences (1972) and Pratt (1972).

[2] The maximum concentration is based on a water application rate which is consistent with goodirrigation practices (10 000 m^3 per hectare per year). If the water application rate greatly exceeds this, the maximum concentrations should be adjusted downward accordingly. No adjustment should be made for application rates less than 10 000 m^3 per hectare per year. The values given are for water used on a continuous basis at one site.

Source : Food and Agricultural Organization (FAO) standard [1985]

Appendix Table 4: Effect of textile waste water on plant height at different growth stages of rice

Treatment	EST	MTS	PIS	Mat.
T1	35.2	75.3	110	112.2
T2	45.9	90.1	130.3	134.1
T3	40.5	79.3	115.9	117.6
T4	43.7	88.9	122.8	124.2
T5	42.2	85.5	120.1	123.4
T6	37.9	82.5	117.7	121.9

Appendix Table 5: Effect of textile waste water on tiller number of rice plant at different growth stage

treatment	ETS	MTS	PIS	Mat.
T1	217	509	371	271
T2	234	612	463	344
T3	222	546	421	304
T4	226	585	454	342
T5	225	568	439	324
T6	223	557	427	312

Appendix Table 6: Effect of textile waste water on straw and grain yield of rice

Yield (t/ha)	T1	T2	T3	T4	T5	T6
Straw	3.47	6.94	3.57	6.02	6.05	4.39
Grain	1.9	4.25	2.42	3.97	3.71	2.55