SEASONAL VARIATION AND INTERRELATIONSHIP OF PHYTOPLANKTON AND *VIBRIO CHOLERAE* IN BANGLADESH

Ph. D. Thesis

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DECLARATION

I do hereby declare that this thesis entitled **"Seasonal variation and interrelationship of phytoplankton and *Vibrio cholerae* in Bangladesh"** has been composed by myself and all the research works presented herein are my own. I do further declare that this work has not been submitted anywhere for any academic degree.

November, 2015 **(Nasima Islam)**

CERTIFICATE

This is to certify that the research work presented in this thesis entitled **"Seasonal variation and interrelationship of phytoplankton and *Vibrio cholerae* in Bangladesh"** was carried out by **Nasima Islam** bearing Registration No. 172/2010-11 under our supervision. It is further certified that the work presented here is original and suitable for submission as a Doctor of philosophy (Ph.D.) thesis.

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Author

Dedicated to

My Parents,

Husband

and

Children

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LIST OF ABBREVIATION

am	Ante-meridiem
chl. *a*	Chlorophyll *a*
ºC	Degree centigrade
E	East
EDTA	Ethylenediaminetetraacetic acid
FAO	Food and Agriculture Organization
Fig.	Figure
Figs	Figures
ft.	Feet
GBM	Ganga-Brahmaputra-Meghna
GF/C	Glass microfiber filter per circles
HBCC	Helber Bacteria Counting Cell
ICDDR, B	International Center for Diarrhoeal Disease Rerearch, Bangladesh
ind/l	Individual per litre
IPCC	Intergovernmental Pannel on Climate Change
km	Kilometer
l	Litre
m	Meter
meq/l	Milleequivalent per litre
mg	Milligram
mg/l	Milligram per litre
µg /l	Microgram per litre
µl	Micro litre
ml	Milli litre
N	North
NGO	Non-government organization
NN	Nitrate-nitrogen
NS	Not sampled
OTS	One time sampling
pH	Negative logarithm of hydrogen ion concentration
pm	Post-meridiem
RDA	Redundancy analysis

SD	Standard deviation
SLR	Sea level rise
SPSS	Statistical programme for social sciences
SST	Sea surface temperature
Stn.	Station
TDS	Total dissolved solids
THC	Thana health complex
UNEP	United Nations Environmental Programme

ABSTRACT

A total of 17 water variables were studied of the two distinct different geographical areas in Bangladesh for two years (October 2010-September 2012). Out of the two study sites, Mathbaria represents estuarine cholera epidemic pattern whereas Chhatak represents inland epidemic pattern for *Vibrio cholerae*. In Mathbaria there are four infested stations among eight stations and in Chhatak site there are two infested stations among seven stations. After analyzing the studied variables, it is observed that in Mathbaria site *Vibrio cholerae* showed a single peak during summer in the month of March through May. Whereas in Chhatak sites cholera peak showed a single peak during autumn in the month of early November i.e. just after the monsoon which contain warm, humid temperature. Stations of Mathbaria showed high level of total dissolved solids (TDS) and salinity while the stations of Chhatak showed higher range in the concentration of soluble reactive phosphorus (SRP), soluble reactive silicate (SRS), nitrate nitrogen (NN), chlorophyll *a*, phaeopigment (PP), phytoplankton and zooplankton densities. Higher ranges of SRP and NO_3-N were found in the infested stations of both the study sites. Maximum cell density of *Vibrio cholerae* at Mathbaria was nearly 500-fold more than Chhatak site. Dominant Phytoplankton in the infested stations of both the study sites belonged to euglenoid and diatoms. During cholera peak of Mathbaria, peak of water temperature, alkalinity, salinity, pH, total dissolved solids (TDS) and phaeopigment also showed the same peak during summer. On the other hand, infested stations of Chhatak showed peak of soluble reactive phosphorus (SRP), nitrate nitrogen (NN) and phaeopigment during autumn season when *Vibrio cholerae* also showed peak.

Pearsons correlation (SPSS v11.5) analysis among the studied variables reveals a significant negative correlation between phytoplankton density and water temperature. In this analysis on one hand significant positive correlation was observed between the phytoplankton and total zooplankton densities. On the other hand, a significant positive correlation between the concentration of phaeopigment and *V. cholerae* in Mathbaria Station 2, 7 and 10 and in the Station 2 of Chhatak was observed. Phaeopigment (phaeophytin *a*, cholorophyllide *a* and two unidentified pigments) is a degraded product of chl *a*, dominant pigment of phytoplankton. In the analysis, significant positive correlation was also observed between phytoplankton density and total zooplankton. Grazing by copepod (zooplankton) is the major reason for the degradation of chlorophyll *a* to phaeopigment. So, it can be said that, phytoplankton enhances the growth of zooplankton since peak growth of both phyto- and zooplankton is nearly overlapping or occurs side by side. After the peaks achieved, the plankton population start declining during which a lot of phaeopigment is released in the habitat. Under this enriched conditions of phaeopigment in the habitat, peaks of *V. cholerae* are mostly observed. To support the strong relationships among the studied environmental and biological variables and sampling periods RDA (Canoco v4.54) is also applied. Results by this multivariate program also support the similar relationship.

Chapter-1

Introduction

And

Aims and Objectives

INTRODUCTION

The impacts of global warming and climate change are worldwide. It influences the Earth's surface temperature, as well as the amount, timing and intensity of precipitation, including storms and droughts. An increasing frequency and severity of droughts and floods is leading to malnutrition and water-borne diseases, threatening human health and destroying livelihoods. In developing countries, an increase in droughts may lead, by 2080, to a decrease of 11 per cent in land suitable for rain-fed agriculture (FAO 2005). For Bangladesh, they are most critical because of the geographic location and geomorphological conditions of Bangladesh have made the country one of the most vulnerable ones to climate change, particularly to sea level rise (SLR). Bangladesh lies between 20°34' N and 26°348' N and 88°01' E and 92°41' E. The tropic of cancer passes through the central part of the country. Straddling the tropic of cancer, Bangladesh has a sub tropical monsoon climate characterized by heavy seasonal rainfall, high temperatures and high humidity. The low-lying country, Bangladesh is vulnerable to flooding and cyclones and stands to be badly affected by any rises in sea levels. It is situated at the interface of two different environments, with the Bay of Bengal to the south and the Himalayas to the north. This peculiar geography of Bangladesh causes not only life-giving monsoons but also catastrophic ravages of natural disasters (Ali A. 1999).

Bangladesh is one of the world's most densely populated developing country, with its people crammed into a delta of rivers that empties into the Bay of Bengal. Because of its location just south of the foot hills of the Himalayas, monsoon winds turn west and north-west. As a result the regions in northeastern Bangladesh receives the greatest average precipitation. Most of the part of Bangladesh are less than 12 m (39.4 ft.) above the sea level. With such low elevations and numerous rivers, water and concomitant flooding is a predominant physical feature. Eelevations decrease in the coastal south, where the terrain is generally at sea level. About 10,000 square kilometers of the total area of Bangladesh is covered with water, and larger areas are routinely flooded during the monsoon season. Warm, intense episodes of precipitation falling on coastal and nearby inland regions transforms the temperature and salinity profiles of estuaries. These changes create favorable growth conditions for the dormant bacterium, and also, most importantly, for phytoplankton species (IPCC 2007).

Increase of temperature is an effect of global warming. Global warming and an increasing number of natural disasters can contribute to an outbreak or occurrence of cholera in new places or to the new serotype of the causative agent (Koelle *et al*. 2005). The disease cholera caused by infection of the intestine with toxigenic *Vibrio cholerae* has a historical context linking it to specific season and bio-geographical zones (Lipp *et al.* 2002). Most severe epidemic limited to a few countries namely Bangladesh, India, countries in Africa and coastal Latin America. This bacterium is a natural inhabitant in the riverine, estuarine and coastal water throughout temperate and tropical regions of the world (Colwell 1996). Historically, there have been seven acknowledged cholera pandemics (Mutreja *et al.* 2011). The first cholera pandemic occurred in the Bengal region of India starting in 1817 through 1824 along the coastal region near the mouth of the Ganges River. Cholera spread rapidly throughout the world after the 1817 epidemic. The pattern and magnitude of the seven global pandemics suggest that cholera outbreaks primarily originate in coastal regions and then spread inland through secondary means (Jutla *et al.* 2010).

Cholera outbreaks in the Bengal Delta region are propagated from the coastal to the inland areas and from spring to fall by two distinctly different transmission cycles, pre-monsoon and post-monsoon, influenced by coastal and terrestrial hydroclimatic processes, respectively (Akanda *et al.* 2011). In Bangladesh, there is a bimodal distribution in the frequency of cholera cases over an annual cycle. The highest peak observed during the post-monsoon (September to January) and second smaller peak during summer (March to May) i.e. in the pre-monsoon (Samadi *et al.* 1993). In addition to the unique dual-incidence pattern observed in some regions of the Bengal Delta (Akanda *et al.* 2009), such as Dhaka and Matlab, single annual peaks observed in coastal (spring peak in Mathbaria) and inland (fall peak in Chhatak) areas. In this outbreak pattern, the first cholera peak of the year occurs during the dry season in spring, and the second, and usually bigger, peak occurs in fall following the wet season.

Cholera incidence data in Bangladesh shows a coastal endemic pattern in the spring (pre-monsoon) while a post-monsoon outbreak pattern in fall is usually observed further inland (Sack *et al.* 2003). The spring peak is linked to the severity of drought and the fall peak is limited to the severity of flooding (Islam *et al.* 2006, Jutla *et al.* 2009ab). During drought condition when contaminant may become concentrated in available water can promote the growth of cholera vibrios by increasing salinity in local water (Lipp *et al.* 2002). On the other hand, wide spread monsoon flooding in Ganga- Brahmaputra-Meghna (GBM) basin region and cross contamination of water resources with bacteria already present in the ecosystem is primarily responsible for autumn outbreak (Akanda *et al*. 2009). The seasonal trend of cholera incidence is strongly related with environmental and climatic factors (Colwell 1996, Patz *et al.* 2005). The driving forces and mechanism of seasonal changes are acknowledged to be related to variation in physical, chemical and biotic environment and to the many possibilities brought about by their mutual interaction which together effect differential specific growth and less rate among the algae.

Cholera is an acute waterborne diarrheal disease caused by most two toxigenic lethal strains of the bacterium *Vibrio cholerae*, O1 and O139 among 16 strains. The presence of *V. cholerae* 0139 has been confirmed since 1992 in the country. The epidemic was first noticed in the southwestern coastal part of Bangladesh and from there, the epidemic moved very first to the northern part of the country (Colwell 1996). In Bangladesh, due to salinity and scarcity of pure drinking water, people use pond, canal and river water for domestic and drinking purposes inviting many water borne infectious diseases such as cholera, diarrhea that occur endemically in many areas every year.

Cholera, which has been established as a seasonal disease, is climate-driven and the cholera bacterium, *V. cholerae* is an autochthonous flora of the surface water ecosystem (Islam *et al*. 1994 ab, Islam *et al*. 1993). In natural surface water, *V. cholerae* shares niche with many aquatic flora and fauna that directly or indirectly contribute to the aquatic life cycle of the bacterium. For many years, the role of chitin-rich copepods, a group of zooplankton, and *Anabaena* sp., a phytoplankton, have been well-documented as reservoirs for *V. cholerae*. Since cholera is a seasonal disease, and since the epidemics occur during the seasonal plankton bloom in pond and river systems, there has been a logical link of the regional climate that presumably play a triggering role. The planktonic flora were shown to be very rich in some estuarine ponds of Bangladesh (Khondker *et al*. 2006ab, 2007ab, 2008abc).

Plankton are those organisms which are drifted rather passively in the water and are incapable of maintaining a certain position within their habitat against water movement, such as current and eddies (Reynolds 1984). Of all the communities of organisms on earth, the plankton community covers the maximum area of water body and is variable with season and space. The plankton community is comprised of the primary producers *i.e*., phytoplankton and secondary producers *i.e*., zooplankton (Battish 1992). The phytoplankton (microscopic drifting plant, mostly algae of natural water) population represents the biological wealth of a water body, constituting a vital link in the food chain (Boyd 1982, Hossain *et al.* 2007). The communities of phytoplankton (composed of both eukaryotic and prokaryotic species**)** in lakes, rivers and ponds are represented by the species of different micro-algal groups.

Variation in phytoplankton community composition depends on the availability of nutrients, temperature, light intensity and on other limnological factors. Normally phytoplankton follows a fairly recognizable annual cycle of growth, but sometimes the synchrony in their normal annual cycle is disrupted by explosive growth of some species (Vaulot 2001). Some of the unique feature of phytoplankton are their population turnover on a much shorter time rate and bursts of growth (bloom) being of only a few weeks. Phytoplankton produces bloom mostly in the epilimnion region of most surface waters. The entire plankton community can be regarded as complex machinery which derives its energy mainly from radiant flux of the sun and its raw material from mineral salts and dissolved nutrients in the water, the producers (phytoplankton) synthesize their plant biomass by the process of photosynthesis and designated as producers form the first trophic level. Zooplankton form an intermediate step in grazing food chain in aquatic bio-loop and an ecosystem (Rao 1993).

Epstein (1993) reported that cholera epidemics have been associated with the seasonality of coastal algal blooms of Bangladesh. Also, nitrates and phosphates in sewage and fertilizers cause eutrophication. Sunlight, pH, temperature and nutrient availability interact to affect the populations and physiological state, virulence and survival of *V. cholerae* in the environment. It is hypothesized that the algae and *Vibrio* sp. population grew exponentially; consumed by fish, mollusks and crustacean, a heavy inoculums of carriers with *V. cholerae* was generated and transported into multiple coastal communities (Epstein 1993). Bacteria can provide the algae with CO_2, vitamins, growth factors, and buffering capacity. Algae can supply bacteria with oxygen and extracellular products that can serve as organic substrates for growth.

Plankton play a vital role in facilitating the survival growth and transmission of *V. cholerae* in the natural aquatic environment. Phytoplankton serves as the primary food source for copepods and other zooplankton also release nutrients into the water through disintegration. The bacteria then proliferate taking advantage of the nutrition condition of the aquatic system (Lipp *et al*. 2000). Increase of phytoplankton has been associated with increased presence of copepods (Reidi *et al*. 2005). In an endemic area like the Gangetic Delta region copepods favour survival of *V. cholerae* because of organism production of chitinase and ability to use chitin as a source of nutrients (Huq *et al*. 1999). There is likely a synergistic effect between phytoplankton and zooplankton in the colonization of chitin by *V. cholerae* (Huq *et al*. 1994). In the ecosystem, zooplankton is dependent on phytoplankton. Thus, the role of phytoplankton in the pelagic food web of ponds seems to be imperative in the natural seasonal cycles of *V. cholerae*. The present research proposal has been aimed to identify the interrelationships of phytoplankton and *V. cholerae* in some clolera prone stations of Bangladesh.

Aims and objectives of the work

The present investigation has been carried out to achieve the following objectives.

General objectives of the research work

- To study the selected physico-chemical water parameters such as depth, temperature, alkalinity, salinity, pH, TDS, soluble reactive phosphorous (SRP), soluble reactive silicate (SRS) and nitrate nitrogen (NO_3-N).
- To identify the niche characteristics of the population of phytoplankton.
- To find the composition of phytoplankton community in different ponds.
- To find the seasonality of phytoplankton biomass as chlorophyll-*a* and phaeopigment.
- To study the relationship between the species composition of phytoplankton and zooplankton.
- To study the relationship between the standing crop and biomass of phytoplankton with that of zooplankton.
- To study the relationship between the standing crop and biomass of phytoplankton with that of *Vibrio cholerae*.
- Determination of phytoplankton quality, population density and grouping of different dominant groups of phytoplankton via microscopic measurements.

Specific objectives of the research work

Identifying logical links of the regional climatic and water related variables with *V. cholerae* via pelagic grazing and consumer food chain of the aquatic habitats that serve as niche for cholera bacteria.

Chapter-2

Literature Review

LITRRATURE REVIEW

Bishagratna (1963) reported that in 1854, Filippo Pacini (1812-1883) an anatomist from Italy was first isolated Comma bacillius *Vibrio cholerae* as the cause of cholera followed by a similar discovery by Robert Koch (1843-1910), the German bacteriologist in 1884. Later on, Bentivoblio and Pacini (1995) reported that John Snow, a British physician, first discovered that cholera spread through contaminated water. Ever since, cholera has been a subject of intense interest for a range of microbiological and epidemiological studies. Pollitzer (1959) reported that cholera is a dreadful diarrheal disease frame time immemorial. But, the species *V. cholerae* comprises both pathogenic and nonpathogenic strains. *Vibrio cholerae* O1 and O139 are the only serotypes responsible for the disease defined clinically and epidemiologically as cholera. Koelle *et al*. (2005) reported that a new serogroup (O139 Bengal) caused epidemic cholera for the first time in history in 1992 in areas surrounding the Bay of Bengal.

In 1960 Cockburn and Cassanos reported cholera seasons in Bangladesh and occurs during the plankton bloom form the aquatic environment. They proposed the theory that ponds of Bangladesh were the main source of infection to the community. It was thus proposed that if the pH in pond were sufficiently elevated, *V. cholerae* could not compete after bacteria and reach infectious dose levels. Experimentally they showed a relationship between elevated pH and onset of cholera cases. On the other hand, Sakazaka and Shimada (1977) reported that *V. cholerae* are the normal inhabitants of aquatic environment. Nevertheless, according to a number of scientists (Martin *et al.* 1969, Mc Cormack *et al*. 1969, Merson *et al.* 1980, Glass *et al*. 1982, Samadi *et al*. 1983 and Islam *et al*. 1983, 1994bc) cholera is an endemic disease in Bangladesh and has regular seasonal pattern of epidemic.

Nalin (1976) reported that in an epidemic area like the Ganges river delta, copepods favor survival at *V. cholerae* because of organism production of chitin’s and ability to use chitin as a source of nutrient. Islam *et al.* (1989) studied that the *V. cholerae* has been found in association with a wide range of aquatic life including cyanobacteria *Anabaena variabilis* Kutz. ex Born. Islam *et al.* (1992) suggested that *V. Cholerae* can survive an inter-epidemic period and colonize the surfaces of algae, phytoplankton and water hyacinth. Epstein (1993) reported that Cholera bacteria attach to zooplanktons by forming a thin pathogenic biofilm.

Particularly for Bangladesh, Rashid (1991) reported 4 seasonal distribution in Bangladesh, i.e. summer (March - May), monsoon (June - early October), autumn (late October

- November) and winter (late November - February). Regarding the seasonality Colwell and Spira (1992) suggested that the seasonality of cholera in Bengal may be explained by primary transmission controlled by environmental factors such as temperature, salinity, nutrient concentration, and Zooplankton bloom, as well as by seasonal variation in seafood harvesting and consumption and in direct water contact. According to Dillard (1989), *V. cholerae* significantly affect nutrient cyling in the marine and estuarine aquatic habitat and often compare a major portion of the natural flora.

Hardy (1993) reported that historically "cholera has been remembered as the disease which made the 19th century its own" and continued into the 20th century, until the present time. The brief historical features of seven major pandemics of cholera that took place during the 19th and 20th centuries (which mostly originated from India). The first pandemic (1817-1821) known as 'Asiatic cholera' began in Jessore near Calcutta and then appeared throughout India before spreading into the Far East and other regions of the world, including Muscat, Tehran and Baghdad. The second pandemic (1829-1851) again started in India and then spread into China, Europe and America. The third pandemic (1852-1860) mainly occurred in Russia with a high mortality rate. The fourth pandemic (1863-1875) began in the Bengal region. Indian Muslim pilgrims visiting Mecca spread this pandemic throughout the Middle East. The fifth pandemic (1881-1896) began in India and reached Europe. Germany, however, was among the countries which were hardly affected. The sixth pandemic (1899-1923) took place at the turn of the 20th century and killed over 800,000 people in India alone and subsequently spread into the Middle East, Eastern Europe and northern Africa. The seventh pandemic (1961-1970s) started in Indonesia and extended to India, Russia and North Africa. In this pandemic the responsible organism was an El Tor biotype of cholera. Collins (2003) reported that the global awareness of cholera began in 1817 with the explosive epidemics breaking out in the lower Ganges River delta and spreading to the entire world in the form of pandemic.

Alam *et al*. (2006) studied an ecological survey of *V. cholerae* in the coastal ecosystems of the Bay of Bengal provided firm evidence that *V. cholerae* O1 cells are present during epidemics in samples collected from water bodies serving as drinking water sources for two rural areas of Bangladesh. The molecular detection of toxigenic *V. cholerae* between 2004 and 2007 showed the presence of *V. cholerae* in Bakerganj between April and June and between August and December. During this study, *V. cholerae* was not detected in water samples during the winter months or during the peak monsoon months. For Mathbaria, *V. cholerae* was present in water samples mainly between March and June and sporadically in the fall. These preliminary results thus strengthen the hypothesis of a contrasted seasonality of the presence of toxigenic *V. cholerae* in the environment and its potential link with the cholera incidence pattern in these areas. Further reports on autecology of *V. cholerae* reveals unique features. Huq *et al*. (1984) reported that 15% salinity, 30°C water temperature and pH 8.5 supported increased attachment and multiplication of *V. cholerae* on copepods. According to Epstein (1963), cholera epidemic had been associated with the seasonality of coastal algal bloom of Bangladesh. Different environmental factors such as sunlight, pH, temperature and nutrient availability interact to effect the population and physiological state, virulence (degree of pathogenicity) and survival of the organism in the aquatic environment. Chitin's and mucinase facilitate the attachment of *V. chloerae* to aquatic organisms, while algal surface film enhance the growth of the pathogen (Epstein *et al.* 1993). Colwell and Huq (2001) reported that Cholera bacteria attach themselves to the zooplankton, more specifically to crustacean copepods, to form a thin pathogenic biofilm, which provides protection from the external environment.

Siddique *et al*. (1994) first suggested plausible pathways of the progression of cholera outbreaks from the coastal regions of Bangladesh to inland areas of the country during major epidemics. It was supported by Lipp *et al.* 2002. Huq and Colwell (1996) presented three case studies to explain qualitatively the plausible mechanisms of transmission of the disease from coastal regions to inland. In Sub-Saharan Africa, initial cholera outbreaks were concentrated along coastal regions before spreading to other parts of the continent. In 1991, over five hundred thousand people were affected by cholera in 20 Latin American countries, with over 5000 deaths. The initial outbreak of this explosive transmission of cholera was identified to be in a coastal village near Lima, Peru. Similarly, December 1992 cholera outbreak originated in coastal Bangladesh that affected over 47 thousand people and killed 846. It was further studied that many of the microbiological and epidemiological studies have primarily focused on the annual and local scale variations of cholera with different ecological and climatic variables. Despite wide advances in the ecological and biological understanding of the cholera bacteria over the last half-century, our understanding of the influence of large scale climatic and geophysical processes on the global transmission of cholera remains limited (Huq and Colwell 1996). Huq and Colwell (1996) suggested that remote sensing can be a helpful tool for tracking cholera outbreaks using ocean chlorophyll signatures.

Ahmed and Alam (1998) studied the temperature trends for the daily maximum series and the daily minimum series on annual and seasonal basis and have shown that the overall temperature regime in Bangladesh is showing a rising trend. Therefore, the ultimate effect of climate change would be more floods and more water borne disease like cholera. Mouriño-Pérez (1998) reported that the role of sea surface temperature (SST) in creating and sustaining favorable environmental conditions for oceanic phytoplankton production is well documented. Garcia and Carr (1999) reported that a closer look at cholera outbreaks and relevant oceanic and terrestrial variables, shows a lack of understanding of the seasonal and interannual variability and the processes governing cholera transmission. For example, cholera incidence data from Bangladesh shows bi-annual peaks while coastal phytoplankton primarily shows a single peak. Bouma and Pascual (2001) reported that the coastal regions of South Asia, for example, have a long history of cholera incidence and are collectively considered the native homeland of the cholera disease since the early 19th century. Bouma and Pascual (2001) reported that land locked regions such as inland districts of the Ganges-Brahmaputra-Meghna (GBM) basin and the East African lake region show epidemic cholera outbreaks in post-flood situation or after extreme precipitation events.

Reidl and Klose (2002) reported that phytoplankton serves as the primary food source for copepods and other zooplankton, also releases nutrients into the water through disintegration. The bacteria then proliferate taking advantage of the nutrition conditions of the aquatic system. Phytoplankton and zooplankton, therefore, play vital role in facilitating the survival, growth, and transmission of *V. cholerae* in the natural aquatic environment. The quality aspects of phytoplankton fro the ponds and rivers in cholera prone areas Mathbaria and Bakerganj, Bangladesh were worked out by Khondker *et al.* 2006ab, 2007ab, 2008 abc).

Longini *et al*. (2002) reported that the epidemic outbreaks have been linked to a range of environmental and climate variables, such as, precipitation. According to Lipp *et al*. (2002) reported that increase in phytoplankton has been associated with increased presence of copepods. However, specific to Bangladesh, Sack *et al*. (2003) showed that areas closer to the coast such as Bakerganj and Matlab experienced recurrent spring cholera outbreaks. The primary outbreaks of cholera in most regions thus show a strong link with the coastal areas, implying a role of the near shore marine environment.

Gleick (2008) reported that the disease cholera remains a public health threat in many regions of the world, specifically in coastal areas of South Asia, Africa, and Latin America. Pascaul *et al*. (2002) reported significant seasonal patterns in cholera incidence with a primary outbreak occurring in the coastal districts. The historic cholera mortality rates in coastal region show significant correlation between sea surface temperature (SST) and spring cholera deaths in the coastal districts. Uz and Yoder (2004) analysed that chlorophyll signatures for the coastal

Bay of Bengal region resemble white noise for a range of pixel sizes (10-100 km); the signal exhibits a lag one autocorrelation value of 0.20 with no apparent temporal structure. Arker *et al*. (2005) stated that chlorophyll production in the coastal areas with freshwater discharge may be controlled by the river discharge. Fisman (2007) reported that issues of seasonality and prediction lead time for cholera are particularly important for the endemic areas of the Bengal Delta where cholera exhibits two peaks per year. Emch *et al*. (2008) reported a two-month lag between plankton blooms and cholera outbreaks in Bangladesh by using satellite chlorophyll measurements and suggested the role of chlorophyll as a key variable to understand cholera dynamics. Jutla *et al*. (2009a) studied that coastal chlorophyll production is driven by upwelling and shows inverse association with SST. In Mozambique, there is strong evidence that coastal chlorophyll intrusion leads to cholera outbreaks (Jutla *et al*. 2009b), a phenomenon similar to observed processes in the Bay of Bengal (BOB) region. These results suggest that it may be feasible to develop predictive models of cholera using large scale oceanic and hydroclimatic signatures using remotely sensed observations. Jutla *et al*. (2009b) concluded that chlorophyll variations on a daily scale, irrespective of spatial averaging, thus may not be useful for understanding chlorophyll-cholera relationships. On the other hand, chlorophyll variations on monthly scales show distinct seasonality in coastal Bay of Bengal with highest chlorophyll levels observed in September and lowest levels in February. Jutla *et al*. (2010) also studied that the life cycle of *V. cholerae* is intricately linked to both micro-environmental and macro-environmental processes, with vastly different space and time scales of interacting variables.

Akanda *et al*. (2009) provided a preliminary explanation of the dual nature of the outbreaks through two distinctly different large scale hydroclimatic drivers. According to that study, intrusion of plankton and bacteria rich coastal water during the spring dry season is the primary mechanism of *V. cholerae* contamination of estuarine rivers and coastal cholera outbreaks; on the other hand, widespread monsoon flooding in the Ganga Brahmaputra Meghna (GBM) Basin region and cross-contamination of water resources with bacteria already present in the ecosystem is primarily responsible for autumn outbreaks. Lower discharge volumes during the dry season (from January through April) and associated saltwater and plankton intrusion may initiate early cholera outbreaks in the GBM basin (Akanda *et al*. 2009). On the other hand, as streamflow direction is predominantly southward in regional rivers during and after the wet season (from June through November). A tentative explanation of the roles of river discharge and coastal plankton intrusion on the dual peak cholera incidence pattern seen in GBM region. Cholera outbreaks in spring (March-April-May) show strong negative correlation with dry season (February-March) river discharge ($r = -0.65$; $p<0.05$), i.e., bigger spring cholera peaks are typically seen in water scarce years (Akanda *et al*. 2009).

Akanda *et al*. (2011) investigated the seasonal nature of cholera cases in four locations of Bangladesh. These four locations are distinctly different in their geographical and meteorological settings, as well as in their seasonal outbreak patterns. Dhaka is a freshwater ecosystem in central Bangladesh, surrounded by several distributaries of the GBM rivers. Mathbaria is a coastal area located in estuarine southwestern Bangladesh, close to the BOB coast. Mathbaria is not typically affected by floods; however, it is prone to freshwater scarcity during the dry spring months because of the reduced amount of streamflow from upstream regions. Chhatak is located in northeastern Bangladesh and is the farthest away from the coast among the four locations; it is, however, prone to rainfall-driven flash floods in the Meghna basin region. Matlab is a well-reported cholera-endemic area frequented by floods, located near the confluence of the three major rivers of the region. However, Matlab is less than 150 km from the BOB coast and thus belongs to the coastal floodplains in our classification. They find that coastal hydroclimatic processes primarily modulate the first outbreak season in spring, whereas inland processes exhibit a strong influence on the second cycle of outbreaks. Mathbaria (data period: 2003-2007), a coastal location close to the BOB, shows cholera outbreaks only during the spring season. On the other hand, Chhatak (1997-2001), which is an inland location that is the farthest away from the coast, shows outbreaks only during fall months. Dhaka (1980-2007) and Matlab (1998-2007), located in the floodplains of the GBM rivers, appear to be affected by both waves of outbreaks. Thus, the two transmission cycles show distinctive seasonal and spatial signatures with respect to their coastal or terrestrial origins. Freshwater scarcity in upstream rivers and resulting saltwater and plankton intrusion as well as the environmental changes during and following the first peak may have an influence on the cholera outbreaks in subsequent seasons of the year. Their study also reported that a coastal reservoir of the bacteria in southern Bangladesh, aided by fall and winter plankton abundance, plays a strong role in cholera outbreaks in the following year. Monsoon rainfall in the region also shows a consistently positive, albeit weaker, relationship with summer and fall cholera prevalence (Akanda *et al*. 2011).

The above review highlights the history, occurrence, geographical distribution, pattern of epidemics and the role of *Vibrio cholerae* in the aquatic ecosystems. Since *Vibrio cholerae* is aquatic and depends upon the energy driven processes occurring the aquatic ecosystems. Therefore, its interrelationships with pelagic primary producers should come forward.

Chapter-3

Materials and Methods

MATERIALS AND METHODS

The present research work was carried out in 15 aquatic ecosystems from two distinct cholera affected areas in Bangladesh namely, Mathbaria and Chhatak. A total of 680 samples were collected from the two study sites (Upazila Mathbaria and Chhatak) in between October 2010 and September 2012. Each sampling event in either of the two study area was termed as a round. During the whole study period there were 52 rounds of sampling in Mathbaria and 45 rounds of sampling in Chhatak. To monitor the physical, chemical and biological variables, samples were collected 2-5 times per month from the selected water bodies.

Study areas

Mathbaria

Upazila Mathbaria of Pirojpur district is a hyper endemic area of cholera, located about 307 km south of Dhaka metropolis and 83 km away from divisional town Barisal. The river Baleshawar flows along the western boundary of this area and it is the lower part of the gangetic delta region adjacent to the Bay of Bengal. Total area of Mathbaria is about 353.25 km^2.

Chhatak

Upazilla Chhatak of Sunamganj district is located about 378 km North-east of Dhaka Metropolis and 47 km away from divisional town Sylhet. The river Surma flows along this area and it is the floodplain of the river Brahmaputra.

Geomorphological and meteorological condition of the sampling area

Mathbaria

The sampling area of Mathbaria lies in the delta formed by the Meghna and Ganges river. The latitude and longitude of this area is 22° 9' 44'' N to 22° 23' 46'' N and 89° 49' 32'' E to 90° 1' 22'' E, respectively. The climate is subtropical and the tropic of cancer passed through the area. Its altitude is 1 m above mean sea level. Rainfall is high during June to August and low from September to February.

Chhatak

The sampling area of Chhatak lies in the flood plain area of river Brahmaputra. Its geographic situation is 25° 1' 60'' N and 91° 40' 0'' E. Its altitude is 6 m above mean sea level. Chhatak is within the monsoon climatic zone and rainfall is high during July to September and low from November to February.

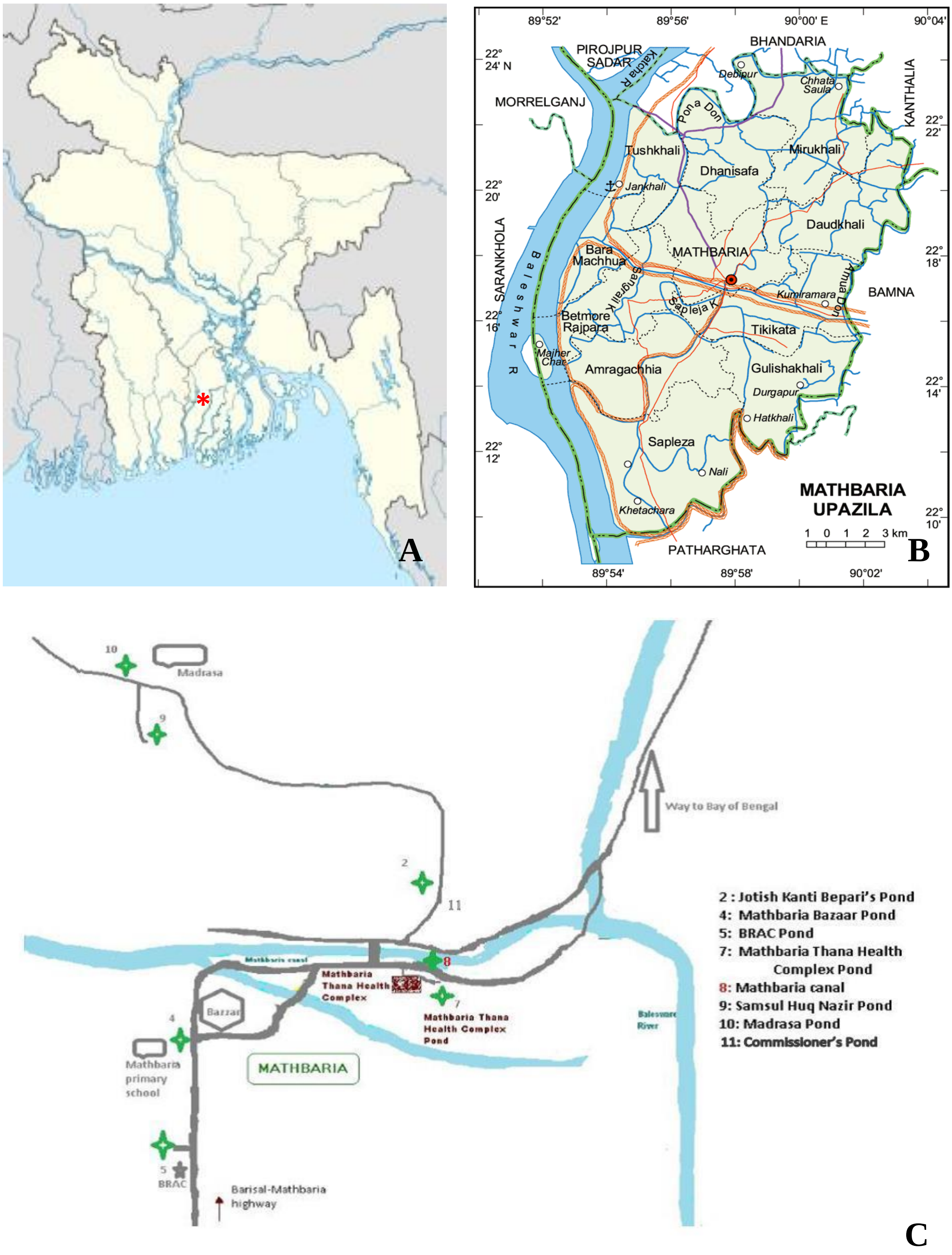
Name and location of the sampling stations

Mathbaria and Chhatak

Eight aquatic habitats including 1 canal and 7 ponds were randomly selected in Mathbaria hence forth abbreviated as Station 2, Station 4, Station 5, Station 7, Station 8 (canal), Station 9, Station 10 and Station 11. In Chhatak, there are altogether 7 stations including 2 river Ghat of Surma and 5 ponds hence forth abbreviated as Station 1, Station 2 (upstream river ghat), Station 4, Station 9, Station 10 (downstream river ghat), Station 11 and Station 12. The name of the studied aquatic ecosystems has been furnished in Table 1. There exits no chronology in the number of ponds, because they were chosen appropriate for the present study and therefore selected from a group of habitats by the ICDDR, B.

Table 1. Showing the number and name of the studied stations.

Mathbaria		Chhatak	
Station number	Name	Station number	Name
2	Jotish Kanti Bepari's Pond	1	Govt. Pond Near to the THC
4	Mathbaria Bazar Pond	2	Surma River Ghat 1
5	BRAC Pond	4	Bagbari Govt. Primary School Pond
7	Mathbaria THC Pond	9	Shamsu Commissioner's Pond
8	Mathbaria Canal	10	Surma River Ghat 2 (Opposite to Lafarge Cement Factory)
9	Samsul Haq Nazir's Pond	11	Mondolibhog Girls High School Pond
10	Madrasha Pond	12	Sarderbari Abdul Khalek's Pond
11	Commissioner's Pond		



Figs 1A-C. A, Showing the map of Bangladesh with the study sties of Mathbaria. B, Mathbaria Upozilla. C, location map of the sampling stations of Mathbaria.

Figs 2A-C. Images of the studied stations of Mathbaria. A, Station 2; B, Station 4; C, Station 5; D, Station 7.

Figs 3A-D. Images of the studied stations of Mathbaria. A, Station 8; B, Station 9; C, Station 10 and D, Station 11.

Description of the stations of Mathbaria

Station 2 (Jotish Kanti Beparis' pond)

This is one the most important ponds which is situated in the village named Kachichira. It is a very small pond but historically never dried up due to a connection with canal. This pond is about 1 km away from Mathbaria Thana Health Complex (THC). People (women) use this pond water for washing their utensils regularly. About 200 - 250 people particularly children use this pond water for bathing regularly.

Station 4 (Mathbaria Bazaar pond)

It is located very near to the Mathbaria Bazaar under Mathbaria Municipality. The size of the pond is larger than the previous one (Station 2) and area about 2 ha. There are many hotels and restaurants near this pond and more than thousand people utilize this pond water for drinking and other daily uses.

Station 5 (BRAC pond)

It is located about 2 km away from Mathbaria Bazaar within the village named North Mithakhali. Its area is about 4.5 ha and is perennial. About 2-3 thousand people utilize this pond-water only for drinking where bathing is restricted. A filtration (sand filter) unit has been set by an NGO (Non-government organization). Most of the village people use this filtered water for drinking. However, other villagers use unfiltered water of the same pond for drinking purpose.

Mathbaria Station 7 (THC pond)

It is located just 46 m away from the Thana health complex. It is a medium sized (about 2 ha) pond and is perennial because of its connection to a canal leading to the river Baleshwar that flows across the Sunderbans and finally falls into the Bay of Bengal. A sand filtration unit has been set there and most of the people use filtered water for drinking. The staff members (doctors and nurses) of Mathbaria THC living in the government quarter use this water for their daily needs. Patients coming mostly with diarrhoea for the treatment in the hospitals also use this filtered water.

Station 8 (Canal)

This canal faces two times tidal flow daily and washes away nearby houses and fields. It is connected to the Baleshwar River that flows across the Sunderbans and finally falls into the

Bay of Bengal by crossing about 10 - 12 km lands and houses. The canal water has high salinity due to the direct connection to the Bay of Bengal. This site was selected to compare and find out any significant ecological differences among the ponds connected directly to this canal and frequently overflowed by its water.

Station 9 (Samsul Haq Nazir’s Pond)

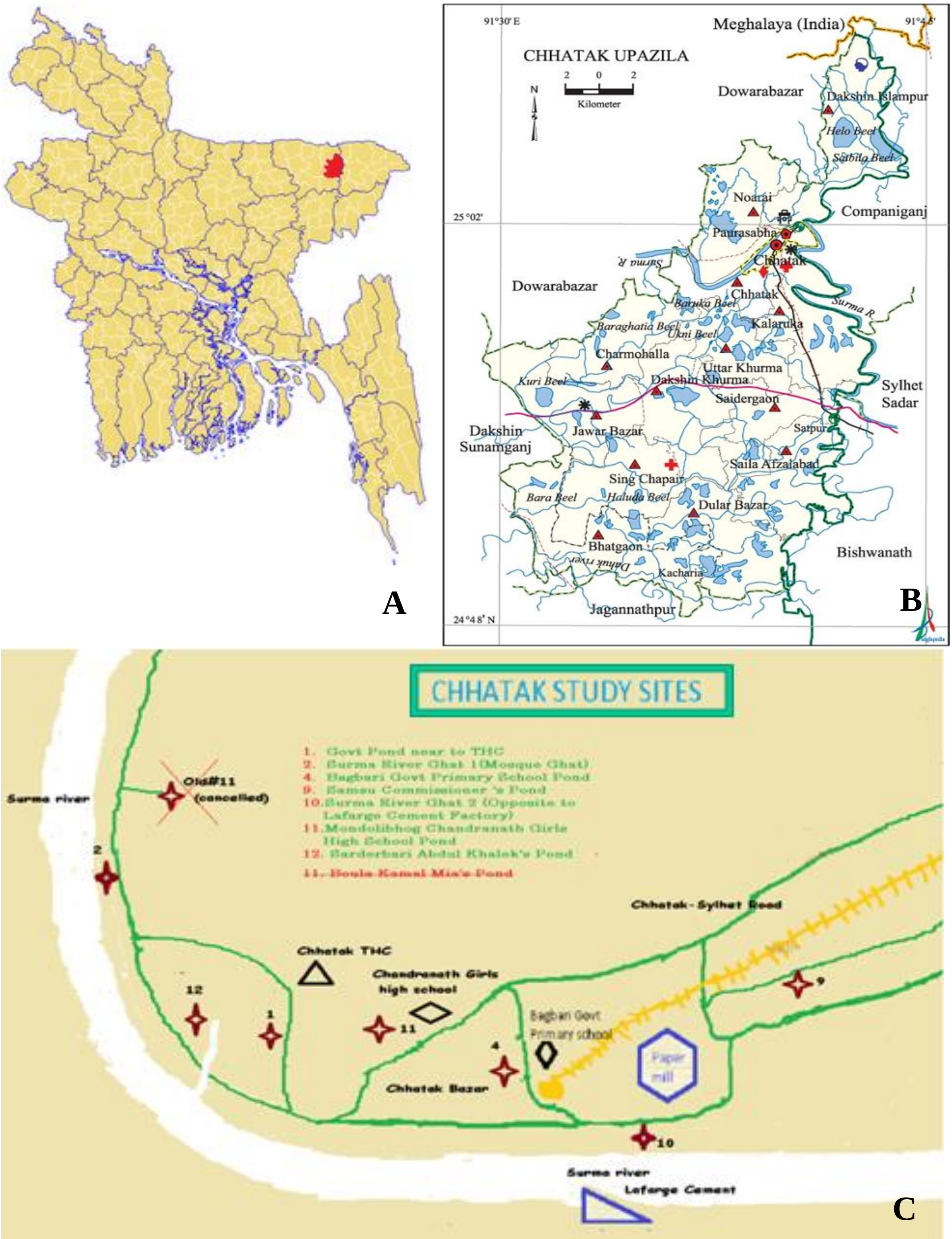
It is a domestic pond and is located in the village named Jariper Char which is about 4 km away from Mathbaria THC. This is a unique pond because it is surrounded by the trees. Tidal water logged across the gaps within the trees surrounding the pond. Strong tidal flow results water to enter into this pond and the pond never dries out. About 500-1000 people use its water for drinking and other household works.

Station 10 (Madrasha Pond)

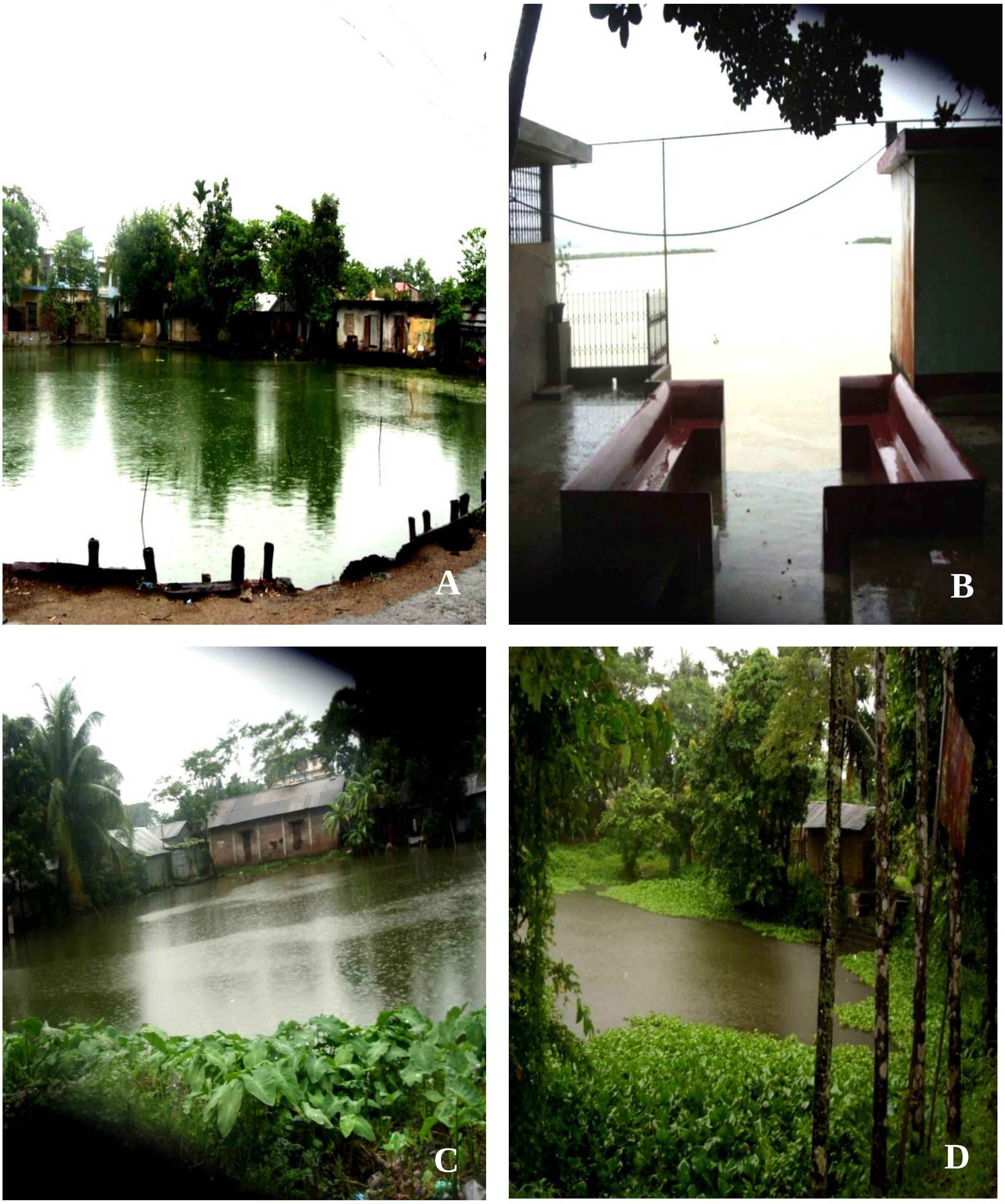
This pond is also within the village named Jariper Char which is about 50 m away from the Samsul Huq Nazir’s Pond. This pond is called “Madrasaha pond” as it is situated near a Madrasah (Islamic school). As the aquifer in this locality is salty, people use the water of this pond for their daily use. About 200-500 people (mostly students and teachers of the Madrasaha) use this water for drinking and other daily uses like ablution. The pond water is also used in the nearby village shops for daily use.

Station 11 (Commissioner’s pond)

It is situated in the village named Kachichira, as a result local people called it Kachichira pond. It is also well known as Commisionar’s pond in this village. It is never dries up due to a connection with canal. This pond is about 1 km away from Mathbaria THC. People (women) use this pond water for washing their utensils regularly. About 200-250 people particularly children use this pond water for bathing regularly.



Figs 4A-C. A, Showing the map of Bangladesh with study sties of Chhatak. B, Chhatak Upozilla. C, location map of the sampling stations of Chhatak.



Figs 5A-D. Images of the studied stations of Chhatak. A, Station 1; B, Station 2; C, Station 4 and D, Station 9.

Figs 6A-D. Images of the studied stations of Chhatak. A, Station 10; B, Station 11; C, Station 12.

Description of the stations of Chhatak

Station 1 (Government Pond Near to the THC)

Chhatak Station 1 is a rectangular pond with an area of approx. 0.30 ha and is located about 100 m away from the Chhatak THC. There are a number of houses surrounding this pond and most of the owners are slum dwellers and farmers. Peoples are extensively using this pond water for their household and bathing purposes.

Station 2 (Surma River Ghat 1)

This is a beautiful ghat near the Mosque situated in the village name Tatikona which is about 3 km away from Chhatak THC. About 500-1000 people uses this water for their daily purposes. People usually take bath and perform ablutions with this Ghat water before offering prayers. The site was selected because it is upstream of the River Surma.

Station 4 (Baghbari Govt. Primary School Pond)

This pond is situated at a village called Baghbari. It is a semi rectangular pond with an area of about 0.2 ha, and is about 2 km away from the THC. There are a number of farmers' houses and grocery shops in the vicinity of the pond. People were using this pond water for bathing, washing and other household work. Good evidence of plankton bloom was found in the pond water.

Station 9 (Shamsu Commissioner's Pond)

This pond is located in the village Bashkhola and named as Shamsu Miah pond with the name of Mr. Shamsu Miah, ward commissioner of the Local Government. It is an isolated pond and properly maintained from the extensive contamination by feces (as per comment by the owner of the pond). About 200-350 people use this pond water daily particularly for bathing and other household purposes. A pump connected to the pond supplies water for the daily house hold works of commissioner's house.

Station 10 (Surma River Ghat 2, opposite to Lafarge Cement Factory)

This study site is about 3 km away from Chhatak THC which is just opposite to Lafarge Cement Factory, Chhatak, Sunamganj. Ferry communication connects this Ghat to Lafarge Cement Factory. About 4000-5000 people have direct or indirect influence with this Ghat-water for their daily purposes. This station was chosen because it is situated in the downstream compared to the other Ghat (Surma River Ghat 1).

Station 11 (Mondolibhog Girls High School Pond)

It is located in the village named Modolibhog. It is a semi rectangular pond with an area of about 0.3 ha, and is about half a km away from the THC and is closer to the Surma River. A girl's high school is situated nearby this pond. More than thousand peoples use this pond-water for their daily needs i.e., washing utensils, bathing and other household works.

Station 12 (Sarderbari Abdul Khalek's Pond)

It is situated in a village called Charerban, located about half a km away from Chhatak THC. It's a very small pond and historically perennial. Villagers frequently affected by diarrheal diseases rush to the THC for treatment. Several hanging latrines were seen surrounding this pond, and is beset by poor sanitary conditions. High rainfalls cause fecal wastes to be washed out into this pond water. About 200-250 peoples particularly women use this pond water regularly. Children taking bath in this pond often suffer from diarrhea (2-3 times in a month) most probably by swallowing pond water.

In situ **sample collection**

The samples were collected in co-operation with the field study team of Laboratory Science Division of International Center for Diarrhoeal Research, Bangladesh (ICDDR, B), Mohakhali, Dhaka and some local people of Mathbaria and Chhatak. On the day of sampling, samples were collected in between 9:00 am and 12:00 noon. After collection, all the samples were preserved in an insulated Igloo box using cool packs and were transported to Dhaka for further analysis within next 12 h.

Collection of water and plankton samples

500 ml sample water from 10 cm depth were collected weekly before and during the cholera season and monthly for the rest of the years from each of the selected station of Mathbaria and Chhatak. For determining the niche characteristics *in situ* and the spot measurement of relevant physical and chemical parameters were carried out.

100 liter water from each station was passed through the plankton net having a mesh width of 64 µm (1^{st} plankton) by holding a 2^{nd} plankton net (pore diameter 20 µm) just below it. So that the released water from the first plankton net passing through it (i.e., 2^{nd} plankton net). All the zooplankton were collected in the first net and phytoplankton in the second net. Pre-washed and autoclaved dark polystyrene bottle was pushed down to 10 cm depth by hand

in an inverted position and thereafter the bottle was made straight to collect the sample water, while a 100 ml aliquot of from the 2nd plankton net was taken and preserved in glass vials containing 0.3 ml of Lugol's solution for quantitative and qualitative analysis of phytoplankton.

***In-situ* measurements**

At the time of sampling in each station water temperature, salinity, pH and TDS were measured routinely, using HACH sens ON 156 portable device. During the measurement the following probes were used:

Probe. 1

Parameters : pH

Calibration : 3pt. using oh 4.7 and 10

Calibration frequency : prior to each round

Storage electrode is stored in pH storage solution.

Probe. 3

Parameters : TDS, salinity, water temperature

Calibration : Using 1000 ms/cm standard

Calibration frequency : prior to each round

Salinity check : Using 1% NaCl sol^n

Water Depth is measured at a fixed point around the center of the pond using a rope tied with a weight at one end and measured by measuring tape.

Laboratory processing

Filtration and preservation

The collected samples were routinely delivered to the National Professor AKM Nurul Islam Laboratory, Department of Botany, University of Dhaka. As soon as the samples arrived, filtration of water sample for chemical analysis was carried out. A vacuum pump fitted to a Sartorius Membrane Filter Holder (Gmbh, Göttingen, FRG) was used for the purpose. The water sample was shaken gently and then 100-250 ml of water was measured with the help of a graduated measuring cylinder and poured into the cup of the Sartorius device. Whatman GF/C 4.7 cm circles were used with the device to filter the water. After filtration the filter paper was rolled up with the help of a Millipore pincet and put into a screw capped Pyrex glass tube of

10 ml capacity. This sample was used for the determination of phytoplankton biomass as chl. *a* and phaeopigment. The filtrate of each sample was transferred to acid washed clean screw capped polystyrene bottles (500 ml capacity) for the analyses of Nitrate-nitrogen, Soluble Reactive Phosphorus (SRP) and Soluble Reactive Silicate (SRS). Unfiltered water samples were used for measuring alkalinity. All analyses were completed within next 24 h.

Table 2. Methodology, equipment, units and relevant references for the measurement of various limnological parameters.

Parameter	Method	Unit	Equipment
Alkalinity	Mackereth *et al.* (1978)	meq/l	Jencons Digitrate, UK
PO_4-P	Murphey and Riley (1962)	µg/l	Spectrophotometer Shimadzu UV-0120-01, Japan
SiO_3^{2-}	Wetzel and Likens (1979)	mg/l	-ditto-
NO_3-N	Mueller and Wiedemann (1955)	µg/l	-ditto-
Chl *a*	Marker *et al.* (1980)	µg/l	-ditto-
Phaepigment	Marker *et al.* (1980)	µg/l	-ditto-
Phytoplankton density	Vollenweider (1969)	Individual/l	Nikon microscope, using Hawksleys counting chamber (Lansing, UK)
Imaging and dimension measuring	Photomicrographic		Nikon Optiphot UFX-IIA,FX-35A, Japan
Identification	Consulting European and American monographs and literatures on phytoplankton of Bangladesh		

A brief description of each measurements

Alkalinity

100 ml of unfiltered water sample was measured with the help of a measuring cylinder and then transferred to a conical flask (Jena Schott, Germany, 250 ml capacity). Then four drops of mixed indicator was added to the sample, the color turned light green. The flask was put on a magnetic stirrer device and was titrated by adding standardized 0.l N HCl from a Digititre (Jencons Digitrate, UK) until the color first disappeared to light yellow. With the help of the volume of acid consumed in the titration the alkalinity was calculated after Mackereth *et al*. (1978).

Soluble reactive phosphorous (SRP)

SRP determination has been followed after Murphy and Riley (1962). The dilution factor ranged from 2-10. Considering the dilution factor accurately measured sample was poured in acid washed 100 ml capacity Pyrex conical flasks. Then required amount of distilled water was added to each sample to make the volume 50 ml. 5 ml mixed reagent (a mixture of 30 ml ammonium molybdate, 75 ml H_2SO_4, 30 ml freshly prepared ascorbic acid and 15 ml potassium antimonyl tartarate) was dispensed in each flask. The solution of the flask was mixed properly and after 5-10 minutes blue color developed, then the extinctions were measured using 885 nm wavelengths with the help of 4 cm path length quartz cuvettes by using a Spectrophotometer (Shimadzu UV-0120-01, Japan).

Nitrate-nitrogen (NO_3-N)

The concentration of NO_3-N in the filtered sample water was determined following the method of Müller and Wiedemann (1955). To a 25 ml sample water in a 100 ml capacity Pyrex conical flask, 1 ml of 5% sodium salicylate was added and digested overnight to dryness in an oven (Eyela, Model- NDS-450D, Japan) set at 100°C temperature. In the next morning the residue in the flask was dissolved by adding 1 ml concentrated H_2SO_4 and then added 50 ml distilled water and 7 ml sodium-potassium-tartrate solution. Light yellow color developed according to the concentration of nitrate nitrogen present in the sample. The sample volume was adjusted to 100 ml by adding distilled water and then the sub-samples were measured in a Spectrophotometer (Shimadzu UV-0120-01, Japan) using 1 cm path length quartz glass cuvette at a wave length of 420 nm. A distilled water plus reagent blank and a series of NO_3-N standards were also treated in the same manner in each batch. The values of NO_3-N were calculated by regression analysis later on with the help of the standard series.

Soluble reactive silicate (SRS)

The determination of soluble reactive silicate was followed after Wetzel and Likens (1979). The dilution factor ranged from 2-5. Considering the dilution factor accurately measured sample was poured in acid washed pyrex conical flasks of 100 ml capacity each used to determine SRS. Sequentially 5 ml 0.25N HCl, 5 ml of 5% ammonium molybdate and 5 ml 1% disodium EDTA was added to it. The sample was mixed properly and kept undisturbed for next five minutes. Then 10 ml of 17% sodium sulfite was added to each flask. Blue color developed according to the concentration of SRS in the sample. A reagent blank and standard series of silica was also treated in the same manner. Sub-samples from each of these were measured in a Schimadzu spectrophotometer (UV-120-02, Japan) at a wave length of 700 nm using 1 cm path length quartz glass cuvette. Finally, the values were calculated by regression analysis with the help of the standard series.

Biological parameters

Chlorophyll *a* (chl. *a*) and phaeopigment

Pigment extraction was done from the fresh cells of phytoplankton trapped onto the filter paper during filtration of water collected from the pelagic zone of each sampling station. The method of extraction was as follows: test tube containing rolled filter paper was treated with 5 ml hot 90% ethanol (kept boiling at 75°C in a water bath, model Eyela, Thermopet NTT-211, Japan). Then the test tube containing filter paper dipped in to ethanol was given a hot and cold treatment by putting it firstly in the hot water bath for three minutes and then cooling in tap water carefully. After cooling, the pigment was extracted (1^{st}) and was transferred to another glass tube while the filter paper was given a second extraction treatment in the same manner as mentioned above. The extracted pigment solutions (1^{st} and 2^{nd}) were poured in a measuring cylinder to make it 10 ml by adding extra 90% alcohol if necessary. Then the pigment samples were taken in 1 cm path length quartz glass cuvette and optical density (OD) was measured in a spectrophotometer (Shimadzu UV-0120-01, Japan) at wave length 665 nm and 750 nm against 90% ethanol as blank. The acidification was done by adding in 3.7 µl HCl in each cuvette (for a volume of 3.7 ml). Finally, the concentration of chl. *a* and phaeopigment were calculated after Marker *et al*. (1980).

Enumeration of phytoplankton with the help of Helber Bacteria Counting Cell (HBCC)

Enumeration of phytoplankton was done under a compound microscope (Nikon SE) at a magnification of 10×40 with the help of Helber Bacteria Counting Cell (Single round, Hawksly, UK). Helber Bacteria Counting Cell is not commonly used for phytoplankton counting but it is mainly used for the counting of bacteria because it can be easily manipulated and it provides reasonably reproducible data at higher magnification which is not possible by Sedgewick Rafter Counting Cell (SRCC). The Helber Bacteria Counting Cell looks just like a glass slide and is 50 mm long, 20 mm wide and 1 mm thick. A microscopic circular counting chamber with engraved grids at the center of the slide surface. The total volume of the chamber is 1.005 µl. The counting was carried out by putting one drop of well mixed phytoplankton sample on the counting chamber (HBCC) and a coverslip was put on it. Before counting HBCC cell was let stand for at least 1 minute to settle down phytoplankton. Phytoplankton present in the bottom of the HBCC cell was then counted. All the cells present were counted and the dominant group was identified. The counting was done in triplicate for each sample. Finally, the cell density of the phytoplankton was calculated per liter water by using the following formula.

$$\text{Density/l} = [\text{units}/3.015\ \mu l \times \{(10000 \div 3.015) \times (50 \div 9.7)\} \div 100]$$

Where,

Units/3.015 µl	=	sum of the counts in triplicate of the phytoplankton individuals for each sample made by Hawkleys Counting Chamber, 3.015 µl= vol. of the Hawkleys Chamber (1.005) × 3 in µl.
10000	=	10 ml sub-sample of phytoplankton concentrate as obtained after passing of sample water through plankton net, in µl.
50	=	volume of phytoplankton concentrate, in ml obtained after filtering 100 liter of sample water through plankton net.
9.7	=	actual vol. of phytoplankton concentrate obtained as sub-sample fixed with 0.3 ml Lugul’s solution (9.7+ 0.3) finally making a volume of 10 ml as supplied to us for counting.
100	=	amount of sample water passed through plankton net in liter.

Qualitative analysis of phytoplankton

Before counting of the phytoplankton individual a random checking of the sedimented planktonic material was carried out under high magnification for identification up to species level. For identification, algal literatures as well as publications available for Bangladesh, other world monographs and books have been consulted (Smith 1950, Skuja 1956, Desikachary 1959, Starmach 1966, Islam and Begum 1970, Islam and Khondker 1981, Germain 1981, Prescott 1982, Huber-Pestalozzi 1955, 1961, 1968, 1983; Dillard 1989, Yamagishi 1998, Ling and Tyler 2000, Islam and Alfasane 2002, 2004; Siddiqui *et al*. 2007, Begum, 2008, 2009; Ahmed *et al*. 2008, 2009).

Enumeration of zooplankton with the help of Sedgewick Rafter counting chamber (data supplied by the ICDDR, B)

Before counting aliquots (10 ml) of the zooplankton, samples were fixed in buffered formalin. The zooplankton samples were enumerated by predominant type, using a Sedgewick Rafter counting chamber. From a 10-ml subsample, separately 3-ml subsamples (1 ml + 1 ml + 1 ml) were analyzed for a zooplankton count. Determination of zooplankton composition and density were measured by analyzing subsamples with a compound photomicroscope (Kruff MBL2100; Germany). Zooplankton taxa were identified to the lowest taxon, based on microscopic examination. When possible, organisms were identified to the species. For each sample, organisms were classified into four groups of abundance, based on enumeration of each subsamples, from most abundant (i.e., group 1) to least numerically abundant (i.e., group 4).

Plate count of *Vibrio cholerae* (data supplied by the ICDDR, B)

Using the whole water and plankton samples, three suitable dilutions from direct (100 µl) and dilutions (10^{-1} to 10^{-4}) are plated on site onto LB Agar. Plates are incubated immediately after reaching the laboratory for overnight at 37ºC. Appropriate plates are counted the next day.

Statistical analysis

Pearson correlation (SPSS v11.5) and RDA (Canoco v4.54) have been performed to observe the relationship among physical, chemical and biological parameters of the selected stations. Prior to apply RDA individual phytoplankton density and environmental data were transformed log(x+1) except for temperature and pH which were standardized.

Chapter-4
Results

RESULTS

Mathbaria sites

Physical parameters

Water depth (WD)

Range of water depth (WD) for the period between October 2010 and September 2012 were recorded 1.04-1.64 m for Station 2, 0.45-3.4 m for Station 4, 1.13-3.46 m for Station 5, 1.24-2.50 m for Station 7, 1.19-2.3 m for Station 9, 1.18-2.36 m for Station 10 and 1.69-2.88 m for Station 11. Highest monthly average of WD for Station 2 was recorded in the month of August whereas lowest in the month of March, for Station 4 highest WD was recorded in the month of September and lowest in the month of April, for Station 5 highest WD was recorded in the month of October and lowest in the month of April, for Station 7 highest WD was recorded in the month of June and lowest in the month of February, for Station 8 which is a canal, the highest WD was recorded 2.04 m. But it was not possible to record its WD regularly, for Station 9 highest WD was recorded in the month of August and lowest in the month of February and for Station 11 highest WD was recorded in the month of July and lowest in the month of May (Table 3). The seasonal variation of the water depth for all the stations of Mathbaria has been plotted in Fig.7.

The seasonal trend of highest to lowest water depth shows an order monsoon - autumn - summer in most of the study stations (Fig. 7). A two-year annual trend in the water depth for all the stations have been shown in Fig. 8. The trend in both the study years (2010-11 and 2011-12) were almost same except Station 4 (Fig. 8). In Station 4, the water depth for 2011-12 were recorded only from October - April because of after round 39 this station was not sampled due to some technical problem.

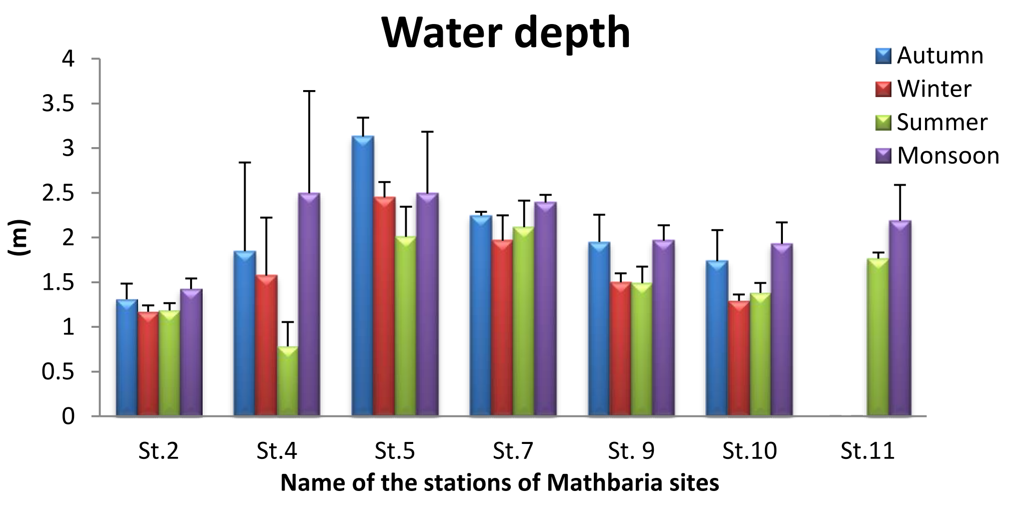


Fig. 7. Seasonal variation of water depth at different stations of Mathbaria during 2010-2012.

Table 3. Monthly mean of water depth (m) at different stations of Mathbaria.

Mathbaria		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	1.22	1.39	3.22	2.2	NM	1.62	1.66	NS
	Max.	1.57	3.46	3.35	2.3	NM	2.22	2.08	NS
	mean	1.35	2.43	3.29	2.26	NM	1.9	1.87	NS
	SD	0.19	1.46	0.07	0.05	NM	0.30	0.30	NS
Nov.	Min.	1.2	1.21	2.85	1.95	NM	1.76	1.39	NS
	Max.	1.21	1.45	3.1	2.25	NM	2.2	1.74	NS
	mean	1.21	1.33	2.98	2.12	NM	1.98	1.57	NS
	SD	0.01	0.17	0.18	0.13	NM	0.31	0.25	NS
Dec.	Min.	1.16	1.34	2.65	2.05	NM	1.59	1.3	NS
	Max.	1.35	2.76	2.7	2.29	NM	1.59	1.3	NS
	mean	1.26	2.05	2.68	2.17	NM	1.59	1.3	NS
	SD	0.13	1.00	0.04	0.17	NM	OTS	OTS	NS
Jan.	Min.	1.12	0.82	2.41	1.95	NM	1.57	1.18	NS
	Max.	1.18	2.41	2.7	2.13	NM	1.62	1.36	NS
	mean	1.15	1.74	2.55	2.06	NM	1.60	1.30	NS
	SD	0.03	0.82	0.15	0.10	NM	0.03	0.10	NS
Feb.	Min.	1.08	0.9	2.25	1.49	NM	1.34	1.22	NS
	Max.	1.23	1.89	2.42	2.26	NM	1.52	1.4	NS
	mean	1.15	1.34	2.32	1.85	NM	1.43	1.29	NS
	SD	0.05	0.43	0.07	0.33	NM	0.06	0.07	NS
Mar.	Min.	1.04	0.58	2.15	1.24	NM	1.25	1.24	NS
	Max.	1.19	1.34	2.5	2.34	NM	1.66	1.5	NS
	mean	1.14	0.96	2.31	1.91	NM	1.44	1.34	NS
	SD	0.05	0.32	0.12	0.42	NM	0.18	0.09	NS
Apr.	Min.	1.06	0.45	1.13	2.1	NM	1.19	1.2	1.69
	Max.	1.35	0.79	2.36	2.35	NM	1.72	1.62	1.92
	mean	1.18	0.62	1.87	2.23	NM	1.44	1.37	1.78
	SD	0.11	0.15	0.46	0.10	NM	0.21	0.15	0.12
May	Min.	1.16	0.6	1.68	1.62	NM	1.29	1.32	1.73
	Max.	1.29	0.7	2.12	2.35	NM	1.77	1.57	1.76
	Mean	1.23	0.66	1.879	2.20	NM	1.57	1.42	1.75
	SD	0.05	0.04	0.14	0.21	NM	0.17	0.08	0.01
Jun.	Min.	1.39	0.69	1.92	2.4	NM	1.68	1.65	2.13
	Max.	1.53	0.69	1.94	2.5	NM	2.16	1.79	2.13
	Mean	1.46	0.69	1.93	2.45	NM	1.92	1.72	2.13
	SD	0.10	OTS	0.01	0.07	NM	0.34	0.10	OTS
Jul.	Min.	1.26	1.52	1.46	2.26	NM	1.81	1.64	2.88
	Max.	1.34	1.52	2.34	2.36	NM	1.94	1.64	2.88
	Mean	1.3	1.52	1.9	2.31	NM	1.88	1.64	2.88
	SD	0.06	OTS	0.62	0.07	NM	0.09	OTS	OTS
Aug.	Min.	1.5	2.72	1.82	2.35	NM	1.95	2.05	1.91
	Max.	1.64	2.72	3.15	2.41	NM	2.3	2.36	1.91
	Mean	1.57	2.72	2.49	2.38	NM	2.13	2.21	1.91
	SD	0.10	OTS	0.94	0.04	NM	0.25	0.22	OTS
Sep.	Min.	1.42	3.15	2.25	2.34	NM	1.9	1.56	1.91
	Max.	1.47	3.44	3.46	2.5	NM	2.12	1.87	2.11
	Mean	1.45	3.30	2.87	2.42	NM	1.98	1.75	2.01
	SD	0.02	0.21	0.56	0.08	NM	0.10	0.14	0.14

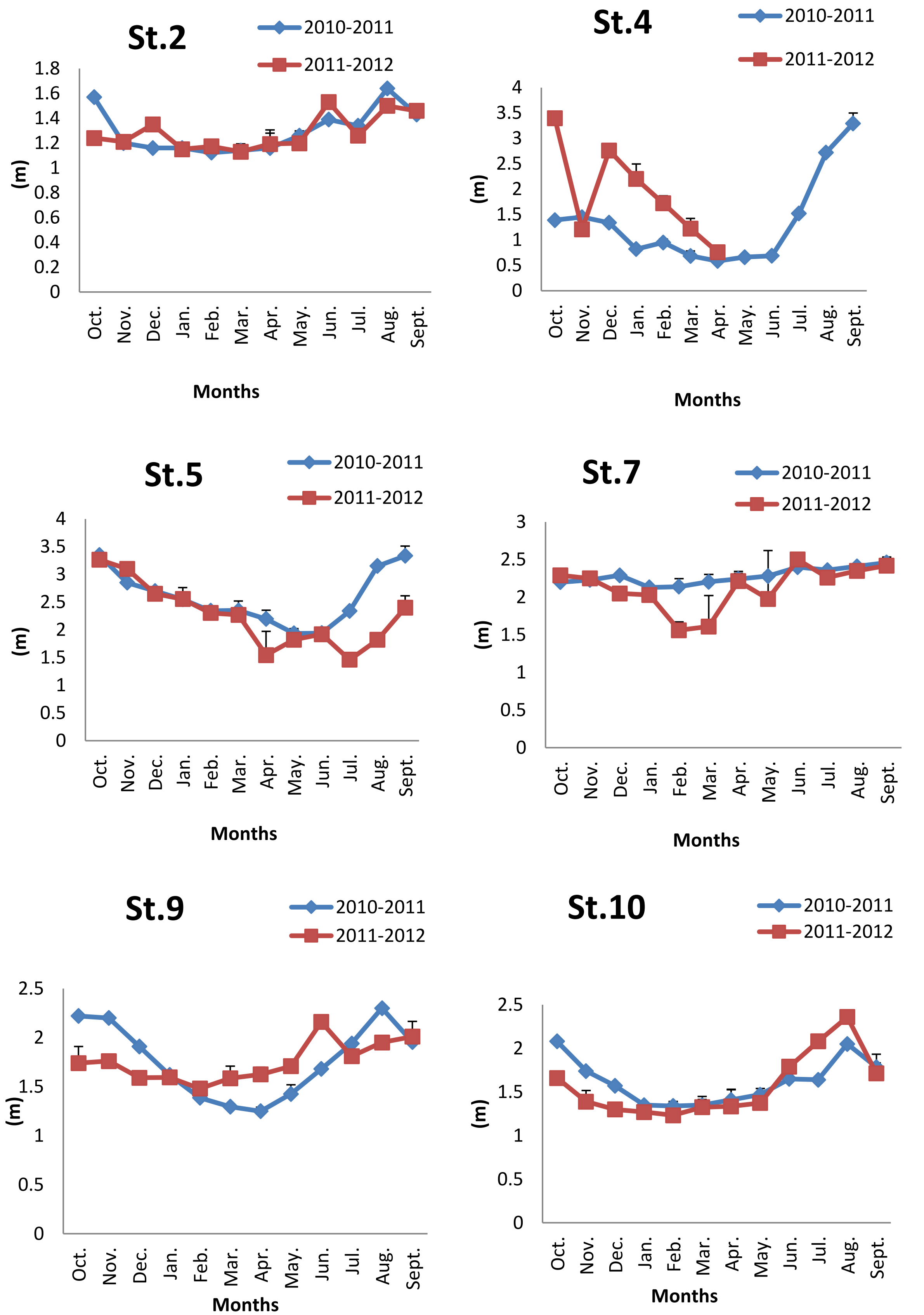


Fig. 8. Comparison of water depth between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 10) of Mathbaria.

Water temperature

Range of water temperature (WT) recorded for the period between October 2010 and September 2012 were 21.61-33.73ºC for Station 2, 22.88-35.03ºC for Station 4, 22.52-34.22ºC for Station 5, 21.95-33.65ºC for Station 7, 21.40-31.85ºC for Station 8, 21.10-32.17ºC for Station 9, 21.44-32.40ºC for Station 10 and 28.80-32.15ºC (April 2012-September 2012) for Station 11. The highest monthly average of WT for Station 2 was recorded in the month of May except Station 4 whereas lowest WT was observed in January for all the Station. In Station 4 highest WT was recorded in the month of July (Table 14).

In the present investigation the seasonal variation of WT showed highest value during summer and lowest in winter in all the Stations (Fig. 9). The highest to lowest WT seasonal trend followed summer-monsoon-autumn-winter (Fig. 9).

WT started increasing just after the month of January and continued until May and thereafter a fluctuating tendency was observed from the month of June to August. Again WT showed a peak in the month of October in all the Stations. WT started falling in November (Fig. 10). Fig. 10 shows a comparison of WT between the two study years i.e. 2010-11 and 2011-12. The annual trend fluctuating WT is almost same in both the study years.

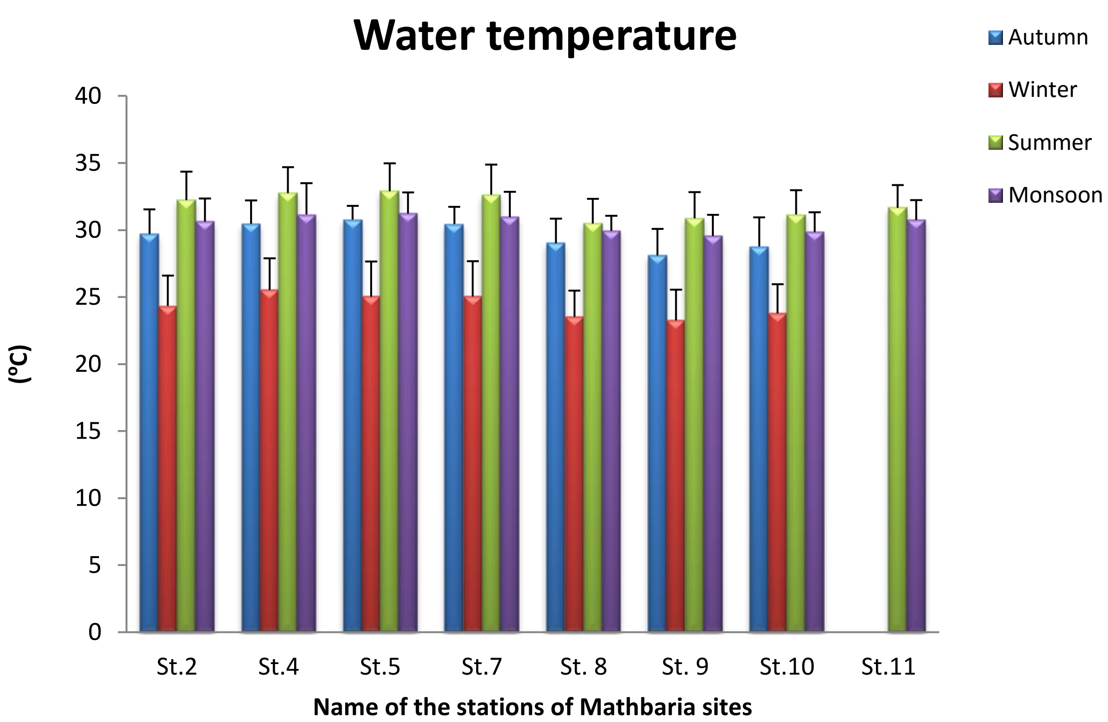


Fig. 9. Seasonal variation of water temperature at different stations of Mathbaria during 2010-2012.

Table 4. Monthly mean of water temperature (°C) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	29.35	30.7	31.15	30.65	30.5	28.6	29.55	NS
	Max.	33	32.13	32.07	33.77	31.67	31.23	31.87	NS
	mean	31.55	31.41	31.75	32.20	30.95	30.17	30.93	NS
	SD	1.93	1.01	0.53	1.56	0.63	1.39	1.22	NS
Nov.	Min.	28	28	29.93	22.03	27.1	26.2	26.35	NS
	Max.	29.2	31	29.95	29.63	27.8	26.93	27.8	NS
	mean	28.6	29.5	29.94	26.22	27.45	26.57	27.08	NS
	SD	0.84	2.12	0.01	3.32	0.49	0.52	1.03	NS
Dec.	Min.	23.35	25.65	24.5	24.5	23.55	23.97	24.67	NS
	Max.	25.13	26.87	27.3	26.27	24.73	23.97	24.67	NS
	mean	24.24	26.26	25.9	25.39	24.14	23.97	24.67	NS
	SD	1.25	0.86	1.98	1.25	0.83	OTS	OTS	NS
Jan.	Min.	19.4	20.85	19.8	19.95	19.1	18.7	19.7	NS
	Max.	23.37	25.1	25.17	23.87	23	23.47	23.1	NS
	mean	21.61	22.88	22.52	21.95	21.4	21.1	21.44	NS
	SD	2.02	2.13	2.69	1.96	2.04	2.39	1.70	NS
Feb.	Min.	24	24.17	22.45	23.8	22.2	21.1	22.03	NS
	Max.	27.15	28.4	28.67	29.03	26.33	26.4	26.55	NS
	mean	25.71	26.61	25.99	26.50	24.38	24.21	24.82	NS
	SD	1.26	1.84	2.22	1.85	1.46	1.80	1.62	NS
Mar.	Min.	28.8	29.97	28.75	29.63	26.15	26.83	26.93	NS
	Max.	32.03	32.27	32.55	33.3	30.63	31.5	31.5	NS
	mean	30.25	31.31	30.80	31.02	28.90	29.24	29.72	NS
	SD	1.33	0.80	1.24	1.25	1.46	1.50	1.53	NS
Apr.	Min.	29.1	31.2	30.9	30.33	28.03	27.3	28.07	27.97
	Max.	34.63	35.9	35.93	35.9	33.73	34.4	34.4	33.03
	mean	32.37	33.22	33.38	32.98	30.38	30.86	31.03	30.86
	SD	1.84	1.71	1.66	2.22	1.82	2.06	1.80	2.60
May	Min.	31.37	32.23	31.67	27.67	30.43	30.7	30.77	31.27
	Max.	36.5	36.37	36.6	35.87	33.3	34.17	34.17	33.4
	Mean	33.73	34.65	34.22	33.65	31.85	32.17	32.40	32.15
	SD	1.51	1.63	1.53	2.35	0.89	1.15	1.12	0.91
Jun.	Min.	28.77	29.1	29.8	28.8	29.27	28.13	28.33	28.8
	Max.	29.23	29.1	30.67	29.83	29.53	28.7	29.17	28.8
	Mean	29	29.1	30.24	29.32	29.4	28.42	28.75	28.8
	SD	0.33	OTS	0.62	0.73	0.18	0.40	0.59	OTS
Jul.	Min.	30.13	35.03	30.73	29.9	29.7	28.77	29.7	29.53
	Max.	32.53	35.03	33.7	32.43	30.9	32.1	32.03	29.53
	Mean	31.33	35.03	32.22	31.17	30.3	30.44	30.87	29.53
	SD	1.70	OTS	2.10	1.79	0.85	2.35	1.65	OTS
Aug.	Min.	27.83	28.63	28.47	28.3	27.7	27.4	27.43	32
	Max.	30.4	28.63	30.33	30.07	29.27	28.4	29	32
	Mean	29.12	28.63	29.4	29.19	28.49	27.9	28.22	32
	SD	1.82	OTS	1.32	1.25	1.11	0.71	1.11	OTS
Sep.	Min.	29.7	30.3	30.3	32.23	29.23	28.87	29.07	31.37
	Max.	32.8	31.7	33.2	33.37	31.43	31.93	31.5	32
	Mean	31.29	31	31.97	32.62	30.3	30.13	30.19	31.69
	SD	1.30	0.99	1.21	0.65	0.90	1.29	1.00	0.45

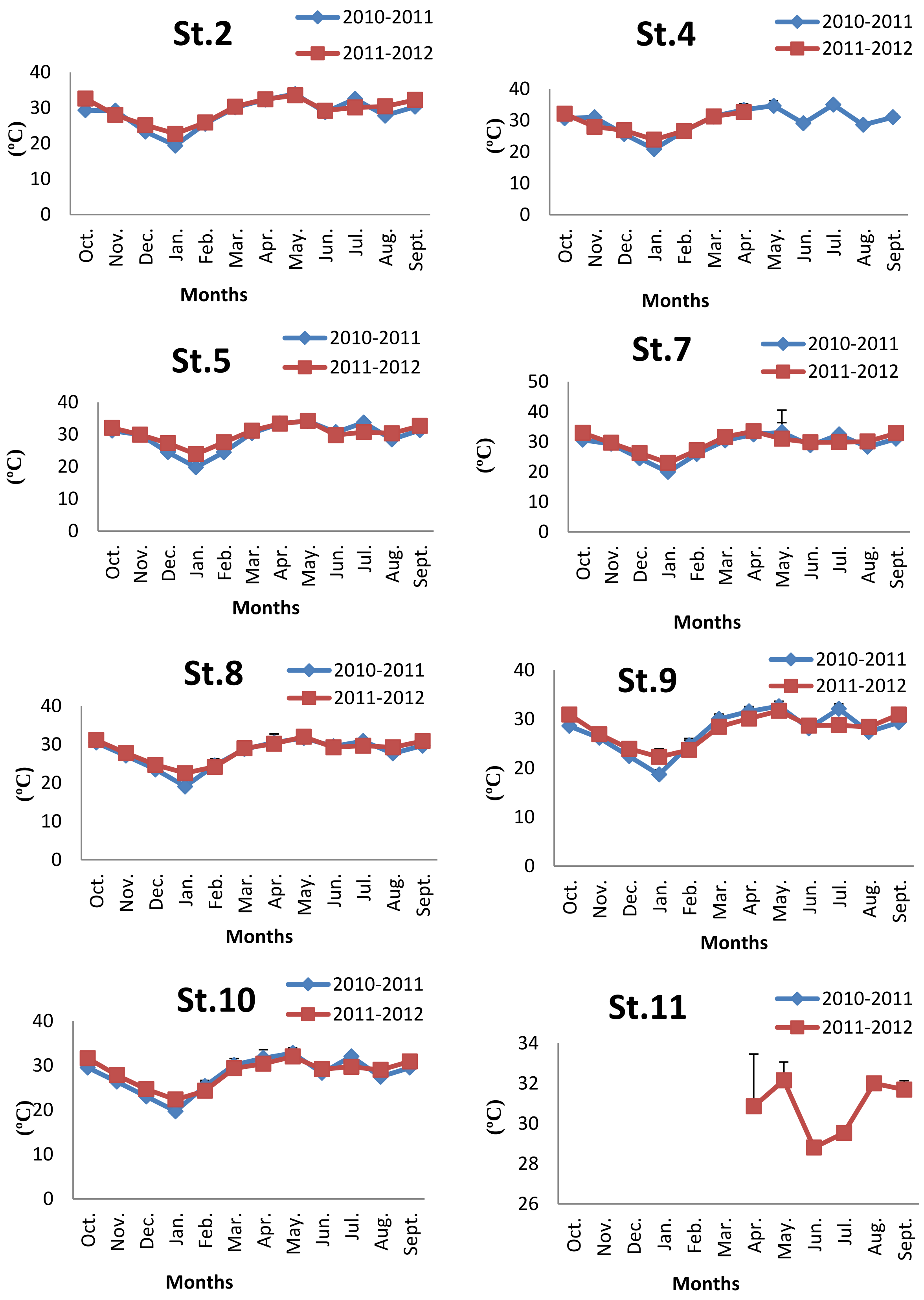


Fig. 10. Comparison of water temperature between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Chemical parameters

Alkalinity

Range of alkalinity for the period between October 2010 and September 2012 were recorded 2.20-3.99 meq/l for Station 2, 2.32-4.6 meq/l for Station 4, 0.8-1.95 meq/l for Station 5, 2.25-3.61 meq/l for Station 7, 1.85-3.67 meq/l for Station 8, 2.45-3.85 meq/l for Station 9, 2.55-4.22 meq/l for Station 10 and 2.0-3.8 meq/l for Station 11. The Highest monthly average of alkalinity for Station 2 was recorded in the month of March whereas lowest alkalinity in the month of July and August. For Station 4 highest alkalinity was recorded in the month of June and lowest in the month of April, for Station 5 highest alkalinity was recorded in the month of May and lowest in October. For Station 7 highest alkalinity was recorded in the month of March and lowest in the month of August. For Station 8 highest alkalinity was recorded in the month of May and lowest in the month of November. For Station 9 highest alkalinity was recorded in the month of May and lowest in November. For Station 10 highest alkalinity was recorded in the month of February and lowest in November and for Station 11 highest alkalinity was recorded in the month of April and lowest in the month of June. (Table 5).

In the present investigation the seasonal variation of alkalinity observed higher during summer and lower in autumn season in all the stations (Fig. 11). The highest to lowest seasonal trend of alkalinity followed summer - winter - monsoon - autumn (Fig. 11).

Alkalinity starts increasing just after the month of November and continues up to April except Station 9. Thereafter it follows a decreasing pattern from the month of May. Alkalinity shows increasing tendency from the month of September in all the stations (Fig. 12).

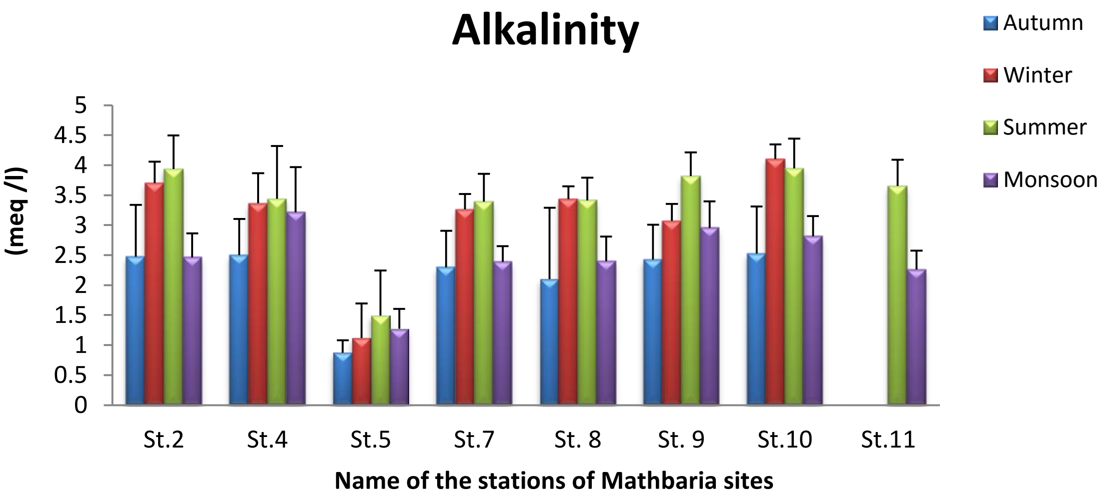


Fig. 11. Seasonal variation of alkalinity at different stations of Mathbaria during 2010-2012.

Table 5. Monthly mean of alkalinity (meq/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	1.5	1.9	0.7	1.6	0.6	2.1	1.9	NS
	Max.	3.2	3.2	1	2.7	3	2.8	3.2	NS
	mean	2.57	2.55	0.9	2.3	2.17	2.53	2.73	NS
	SD	0.93	0.92	0.173	0.61	1.36	0.38	0.72	NS
Nov.	Min.	2	2.1	0.7	2	1.7	1.8	1.8	NS
	Max.	3.2	3.2	1.1	3.3	3.2	3.1	3.3	NS
	mean	2.6	2.65	0.9	2.92	2.45	2.45	2.55	NS
	SD	0.85	0.78	0.28	0.54	1.06	0.92	1.06	NS
Dec.	Min.	3.2	2.5	0.8	2.6	3.1	3	3.8	NS
	Max.	3.3	3.3	0.8	3.2	3.5	3	3.8	NS
	mean	3.25	2.9	0.8	2.9	3.3	3	3.8	NS
	SD	0.07	0.57	0	0.42	0.28	OTS	OTS	NS
Jan.	Min.	3.5	3	0.7	3.2	3.5	2.5	3.8	NS
	Max.	4	3.5	2.8	3.3	3.8	3.2	4.1	NS
	mean	3.7	3.3	1.5	3.23	3.67	2.97	3.97	NS
	SD	0.26	0.26	1.14	0.06	0.15	0.40	0.15	NS
Feb.	Min.	3.5	2.7	0.9	3.3	3.2	2.8	4	NS
	Max.	4.4	4.1	1.1	3.6	3.5	3.4	4.6	NS
	mean	3.85	3.55	1.03	3.4	3.37	3.13	4.22	NS
	SD	0.35	0.53	0.08	0.13	0.14	0.27	0.24	NS
Mar.	Min.	3.7	3.5	0.8	3.4	3.2	3	3.3	NS
	Max.	4.3	4.9	1.4	3.9	3.8	4.7	4.9	NS
	mean	3.99	4.03	1.21	3.61	3.56	3.76	4.16	NS
	SD	0.22	0.54	0.22	0.18	0.19	0.58	0.61	NS
Apr.	Min.	3.3	3.1	1	3.2	3	3.3	3.6	3.4
	Max.	5	4.7	1.4	3.8	4.1	4.3	4.9	4.3
	mean	3.96	3.62	1.2	3.58	3.61	3.84	4.16	3.8
	SD	0.51	0.64	0.14	0.20	0.31	0.31	0.41	0.42
May.	Min.	3.2	2	1.2	1.5	2.3	3.5	3.3	3
	Max.	5.9	2.7	4.8	3.5	3.8	4.5	4	4
	Mean	3.88	2.32	1.95	3.07	3.13	3.85	3.6	3.54
	SD	0.79	0.26	1.07	0.59	0.38	0.30	0.22	0.46
Jun.	Min.	2.7	4.6	1.2	2.4	2.1	3.2	2.7	2
	Max.	2.9	4.6	1.9	3	2.3	4	3.4	2
	Mean	2.8	4.6	1.55	2.7	2.2	3.6	3.05	2
	SD	0.14	OTS	0.50	0.42	0.14	0.57	0.49	OTS
Jul.	Min.	2	3.4	1.2	2.2	2.2	3	2.6	2.1
	Max.	2.4	3.4	1.3	2.4	2.6	3.3	2.8	2.1
	Mean	2.2	3.4	1.25	2.3	2.4	3.15	2.7	2.1
	SD	0.28	OTS	0.07	0.14	0.28	0.21	0.14	OTS
Aug.	Min.	2	2.6	0.8	2.2	1.5	2.5	2.4	2.6
	Max.	2.4	2.6	1.4	2.3	2.2	2.6	2.8	2.6
	Mean	2.2	2.6	1.1	2.25	1.85	2.55	2.6	2.6
	SD	0.28	OTS	0.42	0.07	0.49	0.07	0.28	OTS
Sep.	Min.	2.1	2.6	1	2.2	2.4	2.4	2.4	2
	Max.	3.1	2.9	1.6	2.6	2.8	3	3.2	2.6
	Mean	2.43	2.75	1.3	2.37	2.63	2.78	2.78	2.3
	SD	0.46	0.21	0.35	0.21	0.17	0.26	0.35	0.42

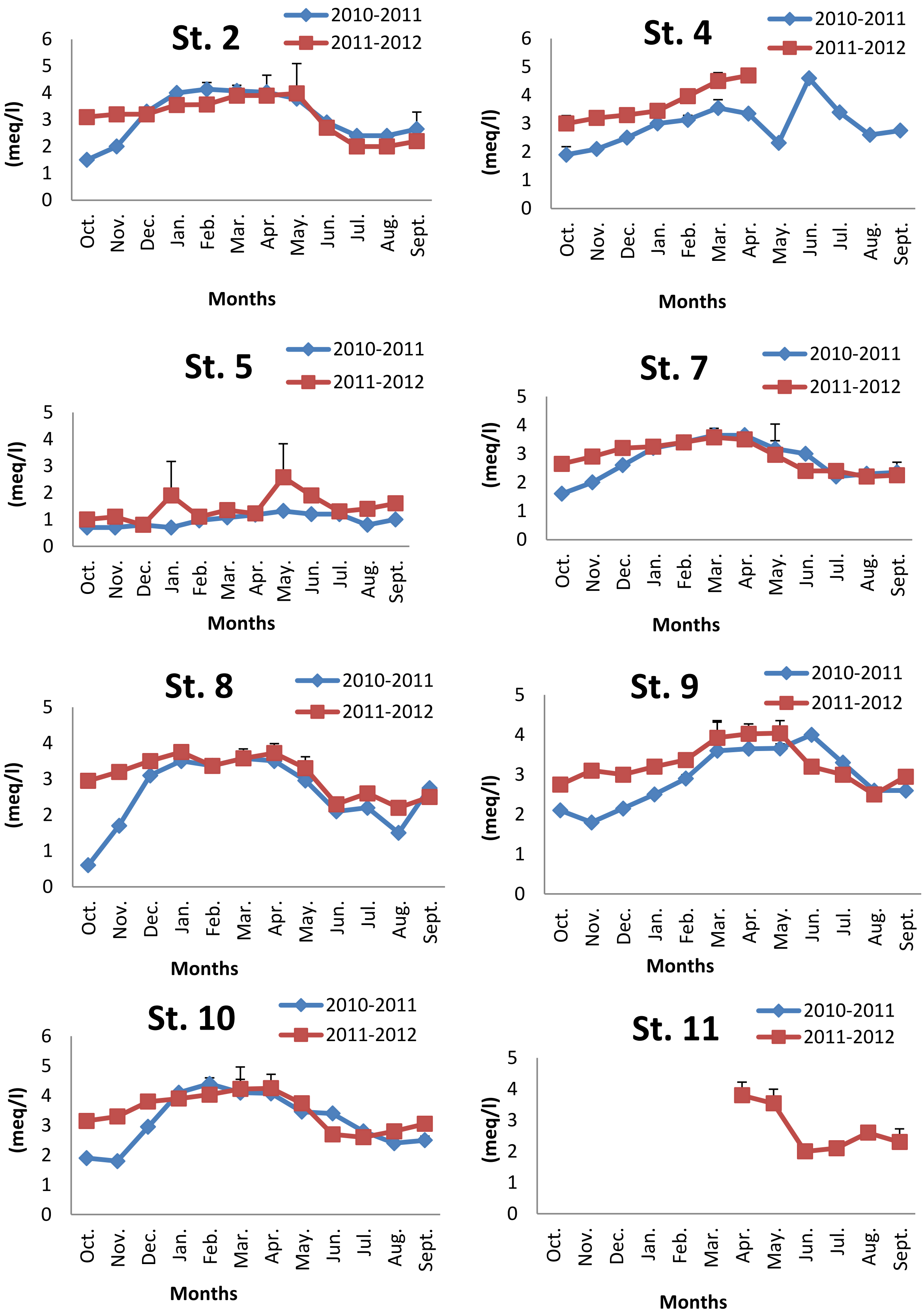


Fig. 12. Comparison of alkalinity between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Salinity

For the period between October 2010 and 2012 the salinity ranged from 0.1-1.14 ‰ for Station 2, 0.1-0.64 ‰ for Station 4, 0.1-1.04 ‰ for Station 7, 0.1-1.15 ‰ for Station 8, 0.1-0.7 ‰ for Station 9, 0.1-1.11 ‰ for Station 10 and 0.2-0.77 ‰ for Station 11. The highest monthly average of salinity was recorded in April in most of the stations except Station 4 and Station 9. In these stations, highest monthly average salinity was recorded in the month of May and June, respectively. Whereas in Station 5, monthly mean average of salinity condition was obtained almost closer to 0 during the study period. The lowest monthly average was recorded in November in most of the stations (Table 6).

The seasonal variation of salinity showed higher concentration during summer and lower in autumn season in all the stations (Fig. 13). The seasonal pattern followed an order of summer - winter - monsoon - autumn in most of the stations (Fig. 13).

The annual trend of variation of seasonality concentration for all the stations has been plotted in Fig. 14. The peak concentration of salinity occurred in most of the stations (i.e. 2, 4, 7, 8, 9 and 10) between April to June in both the study years (Fig. 14). However, Station 5 which is almost a freshwater habitat did not show any annual fluctuation of salinity.

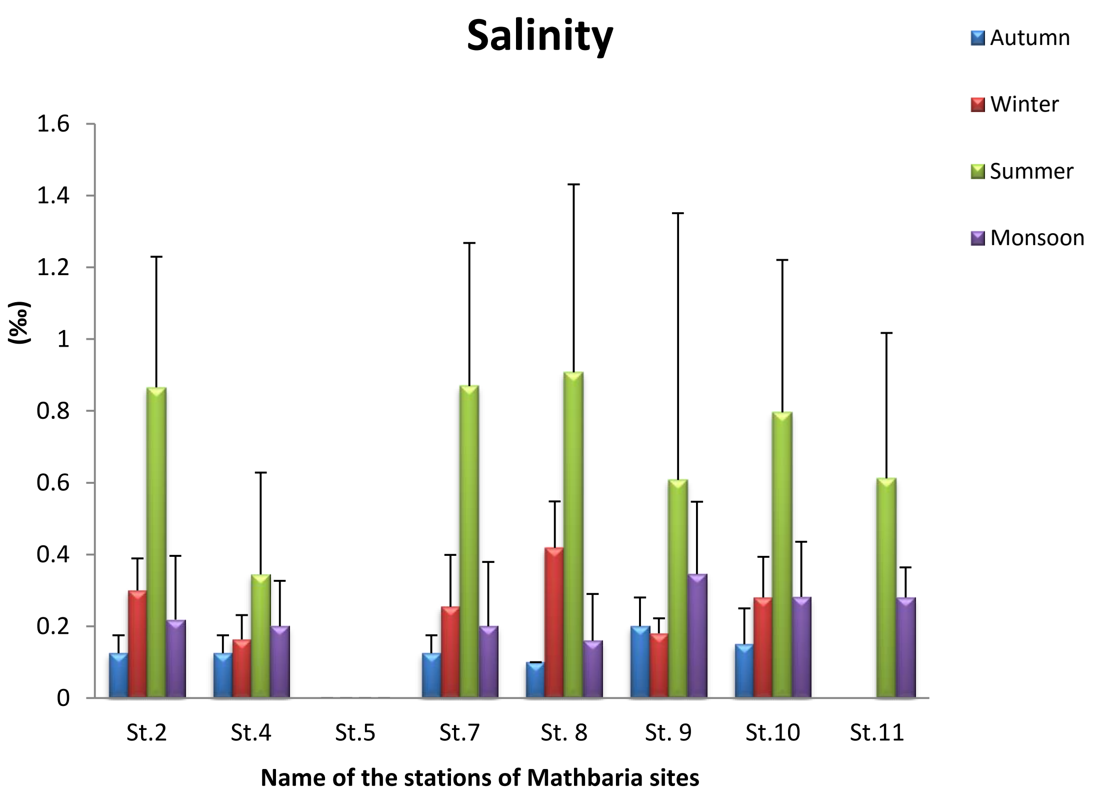


Fig. 13. Seasonal variation of salinity at different stations of Mathbaria during 2010-2012.

Table 6. Monthly mean of salinity (‰) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	1.22	1.39	3.22	2.2	NM	1.62	1.66	NS
	Max.	1.57	3.46	3.35	2.3	NM	2.22	2.08	NS
	mean	1.35	2.43	3.29	2.26	NM	1.9	1.87	NS
	SD	0.19	1.46	0.07	0.05	NM	0.30	0.30	NS
Nov.	Min.	1.2	1.21	2.85	1.95	NM	1.76	1.39	NS
	Max.	1.21	1.45	3.1	2.25	NM	2.2	1.74	NS
	mean	1.21	1.33	2.98	2.12	NM	1.98	1.57	NS
	SD	0.01	0.17	0.18	0.13	NM	0.31	0.25	NS
Dec.	Min.	1.16	1.34	2.65	2.05	NM	1.59	1.3	NS
	Max.	1.35	2.76	2.7	2.29	NM	1.59	1.3	NS
	mean	1.26	2.05	2.68	2.17	NM	1.59	1.3	NS
	SD	0.13	1.00	0.04	0.17	NM	OTS	OTS	NS
Jan.	Min.	1.12	0.82	2.41	1.95	NM	1.57	1.18	NS
	Max.	1.18	2.41	2.7	2.13	NM	1.62	1.36	NS
	mean	1.15	1.74	2.55	2.06	NM	1.60	1.30	NS
	SD	0.03	0.82	0.15	0.10	NM	0.03	0.10	NS
Feb.	Min.	1.08	0.9	2.25	1.49	NM	1.34	1.22	NS
	Max.	1.23	1.89	2.42	2.26	NM	1.52	1.4	NS
	mean	1.15	1.34	2.32	1.85	NM	1.43	1.29	NS
	SD	0.05	0.43	0.07	0.33	NM	0.06	0.07	NS
Mar.	Min.	1.04	0.58	2.15	1.24	NM	1.25	1.24	NS
	Max.	1.19	1.34	2.5	2.34	NM	1.66	1.5	NS
	mean	1.14	0.96	2.31	1.91	NM	1.44	1.34	NS
	SD	0.05	0.32	0.12	0.42	NM	0.18	0.09	NS
Apr.	Min.	1.06	0.45	1.13	2.1	NM	1.19	1.2	1.69
	Max.	1.35	0.79	2.36	2.35	NM	1.72	1.62	1.92
	mean	1.18	0.62	1.87	2.23	NM	1.44	1.37	1.78
	SD	0.11	0.15	0.46	0.10	NM	0.21	0.15	0.12
May	Min.	1.16	0.6	1.68	1.62	NM	1.29	1.32	1.73
	Max.	1.29	0.7	2.12	2.35	NM	1.77	1.57	1.76
	Mean	1.23	0.66	1.879	2.20	NM	1.57	1.42	1.75
	SD	0.05	0.04	0.14	0.21	NM	0.17	0.08	0.01
Jun.	Min.	1.39	0.69	1.92	2.4	NM	1.68	1.65	2.13
	Max.	1.53	0.69	1.94	2.5	NM	2.16	1.79	2.13
	Mean	1.46	0.69	1.93	2.45	NM	1.92	1.72	2.13
	SD	0.10	OTS	0.01	0.07	NM	0.34	0.10	OTS
Jul.	Min.	1.26	1.52	1.46	2.26	NM	1.81	1.64	2.88
	Max.	1.34	1.52	2.34	2.36	NM	1.94	1.64	2.88
	Mean	1.3	1.52	1.9	2.31	NM	1.88	1.64	2.88
	SD	0.06	OTS	0.62	0.07	NM	0.09	OTS	OTS
Aug.	Min.	1.5	2.72	1.82	2.35	NM	1.95	2.05	1.91
	Max.	1.64	2.72	3.15	2.41	NM	2.3	2.36	1.91
	Mean	1.57	2.72	2.49	2.38	NM	2.13	2.21	1.91
	SD	0.10	OTS	0.94	0.04	NM	0.25	0.22	OTS
Sep.	Min.	1.42	3.15	2.25	2.34	NM	1.9	1.56	1.91
	Max.	1.47	3.44	3.46	2.5	NM	2.12	1.87	2.11
	Mean	1.45	3.30	2.87	2.42	NM	1.98	1.75	2.01
	SD	0.02	0.21	0.56	0.08	NM	0.10	0.14	0.14

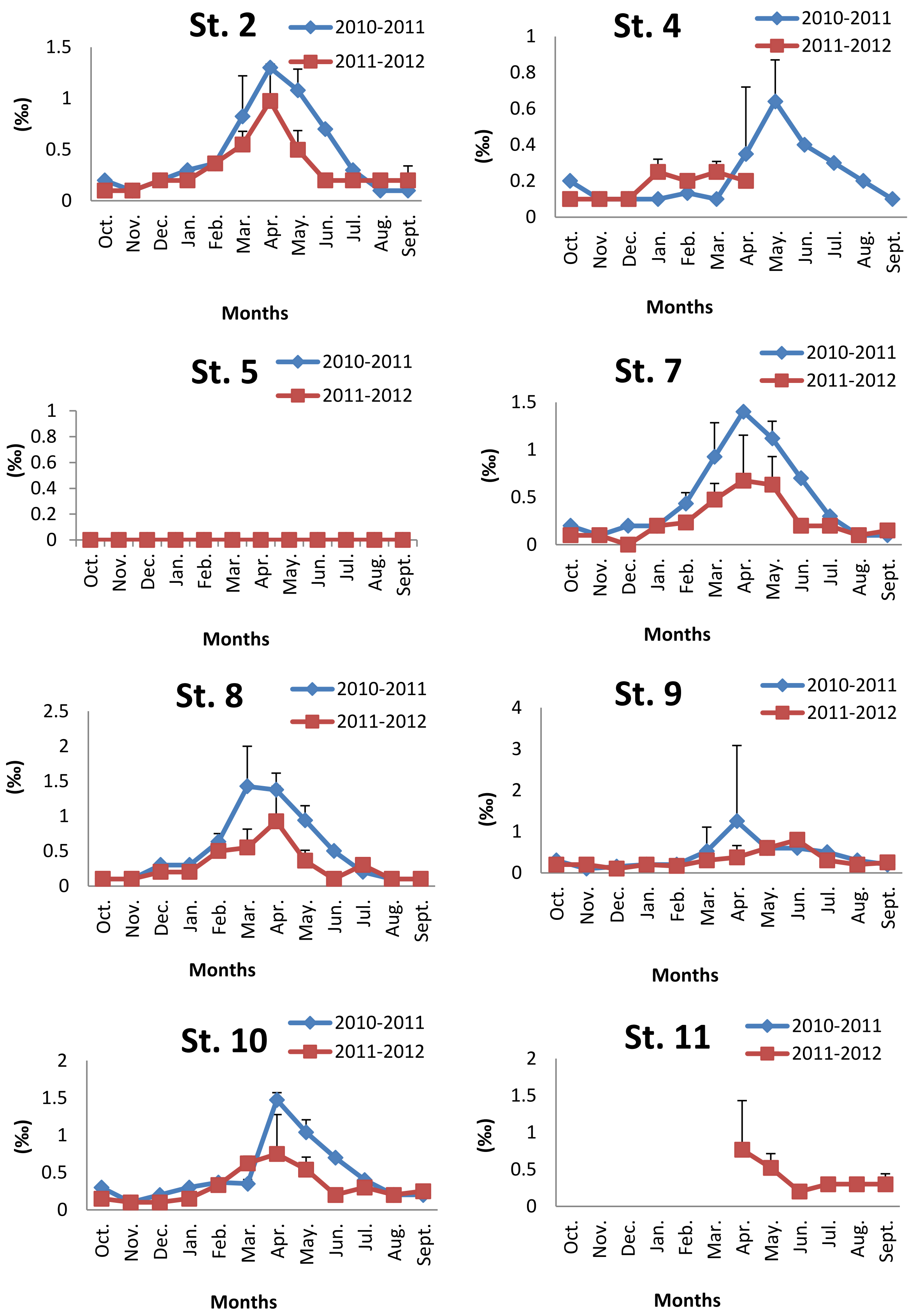


Fig. 14. Comparison of salinity between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

pH

Range of Hydrogen ion concentration (pH) for the period between October 2010 and September 2012 were recorded 7.10-7.95 for Station 2, 7.31-8.03 for Station 4, 7.03-8.43 for Station 5, 7.13-7.90 for Station 7, 7.07-7.73 for Station 8, 7.23-7.57 for Station 9, 7.04-7.67 for Station 10 and 7.14-7.76 for Station 11. However, the pH of some selected stations was closer to neutral or slightly alkaline. The highest monthly average of pH value for station 2 and 7 was recorded in the month of May. For station 9, 10 and 11 highest monthly average of pH was recorded in the month of April. For station 4 and 5 highest monthly average of pH was recorded in the month of January and for station 8 highest monthly average of pH was recorded in the month of February (Table 7).

In the present investigation, the seasonal variation of pH observed higher during summer and lower in autumn season for all the stations (Fig. 15). The trend of seasonal variation of pH in all the stations was variable (Fig. 15).

When pH of all the stations was compared for the two study periods no systematic annual trend for this parameter could be observed (Fig. 16). It was highly fluctuating in nature.

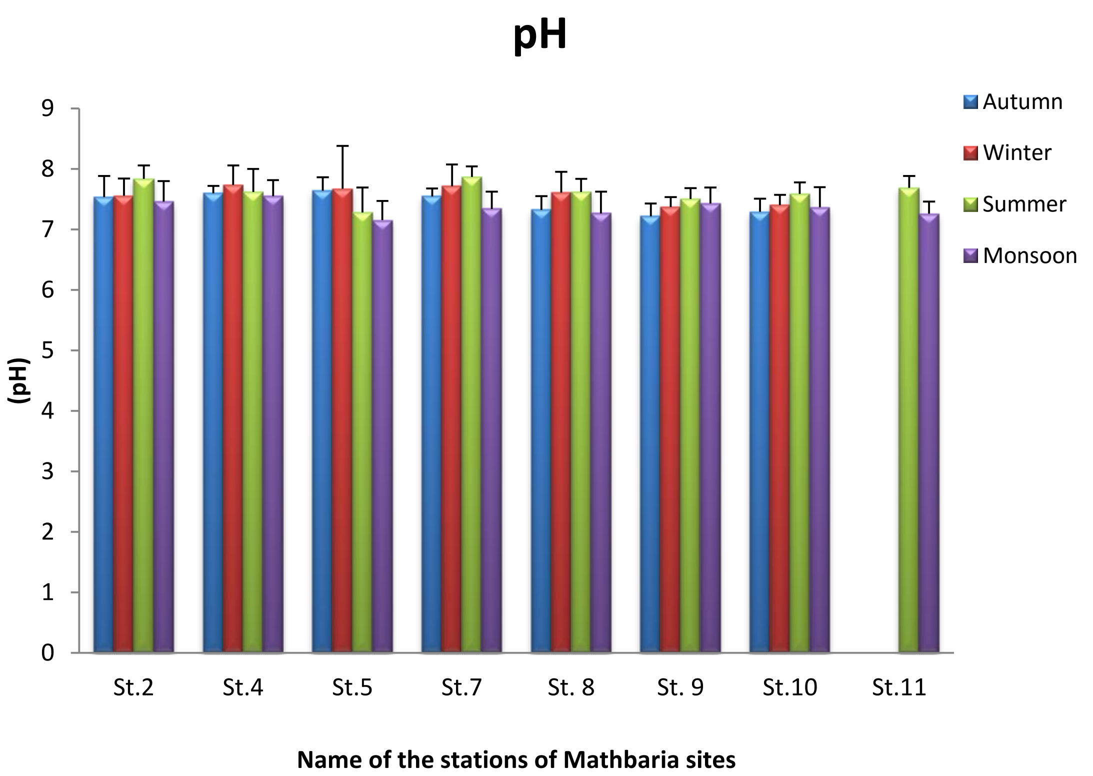


Fig. 15. Seasonal variation of pH at different stations of Mathbaria during 2010-2012.

Table 7. Monthly mean of pH at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	7.12	7.45	7.39	7.37	6.99	6.96	7	NS
	Max.	7.91	7.75	7.62	7.69	7.4	7.46	7.46	NS
	mean	7.46	7.6	7.47	7.49	7.24	7.26	7.26	NS
	SD	0.41	0.21	0.13	0.17	0.22	0.26	0.24	NS
Nov.	Min.	7.39	7.59	7.61	7.55	7.42	7.16	7.23	NS
	Max.	7.71	7.6	7.93	7.92	7.48	7.29	7.46	NS
	mean	7.55	7.60	7.77	7.66	7.45	7.23	7.35	NS
	SD	0.23	0.01	0.23	0.15	0.04	0.09	0.16	NS
Dec.	Min.	6.91	7.3	7.61	6.83	6.96	7.35	7.32	NS
	Max.	7.28	7.69	7.84	7.63	7.47	7.35	7.32	NS
	mean	7.10	7.50	7.73	7.23	7.22	7.35	7.32	NS
	SD	0.26	0.28	0.16	0.57	0.36	OTS	OTS	NS
Jan.	Min.	7.5	7.89	7.63	7.63	7.45	7.12	7.02	NS
	Max.	7.94	8.11	9.1	7.92	7.81	7.43	7.44	NS
	mean	7.69	8.03	8.43	7.82	7.63	7.31	7.24	NS
	SD	0.23	0.12	0.74	0.17	0.18	0.16	0.21	NS
Feb.	Min.	7.44	7.18	6.77	7.43	7.32	7.14	7.36	NS
	Max.	7.87	8	8.12	8.07	8.26	7.7	7.61	NS
	mean	7.64	7.66	7.28	7.82	7.73	7.41	7.50	NS
	SD	0.16	0.33	0.51	0.25	0.34	0.18	0.08	NS
Mar.	Min.	7.6	7.2	6.93	7.63	7.53	7.34	7.43	NS
	Max.	7.98	8.3	7.86	8.07	8.01	7.53	7.86	NS
	mean	7.71	7.79	7.41	7.86	7.68	7.45	7.59	NS
	SD	0.14	0.37	0.32	0.14	0.16	0.07	0.15	NS
Apr.	Min.	7.58	7.17	6.6	7.62	7.22	7.24	7.35	7.58
	Max.	7.98	8.02	7.8	8.06	7.92	7.9	7.82	7.89
	mean	7.82	7.65	7.30	7.83	7.67	7.57	7.67	7.76
	SD	0.15	0.38	0.42	0.15	0.24	0.20	0.17	0.16
May	Min.	7.46	7.08	6.14	7.46	7.27	6.93	7.08	7.29
	Max.	8.27	7.7	7.93	8.24	7.82	7.71	7.76	7.85
	Mean	7.95	7.31	7.15	7.90	7.53	7.48	7.51	7.64
	SD	0.28	0.28	0.47	0.23	0.23	0.22	0.22	0.22
Jun.	Min.	7.09	8	6.98	7.28	6.98	6.99	6.71	7.32
	Max.	7.65	8	7.12	7.59	7.77	7.51	7.36	7.32
	Mean	7.37	8	7.05	7.44	7.38	7.25	7.04	7.32
	SD	0.40	OTS	0.10	0.22	0.56	0.37	0.46	OTS
Jul.	Min.	7.2	7.33	6.7	7.01	6.69	7.32	7.16	7.22
	Max.	7.77	7.33	7.43	7.46	7.78	7.78	7.55	7.22
	Mean	7.49	7.33	7.07	7.24	7.24	7.55	7.36	7.22
	SD	0.40	OTS	0.52	0.32	0.77	0.33	0.28	OTS
Aug.	Min.	7.45	7.32	6.86	7.12	7.01	7.25	7.15	7.61
	Max.	7.55	7.32	7.19	7.14	7.12	7.53	7.6	7.61
	Mean	7.5	7.32	7.03	7.13	7.07	7.39	7.38	7.61
	SD	0.07	OTS	0.23	0.01	0.08	0.20	0.32	OTS
Sep.	Min.	7.08	7.35	6.85	7.09	7.12	7.14	7.18	7.13
	Max.	8.21	7.65	7.8	7.93	7.75	7.88	8.04	7.18
	Mean	7.50	7.5	7.25	7.38	7.31	7.49	7.54	7.16
	SD	0.51	0.21	0.42	0.48	0.30	0.33	0.36	0.04

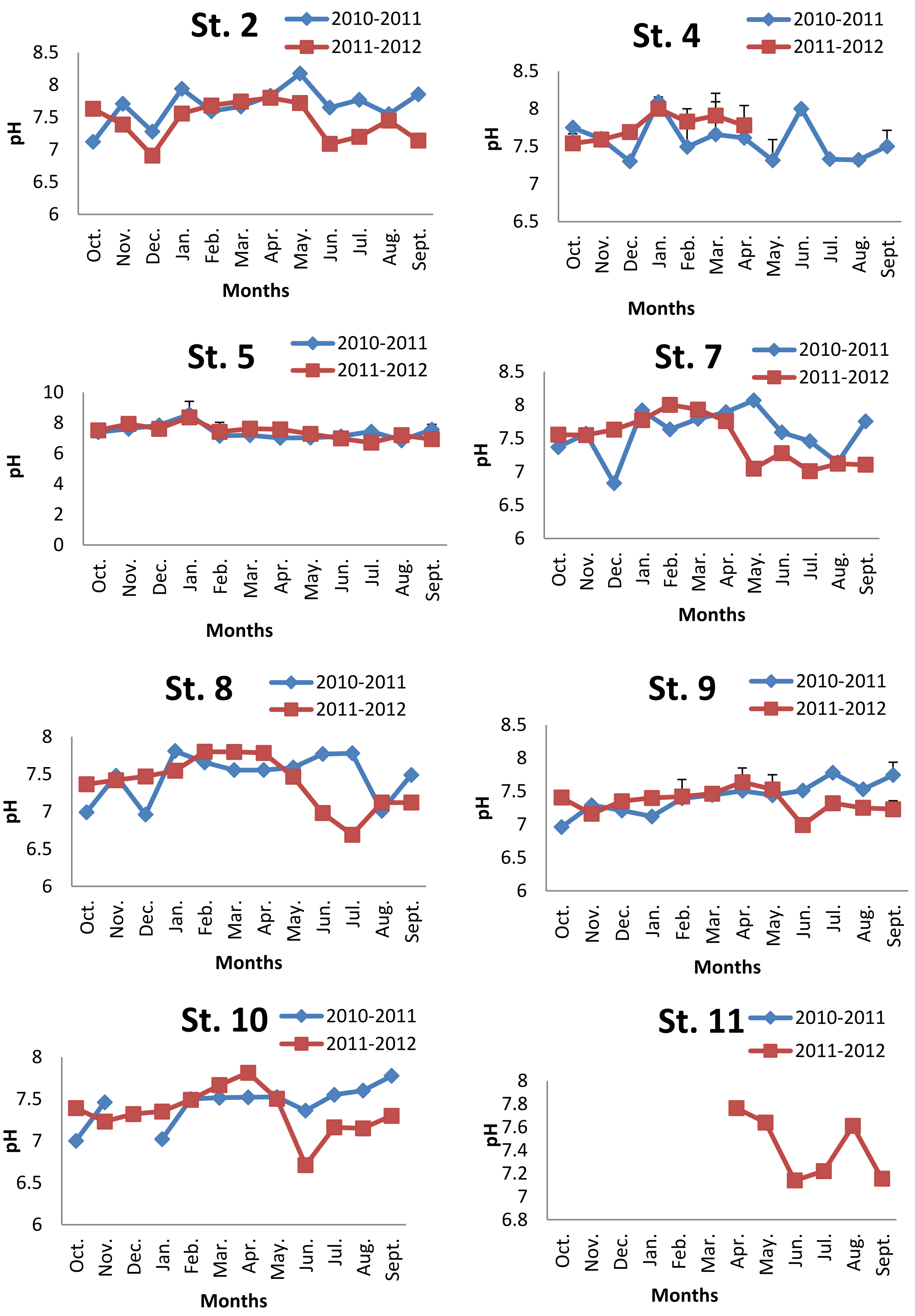


Fig. 16. Comparison of pH between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Total dissolved solids (TDS)

Range of TDS for the period between October 2010 and September 2012 were recorded 164.5-1774.13 mg/l for Station 2, 160.65-1612.8 mg/l for Station 4, 31.6-120.33 mg/l for Station 5, 130.55-1827.63 mg/l for Station 7, 151.05-1887.13 mg/l for Station 8, 112.3-960.7 mg/l for Station 9, 131.6-1933.63 mg/l for Station 10 and 276-1084 mg/l for Station 11. The highest monthly average of TDS for Station 2, 7, 8, 10 and 11 were recorded in the month of April. For station 4 and 9 the highest monthly average of TDS were recorded in the month of May and for station 5 highest monthly average of TDS was recorded in the month of October. TDS concentration was observed lowest in station 5 among all the station (Table 8).

In the present investigation, the seasonal variation of TDS observed higher during summer and lower in autumn season in all the stations (Fig. 17). For the Station 2, 4, 7, 9 and 10 a trend in highest to lowest concentration in TDS was found as summer - monsoon - winter - autumn (Fig. 17).

A peak occurrence of TDS between March to May for both the study years was seen for Stations 2, 4, 7, 8, 9 and 10. Station 5 and 11 did not show any such occurrence (Fig.18).

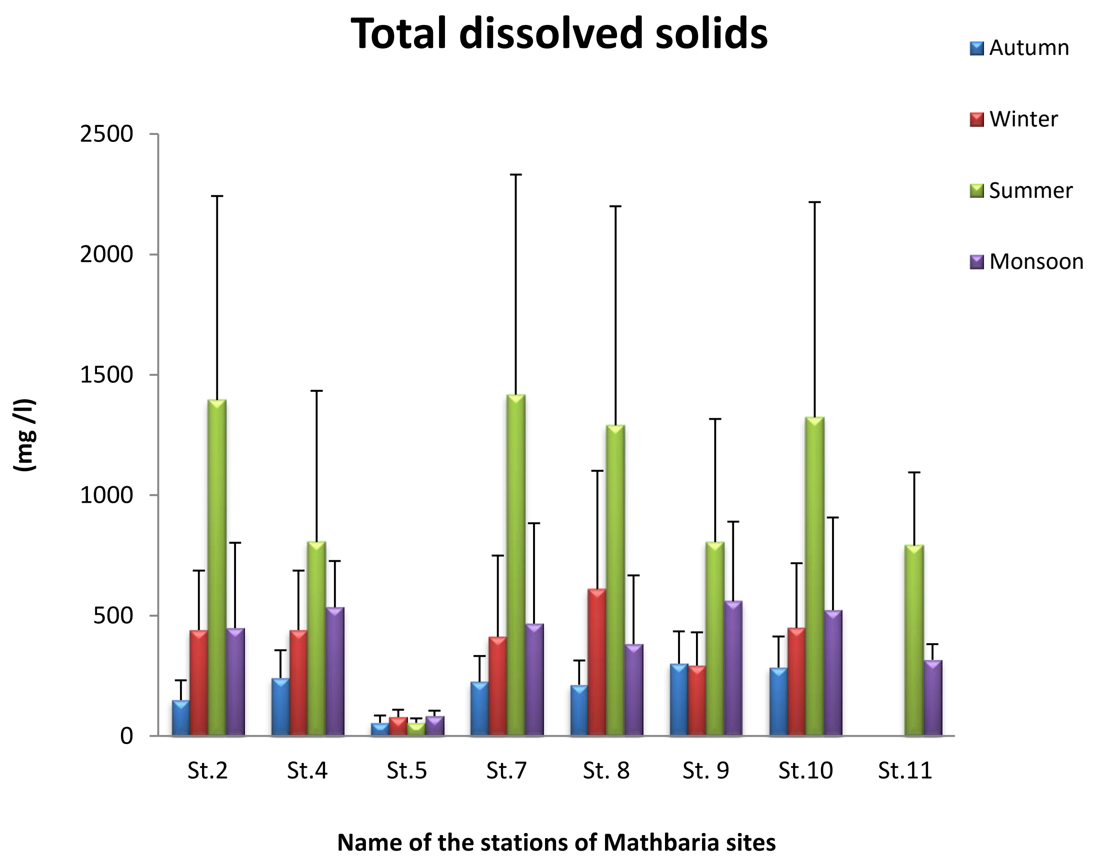


Fig. 17. Seasonal variation of TDS at different stations of Mathbaria during 2010-2012.

Table 8. Monthly mean of TDS (mg/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	37.8	239	64.8	228	186.9	424.33	339	NS
	Max.	432	401	228.7	376	427	70.55	460	NS
	mean	232.6	320	120.33	324.33	324.63	343	413	NS
	SD	197.14	114.55	93.86	83.50	123.90	469	64.86	NS
Nov.	Min.	139	132	30	60.1	133	193.6	156	NS
	Max.	189.3	189.3	41.6	208	169.1	42.99	202	NS
	mean	164.15	160.65	35.8	153.94	151.05	163.2	179	NS
	SD	35.57	40.52	8.20	60.36	25.53	224	32.53	NS
Dec.	Min.	198.8	158.9	30.5	60.1	212	112.3	131.6	NS
	Max.	249	195.7	32.7	201	232	112.3	131.6	NS
	mean	223.9	177.3	31.6	130.55	222	112.3	131.6	NS
	SD	35.50	26.02	1.56	99.63	14.14	OTS	OTS	NS
Jan.	Min.	235	171	31.5	206	234	224.87	120.9	NS
	Max.	282	295	42.6	237	289	37.93	580	NS
	mean	265.33	230.33	35.97	217	261.33	189.6	316.63	NS
	SD	26.31	62.17	5.86	17.35	27.50	265	236.90	NS
Feb.	Min.	366	255	46.9	272	470	356.15	320	NS
	Max.	885	437	136.6	1043	1531	139.50	862	NS
	mean	598	335.33	71.37	604	913.33	150.9	569	NS
	SD	235.38	84.10	33.67	354.31	489.94	491	242.75	NS
Mar.	Min.	422	276	49.8	372	32.9	728.88	68.9	NS
	Max.	2530	442	93.9	2680	2040	796.70	949	NS
	mean	1119.88	359.38	68.04	1180.5	1024.86	290	645.49	NS
	SD	763.64	73.69	16.45	832.05	801.80	2680	276.11	NS
Apr.	Min.	557	284	44.4	726	697	685.88	800	934
	Max.	2650	1878	95.2	2730	2820	172.51	3090	1230
	mean	1774.13	712.8	70.63	1827.63	1887.13	324	1933.63	1084
	SD	870.85	656.52	22.09	943.96	868.15	839	981.35	148.04
May	Min.	380	1532	81.2	19.22	19.24	960.7	422	390
	Max.	2580	1748	105	2620	2600	407.75	2510	847
	Mean	1311.7	1612.8	91.68	1277.62	1023.22	593	1377.3	614.8
	SD	865.77	92.04	8.55	931.97	868.75	1860	818.82	218.39
Jun.	Min.	229	OTS	90.2	254	156.4	825	282	276
	Max.	1413	853	97.6	1550	1156	622.25	1548	276
	Mean	821	853	93.9	902	656.2	385	915	276
	SD	837.21	OTS	5.23	916.41	706.82	1265	895.20	OTS
Jul.	Min.	265	693	85.5	263	367	730	367	307
	Max.	755	693	98.8	973	574	511.95	904	307
	Mean	510	693	92.15	618	470.5	368	635.5	307
	SD	346.48	OTS	9.40	502.05	146.37	1092	379.72	OTS
Aug.	Min.	231	440	69.9	210	200	478.5	270	310
	Max.	340	440	80.4	332	265	265.17	471	310
	Mean	285.5	440	75.15	271	232.5	291	370.5	310
	SD	77.07	OTS	7.42	86.27	45.96	666	142.13	OTS
Sep.	Min.	202	400	32.4	206	183.9	407.25	232	259
	Max.	376	436	123.5	361	355	142.17	440	427
	Mean	315.25	418	78.7	280.67	263.5	240	359.25	343
	SD	80.90	25.46	37.76	77.66	89.22	557	97.80	118.79

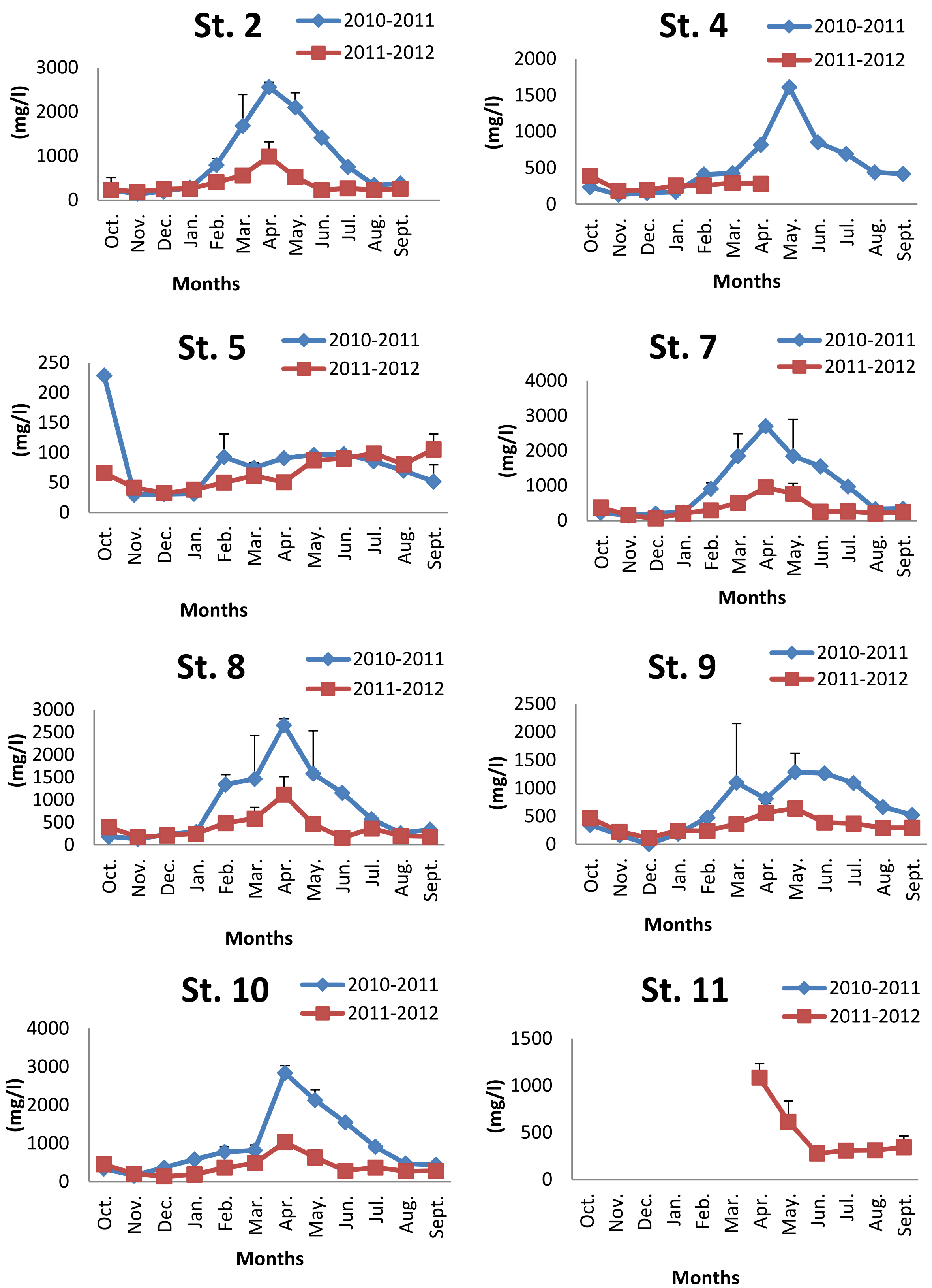


Fig. 18. Comparison of TDS between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Soluble reactive phosphorous (SRP)

Range of SRP for the period between October 2010 and September 2012 were recorded 5.9-331.15 µg/l for Station 2, 3.19-50.87 µg/l for Station 4, 1.68-26.94 µg/l for Station 5, 5.40-38.95 µg/l for Station 7, 10.31-33.76 µg/l for Station 8, 4.51-155.25 µg/l for Station 9, 4.4-577.39 µg/l for Station 10 and 4.51-15.39 µg/l for Station 11. The highest monthly average of SRP for Station 2, and 4 were recorded in the month of March and lowest in the month of November and December, respectively. For station 5 highest monthly average of SRP was recorded in the month of February and lowest in December. For station 7, 8, 9, 10 and 11 highest monthly average of SRP were recorded in the month of June, August, October and September, respectively. Whereas, the lowest concentration of SRP were observed in January for station 7, 8 and 9. For station 10 and 11 lowest monthly average was recorded in the month of December and May, respectively (Table. 9).

The seasonal variation of SRP was observed higher during monsoon and lower in winter season in most the stations (Fig. 19). Seasonal mean values showed highly variable in nature among the studied stations and therefore no trend would be established (Fig. 19).

In the comparison of annual cycles in Fig. 20, it has been observed that a unimodal phosphorous peak in March for Station 2 and 4 were evident. Moat of the other stations showed an almost bimodal peak for this important nutrient (Fig. 20).

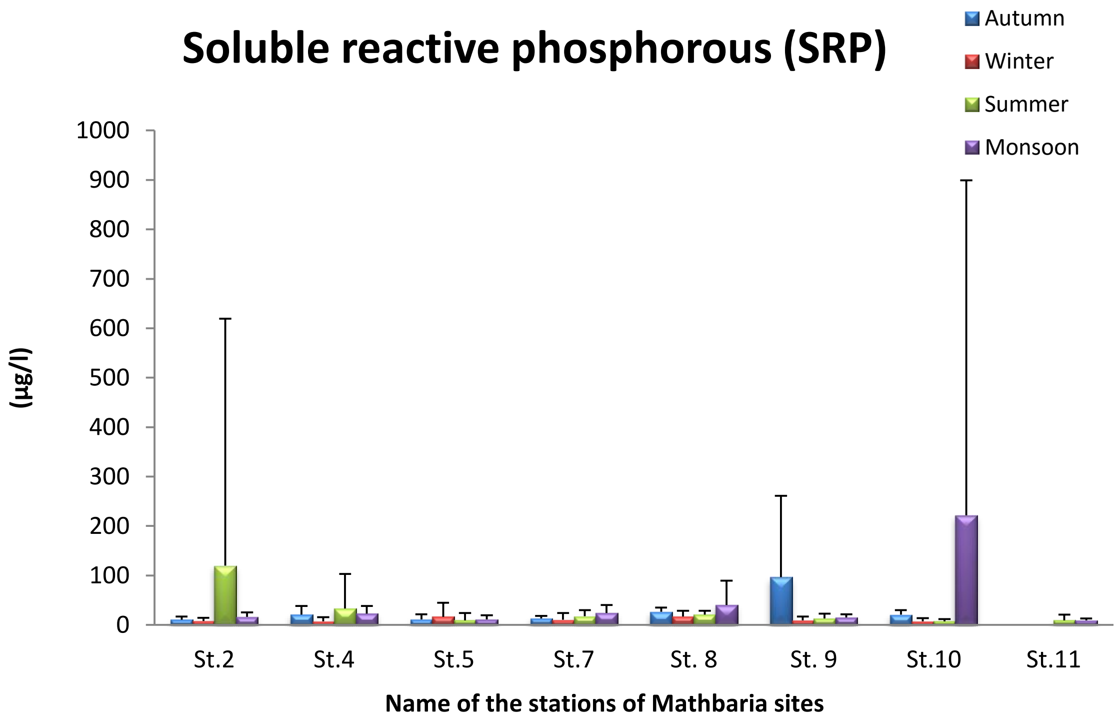


Fig. 19. Seasonal variation of SRP at different stations of Mathbaria during 2010-2012.

Table 9. Monthly mean of SRP (µg/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	13.78	10.37	4.27	14.39	26.04	16.22	15.31	NS
	Max.	38.35	15.43	23.73	31.52	29.1	343	35.71	NS
	mean	23.09	12.9	12.72	21.81	27.92	126.50	28.14	NS
	SD	13.32	3.58	9.98	8.79	1.65	187.50	11.17	NS
Nov.	Min.	3.6	8.2	1.58	0	15.07	12.65	13.59	NS
	Max.	8.2	46.71	15.88	10.66	35.6	15.39	20.44	NS
	mean	5.9	27.46	8.73	5.43	25.34	14.02	17.02	NS
	SD	3.25	27.23	10.11	4.57	14.52	1.94	4.84	NS
Dec.	Min.	10.64	0	0	1.4	20.63	21.87	4.4	NS
	Max.	10.91	6.37	3.35	44.5	29.05	21.87	4.4	NS
	mean	10.78	3.19	1.68	22.95	24.84	21.87	4.4	NS
	SD	0.19	4.50	2.37	30.48	5.95	OTS	OTS	NS
Jan.	Min.	0	0	0	0	6.28	0	0	NS
	Max.	10.3	9.82	8.86	9.58	15.95	7.89	15.59	NS
	mean	5.91	5.34	4.69	5.40	10.31	4.51	10.33	NS
	SD	5.32	4.97	4.45	4.90	5.03	4.06	8.94	NS
Feb.	Min.	0	0	0	0	7.91	0.36	0	NS
	Max.	20.9	23.59	100	23.08	45.13	21.02	14.87	NS
	mean	8.21	9.42	26.94	8.54	18.08	8.87	6.03	NS
	SD	8.17	10.78	36.65	9.10	13.73	8.11	6.54	NS
Mar.	Min.	2.87	0	0	2.07	7.52	0	1.26	NS
	Max.	2561.96	300.55	74.1	21	28.43	40.74	14.95	NS
	mean	331.15	50.87	13.80	13.06	20.46	16.50	7.38	NS
	SD	901.40	103.25	24.83	7.01	6.96	11.89	5.08	NS
Apr.	Min.	0	0	0	4.75	14.52	4.47	2.66	1.1
	Max.	148.58	21.76	21.65	26.68	23.64	27.86	15.17	33.51
	mean	30.17	9.10	6.57	13.81	19.56	15.25	6.60	15.39
	SD	50.76	8.48	8.12	6.71	3.05	9.44	4.02	15.21
May	Min.	0	2.74	0	6.95	9.85	0.86	0	0
	Max.	129.96	63.43	20.54	51.6	48.36	17.23	14.2	14.4
	Mean	22.29	29.36	7.51	23.9	22.12	8.19	7.79	4.51
	SD	39.79	26.33	7.10	16.43	11.44	5.80	4.94	5.90
Jun.	Min.	7.91	OTS	7	32.65	15.02	11.81	21.61	15.35
	Max.	14.38	15.01	20.97	45.24	17.08	27.88	26.01	15.35
	Mean	11.15	15.01	13.99	38.95	16.05	19.85	23.81	15.35
	SD	4.57	OTS	9.88	8.90	1.46	11.36	3.11	OTS
Jul.	Min.	11.96	16.83	16.07	3.17	10.2	5.4	8.85	5.56
	Max.	13.97	16.83	30.52	34.7	46.11	10.01	10.2	5.56
	Mean	12.97	16.83	23.30	18.94	28.16	7.71	9.53	5.56
	SD	1.42	OTS	10.22	22.30	25.39	3.26	0.95	OTS
Aug.	Min.	10.25	29.49	5.49	10.58	23	14.93	13.16	11.54
	Max.	22.7	29.49	11.22	41.61	44.52	15.43	13.25	11.54
	Mean	16.48	29.49	8.36	26.10	33.76	15.18	13.205	11.54
	SD	8.80	OTS	4.05	21.94	15.22	0.35	0.06364	OTS
Sep.	Min.	3.87	13.72	1.15	3.52	12.29	6.2	9.54	6.27
	Max.	23.3	51.28	9.17	27.72	183.9	19.65	2265.27	6.37
	Mean	14.69	32.5	4.33	12.31	63.56	14.18	577.3925	6.32
	SD	8.03	26.55893	3.63	13.39	81.73	6.35	1125.273	0.07

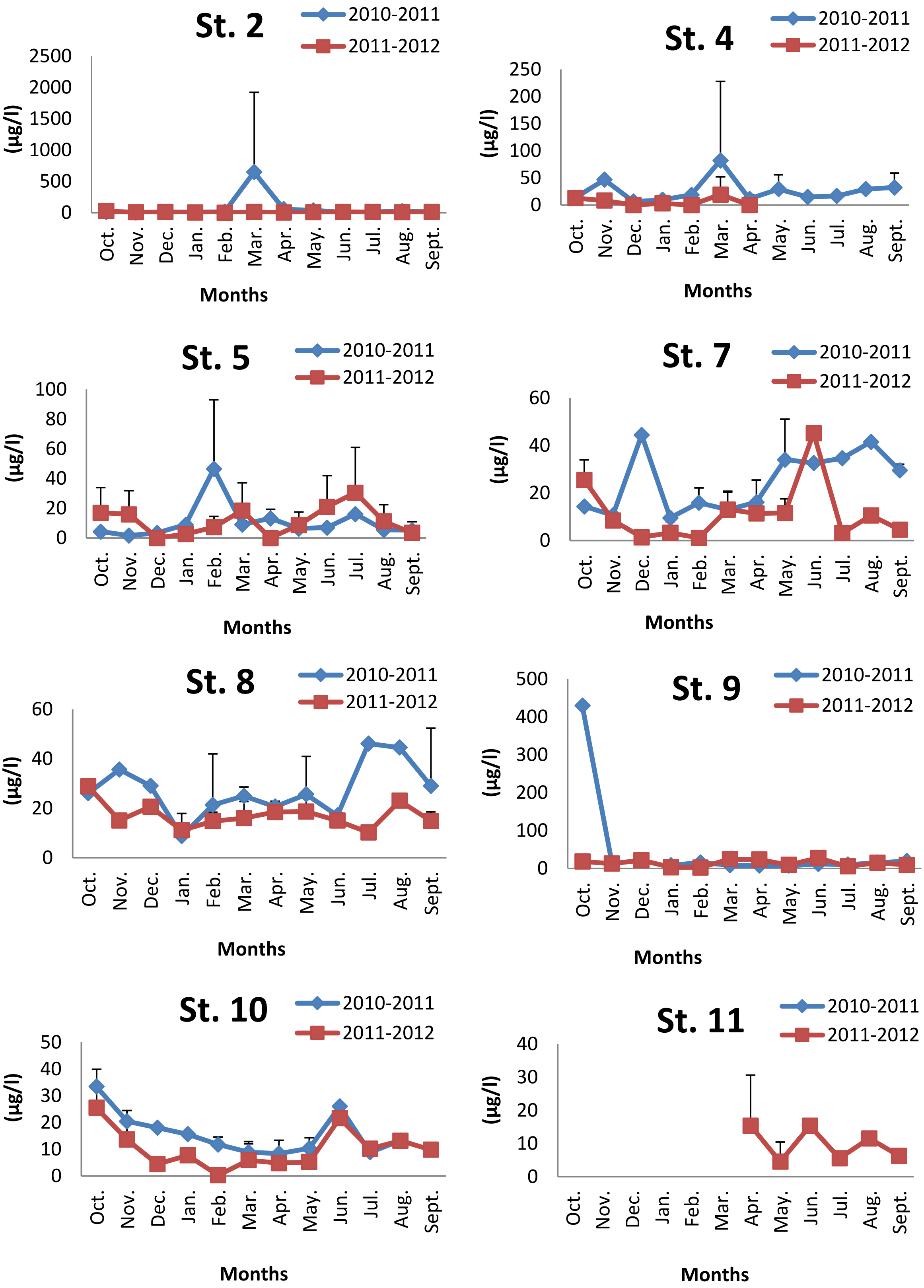


Fig. 20. Comparison of SRP between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Nitrate-nitrogen (NN)

Range of NN for the period between October 2010 and September 2012 were recorded 0-121.25 µg/l) for Station 2, 0-860 µg/l for Station 4, 0-295 µg/l for Station 5, 30.02-145 µg/l for Station 7, 0.41-205 µg/l for Station 8, 0-150 µg/l for Station 9, 0.02-210 µg/l for Station 10 and 46.03-242 µg/l for Station 11. The highest monthly average of NN for station 2, 8, 10 and 11 were recorded in the month of March, September, June and May respectively. For station 4 and 9 highest concentration of NN were recorded in the month of July and for station 5 and 7 highest NN were recorded in August. Whereas lowest concentration of NN were recorded in November among all the station except Station 7. In this station, lowest NN was recorded in October (Table 10).

In the present investigation, the seasonal variation of NN observed higher during monsoon in most of the stations except Station 2 and 11. In these stations higher concentrations of NN were observed in summer. It shows lower concentration of NN in autumn among all the stations (Fig. 21). From highest to lowest concentration of NN, a trend like monsoon - summer - winter - autumn was observed in Stations 4, 8, 9 and 10 (Fig. 21).

During the study period, NN concentration was higher in the year of 2010-2011 than the year of 2011-2012. NN shows rising tendency from the month of November. It shows dropping tendency after the month of January. It raises again after the month of August in most of the station (Figs. 22). When the NN data for two consecutive study years among all the stations were compared no rhythmic pattern of peak concentration was observed (Fig. 22).

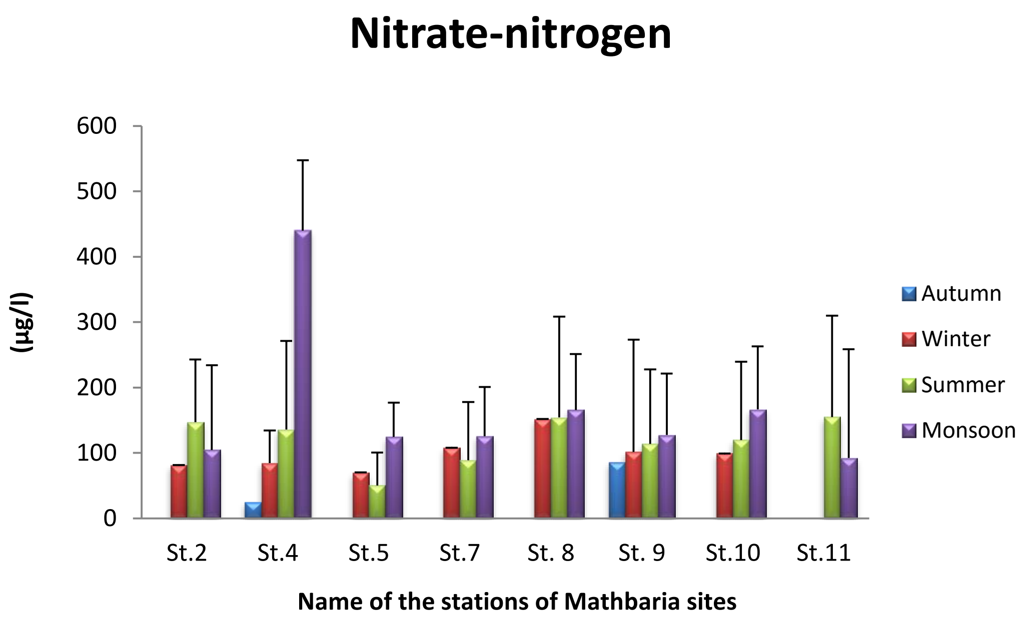


Fig. 21. Seasonal variation of NN at different stations of Mathbaria during 2010-2012.

Table 10. Monthly mean of NN (µg/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	0	0.07	0	0	0	0	0	NS
	Max.	190	100	150	90	180	343	110	NS
	mean	63.36	50.04	50	30.02	60	157.67	36.70	NS
	SD	109.68	70.66	86.60	51.95	103.92	173.17	63.48	NS
Nov.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	110	0.81	0	0.03	NS
	mean	0	0	0	42	0.41	0	0.015	NS
	SD	0	0	0	57.62	0.573	0	0.02	NS
Dec.	Min.	0.35	1	0	0.5	1.75	110	170	NS
	Max.	130	110	110	110	180	110	170	NS
	mean	65.18	55.5	55	55.25	90.88	110	170	NS
	SD	91.68	77.07	77.78	77.43	126.04	OTS	OTS	NS
Jan.	Min.	0	0	0	0	0	0	0	NS
	Max.	130	117.77	99.88	225.14	425.55	210.81	160.71	NS
	mean	86.17	69.26	33.29	108.38	181.85	123.60	96.90	NS
	SD	74.63	61.56	57.67	112.80	219.41	110.02	85.31	NS
Feb.	Min.	0	0	40	50	40	0	0	NS
	Max.	140	230	130	330	390	320	210	NS
	mean	84.5	101.67	93.33	125	156.67	89.33	88.67	NS
	SD	50.05	76.00	32.04	104.07	133.97	118.47	67.71	NS
Mar.	Min.	0	0	0	0	90	0	0	NS
	Max.	230	250	140	190	250	350	410	NS
	mean	121.25	70	65	77.5	159.75	116.25	121.25	NS
	SD	82.88	80.53	56.06	67.77	53.62	110.96	130.65	NS
Apr.	Min.	0	90	0	0	0	0	0	0
	Max.	240	290	100	170	310	170	240	180
	mean	70	150	21.25	85	131.25	87.5	115	46.03
	SD	93.35	80	35.63	56.57	100.77	49.21	85.69	89.34
May	Min.	0	120	0	0	0	0	0	60
	Max.	560	400	150	340	280	360	230	460
	Mean	96	226	62	101	168	133	122	242
	SD	166.41	109.91	55.34	97.46	97.38	109.35	83.11	167.54
Jun.	Min.	90	OTS	90	90	200	140	150	140
	Max.	110	470	160	160	210	160	270	140
	Mean	100	470	125	125	205	150	210	140
	SD	14.14	OTS	49.50	49.50	7.07	14.14	84.85	OTS
Jul.	Min.	70	860	40	90	130	130	130	120
	Max.	140	860	100	150	190	170	150	120
	Mean	105	860	70	120	160	150	140	120
	SD	49.50	OTS	42.43	42.43	42.43	28.28	14.14	OTS
Aug.	Min.	70	680	50	100	100	70	80	90
	Max.	80	680	540	190	120	110	110	90
	Mean	75	680	295	145	110	90	95	90
	SD	7.07	OTS	346.48	63.64	14.14	28.28	21.21	OTS
Sep.	Min.	0	40	0	0	0	70	90	40
	Max.	240	490	140	270	320	190	380	70
	Mean	100	265	60	120	173.48	122.5	207.5	55
	SD	101.00	318.20	60.55	137.48	131.59	61.85	135.25	21.21

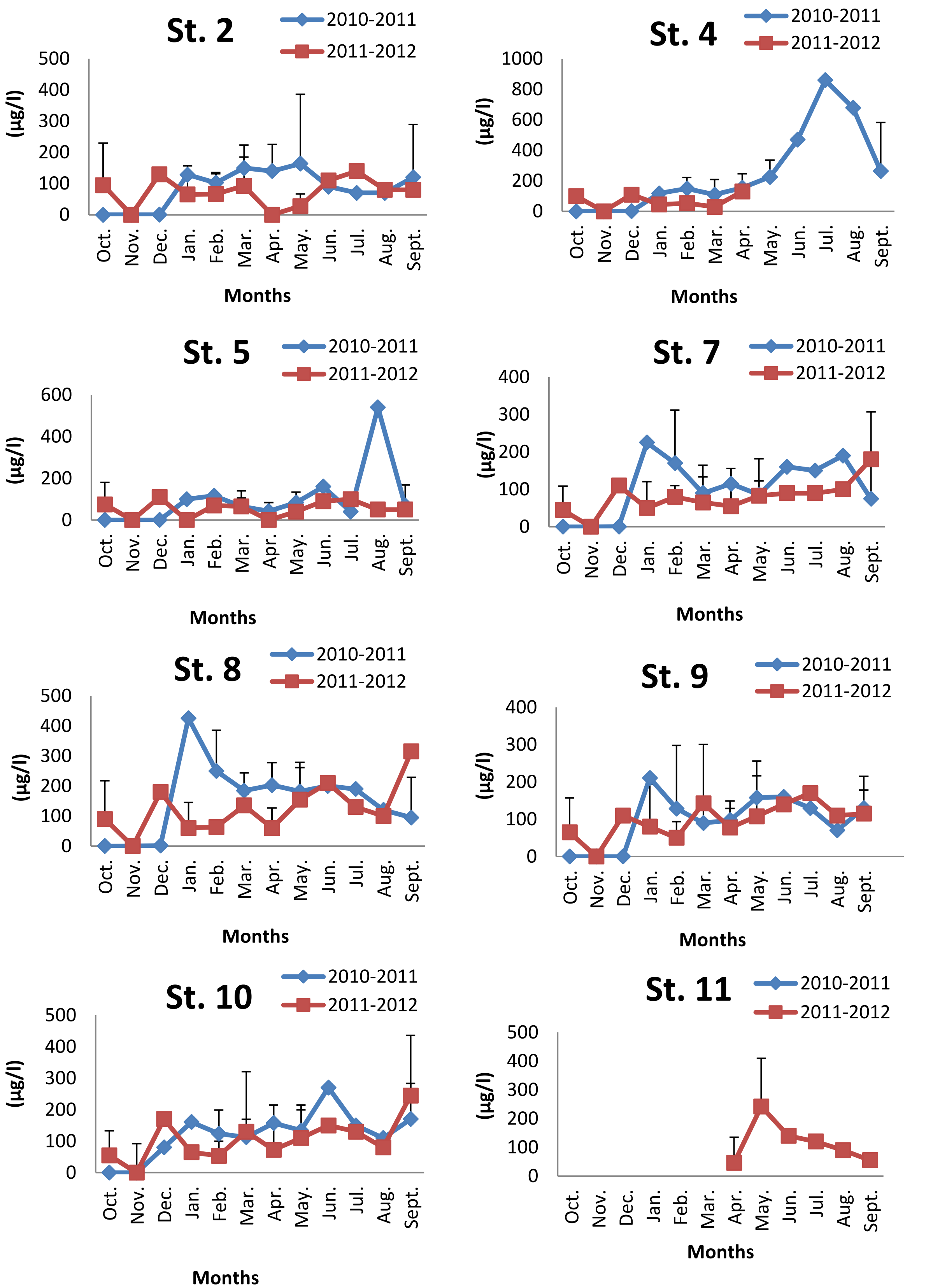


Fig. 22. Comparison of NN between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Soluble reactive silicate (SRS)

Range of SRS for the period between October 2010 and September 2012 were recorded 4.5-7.32 mg/l for Station 2, 0.80-12.72 mg/l for Station 4, 0.9-3.79 mg/l for Station 5, 5.62-7.50 mg/l for Station 7, 4.69-7.90 mg/l for Station 8, 4.71-7.97 mg/l for Station 9, 4.63-7.79 mg/l for Station 10 and 5.05-9.46 mg/l for Station 11. The highest monthly average of SRS for Station 2 and 8 were recorded in the month of January and February, respectively. For station 4, 5, 7, 9 and 11, highest concentration of SRS were recorded in the month of April. For station 10 highest concentration of SRS were recorded in December (Table 11).

In the present investigation, the seasonal variation of SRS observed higher during summer and lower in autumn in most of the stations (Fig. 23). From highest to lowest concentration in the seasonal pattern like winter-summer-monsoon-autumn was observed in Stations 2, 8 and 6 (Fig. 23).

During the study period, the annual variation of SRS showed higher concentration in the year of 2011-2012 than the year of 2010-2011 in most of the stations. A rising tendency after the month of January in most of the stations was shown (Fig. 24).

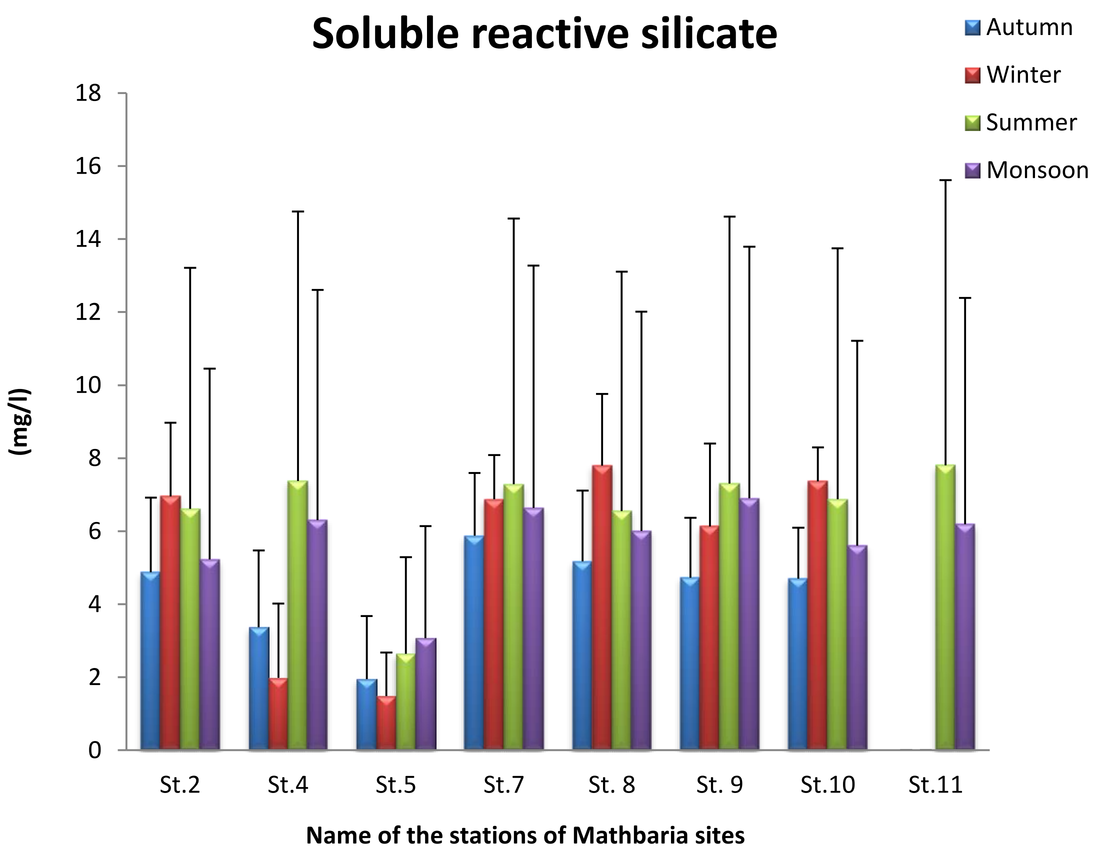


Fig. 23. Seasonal variation of SRS at different stations of Mathbaria during 2010-2012.

Table 11. Monthly mean of SRS (mg/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	3.47	1.86	0	3.95	4.02	6.14	3.59	NS
	Max.	6.93	5	3.72	7.16	7.3	343	5.95	NS
	mean	5.10	3.43	2.05	5.62	5.94	119.78	4.82	NS
	SD	1.74	2.22	1.89	1.60	1.71	193.32	1.18	NS
Nov.	Min.	2.81	1.85	1.02	4.9	3.12	3.25	3.39	NS
	Max.	6.31	6.31	3.04	7.48	6.26	6.16	5.87	NS
	mean	4.56	4.08	2.03	6.51	4.69	4.71	4.63	NS
	SD	2.47	3.15	1.43	1.25	2.22	2.06	1.75	NS
Dec.	Min.	5.16	0	0	5.4	7.45	5.54	7.79	NS
	Max.	5.99	3.07	1.8	6.29	8.16	5.54	7.79	NS
	mean	5.58	1.54	0.9	5.85	7.81	5.54	7.79	NS
	SD	0.59	2.17	1.27	0.63	0.50	OTS	OTS	NS
Jan.	Min.	5.06	0.12	0.12	4.43	5.17	1.65	6.33	NS
	Max.	8.73	1.29	1.51	7.38	9.03	7.65	8.33	NS
	mean	7.32	0.80	0.96	6.40	7.59	5.64	7.60	NS
	SD	1.98	0.61	0.74	1.70	2.11	3.46	1.10	NS
Feb.	Min.	4.84	0.82	0.86	6.53	4.28	3.87	5.68	NS
	Max.	10.69	7.41	4.39	8.38	11.43	8.54	8.67	NS
	mean	7.23	2.72	1.94	7.46	7.90	6.48	7.18	NS
	SD	2.36	2.37	1.32	0.85	2.42	2.02	0.97	NS
Mar.	Min.	4.52	0.38	0.29	3.06	2.58	4.07	4.28	NS
	Max.	8.55	6.75	3.63	8.89	12.55	10.48	9.99	NS
	mean	6.70	3.32	1.60	7.02	6.55	7.24	7.07	NS
	SD	1.29	2.16	1.05	1.89	2.98	2.60	1.61	NS
Apr.	Min.	2.01	3.69	1.71	6.47	5.26	5.18	5.42	4.7
	Max.	9.48	36.99	8.61	8.64	10.35	10.67	8	18.22
	mean	6.53	12.72	3.79	7.50	6.48	7.97	6.48	9.46
	SD	3.12	13.77	2.28	0.67	1.64	1.94	1.00	6.08
May	Min.	3.47	6.89	1.7	6.41	5.72	5.95	5.63	5.68
	Max.	8.49	10.26	3.36	8.63	7.49	8.02	8.95	8.04
	Mean	6.6	8.53	2.56	7.32	6.62	6.83	7.03	6.49
	SD	1.26	1.37	0.52	0.75	0.54	0.69	0.10	0.91
Jun.	Min.	6.52	OTS	0.61	5.34	6.26	6.71	6.05	5.89
	Max.	6.82	8.37	3.65	8.46	6.35	7.08	7.2	5.89
	Mean	6.67	8.37	2.13	6.9	6.31	6.90	6.63	5.89
	SD	0.21	OTS	2.15	2.21	0.06	0.26	0.81	OTS
Jul.	Min.	4.44	7.93	2.58	5.84	4.96	6.49	4.64	5.05
	Max.	4.96	7.93	3.51	6.45	5.47	6.68	4.96	5.05
	Mean	4.7	7.93	3.05	6.145	5.22	6.59	4.8	5.05
	SD	0.37	OTS	0.66	0.43	0.36	0.13	0.23	OTS
Aug.	Min.	4.79	5.84	2.3	6.77	4.01	4.95	4.29	6.23
	Max.	5.57	5.84	4.61	7.43	6.42	6.72	6.31	6.23
	Mean	5.18	5.84	3.46	7.1	5.22	5.84	5.3	6.23
	SD	0.55	OTS	1.63	0.47	1.70	1.25	1.43	OTS
Sep.	Min.	1.63	2.82	3.08	3.3	1.93	2.1	2.57	6.85
	Max.	6.84	7.87	3.95	8.48	183.9	11.43	7.37	6.96
	Mean	4.87	5.35	3.53	6.47	50.50	6.76	5.83	6.91
	SD	2.33	3.57	0.36	2.78	88.98	3.81	2.20	0.08

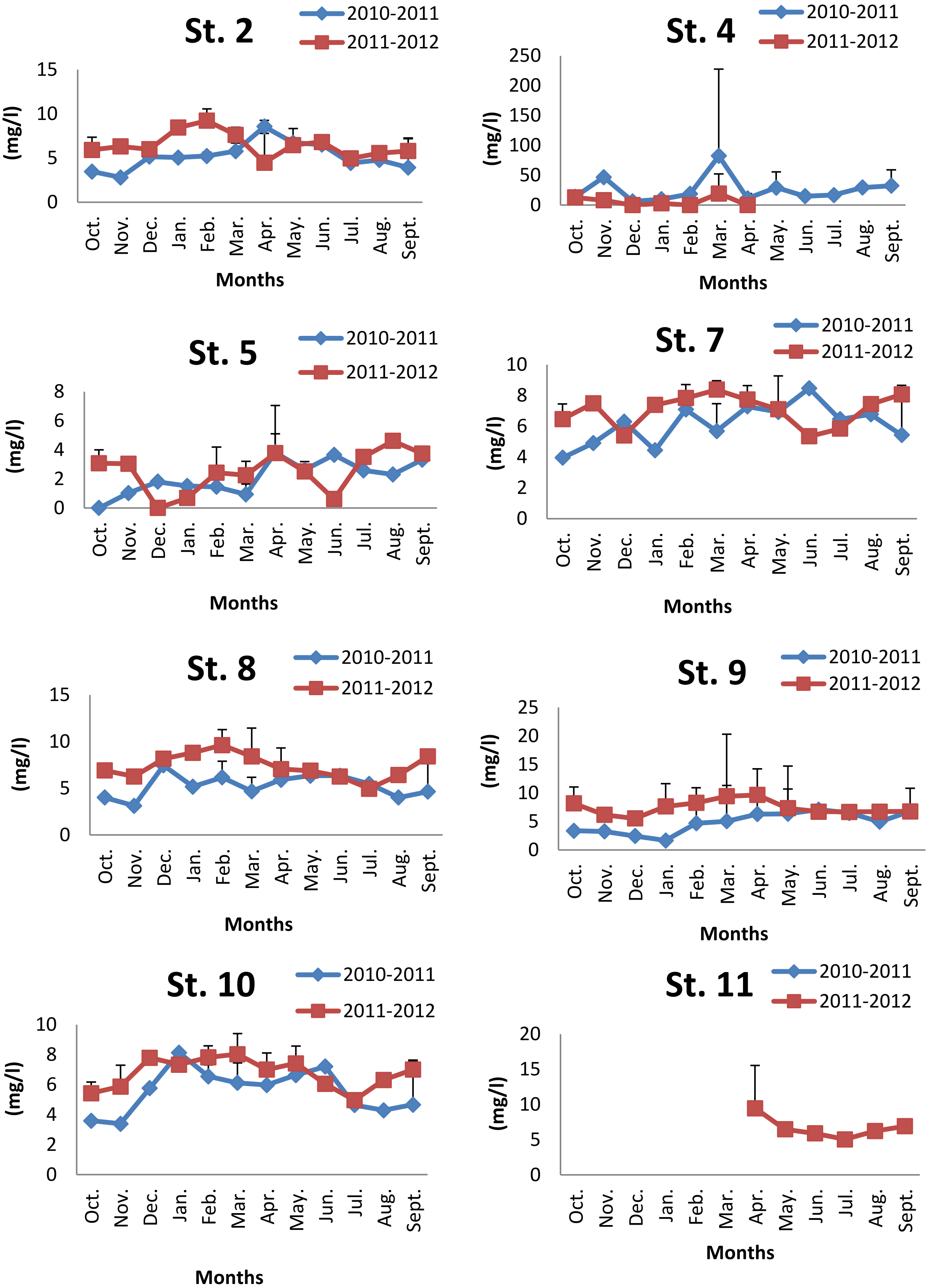


Fig. 24. Comparison of SRS between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Biological parameters

Chlorophyll *a* (chl. *a*)

Range of chl. *a* for the period between October 2010 and September 2012 were recorded 12.14-39.17 µg/l for Station 2, 2.54-61.57 µg/l for Station 4, 8.88-66.90 µg/l for Station 5, 5.02-22.56 µg/l for Station 7, 3.26-8.88 µg/l for Station 8, 7.01-29.52 µg/l for Station 9, 9.47-38.35 µg/l for Station 10 and 13.81-43.45 µg/l for Station 11. The highest monthly average of chl. *a* for Station 2 and 4 were recorded in the month of June. For Station 8 and 9 highest concentration of chl. *a* were recorded in the month of July. For station 5 and 7 highest concentration of chl. *a* were recorded in the month of August and November, respectively. For Station 10 and 11 highest concentration of chl. *a* were recorded during the month of April. Lowest concentration of chl. *a* for station 2 and 7 was recorded during the month of September. For Station 4, 9 and 10 lowest concentration of chl. *a* was recorded during the month of August. For Station 5, 8 and 11 lowest concentration of chl. *a* was recorded during the month of November, December and June, respectively (Table 12).

In the present investigation, the concentration of chl. *a* was higher during summer and lower in autumn in most of the stations (Fig. 25). In case of seasonal concentration from higher to lower, the trend like summer-winter-monsoon-autumn was followed by the stations of 2, 9, 10 and 11 (Fig. 25).

During the study period, the concentration of chl. *a* shows rising tendency after the month of November in most of the Stations. It started declining during the month of February in most of the Stations. The concentration of chl. *a* was higher in the year of 2011-2012 than the year of 2010-2011 in most of the stations. It shows rising tendency after the month of January in most of the stations (Fig. 26).

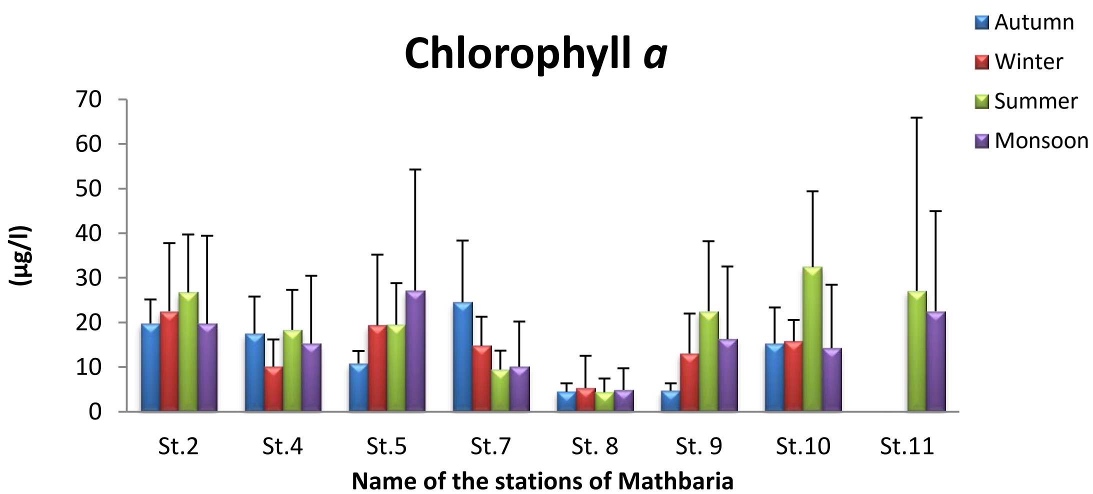


Fig. 25. Seasonal variation of chl. *a* at different stations of Mathbaria during 2010-2012.

Table 12. Monthly mean of chl *a* (µg/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	13.02	7.61	8.46	20.3	3.55	8.29	8.46	NS
	Max.	26.22	26.22	12.69	21.99	6.77	343	26.64	NS
	mean	18.61	16.92	11.28	21.2	5.41	121.83	18.01	NS
	SD	6.83	13.16	2.44	0.85	1.67	191.56	9.13	NS
Nov.	Min.	14.2	14.2	6.76	10.99	2.36	4.73	10.66	NS
	Max.	21.99	21.99	10.99	43.8	5.07	12.69	15.39	NS
	mean	18.10	18.10	8.88	22.56	3.72	8.71	13.03	NS
	SD	5.51	5.51	2.99	14.65	1.92	5.63	3.34	NS
Dec.	Min.	22.49	8.88	7.89	11.84	2.96	12.68	23.68	NS
	Max.	35.52	10.99	35.52	31.96	3.55	12.68	23.68	NS
	mean	29.01	9.94	21.71	21.9	3.26	12.68	23.68	NS
	SD	9.21	1.49	19.54	14.23	0.42	OTS	OTS	NS
Jan.	Min.	9.47	3.38	11.84	10.99	1.69	3.38	11.84	NS
	Max.	47.36	17.76	50.91	14.2	7.1	30.78	21.31	NS
	mean	22.89	8.74	32.36	12.34	4.11	16.18	16.57	NS
	SD	21.22	7.86	19.61	1.66	2.75	13.79	4.74	NS
Feb.	Min.	3.55	4.22	1.18	9.47	0.84	3.55	8.46	NS
	Max.	35.52	22.64	27.23	21.31	26.05	20.13	18.94	NS
	mean	20.13	10.88	12.06	13.61	6.60	11.5	14.04	NS
	SD	15.75	6.77	10.21	4.29	9.78	7.82	4.01	NS
Mar.	Min.	3.55	8.28	4.73	7.1	1.18	5.92	11.84	NS
	Max.	42.62	23.68	35.52	17.76	7.1	43.81	34.33	NS
	mean	23.23	15.2	17.42	10.06	3.42	20.13	23.75	NS
	SD	14.64	5.22	12.49	3.66	1.98	14.01	7.46	NS
Apr.	Min.	5.92	16.57	11.84	4.22	1.18	8.28	21.31	10.66
	Max.	47.36	36.7	33.15	18.94	10.66	31.97	60.38	130
	mean	30.49	28.41	21.02	10.80	5.20	20.83	38.35	43.45
	SD	14.68	10.32	7.10	4.66	4.07	9.74	13.22	57.84
May	Min.	10.65	9.47	9.47	1.69	0.84	5.92	16.57	8.88
	Max.	42.62	16.91	35.52	15.22	10.15	75.78	82.88	19.06
	Mean	26.58	13.19	19.94	7.86	4.44	25.71	34.49	13.98
	SD	10.34	3.24	8.67	4.28	3.01	20.92	22.83	4.40
Jun.	Min.	16.77	61.57	14.2	6.9	1.18	20.72	10.85	13.81
	Max.	61.57	61.57	39.07	16.58	7.1	21.31	14.21	13.81
	Mean	39.17	61.57	26.64	11.74	4.14	21.02	12.53	13.81
	SD	31.68	OTS	17.59	6.84	4.19	0.42	2.38	OTS
Jul.	Min.	14.37	8.46	17.76	10.14	4.74	26.05	13.02	22.83
	Max.	36.7	8.46	43.81	11.84	13.0	32.98	22.5	22.83
	Mean	25.54	8.46	30.79	10.99	8.88	29.52	17.76	22.83
	SD	15.79	OTS	18.42	1.20	5.85	4.90	6.70	OTS
Aug.	Min.	7.1	2.54	16.57	4.74	3.55	6.91	5.92	27.23
	Max.	18.94	2.54	117.22	10.65	3.55	7.1	13.02	27.23
	Mean	13.02	2.54	66.90	7.70	3.55	7.01	9.47	27.23
	SD	8.37	OTS	71.17	4.18	0	0.13	5.02	OTS
Sep.	Min.	5.92	4.23	7.61	2.36	1.97	2.36	5.92	22.49
	Max.	17.76	6.09	13.81	6.77	183.9	24.86	24.86	26.04
	Mean	12.14	5.16	10.39	5.02	48.83	12.43	14.50	24.27
	SD	5.41	1.32	2.942	2.34	90.05	10.70	8.50	2.51

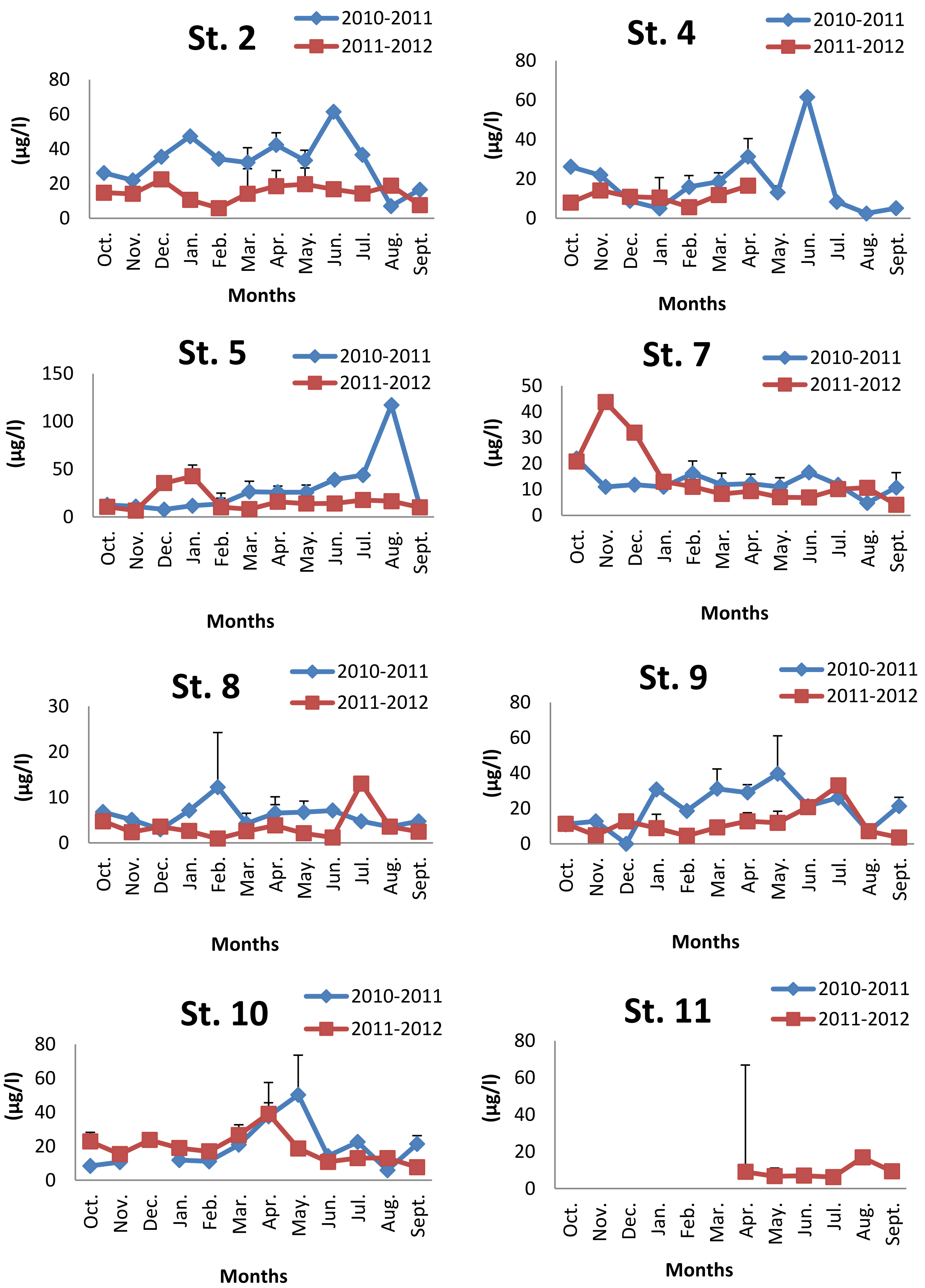


Fig. 26. Comparison of chl *a* between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Phaeopigment (PP)

Range of monthly average PP for the period between October 2010 and September 2012 were recorded 6.11-21.20 µg/l for Station 2, 0.43-57.4 µg/l for Station 4, 3.90-20.72 µg/l for Station 5, 2.29-20.72 µg/l for Station 7, 0.21-6.39 µg/l for Station 8, 2.64-22.95 µg/l for Station 9, 2.78-29.65 µg/l for Station 10 and 6.28-16.86 µg/l for Station 11. The highest monthly average of PP for station 2, 8 and 10 were recorded in the month of April. For Station 4 and 5, highest concentration of PP were recorded in the month of June. For station 7, 9 and 11 highest concentration of PP were recorded in the month of October, May and August respectively. (Table 13).

In the present investigation, the seasonal variation of PP observed higher during summer and lower in autumn in most of the stations (Fig. 27). Clear seasonal trend from highest to lowest concentration of phaeopigment following summer-monsoon-winter-autumn was observed in Station 5, 9 and 10 (Fig. 27).

During the study period, PP concentration was higher in the year of 2010-2011 than the year of 2011-2012 in most of the stations. In both the study year, PP concentration shows highest peak during the month of April in most of the Stations. However, it fell during May in most of the stations (Fig. 28). A peak development of phaeopigment from April-June occurred in almost all the studied Stations expect 2 and 11 (Fig. 28).

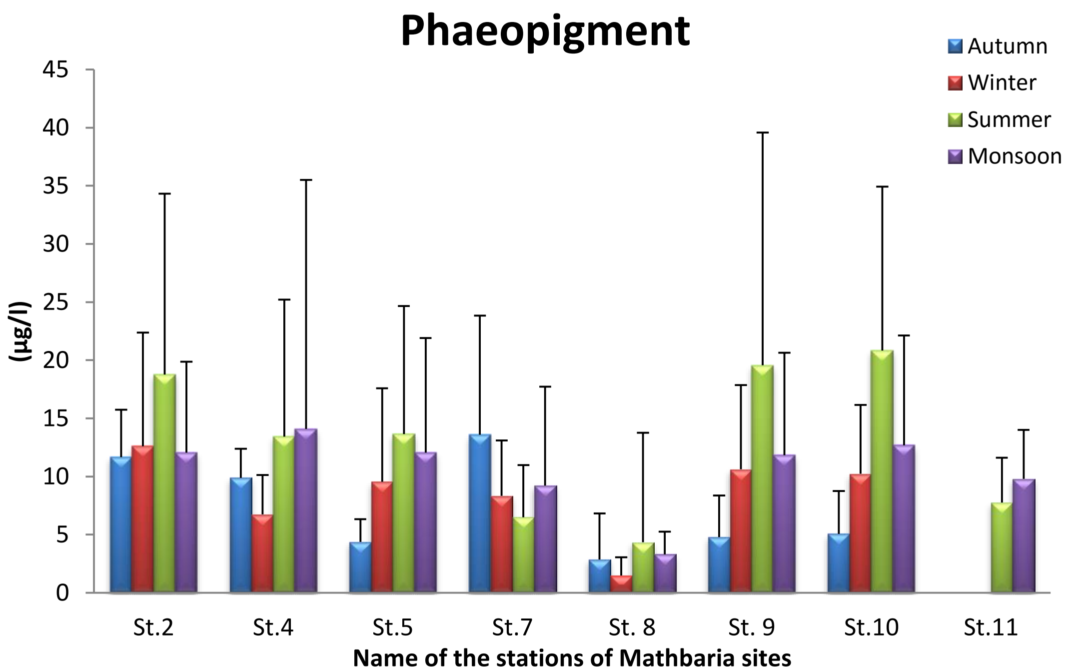


Fig. 27. Seasonal variation of phaeopigment at different stations of Mathbaria during 2010-2012.

Table 13. Monthly mean of phaeopigment (µg/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	13.01	5.21	3.36	6.54	0.61	10.02	4.62	NS
	Max.	17.76	13.01	9.37	27.84	8.69	343	22.66	NS
	mean	15.82	9.11	6.35	20.72	5.29	123.75	12.46	NS
	SD	2.49	5.52	3.01	12.28	4.19	189.92	9.25	NS
Nov.	Min.	7.42	7.42	2.14	4.09	0.12	1.92	1.24	NS
	Max.	9.51	10.7	5.65	14.62	2.06	3.36	4.32	NS
	mean	8.47	9.06	3.90	10.55	1.09	2.64	2.78	NS
	SD	1.48	2.32	2.48	5.22	1.37	1.02	2.18	NS
Dec.	Min.	13.71	6.83	5.28	4.11	BDL	15.24	11.26	NS
	Max.	17.44	8.45	15.23	14.62	0.6	15.24	11.26	NS
	mean	15.58	7.64	10.26	9.37	0.205	15.24	11.26	NS
	SD	2.64	1.15	7.04	7.43	0.56	OTS	OTS	NS
Jan.	Min.	4.8	3.84	7.3	4.09	0.68	2.56	6.46	NS
	Max.	9.22	7.2	30.62	13.95	4.54	18.3	24.44	NS
	mean	6.51	5.13	15.34	10.07	2.22	10.68	15.03	NS
	SD	2.38	1.81	13.24	5.26	2.04	7.88	9.02	NS
Feb.	Min.	2.75	1.8	0.96	2.78	BDL	2.75	3.87	NS
	Max.	31.04	12.62	9.44	12.9	3.58	22.66	12.41	NS
	mean	14.68	7.23	6.44	7.12	1.52	9.81	7.65	NS
	SD	12.49	4.38	4.12	4.38	1.49	8.02	2.91	NS
Mar.	Min.	2.27	2.52	1.08	1.69	0.48	1.56	6.62	NS
	Max.	26.88	13.07	37.22	9.03	16.91	26.27	26.27	NS
	mean	14.10	7.22	11.95	5.13	4.01	12.21	15.49	NS
	SD	9.11	4.77	14.32	2.94	5.38	9.99	6.21	NS
Apr.	Min.	1.56	3.39	6.46	1.12	BDL	1.69	6.4	3.49
	Max.	46.53	53.98	42.56	16.43	46.37	53.22	55.26	14.2
	mean	21.20	22.33	16.53	8.91	6.39	22.69	29.65	9.03
	SD	19.50	19.14	12.06	5.87	16.42	19.87	17.60	4.38
May	Min.	3.26	12.11	3.7	0.68	0.34	3.23	3.39	3.63
	Max.	45.54	19.07	25.76	10.9	10.22	85.63	42.21	12.64
	Mean	20.58	14.47	12.69	5.67	2.95	22.95	18.09	6.76
	SD	16.81	2.72	7.34	3.80	2.97	25.64	13.28	3.48
Jun.	Min.	7.49	57.41	4.92	4.18	0.48	12.56	5.78	6.98
	Max.	21.63	57.41	37.47	15.04	3.71	29.44	18.24	6.98
	Mean	14.56	57.41	21.20	9.61	2.10	21	12.01	6.98
	SD	10.00	OTS	23.02	7.68	2.28	11.94	8.81	OTS
Jul.	Min.	5.23	8.78	11.36	6.49	4.42	9.8	4.44	6.28
	Max.	19.87	8.78	21.09	12.29	4.44	22.21	13.28	6.28
	Mean	12.55	8.78	16.23	9.39	4.43	16.01	8.86	6.28
	SD	10.35	OTS	6.88	4.10	0.01	8.78	6.25	OTS
Aug.	Min.	2.05	0.43	12.58	1.92	1.44	4.19	7.39	16.86
	Max.	10.17	0.43	13.13	2.65	1.44	4.54	11.1	16.86
	Mean	6.11	0.43	12.86	2.29	1.44	4.37	9.25	16.86
	SD	5.74	OTS	0.39	0.52	0	0.25	2.62	OTS
Sep.	Min.	3.23	4.69	2.52	0.96	0.8	1.79	1.56	8.89
	Max.	21.34	7.98	8.43	9.28	183.9	13.02	32.54	9.95
	Mean	12.07	6.335	5.69	4.21	48.39	7.33	14.20	9.42
	SD	9.29	2.33	2.58	4.45	90.36	6.32	14.16	0.75

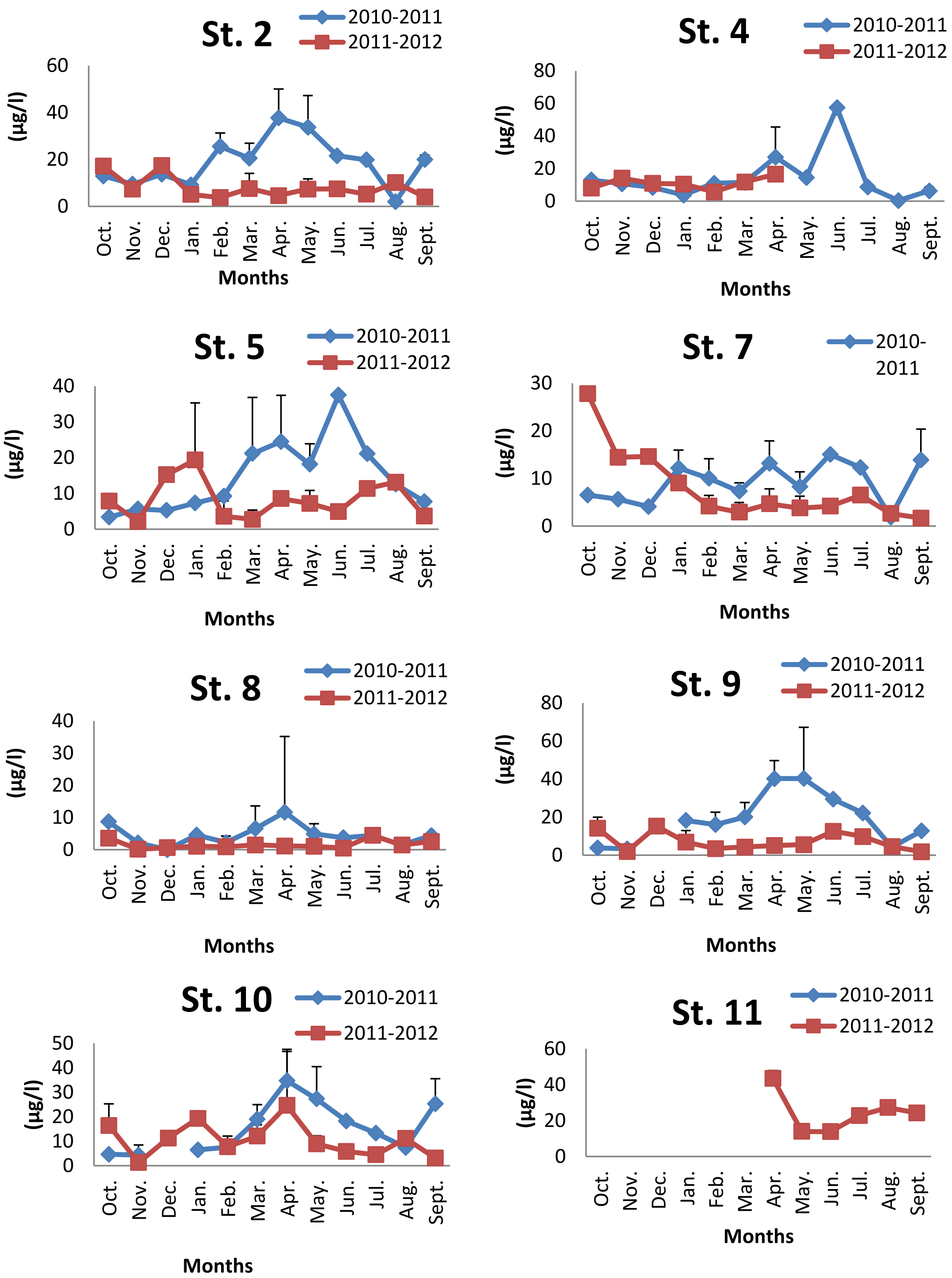


Fig. 28. Comparison of phaeopigment between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Phytoplankton density (PD)

Range of monthly average PD for the period between October 2010 and September 2012 were recorded 32.39-2285.72 ×10^3 ind/l for Station 2, 2.41-77.1 ×10^3 ind/l for Station 4, 11.96-272.21 ×10^3 ind/l for Station 5, 7.21-151.58 ×10^3 ind/l for Station 7, 3.06-537.48 ×10^3 ind/l for Station 8, 2.84-291.40 ×10^3 ind/l for Station 9, 11.82-218.1 ×10^3 ind/l for Station 10 and 9.91-38.94 ×10^3 ind/l for Station 11. Among all the stations PD was minimum in Station 4 and maximum in Station 2. The highest monthly average of PD for station 2, 9, 10 and 11 were recorded during the month of January, May, August and July, respectively. For station 4 and 5 highest amount of PD were recorded during the month of October and September respectively. For station 7 and 8 highest amount of PD were recorded in the month of October, May and August, respectively (Table 14).

In the present investigation, the seasonal variation of PD was observed higher during winter and lower in autumn in most of the stations (Fig. 29).

During the study period, PD showes rising tendency after the month of December and decreasing tendency just after the month of February (Fig. 30). In Stations 7, 8 and 10, on an annual scale, peak growth of phytoplankton occurred during January to April in both the study years (Fig. 30).

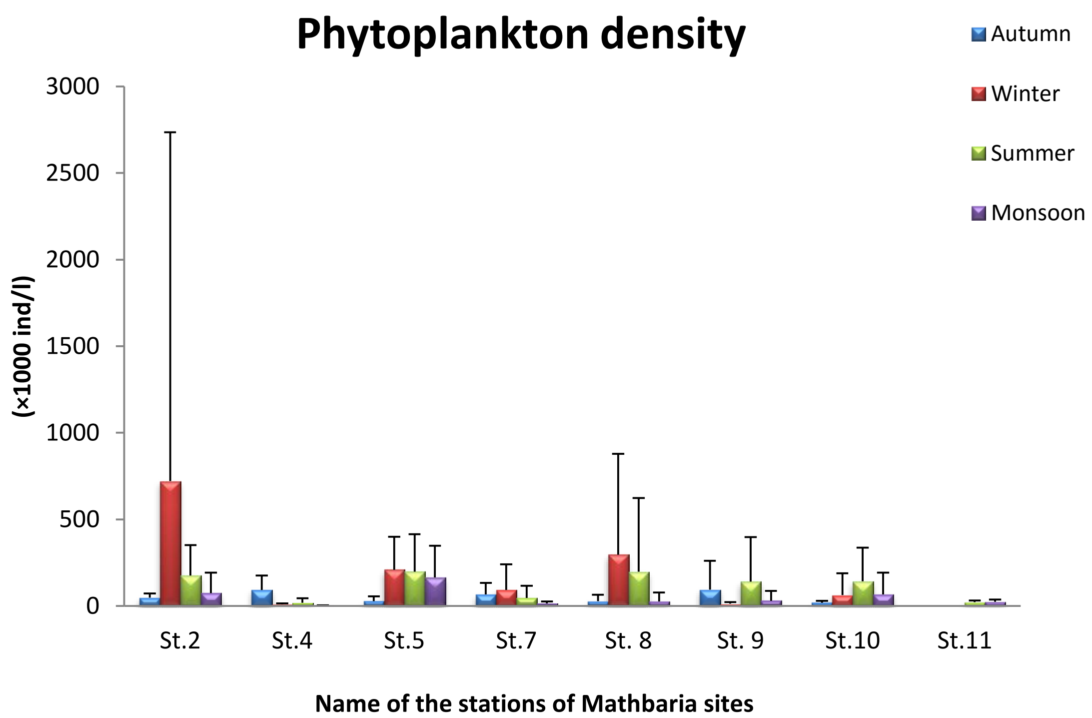


Fig. 29. Seasonal variation of phytoplankton density at different stations of Mathbaria during 2010-2012.

Table 14. Monthly mean of PD (×10³ ind/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	29.55	1.53	9.41	32.18	14.66	1.75	19.7	NS
	Max.	70.42	200.22	13.57	165.8	81.64	343	34.31	NS
	mean	52.29	100.88	11.96	82.12	38.89	115.79	26.90	NS
	SD	20.82	140.50	2.24	72.92	37.14	196.77	7.31	NS
Nov.	Min.	24.29	24.29	17.29	17.51	2.84	0.1	9.19	NS
	Max.	67.47	115.62	69.22	30.53	3.28	30.21	14.45	NS
	mean	45.88	69.96	43.26	23.88	3.06	15.16	11.82	NS
	SD	30.53	64.58	36.72	4.89	0.31	21.29	3.72	NS
Dec.	Min.	11.38	5.47	72.18	16.42	3.06	2.84	15.32	NS
	Max.	567.94	17.29	92.47	26.48	10.07	2.84	15.32	NS
	mean	289.66	11.38	82.33	21.45	6.57	2.84	15.32	NS
	SD	393.55	8.36	14.35	7.11	4.96	OTS	OTS	NS
Jan.	Min.	12.47	2.4	13.57	15.32	3.93	6.78	1.75	NS
	Max.	6776.25	11.6	470.92	22.32	8.54	28.45	418.49	NS
	mean	2285.72	5.54	234.07	18.38	5.91	16.27	143.87	NS
	SD	3889.01	5.25	229.11	3.58	2.37	11.08	237.87	NS
Feb.	Min.	3.5	3.72	39.84	14.22	14.01	5.9	10.29	NS
	Max.	256.31	17.29	605.75	512.67	1874.76	30.86	70.2	NS
	mean	81.97	10.14	238.73	151.58	537.48	11.89	29.83	NS
	SD	100.57	4.41	207.52	186.97	724.77	9.63	22.10	NS
Mar.	Min.	9.84	4.15	4.37	20.57	5.25	5.69	8.1	NS
	Max.	302.93	113.16	408.05	120.11	1085.75	174	853.08	NS
	mean	134.34	24.85	155.49	61.38	352.69	57.40	202.20	NS
	SD	121.81	36.02	174.50	39.48	359.44	60.42	289.55	NS
Apr.	Min.	7.44	5.03	11.6	9.63	5.47	9.84	23.64	4.09
	Max.	187.31	53.68	864.85	42.9	1903.87	90.45	487.39	40
	mean	82.35	19.01	178.45	29.28	264.16	35.88	162.24	18.79
	SD	64.83	19.68	297.14	11.57	663.16	32.43	162.49	15.20
May	Min.	27.36	4.6	26.3	5.12	6.57	6.35	10.73	14.68
	Max.	739.77	14.66	561.15	356.82	61.49	919.89	310.44	30.74
	Mean	282.42	7.79	248.01	49.25	19.81	291.40	77.32	23.63
	SD	220.72	4.06	181.25	108.42	16.25	373.78	108.34	6.35
Jun.	Min.	50.12	2.41	21.01	4.16	5.25	19.92	5.03	9.91
	Max.	54.66	2.41	258.52	10.25	10.25	201.73	23.23	9.91
	Mean	52.39	2.41	139.77	7.205	7.75	110.83	14.13	9.91
	SD	3.21	OTS	167.94	4.31	3.54	128.56	12.87	OTS
Jul.	Min.	33.48	4.16	155.01	4.44	14.45	10.51	16.4	38.94
	Max.	423.92	4.16	216.47	17.07	16.4	23.23	35.68	38.94
	Mean	228.7	4.16	185.74	10.76	15.425	16.87	26.04	38.94
	SD	276.08	OTS	43.46	8.93	1.38	8.99	13.63	OTS
Aug.	Min.	28.35	2.63	7.88	7.85	5.69	3.72	4.82	14.68
	Max.	45.96	2.63	52.95	15.76	9.22	18.1	431.38	14.68
	Mean	37.16	2.63	30.42	11.81	7.46	10.91	218.1	14.68
	SD	12.45	OTS	31.87	5.59	2.50	10.17	301.62	OTS
Sep.	Min.	14.88	2.41	69.01	5.81	3.28	1.75	7.44	17.08
	Max.	67.3	2.85	644.93	33.71	183.9	26.99	127.77	38.94
	Mean	32.39	2.63	272.21	20.46	52.05	11.91	47.92	28.01
	SD	23.94	0.31	257.37	14.00	88.04	11.97	56.37	15.46

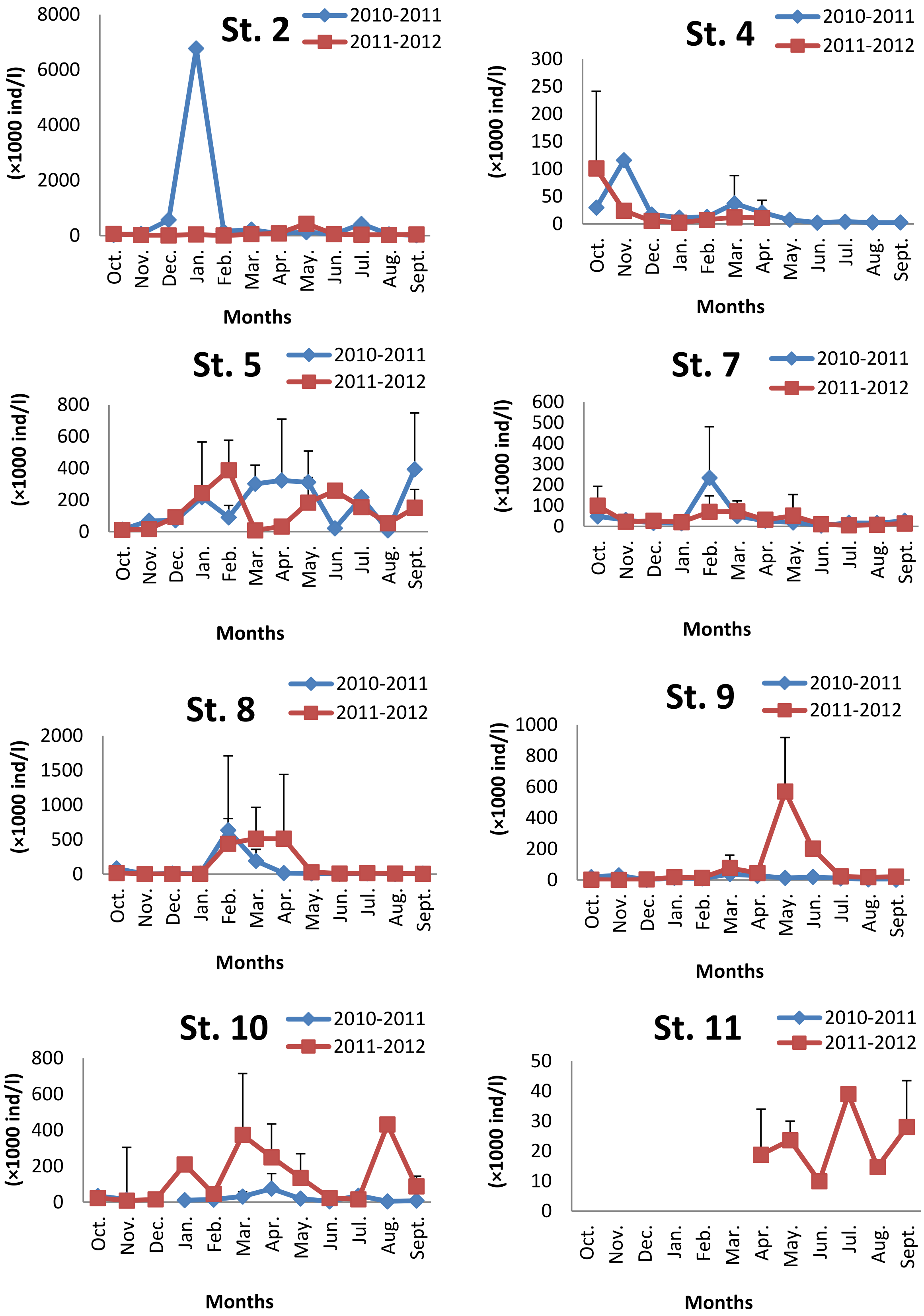


Fig. 30. Comparison of phytoplankton density between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Total zooplankton (TZ)

Range of monthly average TZ for the period between October 2010 and September 2012 were recorded 26.39-1041 $\times10^3$ ind/l for Station 2, 9-3684 $\times10^3$ ind/l for Station 4, 238.5-2897.1 $\times10^3$ ind/l for Station 5, 27-461.63 $\times10^3$ ind/l for Station 7, 7.5-106.5 $\times10^3$ ind/l for Station 8, 6-229.13 $\times10^3$ ind/l for Station 9, 20.25-921.75 $\times10^3$ ind/l for Station 10 and 12-108 $\times10^3$ ind/l for Station 11. The highest monthly average of TZ for Station 2, 7, 9 and 10 were recorded during the month of March. For station 4, 8 and 11 highest monthly average of TZ were recorded during the month of June. For station 5 highest monthly average of TZ were recorded during the month of May. Whereas lowest TZ were recorded for station 2 and 4 were recorded during the month of October and August respectively. For station 5, 8 and 9 were recorded during the month of September (Table 15).

In the present investigation, the seasonal variation of TZ showed highest amount during summer and lowest in autumn in most of the stations (Fig. 31). No distinct seasonal order of zooplankton growth was observed in the study sites. However, winter and summer months favored growth of zooplankton in some stations of the study site (Fig. 31).

During the study period, peak growth of TZ was observed during the month of March in most of the Stations (Fig. 32). Almost overlapping peak growth of zooplankton in both the study years was seen in Stations 2, 7, 8 and 9 (Fig. 32).

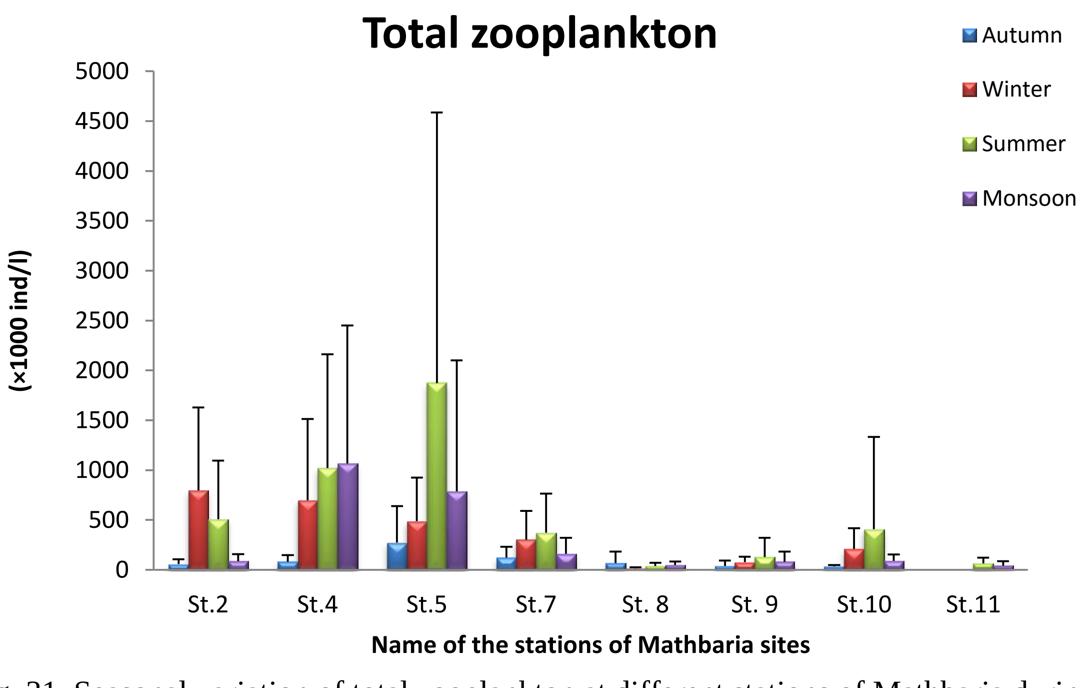


Fig. 31. Seasonal variation of total zooplankton at different stations of Mathbaria during 2010-2012.

Table 15. Monthly mean of TZ (×10³ ind/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	6	45	33	39	6	3	15	NS
	Max.	60	267	978	507	243	120	129	NS
	mean	26	156	420	214	91	43	61	NS
	SD	29.60	156.98	495.16	255.34	131.94	66.70	60.10	NS
Nov.	Min.	33	27	6	75	9	12	30	NS
	Max.	123	75	798	588	12	18	51	NS
	mean	78	51	402	351.6	10.5	15	40.5	NS
	SD	63.64	33.94	560.03	221.77	2.12	4.24	14.85	NS
Dec.	Min.	255	282	231	42	3	6	33	NS
	Max.	771	285	246	570	12	6	33	NS
	mean	513	283.5	238.5	306	7.5	6	33	NS
	SD	364.87	2.12	10.61	373.35	6.36	OTS	OTS	NS
Jan.	Min.	51	15	114	123	6	6	18	NS
	Max.	2856	1377	1500	588	15	129	504	NS
	mean	1026	476	628	318	11	75	230	NS
	SD	1585.96	780.36	759.19	241.40	4.58	62.86	248.86	NS
Feb.	Min.	204	120	120	39	6	30	3	NS
	Max.	1680	2538	1068	840	30	156	585	NS
	mean	777.5	947.5	499.5	295.5	20.5	89	225	NS
	SD	532.42	953.49	343.70	335.75	8.36	53.28	218.00	NS
Mar.	Min.	294	81	81	18	18	24	12	NS
	Max.	2880	1518	972	984	66	840	4635	NS
	mean	1041	696.38	519.43	461.63	37.13	229.13	921.75	NS
	SD	812.44	445.54	376.2038	366.17	16.27	299.33	1555.56	NS
Apr.	Min.	6	240	486	78	6	6	30	9
	Max.	504	2565	3420	864	165	87	696	112
	mean	184.13	1045.5	1767.29	244.88	39.75	31.13	268.13	59.33
	SD	173.10	1035.82	1115.38	256.72	52.64	24.42	221.70	51.54
May	Min.	72	48	96	15	9	9	6	3
	Max.	648	3840	10170	1704	108	396	150	150
	Mean	336.3	1526.4	2897.1	405.33	34.67	123.66	73.67	68.4
	SD	209.22	1871.82	3907.82	511.13	32.28	122.16	58.33	66.18
Jun.	Min.	108	3684	198	87	75	48	156	108
	Max.	279	3684	4650	150	138	192	198	108
	Mean	193.5	3684	2424	118.5	106.5	120	177	108
	SD	120.92	OTS	3148.04	44.55	44.55	101.82	29.70	OTS
Jul.	Min.	45	864	27	63	42	90	78	63
	Max.	72	864	708	414	60	345	120	63
	Mean	58.5	864	367.5	238.5	51	217.5	99	63
	SD	19.09	OTS	481.54	248.19	12.73	180.31	29.70	OTS
Aug.	Min.	42	9	66	96	36	3	105	18
	Max.	96	9	516	210	54	45	123	18
	Mean	69	9	291	153	45	24	114	18
	SD	38.18	OTS	318.20	80.61	12.73	29.70	12.73	OTS
Sep.	Min.	60	165	144	3	9	9	3	6
	Max.	87	1416	618	54	36	75	66	18
	Mean	78	790.5	381	27	23.25	39	20.25	12
	SD	12.73	884.59	204.50	25.63	12.09	28.14	30.53	8.49

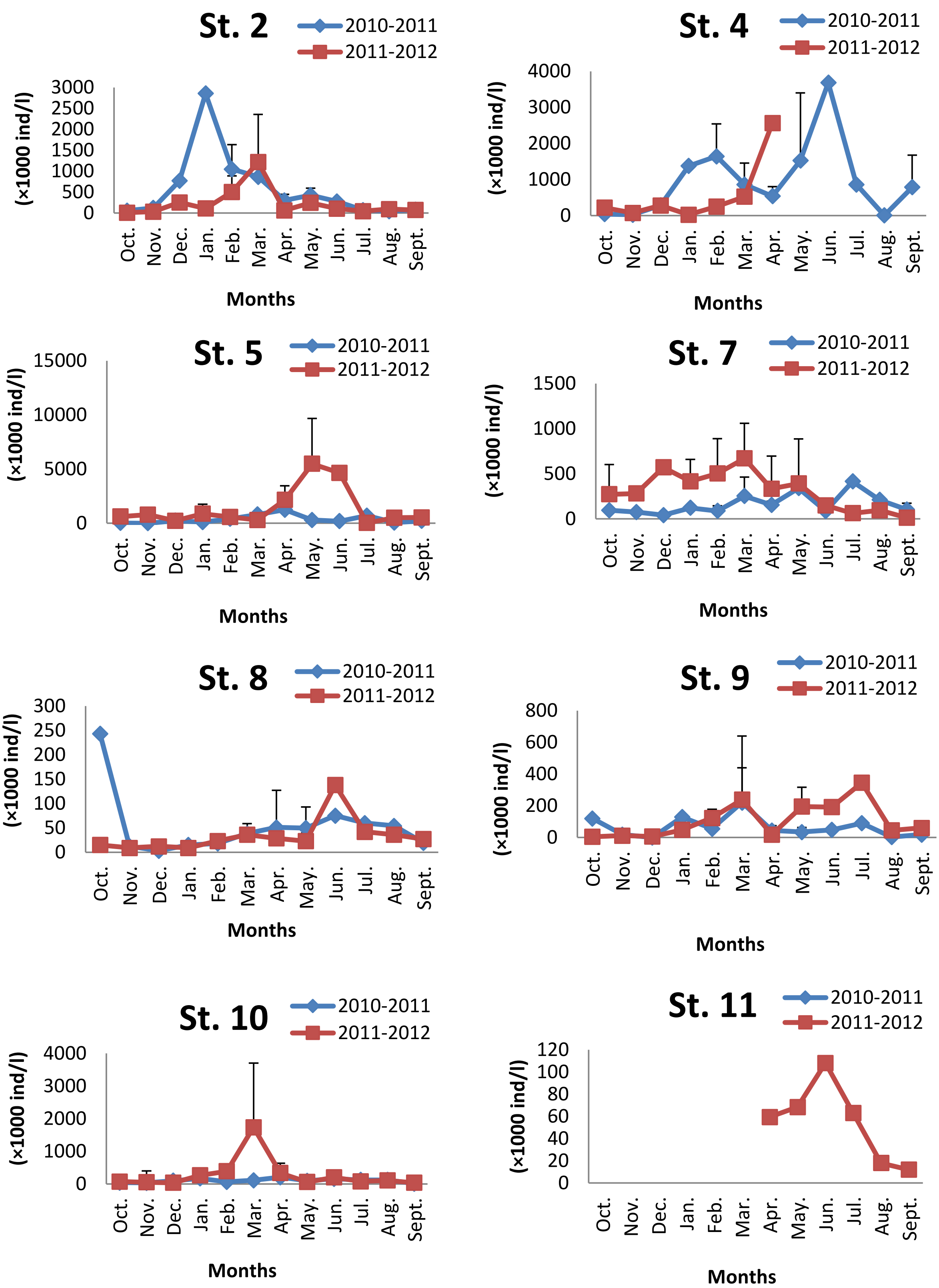


Fig. 32. Comparison of total zooplankton between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Total copepod adult (TCA)

Range of monthly average TCA for the period between October 2010 and September 2012 were recorded 0-271.88 ×10^3 ind/l for Station 2, 6-800 ×10^3 ind/l for Station 4, 13.8-258.86 ×10^3 ind/l for Station 5, 14-117 ×10^3 ind/l for Station 7, 3-37.5 ×10^3 ind/l for Station 8, 6-132 ×10^3 ind/l for Station 9, 9-312.75 ×10^3 ind/l for Station 10 and 7.5-54 ×10^3 ind/l for Station 11. The highest monthly average of TCA for station 2 and 10 were recorded during the month of March. For Station 4, 7, 9 and 11 highest monthly average of TCA were recorded during the month of July. For Station 5 and 8 highest monthly average of TCA were recorded during the month of April and June respectively. Whereas lowest TCA were recorded during the month of November in most of the stations (Table 16).

In the present investigation, the seasonal variation of TCA shows highest amount during summer and lowest in autumn in most of the stations (Fig. 33). In some Stations, summer, monsoon and winter supported their peak growth (Fig. 33).

During the study period TCA shows highest peak during the month of March or April in most of the Stations. It shows down tendency after the month of August (Fig. 34). On an annual scale in Station 2, 5, 7, 8 and 9, total copepod adult (TCA) showed overlapped peak growth in both the study years (Fig. 34). In most cases the time period was January to April.

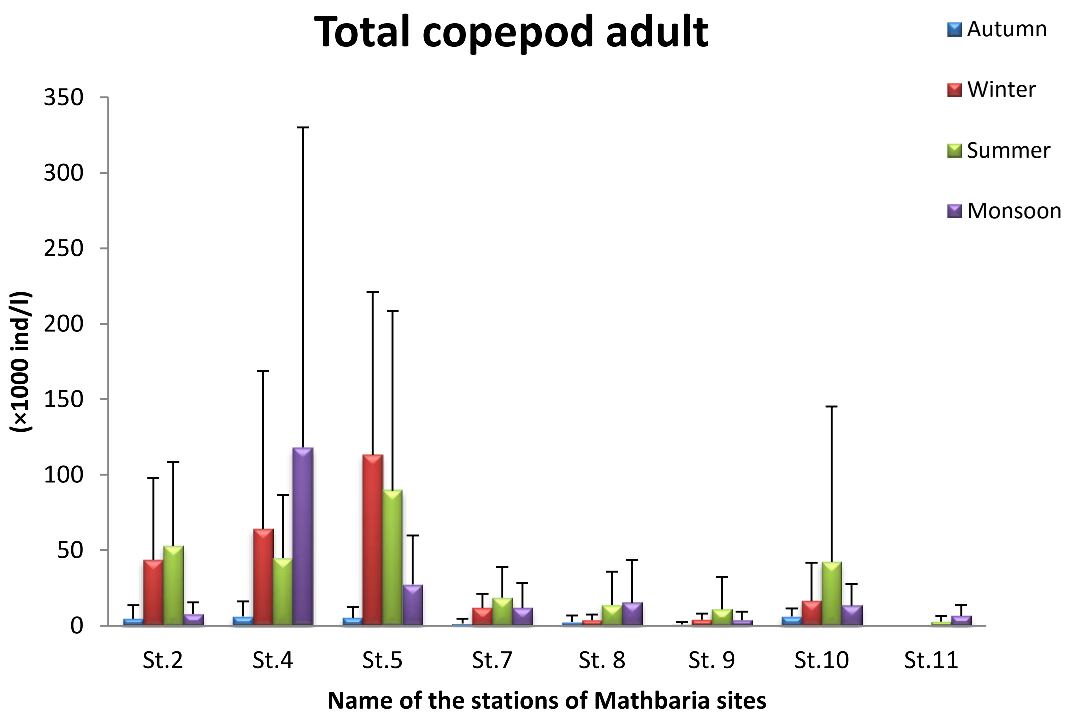


Fig. 33. Seasonal variation of total copepod adult at different stations of Mathbaria during 2010-2012.

Table 16. Monthly mean of TCA (×10^3 ind/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	0	0	0	0	0	0	3	NS
	Max.	18	87	15	15	9	3	12	NS
	mean	7	43.5	9	5	3	1	9	NS
	SD	9.64	61.52	7.94	8.66	5.20	1.73	5.20	NS
Nov.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	3	6	24	0	0	9	NS
	mean	0	1.5	3	12.6	0	0	4.5	NS
	SD	0	2.12	4.24	10.90	0	0	6.36	NS
Dec.	Min.	6	54	3	0	0	0	3	NS
	Max.	21	150	15	24	0	0	3	NS
	mean	13.5	102	9	12	0	0	3	NS
	SD	10.61	67.88	8.49	16.97	0	OTS	OTS	NS
Jan.	Min.	0	0	9	9	0	0	0	NS
	Max.	48	3	84	24	3	9	78	NS
	mean	17	1	35	19	1	4	27	NS
	SD	26.89	1.73	42.46	8.66	1.73	4.58	44.19	NS
Feb.	Min.	0	12	87	0	3	0	0	NS
	Max.	171	348	312	18	12	9	36	NS
	mean	67	83	187	8	6	4.5	13.5	NS
	SD	64.08	132.62	89.69	6.48	3.29	4.14	15.50	NS
Mar.	Min.	24	24	0	3	0	0	0	NS
	Max.	222	120	342	24	36	96	510	NS
	mean	82.88	67.88	141	12.75	13.5	25.88	100.5	NS
	SD	65.10	33.90	133.93	7.98	12.63	32.51	172.29	NS
Apr.	Min.	0	0	0	0	0	0	0	0
	Max.	66	108	336	72	105	6	78	6
	mean	22.13	40.5	74.57	21.75	18	1.88	21.38	2
	SD	24.84	49.81	119.19	22.38	35.86	2.23	25.28	3.46
May	Min.	0	0	0	0	0	0	0	0
	Max.	156	54	360	78	33	30	30	9
	Mean	53.7	10.8	63.9	20.67	10	5.33	9.33	3
	SD	56.01	24.15	108.28	26	12.37	9.81	9.54	4.24
Jun.	Min.	9	OTS	3	0	30	0	12	18
	Max.	18		60	6	96	12	33	18
	Mean	13.5	48	31.5	3	63	6	22.5	18
	SD	6.36	OTS	40.31	4.24	46.67	8.49	14.85	OTS
Jul.	Min.	3	546	3	36	3	0	15	9
	Max.	15	546	108	51	15	15	27	9
	Mean	9	546	55.5	43.5	9	7.5	21	9
	SD	8.49	OTS	74.25	10.61	8.49	10.61	8.49	OTS
Aug.	Min.	0	3	6	0	3	0	9	3
	Max.	12	3	36	6	3	0	39	3
	Mean	6	3	21	3	3	0	24	3
	SD	8.49	OTS	21.21	4.24	0	0	21.21	OTS
Sep.	Min.	0	6	9	0	0	0	0	0
	Max.	21	18	39	6	12	9	0	3
	Mean	6	12	18	4	4.5	3	0	1.5
	SD	10.10	8.49	14.07	3.46	5.20	4.24	0	2.12

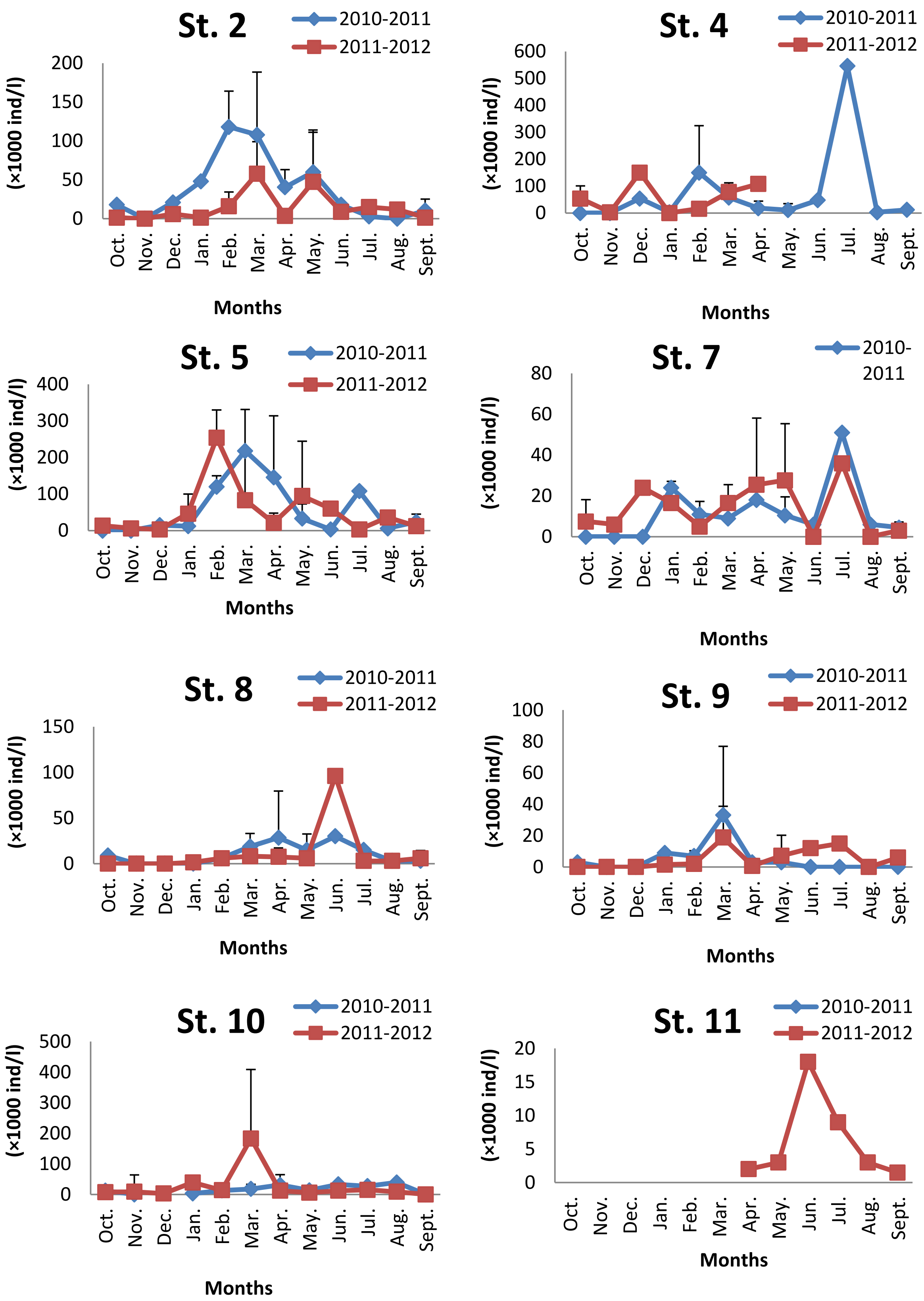


Fig. 34. Comparison of total copepod adult between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Total copepod nauplii (TCN)

Range of monthly average TCN for the period between October 2010 and September 2012 were recorded 0-82.88 $\times10^3$ ind/l for Station 2, 1-546 $\times10^3$ ind/l for Station 4, 1-187 $\times10^3$ ind/l for Station 5, 3-43.5 $\times10^3$ ind/l for Station 7, 0-63 $\times10^3$ ind/l for Station 8, 0-25.88 $\times10^3$ ind/l for Station 9, 0-100.5 $\times10^3$ ind/l for Station 10 and 1.5-18 $\times10^3$ ind/l for Station 11. The highest monthly average of TCN for Station 2, 9 and 10 were recorded during the month of March. For Station 4, and 7 highest monthly average of TCN were recorded during the month of July. For Station 5 highest monthly average of TCN were recorded during the month of February. For Station 8 and 11 highest monthly average of TCN were recorded during the month of June. Whereas lowest TCN were recorded for station 2 during the month of October. For Station 4 and 5 lowest TCN were recorded during the month of August. For Station 7, 10 and 11 lowest TCN were recorded during the month of September (Table 17).

In the present investigation, the seasonal variation of TCN shows highest amount during summer and lowest in autumn in most of the stations (Fig. 35). Station 2, 4, and 5 supported high TCN compared to the rest of the studied Station (Fig. 35).

During the study period TCN showed highest peak during the month of March or April in most of the Stations. It showed an increasing tendency after the month of January. However after the month of August TCN fell (Fig. 36).

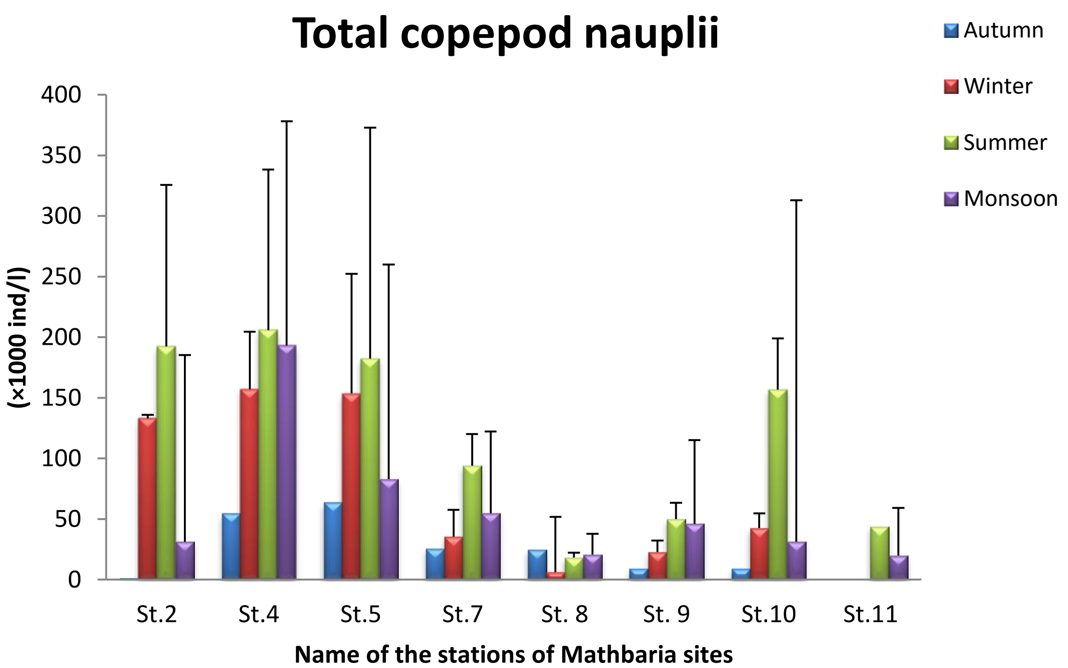


Fig. 35. Seasonal variation of total copepod nauplii at different stations of Mathbaria during 2010-2012.

Table 17. Monthly mean of TCN (×10^3 ind/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	0	12	9	21	0	0	3	NS
	Max.	0	129	174	93	93	21	39	NS
	mean	0	70.5	73	56	33	8	16	NS
	SD	0	82.73	88.50	36.04	52.05	11.36	19.97	NS
Nov.	Min.	0	24	0	0	0	0	0	NS
	Max.	6	66	210	60	6	12	27	NS
	mean	3	45	105	36.6	3	6	13.5	NS
	SD	4.24	29.70	148.49	23.66	4.24	8.49	19.09	NS
Dec.	Min.	42	60	12	9	3	6	12	NS
	Max.	114	189	138	48	3	6	12	NS
	mean	78	124.5	75	28.5	3	6	12	NS
	SD	50.91	91.22	89.10	27.58	0	OTS	OTS	NS
Jan.	Min.	3	15	33	27	0	6	0	NS
	Max.	342	66	132	60	12	48	90	NS
	mean	124	39	69	45	6	27	42	NS
	SD	189.17	25.63	54.74	16.70	6	21	45.30	NS
Feb.	Min.	24	72	12	3	3	12	0	NS
	Max.	396	450	666	84	12	36	105	NS
	mean	156	227	222	33	7.5	23.5	48	NS
	SD	136.94	136.00	239.68	31.92	3.15	8.98	46.75	NS
Mar.	Min.	36	24	51	6	0	0	9	NS
	Max.	636	666	342	186	36	264	1365	NS
	mean	271.88	207.75	197.14	84	15	96	312.75	NS
	SD	193.77	202.12	118.37	64.14	11.67	107.37	466.92	NS
Apr.	Min.	0	117	36	48	6	0	21	6
	Max.	336	462	795	168	60	30	252	84
	mean	128.63	234.75	258.86	79.88	16.88	18	135.38	40
	SD	119.01	157.16	264.44	38.32	18.14	11.22	74.88	39.95
May	Min.	24	21	0	0	6	0	6	0
	Max.	330	510	360	240	69	78	108	90
	Mean	180	180	118.5	115.67	22.33	37.67	37	46.2
	SD	127.26	212.33	121.74	89.19	20.79	27.42	33.64	43.56
Jun.	Min.	24	60	30	6	33	30	24	54
	Max.	105	60	120	48	42	54	60	54
	Mean	64.5	60	75	27	37.5	42	42	54
	SD	57.28	OTS	63.64	29.70	6.36	16.97	25.46	OTS
Jul.	Min.	6	800	3	24	24	27	18	21
	Max.	33	800	276	210	33	237	69	21
	Mean	19.5	800	139.5	117	28.5	132	43.5	21
	SD	19.09	OTS	193.04	131.52	6.36	148.49	36.06	OTS
Aug.	Min.	21	6	0	84	18	0	42	9
	Max.	78	6	27	90	30	45	57	9
	Mean	49.5	6	13.5	87	24	22.5	49.5	9
	SD	40.31	OTS	19.09	4.243	8.49	31.82	10.60	OTS
Sep.	Min.	9	66	42	3	3	6	0	3
	Max.	33	99	114	21	18	63	30	12
	Mean	19.5	82.5	70.5	14	10.5	28.5	9	7.5
	SD	12.37	23.33	31.51	9.64	7.14	24.31	14.07	6.36

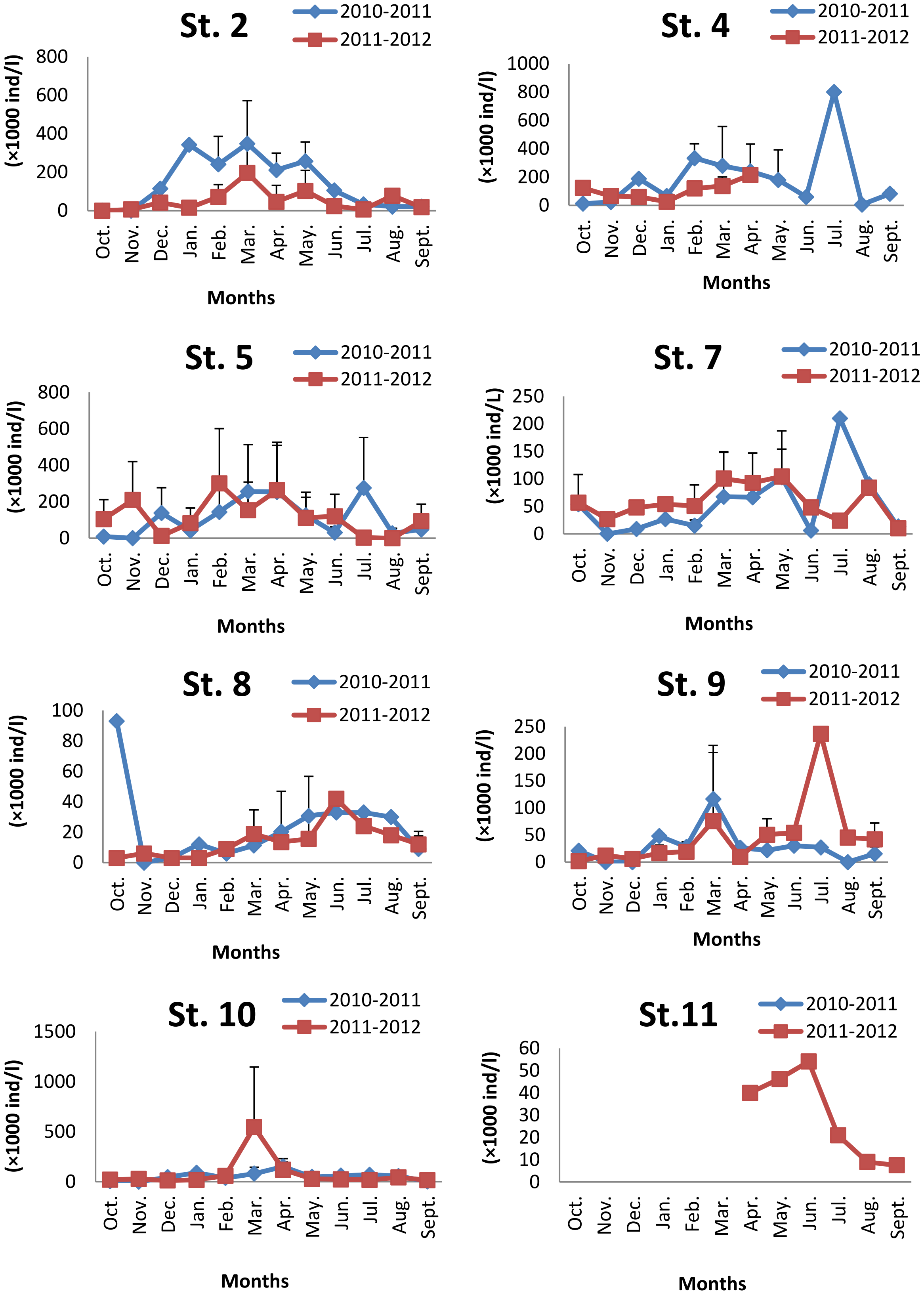


Fig. 36. Comparison of TCN between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

***Vibrio cholerae* in water analysis (VCWA)**

During the study period between October 2010 and September 2012, stations 2, 7, 8, 10 and 11 were found to be infested by *Vibrio cholera*e. The highest amount of VCWA was found in Station 2 during the month of April and the lowest amount in October. In other stations VCWA showed its gowth during the month of March to May. In Station 11, the highest amount of VCWA found in May (2012) among all the stations (Table 18).

In the present investigation, seasonally VCWA showed their occurrence during summer. Its concentration was high in Station 11 followed by 2, 8 and 10 (Fig. 37).

During the study period it shows highest peak during the month of April in most of the station. It fell down after May in both the study year (Fig. 38).

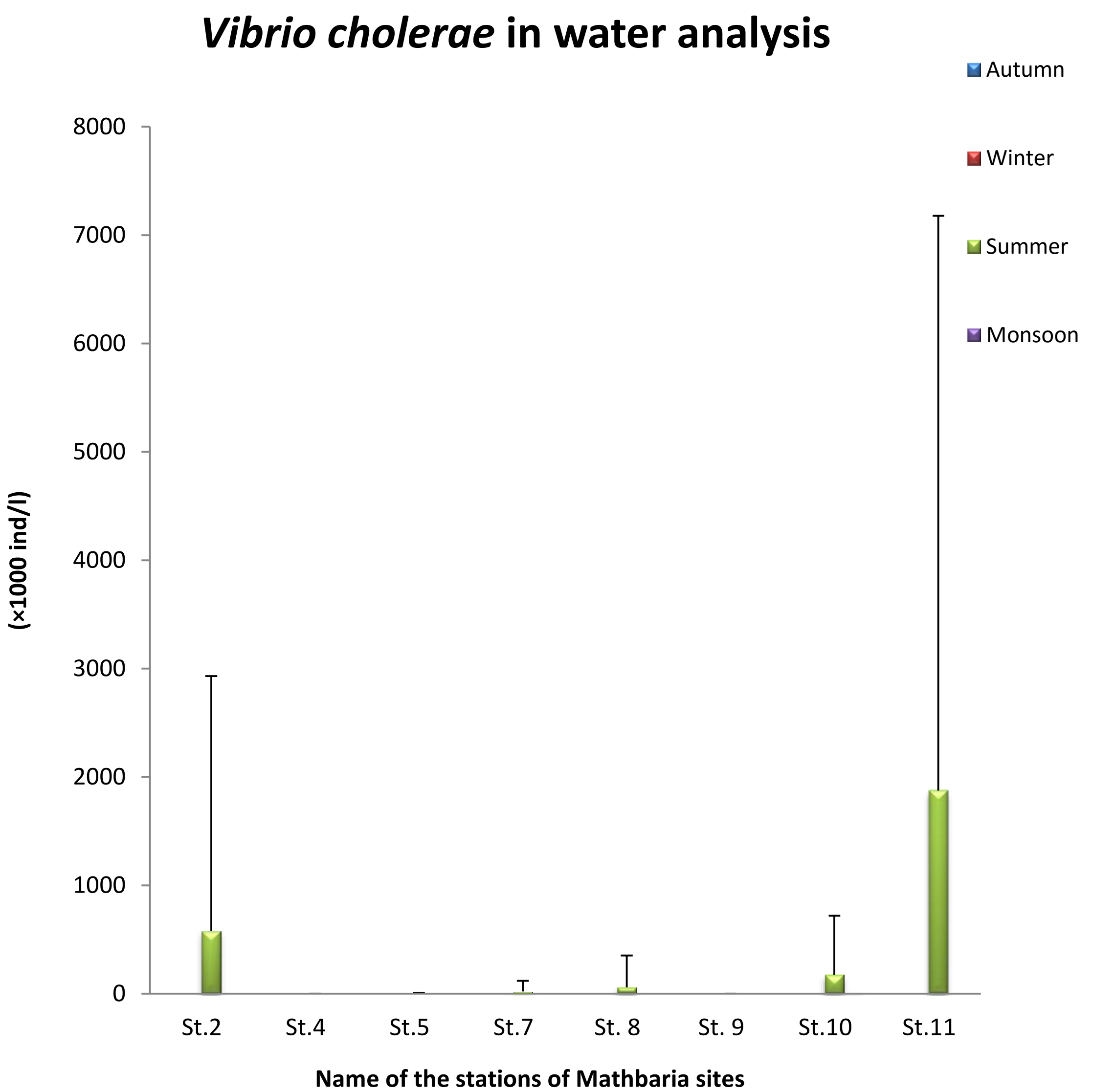


Fig. 37. Seasonal variation of *Vibrio cholerae* in water analysis at different stations of Mathbaria during 2010-2012.

Table 18. Monthly mean of VCWA (×10^3 ind/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	0	0	0	0	0	0	0	NS
	Max.	10	0	0	0	0	0	0	NS
	mean	3.33	0	0	0	0	0	0	NS
	SD	5.77	0	0	0	0	0	0	NS
Nov.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	0	0	0	0	NS
	mean	0	0	0	0	0	0	0	NS
	SD	0	0	0	0	0	0	0	NS
Dec.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	0	0	0	0	NS
	mean	0	0	0	0	0	0	0	NS
	SD	0	0	0	0	0	0	0	NS
Jan.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	0	0	0	0	NS
	mean	0	0	0	0	0	0	0	NS
	SD	0	0	0	0	0	0	0	NS
Feb.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	0	0	0	0	NS
	mean	0	0	0	0	0	0	0	NS
	SD	0	0	0	0	0	0	0	NS
Mar.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	0	0	0	2400	NS
	mean	0	0	0	0	0	0	300	NS
	SD	0	0	0	0	0	0	848.53	NS
Apr.	Min.	0	0	0	0	0	0	0	0
	Max.	12000	0	30	40	1500	0	1400	0
	mean	1875	0	3.75	5	187.5	0	262.5	0
	SD	4125.10	0	10.61	14.14	530.33	0	520.82	0
May	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	500	0	0	0	15000
	Mean	0	0	0	50	0	0	0	3000
	SD	0	0	0	158.11	0	0	0	6708.20
Jun.	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Jul.	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Aug.	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Sep.	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	120	0
	Mean	0	0	0	0	0	0	30	0
	SD	0	0	0	0	0	0	60	0

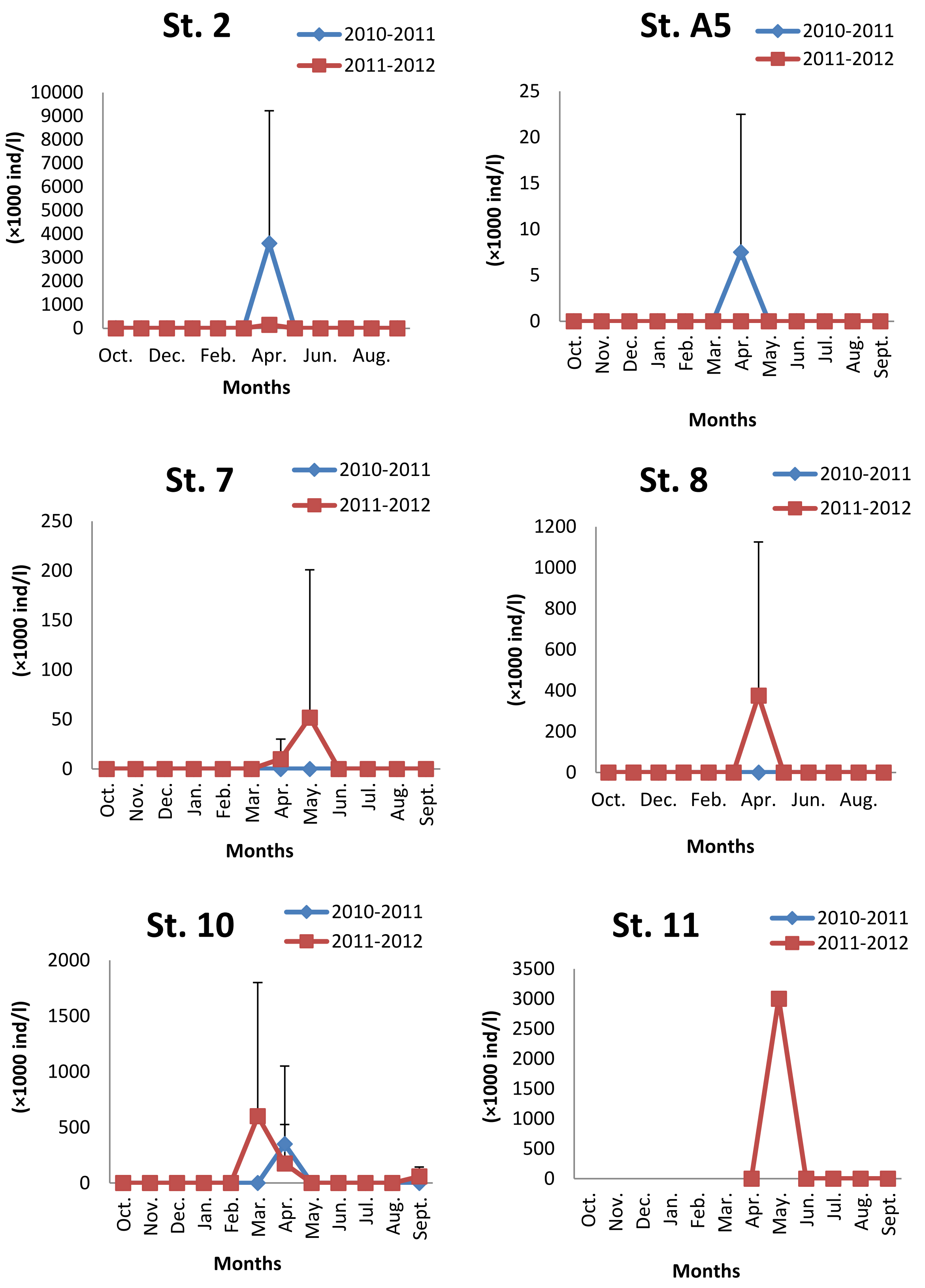


Fig. 38. Comparison of VCWA between the year of 2010-11 and 2011-12 for all the stations (St. 2 to 11) of Mathbaria.

Vibrio cholerae in zooplankton analysis (VCZP)

During the study period, between October 2010 and September 2012, it showed that in Station 2, 7, 8, 10 and 11 *Vibrio cholerae* was found in zooplankton. The highest amount of VCWA was found in Station 2 during the month of April and lowest amount in October. For Station 7 and 8, VCZP showed highest amount during the month of October and lowest amount in May and April, respectively. In Station 10 and 11 the highest amount of VCZP found in May and lowest amount in September (Table 19).

In the present investigation, the seasonal variation of VCZP showed its occurrence in summer in Station 2, 10 and 11. In Station 7 and 8, *V. cholerae* occurred in monsoon. A short occurrence of *V. cholerae* in autumn and monsoon was recorded in Station 2 and 11, respectively (Fig. 39).

During the study period *V. cholerae* showed highest peak during the month of April in most of the stations except the Station 7 and 8. In these stations highest peak observed in October. It fell down after May in both the study years (Fig. 40).

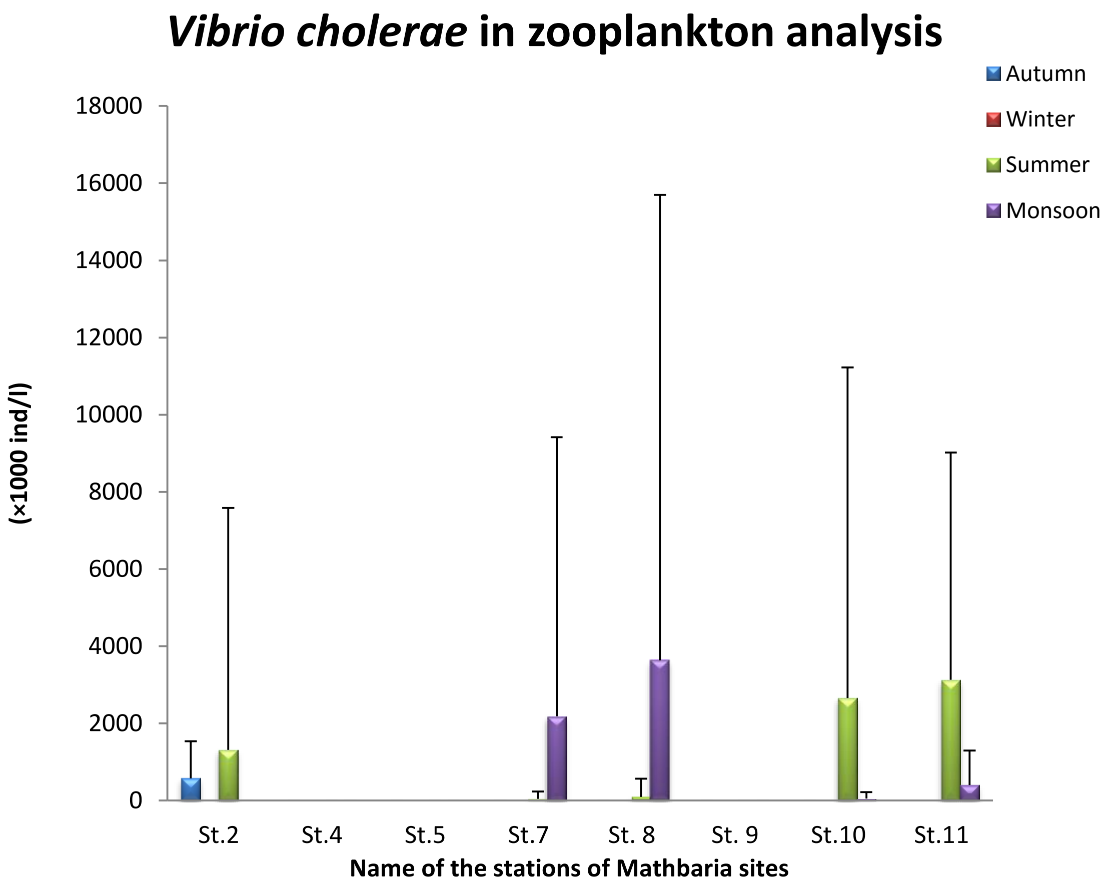


Fig. 39. Seasonal variation of *Vibrio cholerae* in zooplankton analysis at different stations of Mathbaria during 2010-2012.

Table 19. Monthly mean of VCZP (×10^3 ind/l) at different stations of Mathbaria.

Month		St.2	St.4	St.5	St.7	St.8	St.9	St.10	St.11
Oct.	Min.	0	0	0	0	0	0	0	NS
	Max.	2000	0	0	24000	40000	0	0	NS
	mean	666.67	0	0	8000	13333.33	0	0	NS
	SD	1154.70	0	0	13856.41	23094.01	0	0	NS
Nov.	Min.	0	0	0	0	0	0	0	NS
	Max.	300	0	0	0	0	0	0	NS
	mean	150	0	0	0	0	0	0	NS
	SD	212.13	0	0	0	0	0	0	NS
Dec.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	0	0	0	0	NS
	mean	0	0	0	0	0	0	0	NS
	SD	0	0	0	0	0	0	0	NS
Jan.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	0	0	0	0	NS
	mean	0	0	0	0	0	0	0	NS
	SD	0	0	0	0	0	0	0	NS
Feb.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	0	0	0	0	NS
	mean	0	0	0	0	0	0	0	NS
	SD	0	0	0	0	0	0	0	NS
Mar.	Min.	0	0	0	0	0	0	0	NS
	Max.	0	0	0	0	0	0	0	NS
	mean	0	0	0	0	0	0	0	NS
	SD	0	0	0	0	0	0	0	NS
Apr.	Min.	0	0	0	0	0	0	0	0
	Max.	32000	0	0	0	2400	0	40000	4000
	mean	4250	0	0	0	300	0	8625	2666.67
	SD	11234.51	0	0	0	848.53	0	14272.23	2309.40
May	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	1000	0	0	0	17000
	Mean	0	0	0	100	0	0	0	3400
	SD	0	0	0	316.23	0	0	0	7602.63
Jun.	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Jul.	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Aug.	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Sep.	Min.	0	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	550	2000
	Mean	0	0	0	0	0	0	137.5	1000
	SD	0	0	0	0	0	0	275	1414.21

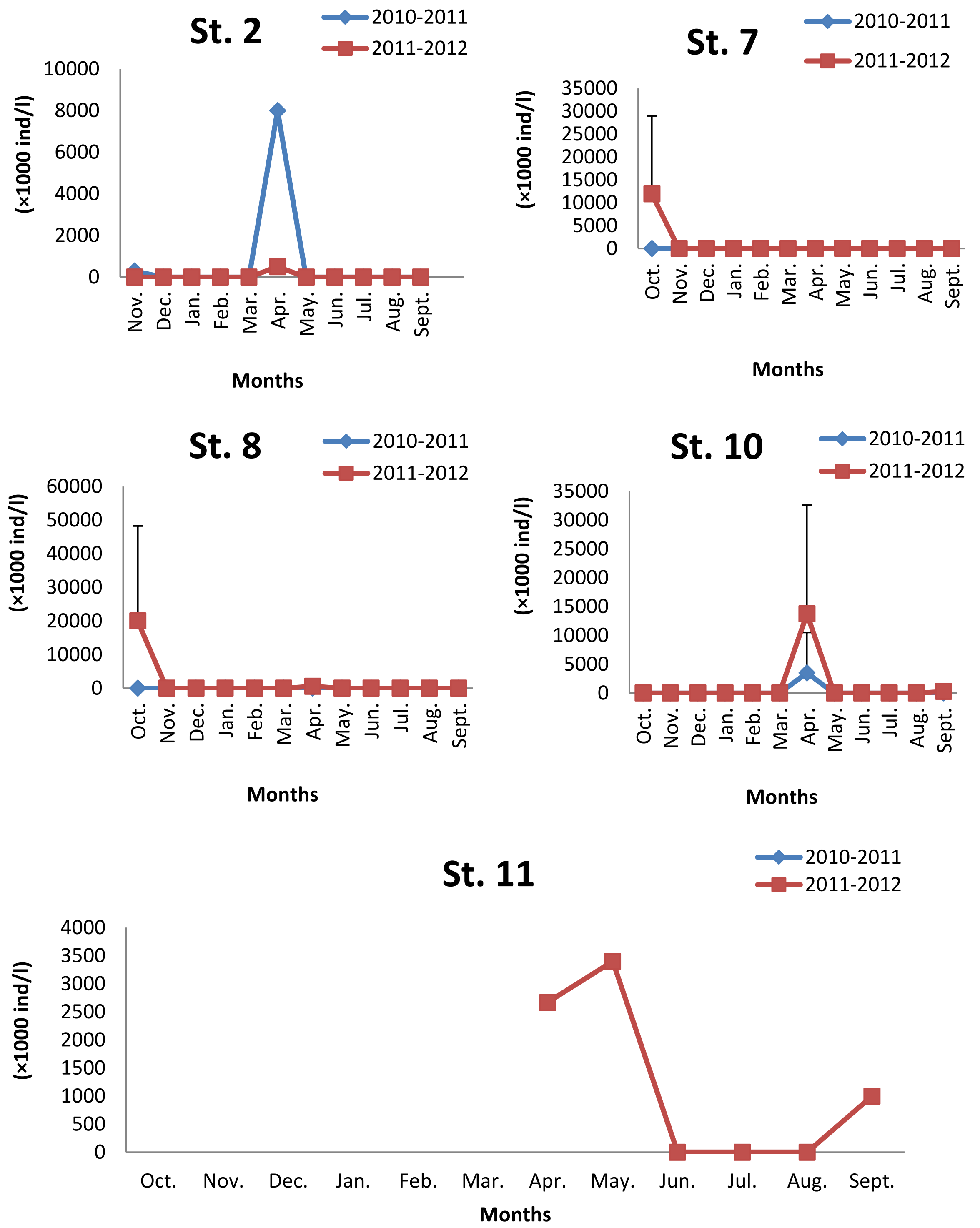


Fig. 40. Comparison of VCZP between the year of 2010-11 and 2011-12 for all the stations (St. 2 to11) of Mathbaria.

Chhatak sites

Physical parameters

Water depth

Range of water depth (WD) for the period between October 2010 and September 2012 were recorded 1.90-3.66 m for Station 1, 1.98-3.19 m for Station 4, 2.07-3.04 m for Station 9, 2.15-3.63 m for Station 11 and 0.55-1.51 m for Station 12. Highest monthly average of WD for Station 1 was recorded in the month of July whereas lowest in the month of April, for Station 4 highest WD was recorded in the month of August and lowest in the month of April, for Station 9 highest WD was recorded in the month of July and lowest in the month of April, for Station 11 highest WD was recorded in the month of July and lowest in the month of March and for Station 12 highest WD was recorded in the month of July and lowest in the month of March (Table 20).

In the present investigation, the seasonal variation of WD observed highest during monsoon and lowest in summer season in most of the stations (Fig. 41). From highest to lowest WD the seasonal pattern followed a trend like monsoon-autumn-winter-summer in most of the studied stations (Fig. 41).

On an annual sequence, the water depth starts increasing just after the month of April and continues up to July and there after the fluctuation takes up a decreasing trend from the month of August to September, it increased again in October and it fell down after the month of November (Fig. 42). The annual pattern of WD fluctuation was observed same in both the study years (Fig. 42).

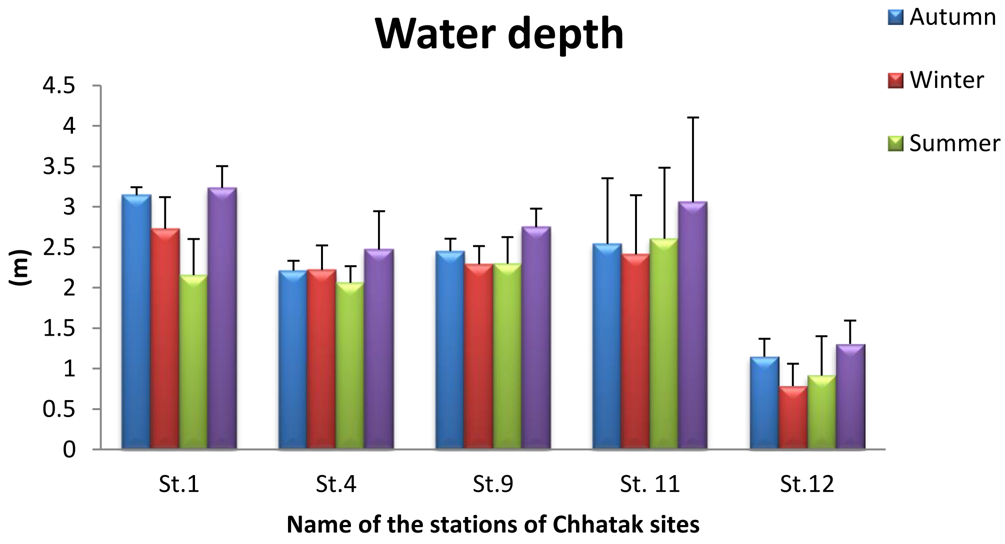


Fig. 41. Seasonal variation of water depth at different stations of Chhatak during 2010-2012.

Table 20. Monthly mean of water depth (m) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	3.05	NS	2.14	2.43	NS	1.78	0.96
	Max.	3.2	NS	2.46	2.73	NS	4	1.48
	mean	3.13	NS	2.28	2.56	NS	2.66	1.21
	SD	0.07	NS	0.15	0.10	NS	1.03	0.22
Nov.	Min.	2.89	NS	2.03	1.92	NS	1.93	0.45
	Max.	3.33	NS	2.28	2.59	NS	3.95	1.4
	mean	3.05	NS	2.18	2.36	NS	3.01	0.97
	SD	0.14	NS	0.09	0.23	NS	1.01	0.29
Dec.	Min.	2.77	NS	1.96	1.98	NS	1.88	0.56
	Max.	2.94	NS	2.98	2.48	NS	3.72	0.88
	mean	2.87	NS	2.31	2.27	NS	2.75	0.68
	SD	0.07	NS	0.46	0.24	NS	1.00	0.15
Jan.	Min.	2.49	NS	1.95	2.08	NS	1.72	0.52
	Max.	2.87	NS	2.18	2.42	NS	3.05	0.66
	mean	2.68	NS	2.07	2.25	NS	2.39	0.59
	SD	0.27	NS	0.16	0.24	NS	0.94	0.10
Feb.	Min.	1.87	NS	1.86	2.14	NS	1.62	0.62
	Max.	1.94	NS	2.65	2.24	NS	3.02	1.42
	mean	1.91	NS	2.26	2.19	NS	2.32	1.02
	SD	0.049	NS	0.56	0.07	NS	0.99	0.57
Mar.	Min.	1.68	NS	1.86	2.01	NS	1.64	0.5
	Max.	2.25	NS	2.12	2.35	NS	2.66	0.6
	mean	1.97	NS	1.99	2.18	NS	2.15	0.55
	SD	0.40	NS	0.18	0.24	NS	0.72	0.07
Apr.	Min.	1.55	NS	1.74	1.86	NS	1.7	0.46
	Max.	2.25	NS	2.22	2.27	NS	3	0.92
	mean	1.9	NS	1.98	2.07	NS	2.35	0.69
	SD	0.49	NS	0.34	0.29	NS	0.92	0.33
May	Min.	2.53	NS	2.2	2.55	NS	2.06	1.48
	Max.	2.66	NS	2.21	2.74	NS	3.42	1.53
	Mean	2.60	NS	2.21	2.65	NS	2.74	1.51
	SD	0.09	NS	0.01	0.13	NS	0.96	0.04
Jun.	Min.	3.07	NS	2.22	2.81	NS	2.13	0.8
	Max.	3.24	NS	2.26	2.86	NS	4.34	1.47
	Mean	3.16	NS	2.24	2.84	NS	3.24	1.14
	SD	0.12	NS	0.03	0.04	NS	1.56	0.47
Jul.	Min.	3.5	NS	2.4	2.95	NS	2.8	1.5
	Max.	3.82	NS	2.72	3.12	NS	4.45	1.52
	Mean	3.66	NS	2.56	3.04	NS	3.625	1.51
	SD	0.23	NS	0.23	0.12	NS	1.17	0.01
Aug.	Min.	3.6	NS	2.7	2.99	NS	2.19	0.75
	Max.	3.7	NS	3.68	3.05	NS	2.7	1.67
	Mean	3.65	NS	3.19	3.02	NS	2.45	1.21
	SD	0.07	NS	0.69	0.04	NS	0.36	0.65
Sep.	Min.	2.91	NS	1.78	2.25	NS	1.91	0.97
	Max.	3.19	NS	3.42	2.77	NS	3.33	1.57
	Mean	3.08	NS	2.35	2.61	NS	2.22	1.30
	SD	0.09	NS	0.44	0.18	NS	0.43	0.23

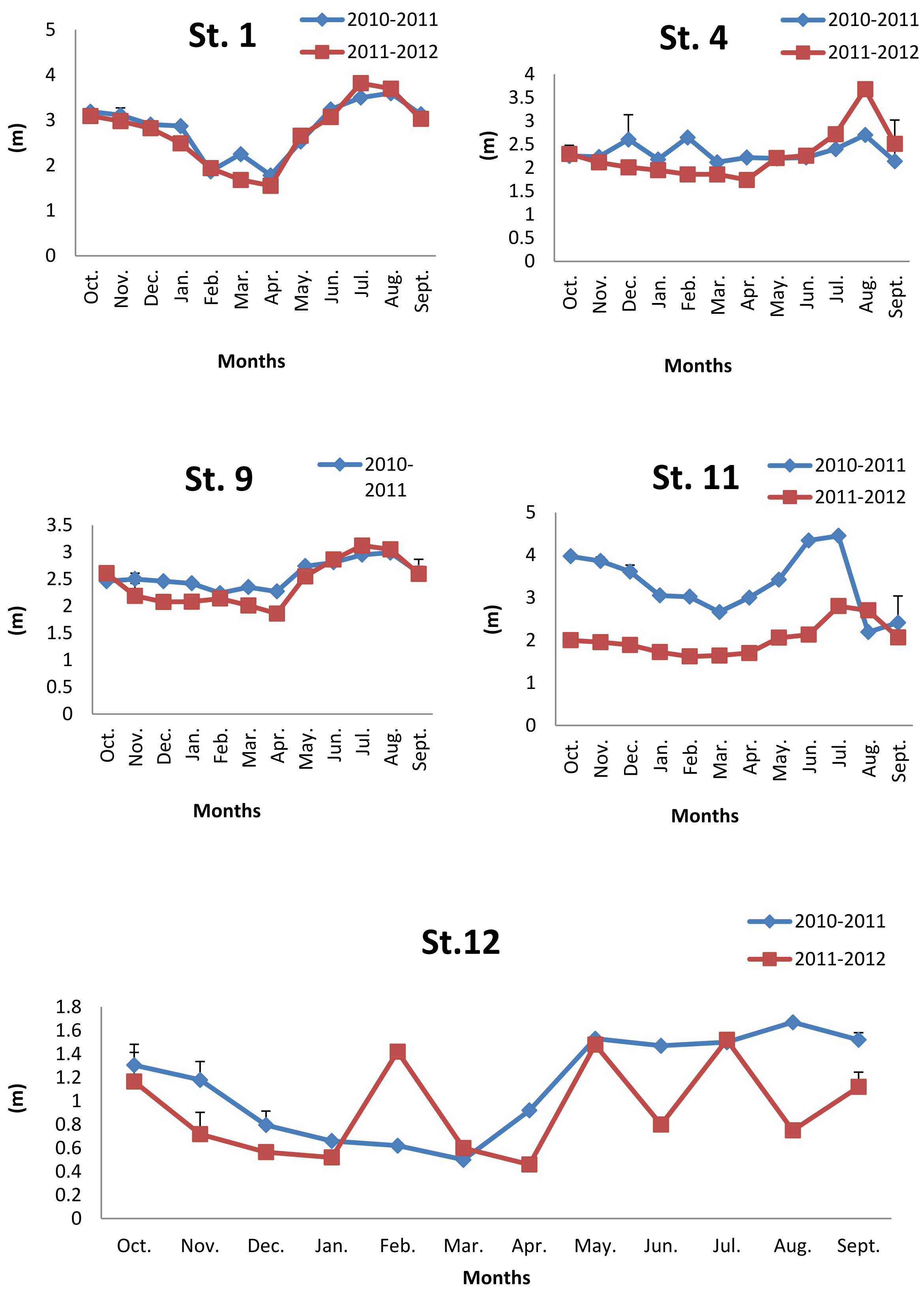


Fig. 42. Comparison of water depth between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Water temperature

Range of water temperature (WT) for the period between October 2010 and September 2012 were recorded 18.79-32.24ºC for Station 1, 20.04-29.91ºC for Station 2, 19.09-31.42ºC for Station 4, 18.32-30.38ºC for Station 9, 19.33-30.8ºC for Station 10, 17.33-31.25ºC for Station 11 and 16.38-29.52ºC for Station 12. The highest monthly average of WT for Station 1, 4, 10 and 11 were recorded in the month of July and for Station 2, 9 and 12 the highest monthly average of WT were recorded in the month of October, June September respectively. Whereas lowest WT was observed in January for all the Station (Table 21.)

In the present investigation the seasonal variation of WT shows higher value during monsoon and lower in winter season in all the stations (Fig. 43). The average temperature of autumn was closer to the WT of monsoon except Station 11 (Fig. 43).

WT started increasing just after the month of January and continued until July and thereafter the fluctuation took a decreasing tendency from the month of July to October. Again it started falling down from November and continued up to January (Fig. 44). The annual trend of fluctuating WT in both the study years and for all the stations fitted nicely (Fig. 44).

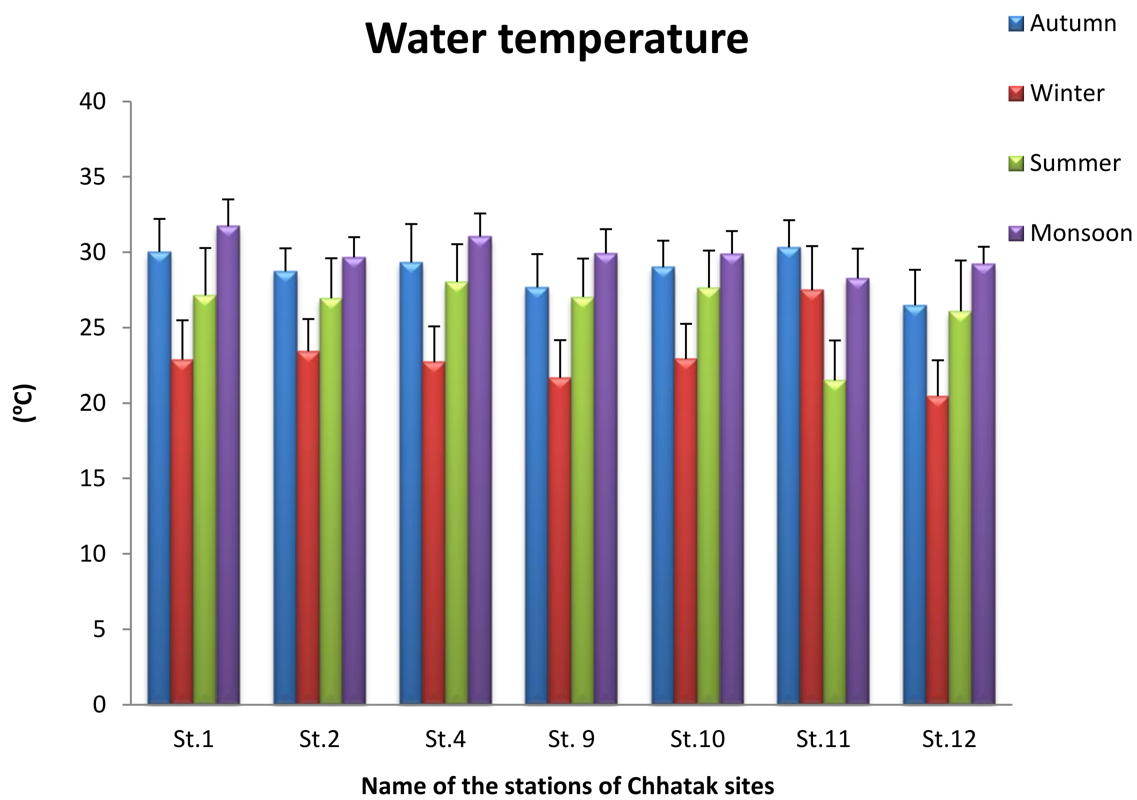


Fig. 43. Seasonal variation of water temperature at different stations of Chhatak during 2010-2012.

Table 21. Monthly mean of water temperature (ºC) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	29.57	29.03	28.17	26.97	28.9	28.47	25.87
	Max.	33.1	31	32.1	30.83	31.07	32.53	30.05
	mean	31.57	29.91	31.03	29.35	30.27	29.98	28.16
	SD	1.17	0.76	1.49	1.25	0.74	1.36	1.35
Nov.	Min.	24.37	25.1	24.33	22.5	24.33	23.4	22.03
	Max.	29.88	28.1	28.55	26.55	28.6	27.65	26.05
	mean	26.66	26.29	25.88	24.74	26.09	25.10	23.34
	SD	1.93	1.18	1.64	1.45	1.49	1.55	1.39
Dec.	Min.	21.6	21.7	21.2	19.95	20.8	20.5	18.65
	Max.	24.13	24.83	23.9	22.8	24.47	23.3	22.53
	mean	22.5	23.20	22.16	20.92	22.47	21.3	20.03
	SD	1.12	1.289	1.27	1.28	1.51	1.34	1.76
Jan.	Min.	18.2	19.4	19	17.63	19.25	17.25	15.85
	Max.	19.37	20.67	19.17	19	19.4	17.4	16.9
	mean	18.79	20.04	19.09	18.315	19.33	17.33	16.38
	SD	0.83	0.90	0.12	0.97	0.11	0.11	0.74
Feb.	Min.	20.9	21.93	20.33	18.93	20.57	19.03	19.57
	Max.	21.3	22.2	23.3	21.75	23.5	20.1	20.55
	mean	21.1	22.07	21.82	20.34	22.04	19.57	20.06
	SD	0.28	0.19	2.10	1.99	2.07	0.76	0.69
Mar.	Min.	24.87	24.53	24.63	23.85	24.13	24.03	22.67
	Max.	25	26.3	25.35	23.87	25.35	25	23.75
	mean	24.94	25.42	24.99	23.86	24.74	24.52	23.21
	SD	0.09	0.89	0.51	0.01	0.86	0.69	0.76
Apr.	Min.	25	23.3	28.1	27.67	27.63	25.67	23.3
	Max.	25.7	29.47	29.3	28.17	29.07	30.07	28.2
	mean	25.35	26.39	28.7	27.92	28.35	27.87	25.75
	SD	0.49	4.36	0.85	0.35	1.02	3.11	3.46
May	Min.	30.8	28.27	30.33	29.23	29.2	29.5	27.43
	Max.	31.53	29.77	30.43	29.4	30.5	30.67	31.13
	Mean	31.17	29.02	30.38	29.32	29.85	30.09	29.28
	SD	0.52	1.06	0.07	0.12	0.92	0.83	2.62
Jun.	Min.	29.57	27.43	28.73	27.33	27.97	28.33	27.43
	Max.	31.53	31.3	33.77	33.43	31.5	31.57	29
	Mean	30.55	29.37	31.25	30.38	29.74	29.95	28.22
	SD	1.39	2.74	3.56	4.31	2.50	2.29	1.11
Jul.	Min.	29.9	28.67	29.8	28.43	29	28.53	28.03
	Max.	34.57	30.37	33.03	31.7	32.6	33.97	30.87
	Mean	32.24	29.52	31.42	30.07	30.8	31.25	29.45
	SD	3.30	1.20	2.28	2.31	2.55	3.85	2.01
Aug.	Min.	28.9	28.3	28.6	27.9	28.57	29.07	27.7
	Max.	32.03	30.13	31.83	30.93	30.27	29.63	29.53
	Mean	30.47	29.22	30.22	29.42	29.42	29.35	28.62
	SD	2.21	1.29	2.28	2.14	1.20	0.40	1.29
Sep.	Min.	29.63	27.67	29.27	28.3	27.63	27.93	27.67
	Max.	35.23	31.67	32.93	31.77	32.07	33.2	30.63
	Mean	32.01	29.7	31.00	29.8	29.71	30.18	29.52
	SD	1.61	1.31	1.06	0.99	1.42	1.55	1.06

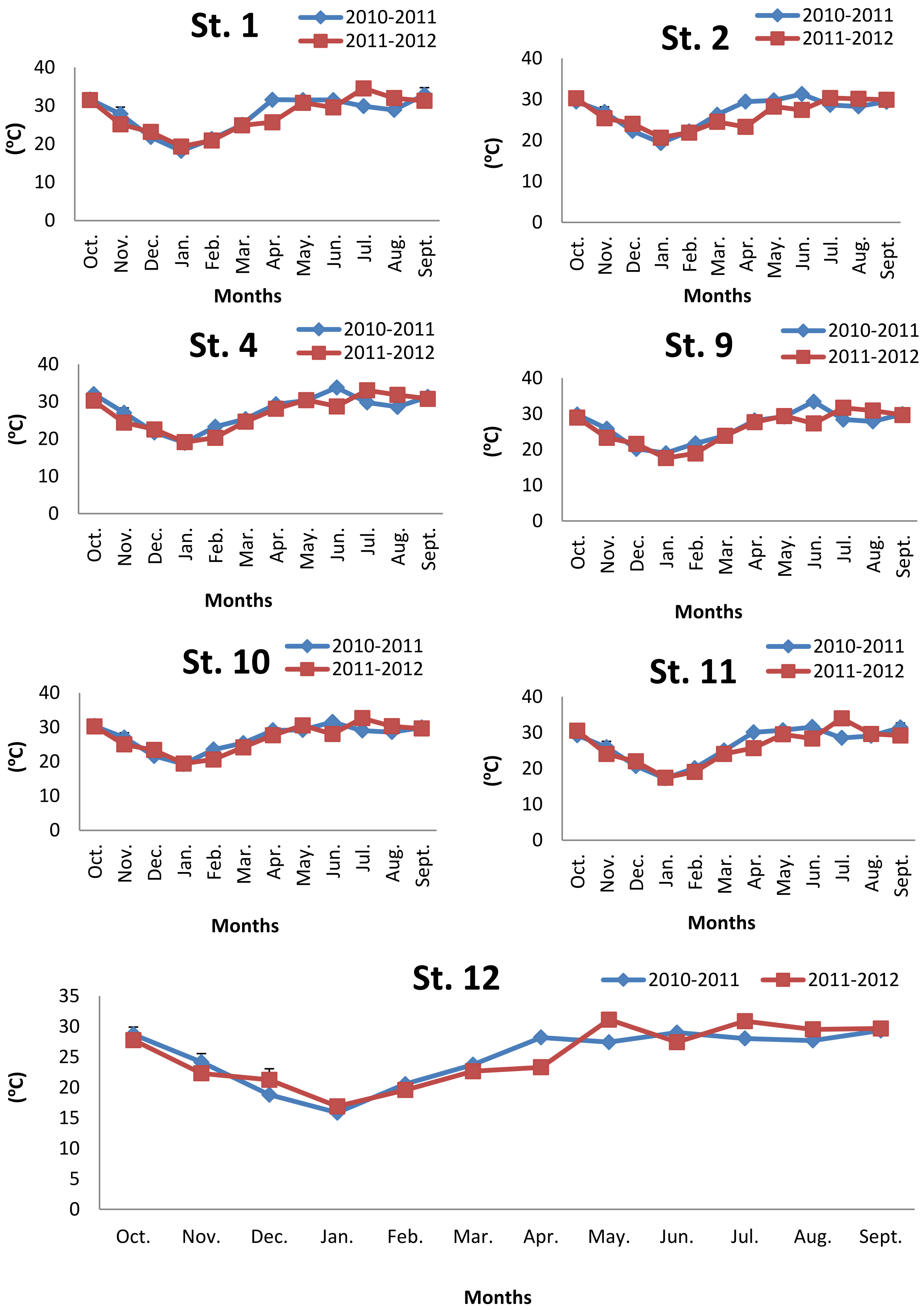


Fig. 44. Comparison of water temperature between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Chemical parameters

Alkalinity

Range of alkalinity for the period between October 2010 and September 2012 were recorded 2.15-5.00 meq/l for Station 1, 0.8-1.26 meq/l for Station 2, 2.25-5 meq/l for Station 4, 2.25-4.85 meq/l for Station 9, 0.8-2.55 meq/l for Station 10, 1.9-4.3 meq/l for Station 11 and 1.2-6.15 meq/l for Station 12 . The Highest monthly average of alkalinity for Station 1 and 4 were recorded in the month of April whereas lowest alkalinity in the month of July, for Station 2 highest alkalinity was recorded in the month of November and lowest in the month of May, for Station 9 highest alkalinity was recorded in the month of March and lowest in June. For Station 10 highest alkalinity was recorded in the month of December and lowest in the month of July. For Station 11 and 12 highest alkalinity was recorded in the month of March and lowest in the month of November. For Station 9 highest alkalinity was recorded in the month of May and lowest in July (Table 22).

In the present investigation, the seasonal variation of alkalinity was observed higher during summer in most of the station except Station 2 and Station 12. In these stations, highest alkalinity was shown in winter whereas lowest alkalinity was observed in monsoon in all the stations (Fig. 45).

Alkalinity showed highest peak during the month of March in most of the stations. Thereafter the fluctuation takes dropping tendency after the month of April and continued up to August. Again it started increasing tendency from the month of September in most of the stations. (Fig. 46). The annual trend of variation in alkalinity was closer in both the study years and for all the stations (Fig. 46).

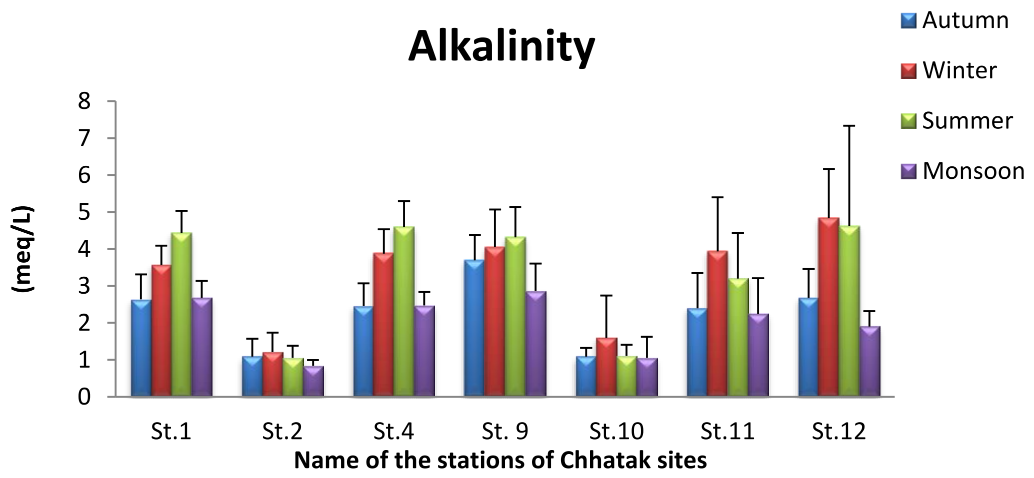


Fig. 45. Seasonal variation of alkalinity at different stations of Chhatak during 2010-2012.

Table 22. Monthly mean of alkalinity (meq/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	1.65	0.7	1	2	0.8	1.4	1
	Max.	3.3	2.4	3.1	4.3	1.5	3.6	3.2
	mean	2.68	1.17	2.36	3.51	1.14	2.51	2.38
	SD	0.73	0.56	0.69	0.74	0.24	0.97	0.74
Nov.	Min.	2.3	0.8	2.33	3.6	0.9	1	2.8
	Max.	3.8	2.9	3.6	4.5	1.3	4.4	4.8
	mean	3.03	1.26	3.05	4.08	1.13	2.67	3.7
	SD	0.63	0.64	0.45	0.37	0.18	1.29	0.73
Dec.	Min.	2.7	1	3.4	1.2	1.1	1.8	3.8
	Max.	4	1	4.3	4.4	5	4.4	6
	mean	3.57	1	3.8	3.45	2.55	3.03	4.68
	SD	0.60	0	0.42	1.52	1.86	1.37	1.04
Jan.	Min.	3.9	0.9	4.5	4.1	1	2.1	5.2
	Max.	4	1	4.6	4.7	1.2	4.7	7
	mean	3.95	0.95	4.55	4.4	1.1	3.4	6.1
	SD	0.07	0.07	0.07	0.42	0.14	1.84	1.27
Feb.	Min.	3.8	1	4.5	3.6	1	2.6	3.8
	Max.	4	1.2	5	5.7	1.2	4.5	7.6
	mean	3.9	1.1	4.75	4.65	1.1	3.55	5.7
	SD	0.14	0.14	0.35	1.48	0.14	1.34	2.69
Mar.	Min.	4.1	1.2	5	4	1.2	2.9	4.3
	Max.	4.5	1.3	5	5.7	1.6	5.7	8
	mean	4.3	1.25	5	4.85	1.4	4.3	6.15
	SD	0.28	0.05	0	1.20	0.28	1.98	2.62
Apr.	Min.	4.5	0.7	4.6	4.4	0.8	2.8	2.6
	Max.	5.5	1.5	5.4	4.7	1.2	5.6	8
	mean	5	1.1	5	4.55	1	4.2	5.3
	SD	0.71	0.57	0.57	0.21	0.28	1.98	3.82
May	Min.	3.7	0.8	3.5	3.4	0.8	2.4	2.2
	Max.	4.3	0.8	4.1	3.7	1	4.2	2.6
	Mean	4	0.8	3.8	3.55	0.9	3.3	2.4
	SD	0.42	0	0.42	0.21	0.14	1.27	0.28
Jun.	Min.	3	0.6	3	0.8	0.6	1.8	1.6
	Max.	3.2	1	3.4	3.7	3.1	4	2.8
	Mean	3.1	0.8	3.2	2.25	1.85	2.9	2.2
	SD	0.14	0.28	0.28	2.05	1.77	1.56	0.85
Jul.	Min.	2	0.8	2.1	1.7	0.8	1.1	1.2
	Max.	2.3	0.8	2.4	2.9	0.8	2.7	1.2
	Mean	2.15	0.8	2.25	2.3	0.8	1.9	1.2
	SD	0.21	0	0.21	0.85	0	1.13	0
Aug.	Min.	2	0.7	2.2	2.5	0.8	2	1.6
	Max.	3.3	1	2.3	3	1	2.8	1.8
	Mean	2.65	0.85	2.25	2.75	0.9	2.4	1.7
	SD	0.92	0.21	0.07	0.35	0.14	0.57	0.14
Sep.	Min.	2.1	0.6	2	2.6	0.7	0.2	1.8
	Max.	3	1	2.7	3.7	1.2	3.2	2.2
	Mean	2.63	0.82	2.37	3.06	0.94	2.26	1.96
	SD	0.36	0.16	0.23	0.36	0.16	0.93	0.12

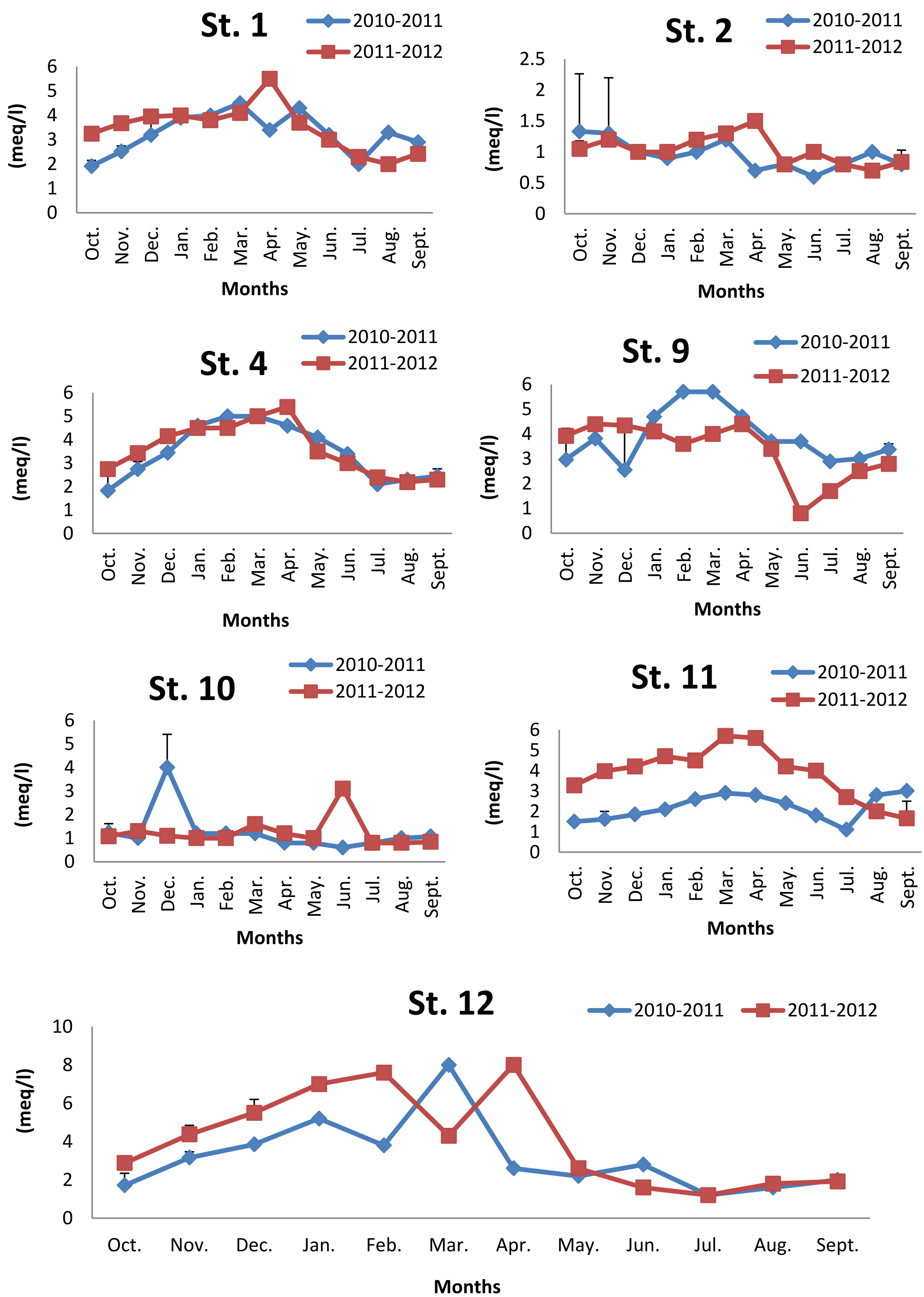


Fig. 46. Comparison of alkalinity between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Salinity

Range of salinity for the period between October 2010 and September 2012 were recorded 0.0-0.2 ‰ for Station 1, 0.0-0.01 ‰ for Station 2, 0.0-0.27 ‰ for Station 4, 0.0-0.1 ‰ for Station 9, 0.0-0.1 ‰ for Station 10, 0-0.2 ‰ for Station 11 and 0.0-0.35 ‰ for Station 12. The Highest monthly average salinity for Station 1 was recorded in the month of February whereas lowest alkalinity in the month of July and August. For Station 2 salinity peak was recorded in the month of November and it was almost 0 for rest of the months, for Station 4 highest salinity was recorded in the month of April and lowest in July and August. For Station 9 highest concentration of salinity was recorded in the month of November and lowest in the month of July and August. For Station 10 highest concentration of salinity was recorded in the month of June and lowest in rest of the months. For station 11 highest concentration of salinity was recorded in the month of January and lowest in July and August and for station 12 highest concentration of salinity was recorded in the month of March and lowest in July to September (Table 23).

Concentration of salinity showed rising tendency after the month of October. In Station 2 it showed highest peak during the month of November and in other stations a fluctuating tendency was observed in different months of both the study years. Concentration dropped in the month of July (Fig. 48).

In the present investigation, the seasonal variation of salinity observed higher during winter and lower in autumn season in most the stations (Fig. 47).

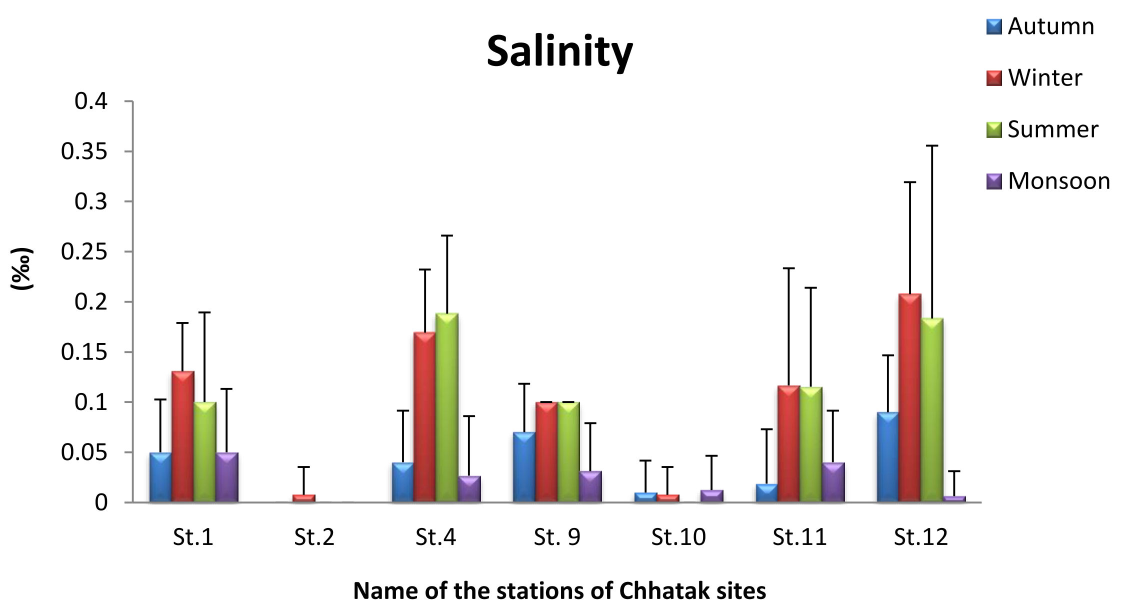


Fig. 47. Seasonal variation of salinity at different stations of Chhatak during 2010-2012.

Table 23. Monthly mean of salinity (‰) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	0	0	0	0	0	0	0
	Max.	0.1	0	0.1	0.1	0.1	0.1	0.1
	mean	0.04	0	0.014	0.04	0.01	0.043	0.06
	SD	0.05	0	0.038	0.05	0.038	0.05	0.05
Nov.	Min.	0	0	0	0.1	0	0	0
	Max.	0.2	0.1	0.1	0.1	0	0.2	0.2
	mean	0.09	0.01	0.09	0.1	0	0.06	0.12
	SD	0.06	0.03	0.03	OTS	0	0.07	0.07
Dec.	Min.	0.1	0	0.2	0.1	0	0	0.2
	Max.	0.1	0	0.2	0.1	0.1	0.2	0.3
	mean	0.1	0	0.2	0.1	0.03	0.1	0.23
	SD	0	0	0	0	0.05	0.12	0.05
Jan.	Min.	0.1	0	0.2	0.1	0	0.1	0.2
	Max.	0.2	0	0.3	0.1	0	0.3	0.4
	mean	0.15	0	0.25	0.1	0	0.2	0.3
	SD	0.07	0	0.07	0	0	0.14	0.14
Feb.	Min.	0.2	0	0.2	0.1	0	0.1	0.2
	Max.	0.2	0	0.2	0.1	0	0.2	0.4
	mean	0.2	0	0.2	0.1	0	0.15	0.3
	SD	0	0	0	0	0	0.07	0.14
Mar.	Min.	0	0	0.2	0.1	0	0.1	0.3
	Max.	0.2	0	0.2	0.1	0	0.2	0.4
	mean	0.1	0	0.2	0.1	0	0.15	0.35
	SD	0.14	0	0	0	0	0.07	0.07
Apr.	Min.	0	0	0.23	0.1	0	0	0.1
	Max.	0.2	0	0.3	0.1	0	0.3	0.3
	mean	0.1	0	0.27	0.1	0	0.15	0.2
	SD	0.14	0	0.05	0	0	0.21	0.14
May	Min.	0.1	0	0.1	0.1	0	0	0
	Max.	0.1	0	0.1	0.1	0	0.1	0
	Mean	0.1	0	0.1	0.1	0	0.05	0
	SD	0	0	0	0	0	0.07	0
Jun.	Min.	0.1	0	0.2	0	0.1	0	0
	Max.	0.2	0	0.2	0.1	0.1	0.2	0.1
	Mean	0.15	0	0.2	0.05	0.1	0.1	0.05
	SD	0.07	0	OTS	0.07	0	0.14	0.07
Jul.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0.1	0
	Mean	0	0	0	0	0	0.05	0
	SD	0	0	0	0	0	0.07	0
Aug.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Sep.	Min.	0	0	0	0	0	0	0
	Max.	0.1	0	0.1	0.1	0	0	0
	Mean	0.06	0	0.02	0.04	0	0	0
	SD	0.05	0	0.04	0.05	0	0	0

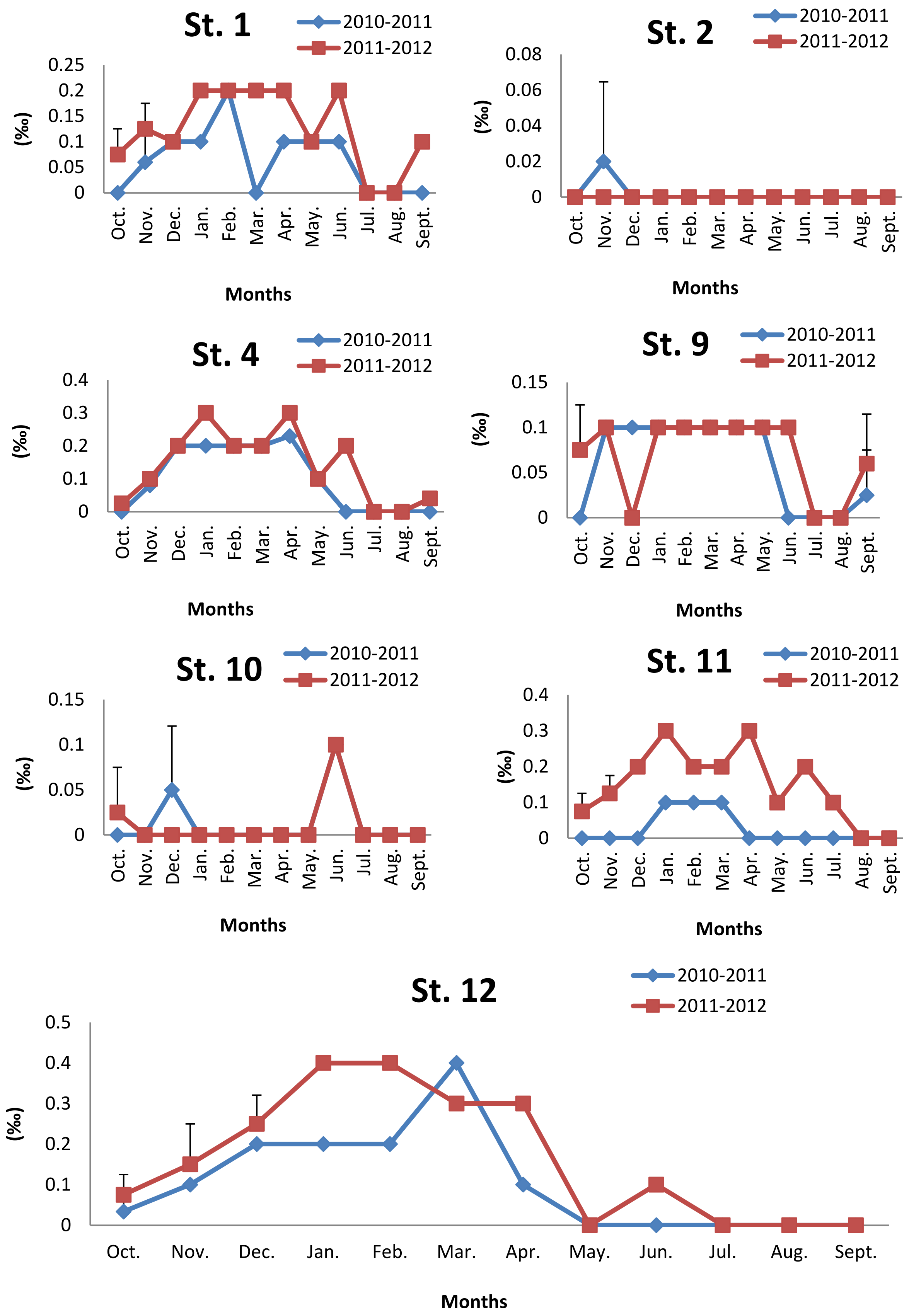


Fig. 48. Comparison of salinity between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

pH

Range of pH for the period between October 2010 and September 2012 were recorded 7.15-8.26 for Station 1, 6.8-7.84 for Station 2, 7.18-7.61 for Station 4, 7.09-7.60 for Station 9, 6.84-7.8 for Station 10, 6.77-8.17 for Station 11 and 6.71-7.75 for Station 12. However, the pH of selected stations was closer to neutral or slightly alkaline. The highest monthly average of pH value for Station 1 was recorded in the month of April and lowest value was recorded in the month of October. For Station 4, 11 and 12 highest monthly average of pH was recorded in the month of June, March and May respectively whereas lowest value of pH for these stations were recorded in July. Rest of the stations (Station 2, 9 and 10) highest monthly average of pH was recorded in the month of January and lowest monthly average of pH was recorded in the month of July (Table 24).

In the present investigation, the seasonal variation of pH was observed higher during summer and lower in autumn season in most of the stations (Fig. 49).

A rise in the pH value was observed in the month of April in most of the stations. In both the study years it showed similar annual trend in most of the stations (Fig. 50). Except the Stations 9 and 10, on an annual range and for the two consecutive years of study, the pH for all other stations showed an identical pattern of fluctuation.

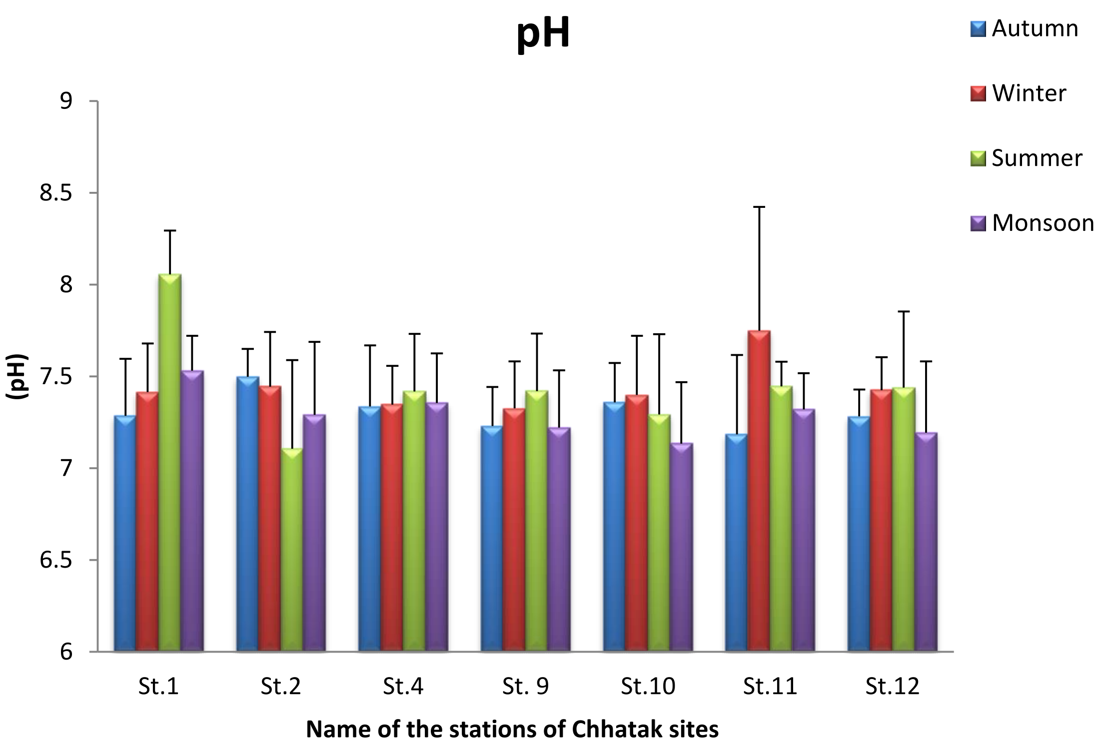


Fig. 49. Seasonal variation of pH at different stations of Chhatak during 2010-2012.

Table 24. Monthly mean of pH at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	6.85	7.22	6.83	6.83	6.9	7	7
	Max.	7.41	7.59	7.8	7.36	7.58	7.59	7.32
	mean	7.15	7.41	7.28	7.12	7.18	7.28	7.21
	SD	0.23	0.11	0.37	0.23	0.23	0.17	0.12
Nov.	Min.	7.1	7.24	7.1	6.95	7.21	7.13	7.39
	Max.	7.85	7.74	7.85	7.61	7.79	7.65	7.57
	mean	7.49	7.55	7.42	7.32	7.46	7.49	7.46
	SD	0.24	0.16	0.22	0.21	0.18	0.16	0.05
Dec.	Min.	6.96	7	7.04	6.82	6.98	7.27	6.97
	Max.	7.51	7.67	7.35	7.37	7.34	7.38	7.49
	mean	7.23	7.30	7.21	7.18	7.23	7.34	7.27
	SD	0.23	0.30	0.15	0.25	0.17	0.05	0.24
Jan.	Min.	7.34	7.83	7.35	7.35	7.33	7.34	7.45
	Max.	7.65	7.84	7.61	7.84	8.27	7.72	7.54
	mean	7.50	7.84	7.48	7.60	7.8	7.53	7.50
	SD	0.22	0.01	0.18	0.35	0.66	0.27	0.06
Feb.	Min.	7.34	6.94	7.22	7.35	7.15	7.37	7.32
	Max.	7.87	7.53	7.38	7.42	7.43	7.42	7.67
	mean	7.61	7.24	7.3	7.39	7.29	7.40	7.50
	SD	0.37	0.42	0.11	0.05	0.20	0.04	0.25
Mar.	Min.	7.84	6.93	6.99	7.21	6.76	6.9	7.51
	Max.	8.04	7.62	7.39	7.79	7.59	7.49	7.99
	mean	7.94	7.28	7.19	7.5	7.18	7.195	7.75
	SD	0.14	0.35	0.28	0.41	0.59	0.42	0.34
Apr.	Min.	8.01	6.73	7.22	7.17	6.93	7.81	7.03
	Max.	8.51	7.72	7.91	7.79	7.94	8.53	7.86
	mean	8.26	7.23	7.57	7.48	7.44	8.17	7.45
	SD	0.35	0.70	0.49	0.44	0.71	0.51	0.59
May	Min.	7.88	6.52	7.43	7.09	7.13	7.23	7.08
	Max.	8.05	7.12	7.57	7.47	7.4	8.53	7.16
	Mean	7.97	6.82	7.5	7.28	7.27	7.88	7.12
	SD	0.12	0.42	0.10	0.27	0.19	0.92	0.06
Jun.	Min.	7.17	6.88	7.3	7.11	6.79	6.49	6.37
	Max.	7.83	6.89	7.92	7.35	7.17	7.35	7.2
	Mean	7.5	6.885	7.61	7.23	6.98	6.92	6.79
	SD	0.47	0.01	0.44	0.17	0.27	0.61	0.59
Jul.	Min.	7.35	6.32	7.12	6.79	6.48	6.64	6.32
	Max.	7.61	7.28	7.24	7.38	7.19	6.9	7.1
	Mean	7.48	6.8	7.18	7.085	6.84	6.77	6.71
	SD	0.18	0.68	0.08	0.42	0.50	0.18	0.55
Aug.	Min.	7.22	6.97	7.12	6.85	6.72	6.65	6.88
	Max.	7.42	7.43	7.43	7.32	7.4	7.51	7.31
	Mean	7.32	7.2	7.28	7.09	7.06	7.08	7.10
	SD	0.14	0.33	0.22	0.33	0.48	0.61	0.30
Sep.	Min.	7.48	7.12	6.97	6.93	6.86	6.8	7.14
	Max.	7.8	7.82	7.82	7.89	7.74	7.89	7.72
	Mean	7.62	7.50	7.37	7.32	7.28	7.31	7.40
	SD	0.10	0.27	0.28	0.32	0.28	0.39	0.20

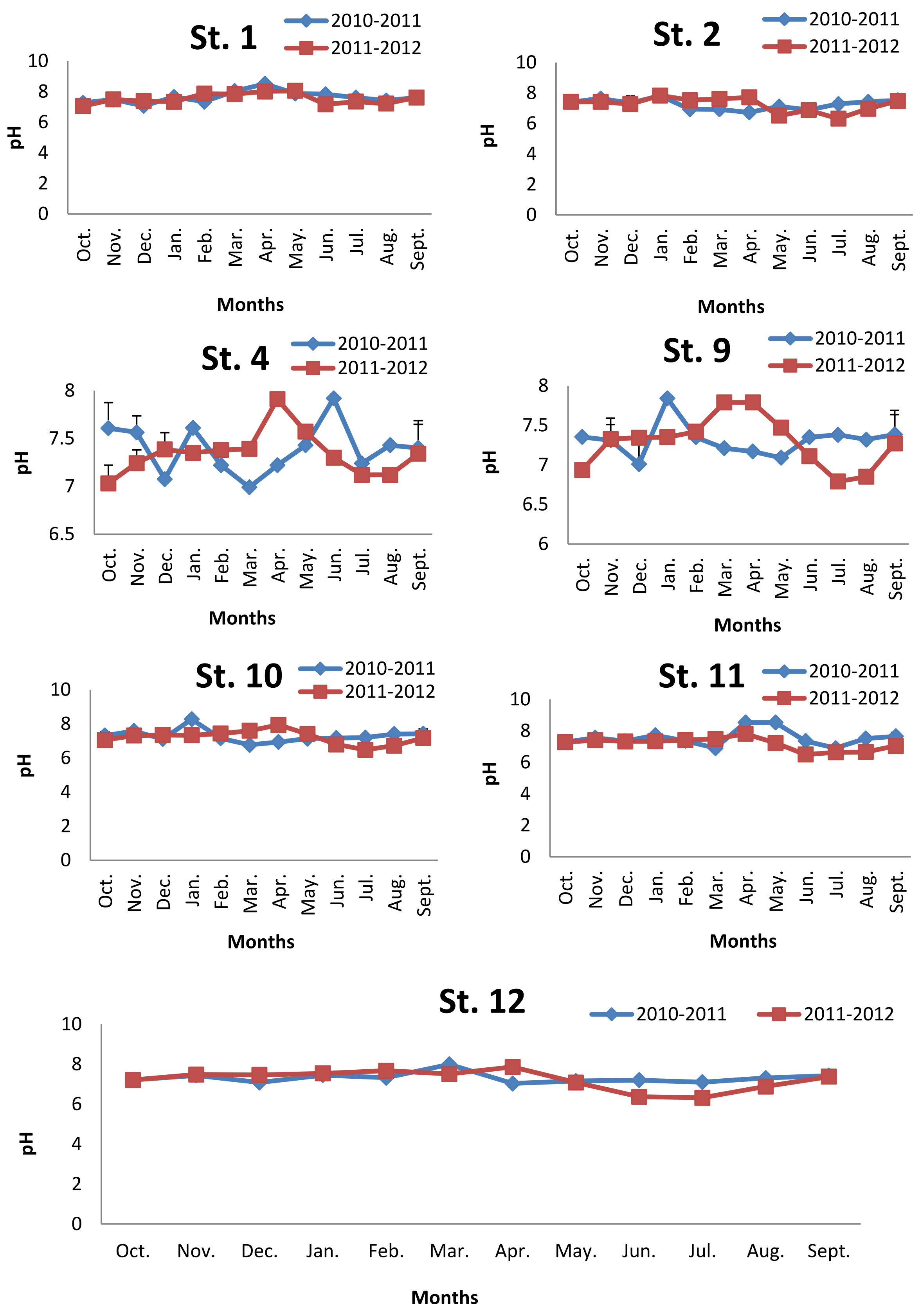


Fig. 50. Comparison of pH between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Total dissolve solids (TDS)

The range of TDS for the period between October 2010 and September 2012 were recorded 101.65-217.8 mg/l for Station 1, 24.15-87 mg/l for Station 2, 98.95-286.9 mg/l for Station 4, 77.45-178.33 mg/l for Station 9, 27.1-195 mg/l for Station 10, 97.35-214.4 mg/l for Station 11 and 44.45-342.5 mg/l for Station 12. The highest monthly average of TDS for Station 1, 2, 9, 10 and 12 were recorded in the month of January, February, December, June and March, respectively. Whereas lowest concentration of TDS observed in July in most of the stations (Table 25).

In the present investigation, the seasonal variation of TDS observed higher during winter and lower in monsoon in most of the stations (Fig. 51). Winter and summer concentration of TDS ran almost parallel in most of the stations (Fig. 51).

Concentration of TDS showed highest peak in the month of February. TDS concentration starts increasing just after the month of October and continues up to April and the fluctuation takes a downward tendency from the month of May (Fig. 52). With few exceptions, the annual fluctuation of TDS in both the study years and in most of the stations were similar (Fig. 52).

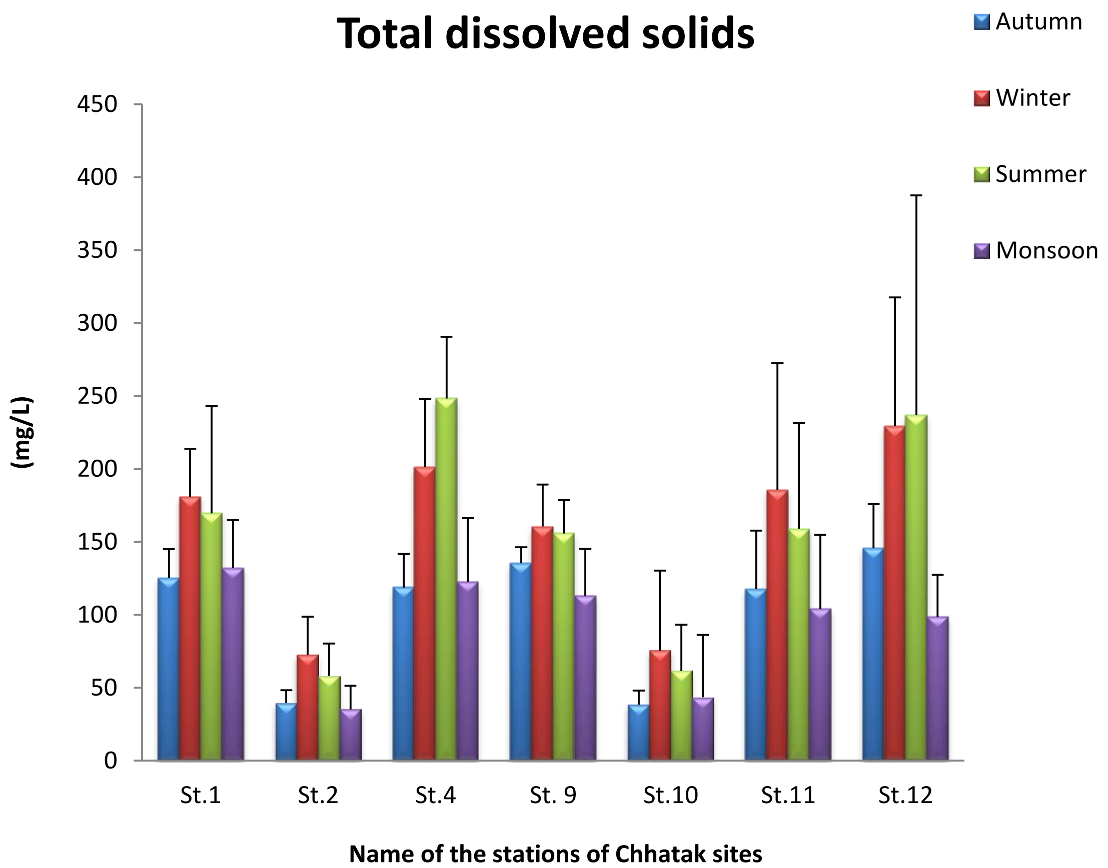


Fig. 51. Seasonal variation of TDS at different stations of Chhatak during 2010-2012.

Table 25. Monthly mean of TDS (mg/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	100.3	25.2	86.4	102.2	23	51.7	96.5
	Max.	145.4	48.8	136.2	144.8	48.1	166.4	187
	mean	122.17	36.26	109.09	126.61	35.31	110.81	135.49
	SD	18.53	9.31	19.85	14.84	10.18	49.84	31.57
Nov.	Min.	111.1	37.5	114.4	134.6	36	69.2	83.8
	Max.	218	145.7	168.8	151.8	56.1	245	212
	mean	151.36	61.72	146.88	145.24	47.47	126.76	160.3
	SD	31.84	33.73	19.13	5.98	6.74	65.83	39.19
Dec.	Min.	150.8	55.4	191.7	150.4	56.7	84.8	196
	Max.	184.4	63.2	210	252.3	252.3	210	289
	mean	171.7	60.4	200.35	178.33	106.48	144.3	233.25
	SD	15.40	3.48	7.5518	49.40	97.22	67.76	42.38
Jan.	Min.	170.6	61.6	229	152.3	55.4	95	235
	Max.	265	84.4	306	162.5	73.6	286	401
	mean	217.8	73	267.5	157.4	64.5	190.5	318
	SD	66.75	16.12	54.45	7.21	12.87	135.06	117.38
Feb.	Min.	190.1	77.4	243	146	72.2	121.1	199.9
	Max.	197.5	96.6	248	174.5	97.6	238	392
	mean	193.8	87	245.5	160.25	84.9	179.55	295.95
	SD	5.23	13.58	3.54	20.15	17.96	82.66	135.84
Mar.	Min.	87.2	66.7	252	139.6	66	117.2	293
	Max.	224	76.9	263	185.1	68.9	261	392
	mean	155.6	71.8	257.5	162.35	67.45	189.1	342.5
	SD	96.73	5.1	7.78	32.17	2.05	101.68	70.00
Apr.	Min.	87.2	61.8	263	170.7	54.4	119.8	128.4
	Max.	272	81.3	310	171.7	117	309	420
	mean	179.6	71.55	286.5	171.2	85.7	214.4	274.2
	SD	130.67	13.79	33.23	0.71	44.26	133.78	206.19
May	Min.	171.9	28.6	191	128	29.5	99	92.4
	Max.	175.4	33.2	211	139.5	32.8	207	95
	Mean	173.65	30.9	201	133.75	31.15	153	93.7
	SD	2.47	3.25	14.14	8.13	2.33	76.37	1.84
Jun.	Min.	149.9	28	155.1	117.7	195	81.3	126.7
	Max.	226	90	269	195.6	195	245	139.4
	Mean	187.95	59	212.05	156.65	195	163.15	133.05
	SD	53.81	43.84	80.54	55.08	OTS	115.75	8.98
Jul.	Min.	90.3	23.2	82.2	66	25.9	47.2	39
	Max.	113	25.1	128	88.9	28.6	147.5	49.9
	Mean	101.65	24.15	105.1	77.45	27.25	97.35	44.45
	SD	16.05	1.34	32.39	16.19	1.91	70.92	7.71
Aug.	Min.	102.2	26.4	86.8	94.2	25.8	102.6	66
	Max.	114.5	28.9	111.1	102	28.4	109.4	100.9
	Mean	108.35	27.65	98.95	98.1	27.1	106	83.45
	SD	8.70	1.77	17.18	5.52	1.84	4.81	24.68
Sep.	Min.	111.8	24.1	90.9	51.3	20.7	105.2	81.7
	Max.	180.2	47	132.7	135	49.1	118	144.4
	Mean	132.03	34.04	112.97	115.74	34.91	113.16	104.52
	SD	21.97	7.93	17.11	25.40	10.25	3.93	17.89

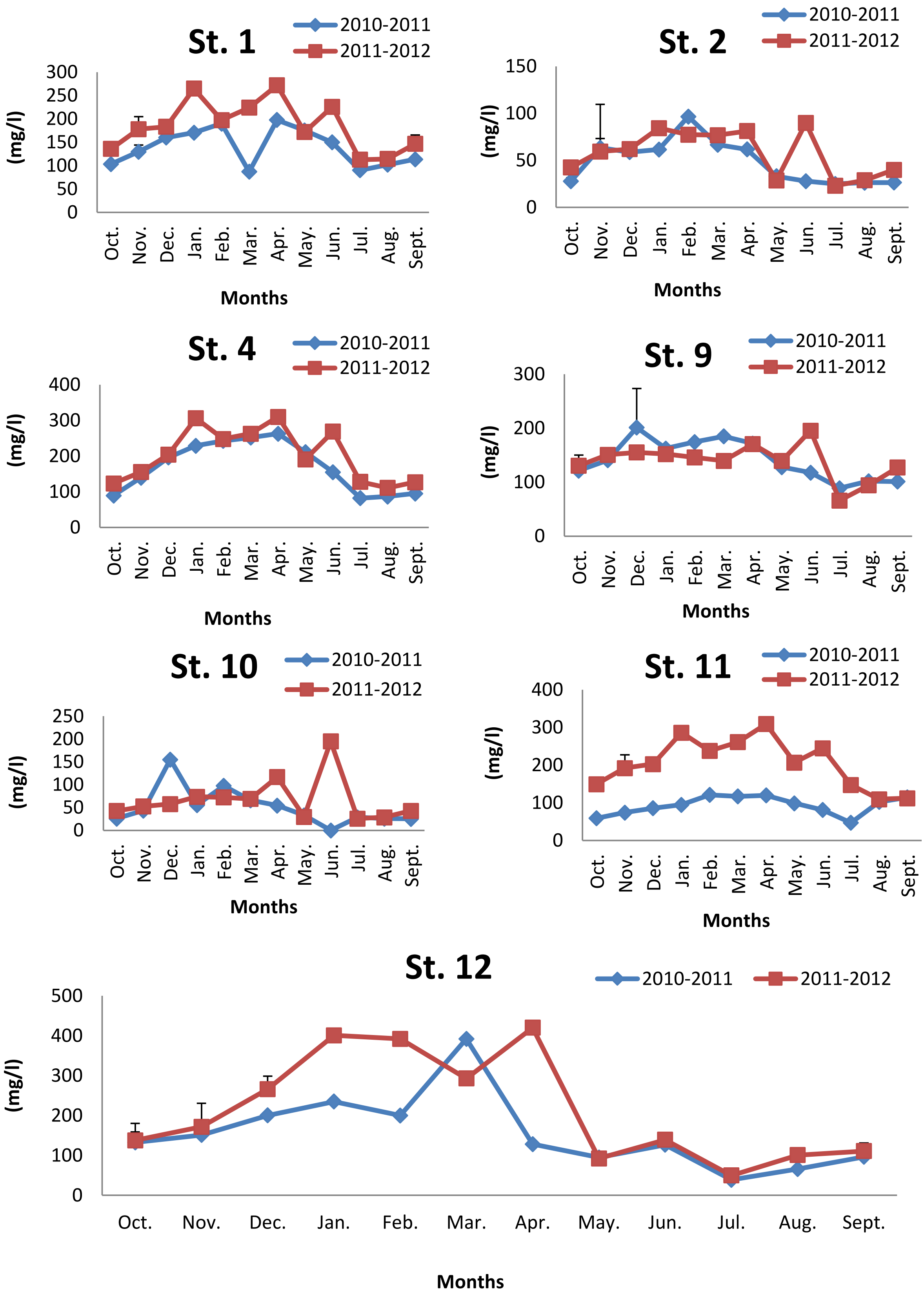


Fig. 52. Comparison of TDS between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

SRP

Range of SRP for the period between October 2010 and September 2012 were recorded 6.18-45.97 μg/l for Station 1, 4.19-20.27 μg/l for Station 2, 2.66-22.84 μg/l for Station 4, 9.29-55.81 μg/l for Station 9, 3.25-43.58 μg/l for Station 10, 9.38-214.16 μg/l for Station 11 and 50.08-1389.21 μg/l for Station 12. The highest monthly average of SRP for Station 2, 9, 10, 11 and 12 were recorded in the month of October, May, July, February and December respectively. For station 1 and 4 highest monthly average of SRP was recorded in the month of April. Whereas lowest monthly averarage of SRP recorded for Station 1 and 11 were in the month of April. For Station 2, 9, 10, 11 and 12 lowest concentration of SRP were observed in the month of October, May, July, February and September, respectively (Table 26).

In the present investigation, the seasonal variation of SRP observed higher during monsoon and lower in winter season in most the stations except Station 2. In this station, concentration of SRP was higher in winter and lower in autumn (Fig. 53).

From Fig. 54 it is evident that the fluctuation tendency is quite different between the two study years (2010-2011 and 2011-2012). It was observed that concentration of SRP dropped from the month of October. Highest concentration also differ among the stations. Station 12 yielded SRP concentration among all the stations (Fig. 54).

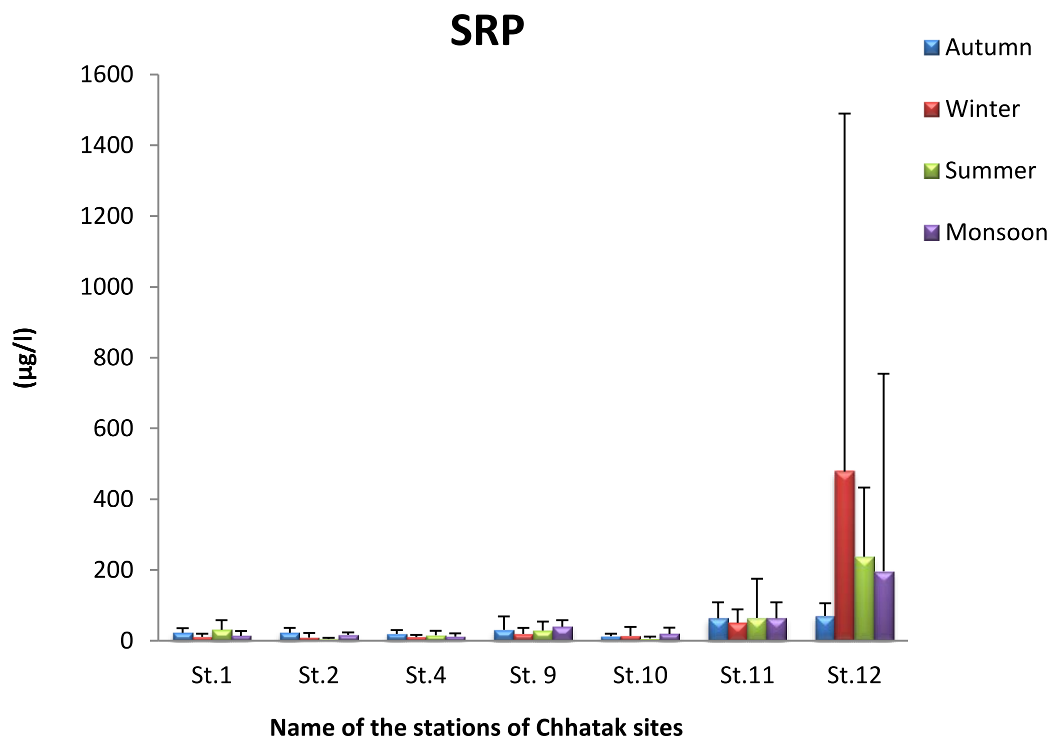


Fig. 53. Seasonal variation of SRP at different stations of Chhatak during 2010-2012.

Table 26. Monthly mean of SRP (µg/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	12.15	12.15	5.41	1.05	5.71	10.52	14.91
	Max.	46.86	31.84	29.65	37.93	22.49	123.09	114.92
	mean	24.95	20.27	18.03	19.57	15.77	71.36	58.93
	SD	12.69	7.06	10.35	15.04	6.89	44.49	40.52
Nov.	Min.	3.9	0	4.4	2.91	0.18	9.91	32.71
	Max.	31.12	55.99	36.74	131.91	12	106.83	113.41
	mean	13.63	13.49	15.26	29.10	6.42	46.83	83.65
	SD	9.24	17.26	9.718	39.69	3.87	35.42	25.61
Dec.	Min.	3.12	4.56	5.89	7.08	0	32.84	18.39
	Max.	18.39	49.15	14.6	66.44	97.86	50.81	2794.46
	mean	9.00	18.48	10.81	28.93	28.93	38.88	1389.21
	SD	6.71	21.05	4.13	28.23	46.17	8.26	1578.56
Jan.	Min.	0	0	0	9.38	0.14	5.97	40.08
	Max.	12.35	10.41	11.7	10.84	11.7	12.78	61.44
	mean	6.18	5.21	5.85	10.11	5.92	9.38	50.76
	SD	8.73	7.36	8.27	1.03	8.17	4.82	15.10
Feb.	Min.	0	0	0	14.43	0	3.65	13.42
	Max.	30.6	8.37	18.47	24.16	20.49	424.67	96.68
	mean	15.3	4.19	9.24	19.30	10.25	214.16	55.05
	SD	21.64	5.92	13.06	6.88	14.49	297.71	58.87
Mar.	Min.	16.22	4.38	12.14	6.6	6.9	14.77	143.2
	Max.	49.46	4.86	28.93	11.97	11.97	57.95	155.53
	mean	32.84	4.62	20.54	9.29	9.44	36.36	149.36
	SD	23.50	0.24	11.87232	3.80	3.59	30.53	8.72
Apr.	Min.	16.22	0	13.42	13.7	0	16.99	142.44
	Max.	75.72	8.77	32.26	29.19	12.05	84.5	388.77
	mean	45.97	4.39	22.84	21.45	6.03	50.75	265.61
	SD	42.07	6.20	13.32	10.95	8.52	47.74	174.18
May	Min.	0	0	0	35.17	0.57	28.71	36.33
	Max.	28.71	8.7	5.32	76.44	5.93	103.91	558.11
	Mean	14.36	4.35	2.66	55.81	3.25	66.31	297.22
	SD	20.30	6.15	3.76	29.18	3.79	53.17	368.95
Jun.	Min.	8.79	11.23	11.39	13.02	6.54	10.43	52.52
	Max.	11.12	11.58	17.3	18	45.2	230.7	100.89
	Mean	9.96	11.41	14.35	15.51	25.87	120.57	76.71
	SD	1.65	0.25	4.18	3.52	27.34	155.75	34.20
Jul.	Min.	6.11	11.25	4.98	30.84	12.21	52.44	44.42
	Max.	25.04	21.47	21.92	33.5	74.95	201.44	55.74
	Mean	15.58	16.36	13.45	32.17	43.58	126.94	50.08
	SD	13.39	7.23	11.98	1.88	44.36	105.36	8.00
Aug.	Min.	10.42	19.38	6.25	49.97	15.82	96.25	29.15
	Max.	39.88	20.68	14.03	59.74	20.18	244.19	2283.61
	Mean	25.15	20.03	10.14	54.86	18	170.22	1156.38
	SD	20.83	0.92	5.50	6.91	3.08	104.61	1594.14
Sep.	Min.	1.65	6.92	1.98	22.58	4.62	117.5	6.1
	Max.	49.48	37.04	30.56	76.38	31.59	267.67	203.72
	Mean	12.26	16.61	10.69	46.49	13.18	189.40	61.30
	SD	15.12	9.81	11.54	16.55	8.77	44.43	64.79

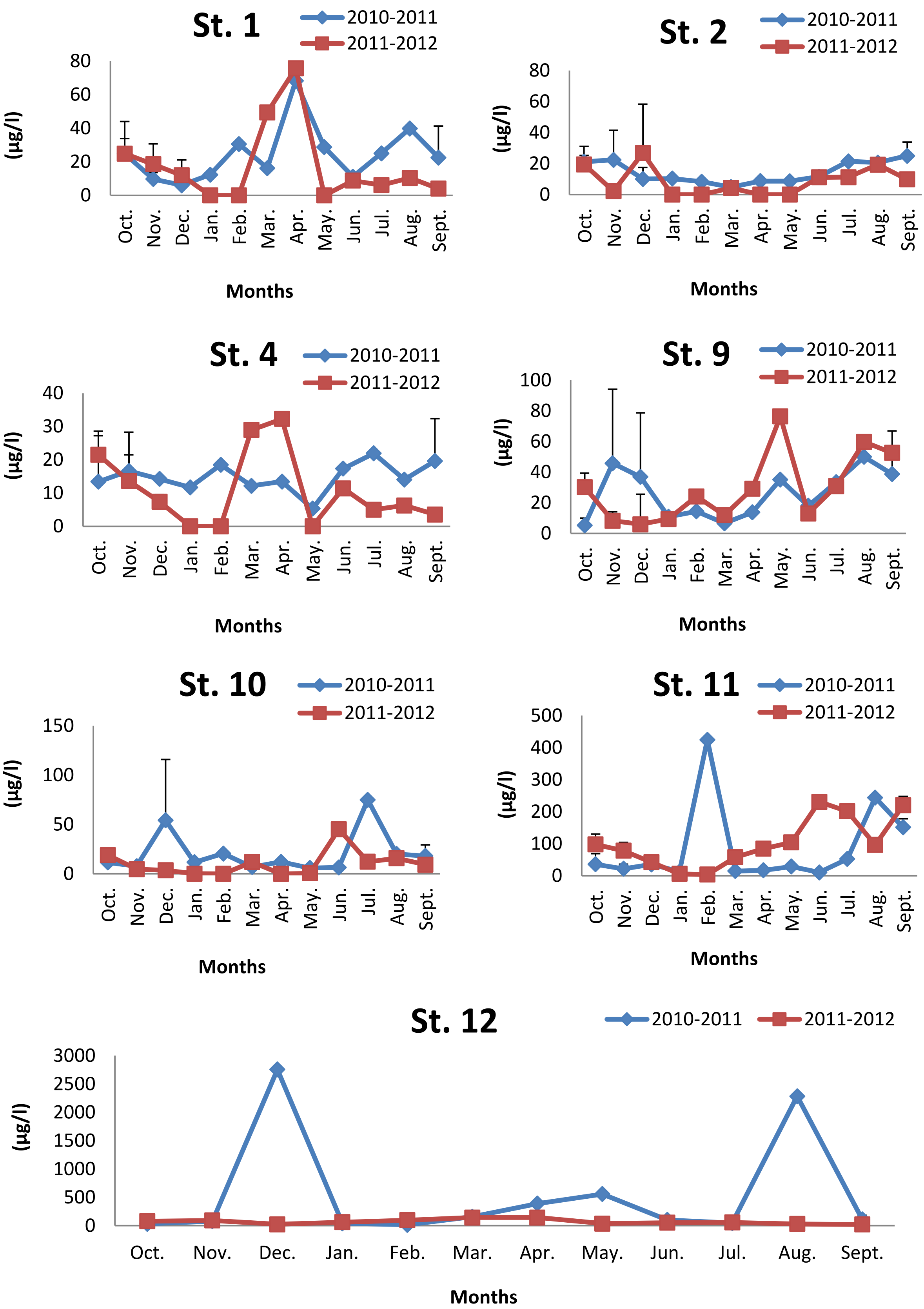


Fig. 54. Comparison of SRP between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Nitrate-nitrogen (NN)

Range of NN for the period between October 2010 and September 2012 were recorded 19.5-310 µg/l for Station1, 115-305 µg/l for Station 2, 45-505.53 µg/l for Station 4, 20-195.3 µg/l for Station 9, 98.5-390 µg/l for Station 10, 30-605 µg/l for Station 11 and 90-560 µg/l for Station 12. The highest monthly average of NN for station 1, 2, 10, 11 and 12 were recorded in the month of July, January, April, February and March, respectively. For Station 4 and 9 the highest concentration of NN were recorded in the month of October. Whereas lowest concentrations of NN for Station 1 and 4 were recorded in the month of March. For Station 9 and 11 lowest concentrations of NN were recorded in the month of January. For Station 2, 10 and 12 lowest concentrations of NN were recorded in the month of August, December and February, respectively (Table 21).

In the present investigation, the seasonal variation of NN observed higher during autumn and lower in winter in most of the stations (Fig. 55).

During the study period NN showed high concentration during October in the year of 2010-2011 in most of the stations. During 2011-2012, high concentration of NN was shown in May in most of the stations (Fig. 56).

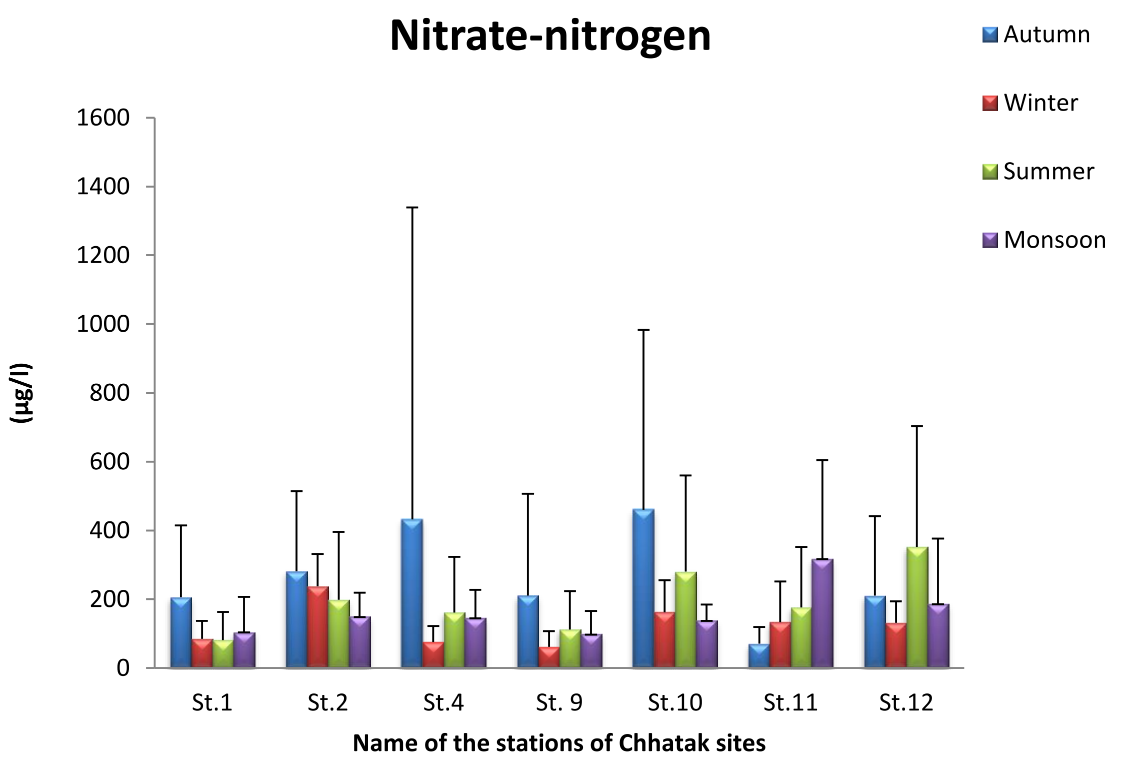


Fig. 55. Seasonal variation of NN at different stations of Chhatak during 2010-2012.

Table 27. Monthly mean of NN (µg/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	0	90	0	0	60.8	0	0
	Max.	425	690	2967	780	1260	500	622.9
	mean	158.41	250.66	505.53	195.3	346.97	250.23	139.84
	SD	182.20	206.87	1088.20	292.30	422.21	219.99	218.71
Nov.	Min.	0	60	0	0	32.65	20	40
	Max.	610	710	610	670	1480	960	620
	mean	177.88	251.20	132.27	131.93	342.00	228.11	211.71
	SD	171.87	190.62	184.85	208.08	474.56	284.46	168.28
Dec.	Min.	0	89.25	55.9	30	30	0	10
	Max.	113	330	90	90	140	184.4	198.69
	mean	78.75	197.06	71.23	64.62	98.5	97.6	136.92
	SD	53.56	125.79	14.07	25.26	49.76	98.28	87.19
Jan.	Min.	10	270	0	0	190	0	50
	Max.	100	340	110	40	210	60	150
	mean	55	305	55	20	200	30	100
	SD	63.64	49.50	77.78	28.28	14.14	42.43	70.71
Feb.	Min.	0	300	60	0	220	40	90
	Max.	50	310	130	60	330	1170	90
	mean	25	305	95	30	275	605	90
	SD	35.36	7.07	49.50	42.43	77.78	799.03	0
Mar.	Min.	0	150	30	70	220	0	220
	Max.	39	350	60	130	410	300	900
	mean	19.5	250	45	100	315	150	560
	SD	27.58	100	21.21	42.43	134.35	212.13	480.83
Apr.	Min.	0	48	0	0	320	0	160
	Max.	39	320	130	130	460	130	380
	mean	19.5	184	65	65	390	65	270
	SD	27.58	192.33	91.92	91.92	98.99	91.92	155.56
May	Min.	140	60	330	150	80	160	200
	Max.	270	260	420	190	190	210	250
	Mean	205	160	375	170	135	185	225
	SD	91.92	141.42	63.64	28.28	77.78	35.36	35.36
Jun.	Min.	20	80	60	70	120	30	260
	Max.	70	300	210	260	190	60	280
	Mean	45	190	135	165	155	45	270
	SD	35.36	155.56	106.07	134.35	49.50	21.21	14.14
Jul.	Min.	170	70	200	70	110	50	120
	Max.	450	210	310	150	230	120	270
	Mean	310	140	255	110	170	85	195
	SD	197.99	98.99	77.78	56.57	84.85	49.50	106.07
Aug.	Min.	40	90	110	40	100	60	90
	Max.	110	140	130	170	130	90	810
	Mean	75	115	120	105	115	75	450
	SD	49.50	35.36	14.14	91.92	21.21	21.21	509.12
Sep.	Min.	20	60	40	0	80	0	0
	Max.	160	260	230	160	220	180	250
	Mean	86.67	152.22	144.44	88.89	132.22	80	127.78
	SD	40	63.20	68.76	52.55	47.64	55.45	79.97

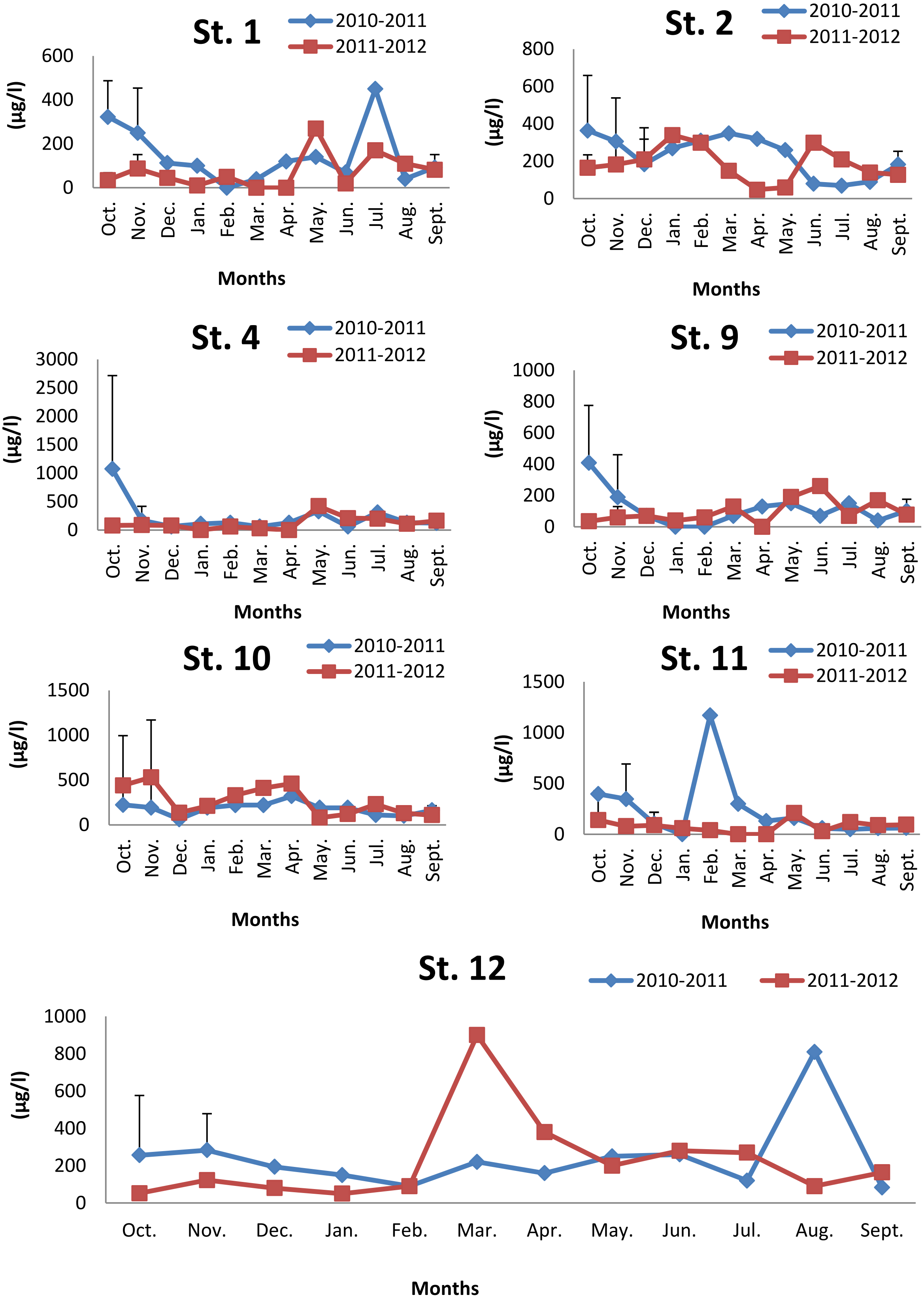


Fig. 56. Comparison of NN between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Soluble reactive silicate (SRS)

Range of SRS for the period between October 2010 and September 2012 were recorded 9.32-20 mg/l for Station 1, 3.83-9.41 mg/l for Station 2, 5.69-13.94 mg/l for Station 4, 2.86-8.63 mg/l for Station 9, 4.93-8.33 mg/l for Station 10, 8.36-18.71 mg/l for Station 11 and 5.57-22.77 mg/l for Station 12. The highest monthly average of SRS for Station 1 and 12 were recorded in the month of March. For station 4 and 11 highest concentrations of SRS were recorded in the month of April. For station 2 highest concentrations of SRS was recorded in October. For Station 9 and 10 highest concentrations of SRS was recorded in November (Table 28).

In the present investigation, the seasonal variation of SRS observed higher during winter and lower in monsoon in most of the stations (Fig. 57).

During the study period, SRS concentration showed higher in the year of 2011-2012 than the year of 2010-2011 in most of the stations (Fig. 58). It showed highest concentration in the month of November in most of the stations (Fig. 58).

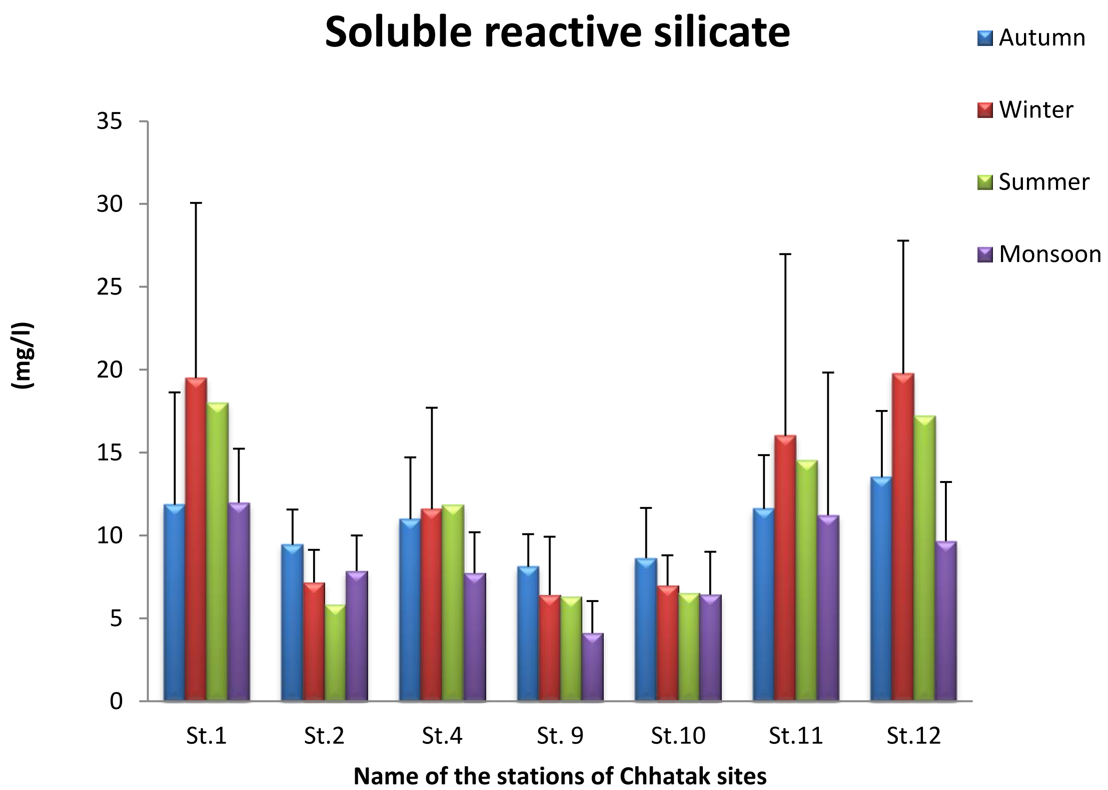


Fig. 57. Seasonal variation of SRS at different stations of Chhatak during 2010-2012.

Table 28. Monthly mean of SRS (mg/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	5.57	6.39	6.52	5.91	1.8	1.25	6.52
	Max.	20.38	13.93	15.23	10.37	13.21	21.73	17.69
	mean	12.98	9.41	11.25	7.75	8.18	12.23	12.37
	SD	6.73	2.59	3.38	1.56	3.51	8.37	4.01
Nov.	Min.	6.45	3.68	5.73	6.52	4.3	4.51	12.56
	Max.	42.33	10.09	17.54	12.28	11.35	26.39	23.2
	mean	17.95	8.55	11.46	8.63	8.33	14.01	17.01
	SD	11.68	1.92	4.74	2.28	1.87	9.79	4.28
Dec.	Min.	7.5	6.4	4.28	3.5	6.05	0.71	16.26
	Max.	26.8	9.52	20.4	12.04	8.96	29.85	31.42
	mean	17.14	7.73	11.72	6.86	7.20	10.68	22.24
	SD	10.85	1.48	7.85	3.66	1.317	13.03	7.28
Jan.	Min.	7.01	3.39	4.49	2.67	3.46	5.48	17.35
	Max.	24.57	8.17	16.99	3.53	9.52	24.21	26.78
	mean	15.79	5.78	10.74	3.1	6.49	14.85	22.07
	SD	12.42	3.38	8.84	0.61	4.29	13.24	6.67
Feb.	Min.	10.07	5.43	5.96	0.4	5.22	6.29	0.92
	Max.	24.74	7.07	17.28	5.88	7.07	26.18	29.45
	mean	17.41	6.25	11.62	3.14	6.15	16.24	15.19
	SD	10.37	1.16	8.00	3.87	1.31	14.06	20.17
Mar.	Min.	14.49	6.35	10.05	2.99	6.17	1.68	17.05
	Max.	25.51	7.4	15.39	7.4	8.83	26.11	28.48
	mean	20	6.88	12.72	5.20	7.5	13.90	22.77
	SD	7.79	0.53	3.78	3.12	1.88	17.27	8.08
Apr.	Min.	14.49	1.64	11.2	2.68	3.72	8.02	9.41
	Max.	23.73	6.02	16.68	12.51	6.63	29.4	28.93
	mean	19.11	3.83	13.94	7.60	5.18	18.71	19.17
	SD	6.53	3.10	3.87	6.95	2.06	15.12	13.80
May	Min.	14.04	6.7	5.42	5.29	6.3	10.41	8.22
	Max.	15.67	6.78	12.34	6.94	7.4	20.44	11.25
	Mean	14.86	6.74	8.88	6.12	6.85	15.43	9.74
	SD	1.15	0.057	4.89	1.17	0.78	7.09	2.14
Jun.	Min.	8.47	6.42	6.65	3.33	5.46	9.61	13.56
	Max.	13.74	7.13	10.2	7.17	6.62	15.93	13.97
	Mean	11.11	6.78	8.43	5.25	6.04	12.77	13.77
	SD	3.73	0.50	2.51	2.72	0.82	4.47	0.29
Jul.	Min.	8.53	5.92	4.43	5.07	4.99	7.58	4.93
	Max.	10.11	8.21	6.95	6.31	8.57	13.34	6.2
	Mean	9.32	7.065	5.69	5.69	6.78	10.46	5.57
	SD	1.12	1.62	1.78	0.88	2.53	4.07	0.90
Aug.	Min.	8.01	6.08	5.95	1.49	4.32	7.11	5.56
	Max.	11.25	9.15	7.64	4.23	5.54	9.6	9.82
	Mean	9.63	7.62	6.80	2.86	4.93	8.36	7.69
	SD	2.29	2.17	1.20	1.94	0.86	1.76	3.01
Sep.	Min.	8.11	3.03	3.99	1.54	2.07	7.57	5.34
	Max.	16.67	10.45	10.58	5.79	10.71	16.01	15.88
	Mean	12.90	8.07	7.67	3.43	6.46	11.91	9.92
	SD	3.44	2.55	2.33	1.54	3.13	3.06	3.63

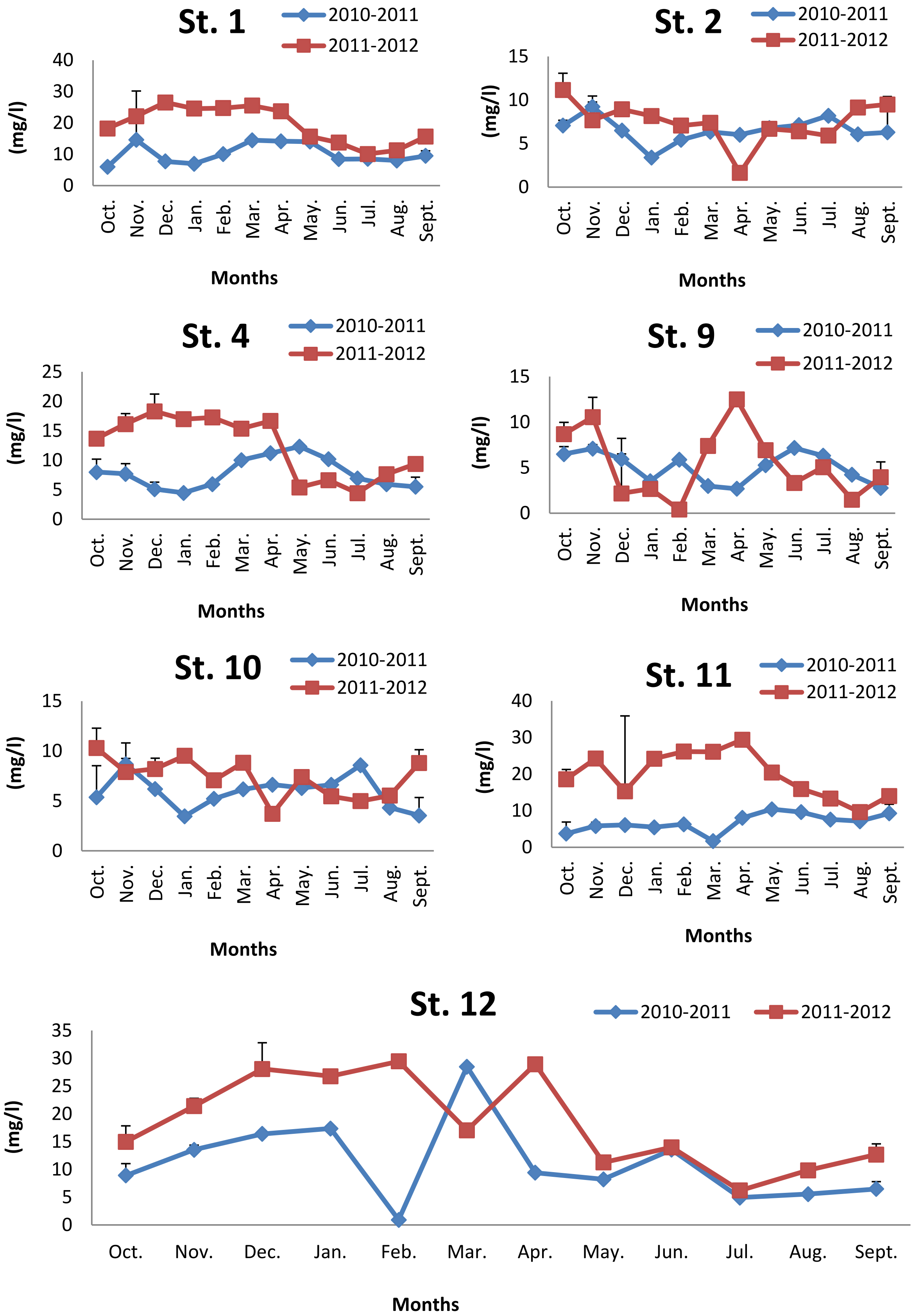


Fig. 58. Comparison of SRS between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatatk.

Biological parameters

Chlorophyll *a* (chl. *a*)

Range of (chl. *a*) for the period between October 2010 and September 2012 were recorded 78.74-677.65 µg/l for Station 1, 5.18-25.98 µg/l for Station 2, 59.79-175.23 µg/l for Station 4, 3.72-47.62 µg/l for Station 9, 2.96-29.18 µg/l for Station 10, 44.6-151.37 µg/l for Station 11 and 20.51-106.03 µg/l for Station 12. The highest monthly average of chl. *a* for Station 1, 4, 10, 11 and 12 were recorded in the month of June. For Station 8 and 9 highest concentration of chl. *a* were recorded in the month of March, June, October, December and February. Whereas, the lowest concentration of chl. *a* for station 1, 2, 4 and 12 were recorded during the month of June, May and July, respectively (Table 29).

In the present investigation, the seasonal variation of Chl. *a* was observed higher during summer and lower in monsoon in most of the stations except in station 2 and 12. In these stations highest concentrations of chl. *a* observed in winter (Fig. 59).

During the study period, concentration of chl. *a* showed a rising tendency after the month of November in most of the stations. Concentration of chl. *a* starts falling during the month of February. In most of the stations higher concentration was observed in the year of 2011-2012 than the year of 2010-2011 in most of the stations. It shows rising tendency after the month of January in most of the stations (Fig. 60).

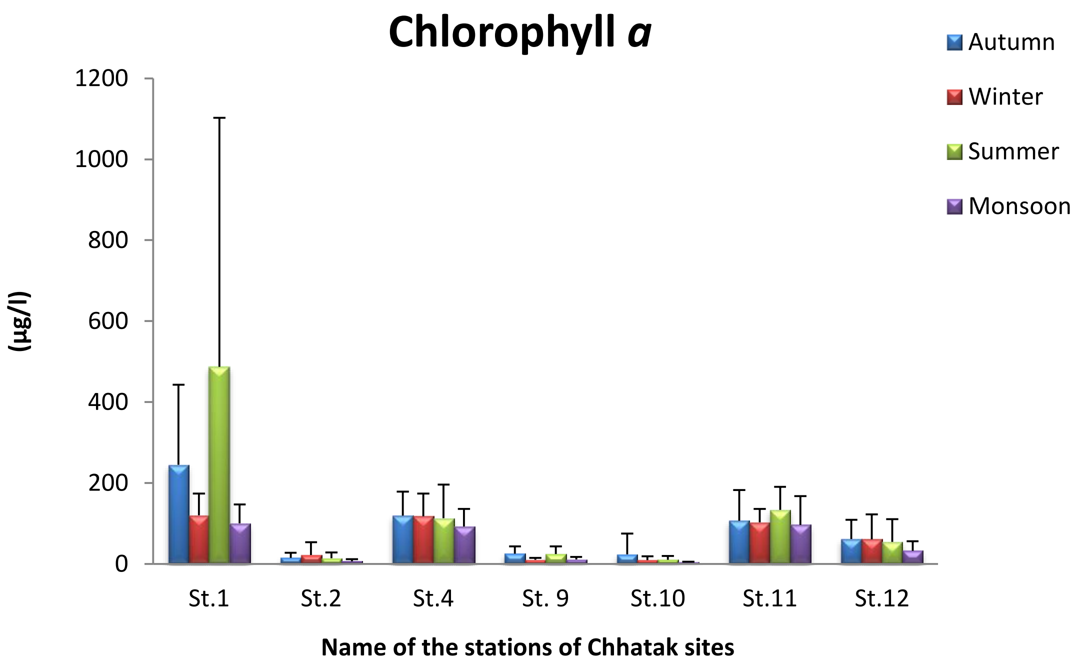


Fig. 59. Seasonal variation of chl. *a* at different stations of Chhatak during 2010-2012.

Table 29. Monthly mean of chl. *a* (µg/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	49.73	5.92	4.74	5.92	2.37	34.34	14.21
	Max.	619.23	48.54	155.1	65.12	170.5	231.87	150.37
	mean	223.69	15.84	97.76	23.91	29.18	120.91	62.24
	SD	218.99	15.04	50.22	22.76	62.36	78.80	53.88
Nov.	Min.	68.67	3.38	91.17	3.38	2.37	4.74	20.72
	Max.	499.25	120.04	215.49	25.37	14.21	210.9	162.21
	mean	165.77	22.43	142.57	17.62	6.79	118.37	65.81
	SD	129.17	36.78	41.22	7.13	3.29	72.94	45.71
Dec.	Min.	88.8	5.92	13.45	8.46	3.55	76.96	8.88
	Max.	222	26.22	190.62	15.39	26.64	221.01	118.4
	mean	147.85	15.33	111.85	11.08	11.18	151.37	43.37
	SD	57.08	9.719	74.59	3.27	10.61	79.89	50.47
Jan.	Min.	46.18	4.74	55.65	3.38	2.54	101.49	15.39
	Max.	203.65	46.18	178.78	6.77	34.34	107.74	29.6
	mean	124.92	25.46	117.22	5.08	18.44	104.62	22.50
	SD	111.35	29.30	87.07	2.40	22.49	4.42	10.05
Feb.	Min.	48.84	3.38	40.31	3.38	1.69	79.92	17.76
	Max.	115.44	10.99	160	8.46	9.87	120.77	194.3
	mean	82.14	7.19	100.16	5.92	5.78	100.35	106.03
	SD	47.09	5.38	84.63	3.59	5.78	28.89	124.83
Mar.	Min.	74.7	4.23	84.36	5.92	5.07	56.83	23.68
	Max.	1280.59	10.99	255.41	16.91	26.05	150.96	35.52
	mean	677.65	7.61	169.89	11.42	15.56	103.90	29.6
	SD	852.69	3.38	120.95	7.77	14.84	66.56	8.37
Apr.	Min.	51.8	9.3	17.76	40.26	10.15	110.11	27.63
	Max.	1280.59	42.62	123.78	54.97	14.38	115.44	35.52
	mean	666.20	25.96	70.77	47.62	12.27	112.78	31.58
	SD	868.89	23.56	74.97	10.40	2.99	3.77	5.58
May	Min.	81.4	3.55	52.1	10.99	1.18	71.04	33.15
	Max.	151.55	13.02	142.42	17.76	4.74	110.18	169.31
	Mean	116.48	8.29	97.26	14.38	2.96	90.61	101.23
	SD	49.60	6.70	63.87	4.79	2.52	27.68	96.28
Jun.	Min.	97.09	1.18	118.4	2.37	4.23	114.85	22.5
	Max.	239.17	23.68	232.06	5.07	5.92	149.97	88.8
	Mean	168.13	12.43	175.23	3.72	5.08	132.41	55.65
	SD	100.47	15.91	80.37	1.91	1.20	24.83	46.88
Jul.	Min.	69.86	4.74	85.25	10.99	4.74	21.71	13.02
	Max.	130.24	5.92	88.8	22.83	4.93	67.49	58.02
	Mean	100.05	5.33	87.03	16.91	4.84	44.6	35.52
	SD	42.70	0.83	2.51	8.37	0.13	32.37	31.82
Aug.	Min.	69.86	4.44	29.6	13.02	3.55	29.6	16.15
	Max.	87.62	5.92	89.98	23.68	4.74	103.96	24.86
	Mean	78.74	5.18	59.79	18.35	4.15	66.78	20.51
	SD	12.56	1.05	42.70	7.54	0.84	52.58	6.16
Sep.	Min.	58.02	2.96	50.91	2.54	1.48	16.28	8.88
	Max.	162.21	8.29	99.46	16.91	7.1	215.27	74.59
	Mean	94.05	5.62	79.00	8.83	3.68	109.85	27.53
	SD	33.71	1.69	15.33	4.92	1.62	82.27	20.45

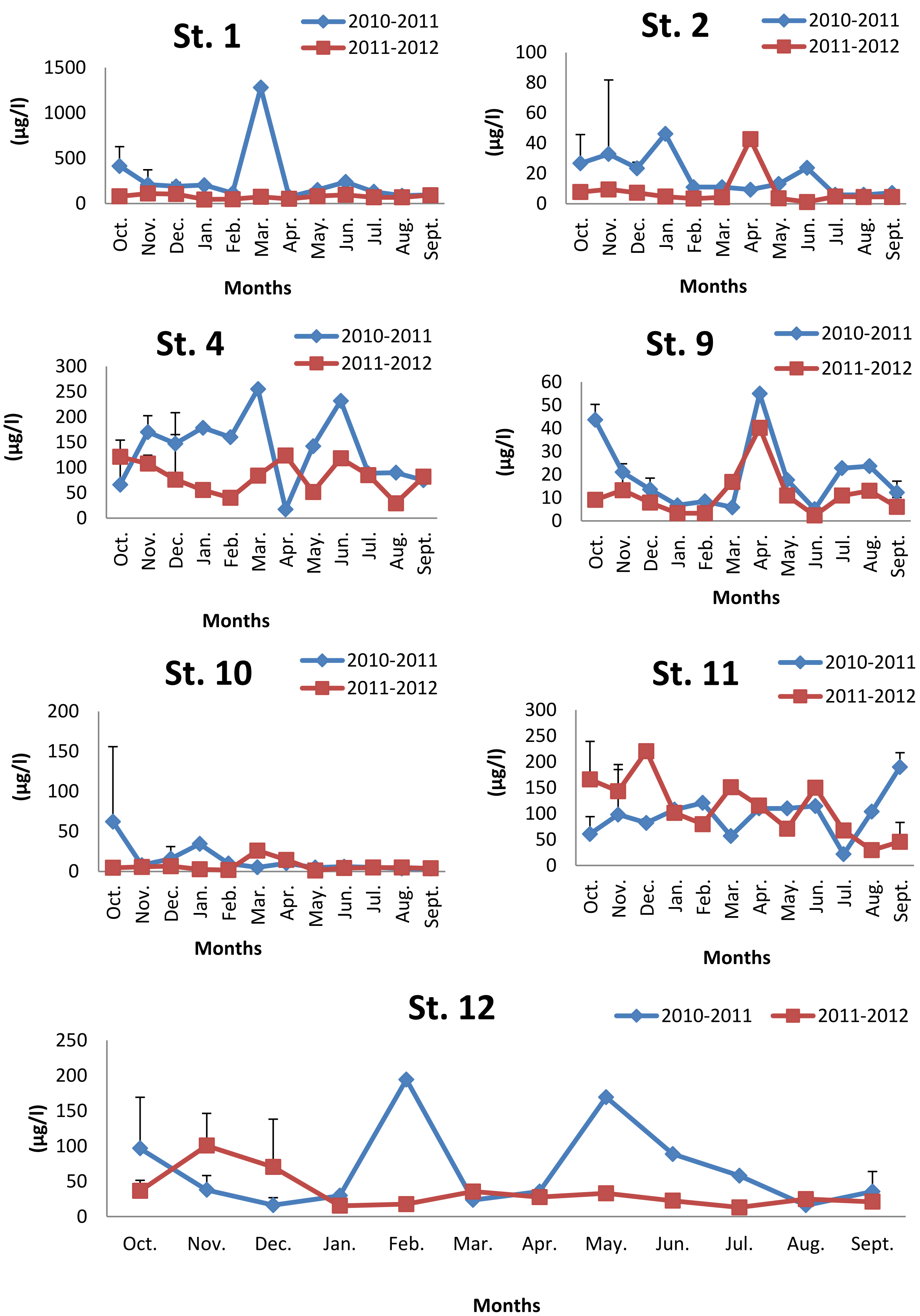


Fig. 60. Comparison of chl *a* between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 11) of Chhatak.

Phaeopigment (PP)

Range of monthly average PP for the period between October 2010 and September 2012 were recorded 29.32-76.4 µg/l for Station 1, 3.45-24.49 µg/l for Station 2, 35.47-146.68 µg/l for Station 4, 2.11-54.01 µg/l for Station 9, 1.86-12.05 µg/l for Station 10, 26.36-118.06 µg/l for Station 11 and 10.06-41.70 µg/l for Station 12. The highest monthly average of PP for Station 1, 4, 10, 11 and 12 were recorded in the month of July, December, January, September and February respectively. For Station 2 and 9, highest concentrations of PP were recorded in the month of April, respectively. Whereas lowest concentrations of PP were recorded in the month of August for Station 1, 2 and 4. For Station 9 and 11 lowest concentrations of PP were recorded in the month of June. For Station 10 and 12 lowest concentrations of PP were recorded in the month of September and March (Table 30).

In the present investigation, the seasonal variation of PP observed higher during winter and lower in summer in most of the stations (Fig. 61).

During the study period, PP concentration is higher in the year of 2010-2011 than the year of 2011-2012. In both the study years, PP concentration showed highest peak during the month of April in most of the stations. It showed a decreasing tendency during May and continued up to September in most of the stations (Fig. 62).

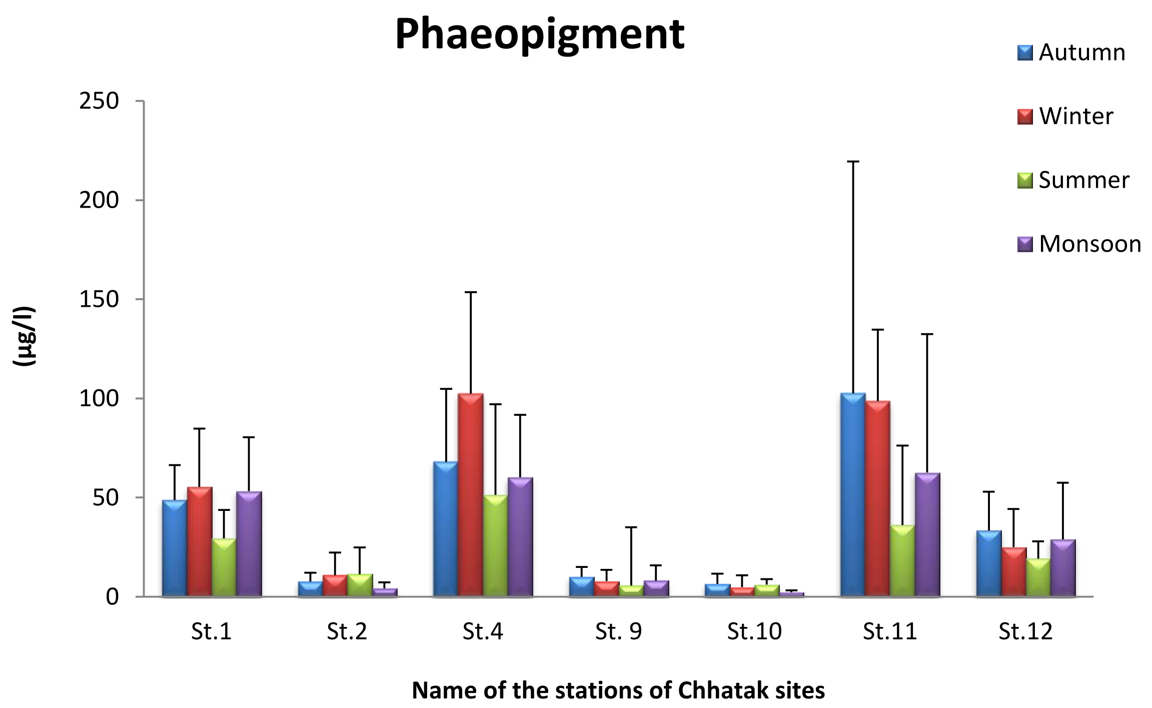


Fig. 61. Seasonal variation of phaeopigment at different stations of Chhatak during 2010-2012.

Table 30. Monthly mean of phaeopigment (µg/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	33.89	3.36	5.25	5.21	1.79	9.06	6.59
	Max.	52.26	16.35	104.42	22.24	8.7	314.13	63.78
	mean	43.40	6.90	59.72	11.27	5.43	111.13	37.83
	SD	7.51	4.35	35.68	5.59	2.90	115.51	22.81
Nov.	Min.	16.19	0.78	27.07	2.51	0.13	5.25	13.98
	Max.	125.2	38.27	157.4	14.03	19.07	119.74	57.41
	mean	60.40	10.28	84.79	7.04	4.98	50.94	27.67
	SD	35.60	11.46	40.64	4.00	5.59	43.15	14.09
Dec.	Min.	41.86	1.81	100.08	5.76	2.18	37.18	4.13
	Max.	56.49	28.51	197.38	21.22	5.62	149.23	62.14
	mean	49.57	12.14	146.68	13.11	4.19	88.65	23.68
	SD	6.09	12.75	53.18	6.46	1.79	54.74	26.35
Jan.	Min.	51.17	5.25	75.81	3.15	1.03	48.67	11.17
	Max.	59.26	14.56	102.43	5.71	23.07	108	19.55
	mean	55.22	9.91	89.12	4.43	12.05	78.34	15.36
	SD	5.72	6.58	18.82	1.81	15.58	41.95	5.93
Feb.	Min.	19.8	2.56	45.55	4.34	0.69	66.43	16.35
	Max.	71.76	10.99	85.1	6.99	4	107.28	67.04
	mean	45.78	6.775	65.33	5.67	2.35	86.86	41.70
	SD	36.74	5.96	27.97	1.87	2.34	28.89	35.84
Mar.	Min.	47.12	2.31	109.08	7.75	4.43	55.49	8.85
	Max.	47.12	12.18	135.63	12.21	8.06	106.96	11.26
	mean	47.12	7.245	122.36	9.98	6.25	81.23	10.06
	SD	OTS	4.94	18.77	3.15	2.57	36.39	1.70
Apr.	Min.	15.8	10.9	23.84	26.3	1.14	88.4	8.43
	Max.	48.54	38.08	114.47	81.71	4.05	143.65	20.22
	mean	32.17	24.49	69.16	54.01	2.60	116.03	14.33
	SD	23.15	19.22	64.09	39.18	2.06	39.07	8.34
May	Min.	28.16	1.44	33.6	2.67	0.48	63.47	14.27
	Max.	44.44	7.78	93.06	11.95	6.08	133.64	31.2
	Mean	36.3	4.61	63.33	7.31	3.28	98.56	22.74
	SD	11.51	4.48	42.04	6.56	3.96	49.62	11.97
Jun.	Min.	17.73	0.48	22.21	0.96	1.57	22.43	5.79
	Max.	59.52	7.1	92.42	3.25	2.31	30.29	38.5
	Mean	38.63	3.79	57.32	2.11	1.94	26.36	22.15
	SD	29.55	4.68	49.65	1.62	0.52	5.56	23.13
Jul.	Min.	29.15	1.92	37.06	6.83	2.75	27.52	4.45
	Max.	29.5	5.17	121.7	29.46	4.08	39.01	77.6
	Mean	29.33	3.55	79.38	18.15	3.42	33.27	41.03
	SD	0.25	2.30	59.85	16.00	0.94	8.12	51.72
Aug.	Min.	37.47	2.84	16.16	3.62	2.27	26.14	16.74
	Max.	115.39	4.06	54.78	11.38	4.42	119.26	18.84
	Mean	76.43	3.45	35.47	7.5	3.35	72.7	17.79
	SD	55.10	0.86	27.31	5.49	1.52	65.85	1.484924
Sep.	Min.	31.44	0.76	32.36	1.03	0.6	4.52	3.6
	Max.	96.7	10.85	111.33	17.97	2.75	282.67	95.97
	Mean	57.50	4.61	61.29	6.86	1.86	118.06	26.32
	SD	23.38	3.64	27.72	5.79	0.80	127.69	29.90

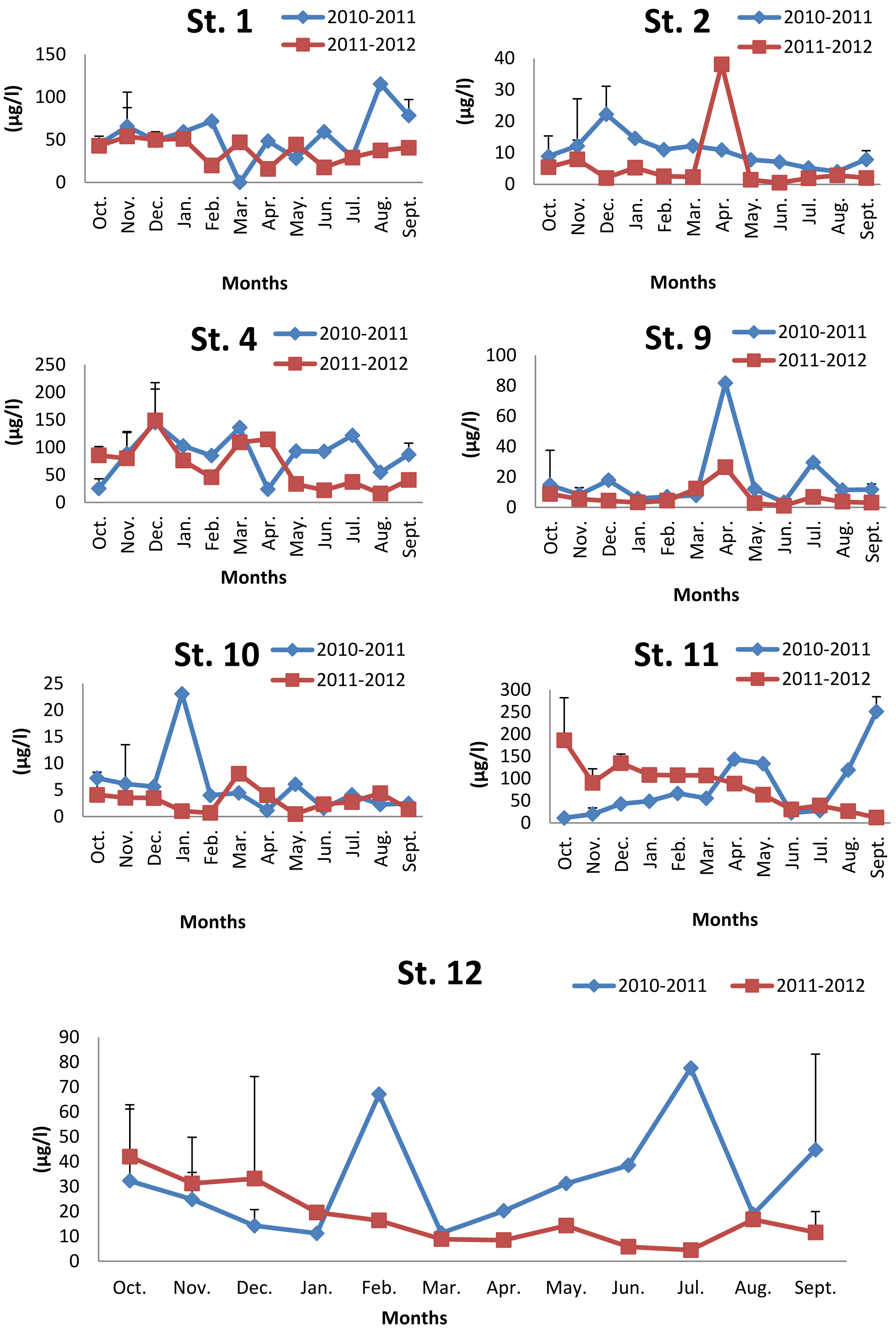


Fig. 62. Comparison of phaeopigment between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Phytoplankton density (PD)

Range of monthly average PD for the period between October 2010 and September 2012 were recorded 1040.04-6851.41 $\times 10^3$ ind/l for Station 1, 8.15-1398.84 $\times 10^3$ ind/l for Station 2, 42.03-531.28 $\times 10^3$ ind/l for Station 4, 19.81-1014.63 $\times 10^3$ ind/l for Station 9, 5.50-984.36 $\times 10^3$ ind/l for Station 10, 225.03-2336.38 $\times 10^3$ ind/l for Station 11 and 70.16-2423.82 $\times 10^3$ ind/l for Station 12. The highest monthly average of PD for station 1 and 9 were recorded during the month of July. For Station 2, 4 and 9 highest amount of PD were recorded during the month of April, March and December, respectively. For Station 10 and 11 highest amount of PD were recorded in the month of January (Table 31).

In the present investigation, the seasonal variation of PD observed higher during winter and lower in monsoon in most of the stations (Fig. 63).

During the study period, the amount of PD were higher in the year of 2011-2012 than the year of 2010-2011. During the study period PD showed a raising tendency after the month of November and decreasing tendency just after January. Again it raised from February and continued up to May (Fig. 64).

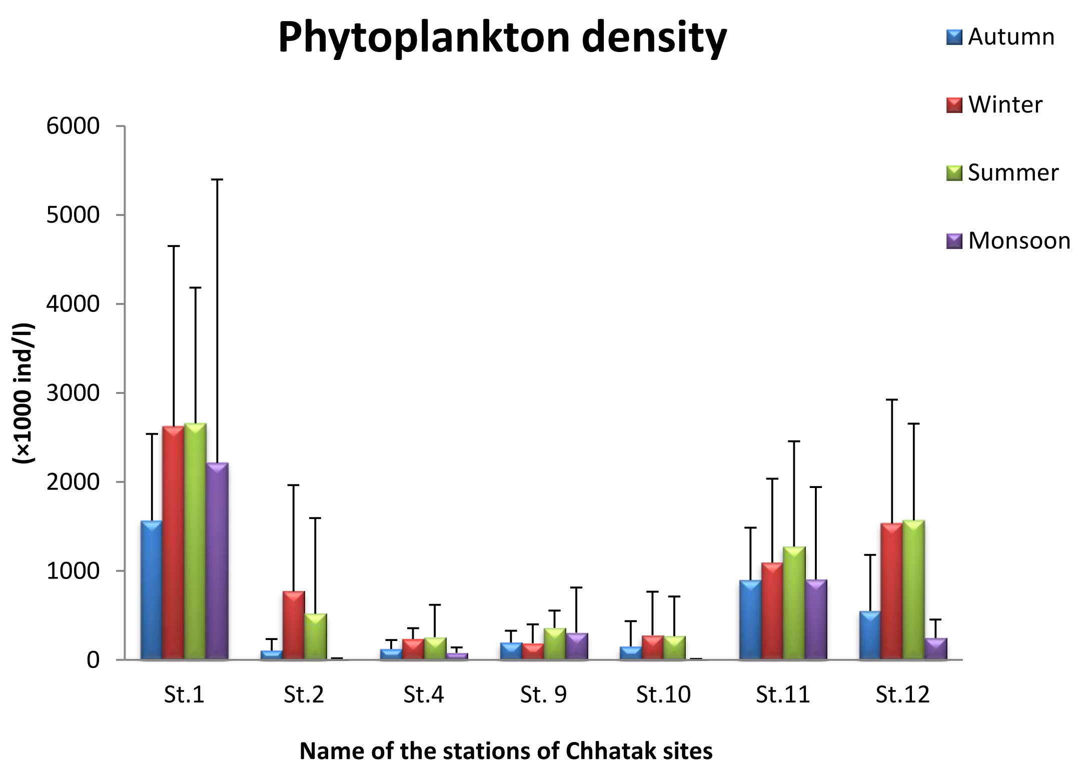


Fig. 63. Seasonal variation of phytoplankton density at different stations of Chhatak during 2010-2012.

Table 31. Monthly mean of PD (×10³ ind/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	583.37	4.38	6.35	30.21	4.82	302.82	20.79
	Max.	2757.29	415.16	289.36	403.01	904.41	3560.14	995.58
	mean	1603.34	95.9	104.37	158.59	193.57	996.02	559.17
	SD	879.65	147.87	109.27	125.54	335.08	1156.95	378.98
Nov.	Min.	170.56	14.06	72.72	90.18	3.06	6.35	53.02
	Max.	3810.43	3810.43	332.53	464.08	135.21	1494.95	2005.65
	mean	1623.93	496.79	196.25	236.48	43.39	818.19	677.79
	SD	1268.98	1244.61	104.17	129.08	43.09	567.41	673.90
Dec.	Min.	799.57	34.15	73.38	15.32	22.33	38.96	68.13
	Max.	4008.9	1794.05	395.3	708.02	358.74	2670.77	4195.93
	mean	2114.23	636.94	219.03	224.61	209.4	945.40	2423.82
	SD	1455.06	818.96	161.62	328.21	145.21	1214.06	1719.20
Jan.	Min.	919.73	142.82	97.73	8.54	144.68	806.08	1199.24
	Max.	6510.37	2471.59	331.82	351.19	1824.04	3866.68	1431.15
	mean	3715.05	1307.21	214.78	179.87	984.36	2336.38	1315.20
	SD	3953.18	1646.69	165.53	242.29	1187.49	2164.17	163.99
Feb.	Min.	2473.67	118.91	106.27	4.82	62.76	467.36	53.41
	Max.	6285.36	693.85	402.68	34.8	510.54	2966.64	3782.25
	mean	4379.52	406.38	254.48	19.81	286.65	1717	1917.83
	SD	2695.27	406.54	209.59	21.20	316.63	1767.26	2636.69
Mar.	Min.	1049.58	42.9	93.24	83.23	12.7	1117.16	659.05
	Max.	4137.11	248.76	969.31	643.12	274.86	2718.49	3053.76
	mean	2593.35	145.83	531.28	363.18	143.78	1917.83	1856.41
	SD	2183.21	102.93	619.48	395.90	185.38	1132.31	1693.32
Apr.	Min.	3802.66	91.11	38.74	290.12	127.94	777.57	752.67
	Max.	4137.11	2706.57	314.89	506.76	1155.1	1496.04	2706.66
	mean	3969.89	1398.84	176.82	398.44	641.52	1136.81	1729.67
	SD	236.49	1849.41	195.27	153.19	726.31	508.04	1381.68
May	Min.	1051.59	13.66	56.25	275.94	16.42	67.56	613.89
	Max.	1774.35	17.73	67.64	356.94	23.57	382.49	1620.59
	Mean	1412.97	15.70	61.95	316.44	20.00	225.03	1117.24
	SD	511.07	2.88	8.05	57.28	5.06	222.69	711.84
Jun.	Min.	3228.14	20.36	29.77	101.97	5.47	593.65	106.59
	Max.	3280.74	40.99	221.88	282.74	11.62	1816.98	372.59
	Mean	3254.44	30.68	125.83	192.36	8.55	1205.32	239.59
	SD	37.19	14.59	135.84	127.82	4.35	865.02	188.09
Jul.	Min.	606.63	4.6	34.16	12.98	3.94	24.95	34.16
	Max.	13096.19	16.4	49.9	2016.27	9.57	1361.95	106.16
	Mean	6851.41	10.5	42.03	1014.63	6.76	693.45	70.16
	SD	8831.45	8.34	11.13	1416.54	3.98	945.40	50.91
Aug.	Min.	541.72	5.03	46.46	325.82	4.16	353.05	20.57
	Max.	4553.85	11.27	117.98	872.02	6.83	548.81	294.9
	Mean	2547.79	8.15	82.22	598.92	5.50	450.93	157.74
	SD	2837.00	4.41	50.57	386.22	1.89	138.42	193.98
Sep.	Min.	123.67	3.72	42.36	40.65	3.5	47.5	54.32
	Max.	2561.61	16.4	223.15	442.74	21.18	1832.19	634.22
	Mean	1040.04	9.02	81.39	125.51	9.63	1006.29	253.38
	SD	871.06	4.77	60.33	143.78	6.64	574.65	183.16

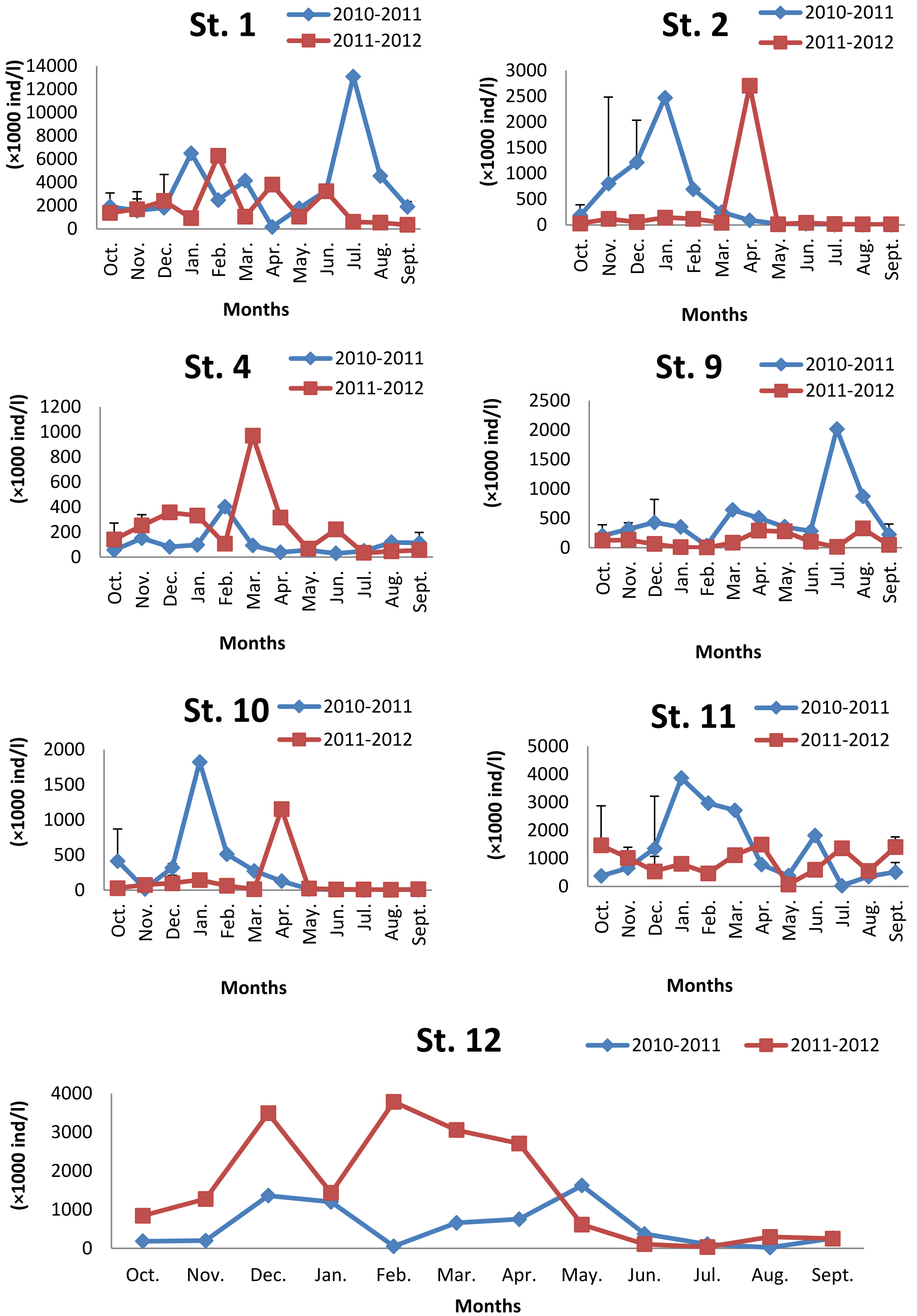


Fig. 64. Comparison of phytoplankton density between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Total zooplankton (TZ)

Range of monthly average TZ for the period between October 2010 and September 2012 were recorded 1500-9409.5 $\times10^3$ ind/l for Station 1, 43.5-1779 $\times10^3$ ind/l for Station 2, 39-7308 $\times10^3$ ind/l for Station 4, 336-3450 $\times10^3$ ind/l for Station 9, 10.5-1357.5 $\times10^3$ ind/l for Station 10, 1110-9150 $\times10^3$ ind/l for Station 11 and 118.5-4068 $\times10^3$ ind/l for Station 12. The highest monthly average of TZ for station 1, 4, 9, 11 and 12 were recorded during the month of August, May, April, March and December. For Station 2 and 10 highest monthly average of TZ were recorded during the month of February. Whereas lowest TZ were recorded for Station 1 and 9 during the month of July. For Station 2, 10 and 12 were recorded during the month of August. For Station 4 and 11 lowest amount of TZ were recorded during the month of April (Table 32).

In the present investigation, the seasonal variation of TZ showed highest amount during winter and lowest in monsoon in most of the station (Fig. 65).

During the study period, it takes up and down tandency after December and continued up to May. In most of the stations, it showed two peak among January to May (Fig. 66).

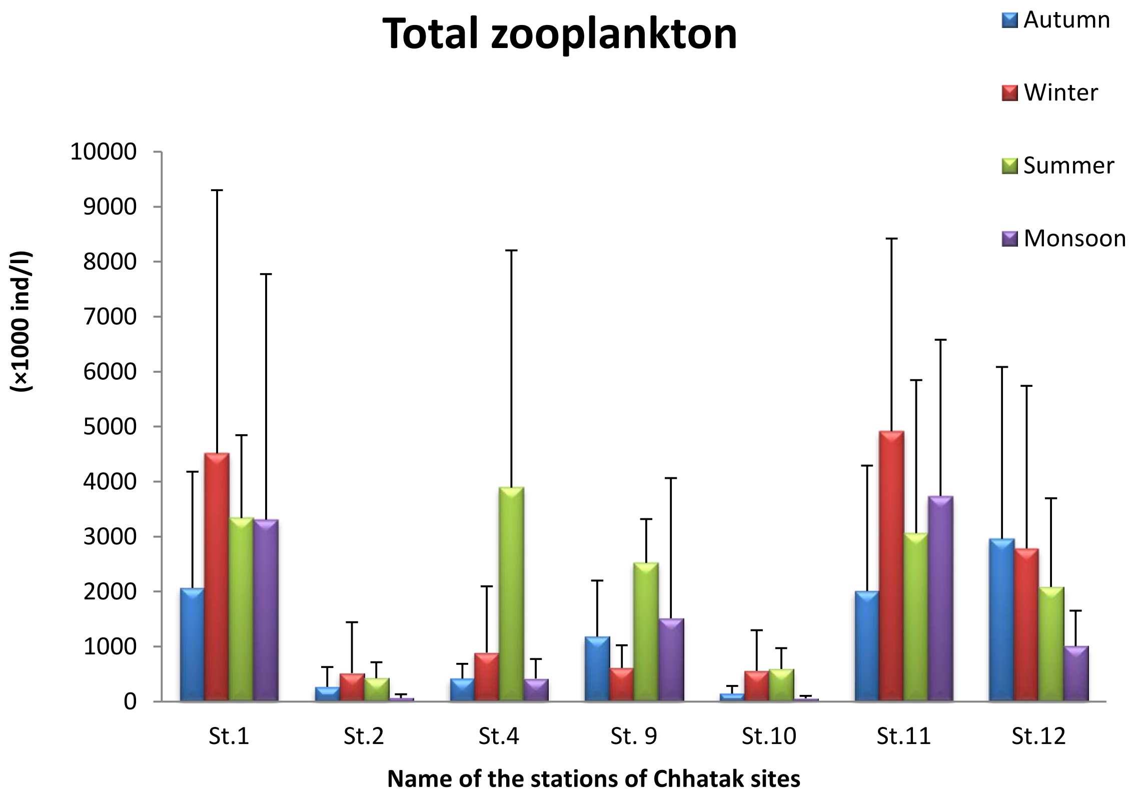


Fig. 65. Seasonal variation of total zooplankton at different stations of Chhatak during 2010-2012.

Table 32. Monthly mean of TZ (×10^3 ind/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	321	3	93	6	24	138	354
	Max.	6930	1113	972	3480	501	6690	10110
	mean	2260.29	224.14	390.43	1392	156.86	2869.29	3098.57
	SD	2495.35	396.61	310.87	1099.96	168.28	2500.56	3467.46
Nov.	Min.	234	60	144	225	9	195	141
	Max.	6735	1152	912	1764	1474	8880	5820
	mean	2396	307.33	431	731.67	294.78	3457.33	2593.67
	SD	2561.34	373.36	242.04	446.95	452.83	2698.70	2072.55
Dec.	Min.	363	6	51	267	30	87	435
	Max.	12210	372	819	1608	1281	10410	11250
	mean	4403.25	190.5	270.75	666	444	4108.5	4068
	SD	5568.71	176.05	368.40	636.18	577.45	4569.33	4871.39
Jan.	Min.	3180	177	1755	279	96	666	948
	Max.	15456	573	4110	738	363	4584	2382
	mean	9318	375	2932.5	508.5	229.5	2625	1665
	SD	8680.44	280.01	1665.24	324.56	188.80	2770.44	1013.99
Feb.	Min.	1410	120	120	42	222	2895	468
	Max.	4914	3438	2400	948	2493	3012	2604
	mean	3162	1779	1260	495	1357.5	2953.5	1536
	SD	2477.70	2346.18	1612.20	640.64	1605.84	82.73	1510.38
Mar.	Min.	4725	294	906	1728	840	9150	216
	Max.	4725	294	906	1728	840	9150	4656
	mean	4725	294	906	1728	840	9150	2436
	SD	OTS	OTS	OTS	OTS	OTS	OTS	3139.55
Apr.	Min.	1548	648	39	3450	975	1110	1680
	Max.	2388	816	39	3450	975	1110	1680
	mean	1968	732	39	3450	975	1110	1680
	SD	593.97	118.79	OTS	OTS	OTS	OTS	OTS
May	Min.	2988	156	5220	2004	165	3210	1695
	Max.	5040	216	9396	2904	384	6180	2178
	Mean	4014	186	7308	2454	274.5	4695	1936.5
	SD	1450.98	42.43	2952.88	636.40	154.86	2100.11	341.53
Jun.	Min.	3036	24	228	828	21	828	270
	Max.	4650	90	1122	3630	177	3564	360
	Mean	3843	57	675	2229	99	2196	315
	SD	1141.27	46.67	632.15	1981.31	110.31	1934.64	63.64
Jul.	Min.	1140	66	384	330	45	342	561
	Max.	1860	300	1320	342	54	7350	675
	Mean	1500	183	852	336	49.5	3846	618
	SD	509.12	165.46	661.85	8.49	6.36	4955.40	80.61
Aug.	Min.	459	33	48	66	6	624	66
	Max.	18360	54	249	2055	15	5670	171
	Mean	9409.5	43.5	148.5	1060.5	10.5	3147	118.5
	SD	12657.92	14.85	142.13	1406.44	6.36	3568.06	74.25
Sep.	Min.	78	24	120	21	18	6	804
	Max.	6765	120	633	10476	126	4170	1920
	Mean	2530.33	50.67	330	1741.67	59.67	1350.67	1338
	SD	2333.58	30.76	202.33	3302.90	38.55	1718.79	422.84

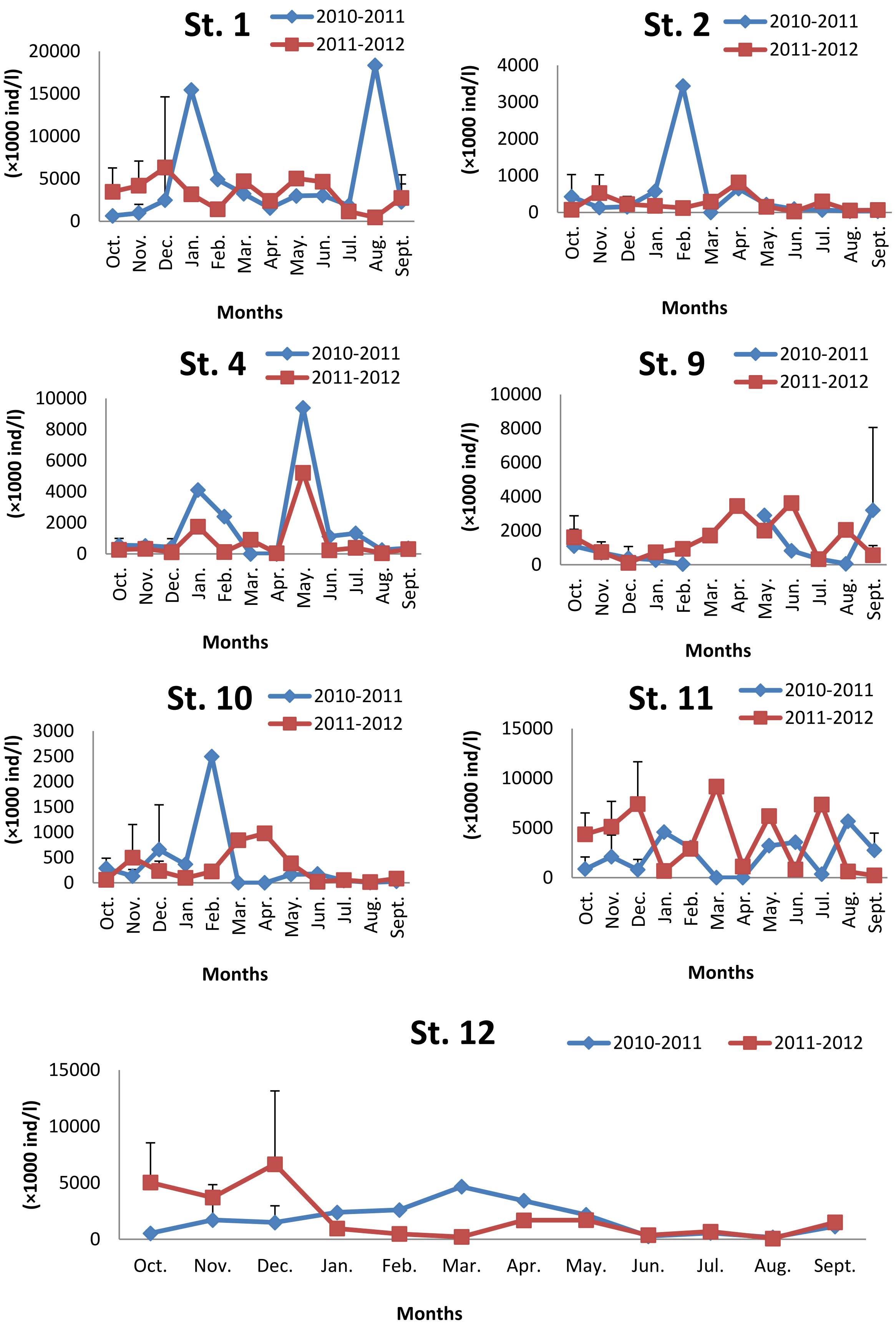


Fig. 66. Comparison of total zooplankton between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Total copepod adult (TCA)

Range of monthly average TCA for the period between October 2010 and September 2012 were recorded 3-5457 $\times10^3$ ind/l for Station 1, 3-150 $\times10^3$ ind/l for Station 2, 0-249 $\times10^3$ ind/l for Station 4, 21-480 $\times10^3$ ind/l for Station 9, 3-153 $\times10^3$ ind/l for Station 10, 71.14-801 $\times10^3$ ind/l for Station 11 and 3-1509 $\times10^3$ ind/l for Station 12. The highest monthly average of TCA for Station 1 were recorded during the month of May. For Station 2 and 10 highest monthly average of TCA were recorded during the month of February. For Station 9 and 11 highest monthly average of TCA were recorded during the month of March. For Station 4 and 11 highest monthly average of TCA were recorded during the month of June and October. Whereas lowest TCA were recorded for Station 1, 4, 9, 11 and 12 during the month of December, March, July, November and February (Table 33).

In the present investigation, the seasonal variation of TCA shows highest amount during summer and lowest in autumn in most of the stations (Fig. 67).

During the study period, TCA showed highest peak during the month of February or March in most of the stations. It showed a decreasing tendency after the month of June in most of the stations (Fig. 68).

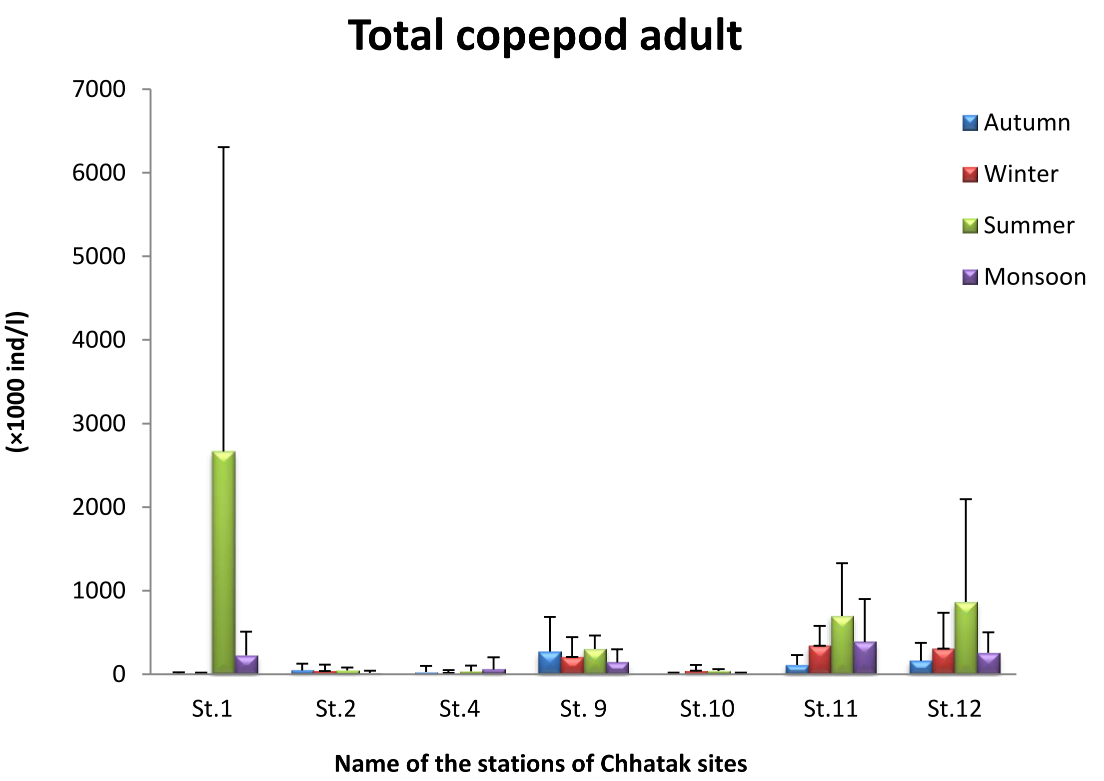


Fig. 67. Seasonal variation of total copepod adult at different stations of Chhatak during 2010-2012.

Table 33. Monthly mean of TCA (×10[3] ind/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	0	0	0	3	0	3	9
	Max.	36	243	237	1365	18	210	510
	mean	11.14	48	35.57	385.71	8.57	71.14	216.43
	SD	12.69	96.54	88.85	463.35	7.23	80.44	216.29
Nov.	Min.	0	3	0	21	0	15	3
	Max.	15	72	24	396	27	2250	1200
	mean	4.67	26.33	9.33	145.33	11.33	801	403.67
	SD	7.05	27.28	7.71	133.71	9.81	727.40	490.06
Dec.	Min.	0	0	0	6	3	30	0
	Max.	12	18	6	801	93	1320	240
	mean	3	7.5	1.5	234.75	27.75	643.5	114.75
	SD	6	7.94	3	380.34	43.57	559.76	108.12
Jan.	Min.	0	30	0	9	30	108	6
	Max.	12	48	12	330	30	984	516
	mean	6	39	6	169.5	30	546	261
	SD	8.49	12.73	8.49	226.98	0	619.43	360.62
Feb.	Min.	0	18	0	0	54	600	0
	Max.	42	282	126	408	252	975	6
	mean	21	150	63	204	153	787.5	3
	SD	29.70	186.68	89.10	288.50	140.01	265.17	4.24
Mar.	Min.	1335	33	0	480	72	600	18
	Max.	1335	33	0	480	72	600	3000
	mean	1335	33	0	480	72	600	1509
	SD	OTS	OTS	OTS	OTS	OTS	OTS	2108.59
Apr.	Min.	156	66	0	315	30	105	210
	Max.	912	96	0	315	30	105	210
	mean	534	81	0	315	30	105	210
	SD	534.57	21.21	0	OTS	OTS	OTS	OTS
May	Min.	1824	6	0	96	24	180	270
	Max.	9090	18	135	324	24	480	824
	Mean	5457	12	67.5	210	24	330	547
	SD	5137.84	8.49	95.46	161.22	0	212.13	391.74
Jun.	Min.	120	0	12	0	3	144	33
	Max.	456	60	486	120	27	192	48
	Mean	288	30	249	60	15	168	40.5
	SD	237.59	42.43	335.17	84.85	16.97	33.94	10.61
Jul.	Min.	420	6	0	18	0	0	3
	Max.	732	108	366	24	12	360	90
	Mean	576	57	183	21	6	180	46.5
	SD	220.62	72.12	258.80	4.24	8.49	254.56	61.52
Aug.	Min.	0	0	3	15	0	108	6
	Max.	9	6	12	75	6	135	36
	Mean	4.5	3	7.5	45	3	121.5	21
	SD	6.36	4.24	6.36	42.43	4.24	19.09	21.21
Sep.	Min.	0	0	0	3	0	0	72
	Max.	855	24	12	540	24	315	735
	Mean	207.33	4.33	5.67	192.67	9.33	87.33	374
	SD	296.54	7.95	3.81	177.37	9.77	122.64	227.68

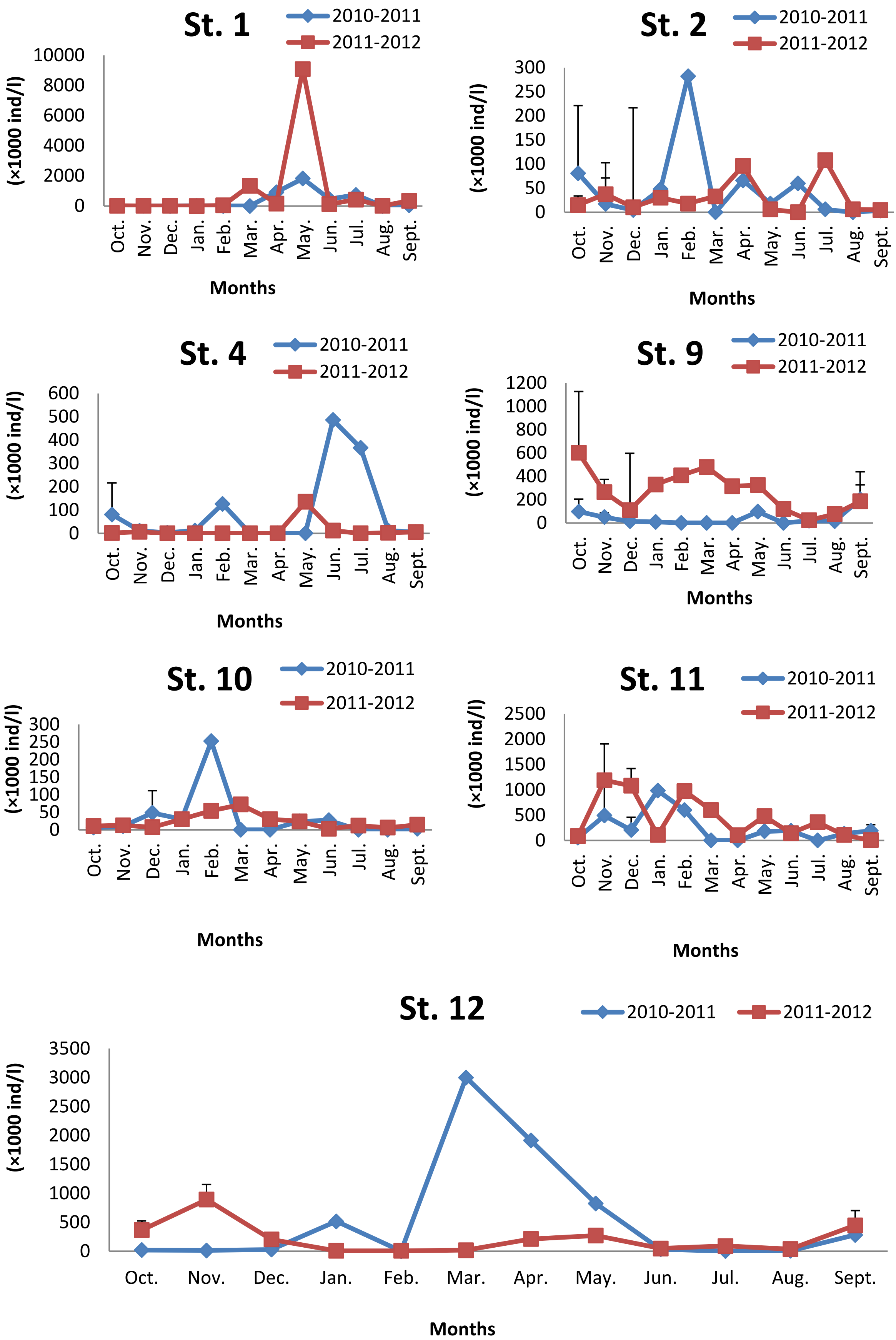


Fig. 68. Comparison of total copepod adult between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

Total copepod nauplii (TCN)

Range of monthly average TCN for the period between October 2010 and September 2012 were recorded 3-2490 $\times 10^3$ ind/l for Station 1, 12-324 $\times 10^3$ ind/l for Station 2, 0-279 $\times 10^3$ ind/l for Station 4, 12-1116 $\times 10^3$ ind/l for Station 9, 1.5-375 $\times 10^3$ ind/l for Station 10, 76.29-3330 $\times 10^3$ ind/l for Station 11 and 10.5-1197 $\times 10^3$ ind/l for Station 12. The highest monthly average of TCA for station 1, 9 and 11 were recorded during the month of March. For Station 2 and 10 highest monthly average of TCA were recorded during the month of April. For Station 4 and 12 highest monthly average of TCA were recorded during the month of June and January. Whereas lowest TCA were recorded for Station 1, 4 and 11 during the month of December, March and October, respectively. For rest of the stations (station 2, 9, 10 and 12) lowest TCA were recorded during the month of August (Table 34).

During the study period, highest peak showed during the month of March to May in most of the stations. It shows rising tendency after the month of January (Fig. 70).

In the present investigation, the seasonal variation of TCN shows highest amount during summer and lowest in monsoon in most of the station (Fig. 69).

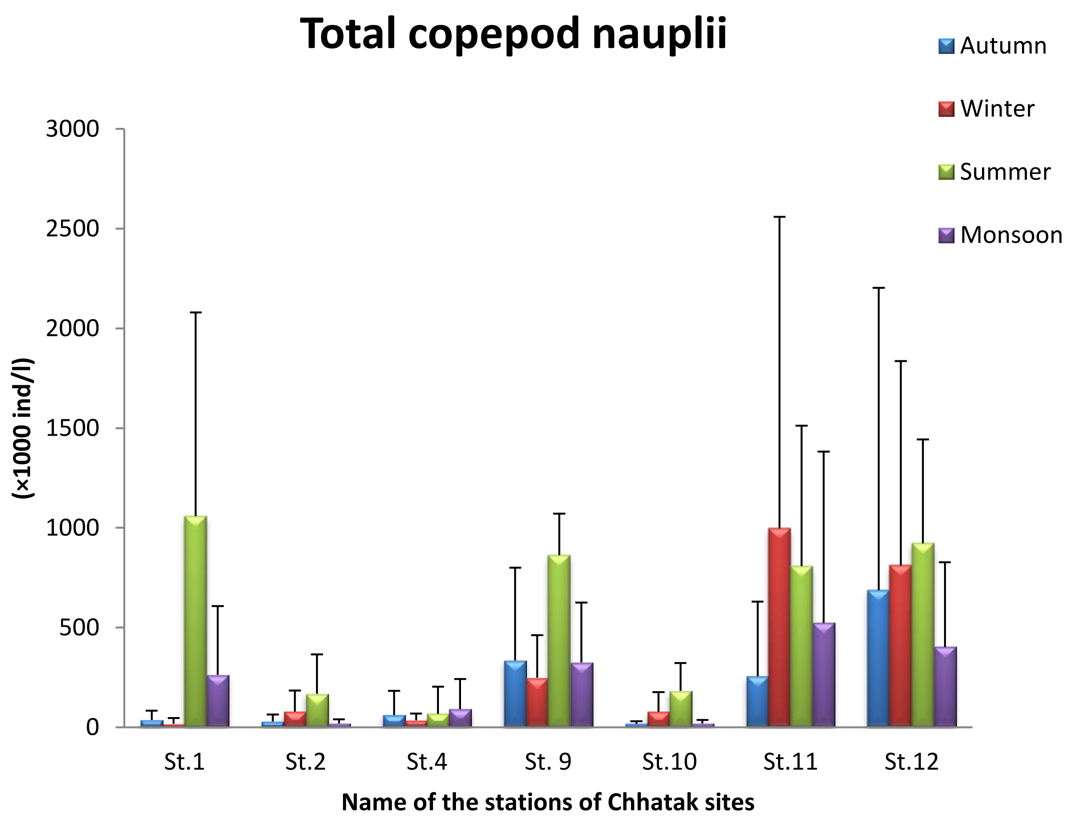


Fig. 69. Seasonal variation of total copepod nauplii at different stations of Chhatak during 2010-2012.

Table 34. Monthly mean of TCN (×10^3 ind/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	15	0	0	0	3	0	3
	Max.	151	36	399	1590	21	210	4950
	mean	56.17	14.14	81	493.71	14	76.29	924
	SD	48.75	11.05	142.85	544.28	6.24	78.53	1781.43
Nov.	Min.	0	9	12	48	0	90	0
	Max.	24	120	72	492	84	2790	1740
	mean	7	48.33	34.33	233.67	33.67	806.33	519.67
	SD	10.82	37.27	20.57	189.16	25.09	808.42	660.40
Dec.	Min.	0	0	3	42	6	0	6
	Max.	12	78	18	720	393	1440	3450
	mean	3	30.75	10.5	231	121.5	747	1039.5
	SD	6	33.80	6.24	327.11	181.87	696.56	1620.42
Jan.	Min.	0	48	0	201	51	300	612
	Max.	30	105	36	228	66	2220	1782
	mean	15	76.5	18	214.5	58.5	1260	1197
	SD	21.21	40.31	25.46	19.09	10.60	1357.65	827.31
Feb.	Min.	24	81	18	27	90	666	30
	Max.	108	414	120	432	90	1875	60
	mean	66	247.5	69	229.5	90	1270.5	45
	SD	59.40	235.47	72.12	286.38	0	854.89	21.21
Mar.	Min.	2490	51	0	1116	156	3330	150
	Max.	2490	51	0	1116	156	3330	1596
	mean	2490	51	0	1116	156	3330	873
	SD	OTS	OTS	0	OTS	OTS	OTS	1022.48
Apr.	Min.	228	132	0	945	375	435	1005
	Max.	1740	516	0	945	375	435	1005
	mean	984	324	0	945	375	435	1005
	SD	1069.15	271.53	0	OTS	OTS	OTS	OTS
May	Min.	144	48	0	660	42	90	810
	Max.	690	90	270	732	156	135	1050
	Mean	417	69	135	696	99	112.5	930
	SD	386.08	29.70	190.92	50.91	80.61	31.82	169.71
Jun.	Min.	0	3	24	186	3	480	27
	Max.	1032	24	534	780	72	1200	60
	Mean	516	13.5	279	483	37.5	840	43.5
	SD	729.73	14.85	360.62	420.02	48.79	509.12	23.33
Jul.	Min.	300	9	36	150	15	33	129
	Max.	444	84	396	273	30	420	225
	Mean	372	46.5	216	211.5	22.5	226.5	177
	SD	101.82	53.03	254.56	86.97	10.60	273.65	67.88
Aug.	Min.	27	6	0	0	0	48	0
	Max.	180	18	33	24	3	195	21
	Mean	103.5	12	16.5	12	1.5	121.5	10.5
	SD	108.19	8.49	23.33	16.97	2.12	103.94	14.85
Sep.	Min.	0	0	9	9	3	0	84
	Max.	1065	42	144	780	36	1035	1290
	Mean	241.67	15.33	44	330.67	17.33	180	624.33
	SD	349.98	13.62	41.11	287.72	9.58	343.69	445.95

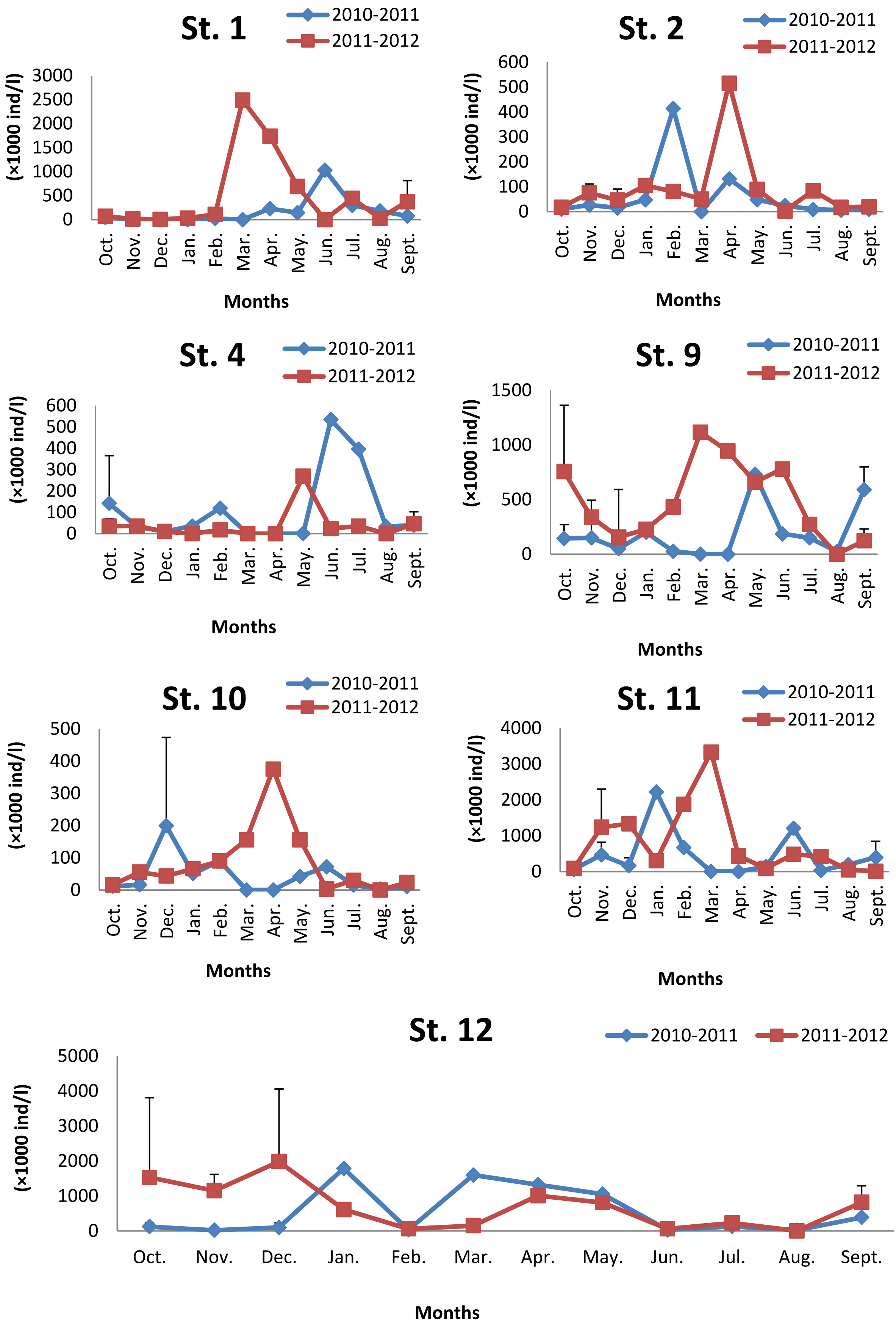


Fig. 70. Comparison of TCN between the year of 2010-11 and 2011-12 for all the stations (St. 1 to 12) of Chhatak.

***Vibrio cholerae* in water analysis (VCWA)**

During the study period between October 2010 and September 2012 it showed that in Station 2 and 12 are infested stations for *Vibrio cholera*e. VCWA was found in Station 2 and 12 during the month of November at the year of 2010 (Table 35).

In the present investigation the seasonal variation of VCWA showed only during autumn (Fig. 71). During the study period peak showed only during the month of November 2010 (Fig. 72).

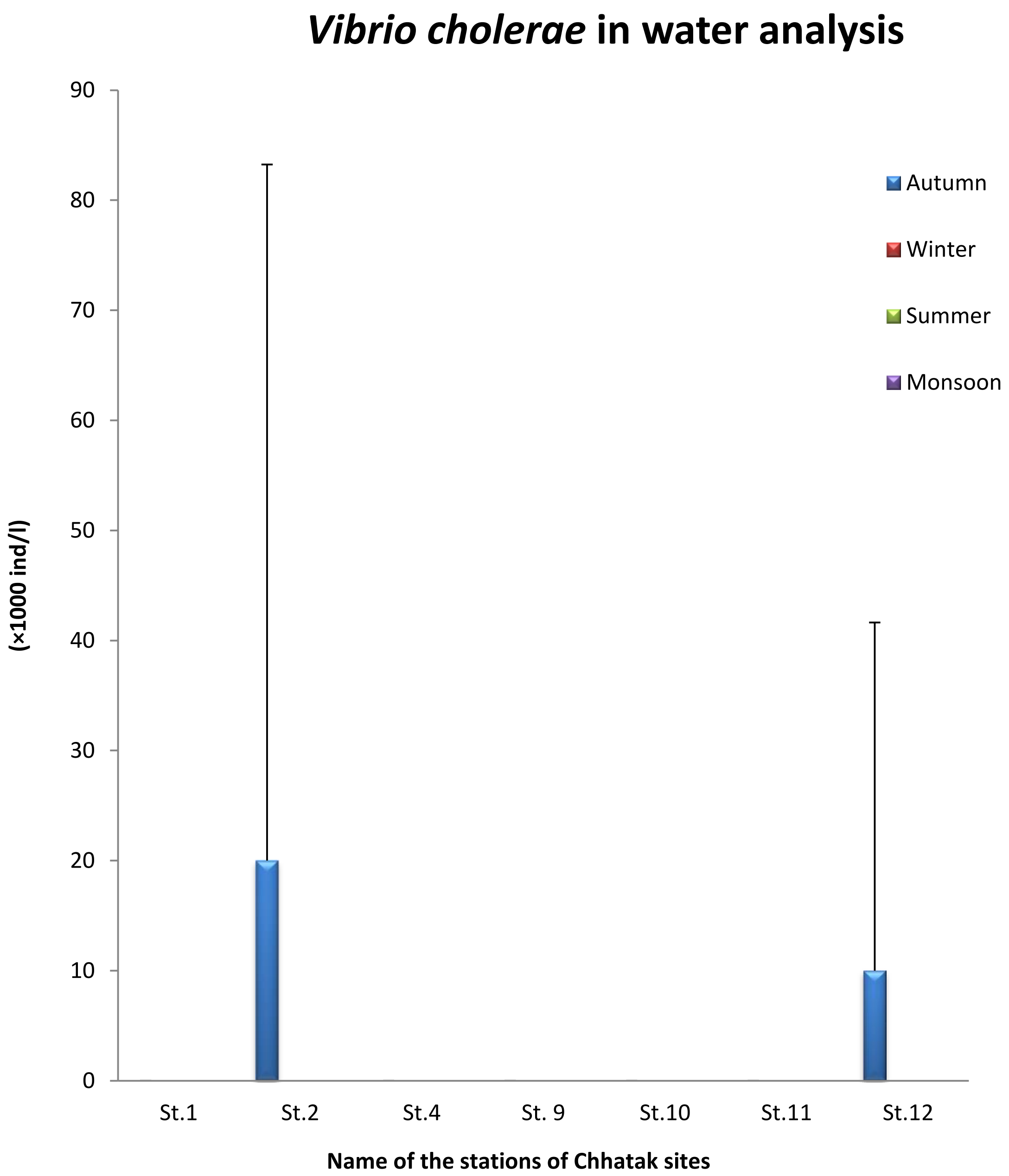
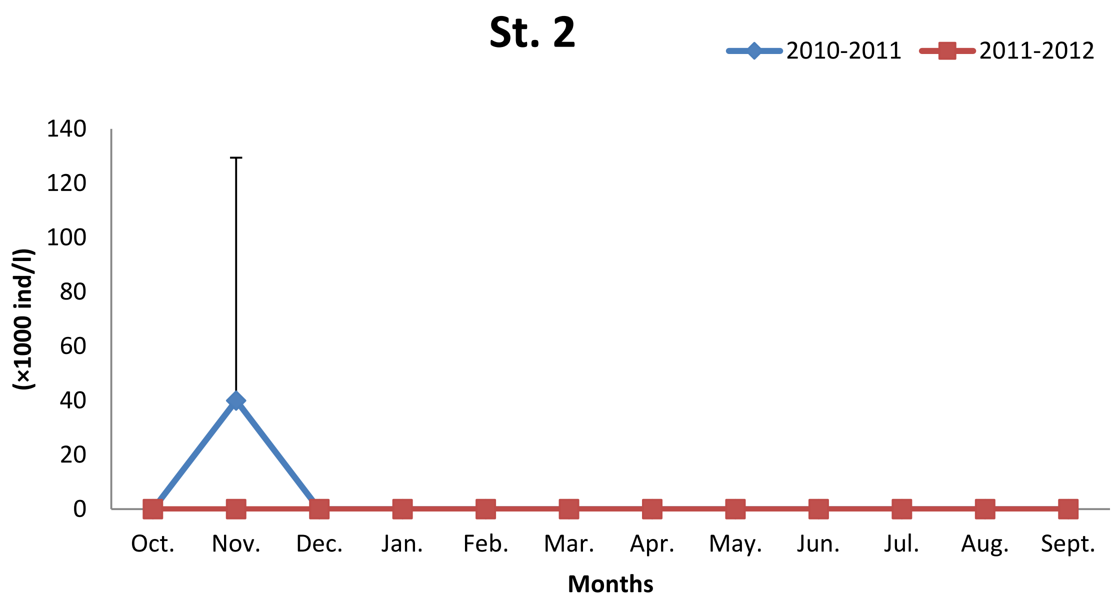


Fig. 71. Seasonal variation of *Vibrio cholerae* in water analysis at different stations of Chhatak during 2010-2012.

Table 35. Monthly mean of VCWA (×10^3 ind/l) at different stations of Chhatak.

Month		St.1	St.2	St.4	St.9	St.10	St.11	St.12
Oct.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Nov.	Min.	0	0	0	0	0	0	0
	Max.	0	200	0	0	0	0	100
	mean	0	22.22	0	0	0	0	11.11
	SD	0	66.67	0	0	0	0	33.33
Dec.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Jan.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Feb.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Mar.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Apr.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
May	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Jun.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Jul.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Aug.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0
Sep.	Min.	0	0	0	0	0	0	0
	Max.	0	0	0	0	0	0	0
	Mean	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0



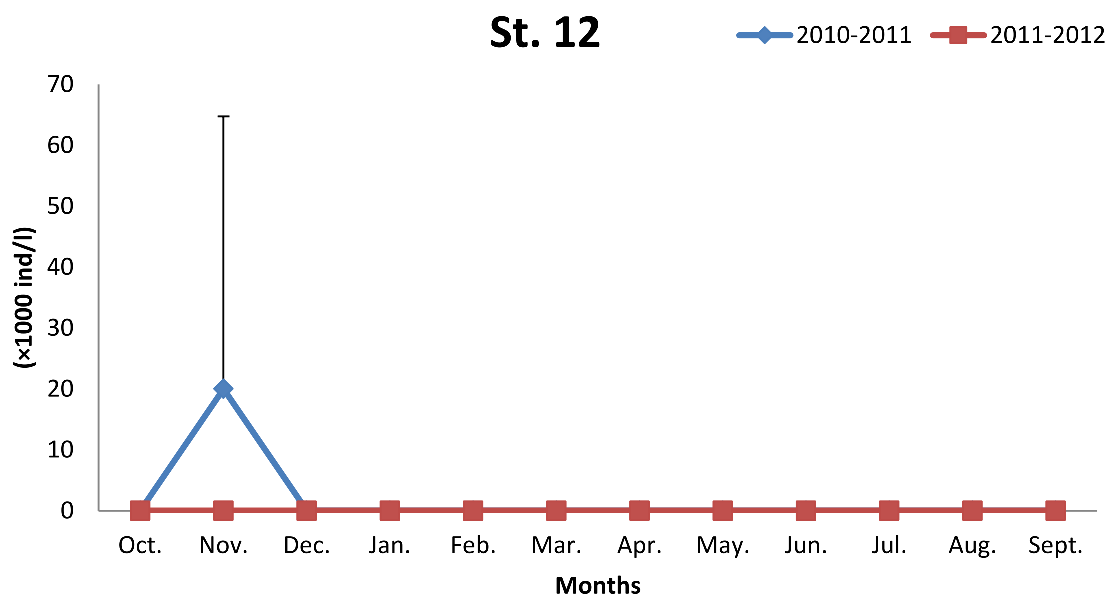


Fig. 72. Comparison of VCWA between the year of 2010-11 and 2011-12 for Station 2 and 12 of Chhatak.

Seasonal variation of phytoplankton in relation to *Vibrio cholerae*

Mathbaria Station 2

It is an infested station for *Vibrio cholerae*. In this station, dominant phytoplankton were *Euglena* sp., *E. acus*, *Strombomonoas*, *Trachelomonas*, *Lepocinclis* and *Phacus* belonging to Euglenophyceae, *Synedra*, *Navicula*, *Nitzschia longissima* and *Chaetoceros* belonging to Bacillariophyceae, *Cryptomonas* and *Rhodomonas* belonging to Cryptophyceae, *Peridinium* belonging to Dinophyceae, *Synura*, *Dinobryon* and *Mallomonas* belonging to Crysophyceae, *Scenedesmus*, *Pediastrum*, *Pandorina* and *Pteromonas* belonging to Chlorophyceae and *Oscillatoria*, *Pelonema aphane*, *Raphidiopsis* and *Microcystis* belonging to Cyanophyceae were observed. During autumn season *Euglena* sp. and *Strombomonoas* were dominant in both the study years of 2010-2011 and 2011-2012 (Table 36). During winter *Dinobryon* population was high in January 2011 and the genus *Euglena* sp. was high in the year of 2011-2012 (Table 37). During summer season *Nitzschia longissima* was highest in both the study years (Table 38). During monsoon in the year of 2010-11 *Euglena* sp. was highest in July 2011 and in the year of 2011-12 *Oscillatoria* was highest in August 2012 (Table 39).

Mathbaria Station 4

It is a non-infested station for *Vibrio cholerae*. In this station dominant phytoplankton are *Euglena* sp., *Strombomonas*, *Trachelomonas*, *Lepocinclis* and *Phacus* belonging to Euglenophyceae, *Surirella*, *Nitzschia longissima*, *Nitzschia* sp., *Cymbella*, *Cyclotella*, *Gyrosigma*, *Rhizosolenia*, *Fragilaria* and *Melosira* belonging to Bacillariophyceae, *Cryptomonas* belonging to Cryptophyceae, *Peridinium* belonging to Dinophyceae, *Synura* belonging to Chrysophyceae, *Hyaloraphidium contortum*, *Westella*, *Cosmarium*, *Schroederia*, *Oedogonium*, *Scenedesmus*, *Coelastrum*, *Crucigenia*, *Chlorella* and *Pediastrum* belonging to Chlorophyceae and *Oscillatoria*, *Pelonema aphane*, *Anabaena* and *Microcystis* belonging to Cyanophyceae were observed. During autumn *Trachelomonas* were highest in both the study year (Table 40). During winter, the density of phytoplankton was very poor (Table 41). During summer *Synechocystis* and *Microcystis* were highest in March 2011 and in the year of 2011-2012 *Euglena* spp. were highest (Table 42). During monsoon the amount of phytoplankton were very poor (Table 43).

Mathbaria Station 5

It is a non-infested station for *Vibrio cholerae*. In this station, dominant phytoplankton were *Euglena* sp., *Euglena acus*, *Trachelomonas*, *Lepocinclis* and *Phacus* belonging to Euglenophyceae, *Nitzschia* sp. and *Nitzschia acicularis* and *Melosira* belonging to Bacillariophyceae, *Cryptomonas* belonging to Cryptophyceae, *Peridinium* belonging to Dinophyceae, *Dinobryon* and *Mallomonas* belonging to Chrysophyceae, *Crucigenia*, *Coelastrum*, *Oocystis*, *Schroederia*, *Monoraphidium*, *Closterium*, *Tetraedron*, *Nephrocytium*, *Chlorococcum*, *Crucigenia*, *Pteromonas* and *Centritractus belenophorus* belonging to Chlorophyceae and *Oscillatoria*, *Anabaena*, *Raphidiopsis*, *Anabaenopsis*, *Lyngbya limnetica* and *Microcystis* belonging to Cyanophyceae were observed. During autumn Euglenophyceae were highest in both the study year (Table 44). During winter *Euglena* sp. was highest both the study years of 2010-2011 and 2011-2012 (Table 45). During summer and monsoon Euglenophyceae were highest in both the study year (Table 46 and 47).

Mathbaria Station 7

It is an infested station for *Vibrio cholerae*. In this station, dominant phytoplankton were *Euglena* sp., *E. acus*, *Collacium*, *Trachelomonas*, *Lepocinclis* and *Phacus* belonging to Euglenophyceae, *Synedra*, *Cyclotella*, *Coscinodiscus*, *Nitzschia longissima* and *Stauronies* belonging to Bacillariophyceae, *Cryptomonas* belonging to Cryptophyceae, *Peridinium* belonging to Dinophyceae, *Dinobryon* and *Mallomonas* belonging to Chrysophyceae, *Pandorina*, *Carteria*, *Pediestrum*, *Hyaliella*, *Chlorococcum*, *Nephrocytium*, *Eudorina* and *Coelastrum* belonging to Chlorophyceae and *Oscillatoria*, *Lingbya limnetica*, *Raphidiopsis* and *Microcystis* belonging to Cyanophyceae were observed. During autumn and winter season Euglenophyceae were dominant in both the study year of 2010-2011 and 2011-2012 (Table 48 and 49). During summer season *Nephrocytium* were highest in the year of 2010-2011 and in the year of 2011-2012 *Peridinium* were highest (Table 50). During monsoon Euglenophyceae were dominant in both the study year and the amount of phytoplankton were comparatively poor (Table 51).

Mathbaria Station 8

It is an infested station for *Vibrio cholerae*. In this station, dominant phytoplankton were *Euglena* sp., *E. acus*, *Strombomonas*, *Trachelomonas* and *Phacus* belonging to Euglenophyceae, *Synedra*, *Cyclotella*, *Navicula*, *Coscinodiscus*, *Nitzschia longissima*, *Nitz. sigmoidea*, *Nitz. acicularis*, *Nitzschia* sp., *Melosira*, *Pleurosigma*, *Gomphonema* and *Gyrosigma* belonging to Bacillariophyceae, *Peridinium* belonging to Dinophyceae, *Mallomonas* belonging to Chrysophyceae, *Schroederia* and *Diacanthos belenophorus* belonging to Chlorophyceae and *Oscillatoria*, *Pelonema aphane* and *Microcystis* belonging to Cyanophyceae were observed. During autumn season Euglenophyceae were dominant in both the study year of 2010-2011 and 2011-2012 (Table 52). During winter and summer *Nitzschia acicularis* and *Nitz. longissima* were dominant in both the study year (Table 53 and 54). During monsoon the amount of phytoplankton were very poor (Table 55).

Mathbaria Station 9

It is a non-infested station for *Vibrio cholerae*. In this station, dominant phytoplankton were *Euglena* sp., *E. acus*, *Lepocinclis*, *Trachelomonas* and *Phacus* belonging to Euglenophyceae, *Navicula*, *Nitzschia longissima* and *Nitzschia* sp. belonging to Bacillariophyceae, *Peridinium* belonging to Dinophyceae, *Mallomonas* belonging to Chrysophyceae, *Cryptomonas* and *Rhodomonas* belonging to Cryptophyceae**,** *Schroederia*, *Tetraedron*, *Scenedesmus*, *Carteria*, *Hyaliella*, *Monoraphidium* and *Crucigenia* belonging to Chlorophyceae and *Oscillatoria*, *Lyngbya* and *Microcystis* belonging to Cyanophyceae were observed. During autumn, winter, summer and monsoon the amount of phytoplankton belonging to Euglenophyceae were dominant but quantitively poor among all the year round (Table 56-59).

Mathbaria Station 10

It is an infested station for *Vibrio cholerae*. In this station, dominant phytoplankton were *Euglena* sp., *E. acus*, *Strombomonas*, *Lepocinclis*, *Trachelomonas* and *Phacus* belonging to Euglenophyceae, *Navicula*, *Nitzschia longissima*, *Nitz. acicularis*, and *Gyrosigma* belonging to Bacillariophyceae, *Peridinium* and *Ceratium* belonging to Dinophyceae, *Mallomonas* belonging to Chrysophyceae, *Cryptomonas* and *Rhodomonas* belonging to Cryptophyceae, *Chlamydomonas* belonging to Chlorophyceae and *Oscillatoria*, *Merismopedia*, *Pelonema aphane* and *Microcystis* belonging to Cyanophyceae were observed. During autumn and winter amount of phytoplankton were poor in both the study years of 2010-2011 and 2011-2012 (Table 60 and 61). During summer *Euglena* sp. and *Nitzschia longissima* were dominant (Table 62). During monsoon in the year of 2010-11 amount of phytoplankton were poor but in the year of 2011-12 *Oscillatoria* belonging to Cyanophyceae were dominant (Table 63).

Mathbaria Station 11

It is an infested station for *Vibrio cholerae*. In this station dominant phytoplankton were *Euglena* sp., *E. acus*, *Strombomonas*, *Trachelomonas* and *Phacus* belonging to Euglenophyceae, *Nitzschia longissima* belonging to Bacillariophyceae, *Peridinium* belonging to Dinophyceae, *Mallomonas* belonging to Chrysophyceae, *Cryptomonas* belonging to Cryptophyceae and *Oscillatoria* and *Pelonema aphane* belonging to Cyanophyceae were observed. Samples were collected only at the time of summer and monsoon in the year of 2012. During summer *Euglena* sp. and *Nitzschia longissima* were dominant (Table 64). During monsoon *Oscillatoria* belonging to Cyanophyceae were dominant (Table 65).

Table 36. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Mathbaria Station 2.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Euglena* sp. 06.24	*Strombomonas* 5.58	*Rhodomonas* 2.41	*Mallomonas* 1.64	+	+
	E. Nov.	2	*Euglena* sp. 34.36	*Strombomonas* 8.59	*Oscillatoria* 6.13	*Trachelomonas* 3.72	-	+
2011-2012	L. Oct.	27	*Strombomonas* 34.36	*Peridinium* 25.77	*Pandorina* 2.62	*Euglena* sp. 1.75	-	-
	E. Nov.	28	*Pelonema aphane* 3.28	*Euglena* sp. 2.40	*Phacus* sp. 2.19	*Trachelomonas* 0.44	-	-

Table 37. Density of dominant phytoplankton (10^3 ind/l) in winter season at Mathbaria Station 2.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	Dec.	3	*Euglena* sp. 180.41	*Lepocinclis* 171.82	*Oscillatoria* 103.02	*Peridinium* 68.73	-	-
	Jan.	4	*Dinobryon* 6357.37	*Synedra* 154.64	*Oscillatoria* 111.68	*Raphidiopsis* 42.96	-	-
	Feb.	5	*Euglena* sp. 146.05	*Peridinium* 60.14	*Dinobryon* 19.04	*Euglena acus* 8.32	-	-
		6	*Euglena* sp. 31.52	*Euglena acus* 23.42	*Phacus* 12.04	*Synura* 11.60	-	-
		7	*Strombomonas* 12.70	*Euglena* sp. 12.48	*Trachelomonas* 9.41	*Euglena acus* 7.22	-	-
2011-2012	Dec.	29	*Euglena* sp. 8.75	*Euglena acus* 2.84	*Mallomonas* sp. 0.87	*Strombomonas* sp. 0.65	-	-
	Jan.	30	*Cryptomonas* sp. 0.65	*Trachelomonas* sp. 0.44	*Navicula* sp. 0.22	*Euglena* sp. 0.22	-	-
		31	*Euglena* sp. 300.68	*Mallomonas* sp. 60.13	*Euglena acus* 25.77	*Phacus* sp. 25.77	-	-
	Feb.	32	*Euglena* sp. 60.13	*Euglena acus* 3.28	*Phacus* sp. 1.53	*Cryptomonas* sp. 1.31	-	-
		33	*Euglena* sp. 10.94	*Euglena acus* 7.00	*Phacus* sp. 3.06	*Cryptomonas* sp. 1.75	-	-
		34	*Euglena* sp. 12.69	*Euglena acus* 10.50	*Nitzschia longissima* 5.03	*Phacus* sp. 4.81	-	-

Table 38. Density of dominant phytoplankton (10^3 ind/l) in summer season at Mathbaria Station 2.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	8	*Lepocinclis* 68.73	*Strombomonas* 51.55	*Euglena acus* 34.36	*Trachelomonas* 25.77	-	-
		9	*Euglena* sp. 12.26	*Strombomonas* 6.13	*Trachelomonas* 5.91	*Lepocinclis* 4.60	-	-
		10	*Euglena* sp. 154.64	*Nitzschia longissima* 60.14	*Phacus* 25.77	*Peridinium* 17.18	-	-
		11	*Euglena* sp. 85.91	*Euglena acus* 77.32	*Nitzschia longissima* 68.73	*Phacus* 42.96	-	-
	April	12	*Nitzschia longissima* 8.54	*Microcystis* 5.03	*Euglena* sp. 4.60	*Euglen acus* 2.85	+	+
		13	*Nitzschia longissima* 17.95	*Strombomonas* 9.85	*Euglena* sp. 8.10	*Microcystis* 5.91	+	-
		14	*Microcystis* 13.57	*Nitzschia longissima* 10.51	*Euglena* sp. 5.03	*Strombomonas* 3.06	-	-
		15	*Nitzschia longissima* 163.23	*Euglena* sp. 5.03	*Euglena acus* 3.28	*Phacus* 3.06	+	-
	May	16	*Strombomonas* 77.32	*Euglena* sp. 68.73	*Peridinium* 34.36	*Nitzschia longissima* 25.77	-	-
		17	*Nitzschia longissima* 12.91	*Euglena* sp. 7.00	*Strombomonas* 1.97	*Phacus* 1.31	-	-
		18	*Euglena* sp.223.37	*Strombomonas* 42.96	*Nitzschia longissima* 34.36	*Trachelomonas* 25.77	-	-
		19	*Strombomonas* 21.67	*Euglena* sp. 10.73	*Nitzschia longissima* 5.47	*Microcystis* 1.75	-	-
		20	*Nitzschia longissima* 12.26	*Phacus* 3.72	*Euglena acus* 2.62	*Euglena* sp. 2.41	-	-
2011-2012	March	35	*Nitzschia longissima* 35.89	*Euglena acus* 23.20	*Euglena* sp. 15.32	*Phacus* sp. 8.31	-	-
		36	*Euglena* sp. 644.33	*Phacus* sp. 171.82	*Euglena acus* 25.77	*Nitzschia longissima* 4.59	-	-
		37	*Euglena* sp. 214.78	*Nitzschia longissima* 51.55	*Phacus* sp. 42.95	*Strombomonas* sp. 34.36	-	-
		38	*Nitzschia longissima* 60.14	*Euglena acus* 51.54	*Phacus* sp. 42.95	*Peridinium* sp. 5.91	-	-
	April	39	*Euglena* sp. 171.82	*Phacus* sp. 10.94	*Euglena acus* 6.56	*Strombomonas* sp. 3.72	+	-
		40	*Euglena* sp. 395.19	*Phacus* sp. 51.54	*Nitzschia longissima* 25.77	*Strombomonas* sp. 5.47	+	+
		41	*Euglena* sp. 146.04	*Nitzschia longissima* 94.50	*Phacus* sp. 7.88	*Euglena acus* 7.22	-	-
		42	*Nitzschia longissima* 25.77	*Euglena* sp. 4.15	*Phacus* sp. 3.72	*Pediastrum* sp. 1.09	-	-
	May	43	*Nitzschia longissima* 10.59	*Phacus* sp. 8.20	*Euglena* sp. 4.78	*Euglena acus* 3.42	-	-
		44	*Euglena* sp. 80.45	*Nitzschia longissima* 53.63	*Strombomonas* sp. 40.23	*Peridinium* sp. 26.82	-	-
		45	*Strombomonas* sp. 14.69	*Pelonema aphane* 10.93	*Euglena* sp. 7.86	*Phacus* sp. 7.51	-	-
		46	*Pelonema aphane* 254.76	*Euglena* sp. 14.69	*Strombomonas* sp. 11.96	*Peridinium* sp. 8.20	-	-
		47	*Pelonema aphane* 7.52	*Nitzschia longissima* 2.05	*Euglena acus* 1.71	*Strombomonas* sp. 1.37	-	-

Table 39. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Mathbaria Station 2.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	21	*Nitzschia longissima* 29.11	*Strombomonas* 7.00	*Peridinium* 4.81	*Euglena* sp. 3.72	-	-
	July	22	*Euglena* sp. 146.05	*Nitzschia longissima* 120.27	*Strombomonas* 77.32	*Peridinium* 60.13	-	-
	Aug.	23	*Euglena acus* 13.79	*Strombomonas* 11.82	*Euglena* sp. 11.60	*Scenedesmus* 1.53	-	-
	Sept.	24	*Chaetoceros* 3.72	*Peridinium* 3.50	*Euglena* sp. 2.19	*Euglena acus* 1.75	-	-
		25	*Peridinium* 4.59	*Strombomonas* 4.38	*Euglena acus* 3.50	*Euglena* sp. 0.87	-	-
	E. Oct.	26	*Euglena* sp. 16.19	*Peridinium* 14.88	*Strombomonas* 14.22	*Pandorina* 2.84	-	-
2011-2012	June	48	*Pelonema aphane* 7.86	*Euglena* sp. 5.47	*Euglena acus* 2.39	*Strombomonas* sp. 1.71	-	-
	July	49	*Pelonema aphane* 4.78	*Euglena* sp. 3.76	*Euglena acus* 1.71	*Strombomonas* sp. 1.37	-	-
	Aug.	50	*Oscillatoria* sp. 415.67	*Trachelomonas* 3.07	*Euglena* sp. 2.39	*Phacus* sp. 2.05	-	-
	Sept.	51	*Oscillatoria* sp. 22.89	*Euglena* sp. 6.15	*Lepocinclis* sp. 4.78	*Phacus* sp. 3.76	-	-
		52	*Oscillatoria* sp. 38.60	*Euglena* sp. 27.33	*Pteromonas* sp. 19.81	*Euglena acus* 11.96	-	-

Table 40. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Mathbaria Station 4.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Euglena sp.*17.18	*Cryptomonas* 8.59	*Trachelomonas volvocina* 2.63	*Strombomonas* 1.09	-	-
	E. Nov.	2	*Trachelomonas volvocina* 94.50	*Hyaloraphidium contortum* 17.18	*Peridinium* 1.09	*Westella* 0.88	-	-
2011-2012	L. Oct.	27	*Trachelomonas* 197.59	*Peridinium* 1.09	*Euglena sp.* 0.66	*Oedogonium* 0.44	-	-
	E. Nov.	28	*Trachelomonas* 14.22	*Euglena sp.* 2.40	*Phacus* 0.44	*Pediastrum* 0.22	-	-

Table 41. Density of dominant phytoplankton (10^3 ind/l) in winter season at Mathbaria Station 4

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	Dec.	3	*Trachelomonas volvocina* 5.47	*Euglena* 5.25	*Lepocinclis* 2.19	*Oscillatoria* 1.75	-	-
	Jan.	4	*Euglena sp.* 8.32	*Melosira* 0.88	*Cryptomonas* 0.44	*Lepocinclis* 0.22	-	-
	Feb.	5	*Cyclotella* 2.85	*Peridinium* 2.19	*Euglena sp.* sp. 1.09	*Cryptomonas* 0.66	-	-
		6	*Euglena sp.* 9.19	*Coelastrum* 3.06	*Pelonema aphane* 0.44	*Cosmarium* 0.22	-	-
		7	*Nitzschia longissima* 6.13	*Lepocinclis* 1.09	*Phacus* 0.66	*Oscillatoria* 0.44	-	-
2011-2012	Dec.	29	*Trachelomonas* 1.75	*Peridinium* 1.31	*Coelastrum* 0.87	*Euglena sp.* 0.65	-	-
	Jan.	30	*Euglena sp.* 1.09	*Microcystis* 0.65	*Peridinium* 0.22	*Phacus* 0.22	-	-
		31	*Cyclotella* 1.09	*Coelastrum* 0.44	*Trachelomonas* 0.22	*Cryptomonas* 0.22	-	-
	Feb.	32	*Euglena sp.* 3.06	*Coelastrum* 2.84	*Peridinium* 1.31	*Nitzschia longissima* 0.44	-	-
		33	*Euglena sp.* 1.31	*Trachelomonas* 0.65	*Phacus* 0.44	*Strombomonas* 0.22	-	-
		34	*Peridinium* 3.72	*Strombomonas* 2.19	*Euglena sp.*1.97	*Coelastrum* 0.65	-	-

Table 42. Density of dominant phytoplankton (10^3 ind/l) in summer season at Mathbaria Station 4.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	8	*Nitzschia longissima* 3.72	*Schroederia* 3.28	*Pelonema aphane* 1.31	*Rhizosolenia* 0.88	-	-
		9	*Nitzschia longissima* 3.06	*Euglena* sp. 2.63	*Coelastrum* 1.31	*Peridinium* 0.66	-	-
		10	*Euglena* sp. 1.75	*Coelastrum* 1.53	*Microcystis* 1.31	*Fragilaria* 0.44	-	-
		11	*Microcystis* 103.09	*Euglena* sp. 3.28	*Nitzschia longissima* 1.28	*Peridinium* 0.88	-	-
	April	12	*Euglena* sp. 42.96	*Coelastrum* 3.50	*Microcystis* 1.75	*Peridinium* 1.53	-	-
		13	*Euglena* sp. 5.69	*Coelastrum* 1.53	*Crucigenia* 0.88	*Microcystis* 0.66	-	-
		14	*Microcystis* 7.88	*Coelastrum* 1.75	*Scenedesmus* 0.88	*Anabaena* 0.66	-	-
		15	*Nitzschia longissima* 0.88	*Oscillatoria* 0.66	*Synechocystis* 0.44	*Euglena* sp. 0.22	-	-
	May	16	*Scenedesmus* 5.47	*Coelastrum* 1.96	*Microcystis* 1.31	*Euglena* sp. 0.88	-	-
		17	*Scenedesmus* 1.53	*Pediastrum* 1.31	*Oscillatoria* 1.09	*Coelastrum* 0.88	-	-
		18	*Scenedesmus* 4.59	*Microcystis* 0.66	*Euglena* sp. 0.44	*Coelastrum* 0.22	-	-
		19	*Oscillatoria* 2.18	*Microcystis* 1.75	*Scenedesmus* 0.44	*Euglena* sp. 0.22	-	-
		20	*Oscillatoria* 2.63	*Nitzschia* 0.66	*Peridinium* 0.44	*Anabaena* 0.22	-	-
2011-2012	March	35	*Euglena* sp. 1.31	*Peridinium* 0.87	*Coelastrum* 0.65	*Phacus* 0.22	-	-
		36	*Peridinium* 17.18	*Coelastrum* 1.75	*Euglena* sp. 1.31	*Strombomonas* 0.43	-	-
		37	*Trachelomonas* 4.16	*Peridinium* 1.75	*Euglena* sp. 0.87	*Ceolastrum* 0.65	-	-
		38	*Euglena* sp. 6.35	*Trachelomonas* 4.16	*Peridinium* 1.53	*Coelastrum* 0.87	-	-
		39	*Strombomonas* 2.62	*Peridinium* 1.97	*Euglena* sp. 1.75	*Pandorina* 1.31	-	-

Table 43. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Mathbaria Station 4.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	21	*Euglena* sp. 0.87	*Nitzschia longissima* 0.66	*Gyrosigma* 0.44	*Cymbella* 0.22	-	-
	July	22	*Surirella* 1.53	*Euglena* sp. 1.09	*Oscillatoria* 0.87	*Trachelomonas* 0.44	-	-
	Aug.	23	*Euglena* sp. 1.09	*Phacus* 0.65	*Gyrosigma* 0.44	*Trachelomonas* 0.22	-	-
	Sept.	24	*Peridinium* 1.09	*Euglena* sp. 0.87	*Pithophora* 0.65	*Trachelomonas* 0.22	-	-
		25	*Euglena* sp. 1.31	*Peridinium* 0.22	*Cryptomonas* 0.22	*Melosira* 0.22	-	-
	E. Oct.	26	*Peridinium* 0.44	*Chlamydomonas* 0.22	*Chlorella* 0.22	*Euglena* 0.22	-	-

Table 44. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Mathbaria Station 5.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Trachelomonas* 4.38	*Peridinium* 2.41	*Euglena* 1.97	*Strombomonas* 1.09	-	-
	E. Nov.	2	*Phacus* 34.36	*Peridinium* 8.59	*Trachelomonas* 5.03	*Westella* 0.88	-	-
2011-2012	L. Oct.	27	*Euglena* 4.16	*Trachelomonas* 3.94	*Peridinium* 1.97	*Oedogonium* 0.44	-	-
	E. Nov.	28	*Euglena* sp. 13.57	*Trachelomonas* sp. 1.75	*Crucigenia* sp. 1.09	*Pediastrum* 0.22	-	-

Table 45. Density of dominant phytoplankton (10^3 ind/l) in winter season at Mathbaria Station 5.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	Dec.	3	*Trachelomonas volvocina* 5.47	*Euglena* 5.25	*Lepocinclis* 2.19	*Oscillatoria* 1.75	-	-
	Jan.	4	*Euglena sp.* 8.32	*Melosira* 0.88	*Cryptomonas* 0.44	*Lepocinclis* 0.22	-	-
	Feb.	5	*Cyclotella* 2.85	*Peridinium* 2.19	*Euglena sp.* sp. 1.09	*Cryptomonas* 0.66	-	-
		6	*Euglena sp.* 9.19	*Coelastrum* 3.06	*Pelonema aphane* 0.44	*Cosmarium* 0.22	-	-
		7	*Nitzschia longissima* 6.13	*Lepocinclis* 1.09	*Phacus* 0.66	*Oscillatoria* 0.44	-	-
2011-2012	Dec.	29	*Euglena* sp 180.41	*Lepocinclis* 171.82	*Oscillatoria* 103.02	*Peridinium* 68.73	-	-
	Jan.	30	*Nitzschia* 111.68	*Lyngbya limneticum* 60.14	*Euglena* 25.77	*Anabaena* 4.82	-	-
		31	*Nitzschia* 103.09	*Trachelomonas* 51.55	*Closterium* 11.16	*Peridinium* 1.97	-	-
	Feb.	32	*Lyngbya limnetica* 20.36	*Nitzschia* 5.47	*Euglena* 4.82	*Trachelomonas* 1.75	-	-
		33	*Nitzschia acicularis* 11.60	Oocystis 10.51	*Lyngbya limnetica* 9.85	*Anabaena* 5.25	-	-
		34	*Euglena* sp. 85.91	*Closterium* sp. 1.53	*Peridinium* sp. 0.87	*Nitzschia* sp. 0.65	-	-

Table 46. Density of dominant phytoplankton (10^3 ind/l) in summer season at Mathbaria Station 5.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	8	*Lyngbya limnetica* 171.82	*Anabaena* 7.88	*Nitzschia acicularis* 6.57	*Trachelomonas* 4.82	-	-
		9	*Anabaena* 223.37	*Lyngbya limnetica* 128.86	*Euglena* sp. 17.51	*Trachelomonas* 14.88	-	-
		10	*Nitzschia acicularis* 111.68	*Dinobryon* 103.09	*Euglena* sp. 94.50	*Anabaena* 77.32	-	-
		11	*Euglena* sp. 137.46	*Lepocinclis* 25.77	*Anabaena* 14.01	*Microcystis* 9.19	-	-
	April	12	*Euglena* sp. 624.15	*Trachelomonas* 120.27	*Lyngbya limnetica* 85.91	*Phacus*10.51	-	-
		13	*Euglena* sp. 12.70	*Trachelomonas* 6.35	*Phacus* 3.94	*Nephrocytium* 3.28	-	-
		14	*Euglena* sp. 223.37	*Oocystis* 85.91	*Microcystis* 17.18	*Tetraedron* 1.75	-	-
		15	*Nephrocytium* 34.58	*Microcystis* 7.00	*Dinobryon* 5.25	*Euglena* sp. 4.38	+	-
	May	16	*Nephrocytium* 128.87	*Euglena* sp. 28.45	*Strombomonas* 1.75	*Dinobryon* 1.53	-	-
		17	*Nephrocytium* 171.82	*Euglena* sp. 6.79	*Nitzschia acicularis* 2.85	*Trachelomonas* 1.31	-	-
		18	*Nephrocytium* 455.32	*Euglena* sp. 85.91	*Nitzschia acicularis* 8.97	*Strombomonas* 2.84	-	-
		19	*Euglena* sp. 309.27	*Nephrocytium* 163.23	*Phacus* 4.15	*Euglena* acus 2.40	-	-
		20	*Euglena* sp. 146.05	*Phacus* 1.53	*Trachelomonas* 0.87	*Tetraedron* 0.66	-	-
2011-2012	March	35	*Coelastrum* sp. 1.53	*Closterium* sp. 0.87	*Trachelomonas* sp. 0.65	*Cryptomonas* sp. 0.43	-	-
		36	*Peridinium* sp. 2.40	*Euglena* sp. 0.87	*Strombomonas* sp. 0.43	*Tetraedron* sp. 0.22	-	-
		37	*Trachelomonas* sp. 4.16	*Peridinium* sp. 1.75	*Euglena* sp.0.87	*Ceolastrum* sp. 0.65	-	-
		38	*Coelastrum* sp. 8.31	*Chlorococcum* sp. 4.16	*Crucigenia* sp. 2.19	*Euglena* sp. 0.65	-	-
	April	39	*Peridinium* sp. 3.94	*Euglena* sp. 3.72	*Trachelomonas* sp. 1.31	*Nitzschia longissima* 1.09	-	-
		40	*Euglena* sp. 12.69	*Trachelomonas* sp. 7.00	*Mallomonas* sp. 5.69	*Euglena acus* 2.84	-	-
		41	*Trachelomonas* sp. 4.59	*Euglena* sp. 3.50	*Nitzschia longissima* 1.97	*Peridinium* sp. 0.87	-	-
		42	*Lyngbya limnetica* 51.54	*Trachelomonas* sp. 12.47	*Mallomonas* sp. 1.75	*Tetraedron* sp. 1.53	-	-
	May	43	*Euglena* sp. 80.45	*Lyngbya limnetica* 40.23	*Coelastrum* sp.2.73	*Trachelomonas* sp. 2.39	-	-
		44	*Euglena* sp. 254.76	*Trachelomonas* sp. 9.57	*Peridinium* sp.3.76	*Nitzschia longissima* 0.34	-	-
		45	*Euglena* sp. 281.58	*Raphidiopsis* sp. 120.68	*Anabaena* sp. 5.46	*Lyngbya limnetica* 2.39	-	-
		46	*Euglena* sp. 53.63	*Trachelomonas* sp. 13.41	*Peridinium* sp.5.12	*Scenedesmus* sp. 1.37	-	-
		47	*Mallomonas* sp. 8.88	*Euglena* sp. 3.76	*Coelastrum* sp.3.42	*Euglena acus* sp. 2.73	-	-

Table 47. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Mathbaria Station 5.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	21	*Euglena* sp. 12.69	*Trachelomonas* 1.75	*Peridinium* 1.31	*Strombomonas* 0.87	-	-
	July	22	*Euglena* sp. 206.18	*Nephrocytium* 5.25	*Crucigenia* 1.31	*Trachelomonas* 1.09	-	-
	Aug.	23	*Euglena* sp. 5.47	*Closterium* 0.87	*Trachelomonas* 0.44	*Crucigenia* 0.44	-	-
	Sept.	24	*Euglena* sp. 128.86	*Trachelomonas* 7.88	*Peridinium* 1.31	*Microcystis* 1.09	-	-
		25	*Euglena* sp. 549.82	*Chlorococcum* 85.91	*Trachelomonas* 5.69	*Closterium* 1.31	-	-
	E. Oct.	26	*Trachelomonas* 4.59	*Chlorococcum* 2.40	*Euglena* sp. 1.53	*Oocystis* 0.44	-	-
2011-2012	June	48	*Mallomonas* sp. 201.13	*Euglena acus* 17.08	*Euglena* sp. 14.01	*Strombomonas* sp. 11.62	-	-
	July	49	*Oscillatoria* sp. 147.49	*Mallomonas* sp. 2.73	*Euglena acus* 1.02	*Trachelomonas* sp. *0.68*	-	-
	Aug.	50	*Chlamydomon-as* sp. 24.26	*Oscillatoria* sp. 7.52	*Rhizosolenia* sp. 3.42	*Mallomonas* sp. 3.07	-	-
	Sept.	51	*Euglena* sp. 201.13	*Pteromonas* sp. 9.57	*Trachelomonas* sp. 4.44	*Peridinium* sp. 3.42	-	-
		52	*Euglena* sp. 38.26	*Peridinium* sp. 10.25	*Centritractus belenophorus* 6.15	*Trachelomonas* sp. 3.50	-	-

Table 48. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Mathbaria Station 7.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Trachelomonas* 14.45	*Euglena* 7.66	*Peridinium* 5.69	*Pandorina* 4.38	-	-
	E. Nov.	2	*Peridinium* 17.18	*Pandorina* 3.28	*Oscillatoria* 1.97	*Lepocinclis* 1.53	-	-
2011-2012	L. Oct.	27	*Euglena* sp. 60.14	*Peridinium* 51.55	*Euglena* acus 42.95	*Strombomonas* 3.72	-	-
	E. Nov.	28	*Euglena* sp. 6.34	*Peridinium* sp. 5.47	*Mallomonas* sp. 4.15	*Strombomonas* sp. 1.75	-	-

Table 49. Density of dominant phytoplankton (10^3 ind/l) in winter season at Mathbaria Station 7.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	Dec.	3	*Euglena* 6.57	*Oscillatoria* 3.50	*Peridinium* 2.63	*Euglena* acus 0.88	-	-
	Jan.	4	*Peridinium* 5.03	*Mallomonas* 3.06	*Euglena* 1.75	*Cryptomonas* 1.53	-	-
	Feb.	5	*Euglena* sp. 15.98	*Peridinium* 10.07	*Trachelomonas* 4.16	*Dinobryon* 2.19	-	-
		6	*Strombomonas* 60.14	*Euglena* 51.55	*Trachelomonas* 17.18	*Euglena* acus 3.06	-	-
		7	*Strombomonas* 249.14	*Trachelomonas* 240.55	*Lepocinclis* 9.63	*Euglena* 6.57	-	-
2011-2012	Dec.	29	*Euglena* sp. 8.31	*Peridinium* sp. 3.28	*Euglena acus* 2.84	*Mallomonas* sp. 2.62	-	-
	Jan.	30	*Euglena* sp. 9.20	*Strombomonas* sp. 4.16	*Mallomonas* sp. 3.94	*Peridinium* sp. 2.40	-	-
		31	*Euglena* sp. 6.13	*Peridinium* sp. 3.94	*Mallomonas* sp. 2.62	*Trachelomonas* sp. 1.53	-	-
	Feb.	32	*Euglena* sp. 146.04	*Nitzschia longissima* 2.40	*Dinobryon* sp. 2.19	*Mallomonas* sp. 1.97	-	-
		33	*Euglena* sp. 10.07	*Peridinium* sp. 1.75	*Lyngbya limnetica* 0.65	*Synedra* sp. 0.44	-	-
		34	*Strombomonas* sp. 12.91	*Peridinium* sp. 12.69	*Euglena* sp. 8.75	*Nitzschia longissima* 1.09	-	-

Table 50. Density of dominant phytoplankton (10^3 ind/l) in summer season at Mathbaria Station 7.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	8	*Trachelomonas* 6.79	*Strombomonas* 5.03	*Euglena* sp. 4.38	*Lepocinclis* 4.16	-	-
		9	*Strombomonas* 20.79	*Euglena* sp. 16.85	*Peridinium* 12.91	*Mallomonas* 10.94	-	-
		10	*Euglena* sp. 4.38	*Microcystis* 3.06	*Euglena* acus 1.97	*Peridinium* 1.53	-	-
		11	*Euglena* sp. 34.36	*Mallomonas* 9.85	*Trachelomonas* 6.35	*Microcystis* 2.19	-	-
	April	12	*Euglena* sp. 10.29	*Strombomonas* 3.94	*Peridinium* 3.28	*Trachelomonas* 3.06	-	-
		13	*Strombomonas* 8.10	*Mallomonas* 7.22	*Euglena* sp. 7.00	*Hyaliella* 1.09	-	-
		14	*Carteria* 10.94	*Strombomonas* 7.00	*Peridinium* 4.82	*Euglena* sp. 4.38	-	-
		15	*Microcystis* 4.60	*Nitzschia longissima* 1.09	*Trachelomonas* 0.66	*Cyclotella* 0.44	-	-
	May	16	*Nephrocytium* 128.87	*Euglena* sp. 28.45	*Strombomonas* 1.75	*Dinobryon* 1.53	-	-
		17	*Strombomonas* 10.29	*Euglena* sp. 3.94	*Colacium* 1.75	*Trachelomonas* 1.09	-	-
		18	*Nephrocytium* 6.35	*Euglena* sp. 3.28	*Phacus* 0.66	*Strombomonas* 0.44	-	-
		19	*Strombomonas* 2.19	*Cyclotella* 1.53	*Colacium* 0.88	*Euglena* sp. 0.65	-	-
		20	*Euglena* sp. 6.56	*Pandorina* 6.35	*Trachelomonas* 2.62	*Strombomonas* 1.97	-	-
2011-2012	March	35	*Euglena* sp. 8.53	*Peridinium* sp. 5.47	*Strombomonas* sp. 5.03	*Nitzschia longissima* 2.62	-	-
		36	*Peridinium* sp. 94.50	*Strombomonas* sp. 6.56	*Euglena* sp. 6.13	*Mallomons* sp. 0.87	-	-
		37	*Peridinium* sp. 94.50	*Euglena* sp. 12.04	*Trachelomonas* sp. 4.37	*Strombomonas* sp. 2.62	-	-
		38	*Pandonrina* sp. 15.54	*Peridinium* sp. 8.75	*Euglena* sp. 6.35	*Nitzschia longissima* 1.75	-	-
	April	39	*Euglena* sp. 16.85	*Pandorina* sp. 9.19	*Nitzschia longissima*7.66	*Peridinium* sp. 3.28	-	-
		40	*Euglena* sp. 5.25	*Peridinium* sp. 5.03	*Nitzschia longissima* 3.94	*Raphidiopsis* sp. 0.65	+	-
		41	*Nitzschia longissima* 17.18	*Peridinium* sp. 6.78	*Euglena* sp. 4.81	*Nitzschia* sp. 1.53	-	-
		42	*Euglena* sp. 25.77	*Pandorina* sp. 3.28	*Peridinium* sp.1.97	*Chlorococcum* sp. 1.31	-	-
	May	43	*Strombomonas* sp. 7.17	*Euglena* sp. 3.76	*Pandorina* sp. 3.07	*Peridinium* sp. 2.73	+	+
		44	*Peridinium* 241.35	*Euglena* sp. 107.27	*Mallomonas* sp. 3.07	*Strombomonas* sp. 2.73	-	-
		45	*Peridinium* sp. 3.07	*Strombomonas* sp. 2.39	*Euglena* sp. 2.05	*Nitzschia longissima* 0.34	-	-
		46	*Euglena* sp. 2.39	*Coscinodiscus* sp. 0.68	*Trachelomonas* sp. 0.34	*Nitzschia longissima* 0.34	-	-
		47	*Euglena* sp. 4.10	*Strombomonas* sp. 1.37	*Colacium* sp. 0.68	*Phacus* sp. 0.34	-	-

Table 51. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Mathbaria Station 7.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	21	*Euglena* sp. 1.09	*Nitzschia longissima* 0.87	*Strombomonas* 0.66	*Euglena* acus 0.44	-	-
	July	22	*Euglena* sp. 7.22	*Strombomonas* 5.03	*Peridinium* 2.40	Colacium 1.31	-	-
	Aug.	23	*Euglena* sp. 6.78	*Strombomonas* 6.56	*Euglena* acus 1.31	*Phacus* 0.44	-	-
	Sept.	24	*Euglena* sp. 128.86	*Trachelomonas* 7.88	*Peridinium* 1.31	Microcystis 1.09	-	-
		25	*Mallomonas* 6.78	*Strombomonas* 5.91	*Euglena* sp. 3.28	*Peridinium* 1.97	-	-
	E. Oct.	26	*Eudorina* 15.32	*Strombomonas* 4.81	*Euglena* sp. 4.38	*Coelastrum* 2.84	-	+
2011-2012	June	48	*Nitzschia longissima* 2.39	*Strombomonas* sp. 2.05	*Cyclotella* sp. 1.02	*Euglena acus* 0.68	-	-
	July	49	*Euglena* sp. 2.73	*Mallomonas* sp. 0.68	*Peridinium* sp. 0.34	*Euglena acus* 0.34	-	-
	Aug.	50	*Euglena* sp. 2.05	*Phacus* sp. 1.37	*Euglena acus* 1.02	*Mallomonas* sp. 0.68	-	-
	Sept.	51	*Euglena* sp. 12.98	*Pteromonas* sp. 1.71	*Cryptomonas* sp. 1.02	*Peridinium* sp. 0.68	-	-
		52	*Peridinium* sp. 2.73	*Mallomonas* sp. 1.02	*Euglena* sp. 0.68	*Phacus* sp. 0.34	-	-

Table 52. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Mathbaria Station 8.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Euglena* 34.36	*Oscillatoria* 17.18	*Phacus* 8.59	*Trachelomonas* 5.69	-	-
	E. Nov.	2	*Euglena* 1.31	*Peridinium* 0.88	*Oscillatoria* 0.44	*Diacanthos belenophorus* 0.22	-	-
2011-2012	L. Oct.	27	*Strombomonas* 5.90	*Peridinium* 4.59	*Euglena* sp. 4.38	*Phacus* 1.97	-	-
	E. Nov.	28	*Euglena* sp. 0.88	*Peridinium* sp. 0.66	*Pelonema aphane* 0.44	*Microcystis* sp. 0.22	-	-

Table 53. Density of dominant phytoplankton (10^3 ind/l) in winter season at Mathbaria Station 8.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	Dec.	3	*Oscillatoria* 3.06	*Strombomonas* 1.75	*Phacus* 1.09	*Euglena* 0.88	-	-
	Jan.	4	*Coscinodiscus* 1.97	*Oscillatoria* 1.53	*Peridinium* 1.31	*Nitzschia sigmoidea* 0.88	-	-
	Feb.	5	*Schroederia* 6.57	*Peridinium* 1.09	*Cyclotella* 0.66	Gomphonema 0.44	-	-
		6	*Nitzschia acicularis* 9.63	*Strombomonas* 0.88	*Pleurosigma* 0.88	*Synedra* 0.88	-	-
		7	*Nitzschia acicularis* 1864.26	*Strombomonas* 3.06	*Trachelomonas* 2.63	*Euglena* 1.53	-	-
2011-2012	Dec.	29	*Euglena* sp. 0.87	*Synedra* sp. 0.65	*Peridinium* sp. 0.43	*Strombomonas* sp. 0.22	-	-
	Jan.	30	*Peridinium* sp. 0.87	*Melosira* sp. 0.65	*Gyrosigma* sp. 0.65	*Coscinodiscus* sp. 0.65	-	-
		31	*Nitzschia* sp. 2.84	*Cyclotella* sp. 0.87	*Peridinium* sp. 0.65	*Navicula* sp. 0.22	-	-
	Feb.	32	*Nitzschia longissima* 103.09	*Nitzschia* sp. 1.09	*Coscinodiscus* sp. 0.87	*Mallomonas* sp. 0.22	-	-
		33	*Nitzschia longissima* 386.59	*Synedra* sp. 0.22	*Coscinodiscus* sp. 0.22	*Peridinium* sp. 0.22	-	-
		34	*Nitzschia longissima* 824.74	*Peridinium* sp. 0.44	*Coscinodiscus* sp. 0.44	*Cyclotella* sp. 0.44	-	-

Table 54. Density of dominant phytoplankton (10^3 ind/l) in summer season at Mathbaria Station 8.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	8	*Nitzschia longissima* 92.59	*Gyrosigma* 2.63	*Strombomonas* 1.31	*Melosira* 0.66	-	-
		9	*Nitzschia longissima* 326.46	*Peridinium* 5.69	*Strombomonas* 2.19	*Gyrosigma* 1.75	-	-
		10	*Peridinium* 1.31	*Microcystis* 0.88	*Cyclotella* 0.44	*Mallomonas* 0.44	-	-
		11	*Nitzschia longissima* 317.87	*Microcystis* 1.75	*Peridinium* 1.53	*Trachelomonas* 1.09	-	-
	April	12	*Nitzschia longissima* 2.40	*Cyclotella* 1.31	*Nitzschia* sp. 0.44	*Peridinium* 0.22	-	-
		13	*Nitzschia longissima* 3.06	*Peridinium* 1.31	*Cyclotella* 0.44	*Phacus* 0.22	-	-
		14	*Coscinodiscus* 3.50	*Nitzschia longissima* 1.75	*Cyclotella* 1.09	*Microcystis* 0.88	-	-
		15	*Nitzschia longissima* 33.05	Microcystis 2.19	*Strombomonas* 1.97	*Scenedesmus* 0.44	-	-
	May	16	*Microcystis* 1.31	*Nitzschia longissima* 0.88	*Strombomonas* 0.66	*Peridinium* 0.44	-	-
		17	*Nitzschia longissima* 19.26	*Euglena* sp. 0.88	*Peridinium* 0.66	*Cyclotella* 0.44	-	-
		18	*Nitzschia longissima* 2.41	*Cyclotella* 1.75	*Euglena* sp. 0.87	*Strombomonas* 0.66	-	-
		19	*Nitzschia longissima* 4.16	*Strombomonas* 1.31	*Cyclotella* 0.87	*Euglena* sp. 0.66	-	-
		20	*Nitzschia longissima* 5.25	*Cyclotella* 2.85	*Melosira* 1.09	*Coscinodiscus* 0.88	-	-
2011-2012	March	35	*Nitzschia longissima* 1082.47	*Peridinium* sp. 1.97	*Euglena* sp. 0.65	*Euglena acus* 0.22	-	-
		36	*Nitzschia longissima* 51.54	*Coscinodiscus* sp. 1.09	*Peridinium* sp. 0.87	*Nitzschia* sp. 0.65	-	-
		37	*Nitzschia longissima* 257.73	*Peridinium* sp. 4.59	*Euglena* sp. 1.31	*Coscinodiscus* 0.87	-	-
		38	*Nitzschia longissima* 635.74	*Cyclotella* sp. 2.19	*Peridinium* sp.1.75	*Euglena* sp. 1.31	-	-
	April	39	*Nitzschia longissima* 60.14	*Peridinium* sp. 1.31	*Coscinodiscus* sp. 0.87	*Trachelomonas* sp. 0.43	-	-
		40	*Nitzschia longissima* 68.73	*Euglena* sp. 3.06	*Cyclotella* sp. 2.19	*Peridinium* sp. 1.31	+	+
		41	*Nitzschia longissima* 1898.62	*Peridinium* sp. 3.06	*Euglena* sp. 1.31	*Phacus* sp. 0.65	-	-
		42	*Nitzschia longissima* 3.06	*Peridinium* sp. 1.53	*Coscinodiscus* sp. 1.31	*Cyclotella* sp. 0.65	-	-
	May	43	*Nitzschia longissima* 53.63	*Peridinium* sp. 2.73	*Euglena acus* 1.37	*Strombomonas* sp. 1.03	-	-
		44	*Nitzschia longissima* 13.41	*Peridinium* sp. 2.39	*Melosira* sp. 0.68	*Strombomonas* sp. 0.34	-	-
		45	*Peridinium* sp. 9.56	*Strombomonas* sp. 9.22	*Nitzschia longissima* 3.42	*Euglena* sp. 2.73	-	-
		46	*Nitzschia longissima* 5.46	*Cyclotella* sp. 3.42	*Peridinium* sp. 2.05	*Coscinodiscus* sp. 1.71	-	-
		47	*Nitzschia longissima* 4.10	*Strombomonas* sp. 3.76	*Peridinium* sp. 1.71	*Cyclotella* sp. 1.37	-	-

Table 55. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Mathbaria Station 8.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	21	*Coscinodiscus* 1.53	*Melosira* 1.31	*Nitzschia longissima* 1.09	*Peridinium* 0.44	-	-
	July	22	*Melosira* 7.00	*Peridinium* 3.06	*Cyclotella* 0.87	*Coscinodiscus* 0.66	-	-
	Aug.	23	*Strombomonas* 1.97	*Euglena* acus 0.87	*Melosira* 0.66	*Euglena* sp. 0.44	-	-
	Sept.	24	*Euglena* sp. 8.75	*Strombomonas* 2.19	*Euglena* acus 1.97	*Phacus* 1.31	-	-
		25	*Melosira* 1.53	*Cyclotella* 0.44	*Euglena* sp. 0.44	*Strombomonas* 0.22	-	-
	E. Oct.	26	*Strombomonas* 4.81	*Euglena* 4.16	*Peridinium* 1.75	*Phacus* 1.31	-	+
2011-2012	June	48	*Coscinodiscus* 4.10	*Melosira* sp. 1.37	*Strombomonas* sp. 1.02	*Cyclotella* sp. 0.68	-	-
	July	49	*Euglena* sp. 2.39	*Phacus* sp. 1.71	*Coscinodiscus* sp. 1.02	*Oscillatoria* sp. 0.68	-	-
	Aug.	50	*Cyclotella* sp. 2.05	*Trachelomonas* sp. 1.71	*Euglena acus* 1.37	*Phacus* sp. 1.02	-	-
	Sept.	51	*Melosira* sp. 2.39	*Coscinodiscus* sp. 1.71	*Cyclotella* sp. 0.68	*Euglena* sp. 0.34	-	-
		52	*Euglena* sp. 1.37	*Cyclotella* sp. 0.68	*Nitzschia* sp. 0.68	*Peridinium* sp. 0.68	-	-

Table 56. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Mathbaria Station 9.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Euglena* 6.13	*Oscillatoria* 3.72	*Lyngbya* 2.30	*Lepocinclis* 2.08	-	-
	E. Nov.	2	*Trachelomonas* 7.00	*Phacus* 6.13	*Euglena* 4.16	*Lepocinclis* 2.85	-	-
2011-2012	L. Oct.	27	*Trachelomonas* 0.44	*Oscillatoria* 0.22	*Tetraedron* 0.22	*Scenedesmus* 0.22	-	-
	E. Nov.	28	*Euglena* sp. 1.31	*Trachelomonas* sp. 0.22	*Scenedesmus* sp. 0.22	*Peridinium* sp. 0.22	-	-

Table 57. Density of dominant phytoplankton (10^3 ind/l) in winter season at Mathbaria Station 9.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	Dec.	3	NS	NS	NS	NS	-	-
	Jan.	4	*Carteria* 2.63	*Euglena* 2.19	*Lepocinclis* 1.53	*Cryptomonas* 0.88	-	-
	Feb.	5	*Euglena* sp. 4.16	*Schroederia* 1.09	*Trachelomonas* 0.66	*Monoraphidium* 0.44	-	-
		6	*Euglena acus* 1.75	*Hyaliella* 1.09	*Cryptomonas* 0.66	*Navicula* 0.44	-	-
		7	*Nitzschia* sp. 1.31	*Euglena* 1.09	*Microcystis 0.88*	*Phacus* 0.66	-	-
2011-2012	Dec.	29	*Euglena* sp. 0.87	*Trachelomonas* sp. 0.65	*Phacus* sp. 0.43	*Navicula* sp. 0.22	-	-
	Jan.	30	*Euglena* sp. 2.84	*Cryptomonas* sp. 1.75	*Euglena acus* 0.65	*Peridinium* sp. 0.44	-	-
		31	*Mallomonas* sp. 18.82	*Euglena* sp. 5.25	*Trachelomonas* sp. 2.40	*Rhodomonas* sp. 0.65	-	-
	Feb.	32	*Euglena* sp. 3.28	*Peridinium* sp. 0.65	*Nitzschia* sp. 0.44	*Nitzschia longissima* 0.22	-	-
		33	*Euglena* sp. 3.06	*Mallomonas* sp. 0.87	*Phacus* sp. 0.44	*Peridinium* sp. 0.22	-	-
		34	*Euglena* sp. 23.64	*Cryptomonas* sp. 2.84	*Euglena acus* 1.75	*Mallomonas* sp. 0.65	-	-

Table 58. Density of dominant phytoplankton (10^3 ind/l) in summer season at Mathbaria Station 9.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	8	*Euglena* sp. 11.82	*Euglena* acus 9.85	*Phacus* 1.97	*Strombomonas* 1.31	-	-
		9	*Euglena* sp. 3.06	*Nitzschia longissima* 1.53	*Phacus* 0.66	*Trachelomonas* 0.44	-	-
		10	*Euglena* sp. 25.77	*Euglena* acus 22.54	*Phacus* 6.79	*Peridinium* 6.79	-	-
		11	*Euglena* sp. 19.48	*Euglena* acus 7.00	*Phacus* 4.82	*Lepocinclis* 3.72	-	-
	April	12	*Euglena* acus 42.96	*Euglena* sp. 8.59	*Phacus* 1.97	*Peridinium* 1.75	-	-
		13	*Euglena* sp. 8.76	*Strombomonas* 2.40	*Euglena* acus 1.75	Microcystis 0.88	-	-
		14	*Trachelomonas* 2.19	*Strombomonas* 1.53	*Euglena* sp. 1.09	*Phacus* 0.88	-	-
		15	Microcystis 4.16	*Euglena* acus 3.06	*Euglena* sp. 2.19	*Nitzschia longissima* 1.53	-	-
	May	16	*Euglena* acus 6.13	*Microcystis* 4.60	*Euglena* sp. 3.94	*Scenedesmus* 1.97	-	-
		17	*Microcystis* 1.53	*Euglena* sp. 1.31	*Scenedesmus* 1.09	*Euglena* acus 0.88	-	-
		18	*Euglena* sp. 3.94	*Euglena* acus 1.75	*Scenedesmus* 0.87	*Trachelomonas* 0.66	-	-
		19	*Euglena* sp. 2.84	*Euglena* acus 2.41	*Microcystis* 1.97	*Scenedesmus* 1.09	-	-
		20	*Microcystis* 7.22	*Euglena* acus 2.85	*Euglena* sp. 2.41	*Crucigenia* 1.31	-	-
2011-2012	March	35	*Euglena* sp. 2.40	*Phacus* sp. 1.09	*Cryptomonas* sp. 0.65	*Peridinium* sp. 0.43	-	-
		36	*Euglena* sp. 7.88	*Phacus* sp. 0.87	*Euglena acus* 0.654	*Nitzschia longissima* 0.22	-	-
		37	*Euglena* sp. 120.27	*Euglena acus* 51.55	*Phacus* sp. 0.87	*Strombomonas* sp. 0.43	-	-
		38	*Euglena* sp. 94.50	*Phacus* sp. 17.18	*Peridinium* sp. 2.84	*Strombomonas* sp. 1.75	-	-
	April	39	*Euglena* sp. 5.69	*Phacus* sp. 2.41	*Peridinium* sp. 0.65	*Oscillatoria* sp. 0.43	-	-
		40	*Euglena* sp. 5.25	*Peridinium* sp. 1.31	*Trachelomonas* sp. 0.87	*Phacus* sp. 0.65	-	-
		41	*Peridinium* sp. 51.54	*Euglena* sp. 25.77	*Phacus* sp. 4.59	*Euglena acus* 3.94	-	-
		42	*Euglena* sp. 60.13	*Euglena acus* 3.06	*Strombomonas* sp. 1.97	*Phacus* sp. 1.53	-	-
	May	43	*Euglena* sp. 53.63	*Phacus* sp. 8.20	*Euglena acus* 7.17	*Strombomonas* sp. 4.10	-	-
		44	*Euglena* sp. 817.92	*Euglena acus* 80.45	*Phacus* sp. 8.54	*Strombomonas* sp. 4.44	-	-
		45	*Euglena* sp. 576.57	*Phacus* sp. 80.45	*Strombomonas* sp. 67.04	*Euglena acus* 53.63	-	-
		46	*Euglena* sp. 563.16	*Phacus* sp. 53.63	*Euglena acus* 40.23	*Peridinium* sp. 3.42	-	-
		47	*Euglena* sp. 281.58	*Phacus* sp. 40.23	*Euglena acus* 16.40	*Strombomonas* sp. 7.17	-	-

Table 59. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Mathbaria Station 9.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	21	*Microcystis* 4.81	*Euglena* sp. 2.84	*Euglena* acus 1.75	*Phacus* 1.53	-	-
	July	22	*Euglena* acus 3.28	*Euglena* sp. 2.19	*Phacus* 1.31	*Cryptomonas* 1.09	-	-
	Aug.	23	*Euglena* sp. 2.18	*Euglena* acus 0.66	*Phacus* 0.44	*Strombomonas* 0.22	-	-
	Sept.	24	*Euglena* sp. 1.31	*Euglena* acus 0.44	*Phacus* 0.22	*Strombomonas* 0.22	-	-
		25	*Euglena* sp. 0.87	*Euglena* acus 0.44	*Nitzschia* sp. 0.22	*Crucigenia* 0.22	-	-
	E. Oct.	26	*Trachelomonas* 0.87	*Euglena* sp. 0.65	*Eudorina* 0.44	*Mallomonas* 0.22	-	-
2011-2012	June	48	*Euglena acus* 80.45	*Euglena* sp. 67.04	*Phacus* sp. 40.23	*Strombomonas* sp. 3.07	-	-
	July	49	*Euglena* sp. 6.49	*Phacus* sp. 5.12	*Euglena acus* 4.44	*Strombomonas* sp. 2.73	-	-
	Aug.	50	*Lepocinclis* sp. 4.10	*Phacus* sp. 2.73	*Trachelomonas* sp. 2.39	*Euglena* sp. 2.05	-	-
	Sept.	51	*Euglena* sp. 7.52	*Euglena acus* 4.10	*Phacus* sp. 3.42	*Oscillatoria* sp. 2.73	-	-
		52	*Euglena* sp. 5.12	*Phacus* sp. 2.05	*Mallomonas* sp. 1.71	*Peridinium* sp. 1.36	-	-

Table 60. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Mathbaria Station 10.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Euglena* sp. 17.18	*Lepocinclis* 8.59	*Trachelomonas* 1.75	*Peridinium* 1.09	-	-
	E. Nov.	2	*Lepocinclis* 5.47	*Strombomonas* 2.19	*Phacus* 1.31	*Ceracium* 1.09	-	-
2011-2012	L. Oct.	27	*Pelonema aphane* 6.13	*Euglena* sp. 4.81	*Strombomonas* 3.06	*Phacus* 1.97	-	-
	E. Nov.	28	*Pelonema aphane* 3.28	*Euglena* sp. 2.40	*Phacus* sp. 2.19	*Trachelomonas* sp. 0.44	-	-

Table 61. Density of dominant phytoplankton (10^3 ind/l) in winter season at Mathbaria Station 10.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	Dec.	3	NS	NS	NS	NS	-	-
	Jan.	4	*Euglena* sp. 5.69	*Euglena* acus 1.97	*Rhodomonas* 0.88	*Phacus* 0.66	-	-
	Feb.	5	*Euglena* sp. 4.16	*Euglena* acus 1.53	*Trachelomonas* 0.88	*Microcystis* 0.66	-	-
		6	*Euglena* sp. 4.16	*Euglena* acus 2.19	*Chlamydomonas* 0.88	*Oscillatoria* 0.66	-	-
		7	*Euglena* acus 5.69	*Strombomonas* 3.94	*Euglena* 1.53	*Lepocinclis* 1.53	-	-
2011-2012	Dec.	29	*Euglena* sp. 8.75	*Euglena* acus 2.84	*Mallomonas* sp. 0.87	*Strombomonas* sp. 0.65	-	-
	Jan.	30	*Cryptomonas* sp. 0.65	*Trachelomonas* sp. 0.44	*Navicula* sp. 0.22	*Euglena* sp. 0.22	-	-
		31	*Euglena* sp. 300.68	*Mallomonas* sp. 60.13	*Euglena acus* 25.77	*Phacus* sp. 25.77	-	-
	Feb.	32	*Euglena* sp. 60.13	*Euglena* acus 3.28	*Phacus* sp. 1.53	*Cryptomonas* sp. 1.31	-	-
		33	*Euglena* sp. 10.94	*Euglena* acus 7.00	*Phacus* sp. 3.06	*Cryptomonas* sp. 1.75	-	-
		34	*Euglena* sp. 12.69	*Euglena* acus 10.50	*Nitzschia longissima* 5.03	*Phacus* sp. 4.81	-	-

Table 62. Density of dominant phytoplankton (10^3 ind/l) in summer season at Mathbaria Station 10.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	8	*Gyrosigma* 1.31	*Cryptomonas* 1.09	*Strombomonas* 0.88	*Phacus* 0.66	-	-
		9	*Euglena* sp. 3.06	*Strombomonas* 1.53	*Euglena* acus 1.31	*Trachelomonas* 0.88	-	-
		10	*Euglena* sp. 8.10	*Euglena* acus 2.19	*Phacus* 1.09	*Strombomonas* 0.88	-	-
		11	*Euglena* sp. 26.05	*Phacus* 6.57	*Euglena* acus 5.47	*Strombomonas* 1.09	-	-
	April	12	*Euglena* sp. 94.50	*Nitzschia longissima* 77.32	*Euglena* sp. acus 17.18	*Phacus* 4.16	+	+
		13	*Euglena* sp. 10.73	*Euglena* acus 2.85	*Phacus* 2.41	*Nitzschia longissima* 1.97	-	-
		14	*Euglena* sp. 5.47	*Nitzschia longissima* 3.06	*Peridinium* 2.85	*Euglena* acus 2.63	-	-
		15	*Nitzschia longissima* 23.20	*Euglena* sp. 7.22	*Euglena* acus 2.85	*Phacus* 2.41	-	-
	May	16	*Nitzschia longissima* 29.33	*Euglena* sp. 4.82	*Phacus* 4.38	*Euglena* acus 3.06	-	-
		17	*Nitzschia longissima* 5.91	*Euglena* sp. 2.85	*Phacus* 1.31	*Nitzschia acicularis* 0.66	-	-
		18	*Nitzschia longissima* 6.35	*Euglena* sp. 2.63	*Euglena* acus 2.41	*Phacus* 1.09	-	-
		19	*Nitzschia longissima* 6.13	*Microcystis* 1.09	*Nitzschia acicularis* 0.88	*Phacus* 0.65	-	-
		20	*Euglena* sp. 3.50	*Phacus* 1.97	*Nitzschia longissima* 1.53	*Merismopedia* 1.09	-	-
2011-2012	March	35	*Nitzschia longissima* 35.89	*Euglena* acus 23.20	*Euglena* sp. *15*.32	*Phacus* sp. 8.31	-	-
		36	*Euglena* sp. 644.33	*Phacus* sp. 171.82	*Euglena* acus 25.77	*Nitzschia longissima* 4.59	-	-
		37	*Euglena* sp. 214.78	*Nitzschia longissima* 51.55	*Phacus* sp. 42.95	*Strombomonas* sp. 34.36	-	-
		38	*Nitzschia longissima* 60.14	*Euglena* acus 51.54	*Phacus* sp. 42.95	*Peridinium* sp. 5.91	+	-
	April	39	*Euglena* sp. 171.82	*Phacus* sp. 10.94	*Euglena* acus 6.56	*Strombomonas* sp. 3.72	+	+
		40	*Euglena* sp. 395.19	*Phacus* sp. 51.54	*Nitzschia longissima* 25.77	*Strombomonas* sp. 5.47	-	+
		41	*Euglena* sp. 146.04	*Nitzschia longissima* 94.50	*Phacus* sp. 7.88	*Euglena acus* 7.22	-	-
		42	*Nitzschia longissima* 25.77	*Euglena* sp 4.15	*Phacus* sp. 3.72	*Pediastrum* sp. 1.09	-	-
	May	43	*Nitzschia longissima* 10.59	*Phacus* sp. 8.20	*Euglena* sp. 4.78	*Euglena acus* 3.42	-	-
		44	*Euglena* sp. 80.45	*Nitzschia longissima* 53.63	*Strombomonas* sp. 40.23	*Peridinium* sp. 26.82	-	-
		45	*Strombomona*-s sp. 14.69	*Pelonema aphane* 10.93	*Euglena* sp. 7.86	*Phacus* sp. 7.51	-	-
		46	*Pelonema aphane* 254.76	*Euglena* sp. 14.69	*Strombomonas* sp. 11.96	*Peridinium* sp. 8.20	-	-
		47	*Pelonema aphane* 7.52	*Nitzschia longissima* 2.05	*Euglena acus* 1.71	*Strombomonas* sp. 1.37	-	-

Table 63. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Mathbaria Station 10.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	21	*Phacus* 1.31	*Euglena* sp. 1.09	*Strombomonas* 0.87	*Euglena* acus 0.66	-	-
	July	22	*Euglena* sp. 12.04	*Strombomonas* 10.72	*Euglena* acus 5.03	*Peridinium* 3.72	-	-
	Aug.	23	*Euglena* sp. 1.97	*Strombomonas* 1.53	*Trachelomonas* 0.65	*Phacus* 0.44	-	-
	Sept.	24	*Euglena* sp. 4.37	*Euglena* acus 1.97	*Phacus* 1.09	*Peridinium* 0.65	-	-
		25	*Euglena* acus 3.94	*Euglena* sp. 1.97	*Phacus* 1.09	*Trachelomonas* 0.44	-	-
	E. Oct.	26	*Euglena* sp. 11.38	*Strombomonas* 5.47	*Euglena* acus 3.50	*Phacus* 3.28	-	-
2011-2012	June	48	*Pelonema aphane* 7.86	*Euglena* sp. 5.47	*Euglena acus* 2.39	*Strombomonas* sp. 1.71	-	-
	July	49	*Pelonema aphane* 4.78	*Euglena* sp. 3.76	*Euglena acus* 1.71	*Strombomonas* sp. 1.37	-	-
	Aug.	50	*Oscillatoria* sp. 415.67	*Trachelomonas* 3.07	*Euglena* sp. 2.39	*Phacus* sp. 2.05	-	-
	Sept.	51	*Oscillatoria* sp. 22.89	*Euglena* sp. 6.15	*Lepocinclis* sp. 4.78	*Phacus* sp. 3.76	-	-
		52	*Oscillatoria* sp. 38.60	*Euglena* sp. 27.33	*Pteromonas* sp. 19.81	*Euglena acus* 11.96	+	+

Table 64. Density of dominant phytoplankton (10^3 ind/l) in summer season at Mathbaria Station 11.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2011-2012	March	35	*Euglena* ***sp***. 11.82	*Euglena acus* 1.97	*Trachelomonas* sp. 1.31	*Cryptomonas* 0.65	-	-
		36	*Euglena* sp. 51.54	*Trachelomonas* sp. 42.95	*Phacus* sp. 3.06	*Strombomonas* 1.97	-	-
		37	*Euglena* sp. 120.27	*Peridinium* sp. 1.53	*Phacus* sp. 1.31	*Strombomonas* sp. 0.43	-	-
		38	*Euglena* sp. 266.32	*Phacus* sp. 60.13	*Strombomonas* sp. 5.47	*Euglena acus* 3.72	-	-
	April	39	*Euglena* sp. 11.60	*Phacus* sp. 1.75	*Peridinium* sp. 1.53	*Strombomonas* sp. 0.65	-	-
		40	*Euglena* sp. 32.39	*Nitzschia longissima* 12.25	*Phacus* sp. 8.31	*Strombomonas* sp. 6.56	-	+
		41	*Euglena* sp. 4.59	*Phacus* sp. 2.62	*Cryptomonas* sp. 1.97	*Euglena acus* 1.53	-	+
		42	*Euglena* sp. 25.77	*Nitzschia longissima* 7.66	*Euglena acus* 1.97	*Strombomonas* sp. 1.31	-	-
	May	43	*Euglena* sp. 5.47	*Nitzschia* longissima 3.07	*Phacus* sp. 2.05	*Strombomonas* sp. 1.71	+	+
		44	*Euglena acus* 6.49	*Euglena* sp. 5.12	*Peridinium* sp. 4.78	*Strombomonas* sp. 4.10	-	-
		45	*Strombomonas* sp. 7.17	*Peridinium* sp. 4.44	*Euglena* sp. 2.05	*Phacus* sp. 1.71	-	-
		46	*Strombomonas* sp. 6.15	*Euglena* sp. 4.78	*Nitzschia longissima* 2.73	*Peridinium* sp. 2.39	-	-
		47	*Strombomonas* sp. 6.15	*Euglena acus* 5.12	*Peridinium* sp. 4.44	*Cryptomonas* sp. 2.73	-	-

Table 65. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Mathbaria Station 11.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2011-2012	June	48	*Pelonema aphane* 7.86	*Euglena* sp. 5.47	*Euglena acus* 2.39	*Strombomonas* sp. 1.71	-	-
	July	49	*Pelonema aphane* 4.78	*Euglena* sp. 3.76	*Euglena acus* 1.71	*Strombomonas* sp. 1.37	-	-
	Aug.	50	*Oscillatoria* sp. 415.67	*Trachelomonas* 3.07	*Euglena* sp. 2.39	*Phacus* sp. 2.05	-	-
	Sept.	51	*Oscillatoria* sp. 22.89	*Euglena* sp. 6.15	*Lepocinclis* sp. 4.78	*Phacus* sp. 3.76	-	+
		52	*Oscillatoria* sp. 38.60	*Euglena* sp. 27.33	*Pteromonas* sp. 19.81	*Euglena acus* 11.96	-	-

Dominant phytoplankton group of Chhatak sites

Chhatak Station 1

It is a non-infested station for *Vibrio cholerae*. In this station dominant phytoplankton were *Euglena* sp., *Trachelomonas*, *Lepocinclis* and *Phacus* belonging to Euglenophyceae**,** *Cyclotella* belonging to Bacillariophyceae, *Peridinium* belonging to Dinophyceae, *Mallomonas* belonging to Crysophyceae, *Cryptomonas* and *Rhodomonas* belonging to Cryptophyceae**,** *Chlamydomonas*, *Pandorina*, *Actinastrum*, *Scenedesmus*, *Coelastrum*, *Micractinium*, *Pediestrum*, *Monoraphidium* and *Crucigenia* belonging to Chlorophyceae and *Oscillatoria*, *Arthrospira*, *Raphidiopsis*, *Merismopedia* and *Pelonema aphane* belonging to Cyanophyceae were observed. During autumn *Peridinium* belonging to Dinophyceae were dominant in both the study year (Table 66). During winter in the year of 2010-2011 *Peridinium* were dominant and in the year of 2011-2012 dominant phytoplankton were *Peridinium*, *Euglena* sp. and *Mallomonas* (Table 67). During summer in the year of 2010-2011 *Trachelomonas* were dominant and in the year of 2011-2012 *Mallomonas* and *Raphidiopsis* were dominant (Table 68). During monsoon *Arthrospira* and *Raphidiopsis* belonging to Cyanophyceae were dominant in both the study year (Table 69).

Chhatak Station 2

It is an infested station for *Vibrio cholerae*. In this station, dominant phytoplankton were *Euglena* sp., *Euglena acus*, *Trachelomonas* sp., *Trachelomonas volvocina*, *Strombomonas*, *Lepocinclis a*nd *Phacus* belonging to Euglenophyceae**,** *Cymbella*, *Melosira*, *Nitzschia* sp., *Synedra*, *Gyrosigma*, *Navicula*, *Rhizosolenia*, *Surirella*, *Pinnularia*, *Fragillaria* and *Cyclotella* belonging to Bacillariophyceae, *Peridinium* and *Ceratium* belonging to Dinophyceae, *Mallomonas* and *Dinobryon* belonging to Chrysophyceae, *Dictyosphaerium*, *Closterium*, *Scenedesmus*, *Coelastrum*, *Pediastrum*, and *Crucigenia* belonging to Chlorophyceae and *Arthrospira*, *Raphidiopsis*, *Merismopedia* and *Pelonema aphane* belonging to Cyanophyceae were observed. During autumn in the year of 2010-2011 *Euglena* sp., *Peridinium* and *Trachelomonas volvocina* were dominant when *Vibrio cholerae* were found and in the year of 2011-2012 *Melosira* were dominant (Table 70). During winter and summer *Melosira* were dominant in both the study year (Table 71 and 72). During summer in the year of 2010-2011 *Trachelomonas* were dominant and in the year of 2011-2012 *Mallomonas* and *Raphidiopsis* were dominant. During monsoon amount of dominant phytoplankton were poor in both the study year (Table 73).

Chhatak Station 4

It is a non-infested station for *Vibrio cholerae*. In this station, dominant phytoplankton were *Euglena* sp., *Trachelomonas* sp., *Lepocinclis a*nd *Phacus* belonging to Euglenophyceae**,** *Melosira* belonging to Bacillariophyceae, *Peridinium* belonging to Dinophyceae, *Chlamydomonas*, *Actinastrum*, *Scenedesmus*, *Pediestrum*, and *Monoraphidium* belonging to Chlorophyceae**,** *Cryptomonas* and *Rhodomonas* belonging to Cryptophyceae and *Anabaenopsis*, *Raphidiopsis*, and *Merismopedia* belonging to Cyanophyceae were observed. During autumn *Merismopedia* were dominant in the year of 2010-2011 and in the year of 2011-2012 Euglenophyceae were dominant (Table 74). During winter Euglenophyceae were dominant in both the study year (Table 75). During summer in the year of 2010-2011 *Merismopedia* were dominant and in the year of 2011-2012 *Raphidiopsis* and *Euglena* sp. were dominant (Table 76). During monsoon amount of Euglenophyceae were dominant in both the study year (Table 77).

Chhatak Station 9

It is a non-infested station for *Vibrio cholerae*. In this station dominant phytoplankton were *Euglena* sp., *Euglena acus*, *Trachelomonas*, *Lepocinclis a*nd *Phacus* belonging to Euglenophyceae**,** *Synedra*, *Rhizosolenia*, *Navicula*, *Fragillaria* and *Nitzschia acicularis* belonging to Bacillariophyceae, *Peridinium* and *Ceratium* belonging to Dinophyceae, *Ankistrodesmus*, *Closterium limneticum*, *Coelastrum*, *Crucigenia* and *Eudorina* belonging to Chlorophyceae**,** *Mallomonas* belonging to Crysophyceae, and *Anabaena*, *Oscillatoria*, *Synechocystis* and *Merismopedia* belonging to Cyanophyceae were observed. During autumn *Mallomonas* were dominant in both the study year (Table 78). During winter in the year of 2010-2011 *Melosira* and *Mallomonas* were dominant and in the year of 2011-2012 *Ceratium* were dominant (Table 79). During summer in the year of 2010-2011 *Mallomonas*, *Euglena* sp. and *Ceratium* were dominant and in the year of 2011-2012 Euglenophyceae were dominant (Table 80). During monsoon in the year of 2010-2011 *Peridinium* and *Ceratium* were dominant and in the year of 2011-2012 *Eudorina* were dominant (Table 81).

Chhatak Station 10

It is a non-infested station for *Vibrio cholerae*. In this station dominant phytoplankton were *Euglena* sp., *Euglena acus*, *Trachelomonas*, *Lepocinclis a*nd *Phacus* belonging to Euglenophyceae**,** *Melosira*, *Synedra*, *Rhizosolenia*, *Cyclotella*, *Fragillaria* and *Nitzschia* sp., *Chaetoceros*, *Surirella*, *Cymbella* and *Stauronies* belonging to Bacillariophyceae, *Peridinium* and *Ceratium* belonging to Dinophyceae, *Scenedesmus*, *Coelastrum*, *Closteriopsis*, *Micractinium*, *Selenestrum*, *Staurastrum* and *Pediestrum* belonging to Chlorophyceae**,** *Mallomonas* belonging to Crysophyceae, and *Anabaena*, and *Lyngbya limnetica* belonging to Cyanophyceae were observed. During autumn *Mallomonas* were dominant in the year of 2010-2011 and in the year of 2011-2012 *Melosira* were dominant (Table 82). During winter and summer *Melosira* were dominant in both the study year (Table 83 and 84). During monsoon abandoned of phytoplankton genera were very poor (Table 85).

Chhatak Station 11

It is a non-infested station for *Vibrio cholerae*. In this station dominant phytoplankton were *Euglena* sp., *Trachelomonas*, *Lepocinclis a*nd *Phacus* belonging to Euglenophyceae**,** *Melosira* and *Cyclotella* belonging to Bacillariophyceae, *Peridinium* belonging to Dinophyceae, *Scenedesmus*, *Coelastrum*, *Monoraphidium*, *Actinastrum*, and *Pediestrum* belonging to Chlorophyceae**,** *Mallomonas* and *Synura* belonging to Crysophyceae, *Cryptomonas* belonging to Cryptophyceae and *Arthrospira*, *Anabaenopsis*, *Raphidiopsis*, *Merismopedia* and *Microcystis* belonging to Cyanophyceae were observed. During autumn *Peridinium* were dominant in the year of 2010-2011 and in the year of 2011-2012 *Arthrospira* and *Pediestrum* were dominant (Table 86). During winter *Peridinium* were dominant in the year of 2010-2011 and in the year of 2011-2012 *Phacus*, *Anabaenopsis* and *Trachelomonas* were abandoned (Table 87). During summer *Mallomonas*, *Trachelomonas* were abandoned in the year of 2010-2011 and in the year of 2011-2012 and *Euglena* sp. and *Trachelomonas* were abandoned (Table 88). During monsoon *Synura* and *Arthrospira* were abandoned in the year of 2010-2011 and in the year of 2011-2012 *Peridinium* and *Trachelomonas* were abandoned (Table 89).

Chhatak Station 12

Dominant phytoplankton were *Euglena* sp., *Euglena acus*, *Phacus*, *Trachelomonas* sp., *Trachelomonas volvosina*, *Lepocinclis a*nd *Strombomonas* belonging to Euglenophyceae**,** *Peridinium* belonging to Dinophyceae, *Closterium* and *Chlamydomonas* belonging to Chlorophyceae**,** *Mallomonas* belonging to Crysophyceae and *Arthrospira*, *Raphidiopsis*, *Merismopedia*, *Oscillatoria* and *Palonema aphani* belonging to Cyanophyceae were observed. During autumn in the year of 2010-2011 *Euglena* sp. and *Trachelomonas volvosina* were abundant and that period *Vibrio cholerae* were also found and in the year of 2011-2012 Euglenophyceae were dominant (Table 90). On the other hand during other season Euglenophyceae were dominant in both the study year (Table 91-93).

Table 66. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Chhatak Station 1.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Euglena* sp. 412.37	*Chlamydomonas* 34.36	*Trachelomonas* 25.77	*Phacus* 17.18	-	-
		2	*Peridinium* 1469.07	*Euglena* 507.56	*Merismopedia* 42.96	*Trachelomonas* 34.36	-	-
		3	*Peridinium* 2379.72	*Oscillatoria* 85.91	*Merismopedia* 60.14	*Pelonema* 34.36	-	-
	E. Nov.	4	*Peridinium* 498.28	*Trachelomonas* 137.46	*Merismopedia* 94.50	*Lepocinclis* 60.14	-	-
		5	*Euglena sp.* 77.32	*Merismopedia* 25.77	*Pandorina* 17.94	*Lepocinclis* 8.59	-	-
		6	*Pandorina* 103.09	*Merismopedia* 77.12	*Lepocinclis* 60.14	*Trachelomonas* 51.55	-	-
2011-2012	L. Oct.	24	*Trachelomonas* 472.51	*Peridinium* 360.82	*Actinastrum* 317.87	*Euglena* sp. 223.37	-	-
		25	*Trachelomonas* 214.78	*Arthrospira* 283.50	*Scenedesmus* 214.78	*Merismopedia* 189.00	-	-
		26	*Trachelomonas* 274.91	*Merismopedia* 266.32	*Raphidiopsis* 111.68	*Peridinium* 68.73	-	-
	E. Nov.	27	*Peridinium* 1400.34	*Euglena sp.* 189.00	*Phacus* 111.68	*Euglena acus* 25.77	-	-

Table 67. Density of dominant phytoplankton (10^3 ind/l) in winter season at Chhatak Station 1.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Nov.	7	*Oscillatoria* 240.55	*Merismopedia* 146.05	*Euglena* sp. 60.14	*Peridinium* 42.96	-	-
		8	*Phacus* 1116.84	*Peridinium* 747.42	*Oscillatoria* 420.96	*Merismopedia* 326.46	-	-
	Dec.	9	*Peridinium* 5063.87	*Oscillatoria* 412.37	*Phacus* 317.87	*Lepocinclis* 292.10	-	-
		10	*Cyclotella* 266.32	*Phacus* 180.41	*Peridinium* 146.05	*Oscillatoria* 120.27	-	-
	Jan.	11	*Peridinium* 3264.60	*Actinastrum* 945.01	*Arthrospira* 687.28	*Pelonema aphane* 670.10	-	-
	Feb.	12	*Peridinium* 2070.44	*Lepocinclis* 189.00	*Pandorina* 128.87	*Arthrospira* 19.70	-	-
2011-2012	L. Nov.	28	*Peridinium* 2319.58	*Euglena* sp. 567.00	*Merismopedia* 10.06	*Arthrospira* 6.56	-	-
		29	*Euglena* sp. 463.91	*Peridinium* 352.23	*Phacus* 120.27	*Trachelomonas* 103.09	-	-
		30	*Trachelomonas* 369.41	*Euglena* sp. 283.50	*Phacus* 274.91	*Merismopedia* 14.88	-	-
	Dec.	31	*Euglena* sp. 266.32	*Arthrospira* 154.63	*Raphidiopsis* 137.45	*Merismopedia* 77.32	-	-
		32	*Euglena* sp. 1975.94	*Arthrospira* 979.37	*Trachelomonas* 455.32	*Actinastrum* 231.95	-	-
	Jan.	33	*Euglena* sp. 360.82	*Pelonema aphane* 197.59	*Trachelomonas* 94.50	*Peridinium* 51.54	-	-
	Feb.	34	*Mallomonas* 5498.26	*Peridinium* 730.24	*Merismopedia* 25.77	*Raphidiopsis* 4.81	-	-

Table 68. Density of dominant phytoplankton (10^3 ind/l) in summer season at Chhatak Station 1.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	13	*Trachelomonas* 1649.48	*Peridinium* 1082.47	*Phacus* 618.55	*Lepocinclis* 300.69	-	-
	April	14	*Lepocinclis* 77.32	*Merismopedia* 60.14	*Arthrospira* 8.54	*Euglena* sp. 7.88	-	-
	May	15	*Arthrospira* 713.06	*Raphidiopsis* 429.55	*Lepocinclis* 309.28	*Trachelomonas* 249.10	-	-
2011-2012	March	35	*Raphidiopsis* 764.60	*Merismopedia* 85.91	*Peridinium* 51.54	*Mallomonas* 42.95	-	-
	April	36	*Mallomonas* 2252.64	*Raphidiopsis* 777.70	*Peridinium* 348.62	*Trachelomonas* 241.35	-	-
	May	37	*Raphidiopsis* 992.24	*Trachelomonas* 40.22	*Anabaenopsis* 6.15	*Peridinium* 4.10	-	-

Table 69. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Chhatak Station 1.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	16	*Peridinium* 1142.62	*Phacus* 446.73	*Arthrospira* 369.41	*Raphidiopsis* 360.82	-	-
	July	17	*Arthrospira* 6554.96	*Raphidiopsis* 5644.31	*Peridinium* 850.51	*Phacus* 16.20	-	-
	Aug.	18	*Arthrospira* 3702.74	*Raphidiopsis* 4510.30	*Peridinium* 214.78	*Actinastrum* 163.23	-	-
	Sept.	19	*Raphidiopsis* 1297.25	*Euglena* sp. 438.14	*Coelastrum* 171.82	*Trachelomonas* 163.23	-	-
		20	*Raphidiopsis* 1323.02	*Phacus* 137.46	*Coelastrum* 128.87	*Actinastrum* 34.36	-	-
		21	*Peridinium* 592.78	*Euglena* sp. 274.91	*Arthrospira* 137.46	*Actinastrum* 120.27	-	-
		22	*Peridinium* 1159.79	*Euglena* 369.41	*Raphidiopsis* 94.50	*Phacus* 68.73	-	-
	E. Oct.	23	*Peridinium* 386.60	*Euglena* sp. 171.82	*Coelastrum* 60.14	*Actinastrum* 34.36	-	-
2011-2012	June	38	*Peridinium* 2172.19	*Raphidiopsis* 817.92	*Merismopedia* 107.27	*Trachelomonas* 40.23	-	-
	July	39	*Raphidiopsis* 522.93	*Euglena* sp. 23.23	*Phacus* 19.13	*Arthrospira* 10.93	-	-
	Aug.	40	*Euglena* sp. 174.31	*Merismopedia* 107.27	*Trachelomonas* 80.45	*Scenedesmus* 53.63	-	-
	Sept.	41	*Arthrospira* 120.68	*Merismopedia* 93.47	*Peridinium* 67.04	*Trachelomonas* 53.63	-	-
		42	*Scenedesmus* 120.68	*Merismopedia* 107.27	*Arthrospira* 93.86	*Peridinium* 80.45	-	-
		43	*Micractinium* 147.49	*Merismopedia* 134.09	*Euglena* sp. 53.63	*Scenedesmus* 40.23	-	-
		44	*Merismopedia* 26.65	*Euglena* sp. 24.94	*Scenedesmus* 22.55	*Phacus* 20.50	-	-
		45	*Arthrospira* 23.91	*Scenedesmus* 19.81	*Euglena* sp. 18.45	*Merismopedia* 13.66	-	-

Table 70. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Chhatak Station 2.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Euglena* sp. 206.18	*Phacus* 94.50	*Trachelomonas volvocina* 42.96	*Lepocinclis* 34.36	-	-
		2	*Euglena* sp. 4.16	*Peridinium* 2.85	*Lepocinclis* 2.19	*Euglena* acus 1.75	-	-
		3	*Peridinium* 60.14	*Euglena* sp. 34.36	*Phacus* 17.18	*Trachelomonas* 3.06	-	-
	E. Nov.	4	*Trachelomonas volvocina* 17.18	*Peridinium* 7.00	*Ceratium* 1.97	*Phacus 1.31*	+	-
		5	*Peridinium* 103.09	*Melosira* 8.59	*Trachelomonas* 5.25	*Mallomonas* 0.66	-	-
		6	*Peridinium* 8.59	*Trachelomonas volvocina* 2.19	*Phacus* 1.32	*Ceratium* 0.88	-	-
2011-2012	L. Oct.	24	*Mallomonas* 1.75	*Melosira* 1.09	*Peridinium* 0.88	*Strombomonas* 0.66	-	-
		25	*Melosira* 68.73	*Phacus* 2.63	*Nitzschia* sp. 2.63	*Raphidiopsis* 1.97	-	-
		26	*Melosira* 5.69	*Mallomonas* 2.63	*Phacus* 2.41	*Trachelomonas* 2.19	-	-
	E. Nov.	27	*Melosira* 103.09	*Trachelomonas* 94.50	*Euglena* 15.10	*Mallomonas* 1.96	-	-

Table 71. Density of dominant phytoplankton (10^3 ind/l) in winter season at Chhatak Station 2.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Nov.	7	*Trachelomonas* 8.59	*Peridinium* 4.16	*Mallomonas* 2.85	*Melosira* 2.41	-	-
		8	*Peridinium* 85.91	*Mallomonas* 34.36	*Trachelomonas* 17.18	*Phacus* 8.59	-	-
	Dec.	9	*Melosira* 1357.38	*Synedra* 352.23	*Rhizosolenia* 25.77	*Cyclotella* 17.18	-	-
		10	*Melosira* 601.37	*Mallomonas* 11.16	*Rhizosolenia* 8.97	*Synedra* 3.06	-	-
	Jan.	11	*Melosira* 1950.17	*Synedra* 455.33	*Euglena* sp.22.98	*Rhizosolenia* 7.66	-	-
	Feb.	12	*Synedra* 292.10	*Lepocinclis* 214.78	*Trachelomonas* 111.68	*Melosira* 27.14	-	-
2011-2012	L. Nov.	28	*Pelonema aphane* 3.28	*Euglena* sp. 2.40	*Phacus* sp. 2.19	*Trachelomonas* sp. 0.44	-	-
		29	*Melosira* 77.31	*Trachelomonas* 5.03	*Mallomonas* 4.37	*Staurastrum* 3.50	-	-
		30	*Melosira* 7.00	*Gyrosigma* 1.75	*Phacus* 1.50	*Rhizosolenia* 0.88	-	-
	Dec.	31	*Melosira* 10.06	*Phacus* 5.25	*Euglena* sp. 4.81	*Trachelomonas* 4.60	-	-
		32	*Closteriopsis* 36.11	*Euglena* sp. 20.79	*Melosira* 9.63	*Phacus* 4.15	-	-
	Jan.	33	*Melosira* 120.27	*Euglena* sp. 13.38	*Synedra* 1.75	*Peridinium* 1.53	-	-
	Feb.	34	*Euglena sp.* 68.73	*Melosira* 42.95	*Navicula* 3.06	*Trachelomonas* 0.87	-	-

Table 72. Density of dominant phytoplankton (10^3 ind/l) in summer season at Chhatak Station 2.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	13	*Melosira* 223.37	*Euglena* sp. 3.72	*Trachelomonas* 3.50	*Dictyosphaerium* 2.63	-	-
	April	14	*Melosira* 77.32	*Mallomonas 3.06*	*Euglena* sp. 2.19	*Nitzschia* sp. 1.31	-	-
	May	15	*Euglena* sp. 3.94	*Melosira* 3.28	*Mallomonas* 1.97	*Phacus* 1.53	-	-
2011-2012	March	35	*Melosira* 28.45	*Euglena* sp. 11.38	*Peridinium* 1.09	*Phacus* 0.87	-	-
	April	36	*Melosira* 2668.31	*Euglena* sp. 12.64	*Coelastrum* 7.17	*Pediastrum* 6.49	-	-
	May	37	*Euglena* sp. 2.73	*Melosira* 2.39	*Mallomonas* 2.05	*Trachelomona* 1.37	-	-

Table 73. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Chhatak Station 2.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	16	*Raphidiopsis* 7.44	*Actinastrum* 1.97	*Merismopedia* 1.53	*Phacus* 1.31	-	-
	July	17	*Peridinium* 0.88	*Phacus* 0.66	*Synedra* 0.14	*Euglena acus*0.22	-	-
	Aug.	18	*Surirella* 1.09	*Euglena* sp. 0.88	*Pinnularia* 0.66	*Closterium* 0.44	-	-
	Sept.	19	*Euglena* sp. 1.09	*Phacus* 0.88	*Trachelomonas* 0.66	*Raphidiopsis* 0.44	-	-
		20	*Trachelomonas* 0.88	*Raphidiopsis* 0.66	*Crucigenia* 0.44	*Euglena* sp. 0.44	-	-
		21	*Euglena* sp. 1.09	*Scenedesmus* 0.66	*Pinnularia* 0.44	*Trachelomonas* 0.22	-	-
		22	*Peridinium* 0.88	*Phacus* 0.66	*Synedra* 0.44	*Fragilaria* 0.22	-	-
	E. Oct.	23	*Phacus* 1.09	*Euglena* sp. 0.88	*Nitzschia* sp. 0.44	*Trachelomonas* 0.22	-	-
2011-2012	June	38	*Melosira* 19.13	*Peridinium* 12.30	*Cymbella* 2.73	*Trachelomonas* 1.37	-	-
	July	39	*Trachelomonas* 4.44	*Euglena* sp. 2.39	*Mallomonas* 2.05	*Pediastrum* 1.37	-	-
	Aug.	40	*Euglena* sp. 3.07	*Synedra* 2.05	*Trachelomonas* 1.02	*Phacus* 0.68	-	-
	Sept.	41	*Merismopedia* 1.71	*Arthrospira* 1.37	*Phacus* 1.02	*Peridinium* 0.68	-	-
		42	*Euglena* sp. 2.39	*Merismopedia* 2.05	*Cyclotella* 1.71	*Trachelomonas* 1.37	-	-
		43	*Trachelomonas* 1.71	*Merismopedia* 1.37	*Euglena* sp. 1.02	*Cyclotella* 0.68	-	-
		44	*Trachelomonas* 1.71	*Mallomonas* 1.02	*Melosira* 0.68	*Dinobryon* 0.34	-	-
		45	*Trachelomonas* 2.39	*Euglena* sp. 1.71	*Peridinium* 1.37	*Phacus* 1.02	-	-

Table 74. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Chhatak Station 4.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Euglena* 2.19	*Phacus* 0.88	*Chlamydomonas* 0.66	*Actinastrum* 0.44	-	-
		2	*Scenedesmus* 7.66	*Euglena* sp. 6.35	*Merismopedia* 4.82	*Pediastrum* 1.53	-	-
		3	*Cryptomonas* 34.36	*Monoraphidium* 25.77	*Peridinium* 8.59	*Scenedesmus* 5.91	-	-
	E. Nov.	4	*Trachelomonas* 42.96	*Scenedesmus* 7.00	*Merismopedia* 5.91	*Cryptomonas* 4.16	-	-
		5	*Merismopedia* 51.55	*Euglena* sp. 8.59	*Scenedesmus* 3.50	*Phacus* 1.09	-	-
		6	*Merismopedia* 34.36	*Rhodomonas* 25.77	*Chlamydomonas* 17.18	*Crucigenia* 8.59	-	-
2011-2012	L. Oct.	24	*Euglena* sp. 6.13	*Trachelomonas* 5.03	*Peridinium* 4.60	*Phacus* 2.63	-	-
		25	*Euglena* sp. 94.50	*Peridinium* 77.32	*Phacus* 25.77	*Scenedesmus* 3.72	-	-
		26	*Euglena* sp. 68.73	*Scenedesmus* 60.14	*Merismopedia* 42.96	*Peridinium* 34.36	-	-
	E. Nov.	27	*Trachelomonas* 120.27	*Euglena* sp. 51.54	*Phacus* 34.36	*Peridinium* 25.77	-	-

Table 75. Density of dominant phytoplankton (10^3 ind/l) in winter season at Chhatak Station 4.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Nov.	7	*Merismopedia* 42.96	*Trachelomonas* 25.77	*Rhodomonas* 17.18	*Lepocinclis* 8.59	-	-
		8	*Euglena* sp. 68.73	*Rhodomonas* 51.55	*Phacus* 42.96	*Euglena* acus 34.36	-	-
	Dec.	9	*Euglena* sp. 34.36	*Scenedesmus* 8.59	*Merismopedia* 6.79	*Cryptomonas* 5.25	-	-
		10	*Crucigenia* 34.36	*Merismopedia* 25.77	*Scenedesmus* 7.00	*Melosira* 5.25	-	-
	Jan.	11	*Euglena* sp. 51.55	*Merismopedia* 10.07	*Crucigenia* 4.60	*Trachelomonas* 4.16	-	-
	Feb.	12	*Euglena* acus 189.00	*Trachelomonas* 103.09	*Phacus* 34.36	*Euglena* sp. 18.17	-	-
2011-2012	L. Nov.	28	*Anabaenopsis* 85.91	*Euglena* sp. 77.31	*Trachelomonas* 68.72	*Peridinium* 25.77	-	-
		29	*Euglena* sp. 94.50	*Trachelomonas* 13.35	*Phacus* 7.00	*Merismopedia* 3.72	-	-
		30	*Euglena* sp. 163.22	*Phacus* 60.13	*Anabaenopsis* 51.54	*Trachelomonas* 42.95	-	-
	Dec.	31	*Trachelomonas* 146.04	*Phacus* 60.13	*Peridinium* 51.54	*Euglena* sp. 42.95	-	-
		32	*Trachelomonas* 103.09	*Peridinium* 85.90	*Phacus* 77.31	*Euglena* sp. 60.13	-	-
	Jan.	33	*Euglena* sp. 223.36	*Trachelomonas* 85.91	*Scenedesmus* 5.47	*Merismopedia* 3.94	-	-
	Feb.	34	*Trachelomonas* 60.13	*Euglena* sp. 25.77	*Peridinium* 4.16	*Phacus* 3.94	-	-

Table 76. Density of dominant phytoplankton (10^3 ind/l) in summer season at Chhatak Station 4.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	13	*Merismopedia* 21.01	*Trachelomonas* 10.07	*Scenedesmus* 7.66	*Chlamydomonas* 6.79	-	-
	April	14	*Merismopedia* 9.85	*Scenedesmus* 6.57	*Euglena* sp 3.94.	*Phacus* 3.50	-	-
	May	15	*Phacus* 15.98	*Euglena* sp. 13.79	*Scenedesmus* 6.57	*Trachelomonas* 5.25	-	-
2011-2012	March	35	*Euglena* sp. 309.27	*Anabaenopsis* 206.18	*Peridinium* 163.22	*Merismopedia* 137.45	-	-
	April	36	*Raphidiopsis* 120.68	*Euglena* sp. 107.27	*Phacus* 26.82	*Merismopedia* 16.40	-	-
	May	37	*Euglena* sp. 25.28	*Peridinium* 14.69	*Trachelomonas* 7.86	*Cryptomonas* 6.49	-	-

Table 77. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Chhatak Station 4.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	16	*Merismopedia* 4.82	*Pediastrum* 4.38	*Trachelomonas* 3.06	*Scenedesmus* 2.85	-	-
	July	17	*Pediastrum* 13.79	*Euglena* sp. 11.38	*Trachelomonas* 5.25	*Scenedesmus* 4.60	-	-
	Aug.	18	*Euglena* sp. 103.09	*Trachelomonas* 7.00	*Phacus* 3.06	*Pediastrum* 1.53	-	-
	Sept.	19	*Peridinium* 103.09	*Trachelomonas* 85.91	*Euglena* sp. 15.76	*Pediastrum* 8.10	-	-
		20	*Peridinium* 85.91	*Trachelomonas* 12.48	*Euglena* sp. 7.66	*Phacus* 5.47	-	-
		21	*Euglena* sp. 27.36	*Peridinium* 5.25	*Phacus* 4.38	*Trachelomonas* 3.94	-	-
		22	*Euglena* sp. 13.13	*Trachelomonas* 10.07	*Peridinium* 8.97	*Pediastrum* 3.94	-	-
	E. Oct.	23	*Peridinium* 13.35	*Euglena* sp. 7.88	*Pediastrum* 3.06	*Cryptomonas* 2.85	-	-
2011-2012	June	38	*Phacus* 134.09	*Euglena* sp. 20.50	*Trachelomonas* 15.71	*Melosira* 15.03	-	-
	July	39	*Pediastrum* 6.83	*Peridinium* 6.15	*Scenedesmus* 4.78	*Melosira* 4.44	-	-
	Aug.	40	*Pediastrum* 10.25	*Scenedesmus* 6.15	*Euglena* sp. 5.81	*Merismopedia* 4.78	-	-
	Sept.	41	*Pediastrum* 19.81	*Phacus*6.49	*Scenedesmus* 6.15	*Euglena* sp. 5.81	-	-
		42	*Pediastrum* 10.93	*Euglena* sp. 9.57	*Scenedesmus* 6.83	*Merismopedia* 5.12	-	-
		43	*Pediastrum* 7.86	*Euglena* sp. 7.52	*Merismopedia* 4.78	*Phacus* 4.44	-	-
		44	*Pediastrum* 10.93	*Euglena* sp. 8.20	*Phacus* 7.52	*Merismopedia* 4.78	-	-
		45	*Euglena* sp. 9.90	*Pediastrum* 7.52	*Merismopedia* 7.17	*Scenedesmus* 6.15	-	-

Table 78. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Chhatak Station 9.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Merismopedia* 60.14	Ankistrodesmus 34.37	*Crucigenia* 8.59	*Euglena* sp. 3.50	-	-
		2	*Trachelomonas* 120.27	*Peridinium* 103.09	*Mallomonas* 68.73	*Phacus* 34.36	-	-
		3	*Euglena* sp. 17.18	*Trachelomonas* 8.59	*Peridinium* 3.50	*Melosira* 2.63	-	-
	E. Nov.	4	*Peridinium* 120.27	*Mallomonas* 111.68	*Lepocinclis* 34.36	*Trachelomonas* 25.77	-	-
		5	*Mallomonas* 223.37	*Peridinium* 77.32	*Trachelomonas* 34.36	*Oscillatoria* 8.59	-	-
		6	*Mallomonas* 111.68	*Phacus* 34.36	*Closterium limneticum* 17.18	*Trachelomonas* 5.03	-	-
2011-2012	L. Oct.	24	*Ceratium* 42.96	*Euglena* sp. 34.36	*Mallomonas* 25.77	*Trachelomonas* 8.59	-	-
		25	*Mallomonas* 77.32	*Euglena* sp. 42.96	*Trachelomonas* 34.36	*Phacus* 17.18	-	-
		26	*Ceratium* 8.54	*Euglena* sp. 6.35	*Mallomonas* 3.72	*Anabaena* 3.06	-	-
	E. Nov.	27	*Mallomonas* 60.13	*Ceratium* 25.77	*Phacus* 4.59	*Euglena* sp. 4.37	-	-

Table 79. Density of dominant phytoplankton (10^3 ind/l) in winter season at Chhatak Station 9.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Nov.	7	*Melosira* 292.10	*Peridinium* 51.55	*Synedra* 34.36	*Phacus* 17.18	-	-
		8	*Mallomonas* 68.73	*Synedra* 51.55	*Trachelomonas* 34.36	*Phacus* 17.18	-	-
	Dec.	9	*Melosira* 575.60	*Synedra* 103.09	*Rhizosolenia* 8.54	*Mallomonas* 5.03	-	-
		10	*Melosira* 68.73	*Trachelomonas* 17.18	*Navicula* 3.50	*Lepocinclis* 1.97	-	-
	Jan.	11	*Mallomonas* 326.46	*Melosira* 5.47	*Navicula* 1.75	*Synechocystis* 1.31	-	-
	Feb.	12	*Peridinium* 13.57	*Mallomonas* 5.91	*Euglena* sp. 2.41	*Coelastrum* 1.75	-	-
2011-2012	L. Nov.	28	*Ceratium* 128.86	*Trachelomonas* 51.54	*Mallomonas* 34.36	*Euglena* sp. 3.94	-	-
		29	*Mallomonas* 51.54	*Ceratium* 42.95	*Melosira* 2.84	*Euglena* sp. 1.75	-	-
		30	*Ceratium* 42.95	*Euglena* sp. 25.77	*Mallomonas* 10.94	*Trachelomonas* 3.06	-	-
	Dec.	31	*Euglena* sp. 4.37	*Ceratium* 3.28	*Mallomonas* 2.19	*Phacus* 1.97	-	-
		32	*Syndera* 10.06	*Ceratium* 3.50	*Euglena* sp. 3.06	*Fragilaria* 2.40	-	-
	Jan.	33	*Ceratium* 2.62	*Euglena* sp. 1.97	*Trachelomonas* 1.75	*Phacus* 1.09	-	-
	Feb.	34	*Euglena* sp. 1.75	*Gyrosigma* 0.65	*Fragilaria* 0.43	*Cymbella* 0.22	-	-

Table 80. Density of dominant phytoplankton (10^3 ind/l) in summer season at Chhatak Station 9.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	13	*Mallomonas* 335.05	*Peridinium* 137.46	*Phacus* 120.27	*Euglena* sp. 12.48	-	-
	April	14	*Euglena* sp. 395.19	*Peridinium* 60.14	*Nitzschia* acicularis 10.94	*Mallomonas* 7.44	-	-
	May	15	*Ceratium* 206.18	*Peridinium* 42.96	*Mallomonas* 27.14	*Phacus* 17.18	-	-
2011-2012	March	35	*Phacus* 51.54	*Trachelomonas* 25.77	*Euglena* sp. 3.06	*Euglena* acus 1.31	-	-
	April	36	*Trachelomonas* 187.72	*Euglena* sp. 80.45	*Phacus* 13.41	*Coelastrum* 4.44	-	-
	May	37	*Euglena* sp. 201.13	*Ceratium* 53.63	*Synedra* 4.44	*Pediastrum* 3.76	-	-

Table 81. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Chhatak Station 9.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	16	*Ceratium* 180.41	*Euglena* sp. 85.91	*Peridinium* 60.14	*Trachelomonas* 9.41	-	-
	July	17	*Ceratium* 1130.92	*Peridinium* 953.61	*Phacus* 11.82	*Euglena* sp. 8.10	-	-
	Aug.	18	*Peridinium* 549.83	*Ceratium* 206.18	*Mallomonas* 103.09	*Trachelomonas* 5.91	-	-
	Sept.	19	*Peridinium* 154.64	*Trachelomonas* 103.09	*Ceratium* 12.04	*Euglena* sp. 7.22	-	-
		20	*Peridinium* 214.78	*Trachelomonas* 94.50	*Synura* 60.14	*Ceratium* 34.36	-	-
		21	*Euglena* sp. 16.20	*Phacus* 7.88	*Trachelomonas* 7.44	*Ceratium* 6.35	-	-
		22	*Mallomonas* 41.15	*Trachelomonas* 24.30	*Euglena* sp. 18.39	*Ceratium* 13.13	-	-
	E. Oct.	23	*Euglena* sp. 77.32	*Ceratium* 34.36	*Trachelomonas* 25.77	*Phacus* 5.25	-	-
2011-2012	June	38	*Ceratium* 80.45	*Euglena* sp. 7.52	*Trachelomonas* 6.83	*Phacus* 2.39	-	-
	July	39	*Melosira* 5.47	*Trachelomonas* 1.70	*Actinastrum* 1.37	*Euglena* sp. 1.02	-	-
	Aug.	40	*Eudorina* 160.90	*Trachelomonas* 80.45	*Lepocinclis* 67.04	*Phacus* 4.44	-	-
	Sept.	41	*Eudorina* 11.96	*Euglena* sp. 6.83	*Lepocinclis* 5.47	*Micractaenium* 5.12	-	-
		42	*Euglena* sp. 2.39	*Merismopedia* 2.05	*Cyclotella* 1.71	*Trachelomonas* 1.37	-	-
		43	*Trachelomonas* 16.74	*Euglena* sp. 5.47	*Eudorina* 3.76	*Micractinium* 3.07	-	-
		44	*Trachelomonas* 24.60	*Mallomonas* 7.52	*Phacus* 3.76	*Euglena* sp. 2.39	-	-
		45	*Trachelomonas* 14.35	*Micractinium* 9.22	*Mallomonas* 5.81	*Eudorina* 4.10	-	-

Table 82. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Chhatak Station 10.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Mallomonas* 816.15	*Trachelomonas* 60.14	*Euglena* sp. 17.18	*Phacus* 5.25	-	-
		2	*Trachelomonas* 1.53	*Mallomonas* 0.66	*Euglena* sp. 0.44	Selenestrum 0.22	-	-
		3	*Trachelomonas* 120.27	*Mallomonas* 77.32	*Lepocinclis* 25.77	*Euglena* sp. 17.18	-	-
	E. Nov.	4	*Peridinium* 8.59	*Melosira* 2.41	*Lepocinclis* 1.53	*Phacus* 1.31	-	-
		5	*Cryptomonas* 8.59	*Mallomonas* 1.75	*Peridinium* 1.09	*Lepocinclis* 0.88	-	-
		6	*Peridinium* 1.53	*Mallomonas* 0.66	*Lepocinclis* 0.22	*Coelastrum* 0.22	-	-
2011-2012	L. Oct.	24	*Melosira* 2.19	*Mallomonas* 1.97	*Cyclotella* 0.88	*Strombomonas* 0.44	-	-
		25	*Melosira* 77.32	*Nitzschia* sp. 0.88	*Scenedesmus* 0.66	*Mallomonas* 0.44	-	-
		26	*Melosira* 6.35	*Mallomonas* 3.28	*Strombomonas* 1.53	*Anabaena* 0.88	-	-
	E. Nov.	27	*Melosira* 128.86	*Synedra* 1.97	*Mallomonas* 1.75	*Ceratium* 1.31	-	-

Table 83. Density of dominant phytoplankton (10^3 ind/l) in winter season at Chhatak Station 10.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Nov.	7	*Melosira* 14.88	*Phacus* 3.50	*Mallomonas* 2.63	*Trachelomonas* 2.41	-	-
		8	*Melosira* 10.29	*Trachelomonas* 2.85	*Synedra* 0.88	*Lepocinclis* 0.66	-	-
	Dec.	9	*Melosira* 120.27	*Peridinium* 94.50	*Lepocinclis* 25.77	*Mallomonas* 10.94	-	-
		10	*Melosira* 343.64	*Rhizosolenia* 5.47	*Synedra* 2.85	*Mallomonas* 1.75	-	-
	Jan.	11	*Melosira* 1348.79	*Synedra* 309.28	*Rhizosolenia* 146.05	*Chaetoceros* 12.48	-	-
	Feb.	12	*Syndera* 343.64	*Melosira* 154.64	*Euglena* acus 6.57	*Euglena* sp. 1.09	-	-
2011-2012	L. Nov.	28	*Melosira* 10.28	*Chaetoceros* 0.87	*Staurastrum* 0.66	*Rhizosolenia* 0.44	-	-
		29	*Melosira* 51.54	*Mallomonas* 3.06	*Synedra* 1.75	*Chaetoceros* 0.66	-	-
		30	*Melosira* 77.31	*Mallomonas* 3.72	*Chaetoceros* 1.53	*Rhizosolenia* 1.31	-	-
	Dec.	31	*Melosira* 9.91	*Rhizosolenia* 4.60	*Peridinium* 2.40	*Mallomonas* 1.53	-	-
		32	*Closteriopsis* 163.22	*Melosira* 9.63	*Mallomonas* 1.09	*Rhizosolenia* 0.87	-	-
	Jan.	33	*Melosira* 137.45	*Mallomonas* 2.84	*Nitzschia* sp. 1.09	*Chaetoceros* 0.87	-	-
	Feb.	34	*Melosira* 60.13	*Euglena* sp. 0.65	*Phacus* 0.43	*Pediastrum* 0.22	-	-

Table 84. Density of dominant phytoplankton (10^3 ind/l) in summer season at Chhatak Station 10.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	13	*Melosira* 266.32	*Synedra* 1.31	*Pedisstrum* 1.09	*Ceracium* 0.88	-	-
	April	14	*Mallomonas* 85.91	*Melosira* 24.95	*Peridinium* 2.41	*Euglena* sp. 1.97	-	-
	May	15	*Melosira* 5.03	*Mallomonas* 2.63	*Trachelomonas* 1.97	*Scenedesmus* 1.75	-	-
2011-2012	March	35	*Melosira* 5.47	*Gyrosigma* 2.84	*Euglena* sp. 1.31	*Surirella* 0.65	-	-
	April	36	*Melosira* 1139.73	*Pediastrum* 4.78	*Trachelomonas* 3.07	*Euglena* sp. 2.39	-	-
	May	37	*Melosira* 9.57	*Euglena* sp. 3.07	*Peridinium* 1.37	*Trachelomonas* 1.02	-	-

Table 85. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Chhatak Station 10.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	16	*Trachelomonas* 1.75	*Nitzschia* sp. 0.88	*Melosira* 0.66	*Synedra* 0.44	-	-
	July	17	*Synedra* 0.88	*Peridinium* 0.66	*Trachelomonas* 0.44	*Lyngbya limnetica* 0.22	-	-
	Aug.	18	*Peridinium* 1.09	*Ceratium* 0.88	*Phacus* 0.66	*Trachelomonas* 0.44	-	-
	Sept.	19	*Trachelomonas* 1.97	*Peridinium* 1.09	*Euglena* sp. 0.44	*Nitzschia* sp. 0.22	-	-
		20	*Peridinium* 2.40	*Trachelomonas* 1.09	*Ceratium* 0.88	*Euglena* sp. 0.66	-	-
		21	*Cymbella* 0.88	*Synedra* 0.66	*Stauroneis* 0.44	*Euglena* acus 0.22	-	-
		22	*Trachelomonas* 0.88	*Euglena* sp. 0.66	*Cymbella* 0.44	*Strombomonas* 0.22	-	-
	E. Oct.	23	*Synedra* 1.09	*Melosira* 0.88	*Trachelomonas* 0.44	*Euglena* acus 0.22	-	-
2011-2012	June	38	*Melosira* 7.86	*Synedra* 1.02	*Peridinium* 0.68	*Phacus* 0.34	-	-
	July	39	*Melosira* 4.10	*Mallomonas* 1.37	*Strombomonas* 1.37	*Peridinium* 0.68	-	-
	Aug.	40	*Trachelomonas* 2.05	*Euglena* sp. 1.37	*Melosira* 0.68	*Phacus* 0.34	-	-
	Sept.	41	*Micractaenium* 1.71	*Euglena* sp. 1.37	*Mallomonas* 1.02	*Trachelomonas* 0.68	-	-
		42	*Phacus* 1.37	*Mallomonas* 1.02	*Euglena* sp. 0.68	*Trachelomonas* 0.34	-	-
		43	*Trachelomonas* 2.39	*Mallomonas* 1.02	*Melosira* 0.68	*Synedra* 0.68	-	-
		44	*Mallomonas* 4.78	*Rhizosolenia* 4.10	*Pteromonas* 2.05	*Trachelomonas* 1.71	-	-
		45	*Mallomonas* 3.41	*Trachelomonas* 2.39	*Melosira* 1.37	*Euglena* sp. 1.02	-	-

Table 86. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Chhatak Station 11.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Peridinium* 257.73	*Trachelomonas* 111.68	*Lepocinclis* 25.77	*Cryptomonas* 17.18	-	-
		2	*Mallomonas* 180.41	*Trachelomonas* 60.41	*Phacus* 25.77	*Closterium limneticum* 2.85	-	-
		3	*Peridinium* 223.37	*Trachelomonas* 103.09	*Closterium limneticum* 34.36	*Lepocinclis* 25.77	-	-
	E. Nov.	4	*Peridinium* 1005.15	*Trachelomonas* 721.65	*Mallomonas* 94.50	*Lepocinclis* 68.73	-	-
		5	*Peridinium* 936.42	*Trachelomonas* 412.37	*Ceratium* 42.96	*Mallomonas* 13.79	-	-
		6	*Peridinium* 94.50	*Trachelomonas* 60.14	*Mallomonas* 5.25	*Lepocinclis* 4.06	-	-
2011-2012	L. Oct.	24	*Arthrospira* 489.69	*Scenedesmus* 120.27	*Pediastrum* 103.09	*Euglena* sp. 77.32	-	-
		25	*Pediastrum* 180.41	*Arthrospira* 111.68	*Euglena* sp. 94.50	*Scenedesmus* 60.14	-	-
		26	*Pediastrum* 1563.57	*Actinastrum* 902.06	*Phacus* 317.87	*Scenedesmus* 189.00	-	-
	E. Nov.	27	*Phacus* 343.64	*Peridinium* 335.05	*Raphidiopsis* 171.82	*Pediastrum* 128.86	-	-

Table 87. Density of dominant phytoplankton (10^3 ind/l) in winter season at Chhatak Station 11.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Nov.	7	*Peridinium* 146.03	*Mallomonas* 8.59	*Trachelomonas* 3.94	*Euglena* acus 1.75	-	-
		8	*Peridinium* 678.69	*Phacus* 223.37	*Mallomonas* 171.82	*Trachelomonas* 146.05	-	-
	Dec.	9	*Peridinium* 798.97	*Mallomonas* 652.92	*Trachelomonas* 541.24	*Phacus* 231.96	-	-
		10	*Mallomonas* 11.38	*Peridinium* 8.97	*Trachelomonas* 8.76	*Melosira* 3.06	-	-
	Jan.	11	*Trachelomonas* 1262.88	*Mallomonas* 1245.70	*Lepocinclis* 816.15	*Phacus* 446.73	-	-
	Feb.	12	*Mallomonas* 1185.56	*Trachelomonas* 859.10	*Lepocinclis* 687.28	*Phacus* 180.41	-	-
2011-2012	L. Nov.	28	*Phacus* 455.32	*Raphidiopsis* 240.55	*Peridinium* 180.41	*Pediastrum* 103.09	-	-
		29	*Phacus* 403.77	*Raphidiopsis* 386.60	*Anabaenopsis* 120.27	*Pediastrum* 77.31	-	-
		30	*Phacus* 395.18	*Anabaenopsis* 163.22	*Peridinium* 85.91	*Merismopedia* 51.54	-	-
	Dec.	31	*Phacus* 60.13	*Anabaenopsis* 42.95	*Raphidiopsis* 34.36	*Scenedesmus* 7.22	-	-
		32	*Anabaenopsis* 378.00	*Merismopedia* 197.59	*Raphidiopsis* 137.45	*Scenedesmus* 85.91	-	-
	Jan.	33	*Anabaenopsis* 360.82	*Trachelomonas* 283.50	*Scenedesmus* 77.32	*Merismopedia* 34.36	-	-
	Feb.	34	*Trachelomonas* 214.77	*Phacus* 77.32	*Merismopedia* 60.13	*Scenedesmus* 25.77	-	-

Table 88. Density of dominant phytoplankton (10^3 ind/l) in summer season at Chhatak Station 11.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	13	*Mallomonas* 1254.29	*Trachelomonas* 678.69	*Lepocinclis* 240.55	*Phacus* 206.18	-	-
	April	14	*Trachelomonas* 446.73	*Euglena* sp. 171.82	*Phacus* 154.64	*Peridinium* 1.53	-	-
	May	15	*Phacus* 120.27	*Trachelomonas* 11.68	*Peridinium* 94.50	*Euglena* sp. 51.00	-	-
2011-2012	March	35	*Euglena* sp. 747.42	*Phacus* 111.68	*Scenedesmus* 77.32	*Merismopedia* 60.13	-	-
	April	36	*Trachelomonas* 911.78	*Euglena* sp. 294.99	*Monoraphidium* 174.31	*Phacus* 80.45	-	-
	May	37	*Merismopedia* 40.23	*Raphidiopsis* 9.57	*Phacus* 7.17	*Euglena* sp. 3.07	-	-

Table 89. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Chhatak Station 11.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	16	*Synura* 893.47	*Mallomonas* 489.69	*Trachelomonas* 240.55	*Euglena* sp. 85.91	-	-
	July	17	*Mallomonas* 10.94	*Trachelomonas* 5.25	*Euglena* sp. 2.63	*Strombomonas* 2.19	-	-
	Aug.	18	*Phacus* 137.46	*Scenedesmus* 85.91	*Euglena* sp. 60.14	*Peridinium* 25.77	-	-
	Sept.	19	*Arthrospira* 19.70	*Pediastrum* 6.57	*Cyclotella* 3.94	*Trachelomonas* 3.06	-	-
		20	*Arthrospira* 506.87	*Merismopedia* 103.09	*Pediastrum* 7.88	*Scenedesmus* 7.66	-	-
		21	*Arthrospira* 584.19	*Scenedesmus* 103.09	*Merismopedia* 51.55	*Pediastrum* 42.96	-	-
		22	*Arthrospira* 257.73	*Raphidiopsis* 85.91	*Scenedesmus* 77.32	*Pediastrum* 28.89	-	-
	E. Oct.	23	*Arthrospira* 128.87	*Pediastrum* 120.27	*Scenedesmus* 103.09	*Phacus* 94.50	-	-
2011-2012	June	38	*Phacus* 268.17	*Euglena* sp. 120.68	*Scenedesmus* 107.27	*Trachelomonas* 80.45	-	-
	July	39	*Peridinium* 1099.50	*Trachelomonas* 187.72	*Phacus* 40.23	*Merismopedia* 26.99	-	-
	Aug.	40	*Phacus* 187.72	*Trachelomonas* 134.09	*Mallomonas* 120.68	*Microcystis* 67.04	-	-
	Sept.	41	*Merismopedia* 442.48	Microcystis 294.99	*Trachelomonas* 187.72	*Phacus* 7.52	-	-
		42	*Trachelomonas* 1005.64	*Merismopedia* 375.44	*Microcystis* 227.95	*Euglena* sp. 24.94	-	-
		43	*Trachelomonas* 455.89	*Merismopedia* 362.03	*Microcystis* 294.99	*Euglena* sp. 14.35	-	-
		44	*Trachelomonas* 737.47	*Microcystis* 308.40	*Merismopedia* 281.58	*Euglena* sp. 38.60	-	-
		45	*Mallomonas* 37.24	*Trachelomonas* 24.94	*Euglena* sp 17.76	*Phacus* 9.91	-	-

Table 90. Density of dominant phytoplankton (10^3 ind/l) in autumn season at Chhatak Station 12.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Oct.	1	*Euglena* sp. 11.56	*Peridinium* 3.28	*Chlamydomonas* 2.19	*Phacus* 1.53	-	-
		2	*Euglena* sp. 51.55	*Euglena acus* 42.96	*Trachelomonas* 25.77	*Phacus* 6.79	-	-
		3	*Euglena* sp. 137.46	*Trachelomonas* 60.14	*Peridinium* 51.55	*Euglena acus* 42.96	-	-
	E. Nov.	4	*Trachelomonas volvocina* 103.09	*Lepocinclis* 34.36	*Oscillatoria* 25.77	*Euglena acus* 17.18	+	-
		5	*Trachelomonas* 17.18	*Peridinium* 8.59	*Euglena acus* 6.13	*Euglena* sp.4.60	-	-
		6	*Euglena acus* 34.36	*Peridinium* 8.59	*Phacus* 3.06	*Trachelomonas* 0.88	-	-
2011-2012	L. Oct.	24	*Phacus* 283.50	*Euglena* sp. 266.32	*Trachelomonas* 146.05	*Euglena acus* 85.91	-	-
		25	*Phacus* 463.92	*Trachelomonas* 266.32	*Euglena* sp. 68.73	*Mallomonas* 60.14	-	-
		26	*Trachelomonas* 223.37	*Phacus* 171.82	*Euglena* sp. 163.23	*Mallomonas* 60.14	-	-
	E. Nov.	27	*Trachelomonas* 1726.80	*Phacus* 111.68	*Euglena* sp. 77.32	*Mallomonas* 60.13	-	-

Table 91. Density of dominant phytoplankton (10^3 ind/l) in winter season at Chhatak Station 12.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	L. Nov.	7	*Euglena acus* 51.55	*Oscillatoria* 8.59	*Trachelomonas* 3.06	*Peridinium* 1.75	-	-
		8	*Euglena* 231.96	*Phacus 68.73*	*Lepocinclis* 60.14	*Peridinium* 51.55	-	-
	Dec.	9	*Euglena* sp. 2147.76	*Phacus* 180.41	*Trachelomonas* 103.19	*Lepocinclis* 85.91	-	-
		10	*Lepocinclis* 25.77	*Phacus* 17.18	*Trachelomonas* 10.29	*Euglena* sp. 8.10	-	-
	Jan.	11	*Trachelomonas* 833.33	*Lepocinclis* 335.05	*Euglena* sp. 12.91	*Phacus* 8.76	-	-
	Feb.	12	*Peridinium* 15.54	*Closterium* 7.88	*Euglena* sp. 6.35	*Mallomonas* 4.16	-	-
2011-2012	L. Nov.	28	*Trachelomonas* 798.96	*Phacus* 111.68	*Euglena* sp. 94.50	*Peridinium* 85.91	-	-
		29	*Trachelomonas* 970.78	*Phacus* 128.86	*Euglena* sp. 111.68	*Peridinium* 51.54	-	-
		30	*Trachelomonas* 386.59	*Euglena* sp. 163.22	*Mallomonas* 94.50	*Phacus* 60.13	-	-
	Dec.	31	*Euglena* sp. 1056.70	*Trachelomonas* 970.78	*Phacus* 541.23	*Mallomonas* 197.59	-	-
		32	*Euglena* sp. 3865.96	*Phacus* 206.18	*Trachelomonas* 77.32	*Arthrospira* 42.95	-	-
	Jan.	33	*Euglena* sp. 13.48.79	*Phacus* 77.32	*Pelonema aphane* 3.72	*Trachelomonas* 0.65	-	-
	Feb.	34	*Euglena* sp. 3694.14	*Phacus* 85.91	*Trachelomonas* 1.09	*Pelonema aphane* 0.22	-	-

Table 92. Density of dominant phytoplankton (10^3 ind/l) in summer season at Chhatak Station 12.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	March	13	*Lepocinclis* 171.82	*Euglena* sp. 481.10	*Trachelomonas* 3.50	*Phacus* 1.31	-	-
	April	14	*Euglena sp.* 403.78	*Phacus* 223.37	*Trachelomonas* 120.27	*Euglena acus* 4.06	-	-
	May	15	*Euglena sp.* 1073.88	*Phacus* 352.23	*Trachelomonas* 189.00	*Strombomonas* 3.72	-	-
2011-2012	March	35	*Euglena sp.* 3006.86	*Phacus* 42.95	*Raphidiopsis* 1.31	*Trachelomonas* 1.09	-	-
	April	36	*Phacus* 1595.62	*Euglena* sp. 1086.10	*Trachelomonas* 19.47	*Peridinium* 2.39	-	-
	May	37	*Trachelomonas* 214.54	*Euglena* sp. 201.13	*Phacus* 174.31	*Strombomonas* 12.98	-	-

Table 93. Density of dominant phytoplankton (10^3 ind/l) in monsoon season at Chhatak Station 12.

Year	Month	R. no.	Dominant group of phytoplankton				*V.cholerae*	
			Group 1	Group 2	Group 3	Group 4	Water	ZP
2010-2011	June	16	*Trachelomonas* 257.73	*Phacus* 60.14	*Euglena* sp. 34.36	*Strombomonas* 7.66	-	-
	July	17	*Strombomonas* 48.15	*Euglena* sp. 17.95	*Phacus* 15.76	*Trachelomonas* 12.04	-	-
	Aug.	18	*Arthrospira* 6.79	*Euglena* sp. 2.63	*Raphidiopsis* 2.41	*Phacus* 1.97	-	-
	Sept.	19	*Euglena* sp. 31.08	*Trachelomonas* 19.92	*Phacus* 12.91	*Euglena acus* 3.50	-	-
		20	*Euglena* sp. 137.46	*Phacus* 85.91	*Trachelomonas* 68.73	*Euglena acus* 12.70	-	-
		21	*Euglena* sp. 128.87	*Phacus* 77.32	*Trachelomonas* 11.82	*Euglena acus* 3.72	-	-
		22	*Euglena* sp. 154.64	*Phacus* 128.87	*Trachelomonas* 103.09	*Euglena acus* 4.16	-	-
	E. Oct.	23	*Euglena* sp. 300.69	*Phacus* 214.78	*Trachelomonas* 189.00	*Mallomonas* 12.26	-	-
2011-2012	June	38	*Euglena* sp. 49.53	*Phacus* 25.28	*Trachelomonas* 9.57	*Peridinium* 8.20	-	-
	July	39	*Euglena* sp. 9.57	*Trachelomonas* 6.49	*Strombomonas* 6.15	*Peridinium* 4.44	-	-
	Aug.	40	*Euglena* sp. 93.86	*Lepocinclis* 80.45	*Euglena acus* 67.04	*Phacus* 40.23	-	-
	Sept.	41	*Euglena* sp. 201.13	*Trachelomonas* 187.72	*Phacus* 174.31	*Mallomonas* 53.63	-	-
		42	*Phacus* 72.42	*Mallomonas* 59.78	*Trachelomonas* 54.32	*Euglena* sp. 42.02	-	-
		43	*Trachelomonas* 18.45	*Euglena* sp. 12.64	*Phacus* 10.59	*Mallomonas* 3.42	-	-
		44	*Mallomonas* 37.24	*Trachelomonas* 24.94	*Euglena* sp 17.76	*Phacus* 9.91	-	-
		45	*Euglena* sp. 73.11	*Trachelomonas* 48.17	*Mallomonas* 32.45	*Phacus* 18.79	-	-

STATISTICAL ANALYSIS

Correlation matrix

Correlation matrix was prepared with the help of SPSS (Statistical programme for Social Science) following Pearsons correlation (version 11.5) method to observed the relationship among physical, chemical and biological parameters of the selected stations of two study sites. Analysis has been performed among 17 physical, chemical and biological parameters of two study sites. The matrix has been presented in Table 94-101 for Mathbaria Station 2, 4, 5, 7, 8, 9, 10 and 11 respectively and for study site Chhatak correlation matrix has been presented in Table 102-108 for Station 1, 2, 4, 9, 10, 11 and 12, respectively.

Study site of Mathbaria

Station 2

Water depth (WD) showed positive correlation with WT and showed highly significant negative correlation with alkalinity, pH, SRS, TZ, TCA and TCN. Water temperature showed positive correlation with salinity, pH, TDS, SRP, NN, PP, VCWA and VCZP but highly significant negative correlation with phytoplankton density (PD) and total zooplankton. Alkalinity showed significant positive correlation with salinity, pH, TDS, SRS, TZ, TCA and TCN. Salinity showed highly significant positive correlation with alkalinity, pH, TDS, chl. *a*, PP, TCA, TCN and VCWA and VCZP and maintain negative correlation with WD. pH showed significant positive correlation with alkalinity, salinity, TDS and TCN and significant negative correlation with water depth. TDS showed highly significant positive correlation with alkalinity, salinity, pH, nitrate nitrogen, chl. *a*, PP, TCA, TCN, VCWA and VCZP and maintain negative correlation with water depth and phytoplankton density.

SRP showed highly significant positive correlation with TCA and TCN but negatively correlated with water depth. SRS showed significant positive correlation with alkalinity and significant negative correlation with water depth. NN showed highly significant positive correlation with TDS, PP and TCN. Chlorophyll *a* showed significant positive correlation with salinity, TDS, PP and TCN and maintain negative correlation with WD and WT. Phaeopigment showed significant positive correlation with salinity, TDS, NN, chl. *a*, TCA, TCN, VCWA and VCZP. Phytoplankton density showed significant positive correlation with total zooplankton and TCN but significant negative correlation with water temperature.

Total zooplankton showed significant positive correlation with alkalinity, chl. *a*, PD, TCA and TCN but showed significant negative correlation with WD and WT. Total copepods adult showed significant positive correlation with alkalinity, salinity, TDS, SRP, NN, PP, TZ and TCN and significant negative correlation with water depth. Total copepods nauplii showed significant positive correlation with alkalinity, salinity, pH, TDS, SRP, NN, chl. *a*, PP, PD, TZ and total copepods adult but significant negative correlation with water depth. *Vibrio cholerae* water analysis showed significant positive correlation with salinity, TDS, PP and VCZP and maintain negative correlation with water depth. *Vibrio cholerae* zooplankton analysis also showed significant positive correlation with salinity, TDS, PP and VCWA and maintain negative correlation with water depth.

Station 4

Water depth (WD) maintain positive correlation with NN and phytoplankton density and showed highly significant negative correlation with chl. *a* and total zooplankton (TZ). Water temperature (WT) showed significant positive correlation with TDS and SRS. Alkalinity showed significant positive correlation with pH and TZ. Salinity showed significant positive correlation with TDS, SRS and PP and maintain negative correlation with WD and PD. pH showed significant positive correlation with alkalinity and significant negative correlation with WT. TDS showed significant positive correlation with WT, salinity, SRS and PP. SRP showed positive correlation with WT, TDS. and PD. SRS showed significant positive correlation with WT, salinity and TDS. Nitrate nitrogen showed significant positive correlation with TCA and TCN. Chlorophyll *a* showed significant positive correlation with PP and TZ and significant negative correlation with water depth. Phaeopigment showed significant positive correlation with salinity, TDS, chl. *a* and TZ. Phytoplankton density showed positive correlation with WD, WT and SRP and maintain negative correlation with alkalinity, salinity, pH, SRS, TZ, TCA and TCN. Total zooplankton showed significant positive correlation with alkalinity, chl. *a* and PP and significant negative correlation with water depth. Total copepods adult showed significant positive correlation with NN and TCN and Total copepods nauplii showed significant positive correlation with NN and TCA.

Station 5

Water depth (WD) showed positive correlation with pH, NN and chl. *a*, and showed significant negative correlation with alkalinity and TZ. Water temperature (WT) showed significant positive correlation with SRS and significant negative correlation with pH. Alkalinity showed significant positive correlation with TZ and significant negative correlation water depth. pH showed positive correlation with WD and showed significant negative correlation with WT and TDS. TDS showed significant negative correlation with pH. SRS showed significant positive correlation with water temperature Nitrate nitrogen showed highly significant positive correlation with chl. *a*, Chlorophyll *a* showed highly significant positive correlation with nitrate nitrogen and phaaeopigment. Phytoplankton density showed significant positive correlation with TCA. Total zooplankton showed significant positive correlation with alkalinity but showed significant negative correlation with water depth. Total copepod adult showed significant positive correlation with total PD, and TCN and Total copepods nauplii showed significant positive correlation with TCN.

Station 7

Water depth (WD) showed significant positive correlation with SRP and showed significant negative correlation with alkalinity, pH and TZ. Water temperature (WT) showed positive correlation with WD, salinity, TDS, SRP, SRS, TCN, VCWA and VCZP but negative correlation with alkalinity, NN, chl. *a* and PD. Alkalinity showed significant positive correlation with salinity, pH, TDS, SRS and TZ and showed significant negative correlation with WD. Salinity showed significant positive correlation with alkalinity, pH and TDS. pH showed significant positive correlation with alkalinity, salinity, TDS and total zooplankton and significant negative correlation with water depth.TDS showed significant positive correlation with alkalinity, salinity and pH. SRP showed significant positive correlation with water depth. SRS showed significant positive correlation with alkalinity. Chlorophyll *a* showed significant positive correlation with phaeopigment. Phaeopigment showed significant positive correlation with chl. *a*, and VCZP. Total zooplankton showed significant positive correlation with alkalinity, pH, TCN and significant negative correlation with WD. Total copepods adult showed significant positive correlation with TCN. Total copepods nauplii showed significant positive correlation with water TZ and TCA. *Vibrio cholerae* water analysis showed positive correlation with water temperature, alkalinity, salinity, TD, SRS, PP, TZ, TCA and TCN. *Vibrio cholerae* zooplankton analysis showed significant positive correlation with phaeopigment.

Station 8

Water temperature (WT) showed positive correlation with salinity, TDS, SRP, PP, TZ, TCA, TCN, VCWA and VCZP. Alkalinity showed significant positive correlation with salinity, pH and SRS and showed significant negative correlation with SRP, TZ and TCN. Salinity showed significant positive correlation with alkalinity, pH, TDS and PP. pH showed significant positive correlation with alkalinity, salinity, TDS and phytoplankton density. TDS showed significant positive correlation with salinity, pH and PP. SRP showed significant negative correlation with alkalinity and SRS. SRS showed significant positive correlation with alkalinity and significant negative correlation with SRP, chl. *a* and phaeopigment. Nitrate nitrogen showed positive correlation with alkalinity, salinity, pH, TDS, chl. *a*, phaeopigment and TCA.

Chlorophyll *a* showed significant positive correlation with phaeopigment and showed significant negative correlation with SRS. Phytoplankton density showed significant positive correlation with pH and *Vibrio cholerae* water analysis. Total zooplankton showed significant positive correlation with TCA and TCN and showed significant negative correlation with alkalinity. Total copepods adult showed significant positive correlation with TZ. Total copepods nauplii showed significant positive correlation with PP and showed significant negative correlation with alkalinity. *Vibrio cholerae* water analysis showed significant positive correlation with PD and *Vibrio cholerae* zooplankton analysis showed positive correlation with water temperature, alkalinity, SRP and phaeopigment.

Station 9

Water depth (WD) showed significant positive correlation with WT, SRP and PD and significant negative correlation with alkalinity and PP. Water temperature (WT) showed significant positive correlation with salinity and TDS. Alkalinity showed positive correlation with salinity, pH, TDS and SRS and significant negative correlation with water depth. Salinity showed significant positive correlation with WT, alkalinity, TDS, chl. *a* and phaeopigment. pH showed significant positive correlation with alkalinity, TDS and SRS and significant negative correlation with SRP. TDS showed significant positive correlation with WT, alkalinity, salinity, pH, chl. *a* and phaeopigment. Nitrate nitrogen showed significant positive correlation with chl. *a*, phaeopigment and TCN. Chlorophyll *a* showed significant positive correlation with salinity, TDS, NN, PP and TCN. Phaeopigment showed significant positive correlation with salinity, TDS, chl. *a*, and significant negative correlation with WD. Total zooplankton showed significant positive correlation with TCA and TCN and Total copepods nauplii showed significant positive correlation with NN, chl. *a*, TZ and TCA.

Station 10

Water depth (WD) showed significant positive correlation with WT, SRP and PD and showed significant negative correlation with alkalinity, SRS and chl. *a*. Water temperature (WT) showed significant positive correlation with salinity. Alkalinity showed significant positive correlation with SRS, chl. *a* and TCN and showed significant negative correlation with water depth. Salinity showed significant positive correlation with WT, TDS, chl. *a*, phaeopigment and VCWA. pH showed significant positive correlation with chl. *a*, and phaeopigment. TDS showed significant positive correlation with salinity, chl. *a* and phaeopigment. SRS showed significant positive correlation with alkalinity and significant negative correlation with water depth. Chlorophyll *a* showed significant positive correlation with alkalinity, salinity, pH, TDS, PP and VCZP and showed significant negative correlation with WD. Phaeopigment showed significant positive correlation with salinity, pH, TDS, chl. *a* and VCZP. Phytoplankton density showed positive correlation with TZ, TCA, TCA, TCN and VCWA.*Vibrio cholerae* water analysis showed significant positive correlation with salinity, PP, TZ, TCA and TCN.

Station 11

Water depth (WD) showed significant positive correlation with WT, SRP and PD and showed significant negative correlation with alkalinity, SRS and chl. *a*. Water temperature (WT) showed significant positive correlation with salinity. Alkalinity showed significant positive correlation with SRS, chl. *a* and TCN and showed significant negative correlation with water depth. Salinity showed significant positive correlation with WT, TDS, chl. *a*, PP and VCWA. pH showed significant positive correlation with chl. *a* and PP. TDS showed significant positive correlation with salinity, chl. *a* and PP. SRS showed significant positive correlation with alkalinity and significant negative correlation with WD. Chlorophyll *a* showed significant positive correlation with alkalinity, salinity, pH, TDS, PP and VCZP and showed significant significant negative correlation with WD. Phaeopigment showed significant positive correlation with salinity, pH, TDS, chl. *a*, and VCZP. Phytoplankton density showed positive correlation TZ, TCA, TCN and VCWA. Total copepods nauplii showed significant positive correlation with alkalinity, PD, TZ, TCA and VCWA and *Vibrio cholerae* water analysis showed significant positive correlation with salinity, PD, TZ, TCA and TCN.

Table 94. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Matbaria Station 2 (n=24).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN	VCWA	VCZP
WD	1	.197	-.744(**)	-.370	-.430(*)	-.269	-.200	-.337	-.025	-.191	-.184	-.208	-.443(*)	-.464(*)	-.489(*)	-.182	-.093
WT	.197	1	-.168	.384	.199	.393	.102	-.071	.055	-.138	.251	-.545(**)	-.575(**)	-.044	-.177	.201	.207
ALK	-.744(**)	-.168	1	.590(**)	.504(*)	.487(*)	.271	.537(**)	.255	.251	.303	.261	.523(**)	.616(**)	.697(**)	.251	.137
SAL	-.370	.384	.590(**)	1	.537(**)	.931(**)	.317	.373	.321	.463(*)	.584(**)	-.046	.126	.464(*)	.591(**)	.582(**)	.543(**)
pH	-.430(*)	.199	.504(*)	.537(**)	1	.540(**)	.099	.109	.191	.312	.382	.276	.329	.338	.508(*)	.194	.124
TDS	-.269	.393	.487(*)	.931(**)	.540(**)	1	.399	.331	.463(*)	.550(**)	.774(**)	-.105	.057	.494(*)	.594(**)	.629(**)	.582(**)
SRP	-.200	.102	.271	.317	.099	.399	1	.012	.330	.150	.222	-.035	.151	.550(**)	.515(*)	.022	.007
SRS	-.337	-.071	.537(**)	.373	.109	.331	.012	1	.308	-.089	.095	-.120	.066	.134	.224	.360	.257
NN	-.025	.055	.255	.321	.191	.463(*)	.330	.308	1	.225	.499(*)	.170	.279	.421(*)	.512(*)	.230	.128
CHL. *a*	-.191	-.138	.251	.463(*)	.312	.550(**)	.150	-.089	.225	1	.651(**)	.393	.431(*)	.389	.565(**)	.279	.279
PP	-.184	.251	.303	.584(**)	.382	.774(**)	.222	.095	.499(*)	.651(**)	1	-.079	.063	.467(*)	.484(*)	.533(**)	.514(*)
PD	-.208	-.545(**)	.261	-.046	.276	-.105	-.035	-.120	.170	.393	-.079	1	.848(**)	.171	.500(*)	-.051	-.067
TZ	-.443(*)	-.575(**)	.523(**)	.126	.329	.057	.151	.066	.279	.431(*)	.063	.848(**)	1	.554(**)	.776(**)	-.040	-.073
TCA	-.464(*)	-.044	.616(**)	.464(*)	.338	.494(*)	.550(**)	.134	.421(*)	.389	.467(*)	.171	.554(**)	1	.855(**)	.090	.067
TCN	-.489(*)	-.177	.697(**)	.591(**)	.508(*)	.594(**)	.515(*)	.224	.512(*)	.565(**)	.484(*)	.500(*)	.776(**)	.855(**)	1	.219	.161
VCWA	-.182	.201	.251	.582(**)	.194	.629(**)	.022	.360	.230	.279	.533(**)	-.051	-.040	.090	.219	1	.970(**)
VCZP	-.093	.207	.137	.543(**)	.124	.582(**)	.007	.257	.128	.279	.514(*)	-.067	-.073	.067	.161	.970(**)	1

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 95. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Matbaria Station 4 (n=19).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN
WD	1	-.075	-.251	-.398	-.211	-.299	-.121	-.353	.120	-.483(*)	-.396	.166	-.492(*)	-.018	-.250
WT	-.075	1	.022	.453	-.461(*)	.552(*)	.330	.646(**)	.322	.197	.170	.225	.108	.337	.439
ALK	-.251	.022	1	.116	.528(*)	-.022	-.234	.287	.091	.288	.246	-.355	.541(*)	.209	.178
SAL	-.398	.453	.116	1	-.083	.902(**)	-.060	.608(**)	.339	.369	.467(*)	-.335	.405	.075	.184
pH	-.211	-.461(*)	.528(*)	-.083	1	-.322	-.242	-.220	-.360	.325	.207	-.108	.269	-.300	-.399
TDS	-.299	.552(*)	-.022	.902(**)	-.322	1	.168	.594(**)	.420	.304	.469(*)	-.227	.424	.115	.287
SRP	-.121	.330	-.234	-.060	-.242	.168	1	-.136	.095	.062	.041	.337	-.036	-.078	.091
SRS	-.353	.646(**)	.287	.608(**)	-.220	.594(**)	-.136	1	.385	.377	.408	-.227	.400	.143	.304
NN	.120	.322	.091	.339	-.360	.420	.095	.385	1	.048	.205	-.341	.278	.614(**)	.529(*)
Chl. *a*	-.483(*)	.197	.288	.369	.325	.304	.062	.377	.048	1	.942(**)	.040	.599(**)	-.108	-.097
PP	-.396	.170	.246	.467(*)	.207	.469(*)	.041	.408	.205	.942(**)	1	-.062	.631(**)	-.047	-.015
PD	.166	.225	-.355	-.335	-.108	-.227	.337	-.227	-.341	.040	-.062	1	-.309	-.182	-.161
TZ	-.492(*)	.108	.541(*)	.405	.269	.424	-.036	.400	.278	.599(**)	.631(**)	-.309	1	.136	.170
TCA	-.018	.337	.209	.075	-.300	.115	-.078	.143	.614(**)	-.108	-.047	-.182	.136	1	.895(**)
TCN	-.250	.439	.178	.184	-.399	.287	.091	.304	.529(*)	-.097	-.015	-.161	.170	.895(**)	1
VCWA	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 96. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Matbaria Station 5 (n=24).

	WD	WT	ALK	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN	VCWA
WD	1	-.232	-.537(**)	.364	-.012	-.224	-.350	.144	.133	-.298	-.157	-.405(*)	-.230	-.201	-.088
WT	-.232	1	.338	-.595(**)	.396	-.090	.469(*)	-.121	-.040	.139	.021	.292	.047	.226	.212
ALK	-.537(**)	.338	1	-.181	.069	.072	.181	-.192	-.103	.039	.236	.781(**)	.170	.117	-.014
SAL	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
pH	.364	-.595(**)	-.181	1	-.506(*)	-.307	-.331	-.377	-.237	-.209	-.040	-.143	-.154	.018	-.189
TDS	-.012	.396	.069	-.506(*)	1	.168	-.052	-.007	-.012	.054	-.112	.042	-.031	-.156	.084
SRP	-.224	-.090	.072	-.307	.168	1	.074	.062	-.167	-.072	-.053	.054	.221	.110	.044
SRS	-.350	.469(*)	.181	-.331	-.052	.074	1	.030	-.060	.170	-.025	-.035	-.053	.152	.249
NN	.144	-.121	-.192	-.377	-.007	.062	.030	1	.841(**)	.190	-.164	-.152	-.104	-.268	-.070
Chl. *a*	.133	-.040	-.103	-.237	-.012	-.167	-.060	.841(**)	1	.441(*)	-.118	-.144	-.084	-.145	.029
PP	-.298	.139	.039	-.209	.054	-.072	.170	.190	.441(*)	1	.153	-.134	.117	.033	.325
PD	-.157	.021	.236	-.040	-.112	-.053	-.025	-.164	-.118	.153	1	.184	.579(**)	.361	.285
TZ	-.405(*)	.292	.781(**)	-.143	.042	.054	-.035	-.152	-.144	-.134	.184	1	.199	.232	.057
TCA	-.230	.047	.170	-.154	-.031	.221	-.053	-.104	-.084	.117	.579(**)	.199	1	.724(**)	.277
TCN	-.201	.226	.117	.018	-.156	.110	.152	-.268	-.145	.033	.361	.232	.724(**)	1	.299
VCWA	-.088	.212	-.014	-.189	.084	.044	.249	-.070	.029	.325	.285	.057	.277	.299	1
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 97. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Matbaria Station 7 (n=24).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN	VCWA	VCZP
WD	1	.227	-.538(**)	-.059	-.431(*)	.091	.548(**)	-.250	.165	-.039	.172	-.341	-.707(**)	-.158	-.120	-.203	.079
WT	.227	1	-.159	.360	-.029	.376	.137	.261	-.205	-.111	.014	-.065	.068	.051	.402	.149	.225
ALK	-.538(**)	-.159	1	.588(**)	.640(**)	.514(*)	-.272	.438(*)	.159	.059	.129	.306	.505(*)	.223	.061	.095	-.063
SAL	-.059	.360	.588(**)	1	.423(*)	.957(**)	.095	.299	.105	-.209	.002	.050	.086	.165	.264	.187	-.156
pH	-.431(*)	-.029	.640(**)	.423(*)	1	.413(*)	-.230	.090	.053	.140	.328	.217	.462(*)	.075	.096	-.267	.011
TDS	.091	.376	.514(*)	.957(**)	.413(*)	1	.180	.270	.210	-.150	.156	.063	.009	.180	.277	.055	-.086
SRP	.548(**)	.137	-.272	.095	-.230	.180	1	-.087	.072	-.238	.060	-.131	-.242	-.185	.182	-.118	.110
SRS	-.250	.261	.438(*)	.299	.090	.270	-.087	1	.140	-.103	-.125	.103	.300	.020	.167	.125	-.021
NN	.165	-.205	.159	.105	.053	.210	.072	.140	1	-.353	-.014	.057	-.120	.296	.119	-.055	-.160
CHL. *a*	-.039	-.111	.059	-.209	.140	-.150	-.238	-.103	-.353	1	.563(**)	.102	.167	-.053	-.190	-.181	.173
PP	.172	.014	.129	.002	.328	.156	.060	-.125	-.014	.563(**)	1	.182	.047	.143	-.081	-.195	.678(**)
PD	-.341	-.065	.306	.050	.217	.063	-.131	.103	.057	.102	.182	1	.088	-.067	-.091	.050	.269
TZ	-.707(**)	.068	.505(*)	.086	.462(*)	.009	-.242	.300	-.120	.167	.047	.088	1	.400	.560(**)	.199	.041
TCA	-.158	.051	.223	.165	.075	.180	-.185	.020	.296	-.053	.143	-.067	.400	1	.591(**)	.279	-.085
TCN	-.120	.402	.061	.264	.096	.277	.182	.167	.119	-.190	-.081	-.091	.560(**)	.591(**)	1	.247	.003
VCWA	-.203	.149	.095	.187	-.267	.055	-.118	.125	-.055	-.181	-.195	.050	.199	.279	.247	1	-.044
VCZP	.079	.225	-.063	-.156	.011	-.086	.110	-.021	-.160	.173	.678(**)	.269	.041	-.085	.003	-.044	1

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 98. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Matbaria Station 8 (n=24)

	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN	VCWA	VCZP
WD	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
WT	1	-.335	.142	-.186	.255	.275	-.195	-.144	-.006	.266	-.125	.347	.247	.390	.136	.201
ALK	-.335	1	.492(*)	.511(*)	.346	-.497(*)	.586(**)	.227	-.118	-.173	.380	-.678(**)	-.139	-.691(**)	.238	.040
SAL	.142	.492(*)	1	.419(*)	.906(**)	-.125	.027	.204	.201	.497(*)	.390	-.084	.139	-.073	.281	-.153
pH	-.186	.511(*)	.419(*)	1	.411(*)	-.072	.254	.244	-.087	-.032	.448(*)	-.334	-.124	-.306	.235	-.032
TDS	.255	.346	.906(**)	.411(*)	1	-.019	-.044	.261	.349	.607(**)	.273	-.021	.192	.007	.170	-.071
SRP	.275	-.497(*)	-.125	-.072	-.019	1	-.495(*)	-.274	-.053	.147	-.185	.091	-.129	.138	-.084	.141
SRS	-.195	.586(**)	.027	.254	-.044	-.495(*)	1	.041	-.447(*)	-.437(*)	.309	-.341	-.043	-.359	.097	.080
NN	-.144	.227	.204	.244	.261	-.274	.041	1	.259	.163	-.014	-.086	.243	-.046	-.163	-.107
CHL. *a*	-.006	-.118	.201	-.087	.349	-.053	-.447(*)	.259	1	.448(*)	.111	.098	-.150	.163	-.066	-.005
PP	.266	-.173	.497(*)	-.032	.607(**)	.147	-.437(*)	.163	.448(*)	1	-.194	.408	.064	.432(*)	-.157	.026
PD	-.125	.380	.390	.448(*)	.273	-.185	.309	-.014	.111	-.194	1	-.093	-.078	-.118	.439(*)	-.083
TZ	.347	-.678(**)	-.084	-.334	-.021	.091	-.341	-.086	.098	.408	-.093	1	.490(*)	.966(**)	-.061	-.119
TCA	.247	-.139	.139	-.124	.192	-.129	-.043	.243	-.150	.064	-.078	.490(*)	1	.378	-.038	-.119
TCN	.390	-.691(**)	-.073	-.306	.007	.138	-.359	-.046	.163	.432(*)	-.118	.966(**)	.378	1	-.057	-.173
VCWA	.136	.238	.281	.235	.170	-.084	.097	-.163	-.066	-.157	.439(*)	-.061	-.038	-.057	1	-.013
VCZP	.201	.040	-.153	-.032	-.071	.141	.080	-.107	-.005	.026	-.083	-.119	-.119	-.173	-.013	1

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 99. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Matbaria Station 9 (n=24).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN
WD	1	.074	-.611(**)	-.276	-.284	-.289	.367	-.232	-.284	-.375	-.530(**)	.035	-.094	-.319	-.129
WT	.074	1	.361	.528(**)	.358	.590(**)	.046	.412	-.037	.189	.267	.257	.061	.068	.108
ALK	-.611(**)	.361	1	.537(**)	.456(*)	.537(**)	-.365	.662(**)	.336	.196	.356	.377	.251	.275	.158
SAL	-.276	.528(**)	.537(**)	1	.144	.602(**)	-.061	.130	.235	.492(*)	.664(**)	.317	.174	.186	.103
pH	-.284	.358	.456(*)	.144	1	.529(**)	-.449(*)	.454(*)	.180	.163	.280	.021	-.191	-.140	-.116
TDS	-.289	.590(**)	.537(**)	.602(**)	.529(**)	1	-.127	.120	.302	.590(**)	.723(**)	.045	-.002	.149	.046
SRP	.367	.046	-.365	-.061	-.449(*)	-.127	1	-.322	-.404	-.141	-.190	-.055	.060	-.064	-.096
SRS	-.232	.412	.662(**)	.130	.454(*)	.120	-.322	1	.041	-.277	-.109	.175	.067	-.047	.040
NN	-.284	-.037	.336	.235	.180	.302	-.404	.041	1	.601(**)	.472(*)	.085	.361	.292	.427(*)
CHL. *a*	-.375	.189	.196	.492(*)	.163	.590(**)	-.141	-.277	.601(**)	1	.792(**)	-.073	.317	.368	.437(*)
PP	-.530(**)	.267	.356	.664(**)	.280	.723(**)	-.190	-.109	.472(*)	.792(**)	1	-.150	-.103	.041	-.001
PD	.035	.257	.377	.317	.021	.045	-.055	.175	.085	-.073	-.150	1	.381	.184	.112
TZ	-.094	.061	.251	.174	-.191	-.002	.060	.067	.361	.317	-.103	.381	1	.773(**)	.867(**)
TCA	-.319	.068	.275	.186	-.140	.149	-.064	-.047	.292	.368	.041	.184	.773(**)	1	.693(**)
TCN	-.129	.108	.158	.103	-.116	.046	-.096	.040	.427(*)	.437(*)	-.001	.112	.867(**)	.693(**)	1
VCWA	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 100. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Matbaria Station 10 (n=23).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN	VCWA	VCZP
WD	1	.266	-.812(**)	-.272	-.313	-.203	.175	-.628(**)	-.070	-.428(*)	-.218	.121	-.277	-.180	-.275	-.257	-.201
WT	.266	1	-.229	.432(*)	.255	.407	.072	-.326	.111	.410	.335	.082	-.017	.053	.087	.205	.182
ALK	-.812(**)	-.229	1	.412	.304	.331	-.251	.833(**)	.217	.442(*)	.354	.247	.375	.280	.426(*)	.385	.305
SAL	-.272	.432(*)	.412	1	.348	.942(**)	-.135	.216	.296	.722(**)	.705(**)	.116	.226	.245	.385	.535(**)	.399
pH	-.313	.255	.304	.348	1	.310	.310	.027	.038	.501(*)	.535(**)	.150	.252	.271	.321	.346	.379
TDS	-.203	.407	.331	.942(**)	.310	1	-.083	.095	.346	.682(**)	.751(**)	-.099	-.006	.061	.179	.317	.286
SRP	.175	.072	-.251	-.135	.310	-.083	1	-.254	.167	.029	.299	-.143	-.126	-.134	-.137	-.088	-.065
SRS	-.628(**)	-.326	.833(**)	.216	.027	.095	-.254	1	.381	.255	.118	.351	.397	.260	.366	.277	.119
NN	-.070	.111	.217	.296	.038	.346	.167	.381	1	.055	.242	-.123	.024	.080	.109	.109	-.090
CHL. *a*	-.428(*)	.410	.442(*)	.722(**)	.501(*)	.682(**)	.029	.255	.055	1	.802(**)	.175	.214	.166	.303	.397	.477(*)
PP	-.218	.335	.354	.705(**)	.535(**)	.751(**)	.299	.118	.242	.802(**)	1	.130	.060	.088	.169	.310	.414(*)
PD	.121	.082	.247	.116	.150	-.099	-.143	.351	-.123	.175	.130	1	.577(**)	.509(*)	.543(**)	.531(**)	.296
TZ	-.277	-.017	.375	.226	.252	-.006	-.126	.397	.024	.214	.060	.577(**)	1	.948(**)	.958(**)	.851(**)	.085
TCA	-.180	.053	.280	.245	.271	.061	-.134	.260	.080	.166	.088	.509(*)	.948(**)	1	.935(**)	.826(**)	-.045
TCN	-.275	.087	.426(*)	.385	.321	.179	-.137	.366	.109	.303	.169	.543(**)	.958(**)	.935(**)	1	.919(**)	.141
VCWA	-.257	.205	.385	.535(**)	.346	.317	-.088	.277	.109	.397	.310	.531(**)	.851(**)	.826(**)	.919(**)	1	.297
VCZP	-.201	.182	.305	.399	.379	.286	-.065	.119	-.090	.477(*)	.414(*)	.296	.085	-.045	.141	.297	1

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (μg/l) CHL. *a*= Chlorophyll-*a* (μg/l), PP=Phaeopigment (μg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 101. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Matbaria Station 11 (n=19).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN	VCWA	VCZP
WD	1	-.634	-.672	-.506	-.493	-.300	-.653	-.048	-.200	-.352	.657	-.621	.171	.447	-.221	-.381	-.624
WT	-.634	1	.541	.235	.345	-.393	.307	.057	.177	.517	.016	.578	-.731	-.887(*)	-.429	.464	.513
ALK	-.672	.541	1	.903(*)	.942(**)	.084	.761	.134	.487	.014	-.141	.901(*)	-.036	-.610	.321	.522	.906(*)
SAL	-.506	.235	.903(*)	1	.986(**)	.311	.900(*)	-.159	.700	-.129	-.109	.751	.079	-.458	.368	.194	.783
pH	-.493	.345	.942(**)	.986(**)	1	.174	.852(*)	-.094	.679	-.098	-.011	.806	-.006	-.561	.292	.286	.826(*)
TDS	-.300	-.393	.084	.311	.174	1	.470	-.435	.425	.251	-.776	.188	.340	.362	.373	-.520	-.171
SRP	-.653	.307	.761	.900(*)	.852(*)	.470	1	-.457	.788	.105	-.291	.625	-.144	-.508	.166	-.060	.622
SRS	-.048	.057	.134	-.159	-.094	-.435	-.457	1	-.760	-.404	.009	.074	.493	.240	.534	.863(*)	.341
NN	-.200	.177	.487	.700	.679	.425	.788	-.760	1	.334	.004	.532	-.378	-.526	-.255	-.462	.197
CHL. *a*	-.352	.517	.014	-.129	-.098	.251	.105	-.404	.334	1	-.395	.363	-.667	-.404	-.597	-.305	-.292
PP	.657	.016	-.141	-.109	-.011	-.776	-.291	.009	.004	-.395	1	-.258	-.264	-.275	-.418	.062	.009
PD	-.621	.578	.901(*)	.751	.806	.188	.625	.074	.532	.363	-.258	1	-.154	-.597	.146	.383	.659
TZ	.171	-.731	-.036	.079	-.006	.340	-.144	.493	-.378	-.667	-.264	-.154	1	.795	.911(*)	.188	.058
TCA	.447	-.887(*)	-.610	-.458	-.561	.362	-.508	.240	-.526	-.404	-.275	-.597	.795	1	.528	-.235	-.535
TCN	-.221	-.429	.321	.368	.292	.373	.166	.534	-.255	-.597	-.418	.146	.911(*)	.528	1	.410	.415
VCWA	-.381	.464	.522	.194	.286	-.520	-.060	.863(*)	-.462	-.305	.062	.383	.188	-.235	.410	1	.723
VCZP	-.624	.513	.906(*)	.783	.826(*)	-.171	.622	.341	.197	-.292	.009	.659	.058	-.535	.415	.723	1

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed

Study site of Chhatak

Station 1

Water depth (WD) showed significant positive correlation with WT and NN and significant negative correlation with alkalinity, salinity, pH, TDS, SRP, SRS and TCN. Water temperature (WT) showed significant positive correlation with WD and significant negative correlation with alkalinity, salinity and TDS. Alkalinity showed significant positive correlation with salinity, pH and SRS and significant negative correlation with WD, WT and NN. Salinity showed significant positive correlation with alkalinity, TDS and SRS and showed significant negative correlation with WD, WT and NN. pH showed significant positive correlation with alkalinity, SRP, TCA and TCN and significant negative correlation with water depth. TDS showed significant positive correlation with alkalinity, salinity and SRS and significant negative correlation with WD, WT, NN, and chl. *a*. SRP showed significant positive correlation with pH and TCN but significant negative correlation with water depth. SRS showed significant positive correlation with alkalinity, salinity and TDS and significant negative correlation with WD and NN. Nitrate nitrogen showed significant positive correlation with WD and significant negative correlation with alkalinity, salinity, TDS and SRS. Chlorophyll *a* showed positive correlation with alkalinity, pH, NN, PP and PD. Phaeopigment (PP) showed significant positive correlation with TZ. Total zooplankton (TZ) showed significant positive correlation with PP. Total copepods nauplii (TCN) showed significant positive correlation with pH and SRP and significant negative correlation with water depth.

Station 2

Water temperature (WT) showed significant positive correlation with SRP and significant negative correlation with alkalinity, pH, TDS and PD. Alkalinity showed significant positive correlation with pH and TDS and significant negative correlation with WT. Salinity showed highly significant positive correlation with VCWA. pH showed significant positive correlation with alkalinity and PD and significant negative correlation with WT. TDS showed significant positive correlation with alkalinity, NN, TZ and TCN and significant negative correlation with WT. SRP showed significant positive correlation with WT and significant negative correlation with TDS and TCN. SRS showed positive correlation with WT, salinity, SRP and VCWA and significant negative correlation with chl. *a*, PP, PD and TCN. Nitrate nitrogen (NN) showed significant positive correlation with TDS. Chlorophyll *a* (chl. *a*) showed significant positive correlation with PP and PD and significant negative correlation with SRS. Phaeopigment (PP) showed significant positive correlation with alkalinity, chl. *a*, PD and TCN and showed significant negative correlation with SRS. Phytoplankton density (PD) showed significant positive correlation with pH, chl. *a*, PP and TCN and significant negative correlation with WT and SRS. Total zooplankton (TZ) showed significant positive correlation with TDS, TCA and TCN. Total copepods adult (TCA) showed significant positive correlation with TZ and TCN. Total copepods nauplii (TCN) showed significant positive correlation with TDS, PP, PD, TZ and TCA and significant negative correlation with SRP and SRS.

Station 4

Water depth (WD) showed positive correlation with water temperature (WT) and showed significant negative correlation with alkalinity, salinity, pH, TDS and SRS. Water temperature (WT) showed positive correlation with NN and significant negative correlation with alkalinity, salinity, TDS and PP. Alkalinity showed significant positive correlation with salinity, TDS, SRS, PP and PD and significant negative correlation with WD, WT and NN. Salinity showed significant positive correlation with alkalinity, TDS, SRS and PD and significant negative correlation with WD, WT and NN. TDS showed significant positive correlation with alkalinity, salinity, SRS and PD and significant negative correlation with WD and WT. SRP showed significant positive correlation with PP and PD. SRS showed significant positive correlation with alkalinity, salinity, TDS and PD and significant negative correlation with WD. Nitrate nitrogen (NN) showed significant positive correlation with WT and significant negative correlation with alkalinity and salinity. Chlorophyll *a* (chl. *a*) showed significant positive correlation with PP. Phaeopigment (PP) showed significant positive correlation with alkalinity, SRP and chl. *a* and significant negative correlation with WT. Phytoplankton density (PD) showed significant positive correlation with alkalinity, salinity, TDS, SRP and SRS. Total copepods adult (TCA) showed significant positive correlation with TCN.

Station 9

Water depth (WD) showed significant positive correlation with WT and SRP and significant positive correlation with alkalinity, salinity, pH, TDS and TCA. Water temperature (WT) showed significant positive correlation with WD and SRP and significant negative correlation with alkalinity, salinity, pH, TDS and TCA. Alkalinity showed significant positive correlation with pH and significant negative correlation with WD, WT and NN. Salinity showed significant positive correlation with TDS and TCN and significant negative correlation with WD and WT. TDS showed significant positive correlation with salinity and significant negative correlation with WD, WT and SRP. Chlorophyll *a* (chl. *a*) showed significant positive correlation with PP. Total zooplankton (TZ) showed significant positive correlation with TCN. Total copepods adult (TCA) showed significant positive correlation with TCN and significant negative correlation with WD. Total copepods nauplii (TCN) showed significant positive correlation with salinity and significant negative correlation with TZ and TCA.

Station 10

Water temperature (WT) showed significant positive correlation with salinity and significant negative correlation with pH and PD. Alkalinity showed significant positive correlation with salinity, TDS and SRP. Salinity showed significant positive correlation with alkalinity and TDS. pH showed significant positive correlation with PP and PD and significant negative correlation with WT. TDS showed significant positive correlation with alkalinity and salinity. Chlorophyll *a* (chl. *a*) showed significant positive correlation with PP and PD. Phaeopigment (PP) showed significant positive correlation with pH, chl. *a* and PD. Phytoplankton density (PD) showed positive correlation with pH, chl. *a* and PP and significant negative correlation with WT. Total zooplankton (TZ) showed significant positive correlation with TCA and TCN.

Station 11

Water depth (WD) showed positive correlation with WT and significant negative correlation with alkalinity, salinity, TDS, SRS and PP. Water temperature (WT) showed positive correlation with WD and significant negative correlation with salinity, TCA and TCN.

Alkalinity showed significant positive correlation with salinity, TDS, SRS, chl. *a*, PP and TCN and significant negative correlation with WD. Salinity showed significant positive correlation with alkalinity, TDS and SRS and significant negative correlation with WD and WT. TDS showed significant positive correlation with alkalinity, salinity and SRS and significant negative correlation with WD. SRP showed significant positive correlation with NN. Chlorophyll *a* (Chl. *a*) showed significant positive correlation with alkalinity, PP and TZ. Phaeopigment (PP) showed significant positive correlation with alkalinity, pH and chl. *a*, and significant negative correlation with WD. Total zooplankton (TZ) showed significant positive correlation with chl. *a*, TCA and TCN. Total copepod adult (TCA) showed significant positive correlation with TZ and TCN and significant negative correlation with WT.

Station 12

Water depth (WD) showed significant positive correlation with WT and significant negative correlation with alkalinity, salinity, TDS and SRS. Water temperature (WT) showed significant positive correlation with WD and significant negative correlation with alkalinity, salinity, pH, TDS, SRS and PD. Alkalinity showed significant positive correlation with salinity, pH, TDS, SRS, PD and TCA and significant negative correlation with WD and WT. Salinity showed significant positive correlation with alkalinity, pH, TDS, SRS and PD and significant negative correlation with WD and WT. pH showed significant positive correlation with alkalinity, salinity, TDS, SRS, PD and TCA and significant negative correlation with WT. SRS showed significant positive correlation with alkalinity, salinity, pH, and TDS and significant negative correlation with WD and WT. Chlorophyll *a* (Chl. *a*) showed positive correlation with PP. Phytoplankton density (PD) showed significant positive correlation with alkalinity, salinity, pH, TDS and SRS and significant negative correlation with WT. Total zooplankton (TZ) showed significant positive correlation with TCA and TCN. Total copepods nauplii (TCN) showed significant positive correlation with alkalinity, TZ and TCA.

Table 102. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Chhatak Station 1 (n=24).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN
WD	1	.489(*)	-.772(**)	-.703(**)	-.585(**)	-.684(**)	-.500(*)	-.549(**)	.434(*)	-.078	.220	.088	.104	-.119	-.454(*)
WT	.489(*)	1	-.556(**)	-.568(**)	.061	-.490(*)	.110	-.370	.394	-.080	-.080	-.232	-.334	.211	.035
ALK	-.772(**)	-.556(**)	1	.602(**)	.444(*)	.646(**)	.384	.554(**)	-.606(**)	.143	-.065	-.024	.270	.135	.403
SAL	-.703(**)	-.568(**)	.602(**)	1	.125	.925(**)	.124	.614(**)	-.550(**)	-.356	-.318	-.116	-.028	.023	.337
pH	-.585(**)	.061	.444(*)	.125	1	.198	.449(*)	.199	.026	.192	-.126	.078	-.050	.424(*)	.448(*)
TDS	-.684(**)	-.490(*)	.646(**)	.925(**)	.198	1	.257	.654(**)	-.527(**)	-.415(*)	-.350	-.208	-.034	.053	.375
SRP	-.500(*)	.110	.384	.124	.449(*)	.257	1	.105	-.161	-.087	.055	.017	.077	-.125	.498(*)
SRS	-.549(**)	-.370	.554(**)	.614(**)	.199	.654(**)	.105	1	-.448(*)	-.187	-.334	-.194	-.167	.046	.348
NN	.434(*)	.394	-.606(**)	-.550(**)	.026	-.527(**)	-.161	-.448(*)	1	.028	-.130	.372	-.265	.326	-.199
CHL. *a*	-.078	-.080	.143	-.356	.192	-.415(*)	-.087	-.187	.028	1	.141	.124	-.038	-.125	-.182
PP	.220	-.080	-.065	-.318	-.126	-.350	.055	-.334	-.130	.141	1	-.087	.605(**)	-.102	-.183
PD	.088	-.232	-.024	-.116	.078	-.208	.017	-.194	.372	.124	-.087	1	.248	-.125	-.047
TZ	.104	-.334	.270	-.028	-.050	-.034	.077	-.167	-.265	-.038	.605(**)	.248	1	.005	-.054
TCA	-.119	.211	.135	.023	.424(*)	.053	-.125	.046	.326	-.125	-.102	-.125	.005	1	.229
TCN	-.454(*)	.035	.403	.337	.448(*)	.375	.498(*)	.348	-.199	-.182	-.183	-.047	-.054	.229	1
VCWA	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/L), PP= Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./L), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 103. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Chhatak Station 2 (n=24).

	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN	VCWA
WD	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
WT	1	.019	-.453(*)	-.517(**)	-.747(**)	.428(*)	.388	-.292	-.323	-.371	-.591(**)	-.360	-.225	-.394	.019
ALK	-.453(*)	.282	1	.529(**)	.520(**)	-.206	-.177	.224	.340	.436(*)	.386	.135	.121	.362	.282
SAL	.019	1	.282	.207	.095	.270	.241	.205	.332	.104	.121	-.076	-.085	-.092	1.000(**)
pH	-.517(**)	.207	.529(**)	1	.293	.045	.013	.039	.400	.318	.419(*)	-.124	-.233	.019	.207
TDS	-.747(**)	.095	.520(**)	.293	1	-.483(*)	-.259	.456(*)	.117	.296	.373	.474(*)	.352	.521(*)	.095
SRP	.428(*)	.270	-.206	.045	-.483(*)	1	.400	-.056	.001	-.223	-.227	-.207	-.212	-.462(*)	.270
SRS	.388	.241	-.177	.013	-.259	.400	1	.007	-.518(**)	-.631(**)	-.685(**)	-.363	-.412	-.607(**)	.241
NN	-.292	.205	.224	.039	.456(*)	-.056	.007	1	.043	-.071	-.044	.267	.270	-.045	.205
CHL. *a*	-.323	.332	.340	.400	.117	.001	-.518(**)	.043	1	.770(**)	.856(**)	.143	.202	.318	.332
PP	-.371	.104	.436(*)	.318	.296	-.223	-.631(**)	-.071	.770(**)	1	.841(**)	.273	.280	.645(**)	.104
PD	-.591(**)	.121	.386	.419(*)	.373	-.227	-.685(**)	-.044	.856(**)	.841(**)	1	.278	.259	.558(**)	.121
TZ	-.360	-.076	.135	-.124	.474(*)	-.207	-.363	.267	.143	.273	.278	1	.931(**)	.723(**)	-.076
TCA	-.225	-.085	.121	-.233	.352	-.212	-.412	.270	.202	.280	.259	.931(**)	1	.723(**)	-.085
TCN	-.394	-.092	.362	.019	.521(*)	-.462(*)	-.607(**)	-.045	.318	.645(**)	.558(**)	.723(**)	.723(**)	1	-.092
VCWA	.019	1.000(**)	.282	.207	.095	.270	.241	.205	.332	.104	.121	-.076	-.085	-.092	1
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL= Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (μg/l) CHL. *a*= Chlorophyll-*a* (μg/l), PP=Phaeopigment (μg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 104. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Chhatak Station 4 (n=24).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN
WD	1	.365	-.548(**)	-.521(**)	-.419(*)	-.523(**)	-.214	-.571(**)	.077	-.141	-.376	-.371	-.108	.019	.001
WT	.365	1	-.621(**)	-.736(**)	.120	-.586(**)	.122	-.348	.405(*)	-.091	-.436(*)	-.403	-.008	.346	.404
ALK	-.548(**)	-.621(**)	1	.867(**)	.134	.899(**)	.142	.491(*)	-.464(*)	.251	.411(*)	.496(*)	.284	-.149	-.215
SAL	-.521(**)	-.736(**)	.867(**)	1	.040	.951(**)	.030	.462(*)	-.405(*)	.060	.307	.460(*)	.082	-.342	-.402
pH	-.419(*)	.120	.134	.040	1	.104	.206	.113	.177	.136	.014	.049	.169	.350	.371
TDS	-.523(**)	-.586(**)	.899(**)	.951(**)	.104	1	.001	.457(*)	-.404	.116	.193	.458(*)	.203	-.244	-.302
SRP	-.214	.122	.142	.030	.206	.001	1	.045	-.138	.304	.438(*)	.430(*)	-.284	.189	.113
SRS	-.571(**)	-.348	.491(*)	.462(*)	.113	.457(*)	.045	1	-.314	-.174	.246	.453(*)	-.116	-.193	-.246
NN	.077	.405(*)	-.464(*)	-.405(*)	.177	-.404	-.138	-.314	1	-.200	-.384	-.293	.207	.143	.237
CHL. *a*	-.141	-.091	.251	.060	.136	.116	.304	-.174	-.200	1	.559(**)	-.049	.211	.393	.326
PP	-.376	-.436(*)	.411(*)	.307	.014	.193	.438(*)	.246	-.384	.559(**)	1	.309	.060	.133	.043
PD	-.371	-.403	.496(*)	.460(*)	.049	.458(*)	.430(*)	.453(*)	-.293	-.049	.309	1	-.129	-.226	-.291
TZ	-.108	-.008	.284	.082	.169	.203	-.284	-.116	.207	.211	.060	-.129	1	.069	.099
TCA	.019	.346	-.149	-.342	.350	-.244	.189	-.193	.143	.393	.133	-.226	.069	1	.979(**)
TCN	.001	.404	-.215	-.402	.371	-.302	.113	-.246	.237	.326	.043	-.291	.099	.979(**)	1
VCWA	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL= Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/L), PP= Phaeopigment (µg/L), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 105. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Chhatak Station 9 (n=24).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN
WD	1	.649(**)	-.662(**)	-.574(**)	-.602(**)	-.619(**)	.487(*)	-.199	.272	-.146	-.151	.363	.000	-.492(*)	-.305
WT	.649(**)	1	-.426(*)	-.538(**)	-.353	-.606(**)	.446(*)	.223	.393	.293	.130	.172	.359	-.146	.115
ALK	-.662(**)	-.426(*)	1	.388	.444(*)	.369	-.385	.138	-.471(*)	.101	.194	-.044	-.255	.204	.008
SAL	-.574(**)	-.538(**)	.388	1	.270	.746(**)	-.146	.170	-.210	-.072	.096	-.293	.244	.417	.451(*)
pH	-.602(**)	-.353	.444(*)	.270	1	.231	-.223	.260	-.166	.126	.006	.042	.031	.192	.298
TDS	-.619(**)	-.606(**)	.369	.746(**)	.231	1	-.412(*)	.040	-.138	-.029	.133	-.240	.119	.122	.181
SRP	.487(*)	.446(*)	-.385	-.146	-.223	-.412(*)	1	.019	.069	-.039	-.127	.171	.158	-.037	-.066
SRS	-.199	.223	.138	.170	.260	.040	.019	1	-.058	.296	.030	.048	.146	.223	.370
NN	.272	.393	-.471(*)	-.210	-.166	-.138	.069	-.058	1	.340	.060	.077	.295	-.123	.050
CHL. *a*	-.146	.293	.101	-.072	.126	-.029	-.039	.296	.340	1	.806(**)	.288	.165	-.083	.091
PP	-.151	.130	.194	.096	.006	.133	-.127	.030	.060	.806(**)	1	.367	.097	-.074	.138
PD	.363	.172	-.044	-.293	.042	-.240	.171	.048	.077	.288	.367	1	-.168	-.351	-.225
TZ	.000	.359	-.255	.244	.031	.119	.158	.146	.295	.165	.097	-.168	1	.343	.746(**)
TCA	-.492(*)	-.146	.204	.417	.192	.122	-.037	.223	-.123	-.083	-.074	-.351	.343	1	.686(**)
TCN	-.305	.115	.008	.451(*)	.298	.181	-.066	.370	.050	.091	.138	-.225	.746(**)	.686(**)	1
VCWA	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL= Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./L), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./L) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 106. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Chhatak Station 10 (n=24).

	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN
WD	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
WT	1	-.332	.145	-.462(*)	-.409	.064	-.092	-.105	-.109	-.383	-.434(*)	-.328	-.365	-.239
ALK	-.332	1	.501(*)	-.075	.822(**)	.516(**)	-.112	-.178	.146	.100	.081	.149	.075	.264
SAL	.145	.501(*)	1	-.252	.791(**)	.332	-.034	-.189	-.101	-.140	-.141	-.124	-.082	-.021
pH	-.462(*)	-.075	-.252	1	-.026	-.244	-.136	.200	.367	.554(**)	.646(**)	.188	.046	.419
TDS	-.409	.822(**)	.791(**)	-.026	1	.320	-.129	.007	-.025	-.025	.207	.335	.276	.429
SRP	.064	.516(**)	.332	-.244	.320	1	-.008	-.386	-.014	.042	-.111	-.034	-.027	-.158
SRS	-.092	-.112	-.034	-.136	-.129	-.008	1	.176	-.256	-.299	-.508(*)	-.180	-.094	-.159
NN	-.105	-.178	-.189	.200	.007	-.386	.176	1	.112	.028	.149	.243	.113	.343
CHL. *a*	-.109	.146	-.101	.367	-.025	-.014	-.256	.112	1	.596(**)	.503(*)	.172	.044	.083
PP	-.383	.100	-.140	.554(**)	-.025	.042	-.299	.028	.596(**)	1	.767(**)	.105	.042	-.003
PD	-.434(*)	.081	-.141	.646(**)	.207	-.111	-.508(*)	.149	.503(*)	.767(**)	1	.351	.205	.416
TZ	-.328	.149	-.124	.188	.335	-.034	-.180	.243	.172	.105	.351	1	.930(**)	.478(*)
TCA	-.365	.075	-.082	.046	.276	-.027	-.094	.113	.044	.042	.205	.930(**)	1	.259
TCN	-.239	.264	-.021	.419	.429	-.158	-.159	.343	.083	-.003	.416	.478(*)	.259	1
VCWA	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

WD= Water Depth (m), WT = Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL= Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS=Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 107. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Chhatak Station 11 (n=24).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL.A	PP	PD	TZ	TCA	TCN
WD	1	.253	-.829(**)	-.690(**)	.062	-.817(**)	-.179	-.741(**)	.250	-.394	-.446(*)	.059	-.331	-.290	-.268
WT	.253	1	-.312	-.535(**)	-.087	-.339	.164	-.200	-.148	-.125	.043	-.404	.037	-.560(**)	-.477(*)
ALK	-.829(**)	-.312	1	.866(**)	.093	.955(**)	-.043	.849(**)	-.242	.488(*)	.419(*)	-.102	.408	.332	.449(*)
SAL	-.690(**)	-.535(**)	.866(**)	1	-.107	.927(**)	-.050	.758(**)	-.149	.338	.131	.108	.186	.335	.405
pH	.062	-.087	.093	-.107	1	-.042	-.305	.015	-.004	.303	.502(*)	.003	.137	.182	.196
TDS	-.817(**)	-.339	.955(**)	.927(**)	-.042	1	-.010	.890(**)	-.263	.369	.249	-.106	.221	.244	.342
SRP	-.179	.164	-.043	-.050	-.305	-.010	1	-.090	.542(**)	.073	-.027	.147	.030	-.150	-.253
SRS	-.741(**)	-.200	.849(**)	.758(**)	.015	.890(**)	-.090	1	-.374	.287	.259	-.238	.243	.249	.343
NN	.250	-.148	-.242	-.149	-.004	-.263	.542(**)	-.374	1	-.063	-.155	.324	-.078	.061	-.178
CHL. *a*	-.394	-.125	.488(*)	.338	.303	.369	.073	.287	-.063	1	.676(**)	.030	.462(*)	.389	.375
PP	-.446(*)	.043	.419(*)	.131	.502(*)	.249	-.027	.259	-.155	.676(**)	1	-.177	.326	.118	.103
PD	.059	-.404	-.102	.108	.003	-.106	.147	-.238	.324	.030	-.177	1	.093	.278	.368
TZ	-.331	.037	.408	.186	.137	.221	.030	.243	-.078	.462(*)	.326	.093	1	.557(**)	.577(**)
TCA	-.290	-.560(**)	.332	.335	.182	.244	-.150	.249	.061	.389	.118	.278	.557(**)	1	.681(**)
TCN	-.268	-.477(*)	.449(*)	.405	.196	.342	-.253	.343	-.178	.375	.103	.368	.577(**)	.681(**)	1
VCWA	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 108. Matrix of product moment correlation (r) among different physicochemical and biological variables recorded from Chhatak Station 12 (n=24).

	WD	WT	ALK	SAL	pH	TDS	SRP	SRS	NN	CHL. *a*	PP	PD	TZ	TCA	TCN	VCWA
WD	1	.632(**)	-.616(**)	-.688(**)	-.348	-.668(**)	.141	-.556(**)	.082	.036	.242	-.357	-.392	-.259	-.379	.076
WT	.632(**)	1	-.737(**)	-.808(**)	-.512(*)	-.730(**)	-.135	-.584(**)	.098	-.025	.080	-.552(**)	-.270	-.054	-.268	-.047
ALK	-.616(**)	-.737(**)	1	.930(**)	.756(**)	.967(**)	-.111	.881(**)	-.095	-.139	-.261	.685(**)	.372	.390	.435(*)	-.045
SAL	-.688(**)	-.808(**)	.930(**)	1	.624(**)	.961(**)	-.060	.809(**)	-.007	-.159	-.261	.676(**)	.287	.297	.280	-.050
pH	-.348	-.512(*)	.756(**)	.624(**)	1	.698(**)	-.061	.599(**)	.049	.037	.052	.486(*)	.361	.423(*)	.404	.094
TDS	-.668(**)	-.730(**)	.967(**)	.961(**)	.698(**)	1	-.123	.862(**)	-.004	-.172	-.315	.694(**)	.249	.294	.313	-.061
SRP	.141	-.135	-.111	-.060	-.061	-.123	1	-.128	.368	-.166	-.156	-.042	-.150	-.098	-.230	-.071
SRS	-.556(**)	-.584(**)	.881(**)	.809(**)	.599(**)	.862(**)	-.128	1	-.104	-.340	-.424(*)	.731(**)	.400	.346	.501(*)	-.031
NN	.082	.098	-.095	-.007	.049	-.004	.368	-.104	1	-.153	-.343	.101	-.370	-.103	-.288	.052
CHL. *a*	.036	-.025	-.139	-.159	.037	-.172	-.166	-.340	-.153	1	.610(**)	-.066	.217	.016	.016	-.057
PP	.242	.080	-.261	-.261	.052	-.315	-.156	-.424(*)	-.343	.610(**)	1	-.243	.157	-.159	-.107	-.004
PD	-.357	-.552(**)	.685(**)	.676(**)	.486(*)	.694(**)	-.042	.731(**)	.101	-.066	-.243	1	.273	-.027	.339	-.155
TZ	-.392	-.270	.372	.287	.361	.249	-.150	.400	-.370	.217	.157	.273	1	.510(*)	.837(**)	-.008
TCA	-.259	-.054	.390	.297	.423(*)	.294	-.098	.346	-.103	.016	-.159	-.027	.510(*)	1	.564(**)	-.104
TCN	-.379	-.268	.435(*)	.280	.404	.313	-.230	.501(*)	-.288	.016	-.107	.339	.837(**)	.564(**)	1	-.193
VCWA	.076	-.047	-.045	-.050	.094	-.061	-.071	-.031	.052	-.057	-.004	-.155	-.008	-.104	-.193	1
VCZP	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)

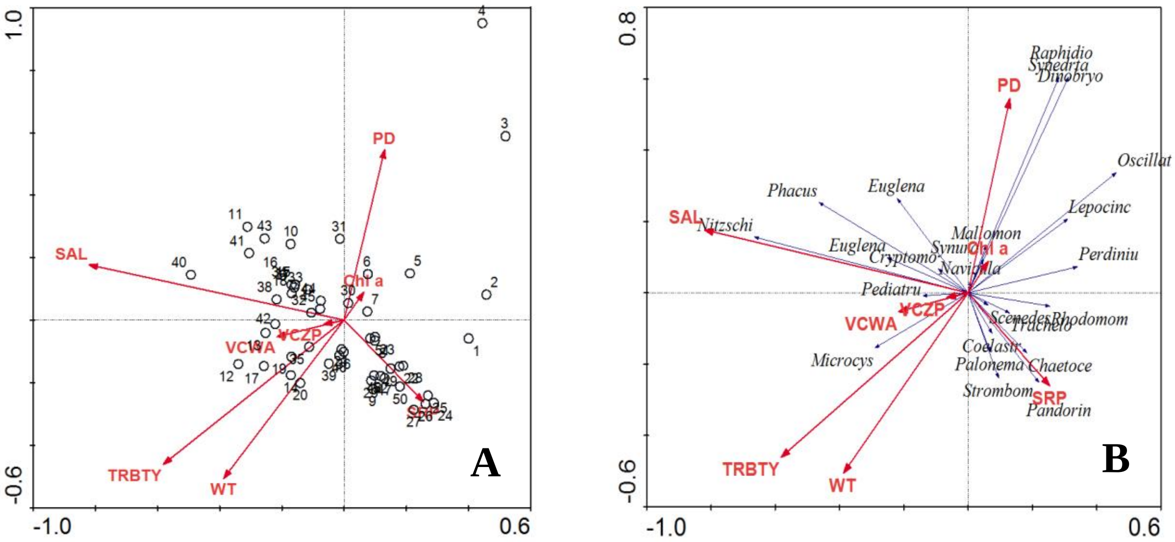
WD= Water Depth (m), WT= Water Temperature (˚C), ALK= Alkalinity (meq/l), SAL=Salinity(‰), TDS (mg/l), SRP= Soluble reactive Phosphate (mg/l), SRS= Soluble reactive silicate, NN= NO_3-N (µg/l) CHL. *a*= Chlorophyll-*a* (µg/l), PP=Phaeopigment (µg/l), PD= Phytoplankton density (× 10^3 ind./l), TZ= Total zooplankton (× 10^3 ind./l), TCA= Total copepods adult (× 10^3 ind./l), TCN= Total copepods nauplii (× 10^3 ind./l), VCWA= *Vibrio cholerae* in water analysis (× 10^3 ind./l) and VCZP= *Vibrio cholerae* in zooplankton analysis (× 10^3 ind./l)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Redundency analysis (RDA)

Mathbaria Station 2

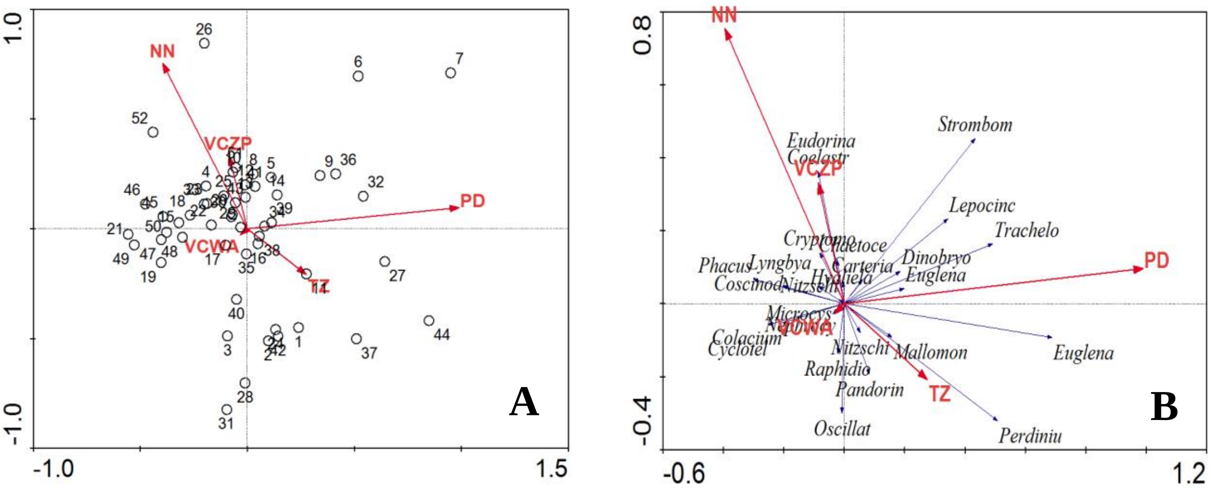
Eight of the 17 environmental variables were only used in RDA analysis according to the Monte Carlo test and the inflation factor (which had to be ≤20). The first two ordination axes explained 62.2% of the variance of the species-environment relation and 22.2% of the variance of species data (Fig. 73). Axis I (eigenvalue = 0.141) was mainly related to salinity (r = -0.6555) and turbidity (r=-0.4645), while axis II (eigenvalue = 0.081) was mainly related to water temperature (r = -0.3901), phytoplankton density (r=0.4208) (Fig. 73A). *Nitzschia* correlated positively with salinity where *Raphidiopsis*, *Synedra and Dinobryon* showed positive correlattion with phytoplankton density. *Pandorina* mainly influeced by SRP as it positively correlated (Fig. 73B).



Figs 73A-B. RDA ordination plot: **A.** Sampling periods & Environmental variables (WT= Water Temperature, PD= Phytoplankton density, SAL= Salinity, TRBTY= Turbidity, VCWA= *Vibrio cholerae* from water & VCZP=*Vibrio Choleare* from zooplankton). **B.** Phytoplankton species (Raphido= *Raphidiopsis*, Dinobryo= *Dinobryon*, Nitzschi= *Nitzschia*, Oscillat= *Oscillatoria*, Lipocinc= *Lipocinclis*, Mallomon= *Mallomonas*, Cryptomon= *Cryptomonas*, Peridiniu= *Peridinium*, Pediastru= *Pediastrum*, Scenedes= *Scenedesmus*, Coelastr= *Coelastrum*, Trachelo= *Trachelomonas*, Microcys= *Microcystis*, Strombom= *Strombomonas*, Chaetoce= *Chaetoceros*, Pandorin= *Pandorina*) and Environmental variables.

Mathbaria Station 7

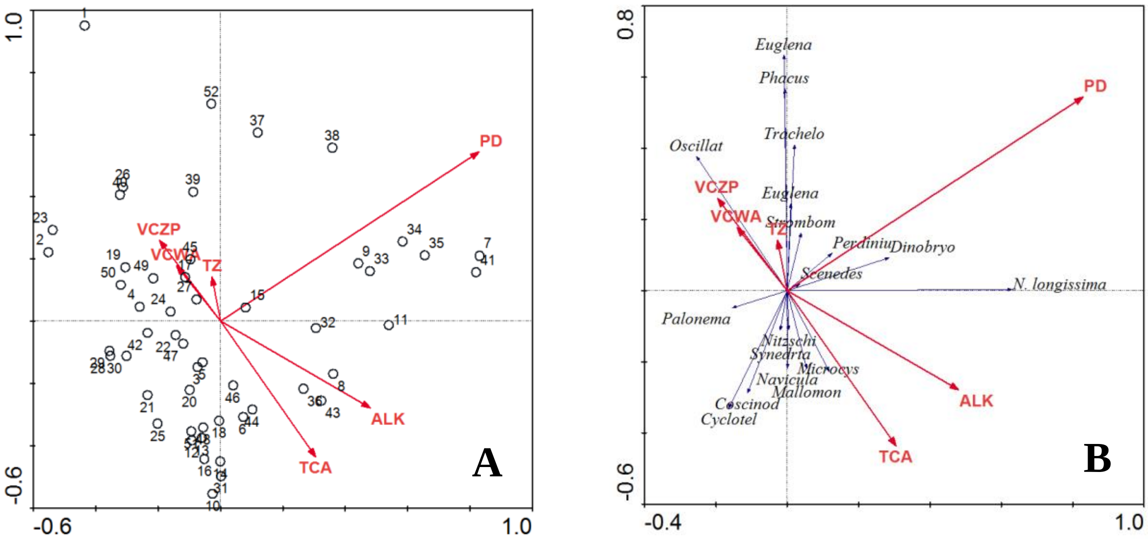
Five of the 17 environmental variables were only used in RDA analysis according to the Monte Carlo test and the inflation factor (which had to be ≤20). The first two ordination axes explained 84.7% of the variance of the species-environment relation and 26% of the variance of species data (Fig. 74). Axis I (eigenvalue = 0.193) was mainly related to phytoplankton density (r = 0.8919) and axis II (eigenvalue = 0.067) was mainly related to nitrate-nitrogen (r = 0.4368) (Fig. 74A). *Coelastrum and Eudorina* correlated positively with Vibrio Cholerae from zooplankton where *Microcyctis and Nephrocytium* Showed positive correlation with Vibrio Cholerae from water sample. *Pandorina* mainly influenced by SRP as it positively correlated (Fig. 74B).



Figs 74A-B. RDA ordination plot: A. Sampling periods & Environmental variables (NN= Nitrate-nitrogen, PD= Phytoplankton density, VCWA= *Vibrio cholerae* from water & VCZP= *Vibrio Choleare* from zooplankton). B. Phytoplankton species (Raphido= *Raphidiopsis*, Dinobryo= *Dinobryon*, Nitzschi= *Nitzschia*, Oscillat= *Oscillatoria*, Lipocinc= *Lipocinclis*, Mallomon= *Mallomonas*, Cryptomon= *Cryptomonas*, Peridiniu= *Peridinium*, Pediastru= *Pediastrum*, Scenedes= *Scenedesmus*, Coelastr= *Coelastrum*, Trachelo= *Trachelomonas*, Microcys= *Microcystis*, Strombom= *Strombomonas*, Chaetoce= *Chaetoceros*, Pandorin= *Pandorina*) and Environmental variables.

Mathbaria Station 8

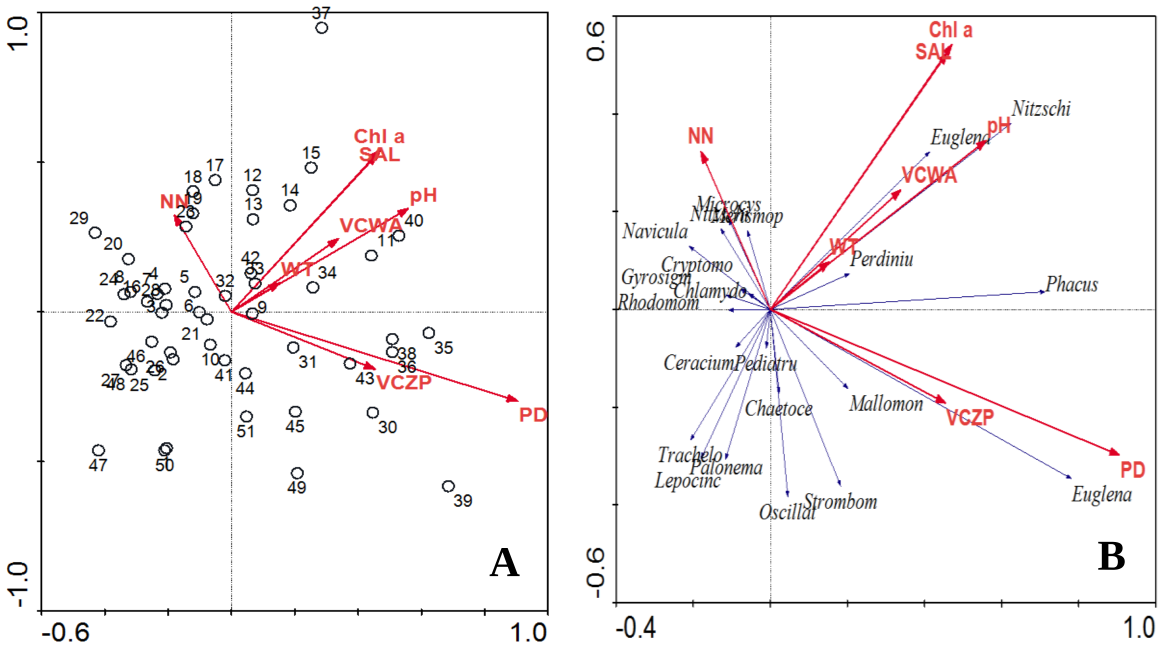
Six of the 17 environmental variables were only used in RDA analysis according to the Monte Carlo test and the inflation factor (which had to be ≤20). The first two ordination axes explained 92.5% of the variance of the species-environment relation and 32.4% of the variance of species data (Fig. 75). Axis I (eigenvalue = 0.223) was mainly related to phytoplankton density (r = 0.5257) and Alkalinity (r= 0.3045) while axis II (eigenvalue = 0.101) was mainly related to TCA (r = -0.3023) (Fig. 75A). *Oscillatoria* correlated positively with Vibrio Cholerae from zooplankton and water sample where TCA correlated negatively with these variables (Fig. 75B).



Figs 75A-B. RDA ordination plot: A. Sampling periods & Environmental variables (ALK= Alkalinity, TCA= Total copepod anapoly), PD= Phytoplankton density, VCWA= *Vibrio cholerae* from water & VCZP= *Vibrio Choleare* from zooplankton). B. Phytoplankton species (Nitzschi= *Nitzschia*, Dinobryo= *Dinobryon*, Oscillat= *Oscillatoria*, Lipocinc= *Lipocinclis*, Mallomon= *Mallomonas*, Cryptomon= *Cryptomonas*, Peridiniu= *Peridinium*, Pediastru= *Pediastrum*, Scenedes= *Scenedesmus*, Coelastr= *Coelastrum*, Trachelo= *Trachelomonas*, Microcys= *Microcystis*, Strombom= *Strombomonas*, Cycotel= *Cycotella*) and Environmental variables.

Mathbaria Station 10

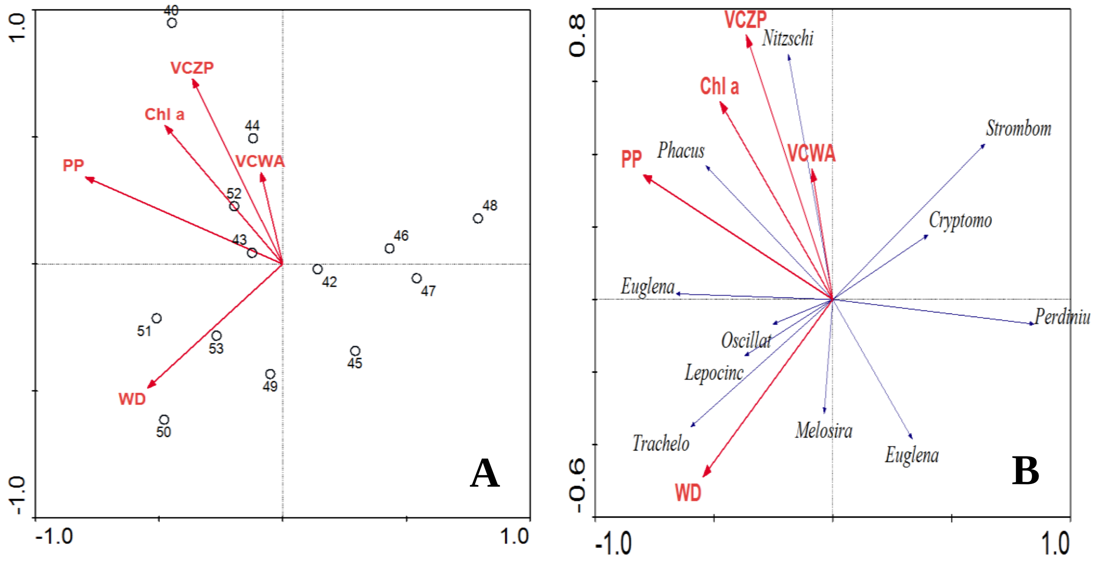
Eight of the 17 environmental variables were only used in RDA analysis according to the Monte Carlo test and the inflation factor (which had to be ≤20). The first two ordination axes explained 77.2% of the variance of the species-environment relation and 39.4% of the variance of species data (Fig. 76). Axis I (eigenvalue = 0.294) was mainly related to phytoplankton density (r = 0.8163), pH (r= 0.5046) VCZP (r=0.4096) and VCWA (r=0.3054) while axis II (eigenvalue = 0.100) was mainly related to Chl *a* (r = 0.4452), salinity (r= 0.4315) (Fig. 76A). *Nitzschia* correlated positively with pH where *Euglena acus* showed positive correlation with *Vibrio cholerae* from water. Other species of *Euglena* mainly impacted by phytoplankton density and Vibrio cholerae from zooplankton (Fig. 76B). Chl *a* and salinity ordinated on the positive side of axis I.



Figs 76A-B. RDA ordination plot: A. Sampling periods & Environmental variables (WT= Water Temperature, PD= Phytoplankton density, SAL= Salinity, NN= Nitrate-nitrogen, VCWA= *Vibrio cholerae* from water & VCZP=*Vibrio Choleare* from zooplankton). B. Phytoplankton species (Rhodomon=*Rhodomonas*, Chlamydo= *Chlamydomonas*, Dinobryo= *Dinobryon*, Nitzschi= *Nitzschia*, Oscillat= *Oscillatoria*, Lipocinc= *Lipocinclis*, Mallomon= *Mallomonas*, Cryptomon= *Cryptomonas*, Peridiniu= *Peridinium*, Coelastr= *Coelastrum*, Trachelo= *Trachelomonas*, Microcys= *Microcystis*, Strombom= *Strombomonas*, Chaetoce= *Chaetoceros*, Gyrosigm= *Gyrosigma*, Merismop= *Merismopedia*) and Environmental variables.

Mathbaria Station 11

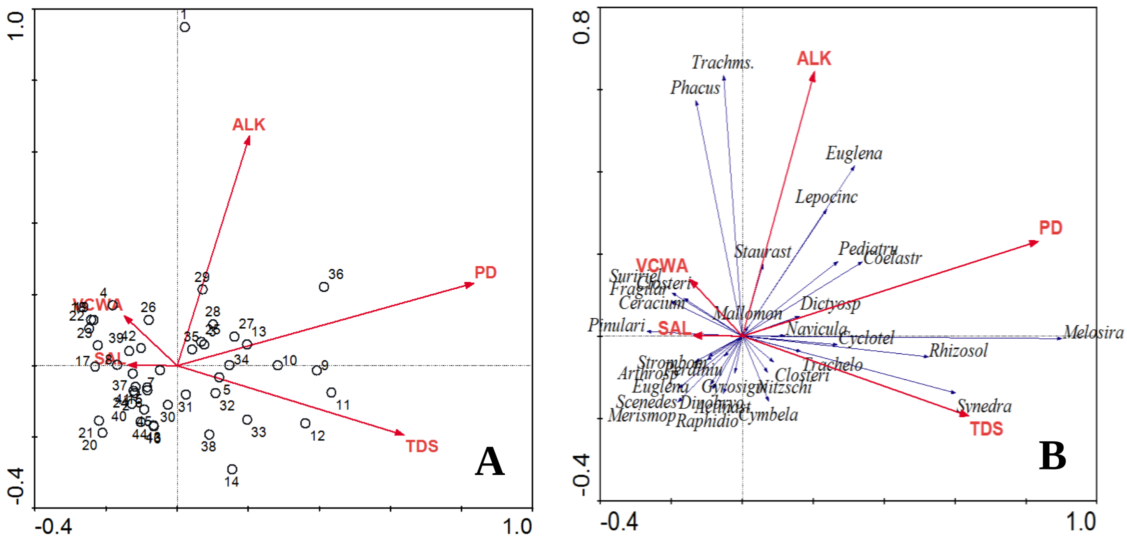
Five of the 17 environmental variables were only used in RDA analysis according to the Monte Carlo test and the inflation factor (which had to be ≤20). The first two ordination axes explained 79.6% of the variance of the species-environment relation and 44.1% of the variance of species data (Fig. 77). Axis I (eigenvalue = 0.302) was mainly related to water depth (r = -0.5065), Chl *a* (r= -0.4407) and phaeopigment (r= -0.7396) while axis II (eigenvalue = 0.139) was mainly related to WCZP (r = 0.5708) (Fig. 77A). *Nitzschia* correlated positively with VCWA where *Euglena and strombomonas* showed negative correlation with Chl *a* and water depth, respectively (Fig. 77B).



Figs 77A-B. RDA ordination plot: A. Sampling periods & Environmental variables (WD=Water depth, PP= Phaeopigment, VCWA= *Vibrio cholerae* from water & VCZP=*Vibrio Choleare* from zooplankton). B. Phytoplankton species (Nitzschi= *Nitzschia*, Oscillat= *Oscillatoria*, Lipocinc= *Lipocinclis*, Mallomon= *Mallomonas*, Cryptomon= *Cryptomonas*, Peridiniu= *Peridinium*, Trachelo= *Trachelomonas*) and Environmental variables.

Chhatak Station 2

Eight of the 17 environmental variables were only used in RDA analysis according to the Monte Carlo test and the inflation factor (which had to be ≤20). The first two ordination axes explained 83.8% of the variance of the species-environment relation and 40.2% of the variance of species data (Fig. 78). Axis I (eigenvalue = 0.346) was mainly related to TDS (r = 0.5940) and phytoplankton density (r=- 0.7768), while axis II (eigenvalue = 0.056) was mainly related to alkalinity (r = 0.4502) (Fig. 78A). *Synedra* correlated positively with TDS where *Suririella*, *Fragilaria*, *Ceracium and Closterium* showed positive affinities with Vibrio cholera from water sample (Fig. 78B).

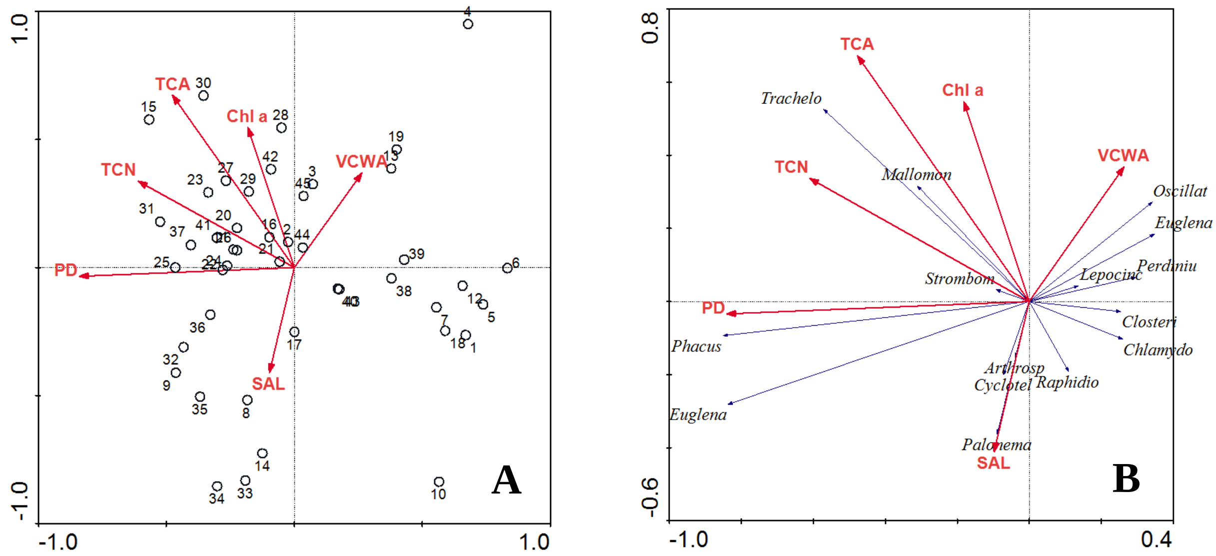


Figs 78A-B. RDA ordination plot: A. Sampling periods & Environmental variables (WD= Water depth, PP= Phaeopigment, VCWA= *Vibrio cholerae* from water & VCZP= *Vibrio Choleare* from zooplankton). B. Phytoplankton species (Raphido= *Raphidiopsis*, Dinobryo= *Dinobryon*, Nitzschi= *Nitzschia*, Oscillat= *Oscillatoria*, Lipocinc= *Lipocinclis*, Mallomon= *Mallomonas*, Cryptomon= *Cryptomonas*, Peridiniu= *Peridinium*, Pediastru= *Pediastrum*, Scenedes= *Scenedesmus*, Coelastr= *Coelastrum*, Trachelo= *Trachelomonas*, Microcys= *Microcystis*, Strombom= *Strombomonas*, Chaetoce= *Chaetoceros*, Pandorin= *Pandorina*, Rhizosol= *Rhizosolenia*, Suririel= *Suririella*, Piniular= *Pinularia*, Fragilar= *Fragilaria*, Staurast= *Staurastrum*, Dictyosp= *Dictyospherium*, Merismop= *Merismopedia*, Arthrosp= *Arthrospira*, Clostri= *Closterium*) and Environmental variables.

Redundency analysis (RDA)

Chhatak Station 12

Six of the 17 environmental variables were only used in RDA analysis according to the Monte Carlo test and the inflation factor (which had to be ≤20). The first two ordination axes explained 83.3 % of the variance of the species-environment relation and 42.8% of the variance of species data (Fig. 79). Axis I (eigenvalue = 0.342) was mainly related to phytoplankton density (r = -0.7717) and TCN (r= -0.5600), while axis II (eigenvalue = 0.086) was mainly related to Chl *a* (r = 0.3932), TCA (r= 0.4835) (Fig. 79A). *Palonema* correlated positively with salinity while *Raphidiopsis* showed more or less negative correlation with Chl *a* and TCA. (Fig. 79B).



Figs 79A-B. RDA ordination plot: A. Sampling periods & Environmental variables (TCA=Total copepod adult, TCN= Total copepod naupoli, PD= Phytoplankton density, SAL= Salinity & VCWA= *Vibrio cholerae* from water). B. Phytoplankton species (Raphido= *Raphidiopsis*, Oscillat= *Oscillatoria*, Lipocinc= *Lipocinclis*, Mallomon= *Mallomonas*, Cryptomon= *Cryptomonas*, Arthrosp= *Arthrospira*, Peridiniu= *Peridinium*, Chlamydo= *Chlamydomonas*, Closteri= *Closterium*, Trachelo= *Trachelomonas*, Strombom= *Strombomonas*, Cycotel= *Cycotella*,) and Environmental variables.

A comparative limnology of the studied habitats

Over the entire sampling period, the environmental characteristics of the water were found different compared to the two study sites. Observation among the studied infested stations of Mathbaria and Chhatak (Table 109) showed that water depth was lowest in the infested station of Chhatak (1.03 m) than Mathbaria (1.29-2.04) site, water temperature was quite higher in Mathbaria (28.10-29.35°C) than Chhatak (25.16-26.60°C), range of alkalinity, salinity and TDS are higher in the infested stations of Mathbaria than Chhatak. On the other hand, average concentrations of SRP, NO_3-N, SRS, phytoplankton biomass as chl. *a* and phaeopigment were found higher in the infested stations of Chhatak than Mathbaria. Total count of phytoplankton, zooplankton and copepod (adult and nauplii) densities were also observed higher in Chhatak but *V. cholerae* in water and zooplankton analysis observed at least 18-90 fold and 500 fold higher in Mathbaria than Chhatak infested stations, respectively.

Table 109. A comparative limnology of water bodies infested by *V. cholerae* from Mathbaria and Chaatak study sites of Bangladesh.

Parameter	Mathbaria	Chaatak
Water depth (m)	1.29-2.04	1.03
Water temperature (°C)	28.10-29.35	25.16-26.60
Alkalinity (meq/l)	2.83-3.33	0.99-3.62
Salinity (‰)	0.39-0.40	0.0008-0.13
pH	7.39-7.56	7.25-7.27
TDS (mg/l)	616.90-680.65	52.95-184.90
SRP (µg/l)	18.19-61.92	11.60-308.05
SRS (mg/l)	5.84-6.59	7.01- 14.76
NO_3-N (µg/l)	80.10-139.56	209.22-231.45
Chl. *a* (µg/l)	4.78-23.91	13.07-50.84
Phaeopigment (µg/l)	3.19-13.51	8.17-25.18
Phytoplankton Density ($\times 10^3$ ind./l)	38.90-393.52	377.87-1027.61
Total Zooplankton ($\times 10^3$ ind./l)	43.19-403.91	375.72-1768.03
Total Copepods Adult ($\times 10^3$ ind./l)	11.06-25.68	41.36-318.00
Total Copepods Nauplii ($\times 10^3$ ind./l)	18.71-95.75	80.41-593.44
Vibrio cholerae in water analysis ($\times 10^3$ ind./l)	18.71-95.75	0.83-1.67
Vibrio cholerae in zooplankton analysis ($\times 10^3$ ind./l)	450.00-858.3	-

Relationship between plankton and *Vibrio cholerae*

Plankton-linked *Vibrio cholerae* has been detected in aquatic environments since the first decades of the 20th century. Studies carried out in several countries have demonstrated adherence of *V. cholerae* to plankton in aquatic environments. Colwell (1996) stated that *V. cholerae* persists in the environment while adhered to plankton. In the present research, occurrence of Vibrio in the studied environment has been shown in relation to the qualitative and quantitative aspects of phytoplankton population in the following paragraphs.

Qualitative

In the *Vibrio* positive ponds of Chhatak (station 2 and 12), at the time of *Vibrio* occurrence, *Trachelomonas volvocina* was dominant. In station 2 of Mathbaria which is *Vibrio* positive, *Euglena* sp. and *Strombomonas* were dominant only in autumn. In the same station during summer and at the time of *Vibrio* occurrence, *Nitzschia longissima* was dominant. Whereas, this species was almost absent in the other seasons. In stations, where *Vibrio* did not occur *Nitz*. *longissima* was not that much abundant. This finding states that qualitatively *T. volvocina*, *Euglena* sp. and *Strombomonas* might have some relationships with *Vibrio* in Chhatak area. On the other hand, in Mathbaria *V. cholerae* occurrence was associated with *Nitz*. *Longissima* in summer season in most of the stations.

Quantitative

Phytoplankton density, biomass and degraded product all were plotted in relation to density of *Vibrio* in Figs. 80-97. In all the infested stations, the *Vibrio* peak (March-May) was found to occur just after peak (Jan-May) growth of phytoplankton and total zooplankton density. This relationship may be interpreted that at the time of peak plankton growth cellular exudation of both phytoplankton and zooplankton and the grazing of zooplankton on phytoplankton releases some nutrients which might be helpful for the growth of *Vibrio*. This was also evident by a parallel occurrence of phaeopigment with of *Vibrio* (Fig. 82, 85, 88, 91, 94 and 97).

Nitzschia longissima is a diatom which moves in jerking manner and in going to do so this species secretes a lot of gelatinous material in the environment. This material in combination with the degraded products of chlorophyll as phaeophytin might have some relationship with *Vibrio* bacterium. In village area, it is a common belief that cholera occurs after drinking ‘rotten water’. When natural water becomes loaded with degraded plant products (i.e. phaeophytin), its color changes to light brown. This might be the concept of our so called “rotten water”.

Mathbaria Station 2

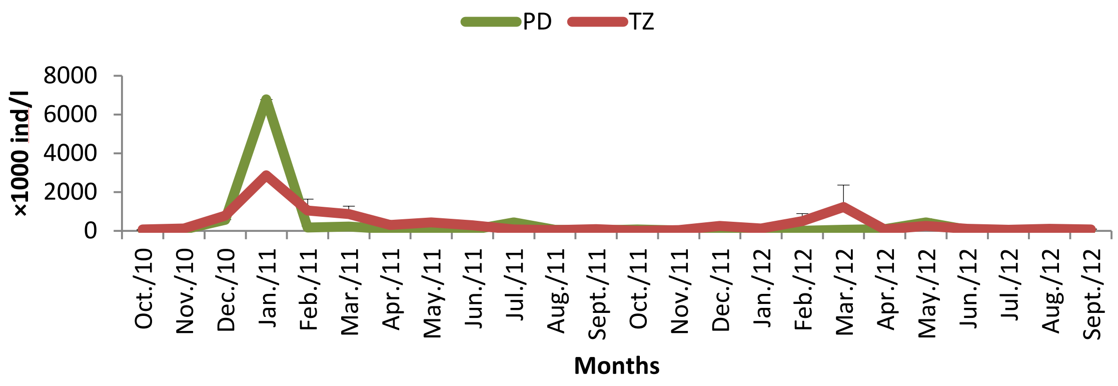


Fig. 80. Phytoplankton density (PD) and Total Zooplankton (TZ) (2010-2012).

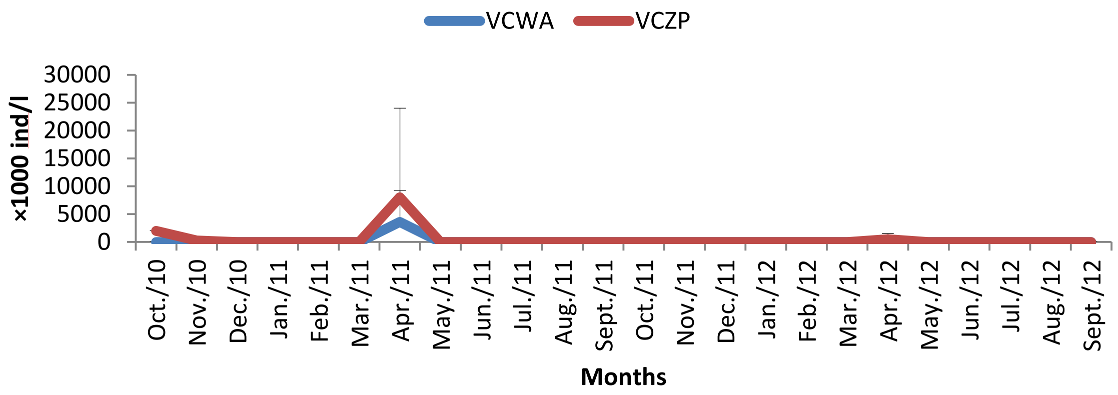


Fig. 81. Vibrio occurrence in water (VCWA) and in zooplankton (VCZP).

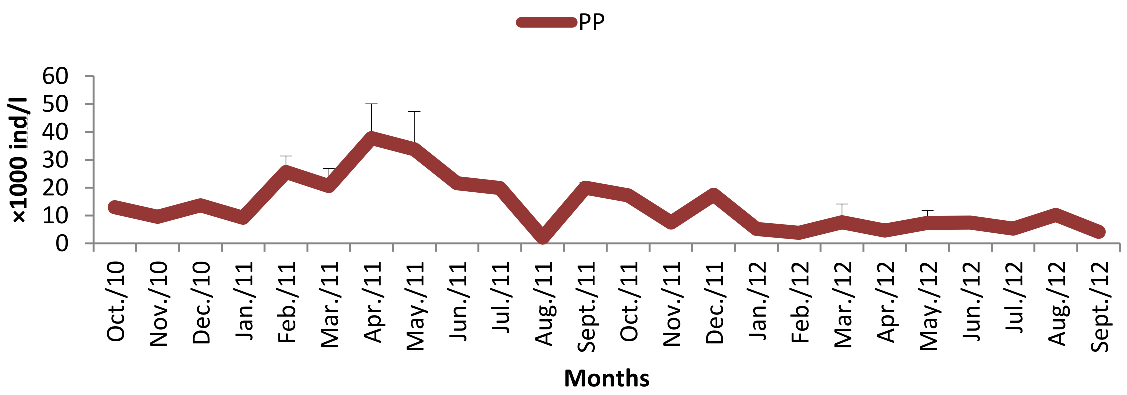


Fig. 82. Phaeopigment concentration (PP).

Mathbaria Station 7

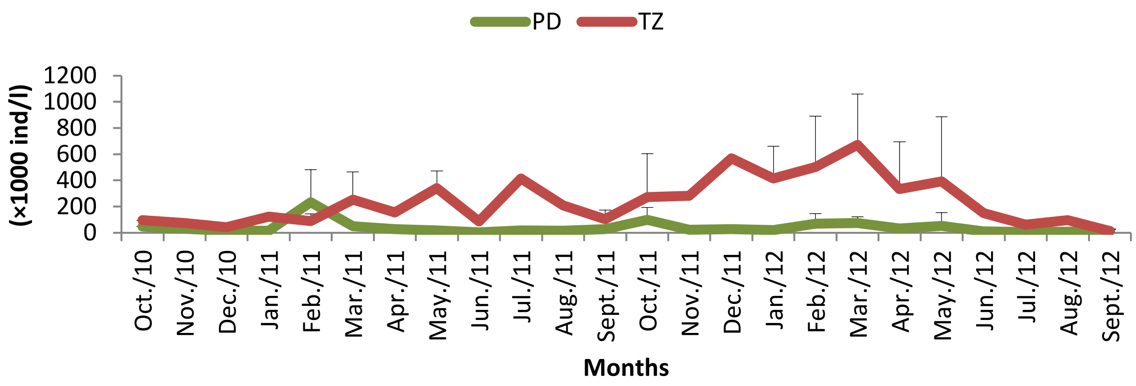


Fig. 83. Phytoplankton density (PD) and Total Zooplankton (TZ) (2010-2012).

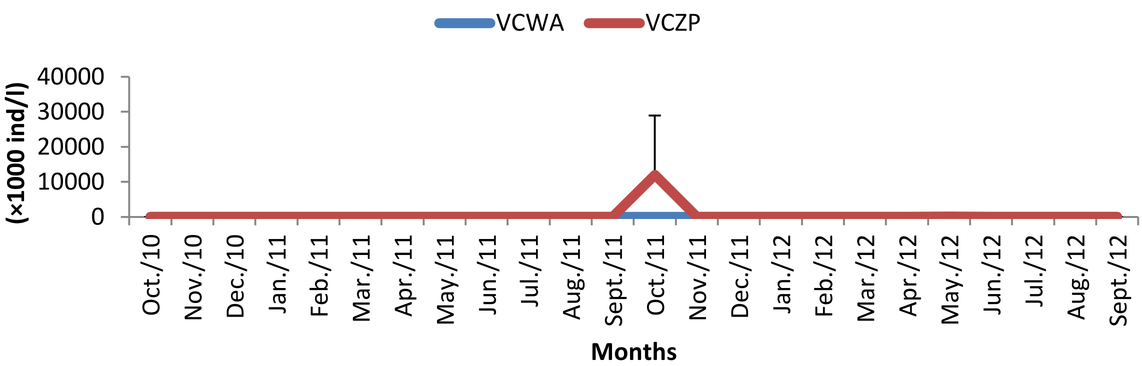


Fig. 84. Vibrio occurrence in water (VCWA) and in zooplankton (VCZP).

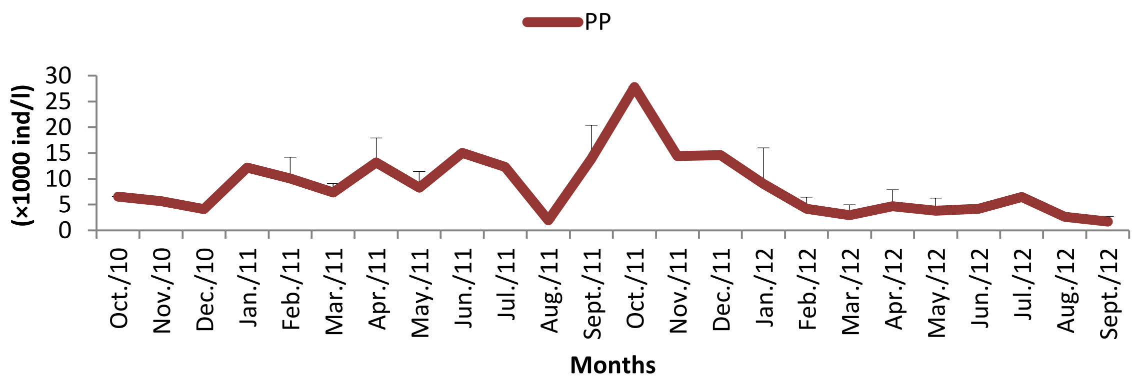


Fig. 85. Phaeopigment concentration (PP).

Mathbaria Station 8

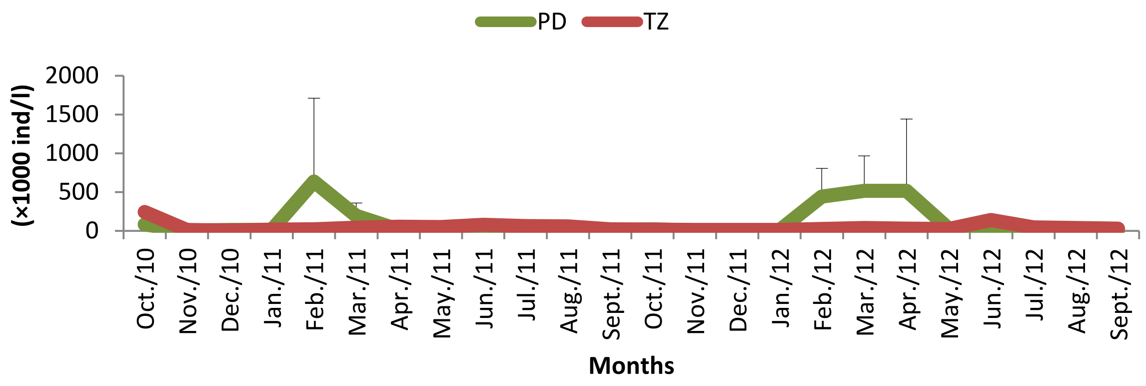


Fig. 86. Phytoplankton density (PD) and Total Zooplankton (TZ) (2010-2012).

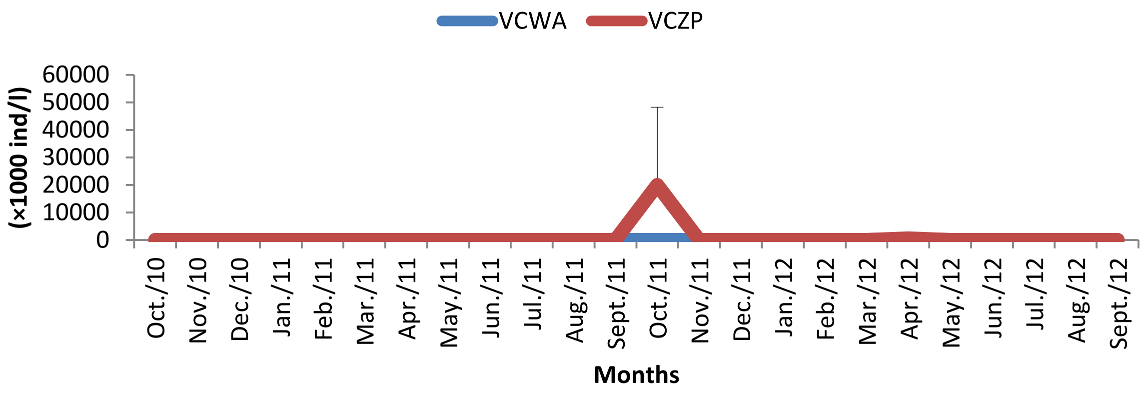


Fig. 87. Vibrio occurrence in water (VCWA) and in zooplankton (VCZP).

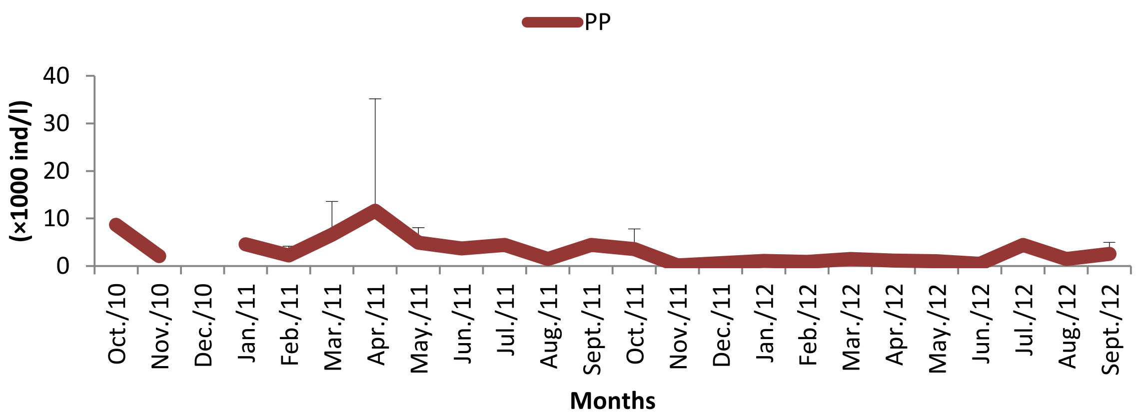


Fig. 88. Phaeopigment concentration (PP).

Mathbaria Station 10

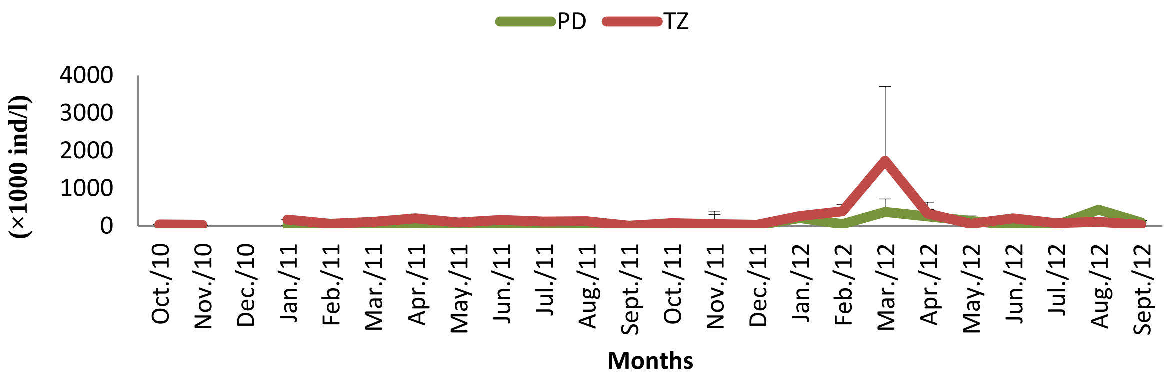


Fig. 89. Phytoplankton density (PD) and Total Zooplankton (TZ) (2010-2012).

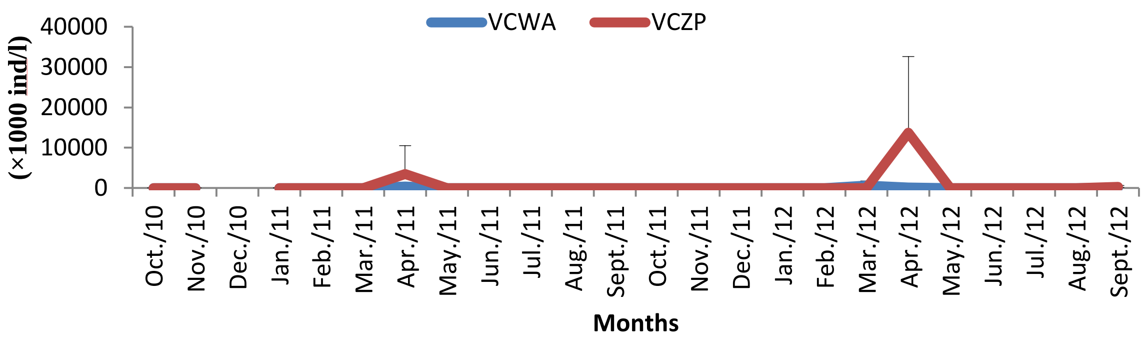


Fig. 90. Vibrio occurrence in water (VCWA) and in zooplankton (VCZP).

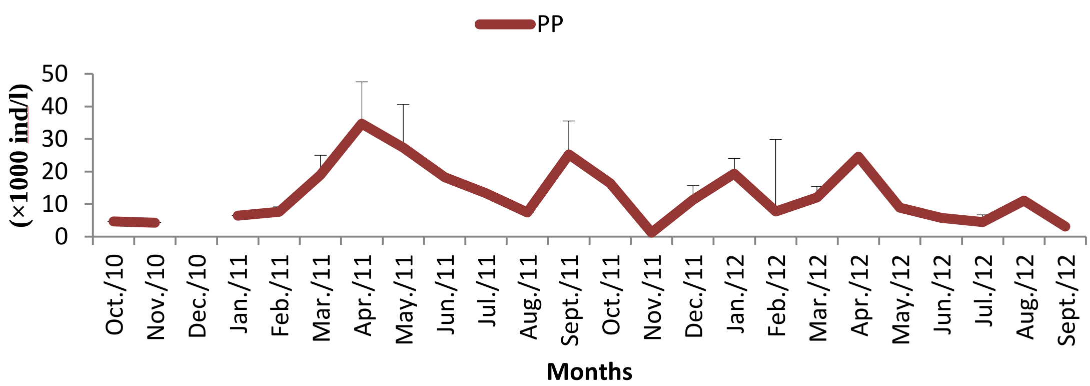


Fig. 91. Phaeopigment concentration (PP).

Chhatak station 2

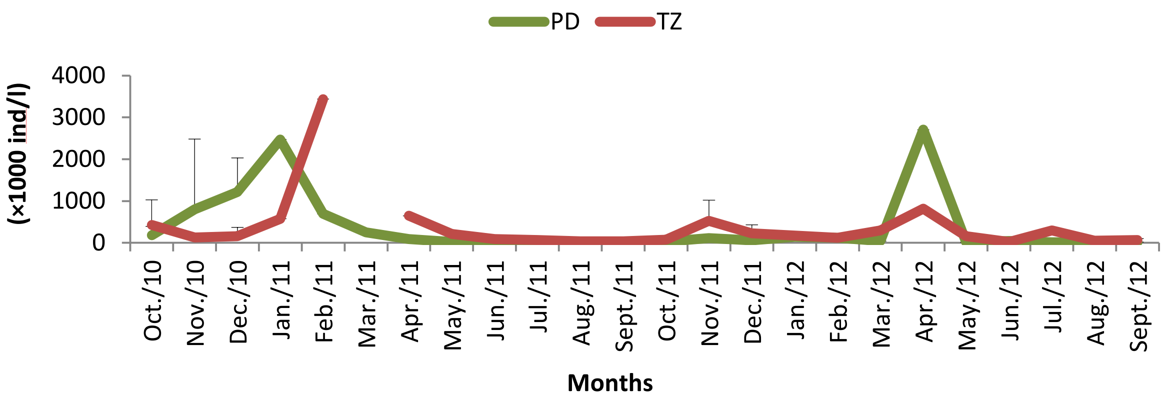


Fig. 92. Phytoplankton density (PD) and Total Zooplankton (TZ) (2010-2012).

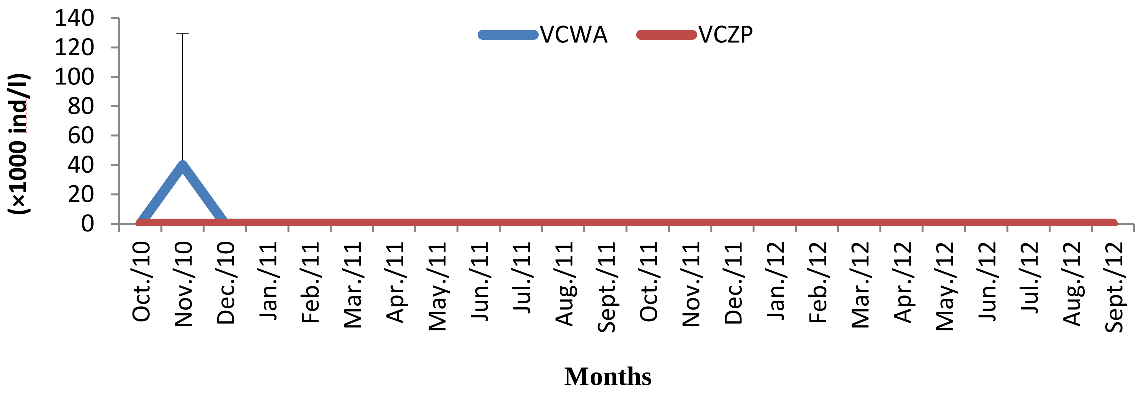


Fig. 93. Vibrio occurrence in water (VCWA) and in zooplankton (VCZP).

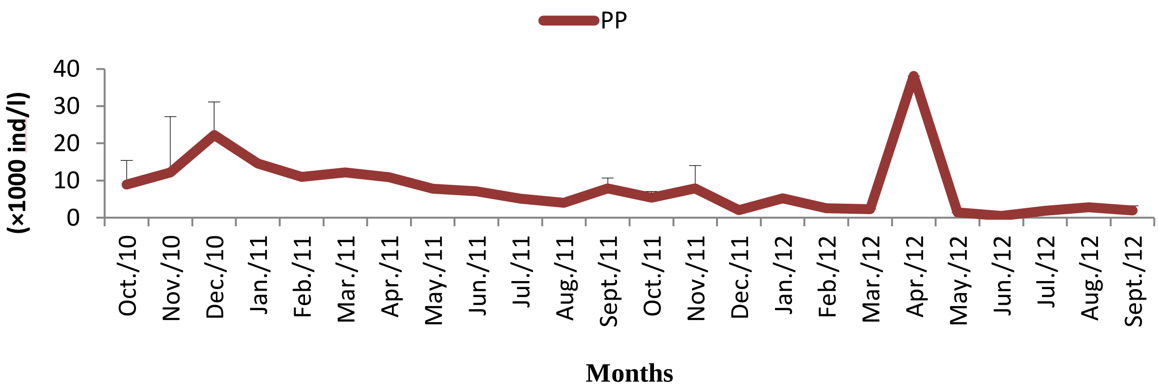


Fig. 94. Phaeopigment concentration (PP).

Chhatak station 12

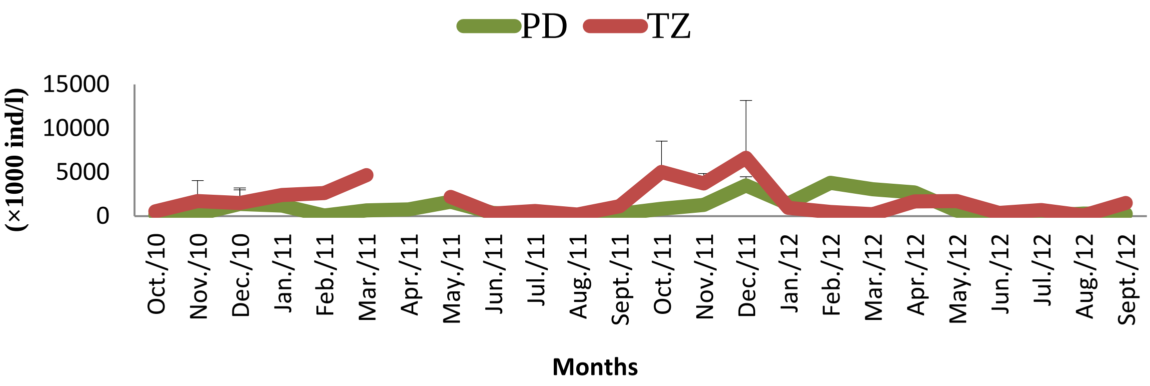


Fig. 95. Phytoplankton density (PD) and Total Zooplankton (TZ) (2010-2012).

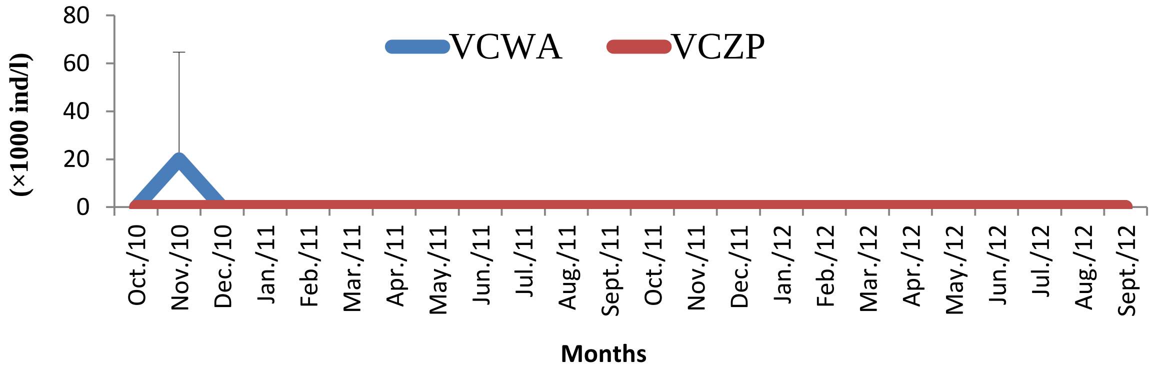


Fig. 96. Vibrio occurrence in water (VCWA) and in zooplankton (VCZP).

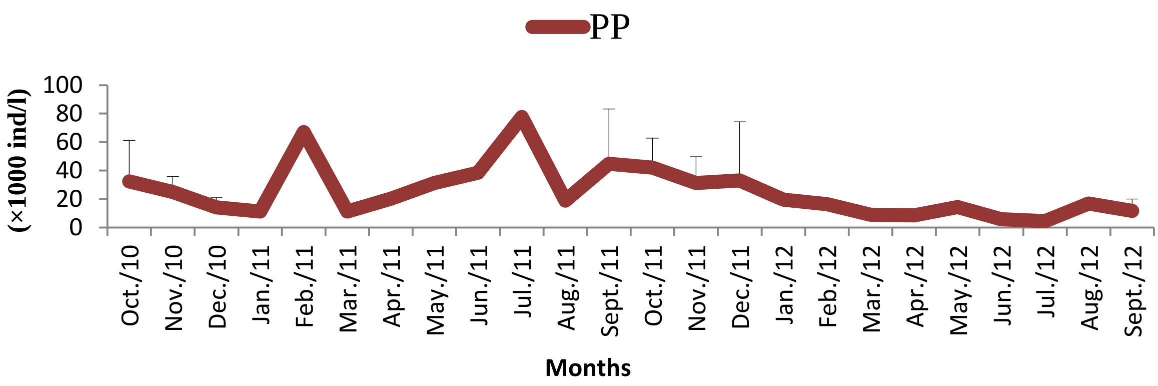


Fig. 97. Phaeopigment concentration (PP).

Chapter-5

Discussion

DISCUSSION

The present research work has been undertaken at the time when there was a growing debate about the effects of climate change and global warming. As climate change threatens to increase global temperature resulting rises in sea levels and temperature may influence the temporal fluctuation of cholera and increased environmental water temperature correspond with the increased detection rate of *Vibrio cholerae* which suggest a triggering factor may be responsible for enhancing the number of organism in a given environment (Huq *et al*. 2002). Many investigators postulate that the temporal variation of the disease is due to environmental and climatic factors that affect the seasonal patterns of infection (Islam *et al*. 1994, Lipp *et al*. 2002, Sack *et al*. 2003, Pascual *et al*. 2005, Alam *et al*. 2006). To assess the seasonal variation of phytoplankton in relation to *V. cholerae*, 17 water parameters were regularly observed from the fifteen stations of two study sites (Mathbaria and Chhatak) for two years. These are water depth, water temperature, alkalinity, salinity, pH, TDS, SRP, NO_3-N, SRS, chlorophyll-*a*, phaeopigment, phytoplankton density, total zooplankton, total copepod adult, total copepod nauplii, *V. cholerae* in water analysis and *V. cholerae* in zooplankton analysis. The present discussion is based on the composition, concentration, seasonality and diversity of the above mentioned parameters together with their relationships among themselves and their comparision between two distinct study sites along with other similar studied areas.

The geographical position of Mathbaria and Chhatak are in the southern part and north-eastern part of Bangladesh, respectively. The present study indicates that the study area of Mathbaria represents the coastal epidemic pattern of cholera. On the other hand, Chhatak represents the inland epidemic pattern of cholera. This observation is similar to the previous reports made by many investigators (Bouma and Pascual 2001, Sack *et al*. 2003).

Cholera bacteria, a causative agent for cholera outbreaks, are known to survive and thrive in brackish waters, particularly in the presence of abundant zooplankton and phytoplankton; suggesting a high correlation between plankton abundance and disease outbreaks (Huq *et al.* 1984, Reidl and Klose 2002, Alam *et al.* 2006, Epstein 1993). Jutla *et al.* (2010) also reported a strong correlation ($r=0.81$; $p<0.05$) between preceding autumn chlorophyll in coastal regions and spring cholera outbreaks in Bangladesh. On the other hand, Akanda *et al*. (2011) studied that autumn cholera outbreaks are strongly associated with the widespread breakdown of sanitary conditions due to flooding in the Bengal delta. Akanda *et al.* (2009) provide a tentative explanation of the roles of river discharge and coastal plankton intrusion on the dual peak cholera incidence pattern seen in this region. Cholera outbreaks in spring (March-April-May) show strong negative correlation with dry season (February-March) river discharge ($r = -0.65$; $p<0.05$), i.e., bigger spring cholera peaks are typically seen in water scarce years (Akanda *et al*. 2009). However, a new transmission environment emerges in autumn, when water abundance contributes to elevated cholera outbreaks, i.e., bigger autumn peaks are seen in high flood years.

In Mathbaria, *V. cholerae* found in water sample during summer (Fig. 37). Highest peak of *V. cholerae* in water sample observed in the month of April or May (Fig. 38) among all the infested (Station 2, 7, 8, 10 and 11) stations, when contaminants become concentrated in available water. During cholera peak of Mathbaria, peak of water temperature (Fig. 10), alkalinity (Fig. 12), salinity (Fig. 14), pH (Fig. 16), total dissolved solids (Fig. 18) and phaeopigment (Fig. 28) also showed the same peak during summer. On the other hand, infested stations (Station 2and 12) of Chhatak showed peak of *V. cholerae* in the month of early November (Fig. 72), when salinity (Fig. 48), TDS (Fig. 52), nitrate-nitrogen (Fig. 55) and phaeopigment (Fig. 61), also showed the same peak during autumn.

However, epidemics of cholera in Bangladesh have two distinct peaks, one in late spring and one in late fall. Once an algal bloom disintegrates, the bacterial cells require another mechanism of survival and multiplication in the environment to cause later epidemics during a given year (Silvery and Roach 1964). Instead of any direct influence of phytoplankton on *V. cholerae*, it is more likely that the high nutrient levels arising from the breakdown of phytoplankton via algal viruses or other bacteria (Shilo 1975).

It is recognized that *V. cholerae* is a component of coastal and estuarine microbial ecosystems, with copepod species of zooplankton that comprise the aquatic fauna of rivers, bays, estuaries and the open ocean serving as hosts for the bacterium (Magny *et al*. 2008). The growth and abundance of the organisms in coastal waters is influenced by changes in environmental factors including temperature, salinity, nutrient availability, sea surface height, and rainfall (Cash *et al*. 2010, Emch *et al*. 2008, Lobitz *et al*. 2000). One of the main reasons that *V. cholerae* can survive and reproduce in marine and estuarine environments is that the salinity is appropriate, and there are a large number of phytoplankton and zooplankton which provide rich carriers for the spread of *V. cholerae*. Plankton is a significant marine reservoir of *V. cholerae*, and the bacterium attaches primarily to zooplankton, specifically copepods.

Phytoplankton blooms coincided with zooplankton blooms, which in turn are linked to cholera cases, nutrient concentration, and related parameters (Lobitz *et al*. 2000). *V. cholera*e also shows a seasonal pattern of occurrence, which was correlated with higher temperatures. The frequency of occurrence of *V. cholerae* is significantly greater at temperatures above 19 °C (Louis *et al*. 2003).

Observation among the studied infested stations of Mathbaria and Chhatak (Table 109) showed that water depth was lowest in the infested station of Chhatak (1.03 m) than Mathbaria (1.29-2.04) site, water temperature was quite higher in Mathbaria (28.10-29.35°C) than Chhatak (25.16-26.60°C), range of alkalinity, salinity and TDS are higher in the infested stations of Mathbaria than Chhatak. On the other hand, average concentrations of SRP, NO_3-N, SRS, phytoplankton biomass as chl. *a* and phaeopigment were found higher in the infested stations of Chhatak than Mathbaria. Total count of phytoplankton, zooplankton and copepod (adult and nauplii) densities were also observed higher in Chhatak but *Vibrio cholerae* in water and zooplankton analysis observed at least 18-90 fold and 500 fold higher in Mathbaria than Chhatak infested stations, respectively.

Magny *et al.* (2008) suggested that chlorophyll may be used as a predictor variable for cholera outbreaks in Bengal Delta, however, the study did not elaborate, if chlorophyll can predict seasonal double peak cholera outbreaks for this region. Identification of appropriate predictor variables is important to understand cholera dynamics for the region. Chlorophyll production in the coastal areas with freshwater discharge may be controlled by the river discharge (Arker *et al.* 2005, Jutla *et al.* 2009a). In other regions, coastal chlorophyll production is driven by upwelling and shows inverse association with SST (Legaard and Thomas 2006, Smyth *et al.* 2001). For example, in the Bay of Bengal, plankton blooms immediately follow the peak monsoon discharge volumes carrying terrestrial nutrients.

Chlorophyll, a key biochemical component that gives plants its green color, is responsible for facilitating absorption of sunlight for photosynthetic purposes. The global overview of chlorophyll concentrations and possible vulnerable regions for cholera outbreaks is supported by various studies. Huq and Colwell (1996) presented an epidemiological global picture of cholera outbreaks in three continents (Africa, South Asia and South America) suggesting the role of coastal regions behind cholera outbreaks. They also suggested that remote sensing can be a helpful tool for tracking cholera outbreaks using ocean chlorophyll signatures. In the Bay of Bengal (BoB), however, a positive relationship between phytoplankton and SST is observed (Lobitz *et al*. 2000, Chaturvedi 2005, Emch *et al*. 2008, Magny *et al*. 2008). Preliminary analyses, using SeaWiFS data, suggest that terrestrial nutrient transport through fresh water discharge from the Ganges and the Brahmaputra rivers is the dominant process affecting phytoplankton production in the coastal BoB region (Jutla *et al.* 2009a), which alters the usually observed inverse relationship between SST and chlorophyll. Lobitz *et al.* (2000) used limited length SeaWiFS data (16 months) to stress the potential role of remotely sensed chlorophyll for understanding chlorophyll-cholera relationships. Since then there have been other studies that have qualitatively emphasized the use of remote sensing data for cholera (e.g., Colwell and Huq 2001, Colwell *et al.* 2003, Koelle *et al.* 2005). There do not appear to be any quantitative analyses, however, that have used satellite based data to strengthen chlorophyll-cholera relationships. Magny *et al.* (2008) developed a model for predicting cholera outbreaks based on several variables including coastal chlorophyll and other climatological data on a monthly time scale with approximately 100 km aggregated pixel scale. They concluded that there is approximately a month lag between plankton blooms in the Bay of Bengal and cholera incidence in Bangladesh. Magny *et al.* (2008) also recommended that finer temporal and spatial scale chlorophyll data may be required for real-time tracking of cholera outbreaks. Emch *et al.*, (2008) have used satellite chlorophyll measurements from two coastal regions in South Asia (Bangladesh and Vietnam) and reported a two-month lag between plankton blooms and cholera outbreaks in Bangladesh.

The causative agent of cholera outbreaks, *V. cholerae*, cannot be measured from space. However, the bacteria show strong affinity with plankton blooms which can be estimated from satellites by measuring chlorophyll present in plankton. Increase in phytoplankton has been associated with increased presence of copepods (Reidl and Klose 2002). Cholera bacteria attach themselves to the zooplankton, more specifically to crustacean copepods, to form a thin pathogenic biofilm, which provides protection from the external environment. Thus phytoplankton and zooplankton play vital roles in facilitating the survival, growth, and transmission of *V. cholerae* in the marine environment. SST is an important driver of outbreaks by promoting extreme rainfall and encouraging pathogen proliferation in the coastal environment. Peaking SSTs in the lead up to the outbreak crest could have enabled pathogen proliferation.

A closer look at relationship between cholera and remote sensing reveals limited understanding of what remote sensing data can offer for establishing coastal and hydrological connections with cholera incidence. Satellite remote sensing provides estimate of chlorophyll, a surrogate for phytoplankton abundance. Phytoplankton concentrations are found to be considerably higher near the coastal zone (21-22.50° N and 86-93°E) of the Bay of Bengal (BoB). The coastal zone of the BoB also shows high chlorophyll variability compared to relatively constant values away from the coast. There is limited understanding on the inter- and intra-annual variability of chlorophyll in coastal regions and its relationship with cholera incidence. Several other studies from various ocean basins across the globe, suggest an inverse relationship between phytoplankton and SST.

A significant reservoir of *V. cholerae* is marine plankton, both phytoplankton and zooplankton (Colwell and Huq 2001). Phytoplankton serves as the primary food source for copepods and other zooplanktons, also releases nutrients into the water through disintegration. The bacteria then proliferate taking advantage of the nutrition conditions of the aquatic system (Lipp *et al*. 2002). Phytoplankton and zooplankton, therefore, play a vital role in facilitating the survival, growth, and transmission of *V. cholerae* in the natural aquatic environment (Lipp *et al*. 2002, Mouriño-Pérez 1998). The role of sea surface temperature (SST) in creating and sustaining favorable environmental conditions for oceanic phytoplankton production is well documented (e.g., Timmermann and Jin 2002, Legaard and Thomas 2006, Garcia and Carr 1999).

Common phytoplankton of the studied stations belong to the algal classes Euglenophyceae (*Euglena, Phacus*, *Trachelomonas*, *Strombomonas*) together with Dinophyceae (*Peridinium*, *Ceratium*) and Bacillariophyceae (centric diatoms: *Melosira, Cyclotella).* Besides, sporadic occurrence of Cyanophyceae represented by the genera *Raphidiopsis*, *Anabaenopsis*, *Oscillatoria*, *Microcystis* and *Coelospharium* were also recorded among the stations of Mathbaria and Chhatak. Three phytoplankton genera characteristic to brackish water were also recorded from Mathbaria area (*Chaetoceros*, *Coscinodiscus, Rhizosolenia*. In Mathbaria sites, one pinnate diatom *Nitzschia longissima* from Bacillariophyceae was abundant at the time of *Vibrio* occurrence in water i.e. in summer season (March through May) among all the infested stations. But other season *Nitzschia longissima* was not dominant. Statistical programme RDA correlates that salinity is important factor for

Nitzschia longissima. During autumn and winter season members of Euglenophyceae were dominant in the infested station of Mathbaria Station 2 (Table 36 and 37) and 10 (Table 60 and 61) and in monsoon members of Cyanophyceae were dominant (Table 39 and 63, respectively) in the year of 2011-2012. Interestingly, in Mathbaria Station 7 members of Euglenophyceae were dominant all the year round (Table 48-51). Station 8, which is a canal of Mathbaria site, members of Bacillariophyceae were dominant in most of the seasons except in autumn when the members of Euglenophyceae were dominant but in that period phytoplankton density were poor (Table 52-55). In Station 11 of Mathbaria members of Euglenophyceae were dominant in summer (Table 64) and members of Cyanophyceae were dominant in monsoon (Table 65). Among the non infested stations of Mathbaria, it was observed that during autumn, winter and summer members of Euglenophyceae were dominant but in monsoon members of Cyanophyceae were dominant.

In Chhatak Station 2 (infested station) which is a river, members of Euglenophyceae were dominant in autumn and during winter and summer members of Bacillariophyceae were dominant. Interestingly during monsoon phytoplankton count was found very poor among all the station. Chhatak Station 12 also an infested station where members of Euglenophyceae were dominant all the year round. Among these two infested station *Trachelomonas volvovocina* Ehr. found abundant when *Vibrio cholerae* were found in water sample.

Association between *V. cholerae* and plankton has been observed in different countries such as Brazil (Goncalves *et al*. 1990) and Peru (Tamplin and Carrillo 1991) and also Bangladesh (Tamplin *et al*. 1990). It has been found in association with a wide range of aquatic life, including cyanobacteria (*Anabaena variabilis*) (Islam *et al*. 1989), diatoms (*Skeletonema costatum*) (Martin and Bianchi 1980) and freshwater filamentous green algae (*Rhizoclonium fontanum*) (Islam *et al*. 1989). Binsztein *et al.* (2004) found an association with estuarine diatoms like *Thalassionema nitzschioides, Pleurosigma* cf. *normanii, Coscinodiscus* sp. and dinoflagellates such as *Ceratium furca* and *Noctiluca scitillans*. One feasible explanation for the attachment of *V. cholerae* to aquatic organisms is its capacity to produce enzymes such as chitinases and mucinases (Epstein *et al*. 1993), which would allow it to adhere for example to the surface of copepods (Haq *et al*. 1983, Tamplin *et al*. 1990) and *Volvox* sp., a type of mucilaginous phytoplankton colony (Colwell *et al*. 1990). Another possible explanation for the prolonged survival of toxigenic *V. cholerae* when attached to *Rhizoclanium fontanum*, for example, could be its ability to derive nutrients from the extracellular products released by this species (Borroto 1997). Islam *et al*. (1989) hypothesized that *V. cholerae* 01 uses extracellular products released from *A. variabilis* for nutrition and that the availability of salts on the mucilaginous surface of this blue-green alga enables *V. cholerae* 01 to survive for prolonged periods in freshwater environments.

In the present analysis it is evident that *Vibrio* were associated mostly at the down-setting (declining phase) of the phytoplankton density. Significant positive correlation was also observed between phytoplankton density and total zooplankton. Phytoplankton enhances the growth of zooplankton since peak growth of both phyto- and zooplankton is nearly overlapping or occurs side by side. Grazing by copepod (zooplankton) is the major reason for the degradation of chl *a* to phaeopigment. It is also evident that, under this enriched conditions of phaeopigment in the habitat, peaks of *Vibrio* are mostly observed. So it can be assumed that the phaeopigment may serves some sorts of nutrition to *Vibrio* (Fig. 80-97).

Huq *et al*. (2000) studied that Phytoplankton provide the main food source for zooplankton so the two forms of plankton are tightly linked in space and time. Under adverse conditions of temperature and nutrients. Huq *et al*. (1984) also suggest that there may be a synergistic effect between phytoplankton and zooplankton in chitin colonization by *V. cholerae*. An alkaline pH of 8.5, often associated with algal blooms, was found to positively influence the attachment of *V. cholerae* to copepods (Huq *et al*. 1984). Huq *et al*. (1988) proposed that once cells of *V. cholerae* attach to zooplankton, they are protected from the external environment and begin to proliferate, taking advantage of the increased surface area and improved conditions of nutrition, the latter derived from the disintegration of phytoplankton and release of nitrogenous products into the water. It was further suggested that during interepidemic monsoon seasons in Bangladesh, when there is a significant alteration of nutritional conditions arising from seasonal changes in the chemical parameters of the water (Oppenheimer *et al.* 1978). According to Oppenheimer *et al.* during the Indian Ocean monsoon (rainy) season in June and July, zooplankton populations decrease because of reduced levels of nutrients. During August and September, after the monsoon season, levels of nutrients significantly increase and blooms of phytoplankton followed by zooplankton occur. In Bangladesh, cholera outbreaks are related to the end of the monsoon season on an annual basis.

Pearsons correlation (SPSS v11.5) analysis of the present research among the studied variables, found a significant negative correlation between phytoplankton density and water temperature in most of the station. In this analysis significant positive correlation was observed between the phytoplankton and total zooplankton densities. However, Monthly mean value of phaeopigment and *V. cholerae* showed the peak at the same time of Mathbaria Station 2, 7 and 10 and in the Station 2 of Chhatak.

In the *Vibrio* positive ponds of Chhatak (station 2 and 12), at the time of *Vibrio* occurrence, *Trachelomonas volvocina* was dominant. In station 2 of Mathbaria which is *Vibrio* positive, *Euglena* sp. and *Strombomonas* were dominant only in autumn. In the same station during summer and at the time of *Vibrio* occurrence, *Nitzschia longissima* was dominant. Whereas, this species was almost absent in the other seasons. In stations, where *Vibrio* did not occur *Nitz. longissima* was not that much abundant. This finding states that qualitatively *T. volvocina*, *Euglena* sp. and *Strombomonas* might have some relationships with *Vibrio* in Chhatak area. On the other hand, in Mathbaria *V. cholerae* occurrence was associated with *Nitz. longissima* in summer season in most of the stations.

Nitzschia longissima is a diatom which moves in jerking manner and in going to do so this species secretes a lot of gelatinous material in the environment. This material in combination with the degraded products of chlorophyll as phaeophytin might have some relationship with *Vibrio* bacterium. In village area, it is a common belief that cholera occurs after drinking 'rotten water'. When natural water becomes loaded with degraded plant products (i.e. phaeophytin), its color changes to light brown. This might be the concept of our so called "rotten water".

Most *Vibrio* spp., including *V. cholerae*, are characterized by an increased growth rate at warm temperatures, which is evident in the higher rates of isolation in the environment during warm months. Although optimal salinity for growth is between 5 and 25‰, *V. cholerae* is one of the few *Vibrio* spp. that can withstand a salinity of 0‰, provided Na^+ is available (Cavari and Colwell 1981). *V. cholerae* can withstand low-salinity conditions, it is well adapted to both fresh and brackish water of areas of endemicity such as Bangladesh.

Our research findings support the previous hypothesis that small ponds can act as a source of cholera epidemic. Ponds, which serve as the source of village water supply has great potential for spread of cholera (Cockburn and Cassanos 1960). Other study reveals the isolation rate of *V. cholerae* non-O1 is significantly higher in pond compare to river and lake water (Khan *et al*., 1984). Ponds are potential source of *V. cholerae* in endemic areas. Among the 15 studied station, most of our infested stations are pond (Station 2, 7,10 and 11 of Mathbaria and Station 12 of Chhatak). Observation among the studied infested stations of Mathbaria and Chhatak (Table 109) showed that water depth was lowest in the infested station of Chhatak (1.03 m) than Mathbaria (1.29-2.04) site, water temperature was quite higher in Mathbaria (28.10-29.35°C) than Chhatak (25.16-26.60°C), range of alkalinity, salinity and TDS are higher in the infested stations of Mathbaria than Chhatak. On the other hand, average concentrations of SRP, NO_3-N, SRS, phytoplankton biomass as chl. *a* and phaeopigment were found higher in the infested stations of Chhatak than Mathbaria.

Increase of temperature is the major concern to the scientists as an impact of climate change. Further more climatologists forecast increase of temperature in winter and prolongation of rainfall during rainy season in Bangladesh (Ahmed and Alam 1998). In Matlab, seasonal outbreak of cholera is predicted by increase of water temperature (Sack *et al*. 2001) and presence of higher number of *V. cholerae* during times of warm water temperature (Lipp *et al*. 2002). Association of *V. cholerae* with algae is now well known. Blue-green algae and several related algal species serve as reservoir of cholera pathogen during the interepidemic period (Islam 1994a, 1990b, 1993). Warm water temperature may lead to the formation of algal bloom in natural waterbodies and thereby favour *V. cholerae* pathogen. Association of cholera incidence with sea surface temperature and chlorophyll has been reported in several previous studies (Lobitz *et al*. 2000, Colwell, 1996). The present research suggests that where there is chlorophyll there must be phaeopigment. Interestingly there is no report about phaeopigment in relation to cholera. After phytoplankton bloom formation, the next stage is the release of phaeopigment. Phaeopigment can also be released at the time of heavy grazing by zooplankton on phytoplankton.

An important implication of this study is likely to understand the plankton-cholera relationships among the study site of estuarine and inland area of Bangladesh. Given the seasonal variability of phytoplankton, findings from this study suggest that continuous measurements of plankton will be necessary for an extended period of time to develop any meaningful time series for analysis and model development.

CONCLUSION

Pearsons correlation analysis reveals a significant positive correlation between the concentration of phaeopigment and *Vibrio* in Mathbaria Station 2, 7 and 10 and it also showed significant positive correlation between salinity and *Vibrio cholerae* in stations 2 & 10 of Mathbaria and station 2 of Chhatak. Statistics programme RDA also represents the similar results. Phaeopigment (phaeophytin *a*, cholorophyllide *a* and two unidentified pigments) is a degraded product of chl *a*, dominant pigment of phytoplankton. In the analysis, significant positive correlation was also observed between phytoplankton density and total zooplankton. Grazing by copepod (zooplankton) is the major reason for the degradation of chlorophyll *a* to phaeopigment. So, it can be said that, phytoplankton enhances the growth of zooplankton since peak growth of both phyto- and zooplankton is nearly overlapping or occurs side by side. After the peaks achieved, the plankton population start declining during which a lot of phaeopigment is released in the habitat. Phytoplankton density showed a significant negative correlation with water temperature. Under this enriched conditions of phaeopigment in the habitat, peaks of *Vibrio* are mostly observed. In Mathbaria sites *Nitzschia longissima* occurs in abundance at the time of *Vibrio* occurrence. But in the non-infested stations, *Nitzschia longissima* were not dominant. Since it is a pennate diatom which moves from one place to another via secreting a kind of mucilage. So these findings can be used in the early warning system to mitigate cholera outbreak and reducing death.

References

REFERENCES

Acker JG, Harding LW, Leptoukh G, Zhu T, Shen S. 2005. Remotely-sensed Chl-*a* at the Chesapeake Bay Mouth is Correlated with Annual Freshwater Flow to Chesapeake Bay. Geophys Res Lett. **32**: L05601.

Ahmed, A.U. and Alam, M. 1998. Development of climate change scenario, with General Circulation Model. In: Ahmed, A.U. (2006), Bangladesh climate change: impacts and vulnerability, Climate change cell, Department of Environment, p. 6.

Ahmed, Z.U., Khondker, M., Begum, Z.N.T., Hassan, M.A., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rahman, A.K.A. (eds.) 2009. Encyclopedia of Flora and Fauna of Bangladesh. Vol. 4. Algae, Charophyta – Rhodophyta. Asiatic Society of Bangladesh, Dhaka. pp. 543.

Ahmed ZU, Begum ZNT, Hassan MA, Khondker M, Kabir SMH, Ahmed ATA Ahmed, Rahman AKA and Haque EU (eds.) 2008. Encyclopedia of Flora and Fauna of Bangladesh, **vol.3**. Algae, Chlorophyta (Aphanochaetaceae-Zygnemataceae). Asiatic Society of Bangladesh, Dhaka. pp. 812.

Ahmed, A.U. and Alam, M. (1998) Development of climate change scenario, with General Circulation Model. In: Ahmed, A.U. (2006), Bangladesh climate change: impacts and vulnerability, Climate change cell, Department of Environment, p. 6.

Akanda *et al*. 2011. Hydroclimatic Influences on Seasonal and Spatial Cholera Transmission Cycles: Implications for Public Health Intervention in the Bengal Delta. Water Resources Research. **47**:W00H07.

Akanda AS, Jutla AS, Islam S. 2009. Bimodal Cholera Transmission in Bengal Delta: A Hydroclimatological Explanation. Geophy Res Lett. **36**: L19401.

Alam M., Sultana M., Nair G. B., Sack R. B., Sack D. A., Siddique A. K., Ali A., Huq A., Colwell R. R. 2006a. Toxigenic *Vibrio cholerae* in the aquatic environment of Mathbaria, Bangladesh. Appl. Environ. Microbiol. **72**: 2849–2855.

Alam M., Hasan N. A., Sadique A., Bhuiyan N. A., Ahmed K. U., Nusrin S., Nair G. A., B., Siddique A. K., Sack R. B., Sack D. A., Huq A., Colwell R. R. 2006b. Seasonal, cholera caused by *Vibrio cholerae* serogroups O1 and O139 in the coastal aquatic environment of Bangladesh. Appl. Environ. Microbiol. **72**: 4096–4104.

Ali A. 1999. Climate change impacts and adaptation assessment in Bangladesh. Climate Research. **12**: 109-116.

Battish SK 1992. Freshwater Zooplankton of India. Oxford and IBH Publishing Co. Ltd New Delhi.

Begum ZNT 2009. A taxonomic account on the phytoplankton of a pond receiving textile industrial effluents II Euglenophyceae and Bacillariophyceae. Bangladesh J. Plant Taxon. **16** (1): 9 - 19.

Bentivoglio M, Pacini P. Filippo Pacini. 1995. A Determined Observer. Brain Res Bull. **38** (2): 161–165.

Binsztein N., Costagliola MC, Pichel M., *et al.* 2004. Viable but Nonculturable *Vibrio cholerae* O1 in the aquatic environment of Argentina. Appl. Environ. Microbiol. **70**: 7481-7486.

Bishagratna K. 1963. An English Translation of the Sushruta Samhita. Chowkhamba Sanskrit Series Office; Varanasi, India. pp. 352–356.

Bouma MJ, Pascual M. 2001. Seasonal and Interannual Cycles of Endemic cholera in Bengal 1891–1940 in Relation to Climate and Geography. Hydrobiologia. J. Plant Taxon. **460** (1–3): 1573–5117.

Boyd CE 1982. Water Quality Management of Pond Fish Culture. Elsevier Science Publisher Company, Amsterdam, Oxford, New York, pp: 318.

Cash B.A., Rodó X., Kinter J.L., Yunus M. 2010. Disentangling the impact of ENSO and Indian oceanvariability on the regional climate of Bangladesh: Implications for cholera risk. J. Clim. **23**: 2817–2831.

Chturvedi N. 2005. Variability of Chlorophyll Concentration in the Arabian Sea and Bay of Bengal as Observed from SeaWiFS Data from 1997–2000 and its Interrelationship with Sea Surface Temperature (SST) Derived from NOAA AVHRR. Int J Remote Sen. **26**: 3695–3706.

Cockburn TA, Cassanos JG. 1960. Epidemiology of Endemic Cholera. Public Health Reports. **75** (9): 791–803.

Collins AE. 2003. Vulnerability to Coastal Cholera Ecology. Soc Science & Med. **57**: 1397–1407.

Colwell RR. 1966. Global Climate and Infectious Disease: The Cholera Paradigm. Science. **274**: 5295.

Colwell R, Huq A. 2001. Marine ecosystems and cholera. Hydrobiologia. **460**: 141-145.

Colwell RR, Huq A. 1999. Global microbial ecology: biogeography and diversity of *Vibrios* as a model. J of App Microbiol Symp Suppl. **85**:134S–7S.

Colwell RR, Huq A. 1994. Environmental reservoir of *Vibrio cholerae*. The causative agent of cholera. Ann N Y Acad Sci. **740**: 44–54.

Colwell RR, Huq A, Islam MS, Aziz KMA, Yunus M, Khan NH, Mahmud A, Sack RB, Nair GB, Chakraborty DA, Sack DA, Russek-Cohen E. 2003. Reduction of Cholera in Bangladeshi Villages by Simple Filtration. PNAS. **100** (3): 1051–1055.

Colwell RR, Spira WM. 1992. The ecology of *Vibrio cholerae*. eds Barua D, Greenough WB, 3rd edition (New York: Plenum Medical Book Co.) pp. 107–127.

De Magny G.C., Murtugudde R., Sapiano M., Nizam A., Brown C., Busalacchi A., Yunus M., Nair G., Gil A., Lanata C. 2008. De MagnyEnvironmental signatures associated with cholera epidemics. GProc. Natl. Acad. Sci. USA. **105**: 17676–17681.

Desikachary TV 1959. Cyanophyta. Indian Council of Agric. Research, New Delhi. pp.686.

Dillard GE 1989. Freshwater Algae of Southeastern United states. Part 1. Chlorophyceae: Volvocales, Tetrasporales and Chlorococcales. Bibl. Phycol. Vol. **81**. J. Cramer, Berlin, 202 pp. + 37 pls.

Epstain PR 1993. Algal bloom in the spread and persistence of cholera. Biosystems **31**: 209-221.

Emch M, Feldacker C, Yunus M, Streatfield PK, Thiem V, Canh D, Mohammad A. 2008. Local Environmental Predictors of Cholera in Bangladesh and Vietnam. Am J Trop Med Hyg. **78**: 823–832.

FAO 2005. Special Event on Impact of Climate Change, Pests and Diseases on Security and Poverty Reduction. Paper presented to the 31st Session of the Committee on World Food Security, 23-26 May 2005 in Rome. Food and Agriculture Organization of the United Nations, Rome.

Fisman DN. 2007. Seasonality of infectious diseases. Annual Review of Public Health. **28**: 127 - 143.

Garcia GE, Carr M. 1999. The Climatological Annual Cycle of Satellite Derived Phytoplankton Pigment in the Alboran Sea. Geophys Res Lett. **26** (19): 2985–2988.

Germain H 1981. Flora Des Diatomees, Diatomophyceaes. Soc. Nouv. Des. Edin. Boubee. Paris. pp. 444.

Glass, R. I., S. Becker, M. I. Huq, B. J. Stoll, M. U. Khan, M. H. Merson, J. V. Lee & R. E. Black. 1982. Poverty Reduction. Endemic cholera in rural Bangladesh, 1966–1980. Am. J. Epidem. **116**: 959–970.

Gleick P. 2008. The World's Water 2008–2009: The Biennial Report on Freshwater Resources. Island Press; USA: 2008.

Gonçalves E., Da G., Lopes M. J. *et al.* 2004. Associação de *Vibrio cholerae* com o zooplâcton de águas estuárias da Baía de São Marcos/São Luis- MA, Brasil. Rev. Soc. Bras. Med. Trop. **37**: 318-323.

Hardy A. 1993. Cholera, quarantine and the english preventive system, 1850-1895. Med History. **37**: 250–69.

Hood Tamplin M., Carrillo C. 1991. Environmental spread of *Vibrio cholerae* in Peru. Lancet. **338**: 1216-1217.

Hossain MY, Jasmine S, Ibrahim AHM, Ahmed ZF and J Ohtomi. 2007. A Preliminary observation on water quality and plankton of an earthen fish pond in Bangladesh: Recommendation for future studies. Pak. J. Biol. Sci. **10**: 868 - 873.

Huq A, Colwell RR. 1996. Vibrios in the Marine and Estuarine Environment: Tracking of *Vibrio cholerae*. J Ecosystem Health. **2**: 198–214.

Huq, A., P. A. West, E. B. Small, M. I. Huq & R. R. Colwell, 1984. Influence of water Temperature, salinity and pH on survival and growth of toxigenic *Vibrio cholera* Serovar 01 associated with livecopepods in laboratory microcosms. Applied and Envir. Microb. **48**: 420–424.

Huq A, Sack RB, Nizam A, Longini IM, Nair GB, Ali A, Morris JG, Khan MNH, Siddique AK, Yunus M, Albert MJ, Sack DA, Colwell RR. 2005. Critical Factors Influencing the

Occurrence of Vibrio Cholerae in the Environment of Bangladesh. Appl Environ Microbiol. **71**(8): 4645–4654.

Huber-Pestalozzi GH 1955. Das Phytoplankton des Süßswassers: Systematik und Biologie. Euglenophyceen E. Schweizerb. Verlagsb. (Nägele u. Obermiller), Stuttgart, Germany. pp. 606 + Pls. 1 - 114.

Huber-Pestalozzi GH 1961. Das Phytoplankton des Süßswassers. Systematik und Biologie. 5. Teil: Chlorophyceae (Grünalgen), Ordnung: Volvocales. E. Schweizerb. Verlagsb. (Nägele u. Obermiller), Stuttgart, Germany. pp. 744 + pls. 157.

Huber-Pestalozzi GH 1968. Das Phytoplankton des Süßswassers. Systematik und Biologie. 3. Teil: Cryptophyceae, Chloromonadophyceae, Dinophyceae. E. Schweizerb. Verlagsb. (Nägele u. Obermiller), Stuttgart, Germany. pp. 322.

Huber-Pestalozzi GH 1983. Das Phytoplankton des Süßswassers. Systematik und Biologie. 7. Teil: 1 Hälfte Chlorophyceae. Schweizerb. Verlagsb. (Nägele u. Obermiller), Stuttgart, Germany. pp. 1044.

IPCC. 2007. The physical science basis. Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change.

Islam AKMN and Alfasane MA. 2004. Euglenophyceae from Barisal district, Bangladesh: III. Genus *Trachelomonas* Ehr. Bangladesh J. Plant Taxon. **11** (2): 33 - 38.

Islam AKMN and Alfasane MA 2002. Euglenophyceae from Barisal district, Bangladesh: I. Genus *Phacus.* Bangladesh J. Plant Taxon. **9** (2): 3 - 18.

Islam AKMN and Begum ZNT 1970. Studies on the phytoplankton of Dacca district. J. Asiatic Soc. Pakistan **15**: 227 - 271.

Islam AKMN and Khondker M 1981. Euglenophyta of Bangladesh I. Genus *Trachelomonas*. Ehr. Int. Revue. ges. Hydrobiol. **66** (1): 109 - 125.

Islam MS, Alam MJ, Neogi PKB (1992). Seasonality and toxigenicity of *Vibrio cholerae* non-O1 isolated from different components of pond ecosystems of Dhaka city, Bangladesh. World Journal of Microbiology and Biotechnology. **8**: 160–163.

Islam MS, Brooks A, Kabir MS, Jahid IK, Islam MS, Goswami D, Nair GB, Larson C, Yukiko W, Luby S. 2006. Fecal Contamination of Drinking Water Sources of Dhaka city During the 2004 Peak Flow in Bangladesh. J Appl Microbiol. 80–87.

Islam, M.S., Drasar, B.S. and Sack, R.B. 1994a. The aquatic flora and fauna as reservoirs of *Vibrio cholerae*: A review. J. Diarrhoeal Dis. Res, **12**: 87-96.

Islam, M.S., Drasar, B.S. and Sack, R.B. 1994b. Probable role of Blue-green algae in maintaining endemicity and seasonality of cholera in Bangladesh: A hypothesis. J. Diarrhoeal Disease Research. **12**(4): 245-256.

Islam, M.S., Mia, M.A., Hasan M.K., Sack, R.B. and Albert, M.J. 1994c Detection of non-culturable Vibrio cholerae O1 associated with a cyanobacterium from an aquatic environment in Bangladesh. Transactions of the Royal Society of Tropical Medicine and Hygiene. **88**: 298-299.

Islam, M.S., Drasar, B.S. and Sack, R.B. (1993) The aquatic environment as a reservoir of *Vibrio cholerae*: Areview. J. Diarrhoeal Disease Research. **11** (4): 197-206.

Islam, M.S., Harun-or-Rashid M, Aziz KMS, Huq MI, Choudhury AA, Rahim MZ. 1983. A Preliminery Servey of isolation of culturable Vibrios from water plants, water and soil Sediments in ponds of Dhaka city (Abstract). In. Proceedings of 2nd Asian Conference of Diarrhoeal Diseases. p. 23.

Jutla, A. S., A. S. Akanda, and S. Islam 2010. Tracking cholera in coastal regions using satellite observations J. Am. Water Resour. **46** (4): 651-662.

Jutla AS, Akanda AS, Islam S. 2009a. Relationship between Phytoplankton, Sea Surface Temperature and River Discharge in Bay of Bengal. Geophysical Reasearch Abstracts: EGU2009–1091–2, EGU General Assembly 2009. Vienna, Austria.

Jutla AS, Akanda AS, Islam S. 2009b. Satellites and Human Health: Potential for tracking cholera outbreaks. American Geophysical Union, Fall Meeting; San Francisco, USA.

Khondker M, RA Bhuiyan, J Yeasmin, M Alam, RB Sack, A Huq and RR Colwell. 2006a. New records of phytoplankton for Bangladesh. 1. Cyanophyceae. Bangladesh J. Bot. **35** (2): 173-179.

Khondker M, RA Bhuiyan, J Yeasmin, M Alam, RB Sack, A Huq and RR Colwell. 2006b. New records of phytoplankton for Bangladesh. 2. Cryptophyceae and Synurophyceae. Bangladesh J. Bot. **36** (1): 53-59.

Khondker M, RA Bhuiyan, J Yeasmin, M Alam, RB Sack, A Huq and RR Colwell. 2007a. New records of phytoplankton for Bangladesh. 3. Volvocales. Bangladesh J. Plant Taxon. **14** (1): 1-12.

Khondker M, RA Bhuiyan, J Yeasmin, M Alam, RB Sack, A Huq and RR Colwell. 2007b. New records of phytoplankton for Bangladesh. 4. Chlorococcales. Bangladesh J. Plant Taxon. **14** (2): 83-91.

Khondker M, RA Bhuiyan, J Yeasmin, M Alam, RB Sack, A Huq and RR Colwell. 2008a. New records of phytoplankton for Bangladesh. 5. *Euglena*, *Euglenocapsa*. Bangladesh J. Plant Taxon. **15** (1): 39-46.

Khondker M, RA Bhuiyan, J Yeasmin, M Alam, RB Sack, A Huq and RR Colwell. 2008b. New records of phytoplankton for Bangladesh. 7. *Phacus* Bangladesh J. Bot. **37**(1): 83-89.

Khondker M, RA Bhuiyan, J Yeasmin, M Alam, RB Sack, A Huq and RR Colwell. 2008c. New records of phytoplankton for Bangladesh. 8. *Trachelomonas* Ehr. Bangladesh J. Bot. **37** (2): 133-139.

Koelle K, Pascual M, Yunus Md. 2005. Pathogen adaptation to seasonal forcing and climate change. Proceedings of the Royal Society. B: Biological Sciences. **272** (1566): 971–977.

Legaard KL, Thomas AC. 2006. Spatial Patterns in Seasonal and Interannual Variability of Chlorophyll and Sea Surface Temperature in the California Current. J Geophys Res. **111**: C06032.

Lipp E, Huq A, Colwell R. 2002. Effects of global climate on infectious disease: the cholera model. Clin. Microbiol Rev. **15** (4):757–770.

Ling HU and Tyler PA 2000. Australian Freshwater Algae (exclusive of diatoms). Bibl. Phycol. Bd. J. Cramer, Berlin. Pp 643+ 159 pls.

Lobitz B., Beck L., Huq A., Wood B., Fuchs G., Faruque A.S.G., Colwell R. 2000. Climate and infectious disease: Use of remote sensing for detection of *Vibrio cholerae* by indirect measurement. Proc. Natl. Acad. Sci. **97**: 1438–1443.

Longini, I. M., Jr., et al. 2002. Epidemic and endemic cholera trends over a 33-year period in Bangladesh. J. Infect. Dis. **186**: 246–251.

Louis V.L., Russek-Cohen E., Choopun N., Rivera I.N.G., Gangle B., Jiang S.C., Rubin A., Patz J.A., Huq A., Colwell R.R. 2003. Predictability of Vibrio cholera in Chesapeake Bay. Appl. Environ. Microbiol. **69**: 2773–2785.

Mackereth FJH, Heron J and Talling JF. 1978. Water analysis: some revised methods for limnologists. Freshwater. Biol. Assoc. Pub. PP: 120.

Marker AFH, Nusch EA, Rai H and Riemann B. 1980. The measurement of photosynthetic pigments in freshwater and standardization of methods: conclusion and recommendations. Arch. Hydrobiol. Beih. Ergebn. Limnol. **14**: 91 - 106.

Martin AR, Mosely WH, Sau BB, Ahmed S, Huq I: Epidemiologic analysis of endemic cholera in urban East Pakistan, 1964–1966. American Journal of Epidemiology 1969. **89** (5):572.

Martin Y. P., Bianchi M. A. 1980. Structure, diversity and catabolic potentialities of aerobic heterotrophic bacterial population associated with continuous cultures of natural marine phytoplankton. Microb. Ecol. **5**: 265.

McCormack WM, Mosley WH, Fahimuddin M, Benenson AS. 1969. Endemic Cholera in Rural East Pakistan. American Journal of Epidemiology. **89** (4):393.

Merson MH, Black RE, Khan MU, Huq I, 1980. Enterotoxigenic *Escherichia coli* diarrhoea: acquired immunity and transmission in an endemic area. Cholera and Related Diarrheas: Molecular Basis of a Global Health Problem. 43rd Nobel Symposium. Basel, Switzerland: S. Karger, 34–45.

Mourina-Perez, R. R. 1998. Oceanography and the 7th cholera pandemic. Epidemiology **9**: 355-357.

Müller R and Wiedemann 1955. Die Bestimmung des Nitrats in Wasser. Jahrbuch für Wasserchemie and Wasserreiningungstechnik. Verlag Chemie, Reinbek **12**: 247 - 271.

Murphy J and Riley JP 1962. A modified single solution method for the determination of phophprus in natural waters. Analyt. Chem. Acta **27**: 31 – 36.

Mutreja A, Kim DW, Thomson NR, Connor TR, Lee JH, Kariuki S, Croucher NJ, Choi SY, Harris SR, Lebens M, Niyogi SK, Kim EJ, Ramamurthy T, Chun J, Wood JL, Clemens JD, Czerkinsky C, Nair GB, Holmgren J, Dougan G 2011. Evidence for several waves of global transmission in the seventh cholera pandemic. Nature. **477** (7365): 462-465.

Nalin, D. 1976. Cholera, copepods and chitinase. Lancet. **2** (7992): 958.

Oppenheiner JR, Ahmed MG, Huq A, Alam AKMA, Aziz KMS, Ali S and Haque ASMM 1978. Limnological studies of three ponds in Dhaka, Bangladesh. Bangladesh J. Fish. **1** (1): 1-28.

Pascual M, Bouma MJ, Dobson AP. 2002.Cholera and climate: revisiting the quantitative evidence. Microbes Infect. **4** (2): 237–45.

Patz, J.A., Lendrum, D.C., Holloway, T. and Foley, J. A. 2005. Impact of Regional Climate Change on Human Health. Nature. **438**: 310-317.

Pollitzer, R., 1959. Cholera. Monograph. WHO. Rasmusson, E. M. & T. H. Carpenter, 1983. The relationship between Eastern Equatorial Pacific sea surface temperatures and rainfall over India and Srilanka Monthly Weather Review. **111**: 517–528.

Prescott GW 1982. Algae of the Western Great Lakes Area. Otto Koeltz Sci. Publ., W-Germany. 977 pp.

Rao KS 1993. “Recent advancement in Fresh water biology”, Anmol Publishing Pvt. Ltd. New Delhi.

Rashid, H.E. 1991. Geography of Bangladesh. 2nd ed. Univ. Press Ltd. Pp. 529.

Reidl J, Klose KE. 2002. *Vibrio Cholerae* and cholera: out of the water and into the host. FEMS Microbiology Reviews. **26** (2): 125–139.

Reynolds C. 1984. The ecology of freshwater phytoplankton. Freshwater Biol. Ass. Cambridge Univ. Press. Cambridge. PP: 384.

Sack RB, Siddique AK, Huq A, Longini IM, Nair GB, Qadri F, Yunus M, Albert MJ, Sack DA, Colwell RR. 2003. A 4-Year Study of the the Epidemiology of *Vibrio Cholerae* in Four Rural Areas of Bangladesh. J Infectious Diseases. **187**: 96-101.

Sakazaki R and Shimada T (1977) Serovars of Vibrio cholerae. Jpn. J. Med. Sci. Biol. **30**: 279-282.

Samadi, A. R., N. K. Chowdhury, M. I. Huq, and M. U. Khan. 1983. Seasonality of classical and EI Tor cholera in Dhaka, Bangladesh: 17 year trends. Trans R. Soc. Trop. Med. Hyg. **77**: 853-856.

Shilo, M. 1975. Factors involved in dynamics of algal blooms in nature, p. 127-132. In W. H. van Dobben and R. H. Lowe-McConnell (ed.), Unifying concepts in ecology. Dr. W. Junk B.V. Publishers, The Hague, The Netherlands.

Siddique AK, Zaman K, Akram K, Mutsuddy P. 1994.Emergence of a New Epidemic Strain of *Vibrio Cholerae* in Bangladesh: An Epidemiological Study. Trop Geograph Med. **46**: 147–150.

Siddiqui KU, Ahmed MA, Ahmed ZU, Begum ZNT, Hassan MA, Khondker M, Kabir SMH, Ahmad M, Ahmed ATA, Rahman AKA and Haque EU (eds.). 2007. Encyclopedia of Flora and Fauna of Bangladesh, vol. 2. Cyanobacteria, Bacteria and Fungi. Asiatic Society of Bangladesh, Dhaka.

Silvery, J. K. G., and A. W. Roach. 1964. Studies on microbiotic cycles in surface waters. J. Am. Water Works Assoc. **56:** 60-72.

Skuja H 1956. Taxonomische und biologische studien über das phytoplankton Schwedischer binnengeswässer. Nova. Acta. Reg. Soc. Sci. Upsaliensis, Ser. 4, **16** (3): 1-404 + pls 1 - 73.

Smith, G. 1950. The freshwater algae of the United States. 2nd Ed. McGraw-Hill Book Company, New York, pp. 1 - 719.

Smyth TJ, Miller PI, Groom SB, Lavender SJ. 2001. Remote Sensing of Sea Surface Temperature and chlorophyll during Lagrangian Experiments at the Iberian Margin. Prog Oceanogr. **51**: 269–281.

Starmach K 1966. Cyanophyta-sinice, Glaucophyta-Glaukofity. Flora Slodkowodna PolskiTom-2. Polska Akademia Nauk, Warszawa. pp. 806.

Tamplin M. L., Gauzens A. L., Huq A. *et al*. 1990. Attachment of *Vibrio cholerae* serogroup O1 to zooplankton and phytoplankton of Bangladesh Appl. Environ. Microbiol. **56**: 1977-1980.

UNEP 2007. Global Environment Outlook GEO 4. Nairobi: United Nations Environnent Programme. http://www.unep.org/geo/geo4/report/04_water.pdf

Uz BM, Yoder JA. 2004.High Frequency and Mesoscale Variability in Sea WiFS Chlorophyll Inagery and its Relation to Other Remotely Sensed Oceanographic Variables. Deep-Sea Res- II. **51**: 1001-1071.

Vaulot, D. 2001.Phytoplankton. Encyclopedia of Life Sciences. Nature Publishing Group. London. http://www.els.net

Wetzel RG and Likens GE 1979. Limnological analysis. WB Saunders Co. Philadelphia. PP: 357.

Yamagishi T 1998. Guide book to Photomicrographs of the freshwater algae. Uchida, Rokakuho, Japan. pp. 132.

Appendices

APPENDIX

(Phytoplankton flora of the studied stations)

MATHBARIA

Photomicrographs of phytoplankton

(Magnification of the images ranges from 400 - 1000×)

Station 2

Plate 1

Fig. 1. *Euglena* sp.

Fig. 2,3. *Euglena rostifera* Johnson

Fig. 4. *Euglena variabilis* Klebs

Fig. 5,6. *Euglena allorgei* Defl.

Fig. 7. *Stephanodiscus*

Fig. 8. S*trombmonas*

Fig. 9. *Str*. *Verrucosa* var. borystheniensis (Roll) Defl.

Fig. 10, 13 *Mallomonas*

Fig. 11. *Str*. *Verrucosa*

Fig. 12, 14. *Trachelomonas*

Fig. 15, 16. *Palonema aphane*

Plate - 1

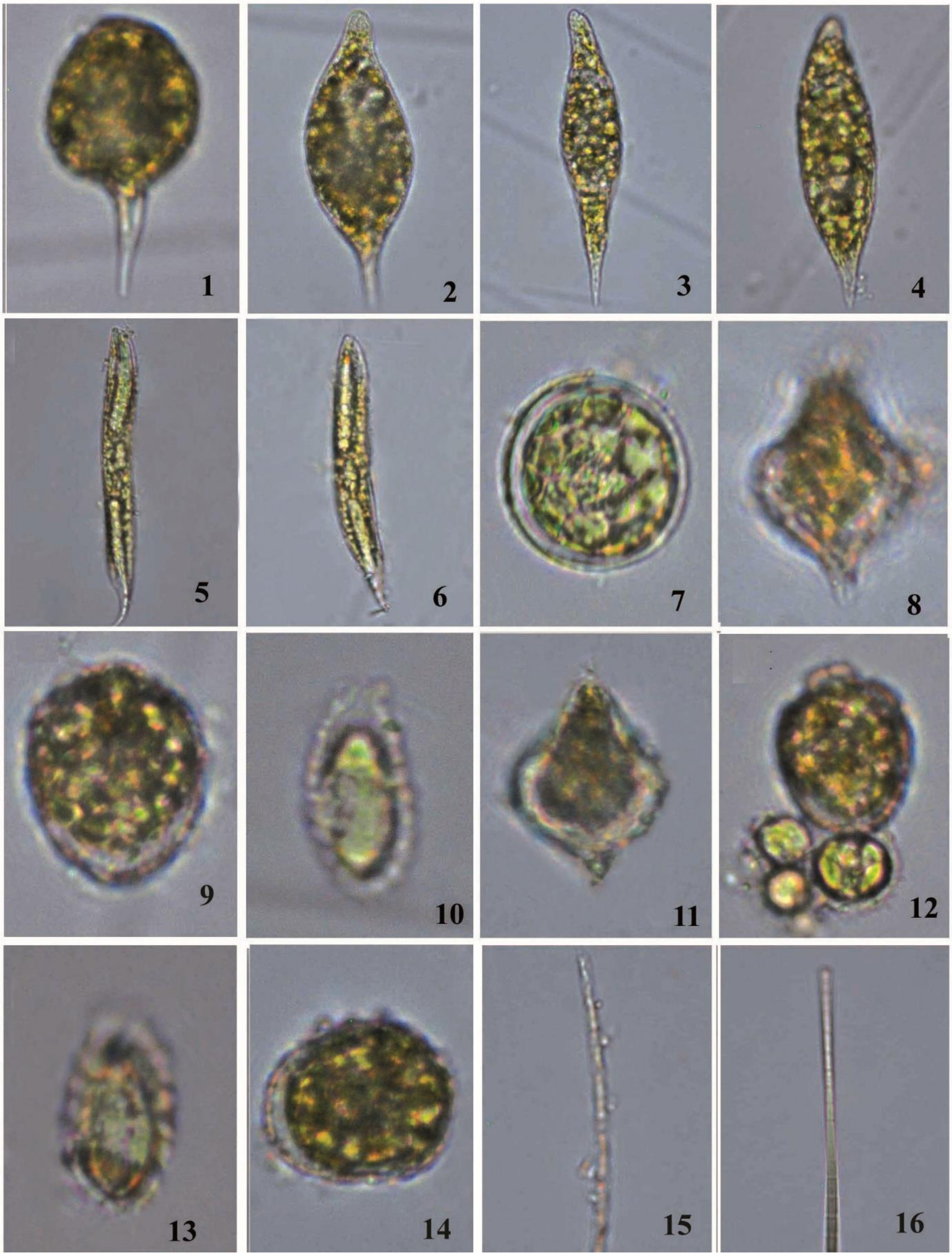


Plate 2

Fig. 17, 18. *Phacus longicauda* var. major suir.

Fig. 19. *Euglena tripteris* (Dujardin) Klebs.

Fig. 20. *E. acus* (Müller) Klebs.

Fig. 21. *Mallomonas*

Fig. 22. *Euglena* sp.

Fig. 23. *Coscinodiscus*

Fig. 24. *Tetraedron limneticum* Barge.

Fig. 25. *Chlorococcum*

Fig. 26. *Peridinium*

Fig. 27. *Chroomonas acute* Utermohl.

Fig. 28, 30. *Nitzschia acicularis* (Kütz.) W. Smith

Fig. 29. *Palonema aphane*

Fig. 31. Melosira

Plate - 2

Plate 3

Fig. 33. Melosira

Fig34, 35. *Nitzschia acicularis* (Kütz.) W. Smith

Fig. 36, 37. *Euglena acus* (Müller) Klebs.

Fig. 38. *Euglena oxyuris*

Fig. 39. *Nitzschia acicularis* var. closterioids

Fig. 40. *Palonema aphane*

Fig. 41, 42, 43, 45. *Euglena* sp.

Fig. 44. *Lepocinclis*

Fig. 46. *Chaetoceros*

Fig. 47. *Oscillatoria*

Fig. 48. *Chlorococcum*

Plate - 3

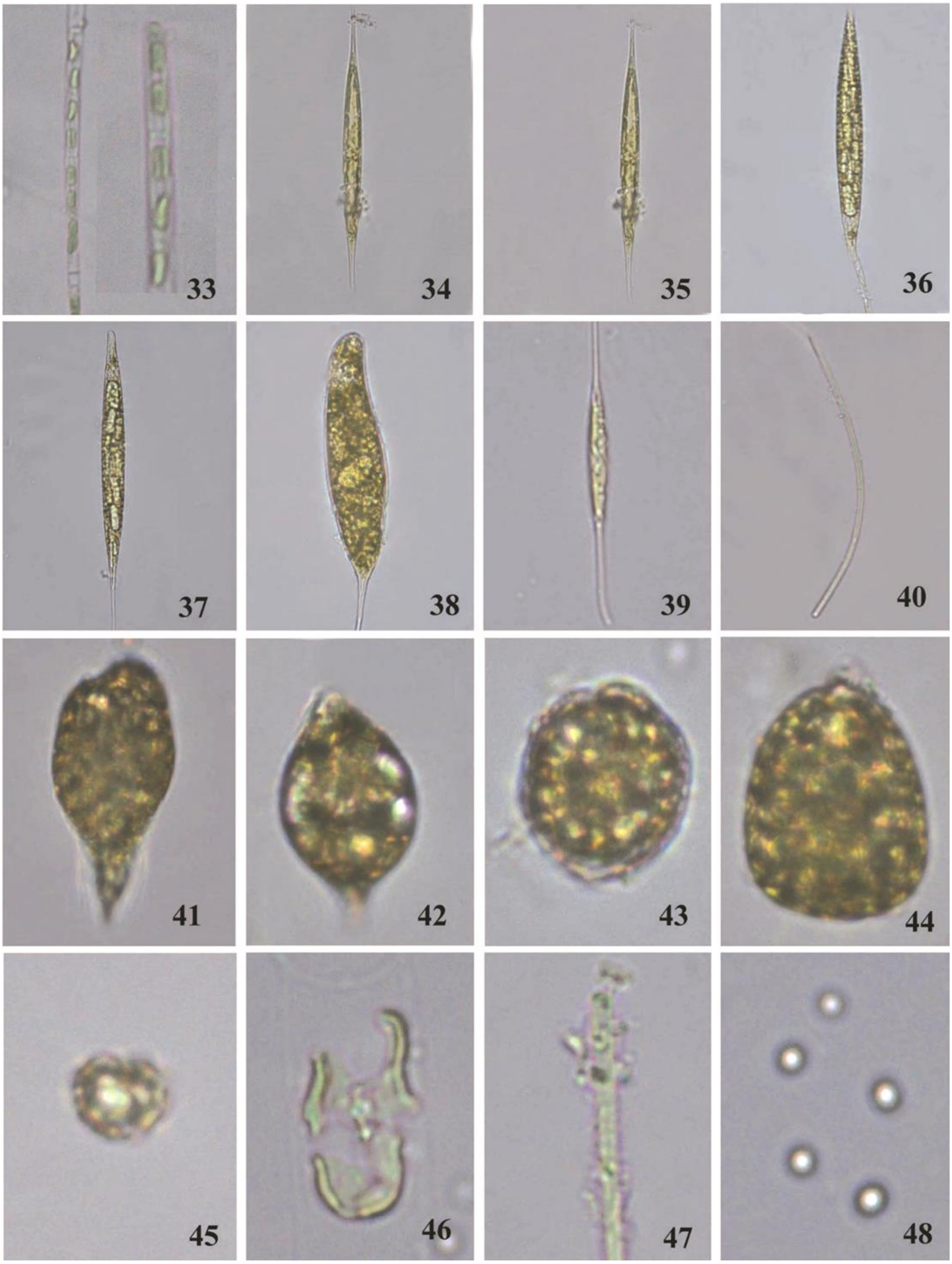


Plate 4

Fig. 49, 50, 51, 52, 53. *Euglena* sp.

Fig. 54. *Euglena tripteris*

Fig. 55. *E. acus*

Fig. 56, 63. *Mallomonas*

Fig. 57. *Nitz acicularis*

Fig. 58. *Palonema*

Fig. 59. *Synedra*

Fig. 60. *Melosira*

Fig. 61. *Coelosphaerium*

Fig. 62. *Chaetoceros*

Plate - 4

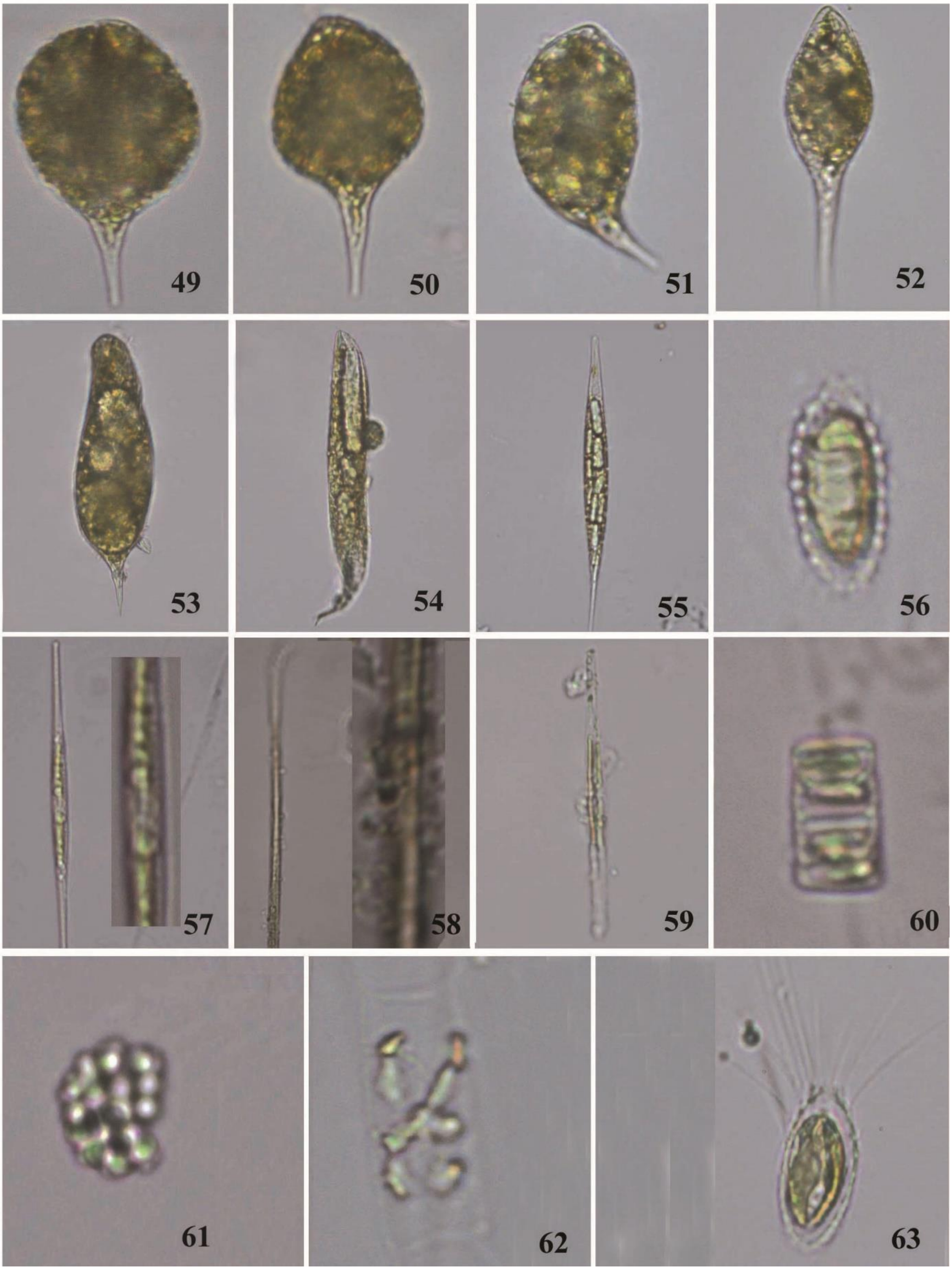


Plate 5

Fig. 65, 66 67. *Coscinodiscus*

Fig. 68. *Peridinium*

Fig. 69, 70, 71, 72. *Cryptomonas*

Fig. 73. *Euglena* sp.

Fig. 74. *Euglena oxyuris*

Fig. 75. *Oscillatoria*

Fig. 76. *Palonema*

Fig. 77. S*trombmonas*

Fig. 78. *Fragilaria*

Fig. 79. *Pediestrum duplex*

Fig. 80. *Phosmidium*

Plate - 5

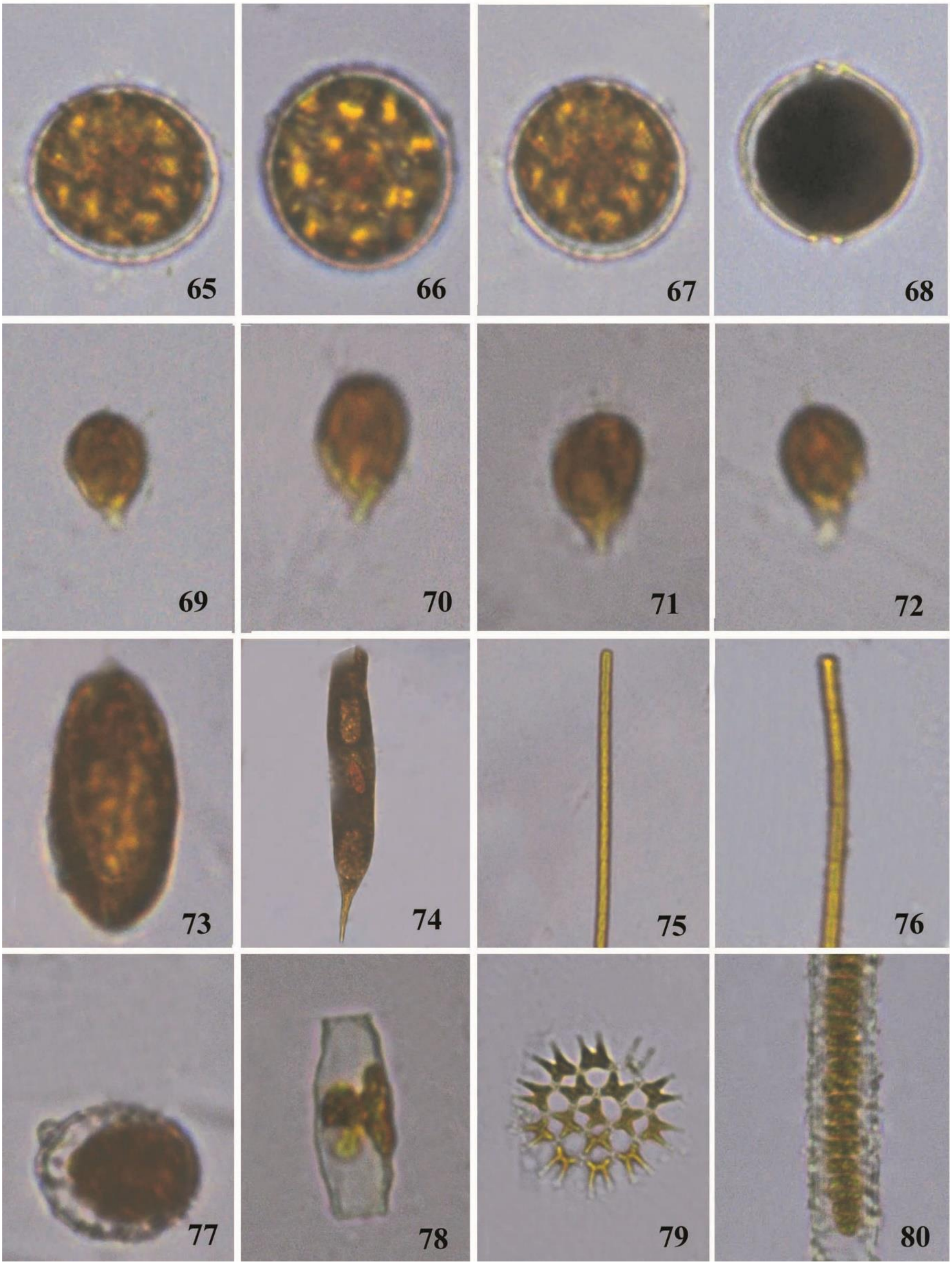


Plate 6

Fig. 81. *Lepocinclis*

Fig. 82. S*trombmonas*

Fig. 83, 86, 89. *Euglena* sp.

Fig. 84. *Peridinium*

Fig. 85. *E. tripteris*

Fig. 86. *Euglena*

Fig. 87. *Mallomonas*

Fig. 88. S*trombmonas bonariensis* (Seekt) HP.

Fig. 90. *Coscinodiscus*

Fig. 91. *Coelastrum*

Fig. 92. *Melosira*

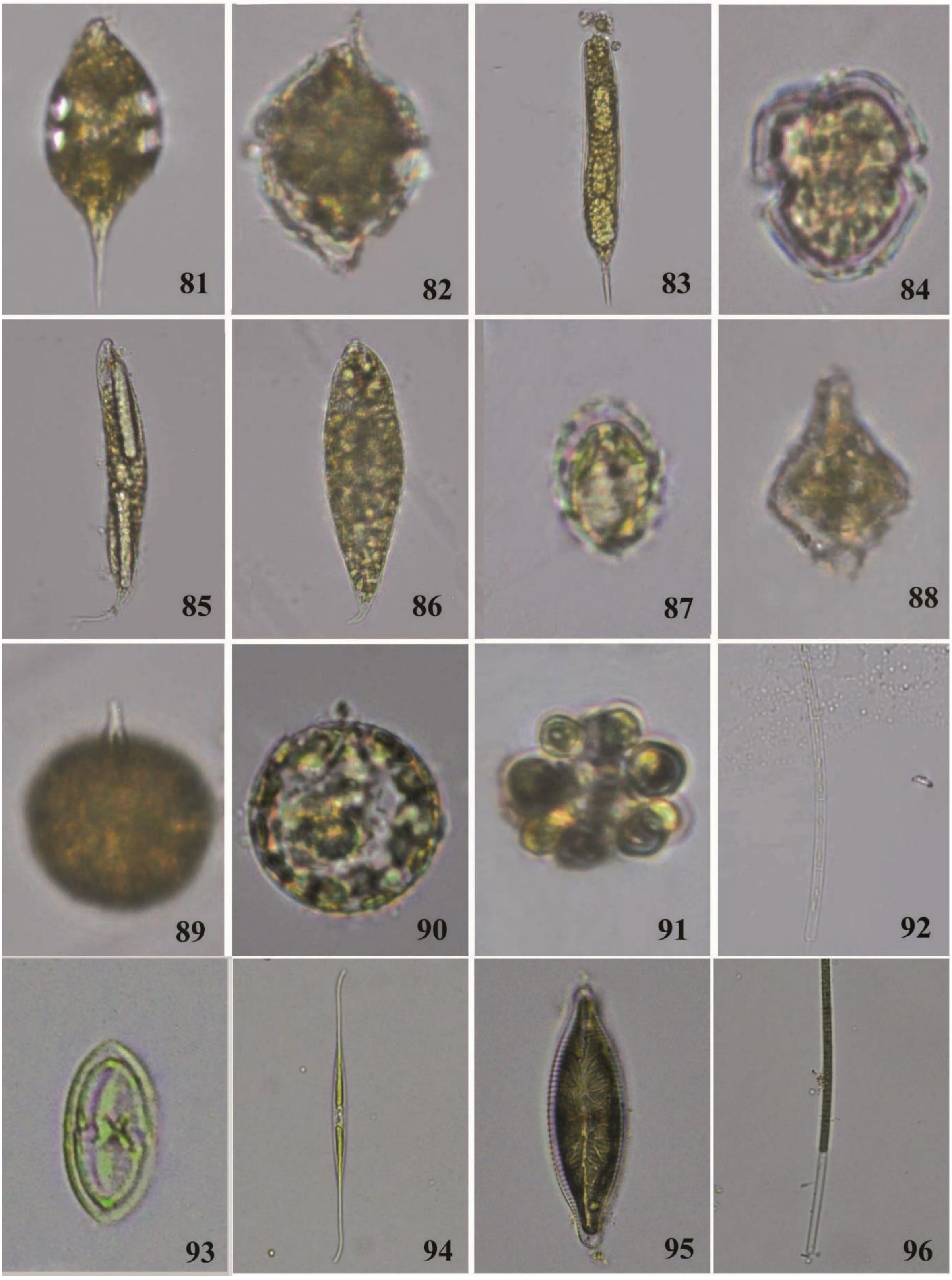
Fig. 93. *Nitzschia tryblionella*

Fig. 94. *Nitzschia longissima*

Fig. 95. *Navicula*

Fig. 96. *Lyngbya*

Plate - 6



Station 5

Plate 1

Fig. 1. *Phacus ranula* Pochman

Fig. 2, 7. *Euglena* sp.

Fig. 3, 8. *E. acus*

Fig. 4. *E. oxyuiris* var. *minor* Prescott

Fig. 5. Phacus

Fig. 6. *Chlorococcum*

Fig. 9. *Closteriopsis*

Fig. 10, 11. *Pelonema*

Fig. 12. *Chaetoceros*

Fig. 13. *Oscillatoria*

Fig. 14. *Rhizosolenia*

Fig. 15. *Peridinium*

Fig. 16. *Coelastrium microporum*

Plate - 1

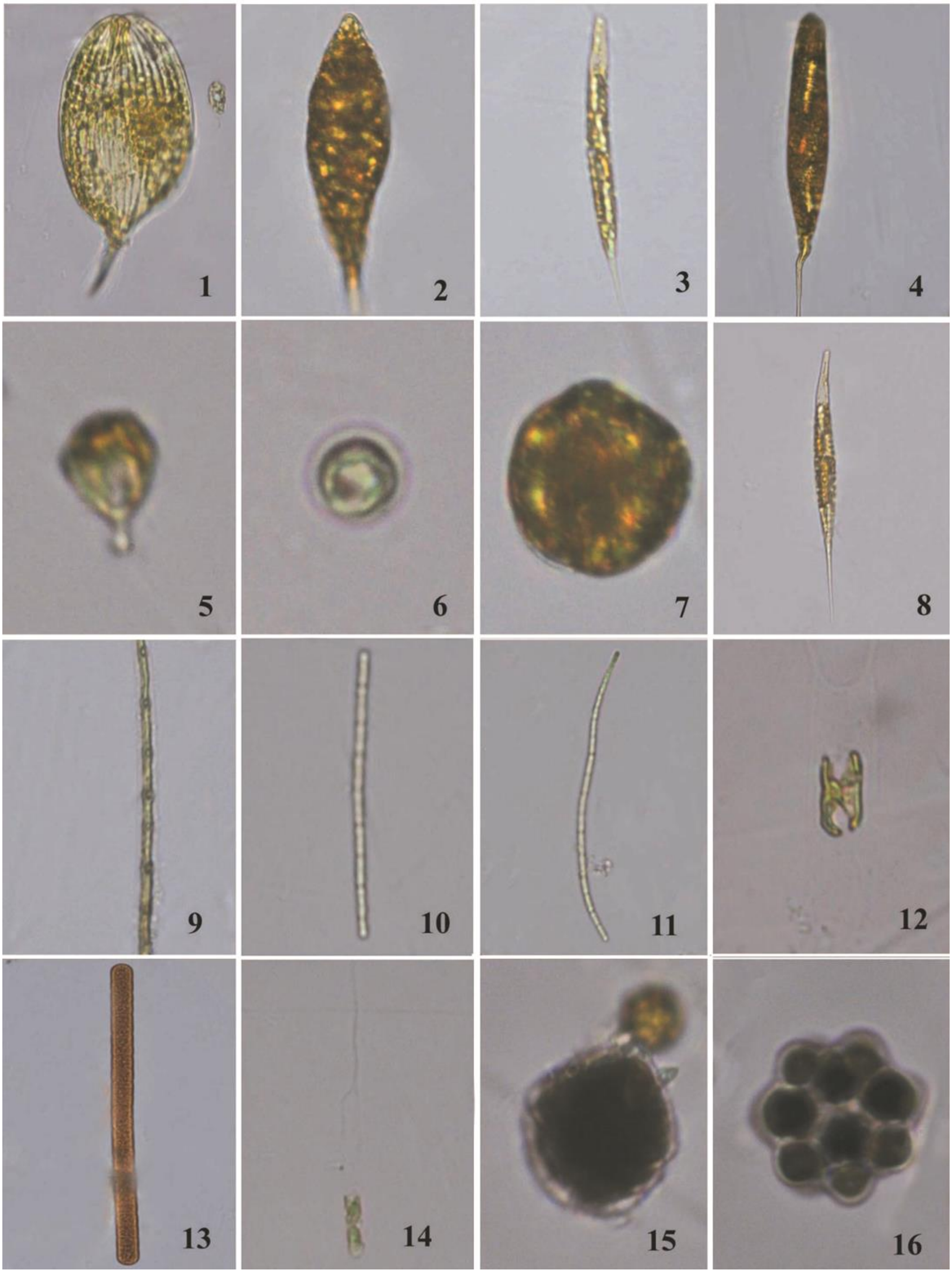


Plate 2

Fig. 17. *Characium*

Fig. 18, 19. *Strombomonas napiformis*

Fig. 20. *Str*. *flwiatilis* (Lemn.) Defl.

Fig. 21. *Euglena* (cyst)

Fig. 22, 23, 24, 26, 29, 30, 31. *Euglena* sp.

Fig. 25. *Trachelomonas hispida*

Fig. 27. *Tr. volzi* var. *cylindrica* Playf.

Fig. 28. *Cyclotella*

Fig. 32. *Synnechocystis*

Plate - 2

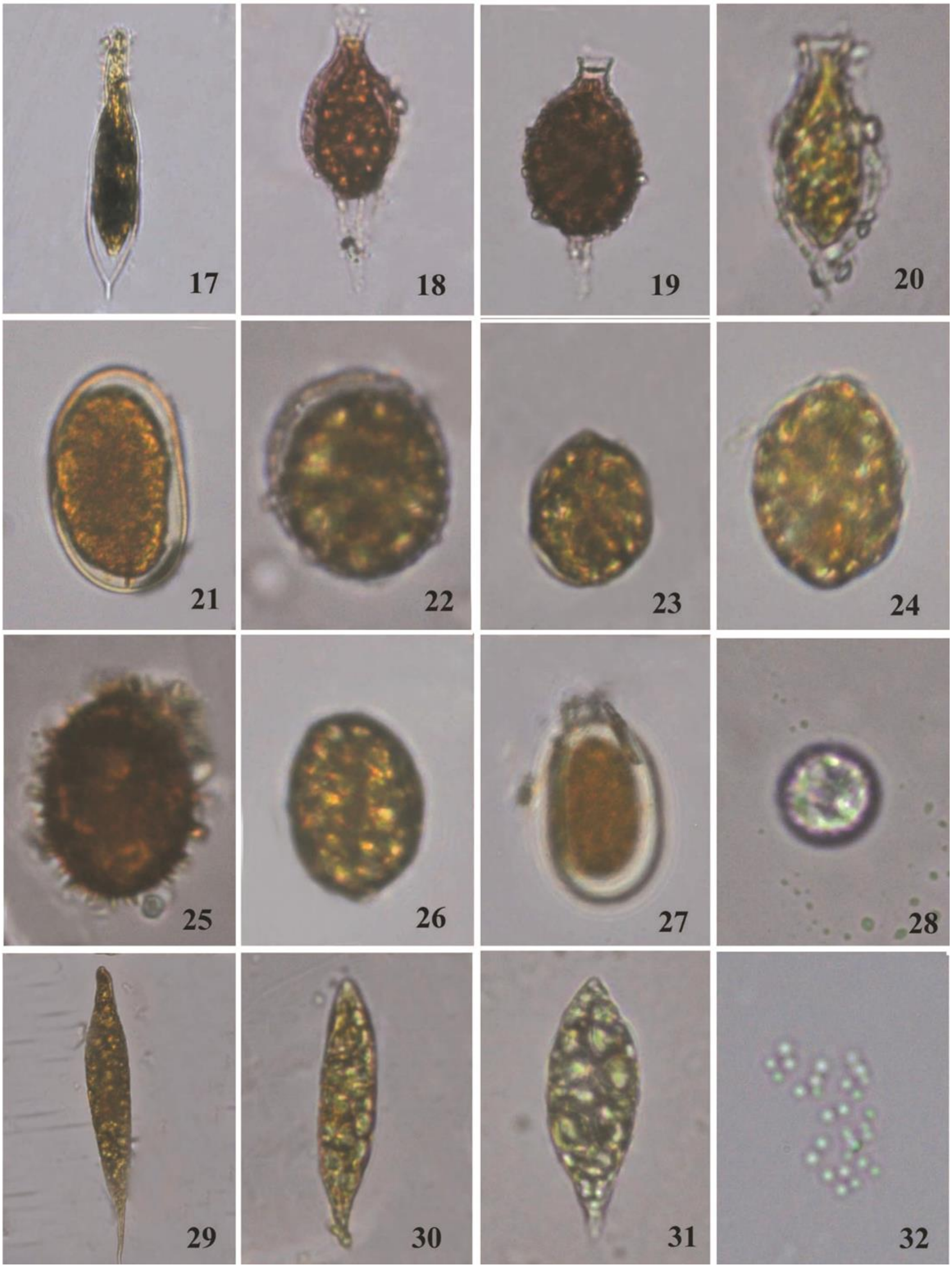


Plate 3

Fig. 33-37. *Euglena* sp.

Fig. 38-40, 45. *Trachelomonas*

Fig. 41-42. *Cyclotella*

Fig. 43-44. *Peridinium*

Fig. 46. *Rhizosolenia*

Fig. 47. *Closteriopsis*

Fig. 48. *Scenedesmus*

Plate - 3

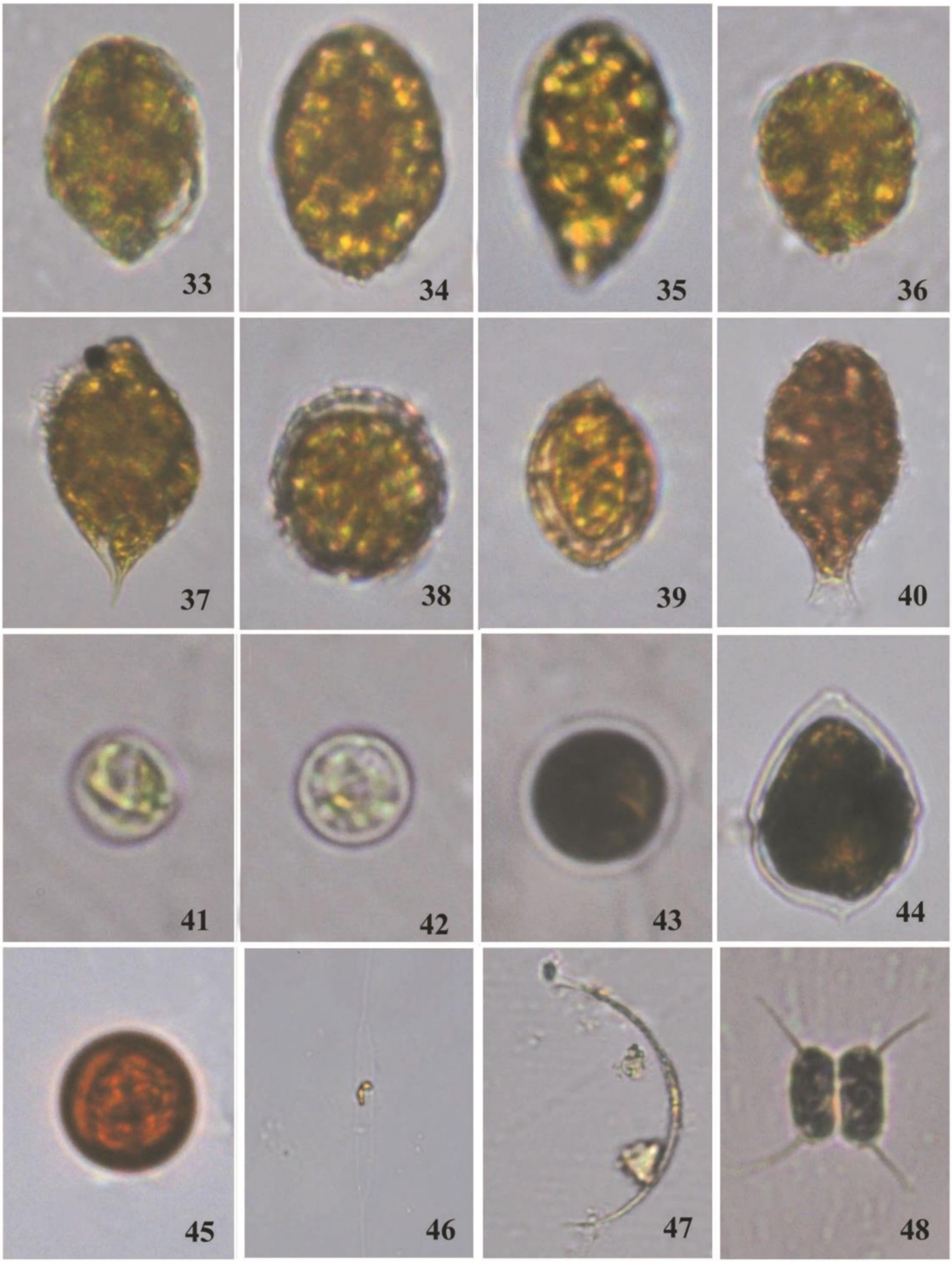


Plate 4

Fig. 49. *Euglena sp.lendens* Dang.

Fig. 50-51. *Phacus*

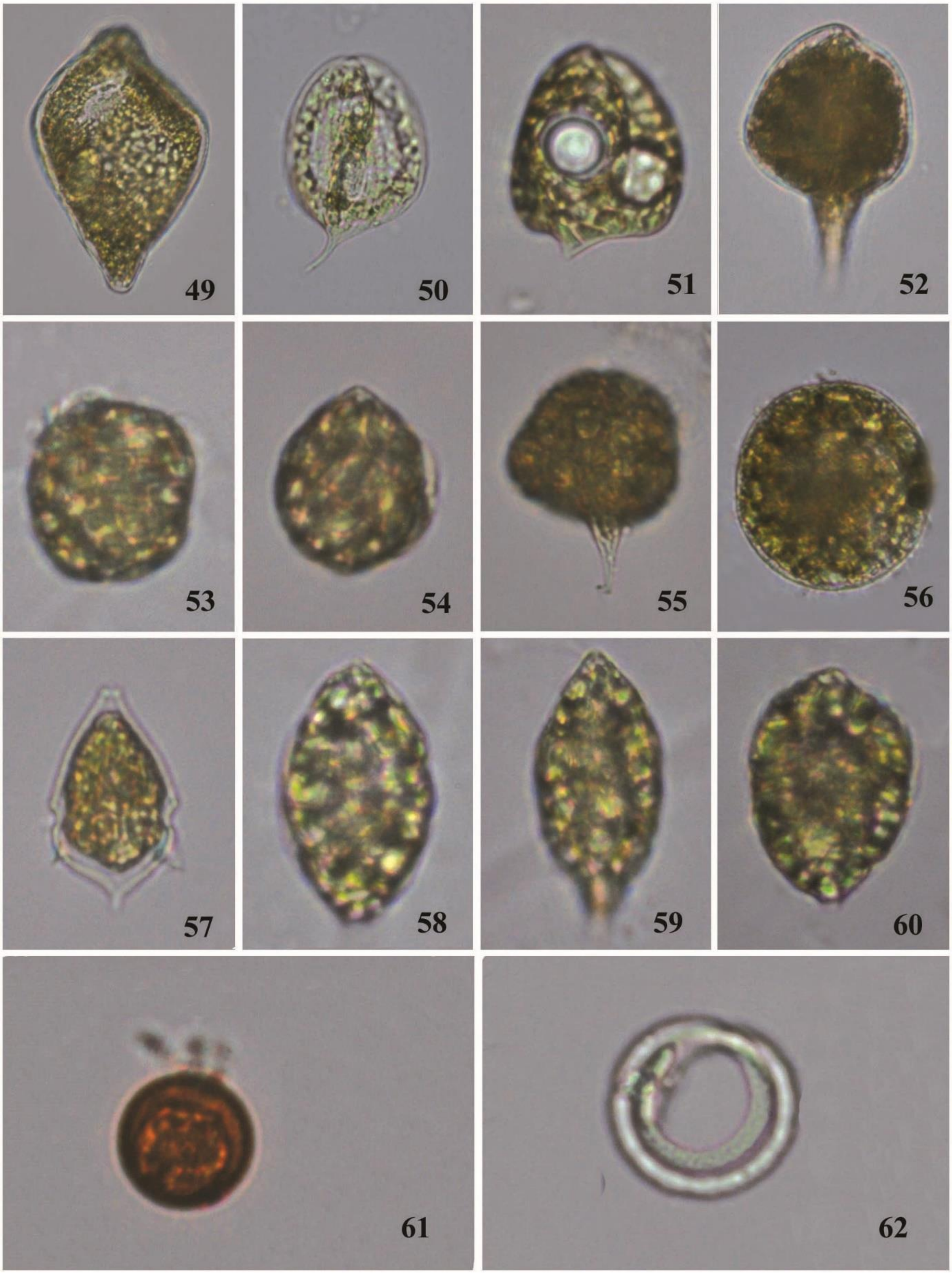
Fig. 52-56, 58-60. *Euglena* sp.

Fig. 57. *Peridinium*

Fig. 61. *Trachelomonas*

Fig. 62. *Anabaenopsis*

Plate - 4



Station 7

Plate 1

Fig. 1. *Merismopedia*

Fig. 2, 9, 12-14. *Mallomonas*

Fig. 3-4. *Euglena oxyuiris*

Fig. 5, 8, 16. *Oscillatoria*

Fig. 6. *Melosira*

Fig. 7. *Eunotia*

Fig. 10. *Euglena* sp.

Fig. 11. *Chroomonas*.

Fig. 15. *Phacus*.

Plate - 1

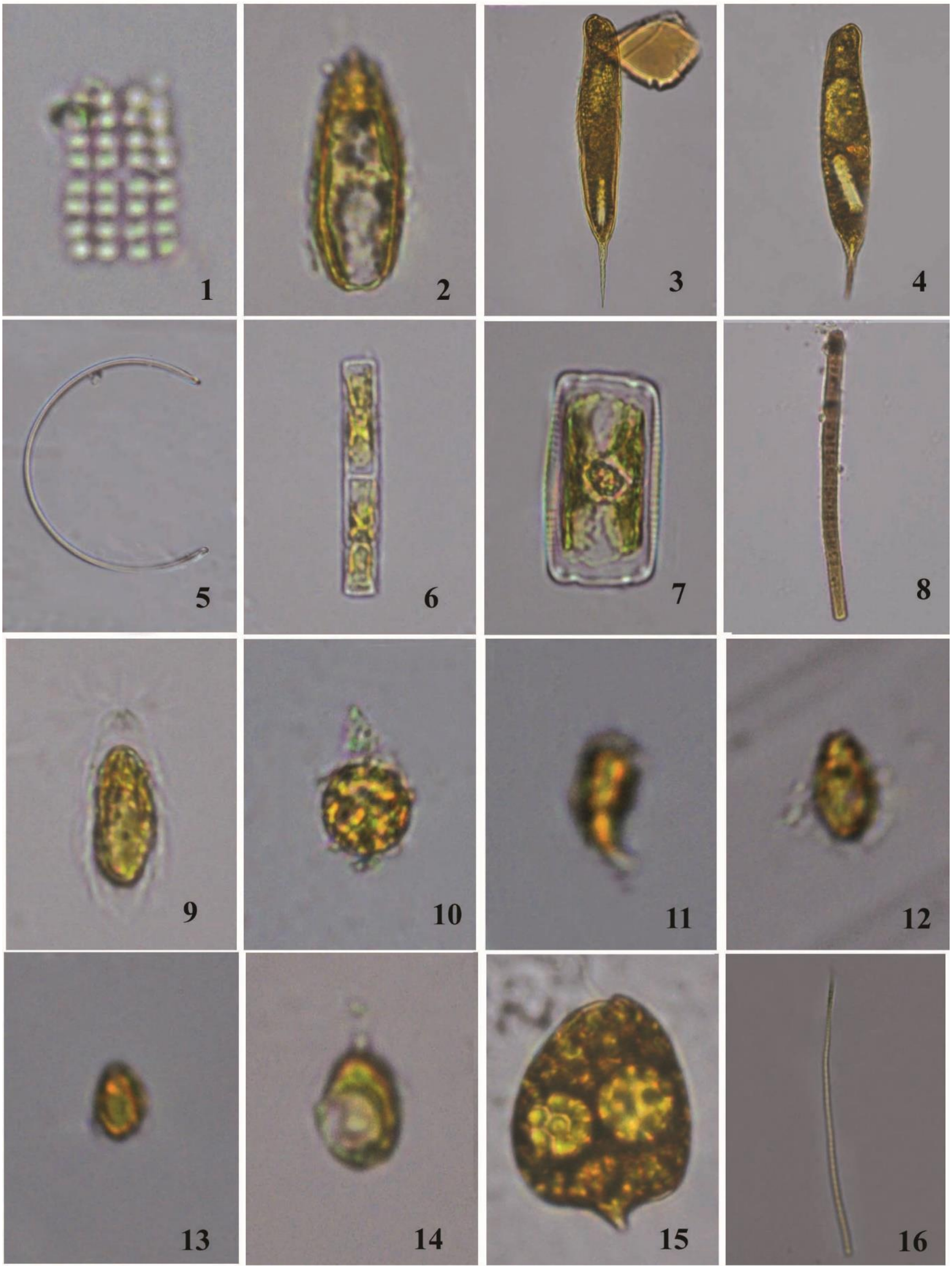


Plate 2

Fig. 17, 19-20. *Peridinium*

Fig. 18. *Mallomonas*

Fig. 21, 23. *Chlorococcum*

Fig. 22. *Rhizosolenia*

Fig. 24. *Phacus*

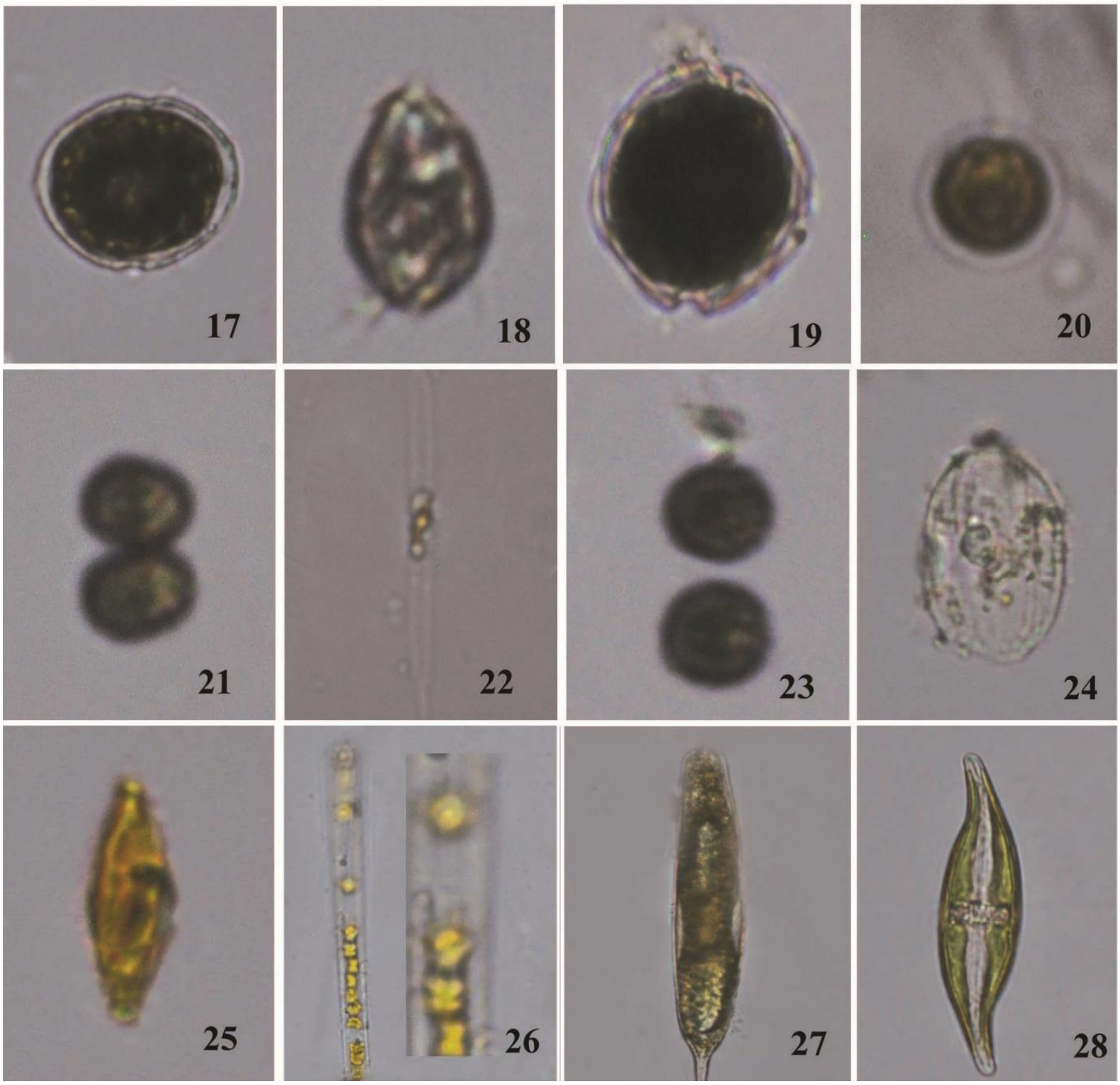
Fig. 25. *Navucula*

Fig. 26. Unidentified

Fig. 27. *Euglena* sp.

Fig. 28. *Gyrisigma*

Plate - 2



Station 8

Plate 1

Fig. 1-3. *Euglena* sp.

Fig. 4. *Phacus*

Fig. 5- 6. *Coscinodiscus*

Fig. 7. *Trachelomonas*

Fig. 8. *Chaetoceros*

Fig. 9. *Navucula*

Fig. 10. *Melosira*

Plate - 1

Station 9

Plate 1

Fig. 1-3. *Euglena acus*

Fig. 4. *Hantzschia*

Fig. 5. *Phacus*

Fig. 6. *Strombomonas napiformis*

Fig. 7. *Euglena spathyrhyncha* Skuja.

Fig. 8. *Sp.irulina*

Fig. 9-10. *Trtraedron limneticum*

Fig. 11. *Tahannes baptistia*

Fig. 12. *Pelonema*

Fig. 13, 16. *Trachelomonas*

Fig. 14-15. *Peridium*

Plate - 1

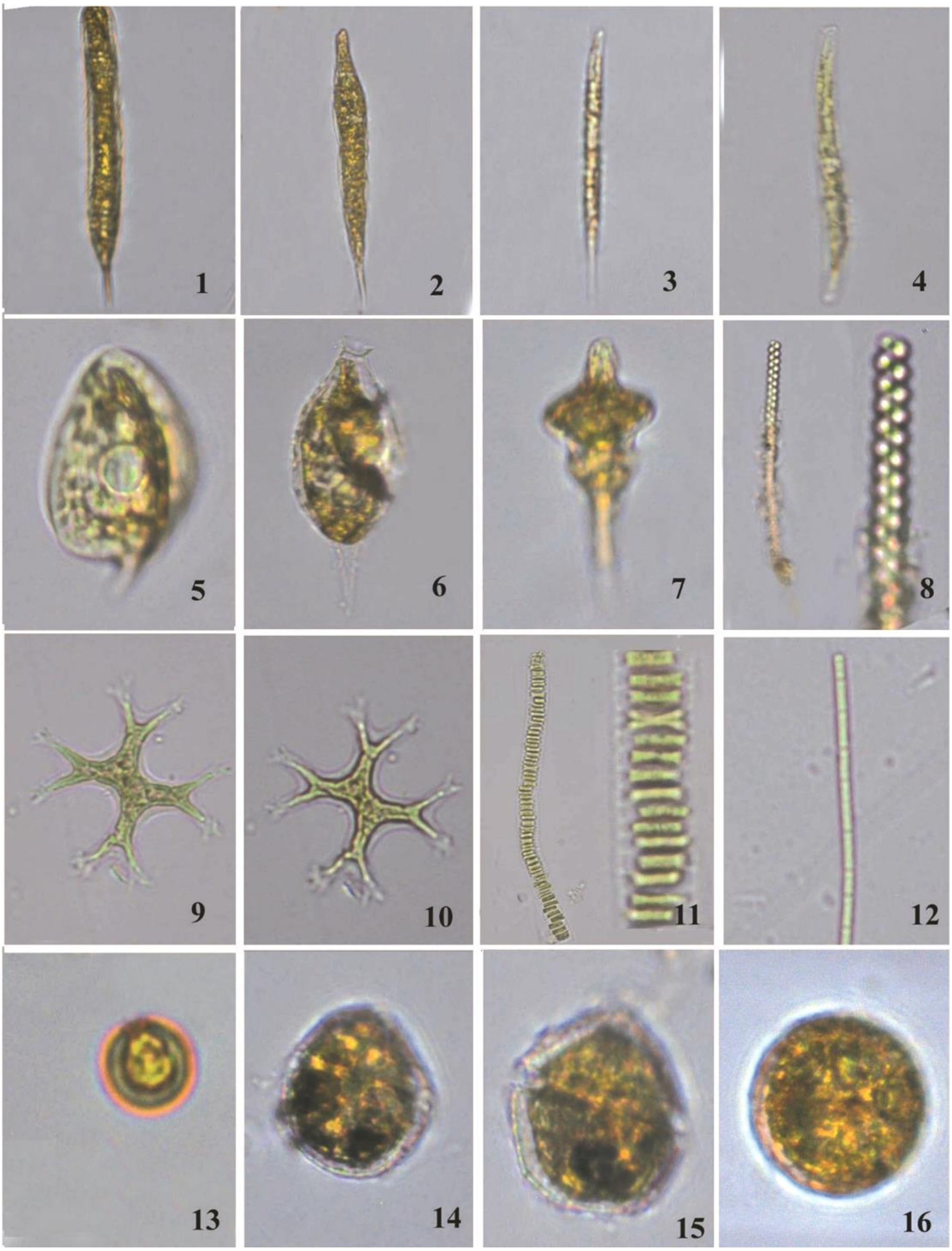


Plate 2

Fig. 17-18. *Phacus longcauda*

Fig. 19. *Phacus*

Fig. 20-21. *Lepocinclis ovum*

Fig. 22, 25-26. *Euglena* sp.

Fig. 23. *Lepocinclis*

Fig. 24. *Cryptomonas*

Fig. 27. *Nitzschia*

Fig. 28. *Peridium*

Fig. 29-30, 32. *Oscillatoria*

Fig. 31. *Lyngbya*

Plate - 2

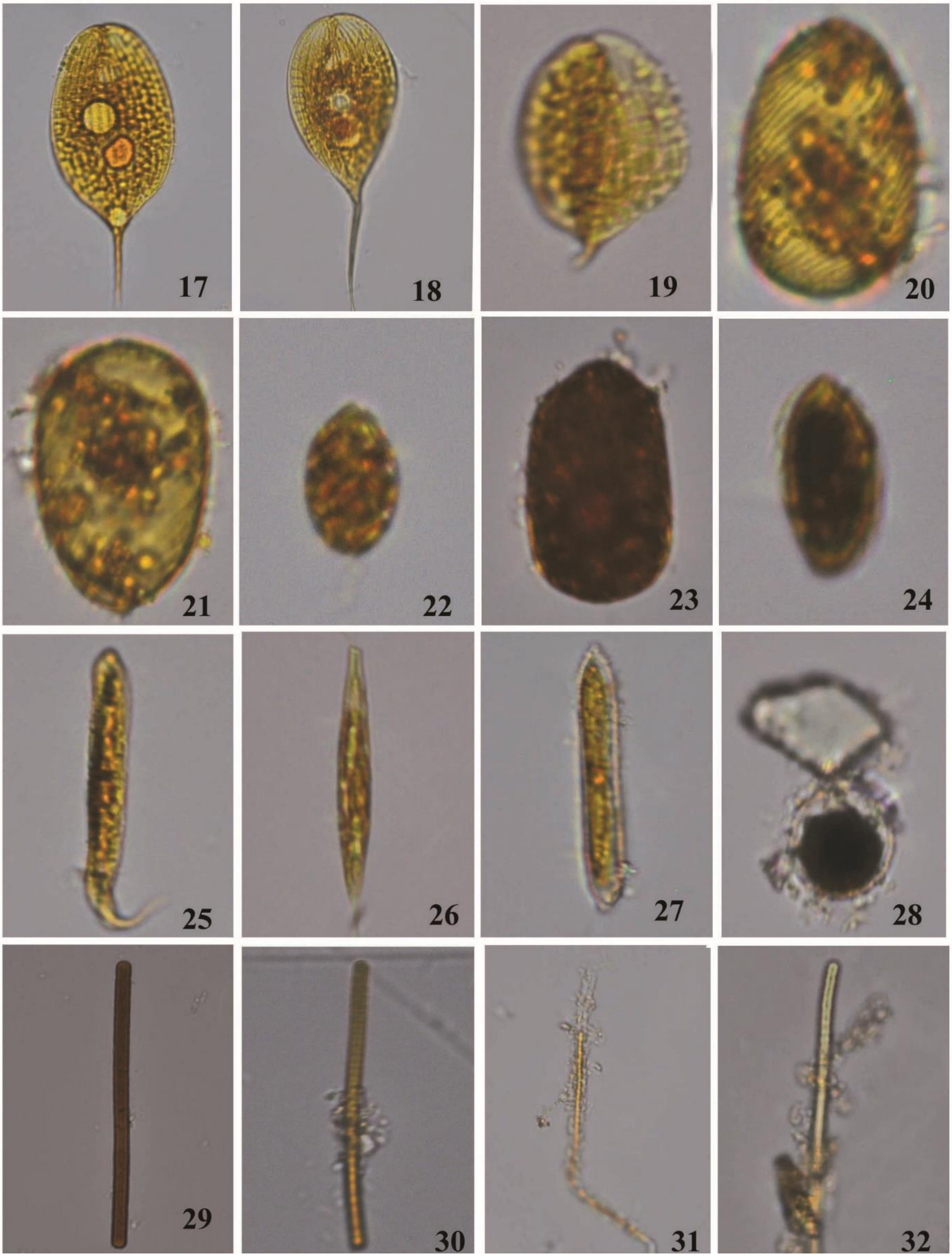


Plate 3

Fig. 33-34. *Phacus*

Fig. 35, 37-43, 46. *Euglena* sp.

Fig. 36. *Lepocinclis*

Fig. 44. *Trachelomonas*

Fig. 45. Unidentified

Fig. 47-48. *Strombomonas*

Plate - 3

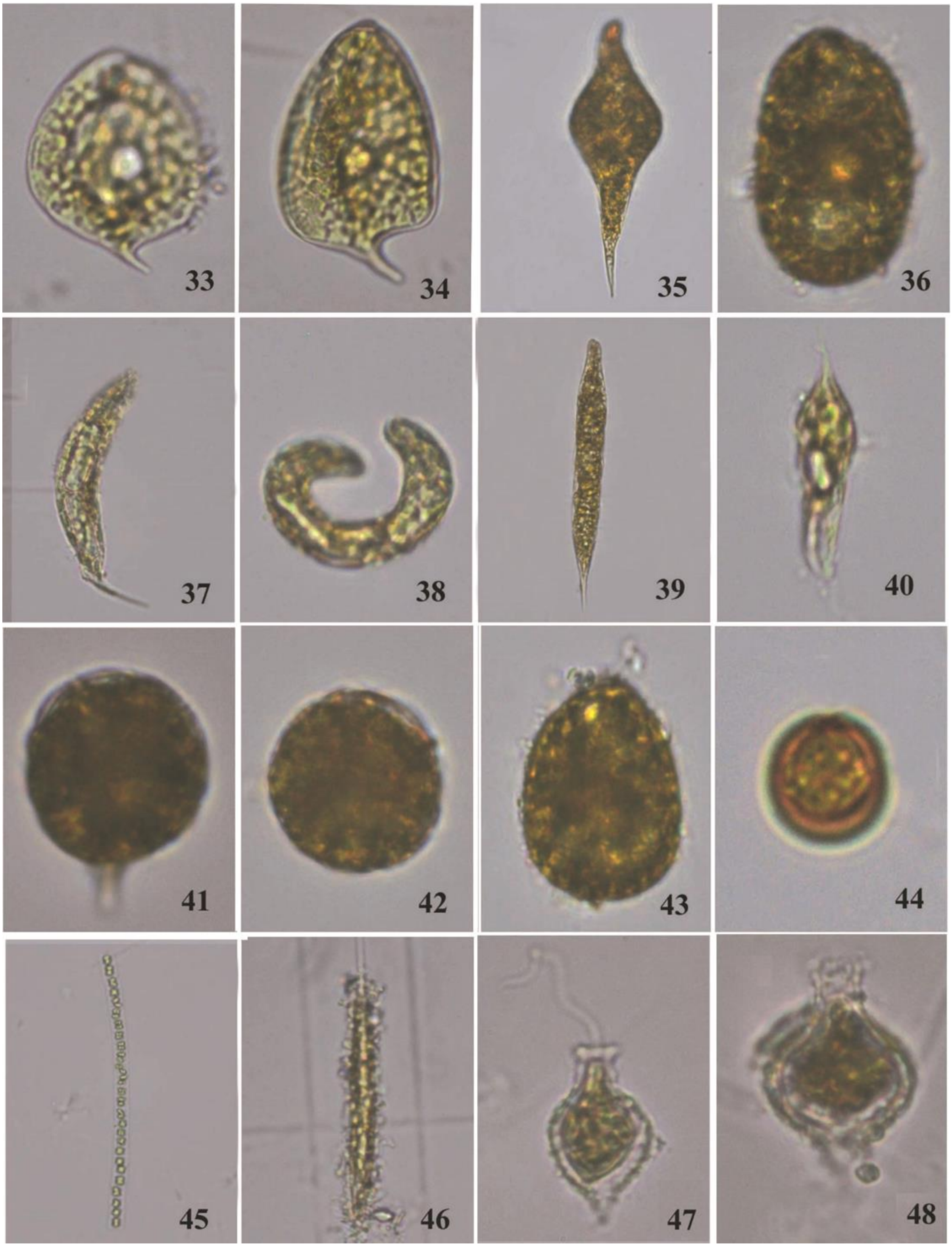


Plate 4

Fig. 49-51. *Phacus longicauda*

Fig. 52, 54. *Euglena* sp.

Fig. 53. *Phacus*

Fig. 55. *Rhodomonas*

Fig. 56-57. *Strombomonas*

Fig. 58. *Trachelomanas*

Fig. 59-60. *Lepocinclis*

Fig. 61-64. *Euglena acus*

Plate - 4

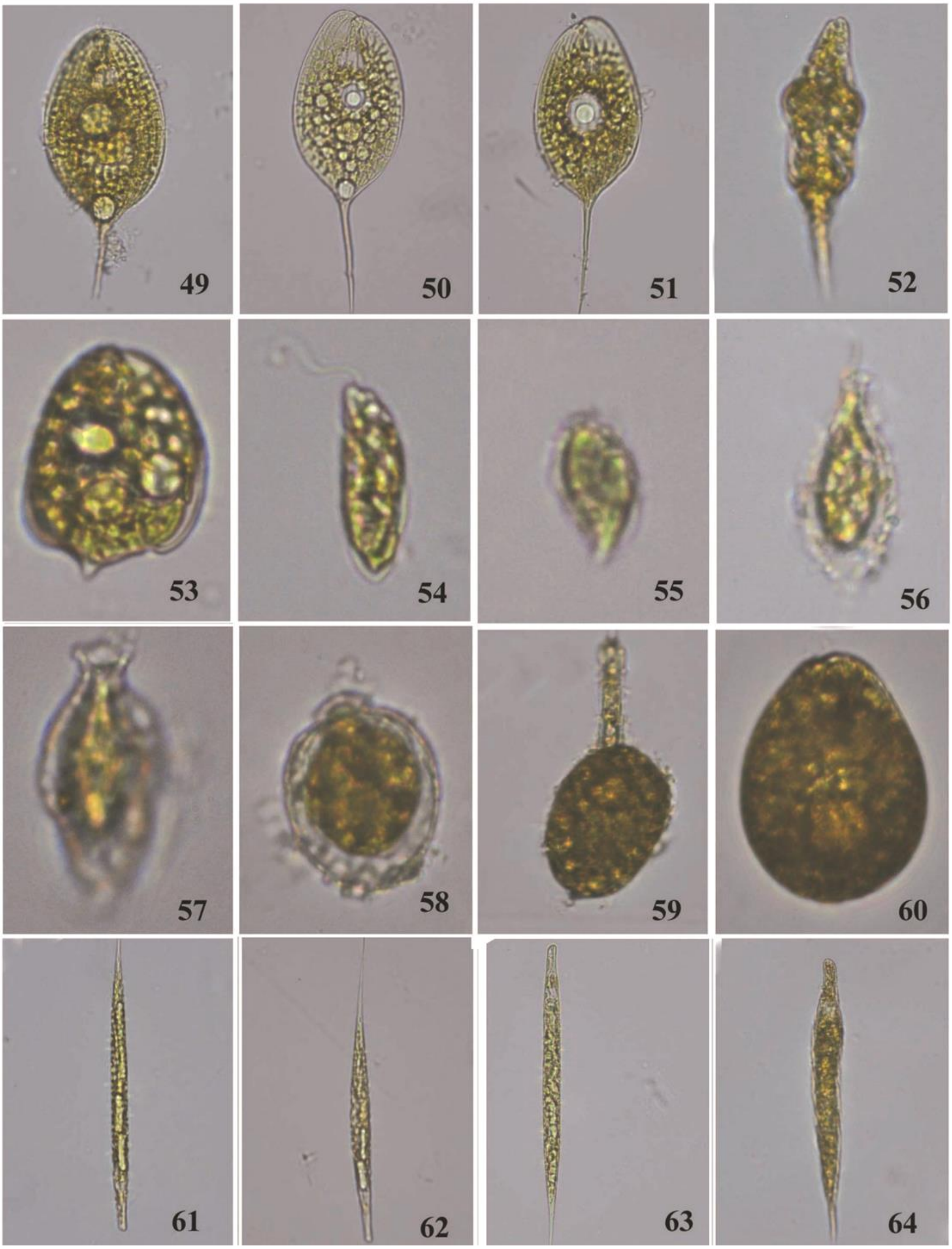


Plate 5

Fig. 65. *Gyrosigma macrus*

Fig. 66-68. *Sp.irulina*

Fig. 69, 71. *Oscillatoria*

Fig. 70. *Pelonema*

Fig. 72-76, 78. *Euglena* sp.

Fig. 77. *Strombomonas*

Fig. 79. *Phacus*

Fig. 80. *Mallomonas*

Plate - 5

Plate 6

Fig. 81-83. *Phacus*

Fig. 84, 89-90. *Euglena* sp.

Fig. 85. *Chlamydomonas*

Fig. 86. *Trachelomonas*

Fig. 87-88. *Mallomonas*

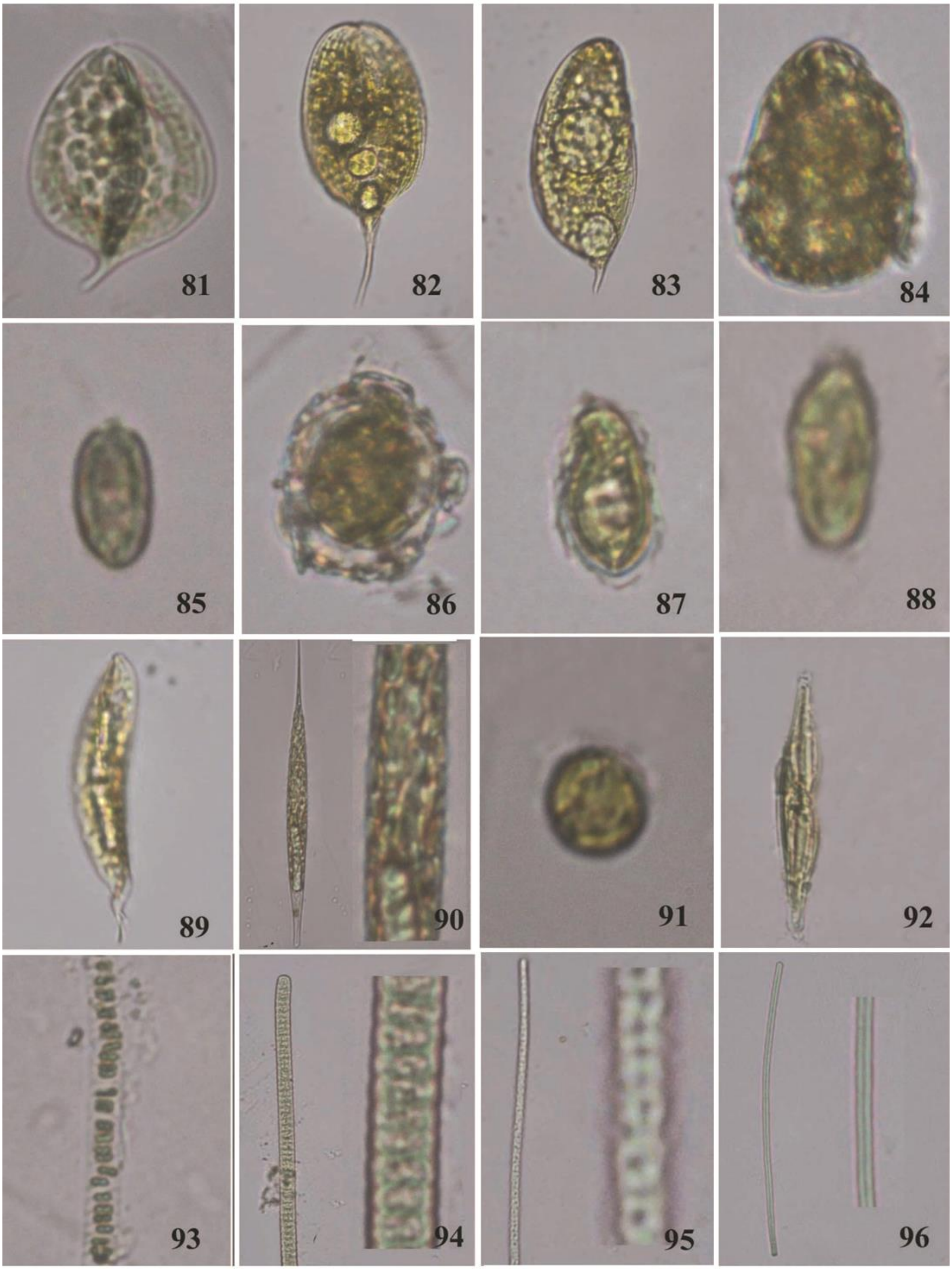
Fig. 91. *Cyclotella*

Fig. 92. Unidentified

Fig. 93. Unidentified

Fig. 94-96. *Oscillatoria*

Plate - 6



Station 10

Plate 1

Fig. 1. *Phacus longicauda*

Fig. 2, 6, 9. *Euglena* sp.

Fig. 3. *Mallomonas*

Fig. 4. *Phacotus*

Fig. 5. *Cryptomonas*

Fig. 7. *Phacus*

Fig. 8. *Strombomonas*

Fig. 10. *Palonema*

Fig. 11-12, 14-15. *Oscillatoria*

Fig. 13. *Navicula*

Fig. 16. *Phormidium*

Plate- 1

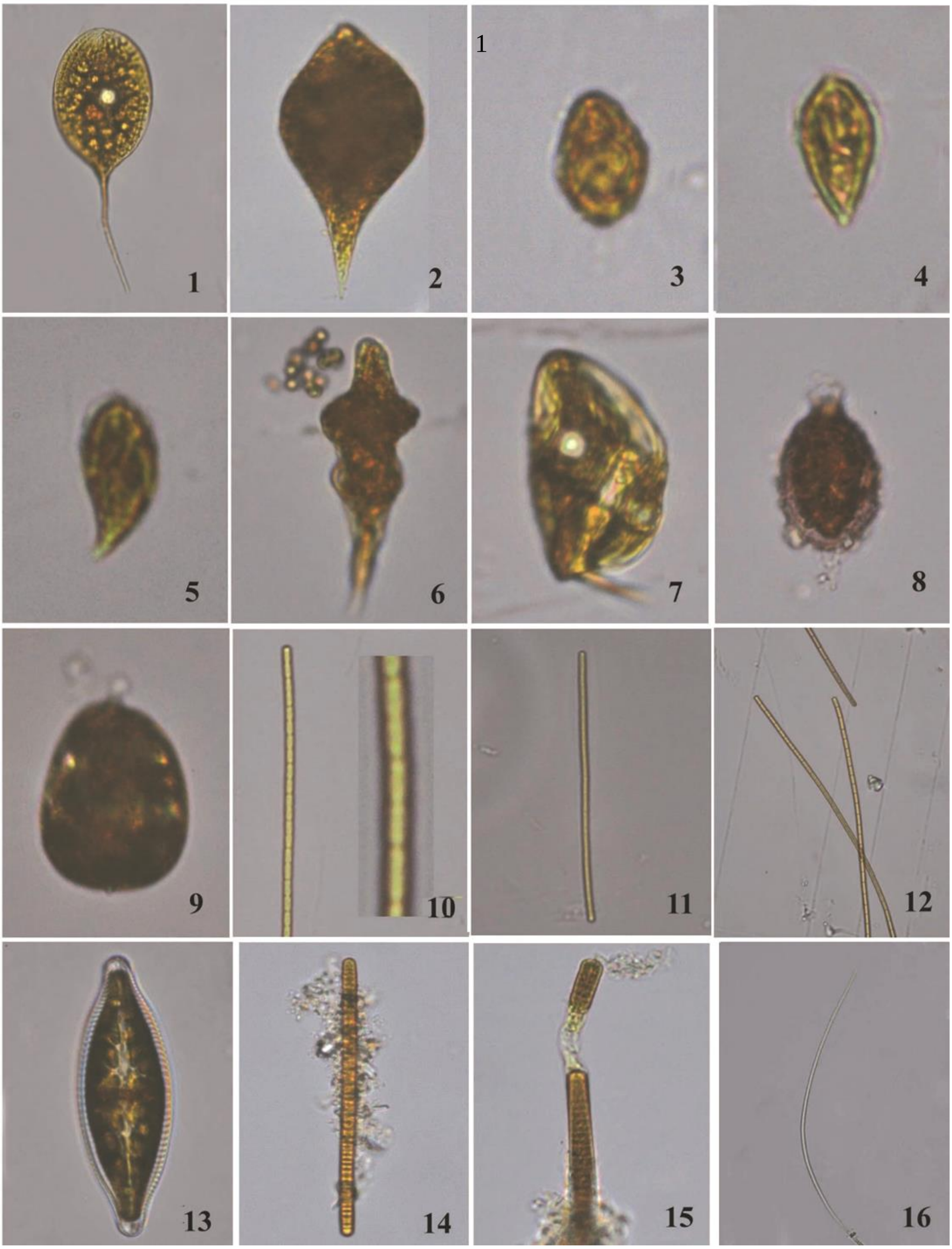


Plate 2

Fig. 17-21, 25-26, 30-32. *Euglena* sp.

Fig. 22-23. *Palonema*

Fig. 24. *Epithemia*

Fig. 27. *Trachelomonas*

Fig. 28. *Peridinium*

Fig. 29. *Phacus*

Plate - 2

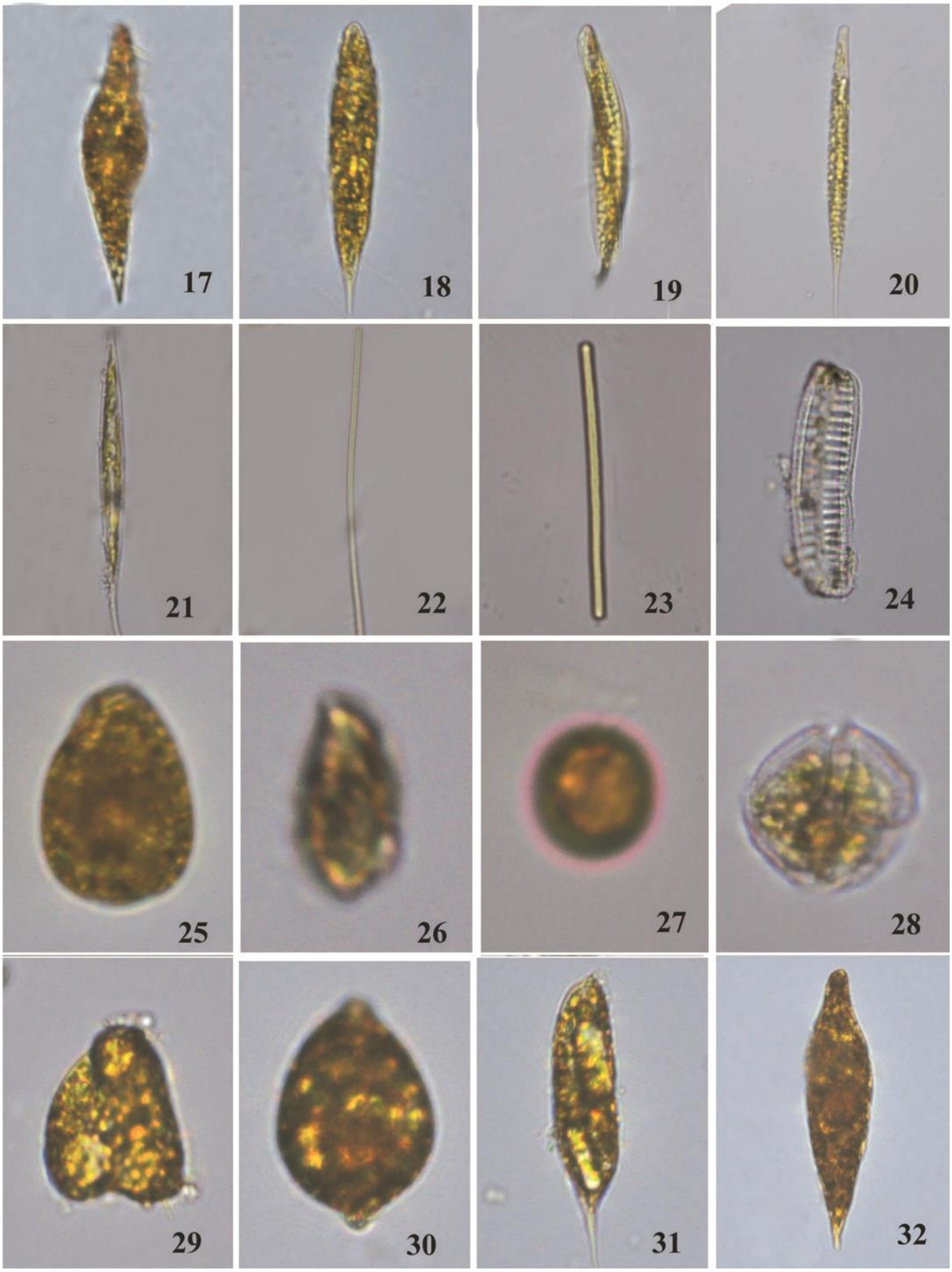


Plate 3

Fig. 33-35. *Phacus*

Fig. 36-39, 43. *Euglena* sp.

Fig. 40. *Euglena acus*

Fig. 41-42. *Strombomonas*

Fig. 44. *Lepocinclis*

Fig. 45. *Mallomonas*

Fig. 46. *Trachelomonas*

Fig. 47. *Gyrosigma*

Fig. 48. *Raphidiopsis*

Plate - 3

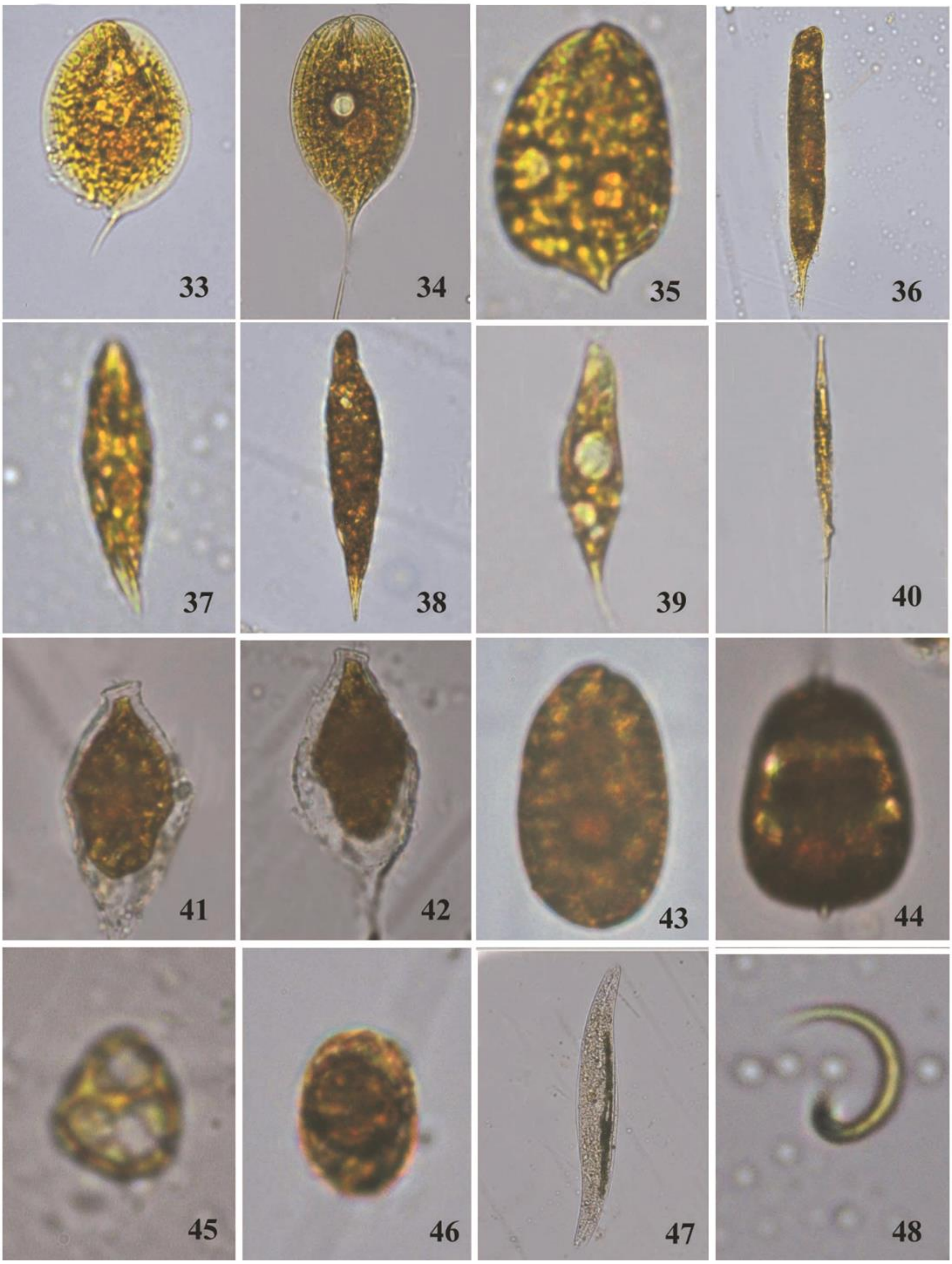


Plate 4

Fig. 49-53. *Phacus*

Fig. 54-56. *Euglena* sp.

Fig. 57-58, 60. *Euglena acus*

Fig. 59. *Nitz. longiformis*

Fig. 61-62. *Pelonema*

Fig. 63-64. *Oscillatoria*

Plate - 4

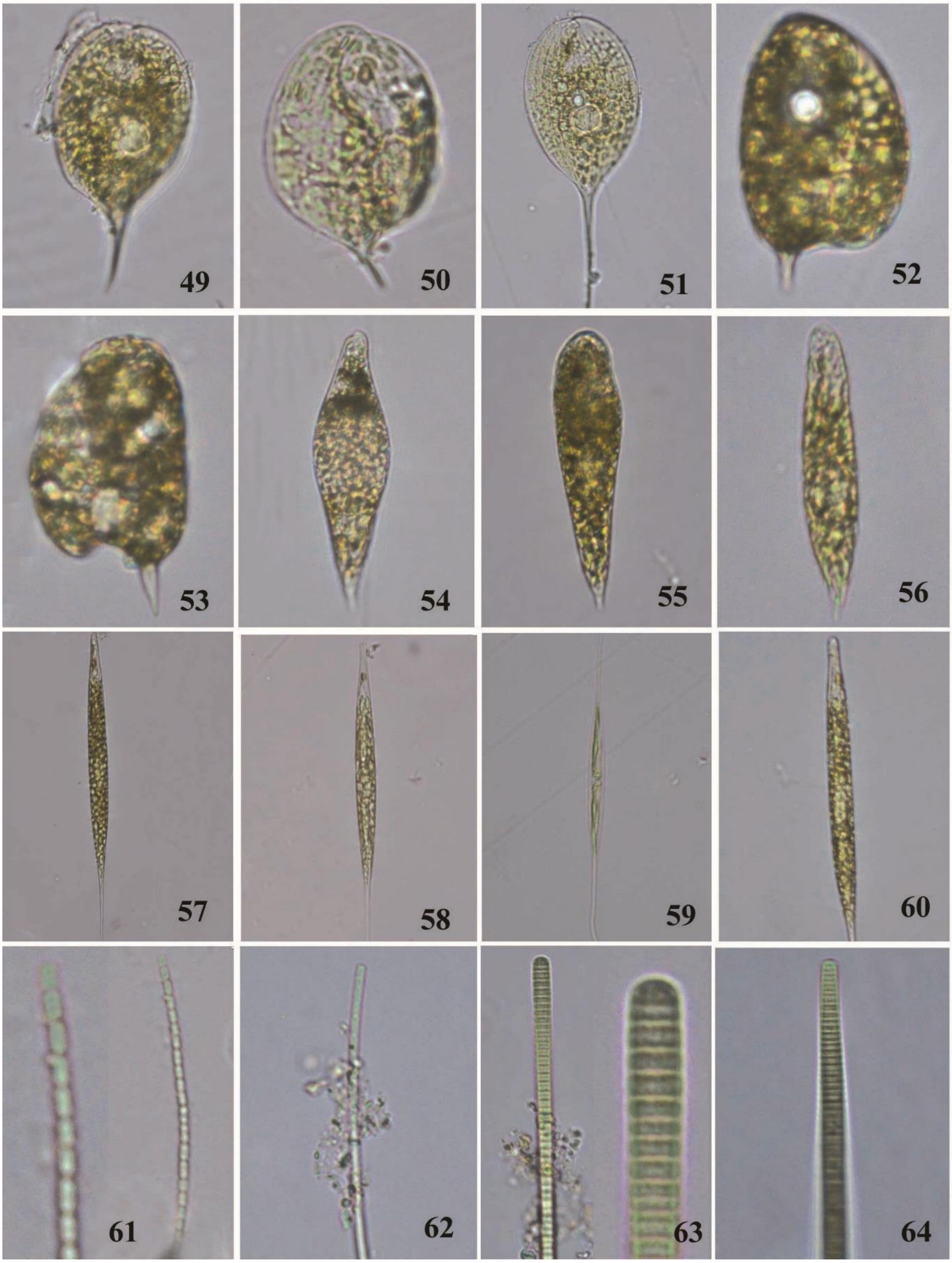


Plate 5

Fig. 65-66. *Phacus*

Fig. 67-68, 71. *Lepocinclis*

Fig. 69, 72-76, 80. *Euglena* sp.

Fig. 70. *Strombomonas*

Fig. 77-79. *Pelonema*

Plate - 5

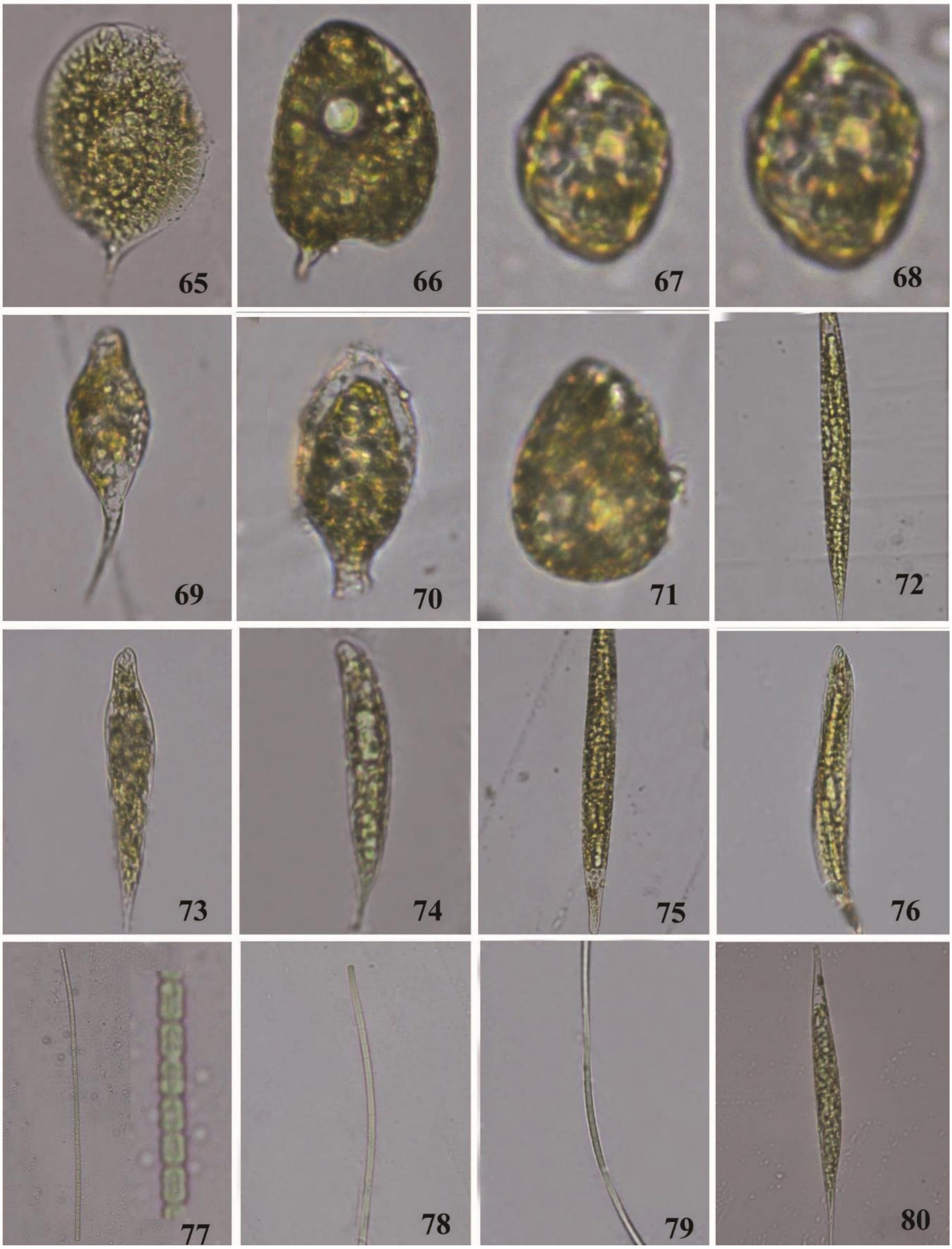


Plate 6

Fig. 81. *Phacus longicauda*

Fig. 82. *Strombomonas gibberosa* (Plays) Defl.

Fig. 83-84. *Euglena* sp.

Fig. 85-86, 89-90. *Euglena acus*

Fig. 87. *Oscillatoria*

Fig. 88. *Pediastrum duplex*

Fig. 91. *Pelonema*

Plate -6

Station 11

Plate 1

Fig. 1-4, 6-7, 10. *Euglena* sp.

Fig. 5. *Mallomonas*

Fig. 8. *Closteriopsis*

Fig. 9. *Phacus*

Fig. 11. *Diacanthes*

Fig. 12. *Crucigenia*

Fig. 13. *Oscillatoria*

Fig. 14. *Merismopedia*

Fig. 15. *Scenedesmus*

Fig. 16. *Schroederia*

Plate - 1

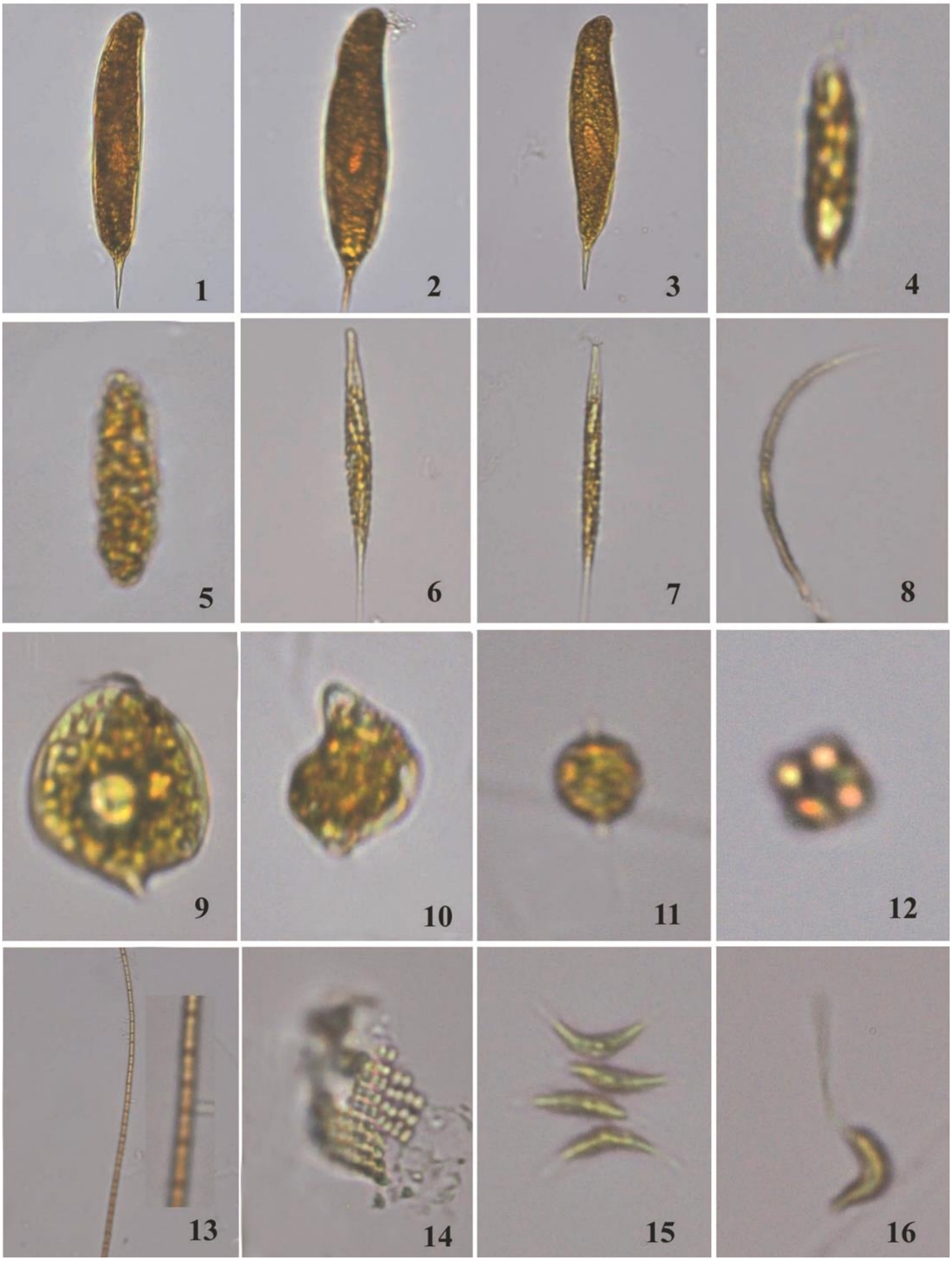


Plate 2

Fig. 17. *Strombomonas*

Fig. 18, 23-27. *Euglena* sp.

Fig. 19, 28. *Cryptomonas*

Fig. 20. *Mallomonas*

Fig. 21, 31. *Pelonema*

Fig. 22. *Sphaerocystis*

Fig. 29. *Rivularia*

Fig. 30. *Oscillatoria*

Fig. 32. *Spermatozoopsis*

Plate - 2

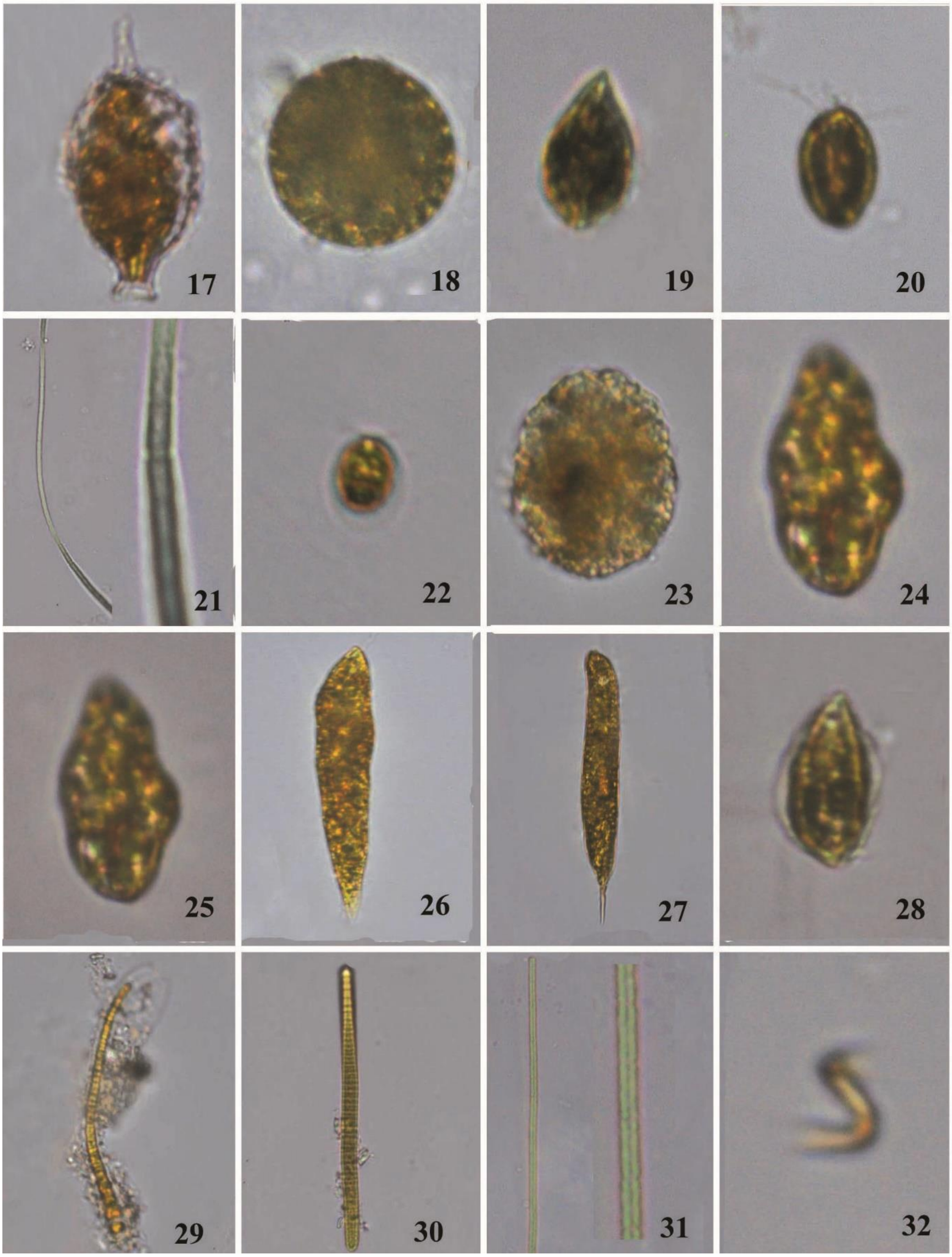


Plate 3

Fig. 33. *Phacus*

Fig. 34-36, 42-43. *Euglena* sp.

Fig. 37. *Lepocinclis*

Fig. 38. *Trachelomonas*

Fig. 39-41. *Strombomonas*

Fig. 44, 46, 48. *Peridinium*

Fig. 45. *Chlamodomonas*

Fig. 47. *Mallomonas*

Plate - 3

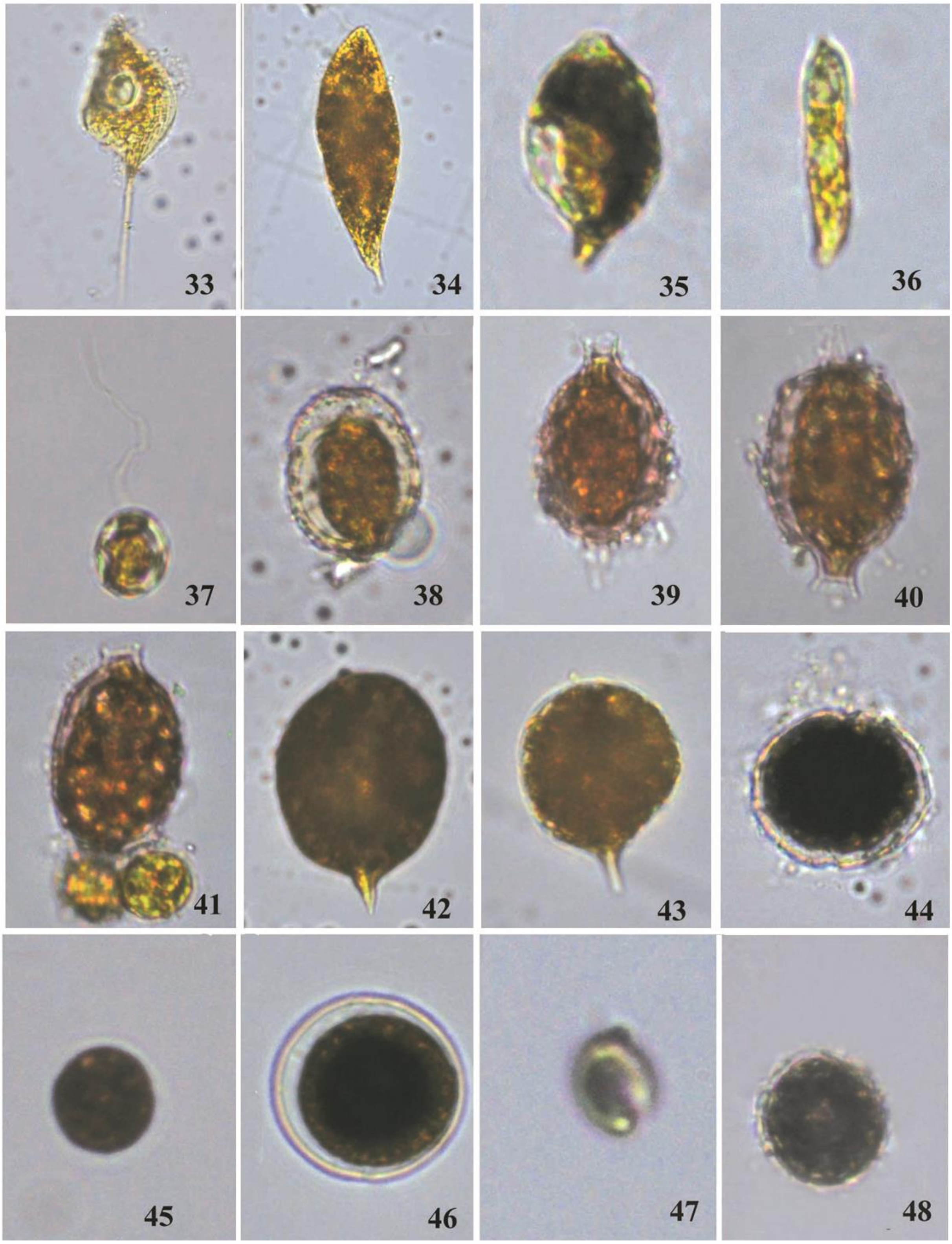


Plate 4

Fig. 49-51. *Phacus*

Fig. 52. *Coscinodiscus*

Fig. 53-56, 62-64. *Euglena* sp.

Fig. 57. *Nitz. longissima*

Fig. 58, 61. *Pelonema*

Fig. 59. *Scenedesmuss*

Fig. 60. *Ankistrodesmus*

Plate - 4

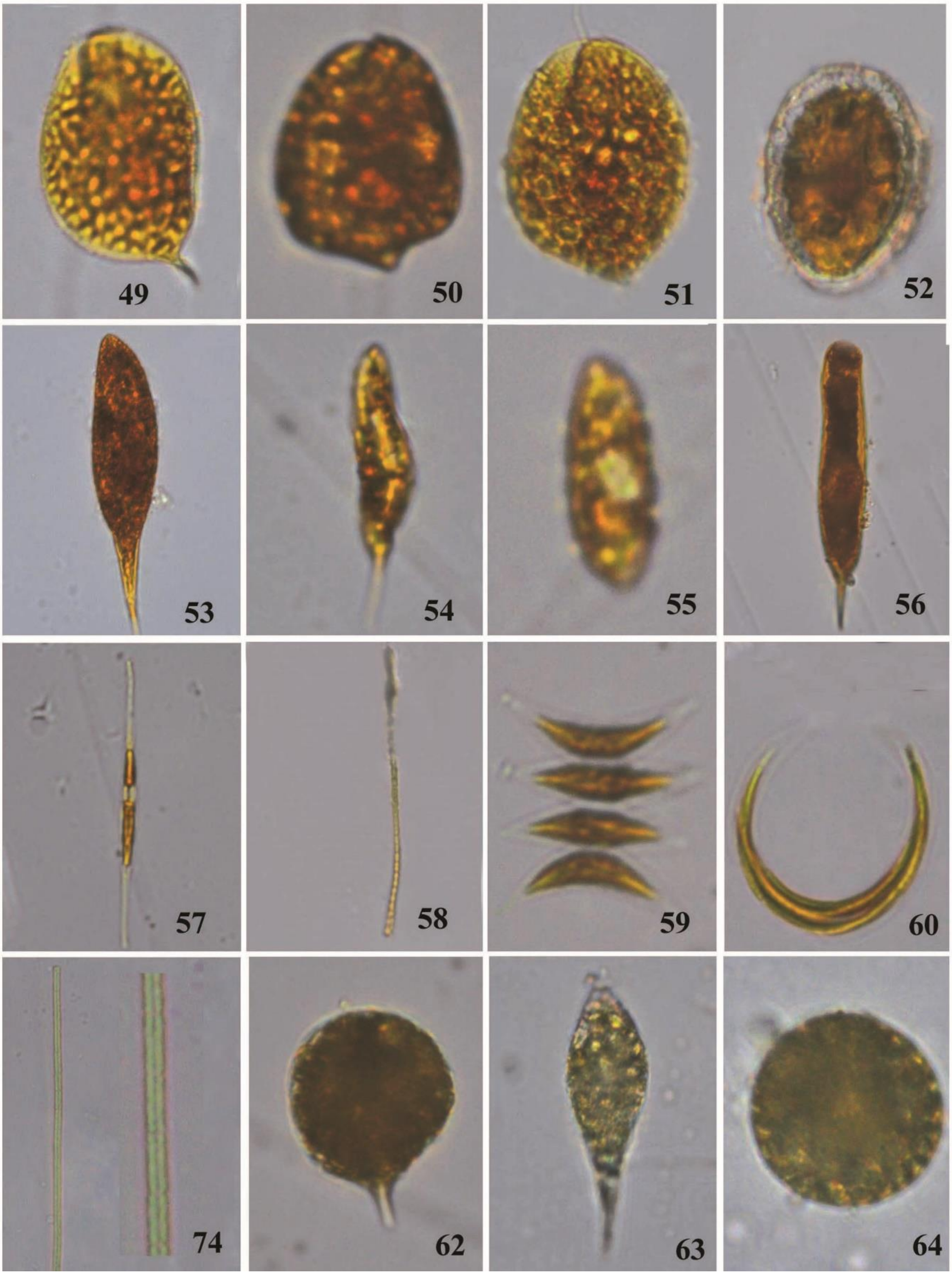


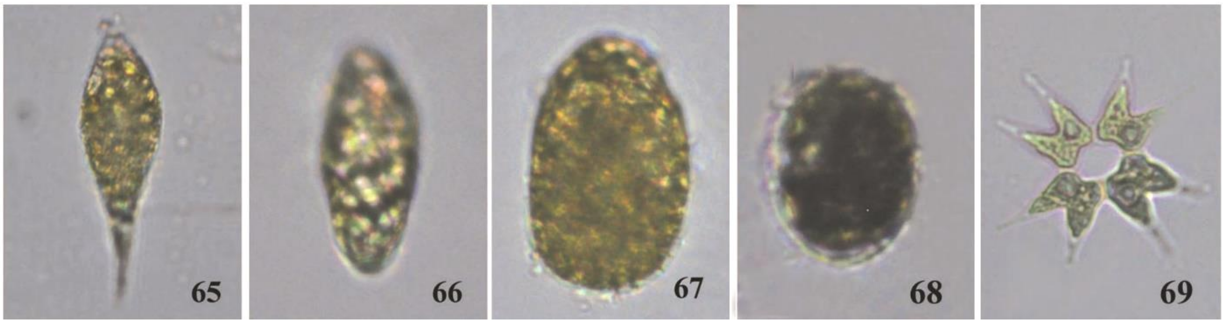
Plate 5

Fig. 65-67. *Euglena* sp.

Fig. 68. *Peridinium*

Fig. 69. *Pediastrum duplex*

Plate - 5



APPENDIX

(Phytoplankton flora of the studied stations)

CHHATAK

Photomicrographs of phytoplankton

(Magnification of the images ranges from 400 - 1000×)

Station 1

Plate 1

Fig. 1, 2, 4, 9. *Trachelomonas*

Fig. 3. *Lepocinclis*

Fig. 5-6. *Anabaena*

Fig. 7. *Synnechosystis*

Fig. 7. *Scenedesmus*

Fig. 10. *Peridinium*

Fig. 11, 15. *Raphidiopsis*

Fig. 12, 16. *Oscillatoria*

Fig. 13. *Spirulina*

Fig. 14. *Anabaena*

Plate - 1

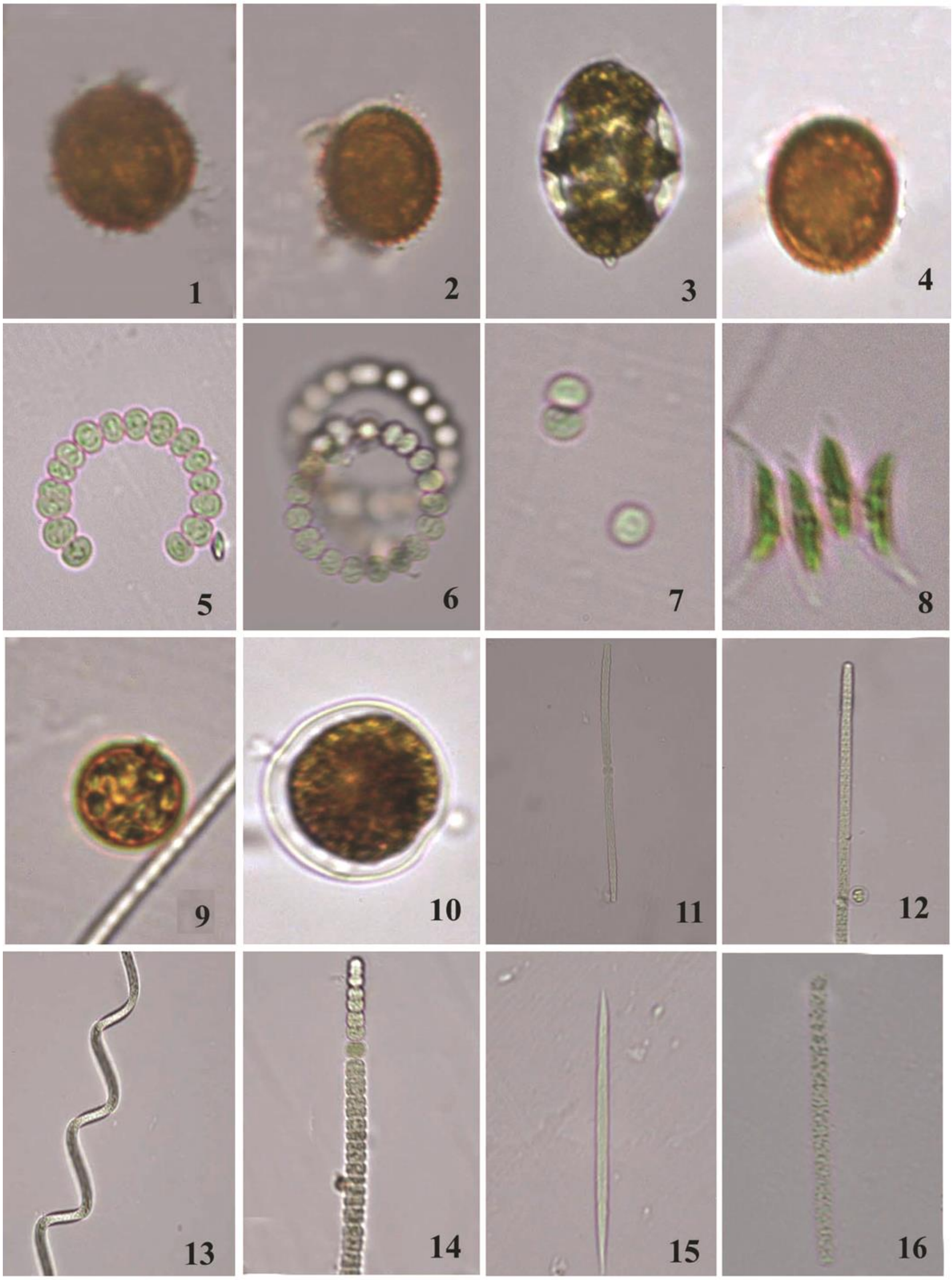


Plate 2

Fig. 17-21. *Phacus*

Fig. 22-24. *Oocystis*

Fig. 25-26. *Micricystis*

Fig. 27, 31. *Pediestrum*

Fig. 28. *Anabaena*

Fig. 9. *Pelonema*

Fig. 30. *Merismopedia*

Fig. 32. *Pleurocapsa*

Plate - 2

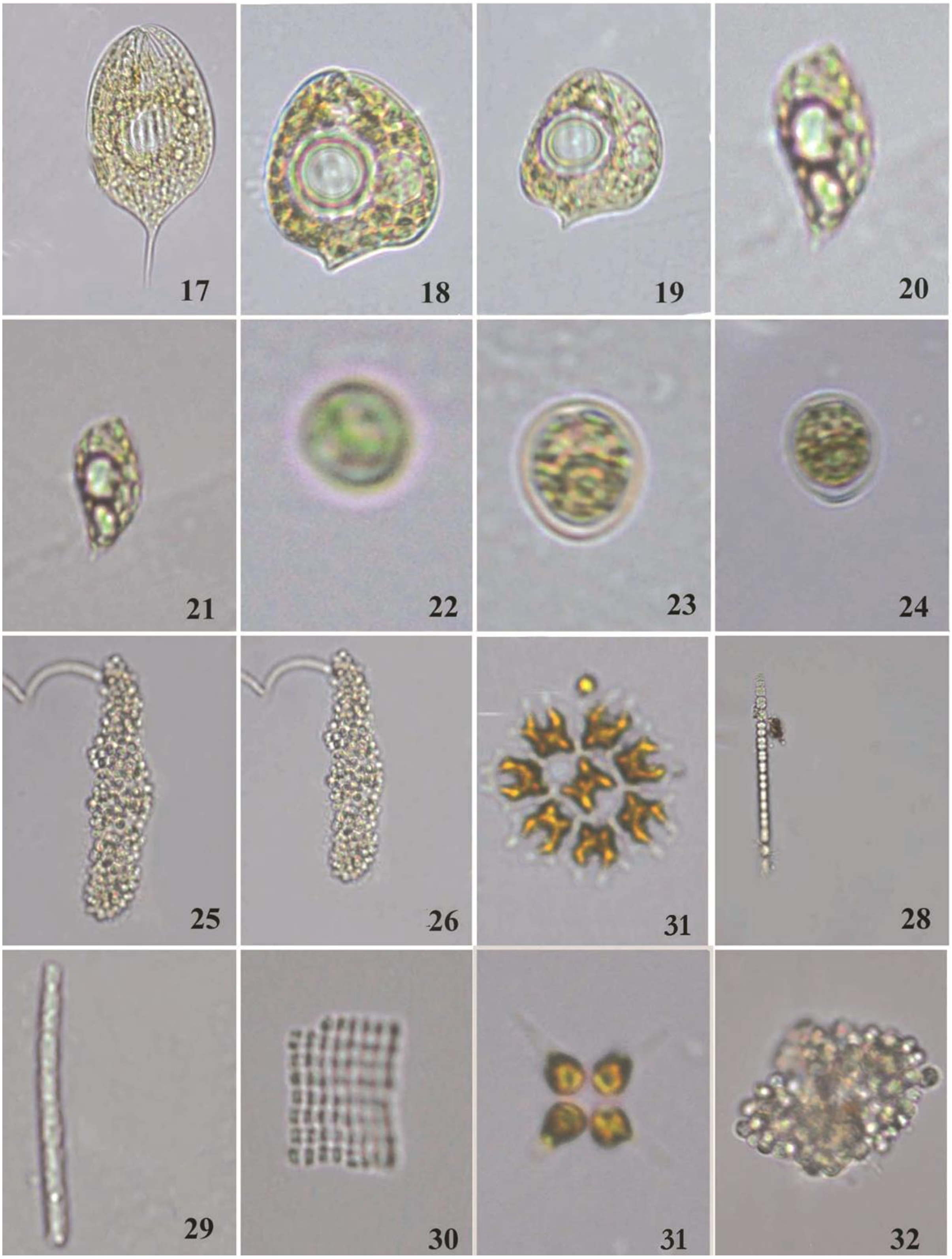


Plate 3

Fig. 33-34. *Scenedesmus*

Fig. 35-36. *Peridinium*

Fig. 37-41. *Euglena* sp

Fig. 42. *Phacus*

Fig. 43. *Pelonema*

Fig. 44. *Oscillatoria*

Fig. 45. *Microcystis*

Fig. 46. *Pleurocapsa*

Fig. 47. *Coelastrum*

Fig. 48. *Dictyosphaerium*

Plate - 3

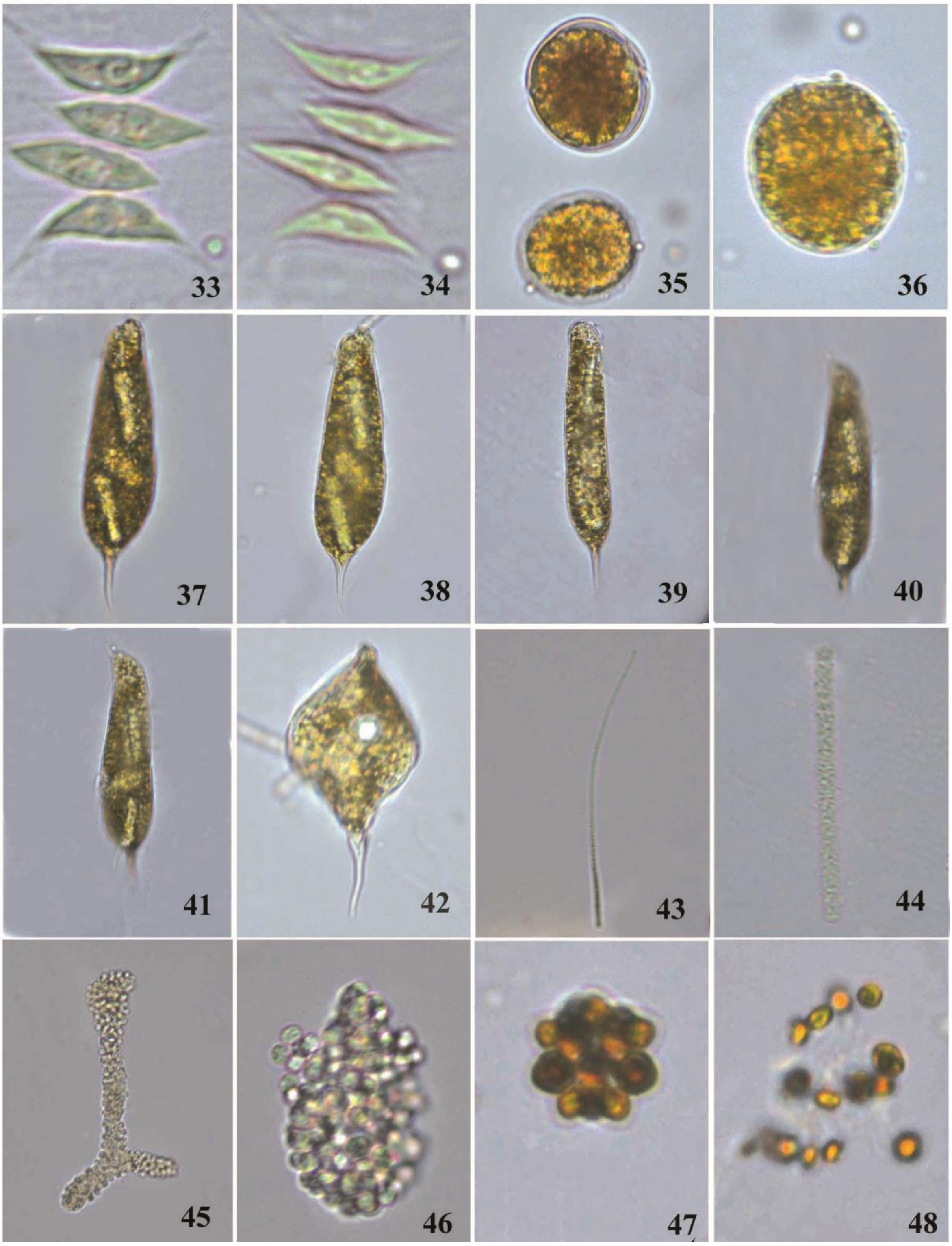


Plate 4

Fig. 49-51, 53. *Phacus*

Fig. 52. *Cryptomonas*

Fig. 54, 56. *Trachelomonas*

Fig. 55. *Peridinium*

Fig. 57. *Scenedesmus*

Fig. 58. *Actinastrum*

Fig. 59-61. *Raphidiopsis*

Fig. 62. *Hantzschia*

Fig. 63. *Merismopedia*

Fig. 64. *Ankistrodesmus*

Plate - 4

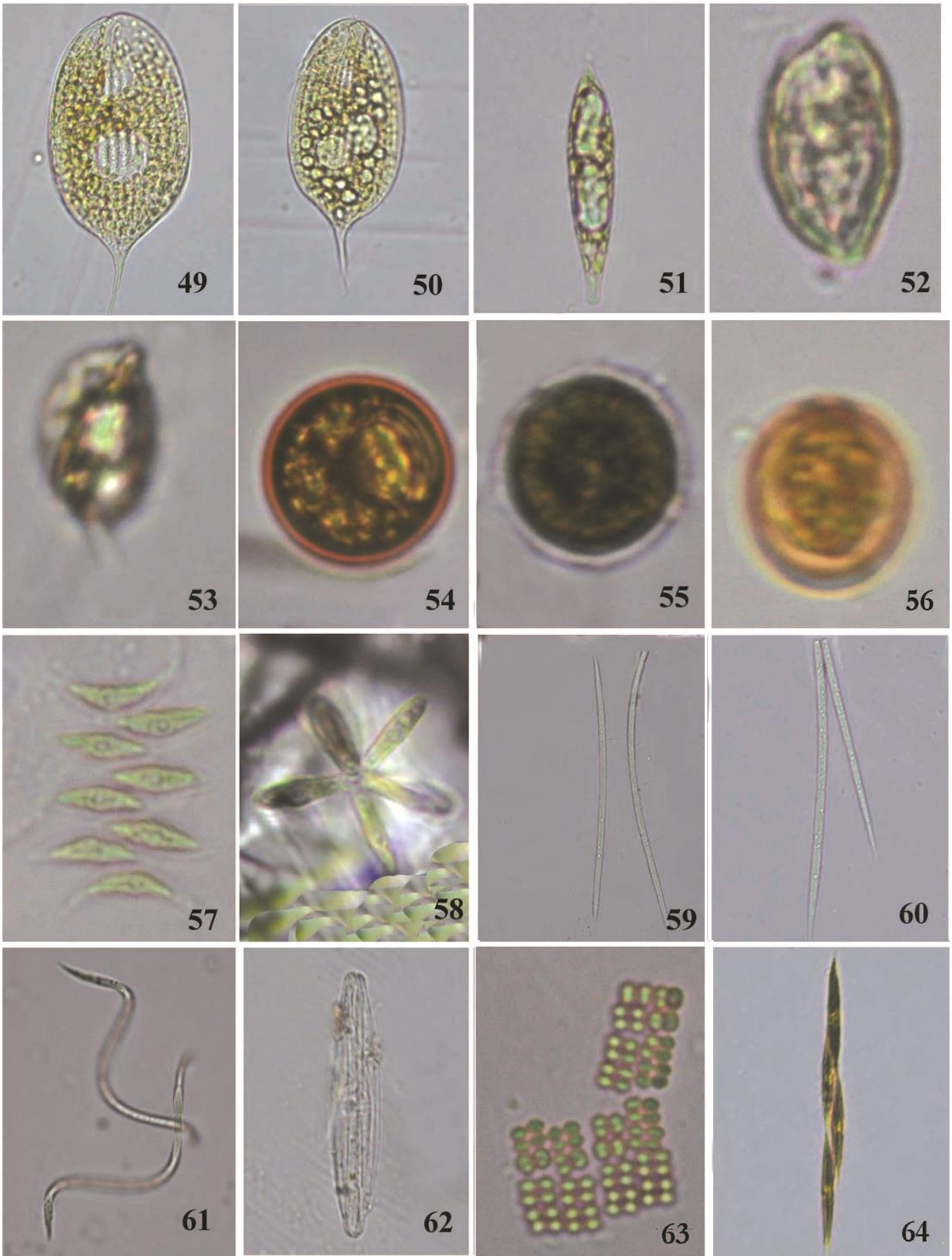


Plate 5

Fig. 65-67. *Cryptomonas*

Fig. 68. *Euglena* sp

Fig. 69. *Trachelomonas*

Fig. 70. *Peridinium*

Fig. 71. *Chlamydomonas*

Fig. 72. *Phacus*

Fig. 73, 76. *Pelonema*

Fig. 74. *Nitzschia longissima*

Fig. 75. *Korschikoviella*

Fig. 77. *Eudorina*

Fig. 78-80. *Pandorina*

Plate - 5

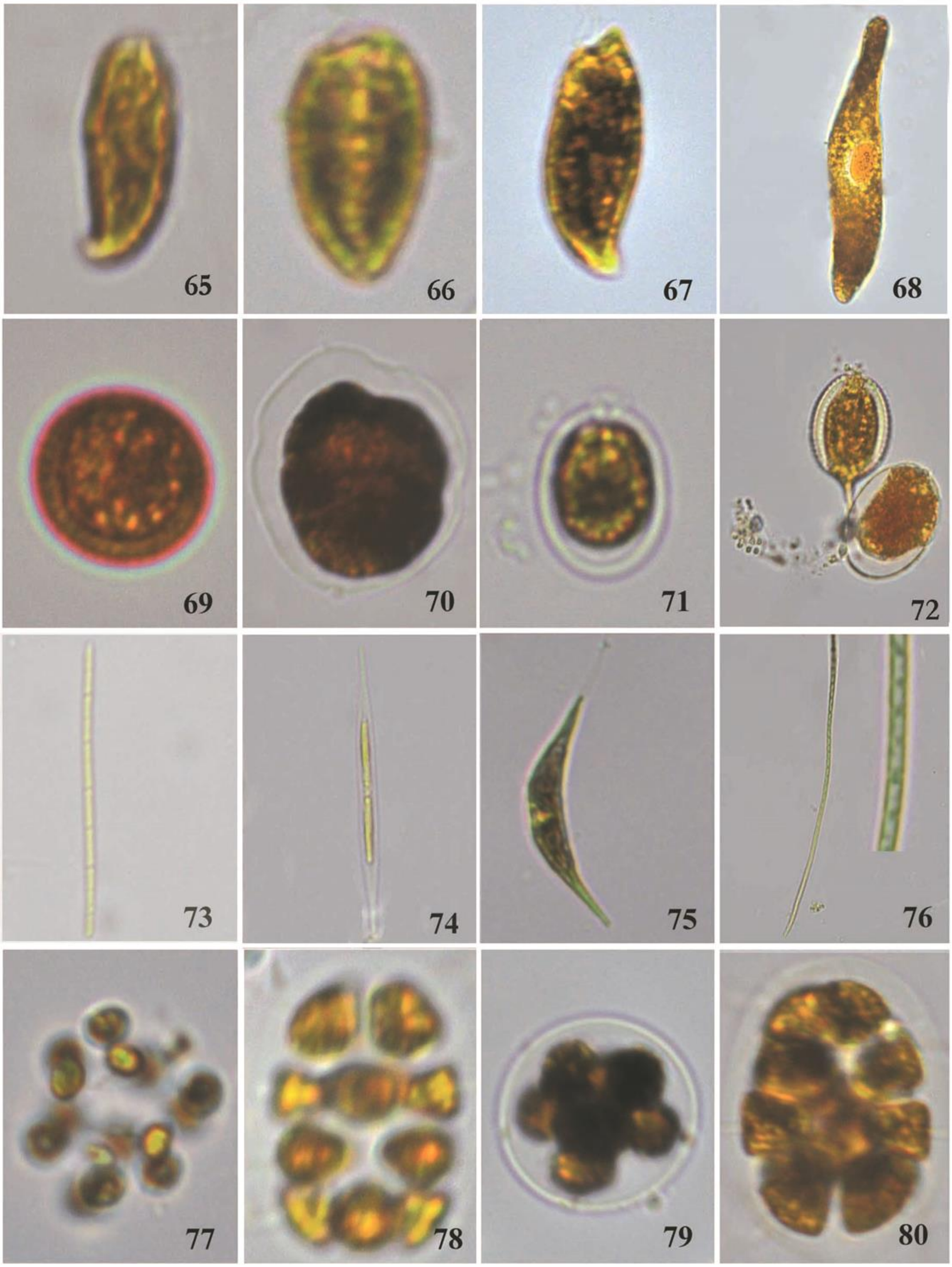


Plate 6

Fig. 81-83. *Anabaenopsis*

Fig. 84. *Actinastrum*

Fig. 85. *Gomphosphaeria*

Fig.8 6. *Merismopedia*

Fig. 87. *Crucigenia*

Fig. 88. *Peridinium*

Fig. 89, 91. *Scenedesmus*

Fig. 90. *Pediastrum*

Fig. 92. *Cryptomonas*

Fig. 93. *Epithema*

Fig. 94, 96. *Nitzs. longissima*

Fig. 95. *Melosira*

Plate - 6

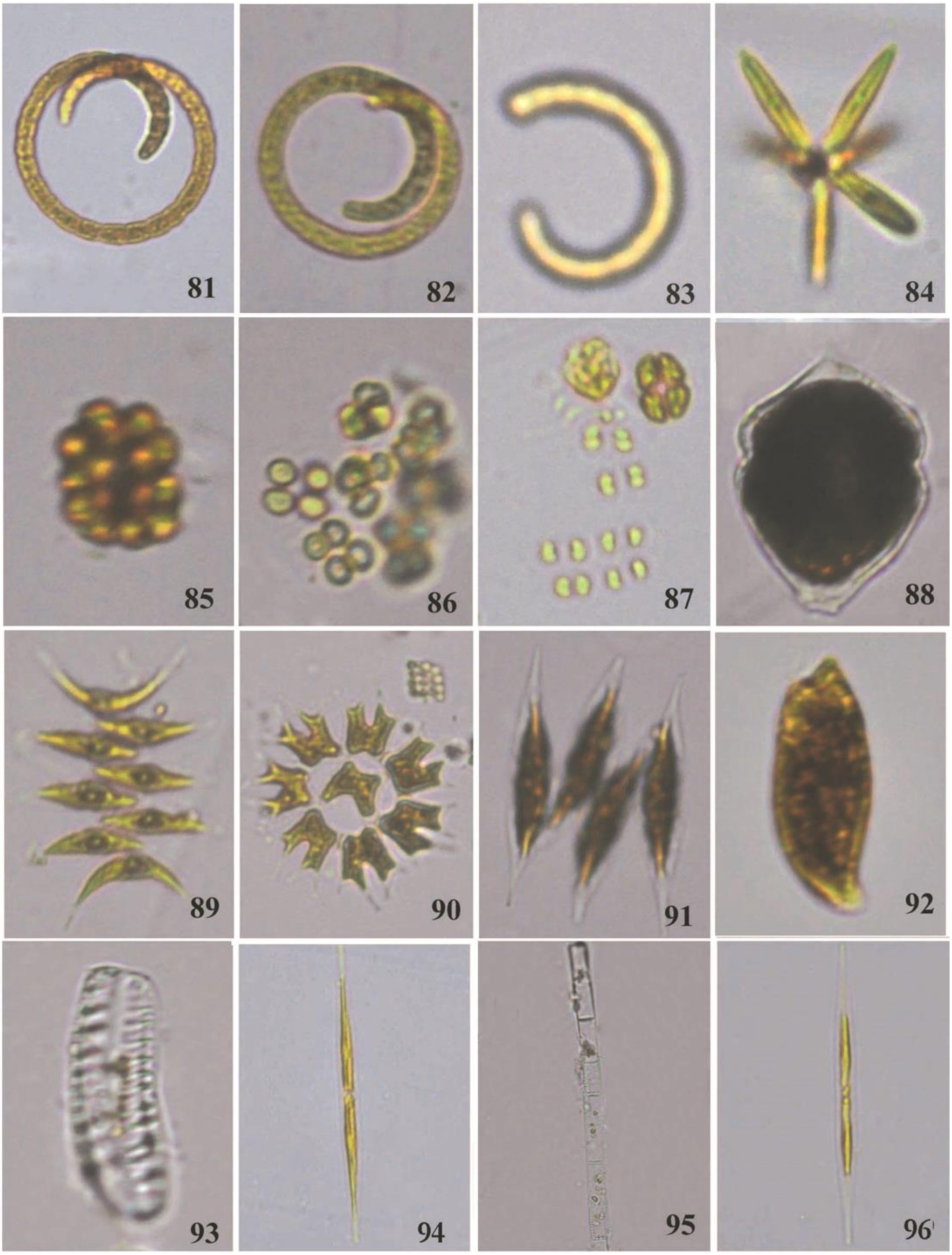


Plate 7

Fig. 97. *Pediastrum*

Fig. 98. *Coelastrum*

Fig. 99-100. *Scenedesmus*

Fig. 101-102. *Actinastrum*

Fig. 103-104, 107. *Trachelomonas*

Fig. 105, 111. *Euglena* sp

Fig. 106. *Lepocinclis*

Fig. 108. *Phacus*

Fig. 109. *Merismopedia*

Fig. 110. Unidentified

Fig. 112. *Dactylococcopsis*

Plate - 7

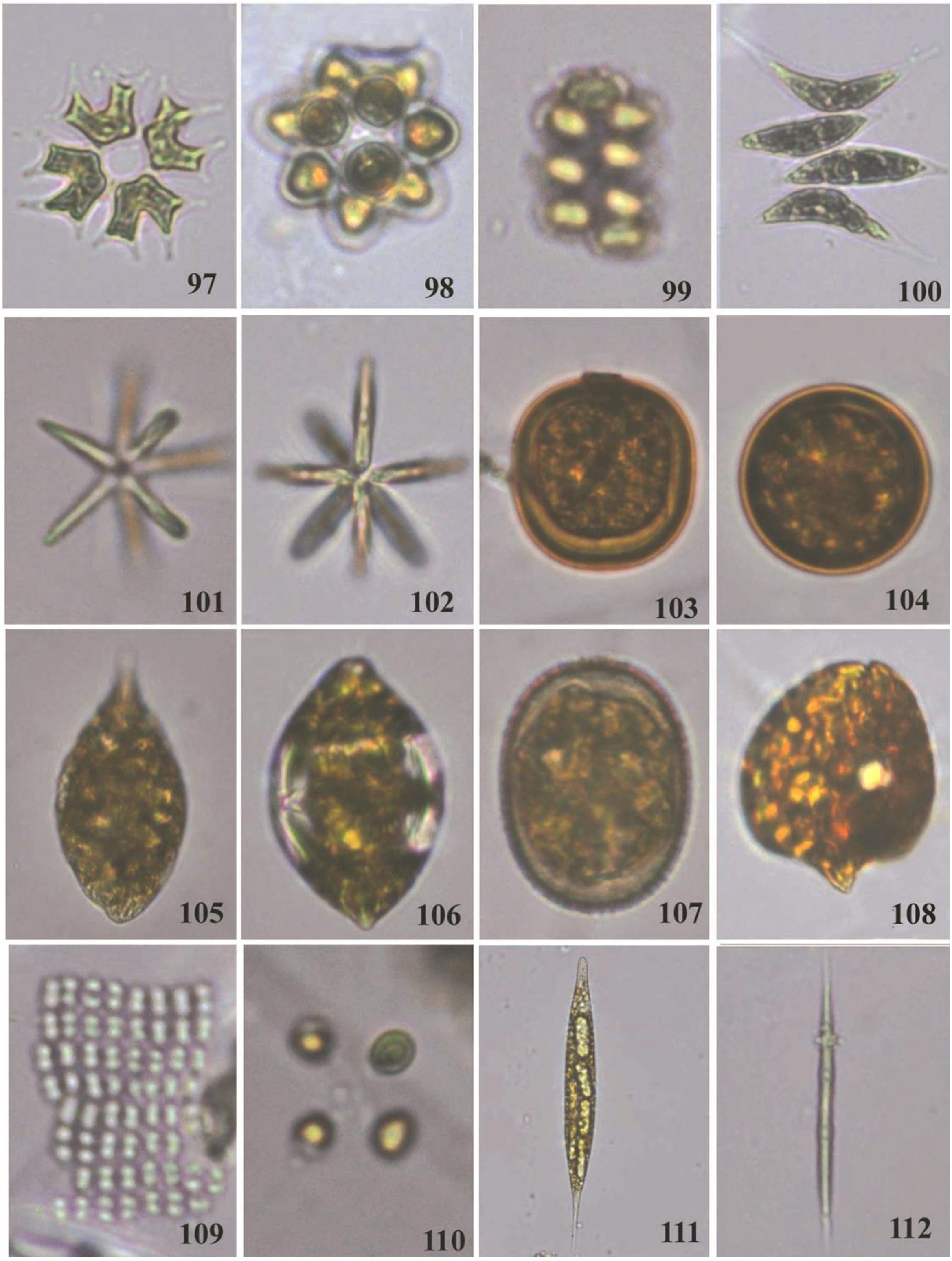


Plate 8

Fig. 113. *Pediastrum biradiatum* var. longicornatum Gutw.

Fig. 114. *Pediastrum duplex* var. gracillimum West and West.

Fig. 115. *Crucigenia tetrapedia* (Kirsher) W West and GS West.

Fig. 116. *Trachelomonas volvocina*

Fig. 117-119. *Pelonema*

Fig. 120. *Anabaena*

Fig. 121. *Anabaena*

Fig. 122, 124. *Euglena* sp

Fig. 123. *Astasia*

Fig. 125. *Peridinium*

Fig. 126. *Anabaenopsis*

Fig. 127. *Coelosphaerium*

Fig. 128. *Crucigenia lauterbornis* (Schmidle) Schmidle

Plate- 8

Plate 9

Fig. 129, 130. *Pediastrum duplex*

Fig. 131. *Phacus*

Fig. 132. *Trachelomonas*

Fig. 133. *Anabaenopsis*

Fig. 134. *Pediastrum simplex* Meyer

Fig. 135. *Coelastrum microporum* Nageli

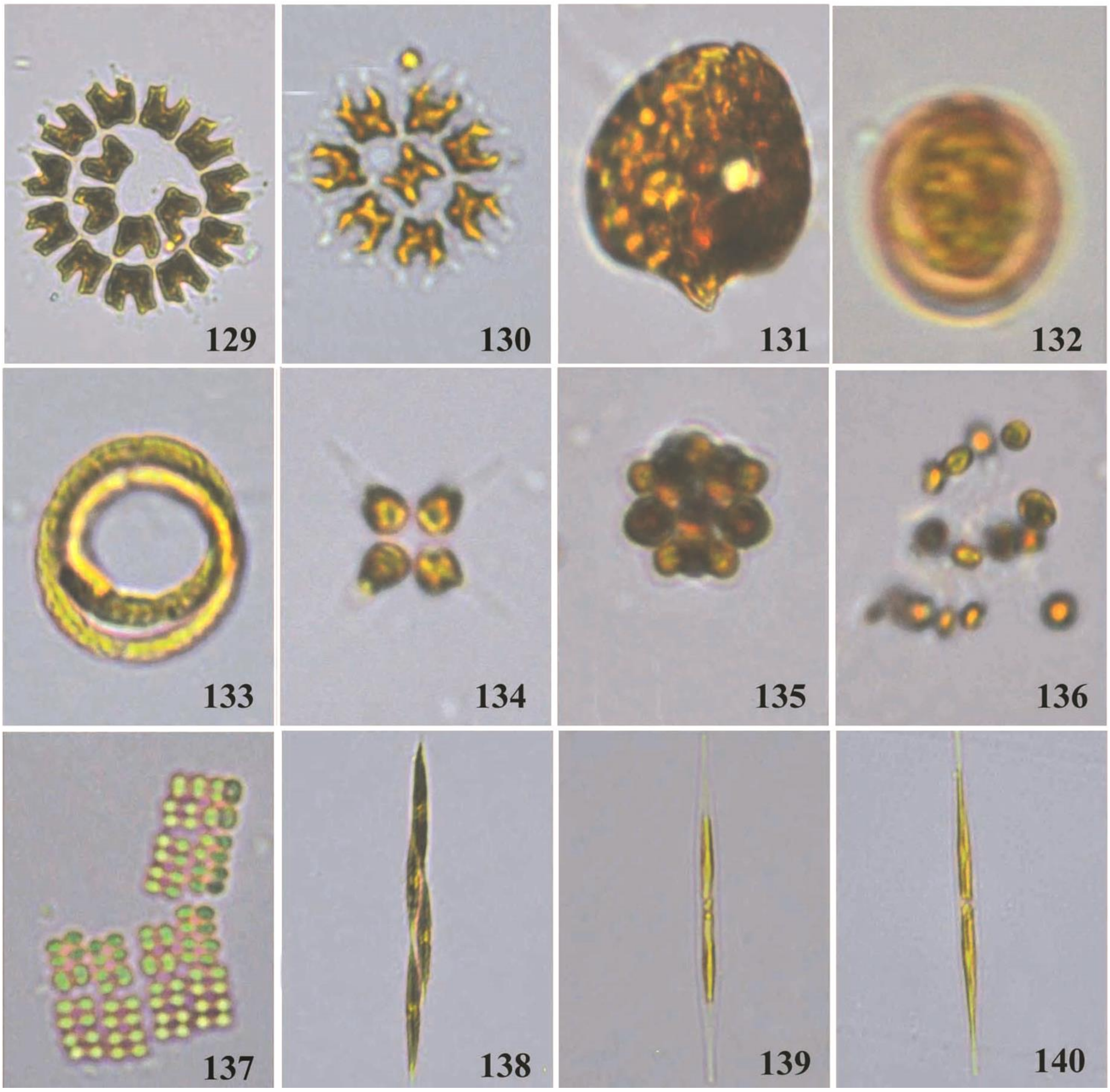
Fig. 136. *Dictyosphaerium*

Fig. 137. *Merismopedia*

Fig. 138. *Ankistrodesmus densus* Kors

Fig. 139-140. *Nitz. longissima*

Plate - 9



Station 2

Plate 1

Fig. 1, 11-12. *Mallomonas*

Fig. 2, 3. *Trachelomonas*

Fig. 4. *Gymnodinium*

Fig. 5, 6. *Frustulia*

Fig. 7. *Cocconeis*

Fig. 8, 13. *Melosira*

Fig. 9. *Phacus*

Fig. 10. *Euglena* sp

Fig. 14. *Cymbella*

Fig. 15. *Pediastrum duplex*

Fig16. *Oedogonium* (part of filament)

Plate - 1

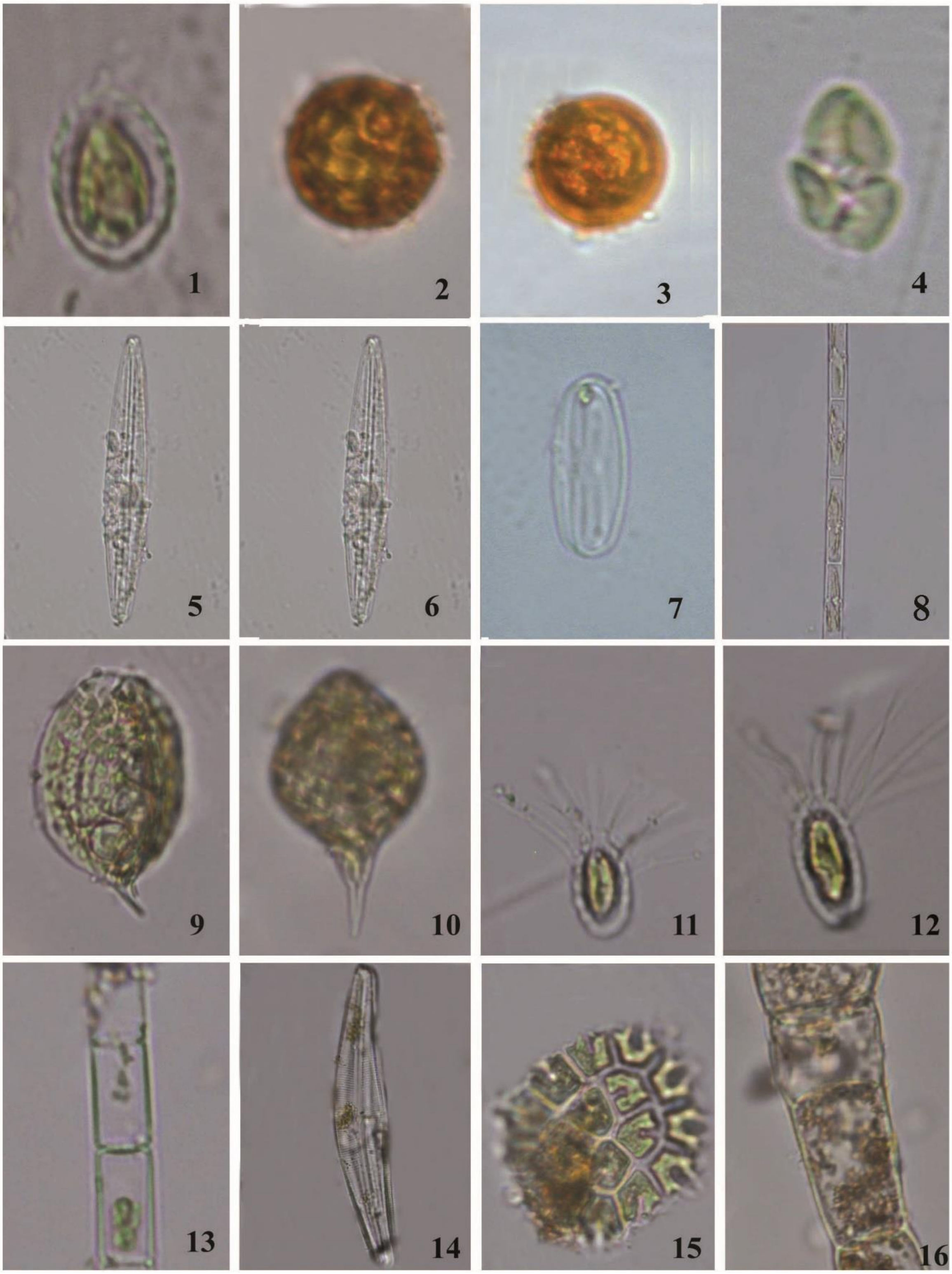


Plate 2

Fig. 17, 23. *Synedra*

Fig. 18. *Euglena acus*

Fig. 19, 20. *Coelastrum*

Fig. 21. *Coscinodiscus*

Fig. 22, 32. *Eunotia*

Fig. 24, 29. *Phacus*

Fig. 25. *Surirella*

Fig. 26-27. *Melosira*

Fig. 28. *Cyclotella*

Fig. 30. *P. longicauda*

Fig. 31. *Pelonema*

Plate - 2

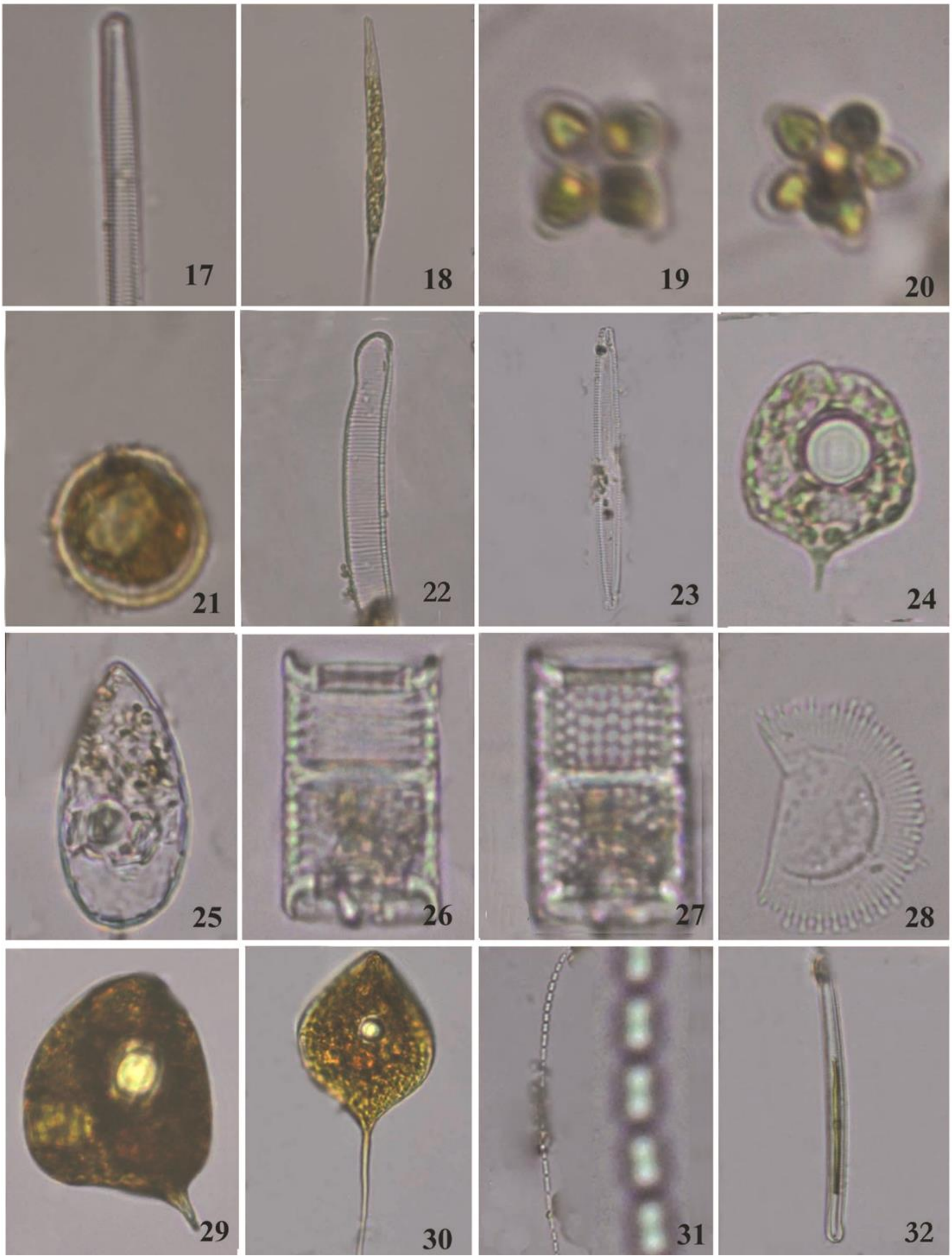


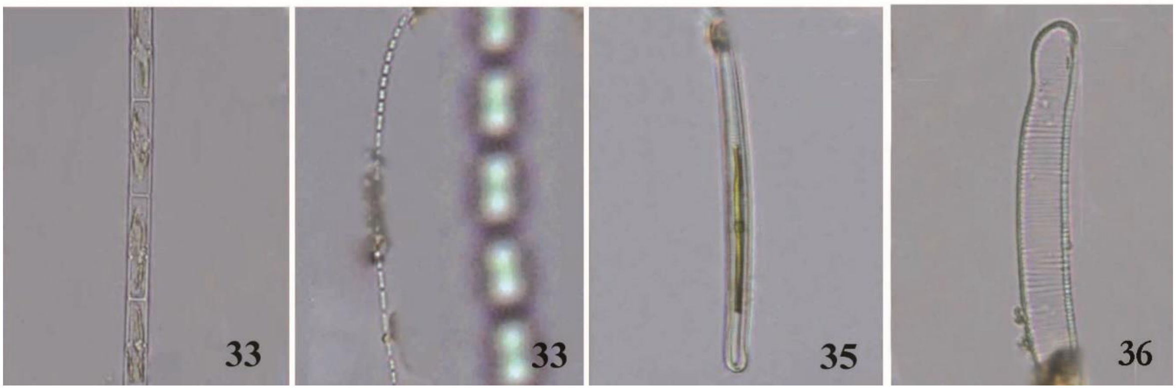
Plate 3

Fig. 33. *Melosira*

Fig. 34. *Pelonema*

Fig35-36. *Eunotia*

Plate - 3



Station 4

Plate 1

Fig. 1-3. *Lepocinclis*

Fig. 4. *Euglena* sp

Fig. 5. *Phacus*

Fig. 6-8. *Pediastrum duplex*

Fig. 9. *Euglena acus*

Fig. 10. *Gonatozygon*

Fig. 11-12. *Melosira*

Fig. 13. *Trachelomonas volvocina* Ehr.

Fig. 14, 15. *Tr. dybowski* Drez.

Fig. 16. *Didymocystis*

Plate - 1

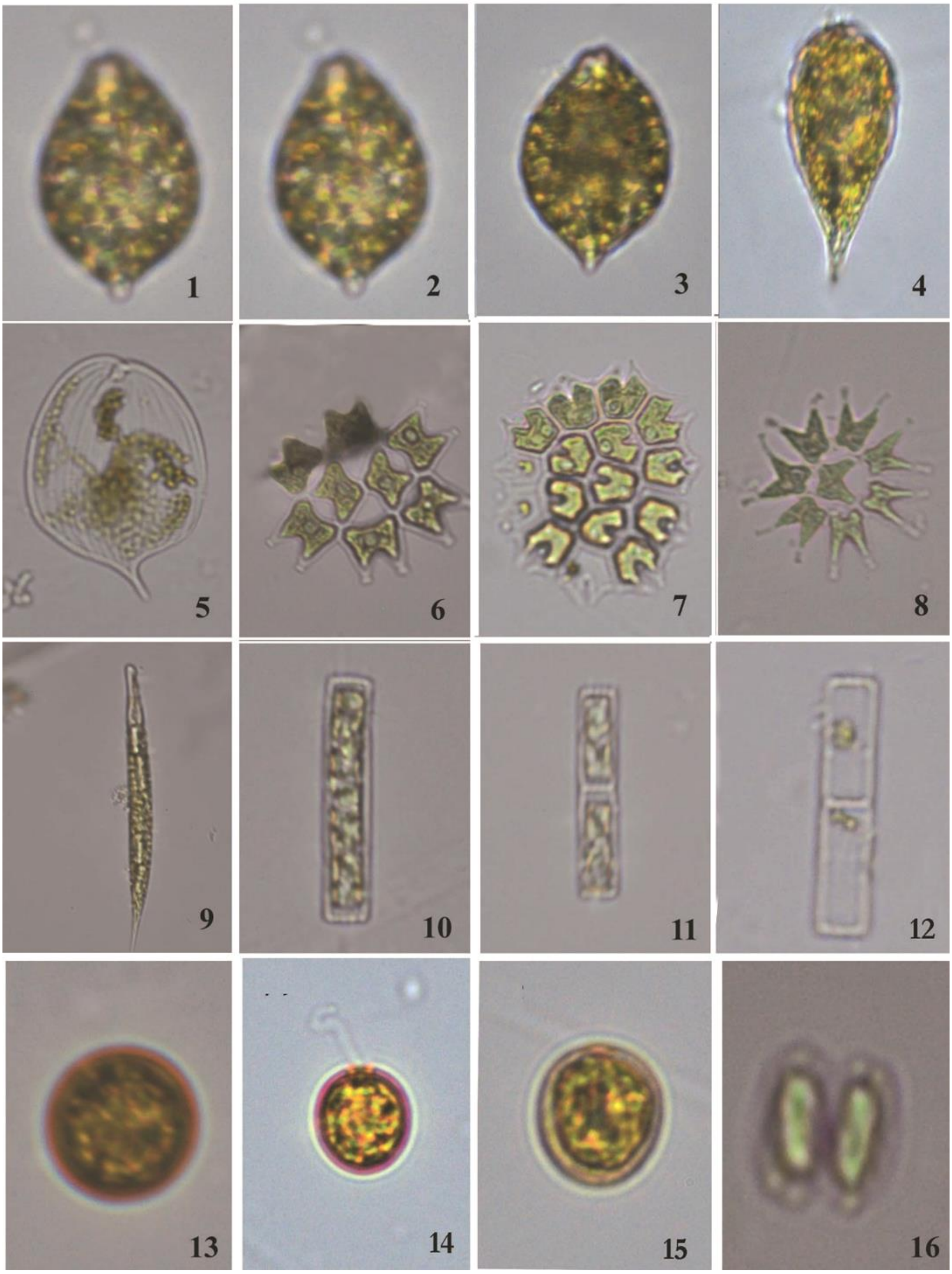


Plate 2

Fig. 17. *Microcystis*

Fig. 18, 20. *Coelosphaerium*

Fig. 19. *Cyclotella*

Fig. 21. *Euglena* sp

Fig. 22. *Trachelomonas*

Fig. 23. *Phacus*

Fig. 24-28. *Pediastrum duplex*

Fig. 29. *Scenedesmus*

Fig. 30. *Euglena acus*

Fig. 31. *Cyclotella*

Fig. 32. *Melosira*

Plate - 2

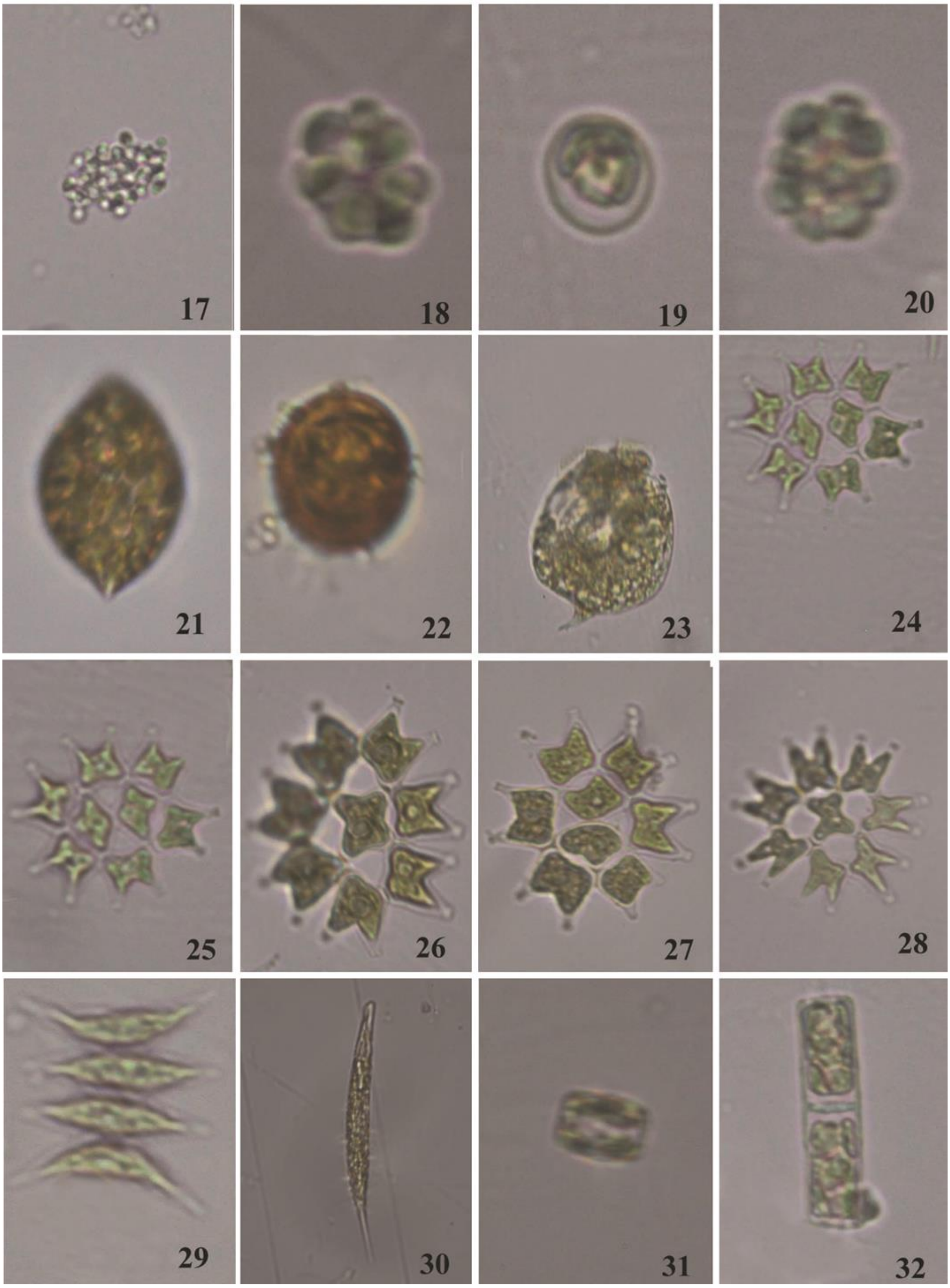


Plate 3

Fig. 33, 41. *Crucigenia*

Fig. 34-35. *Pediastrum duplex*

Fig. 36. *P. biradiatum*

Fig. 37. *Chaetoceros*

Fig. 38. *Mellosira*

Fig. 39. *Chlamydomonas*

Fig. 40. *Phacus*

Fig. 45-47. *Coelosphaerium*

Fig. 48. *Myrmecia*

Plate - 3

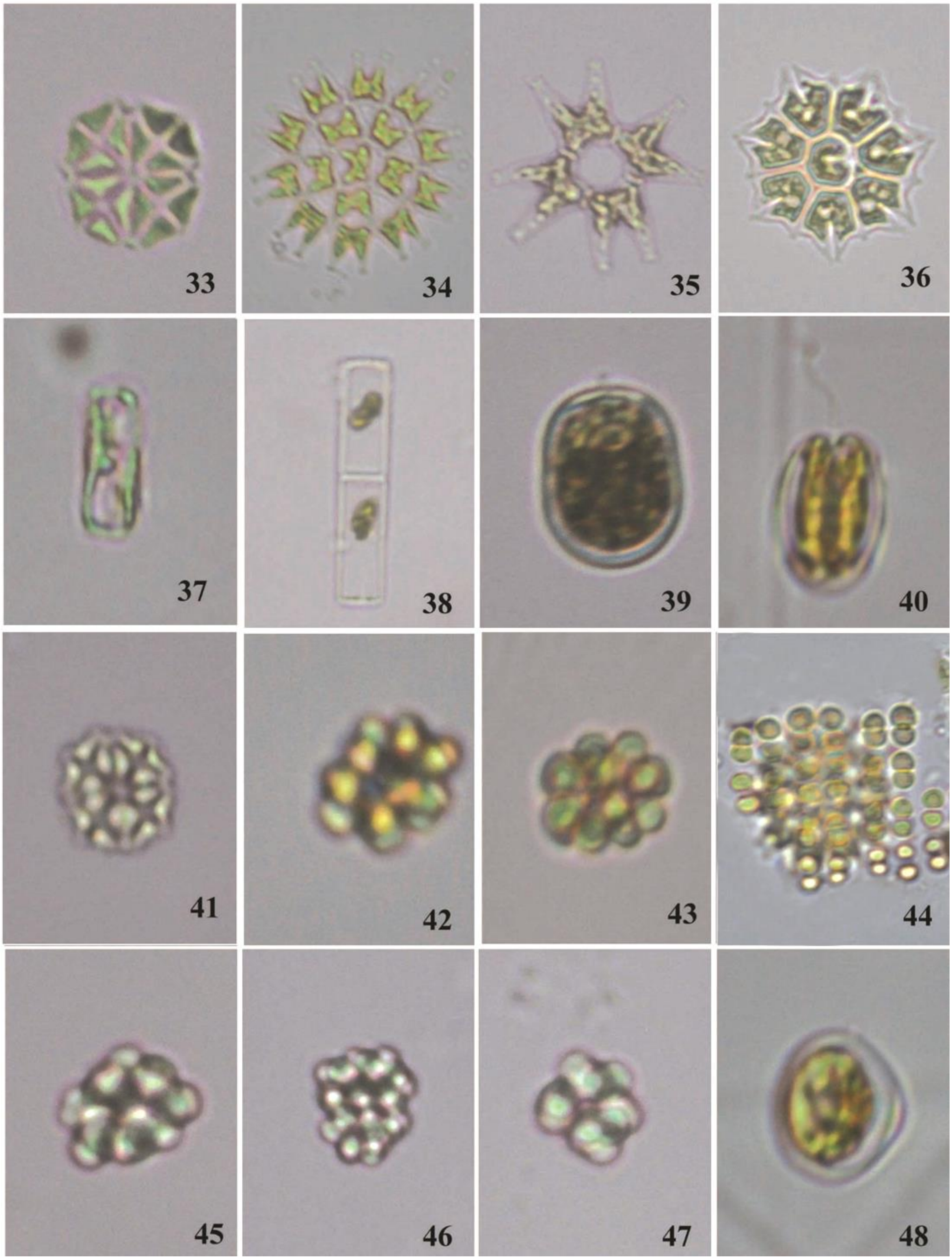


Plate 4

Fig. 49. *Euglena splendens* Dang.

Fig. 50. *Lepocinclis ovum* (Ehr.) Lemm.

Fig. 51-52. *Phacus*

Fig. 53-57. *Coelosphaerium*

Fig. 58. *Myrmecia*

Fig. 59. *Trachelomonas*

Fig. 60. *Merismopedia*

Fig. 61-63. *Pediastrum duplex*

Fig. 64. *Scenedesmus*

Plate -4

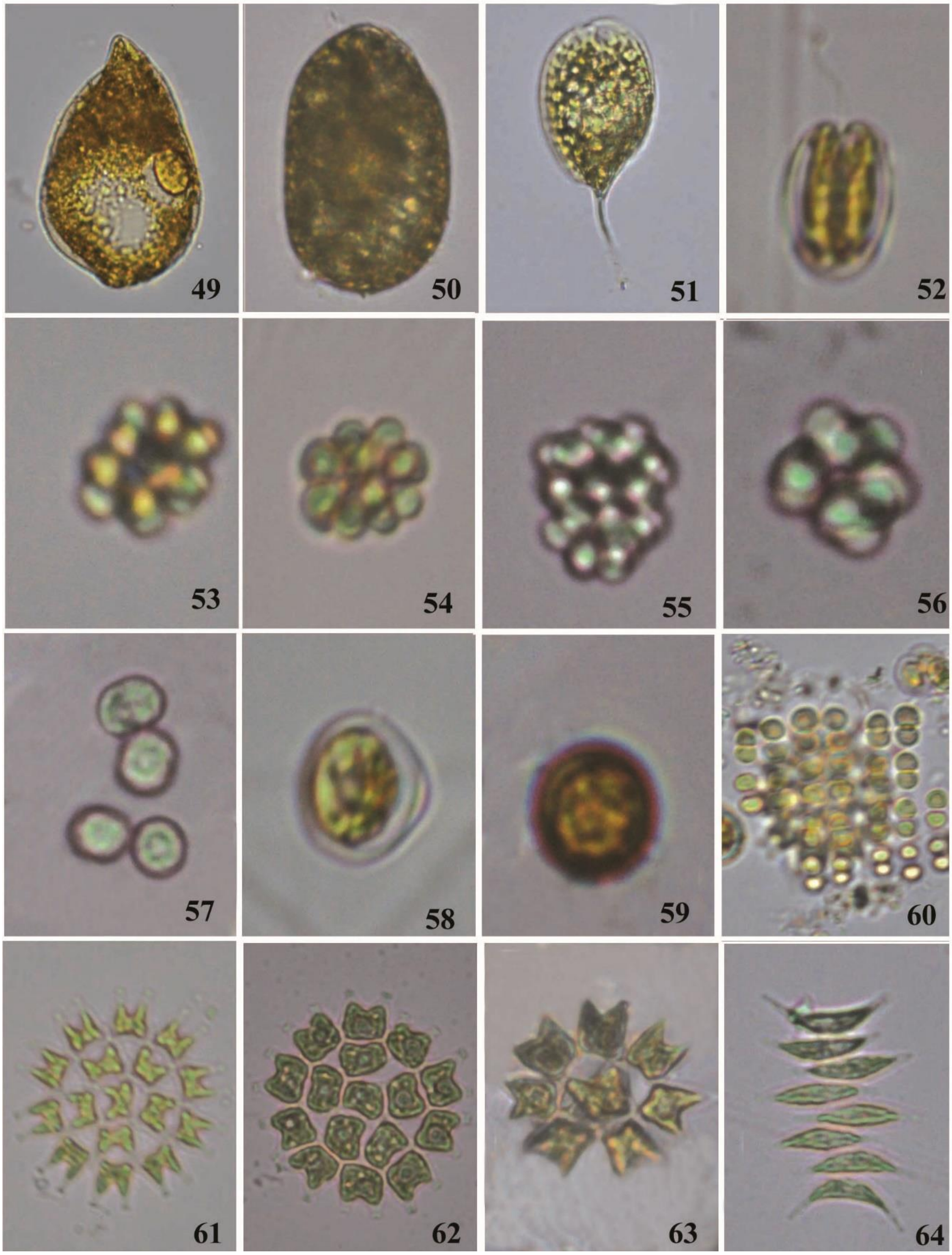


Plate 5

Fig. 65, 67, 70-71, 74. *Euglena* sp

Fig. 66, 68-69, 72. *Phacus*

Fig. 73. *Lepocinclis*

Fig. 75, 76. *Pediastrum duplex*

Fig. 77-78, 80. *Coelosphaerium*

Fig. 79. *Unidentified*

Plate - 5

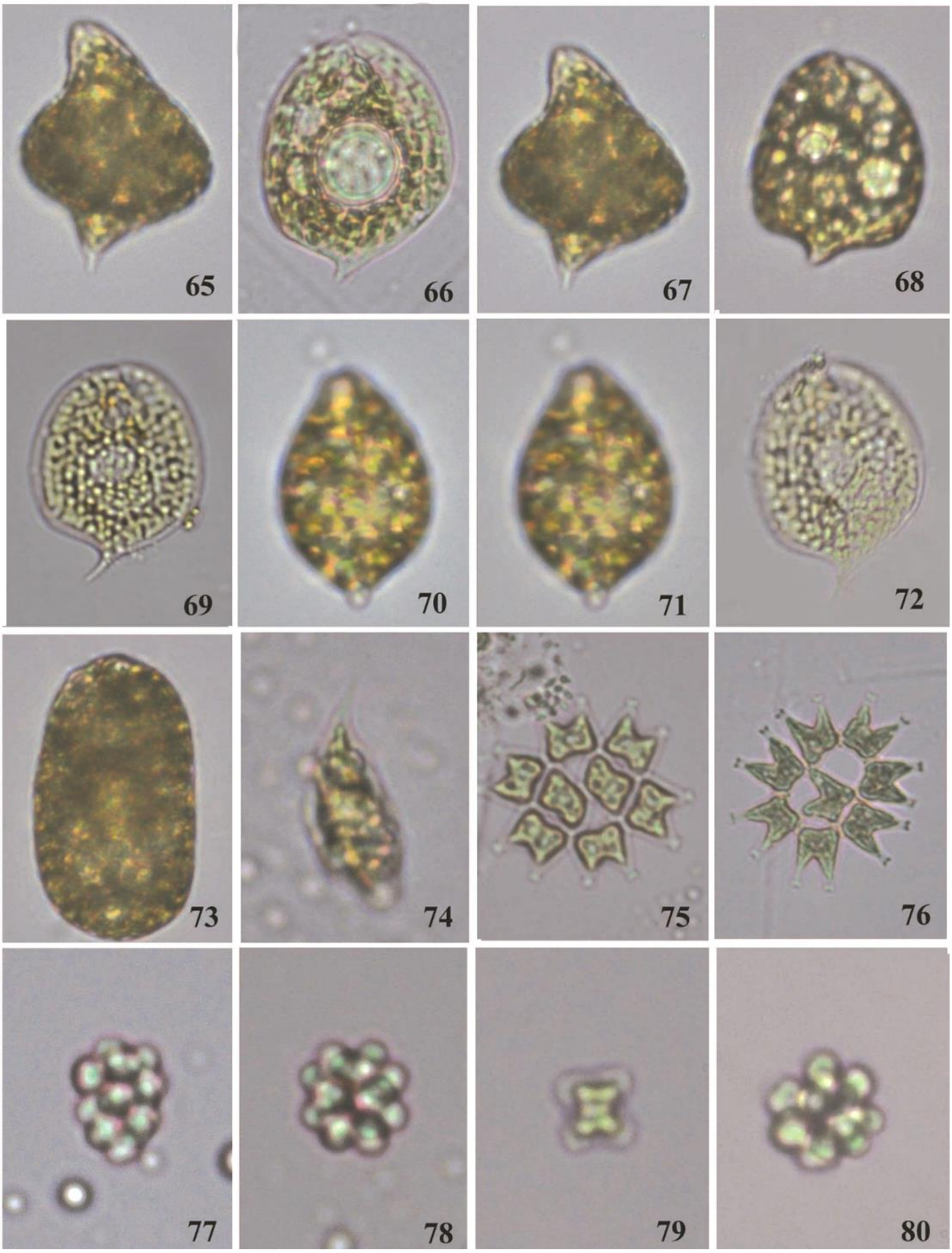


Plate 6

Fig. 81. *Peridinium*

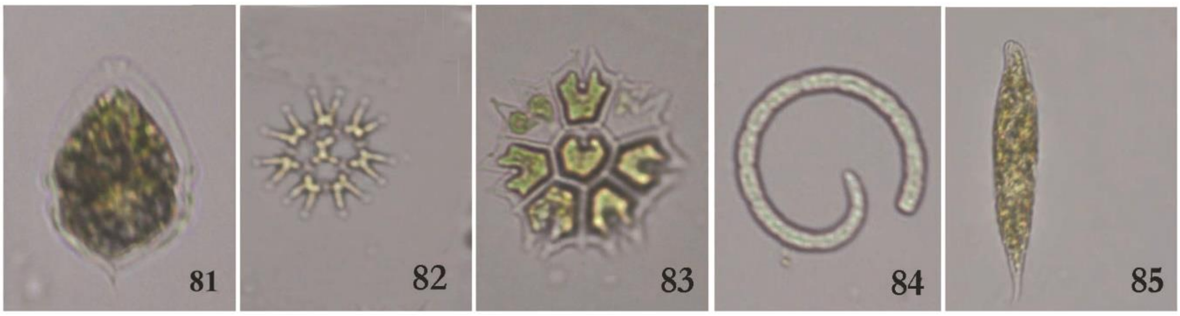
Fig. 82. *Pediastrum duplex*

Fig. 83. *Pediastrum biradiatus*

Fig. 84. *Raphidiopsis*

Fig. 85. *Euglena* sp

Plate - 6



Station 9

Plate 1

Fig. 1. *Phacus*

Fig. 2, 11. *Lepocinclis*

Fig. 3-4. *Strombomonas*

Fig. 5-8. *Trachelomonas*

Fig. 9-10. *Pandorina*

Fig. 12. *Colacium*

Fig. 13. *Pediastrum duplex*

Fig. 14. *Ceratium*

Fig. 15, 16. *Botryococcum*

Plate - 1

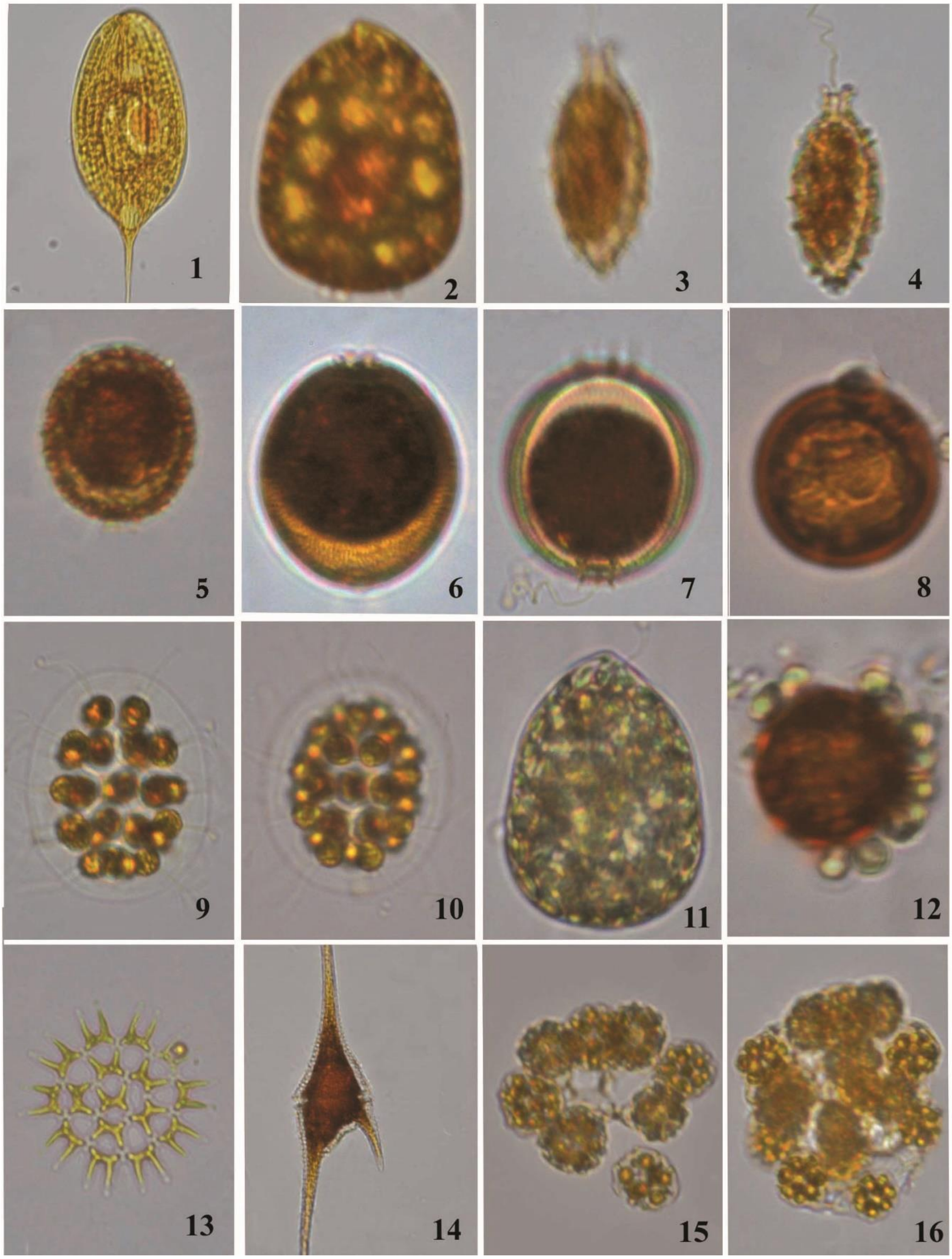


Plate 2

Fig. 17, 18. *Ceratium*

Fig. 19. *Euglena* sp

Fig. 20. *Mallomonas*

Fig. 21. *Lepocinclis ovum*

Fig. 22. *Melosira*

Fig. 23, 24. *Flagilaria*

Fig. 25-29. *Coelastrum*

Fig. 30-31. *Dictyosphaerium*

Fig. 32. *Coelosphaerium*

Plate - 2

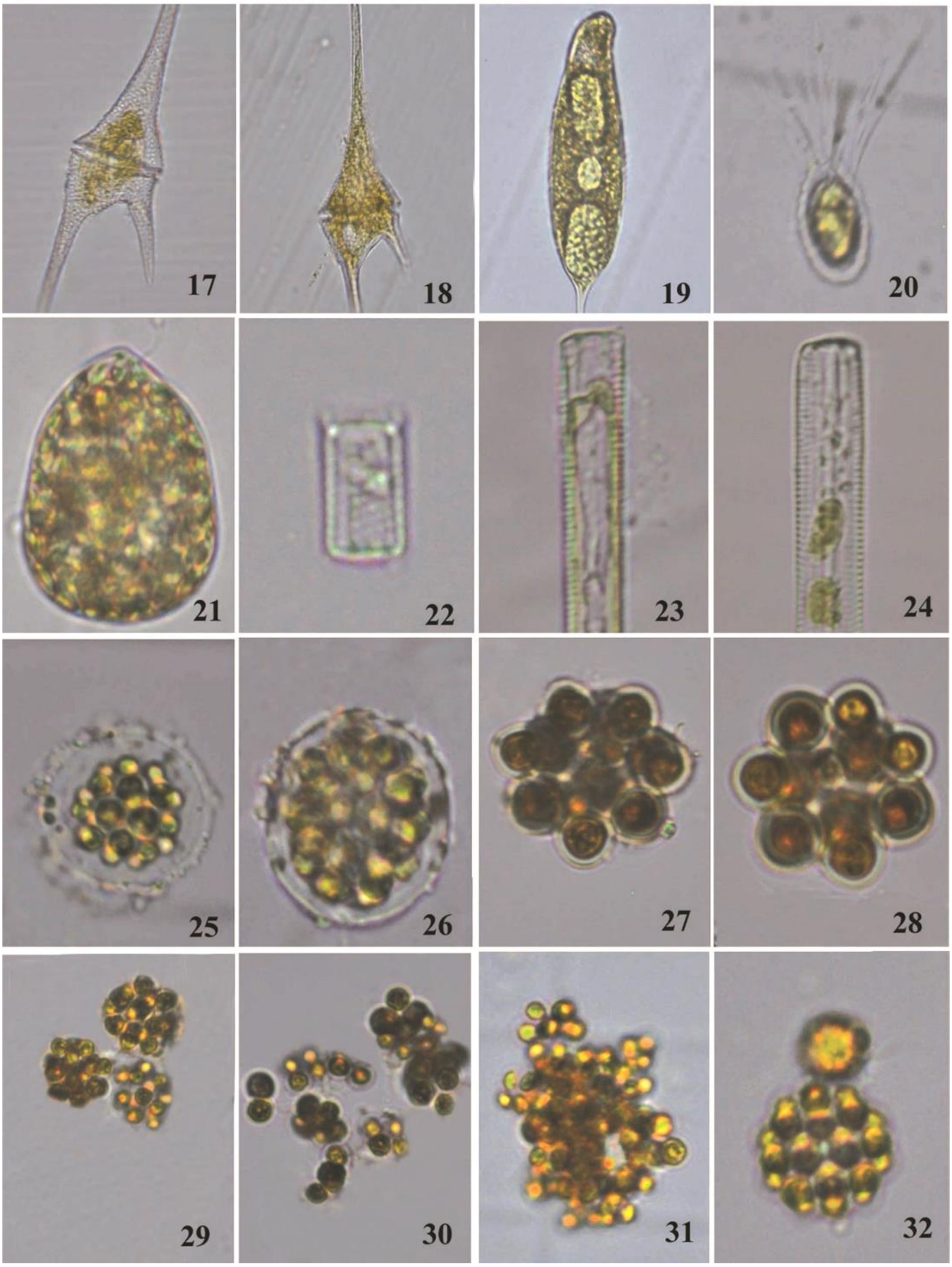


Plate 3

Fig. 33, 34. *Phacus*

Fig. 35-38. *Euglena* sp

Fig. 39. *Scenedesmus*

Fig. 40. *Trachelomonas*

Fig. 41-42. *Pediastrum duplex*

Fig. 43. *Coelosphaerium*

Fig. 44. *Crucigenia*

Fig. 45. *Tetrastrum punctatum* (Schmidle) Ahlstr. & Tiff.

Fig. 46. *Didymocystis*

Fig. 47. *Melosira*

Fig. 48. *Centritractus*

Plate - 3

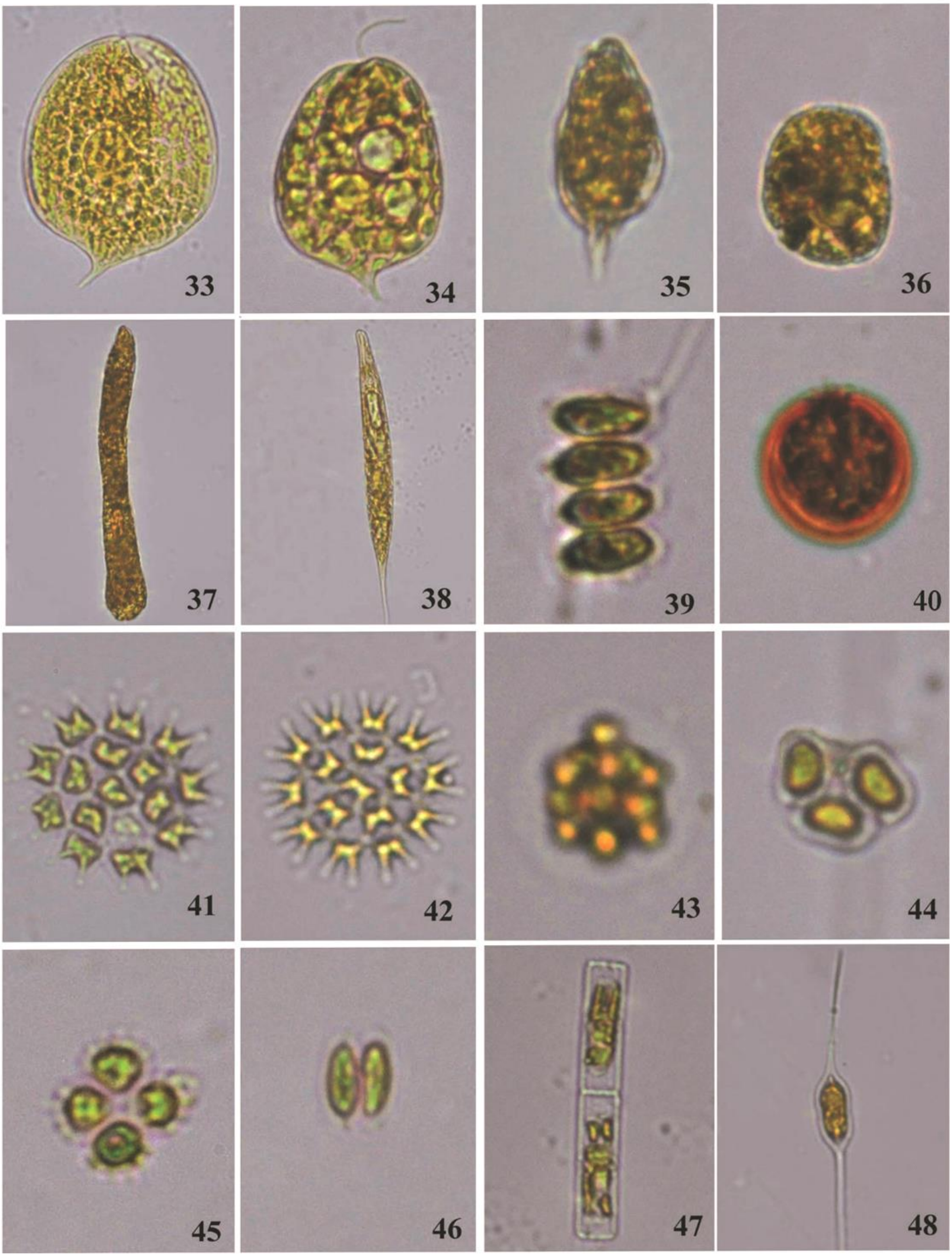


Plate 4

Fig. 49, 55. *Phacus*

Fig. 50. *Cryptomonas*

Fig. 51, 57. *Coscinodiscus*

Fig. 52, 58, 60. *Trachelomonas*

Fig. 53-54, 56, 62. *Mallomonas*

Fig. 59. *Coelosphaerium*

Fig. 61. *Tetrastrum*

Fig. 63. Unudentified

Fig. 64. *Planktosphaeria gelatinosa* Smith

Plate - 4

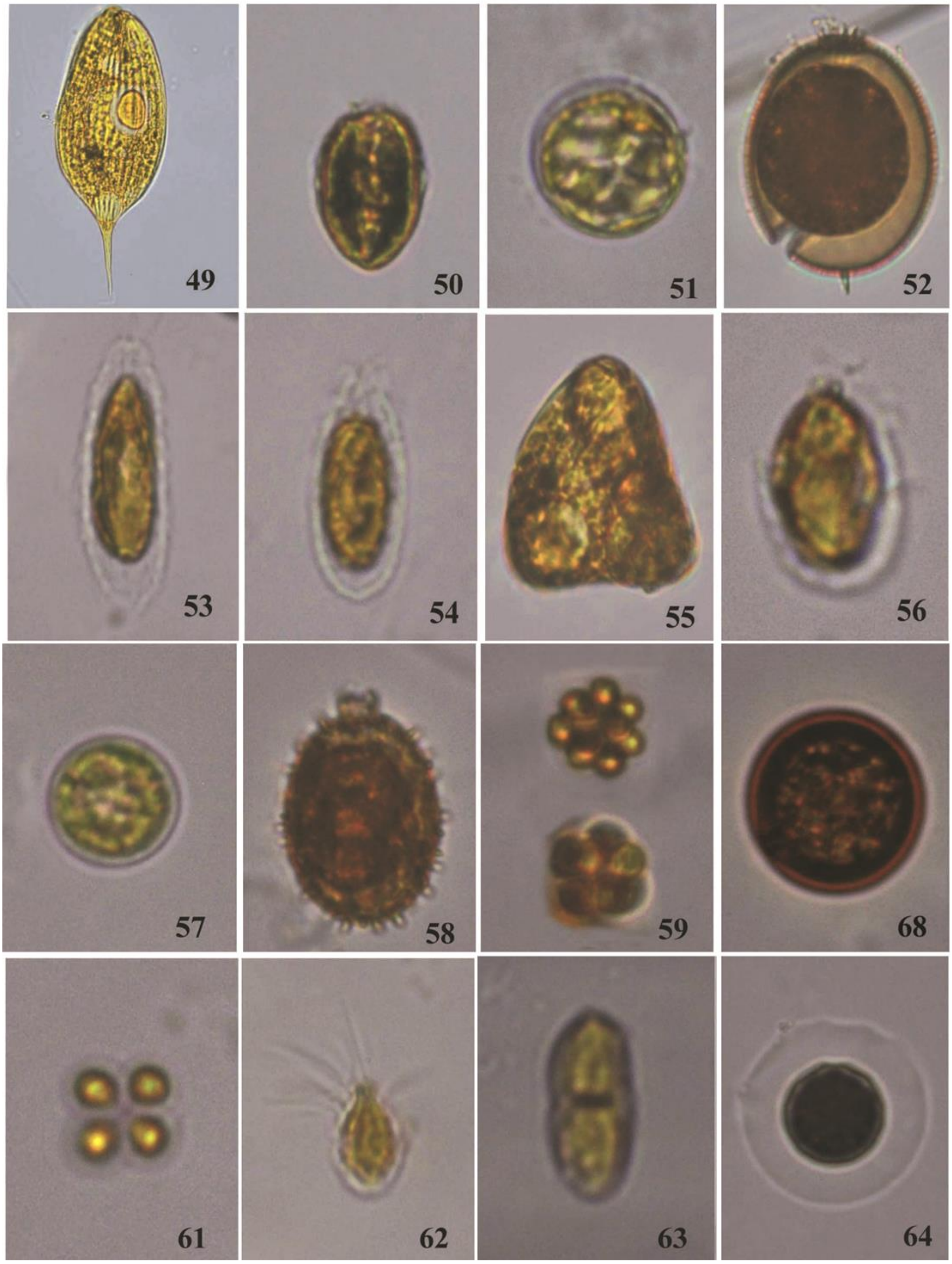


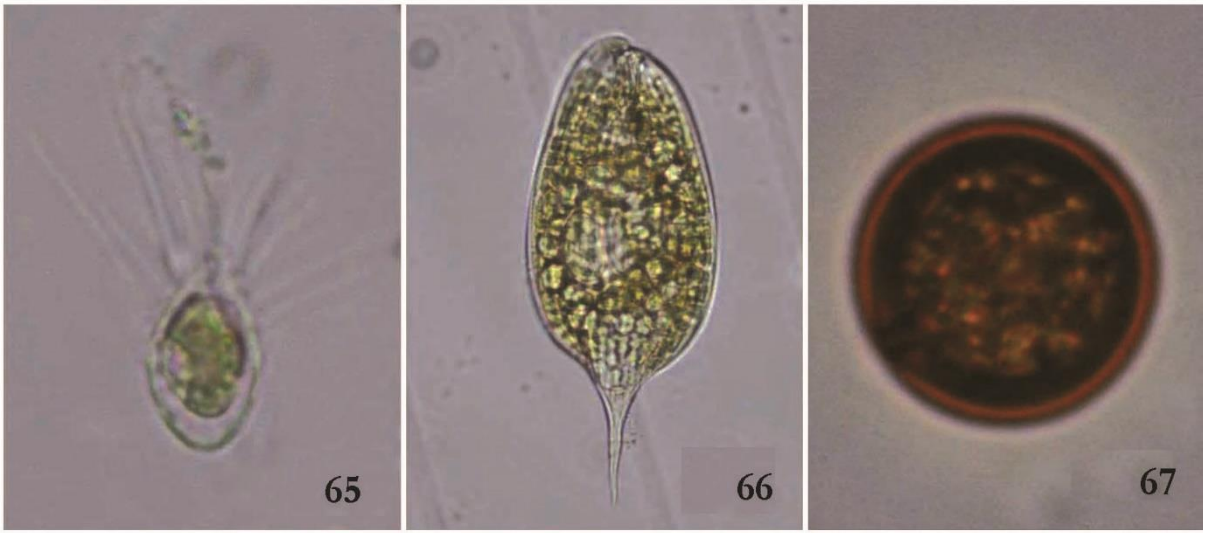
Plate 5

Fig. 65. *Mallomonas*

Fig. 66. *Phacus*

Fig. 67. *Trachelomonas*

Plate - 5



Station 10

Plate 1

Fig. 1. *Gloeotila*

Fig. 2-3. *Melosira*

Fig. 4. *Trachelomonas*

Fig. 5. *Fragilaria*

Fig. 6. *Synedra*

Fig. 7. *Frustulia*

Fig. 8, 10-13, 15. *Mallomonas*

Fig. 9. *Pediastrum duplex*

Fig. 14, 16. *Strombomonas*

Plate - 1

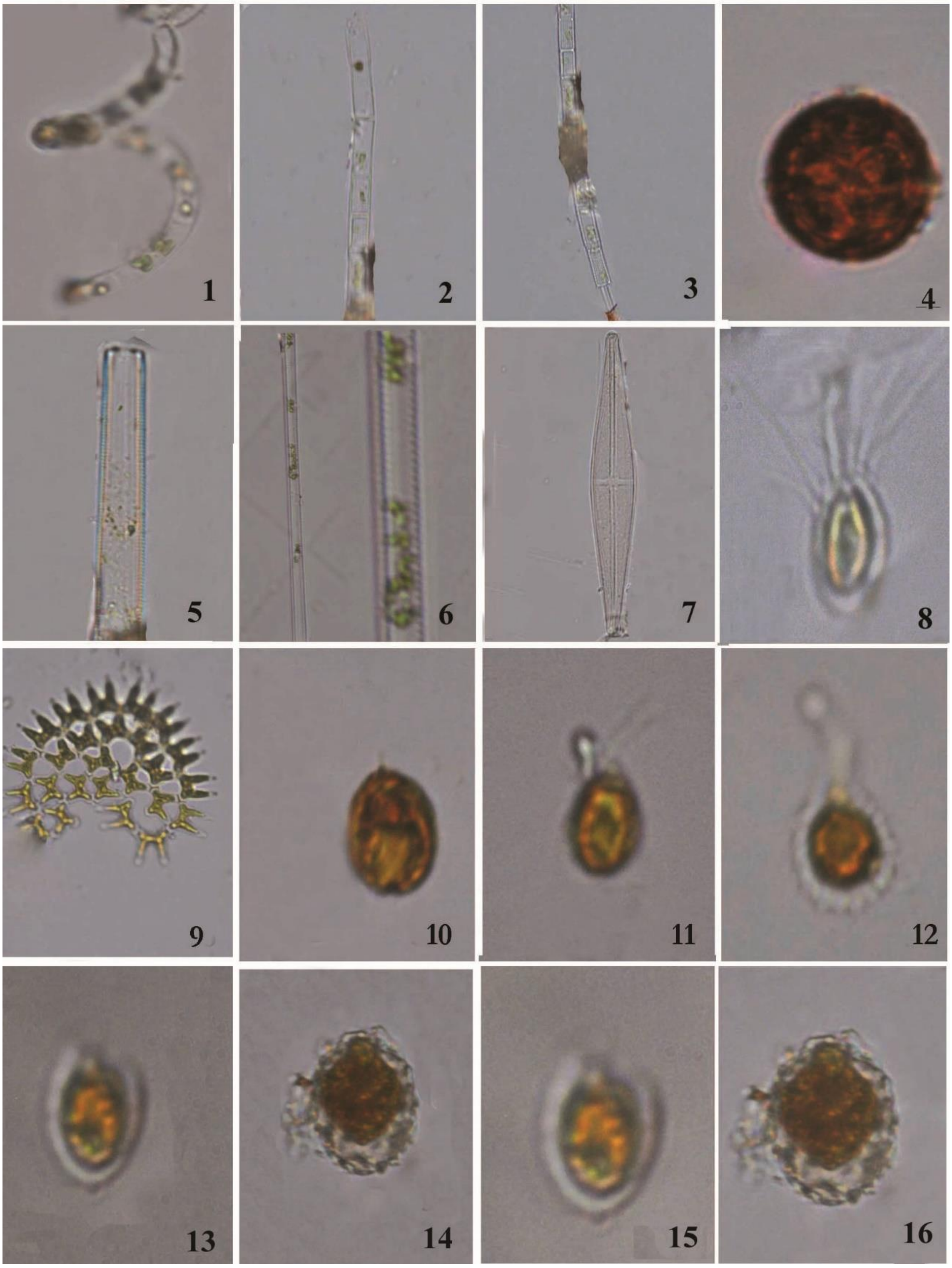


Plate 2

Fig. 17-18. *Phacus*

Fig. 19. *Trachelomonas*

Fig. 20-21. *Mallomonas*

Fig. 22. *Euglena* sp

Fig. 23-24, 27-28. *Melosira*

Fig. 25. *Gomphonema*

Fig. 26. *Synedra*

Fig. 29. *Oscillatoria*

Fig. 30. *Fragilaria*

Fig. 31. *Eunitia*

Fig. 32. *Navicula*

Plate - 2

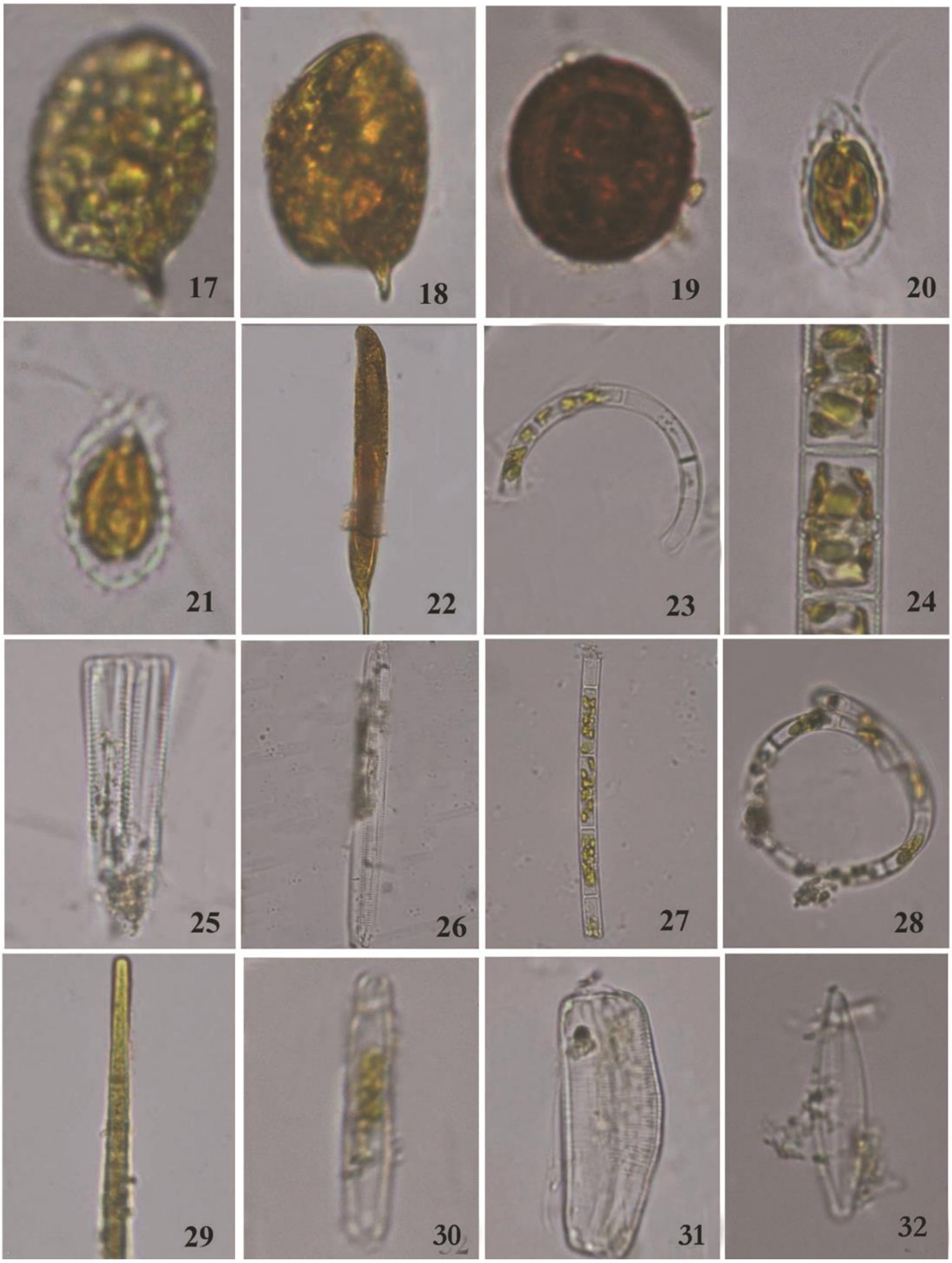
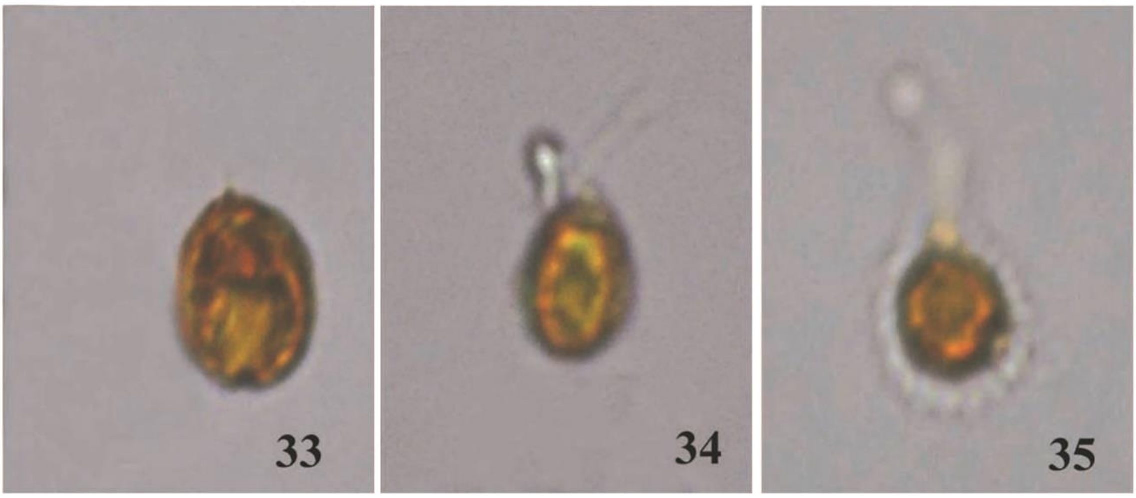


Plate 3

Fig. 33-35. *Mallomonas*

Plate- 3



Station 11

Plate 1

Fig. 1. *Phacus longicauda*

Fig. 2-5, 9. *Phacus*

Fig. 6-8. *Lepocinclis*

Fig. 10. *Trachelomonas*

Fig. 11. *Synechococcum*

Fig. 11. *Synechocystis aquatilis* Sauw

Fig. 11. *Merismodedia*

Fig. 14-15. *Scenedesmus*

Fig. 16. *Pediastrum duplex*

Plate - 1

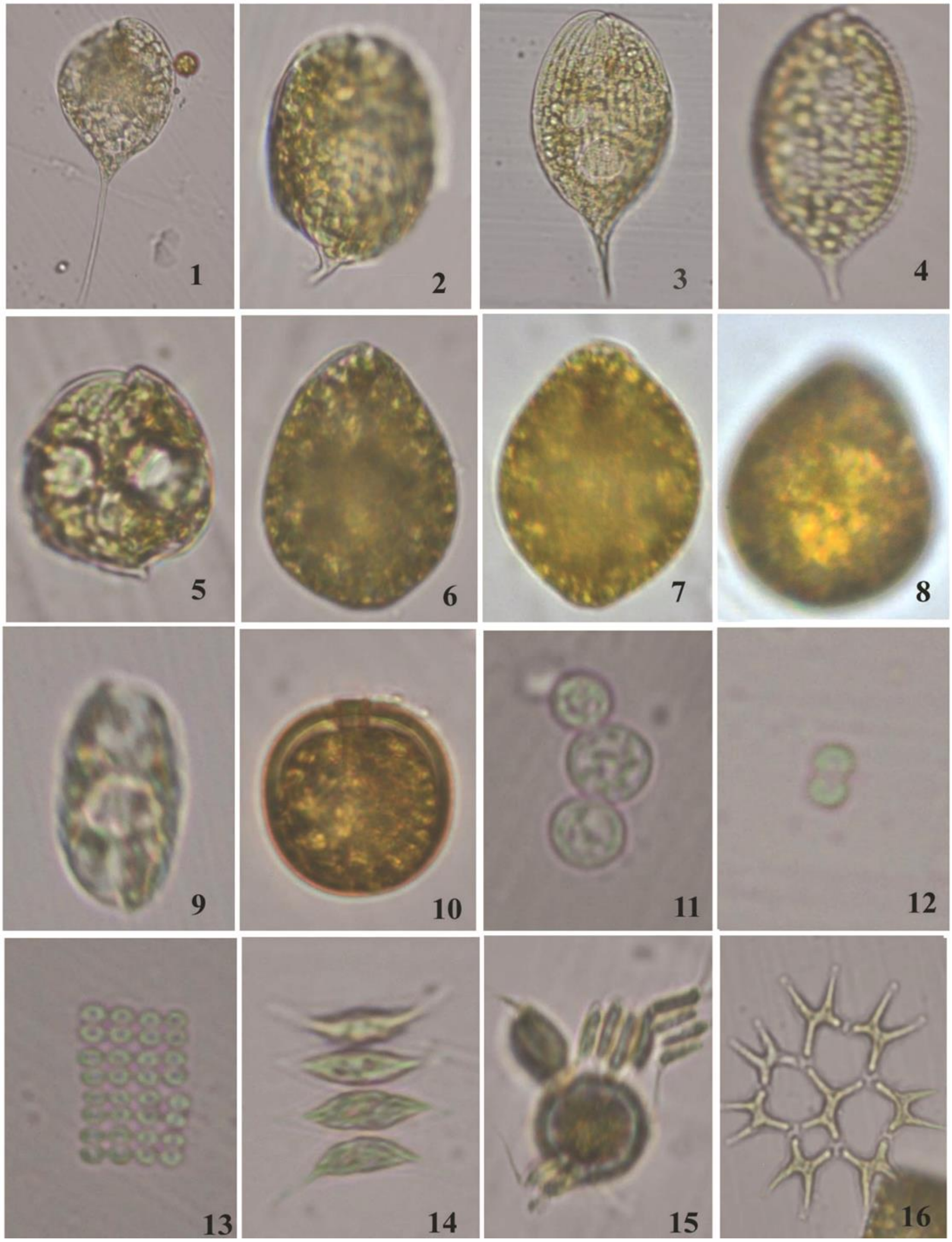


Plate 2

Fig. 17. *Peridinium*

Fig. 18. *Lepocinclis*

Fig. 19-24. *Trachelomonas*

Fig. 25. *Microcystis*

Fig. 26. *Cosmarium*

Fig. 27. *Euglena acus*

Fig. 28, 32. *Merismopedia*

Fig. 29. *Scenedesmus*

Fig. 30-31. *Synechococcus*

Plate - 2

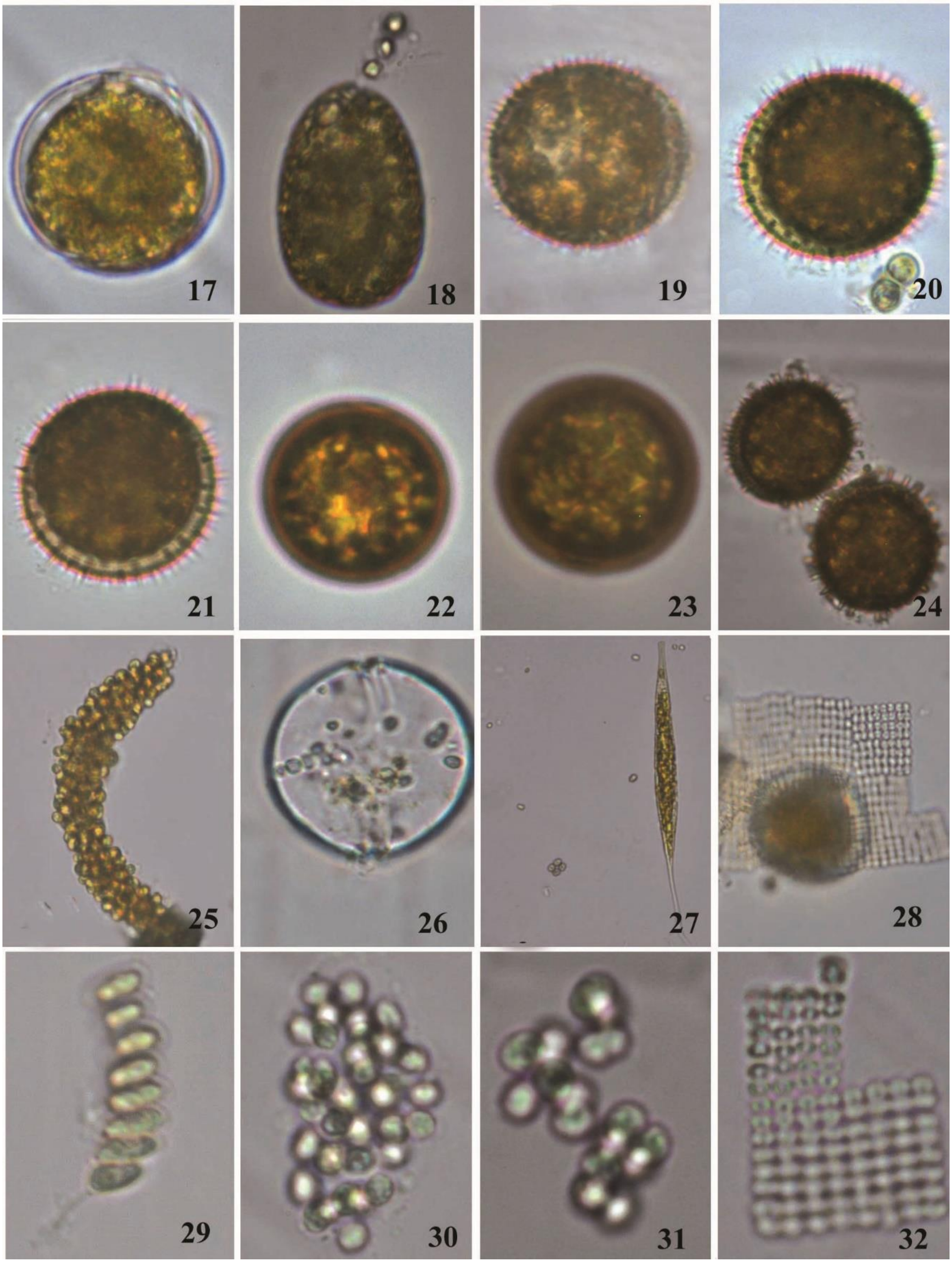


Plate 3

Fig. 33. *Anabaenopsis*

Fig. 34. *Pediastrum duplex*

Fig. 35. *Pediastrum biradiatus*

Fig. 36. *Crucigenia*

Fig. 37-39. *Pelonema*

Fig. 40. *Anabaena*

Fig. 41. *Euglena acus*

Fig. 42. *Euglena* sp

Fig. 43. *Astasia*

Fig. 44. *Scenedesmus*

Fig. 45. *Trachelomonas*

Fig. 46. *Peridinium*

Fig. 47. *Coelosphaerium*

Fig. 48. *Crucigenia*

Plate - 3

Plate 4

Fig. 49, 53. *Phacus*

Fig. 50. *Lepocinclis*

Fig. 51-52. *Trachelomonas*

Fig. 54. *Tetrastrum punctatum* (Schmidle) Ahlstr & Tiff

Fig. 55. *Coelastrum*

Fig. 56. *Dictyosphaerium*

Fig. 57-59. *Pediastrum*

Fig. 60. *Anabaenopsis*

Fig. 61, 63. *Nitz. longissima*

Fig. 62. *Ankistrodesmus densus*

Fig. 64. *Merismopedia*

Plate - 4

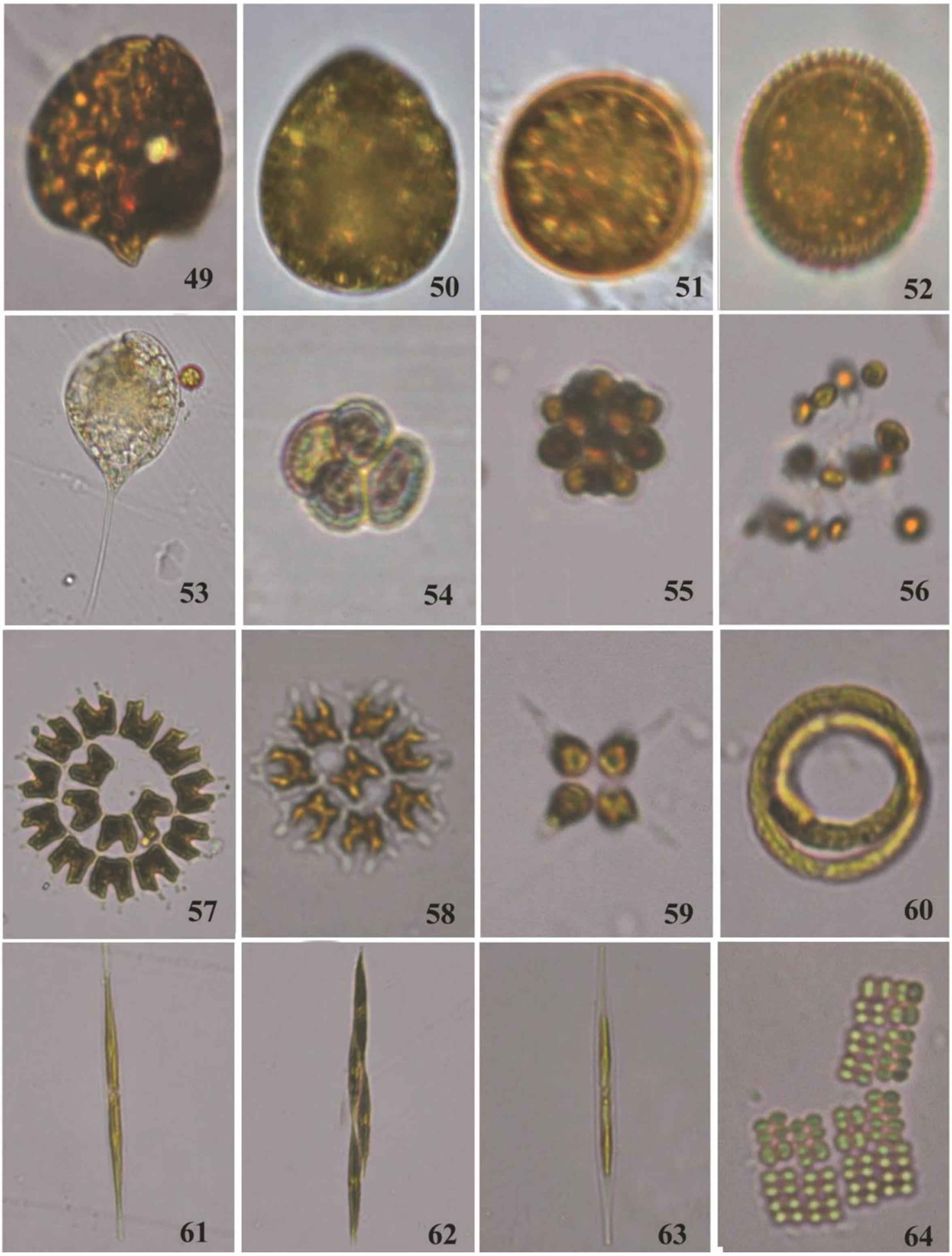


Plate 5

Fig. 65-66. *Phacus longicauda*

Fig. 67-69, 71-72, 78. *Euglena* sp

Fig. 70. *Lepocinclis*

Fig. 73. *Coelosphaerium*

Fig. 74-76. *Trachelomonas*

Fig. 77. *Peridinium*

Fig. 79. *Microcystis*

Fig. 80. *Anabaenopsis*

Plate - 5

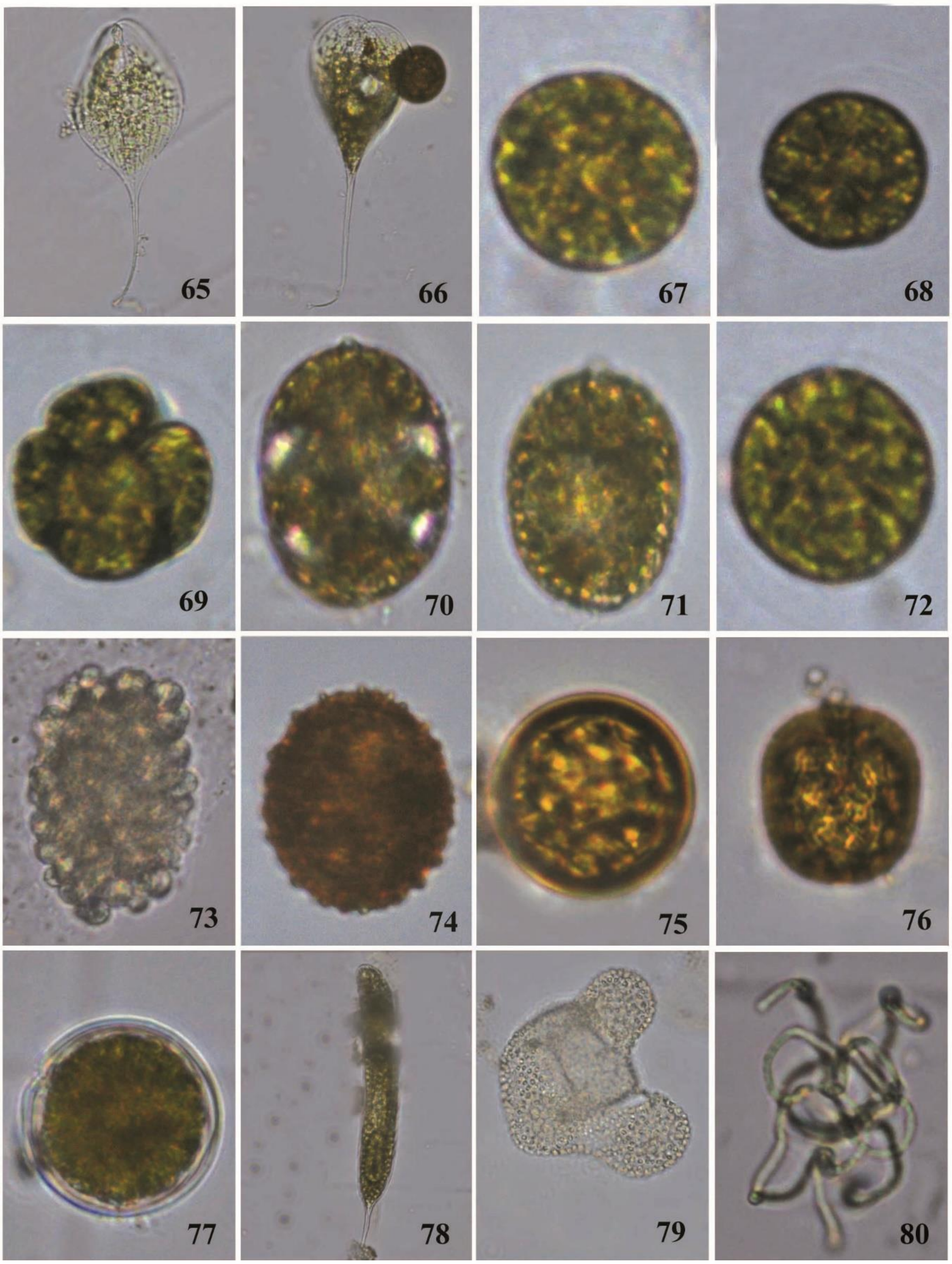


Plate 6

Fig. 81-82. *Phacus*

Fig. 83-84. *Lepocinclis*

Fig. 85, 86. *Trachelomonas*

Fig. 87. *Aphanothece*

Fig. 88. *Microcystis*

Fig. 89. *Euglena*

Fig. 90. *Pinnularia*

Fig. 91. *Tetraedron*

Fig. 92. *Merismopedia*

Fig. 93. *Synechococcus*

Fig. 94-96. *Microcystis*

Plate - 6

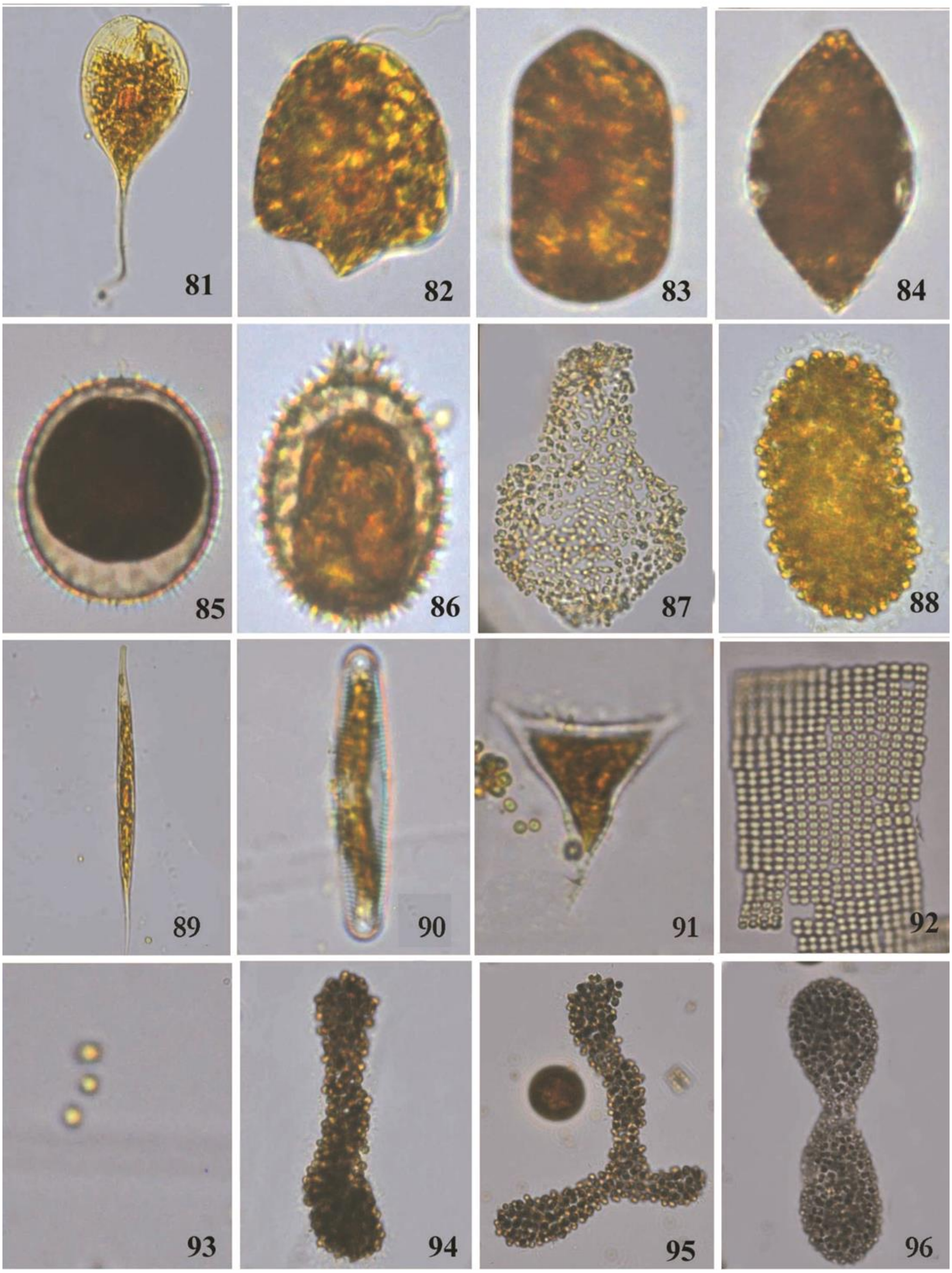


Plate 7

Fig. 96-97. *Phacus*

Fig. 98. *Lepocinclis*

Fig. 99-105. *Trachelomonas*

Fig. 106. *Coelossphaerium*

Fig. 107. *Pandorina*

Fig. 108-110. *Microcystis*

Fig. 111. *Merismopedia*

Plate - 7

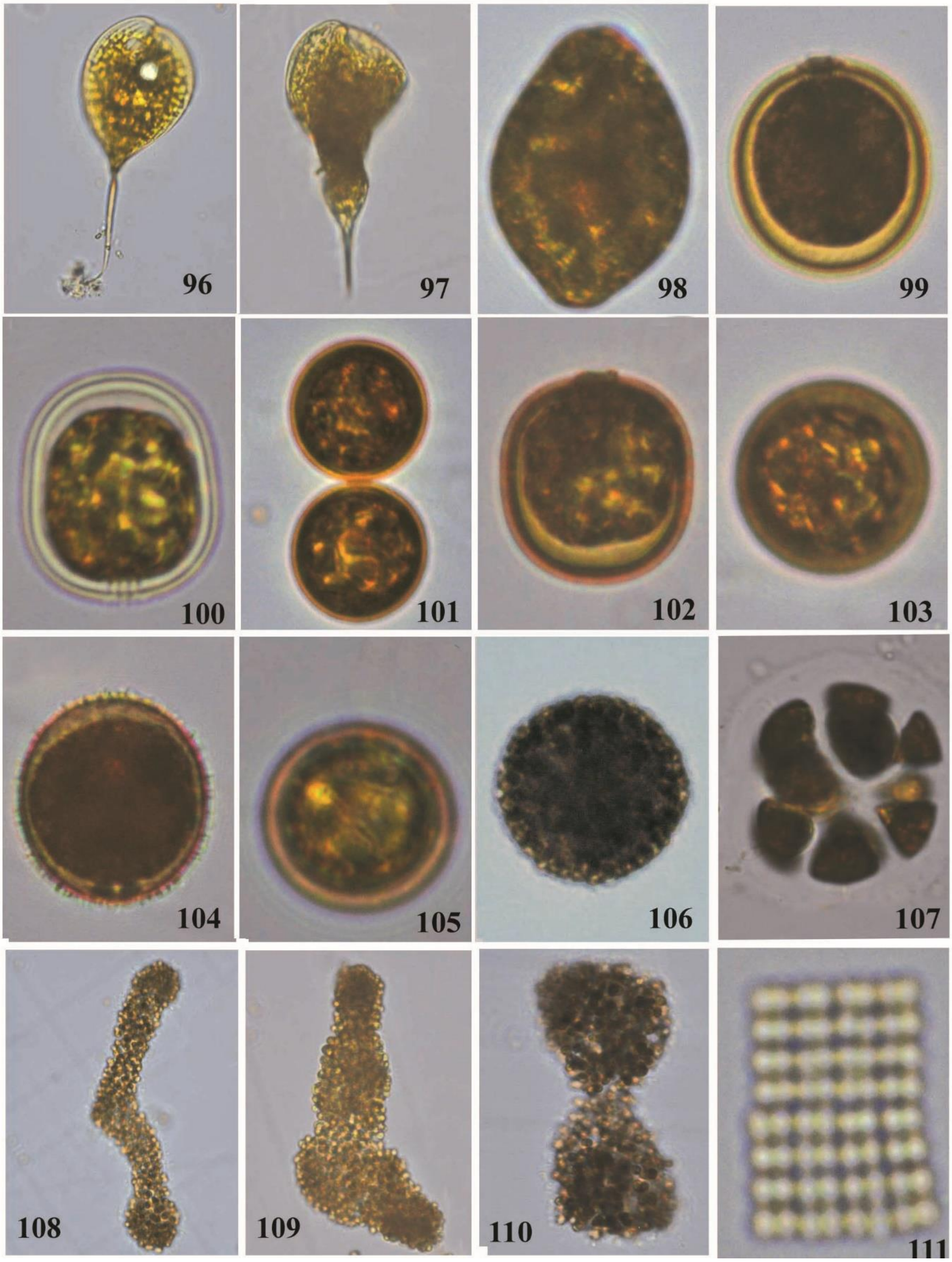


Plate 8

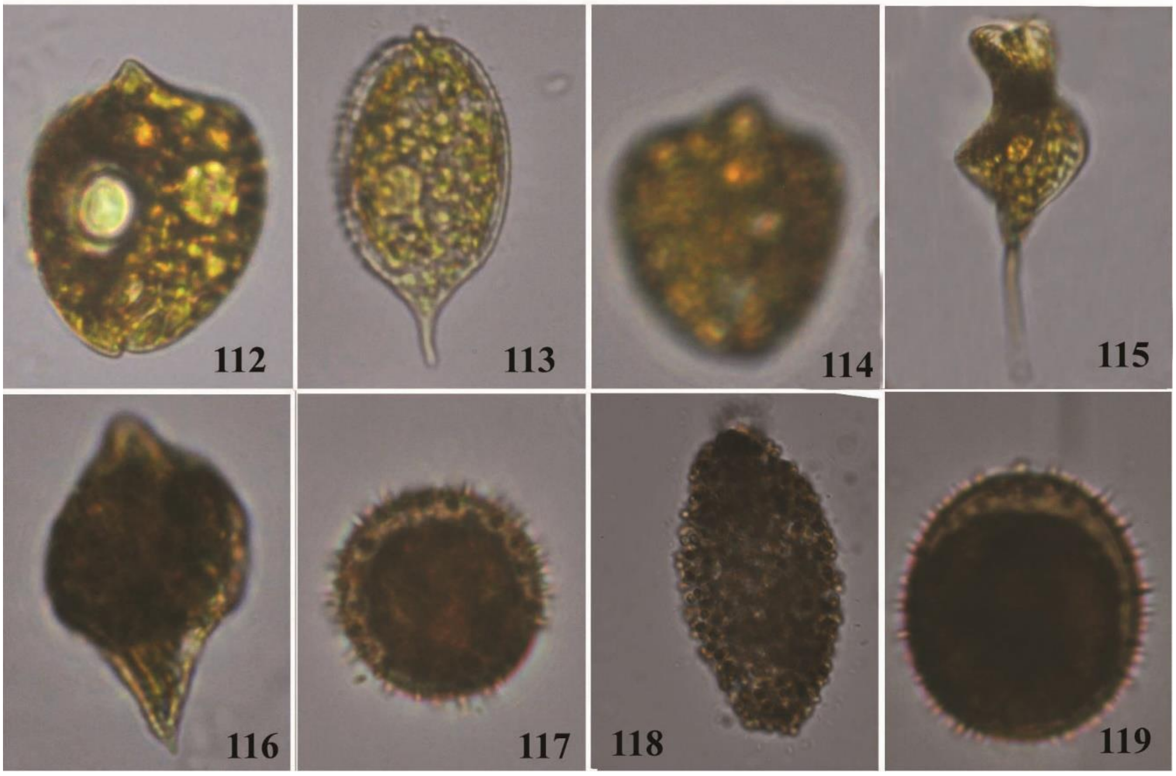
Fig. 112-115. *Phacus*

Fig. 116. *Euglena* sp

Fig. 117, 119. *Trachelomonas*

Fig. 118. *Microcystis*

Plate-8



Station 12

Plate 1

Fig. 1-4. *Phacus*

Fig. 5, 8. *Lepocinclis*

Fig. 6. *Peridinium* (upper black)

Fig. 7, 9. *Euglena* sp

Fig. 10-12. *Trachelomonas*

Fig. 13-14. *Astasia*

Fig. 15-16. *Hyaloraphidium contortum*

Plate - 1

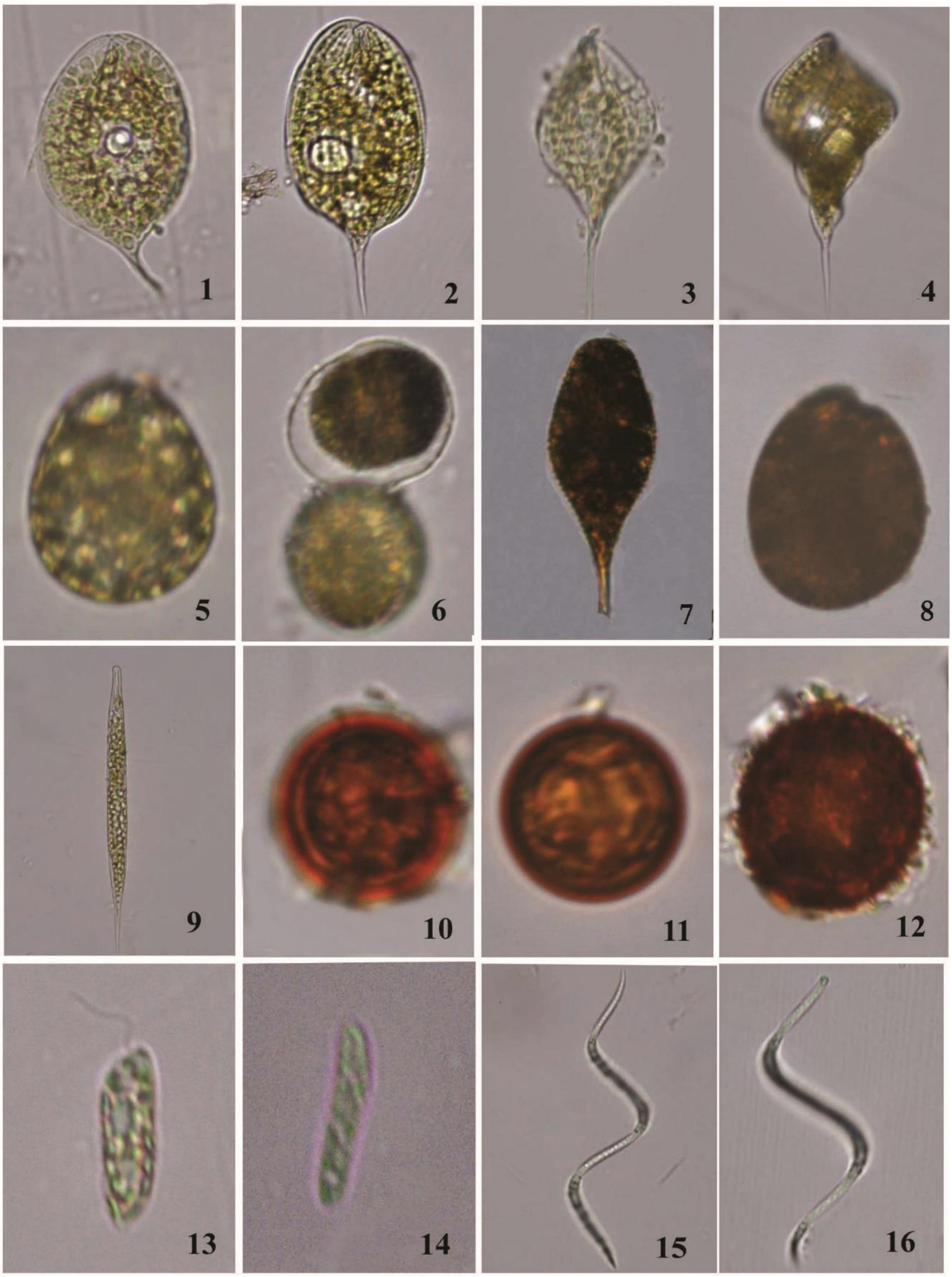


Plate 2

Fig. 17. *Chlamydomonas*

Fig. 18-21, 24. *Mallomonas*

Fig. 22. *Phacus*

Fig. 23. *Euglena* sp

Fig. 25-26. *Trachelomonas*

Fig. 27. *Coelastrum*

Fig. 28. *Chaetoceros*

Fig. 29-30. *Navicula*

Fig. 31. *Melosira*

Fig. 32. *Pelonema*

Plate - 2

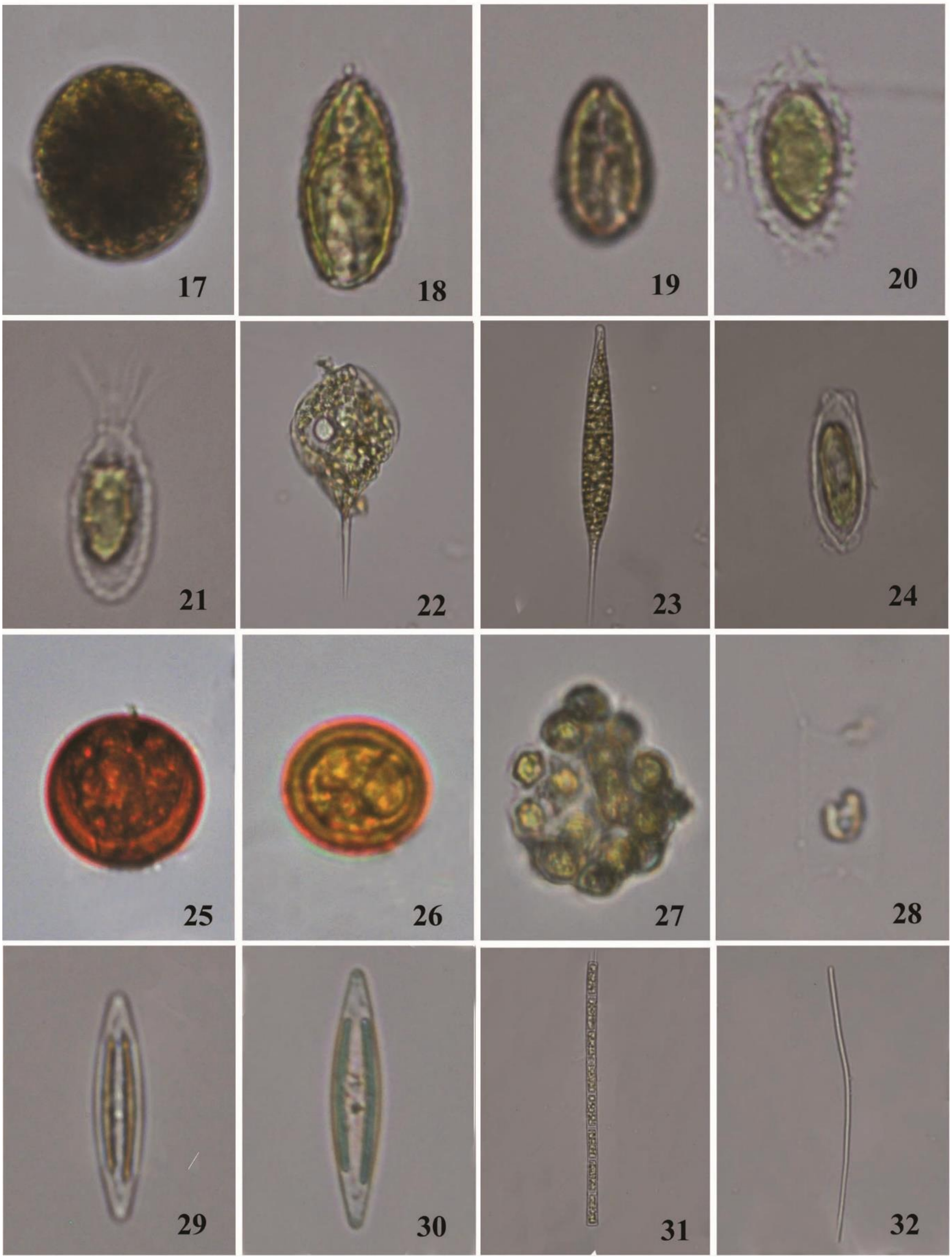


Plate 3

Fig. 33, 38. *Phacus*

Fig. 34-37, 39-40. *Euglena* sp

Fig. 41-42. *Mallomonas*

Fig. 43. *Straurastrum*

Fig. 44-47. *Trachelomonas*

Fig. 48. *Peridinium*

Plate - 3

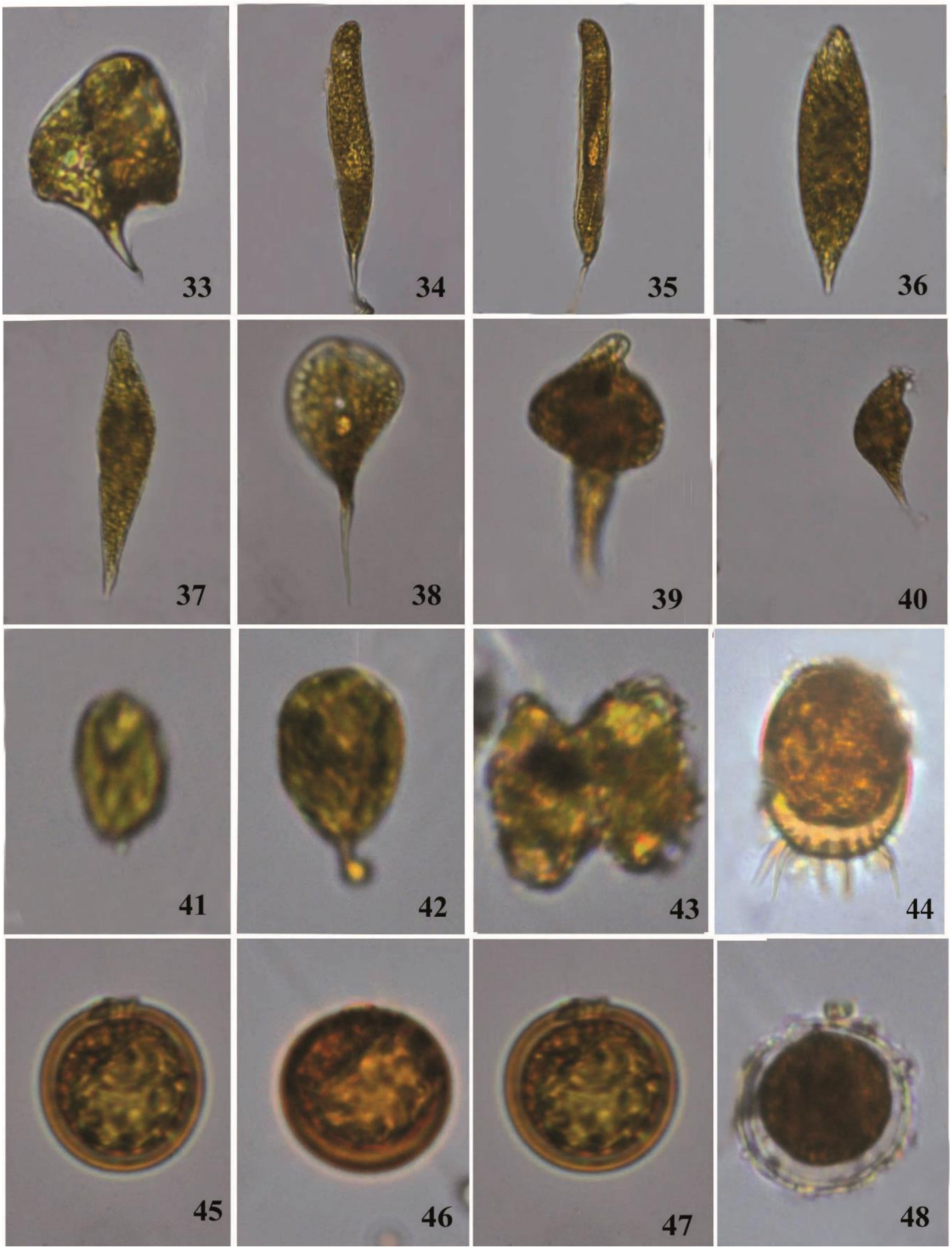


Plate 4

Fig. 49-50, 57. *Phacus*

Fig. 51-54, 63-64. *Euglena* sp

Fig. 55-56. *Oscillatoria*

Fig. 58-59. *Trachelomonas*

Fig. 60. *Mallomonas*

Fig. 61. *Scenedesmus*

Fig. 62. *Lepocinclis*

Plate - 4

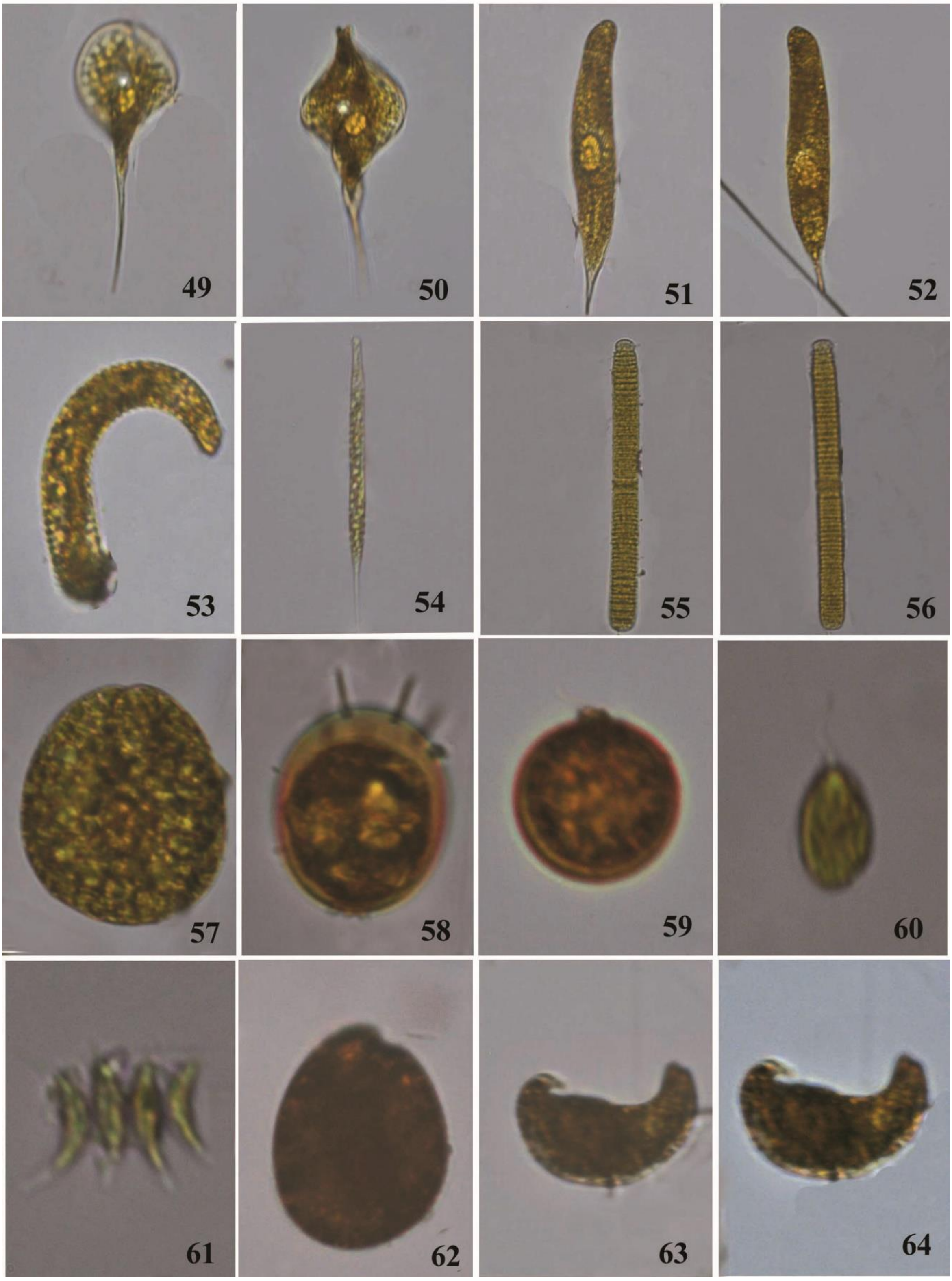


Plate 5

Fig. 65-69. *Phacus*

Fig. 70. *Lepocinclis*

Fig. 71-72, 74, 77-80. *Trachelomonas*

Fig. 73. *Cryptomonas*

Fig. 75. *Euglena* sp

Fig. 76. *Coelosphaerium*

Plate -5

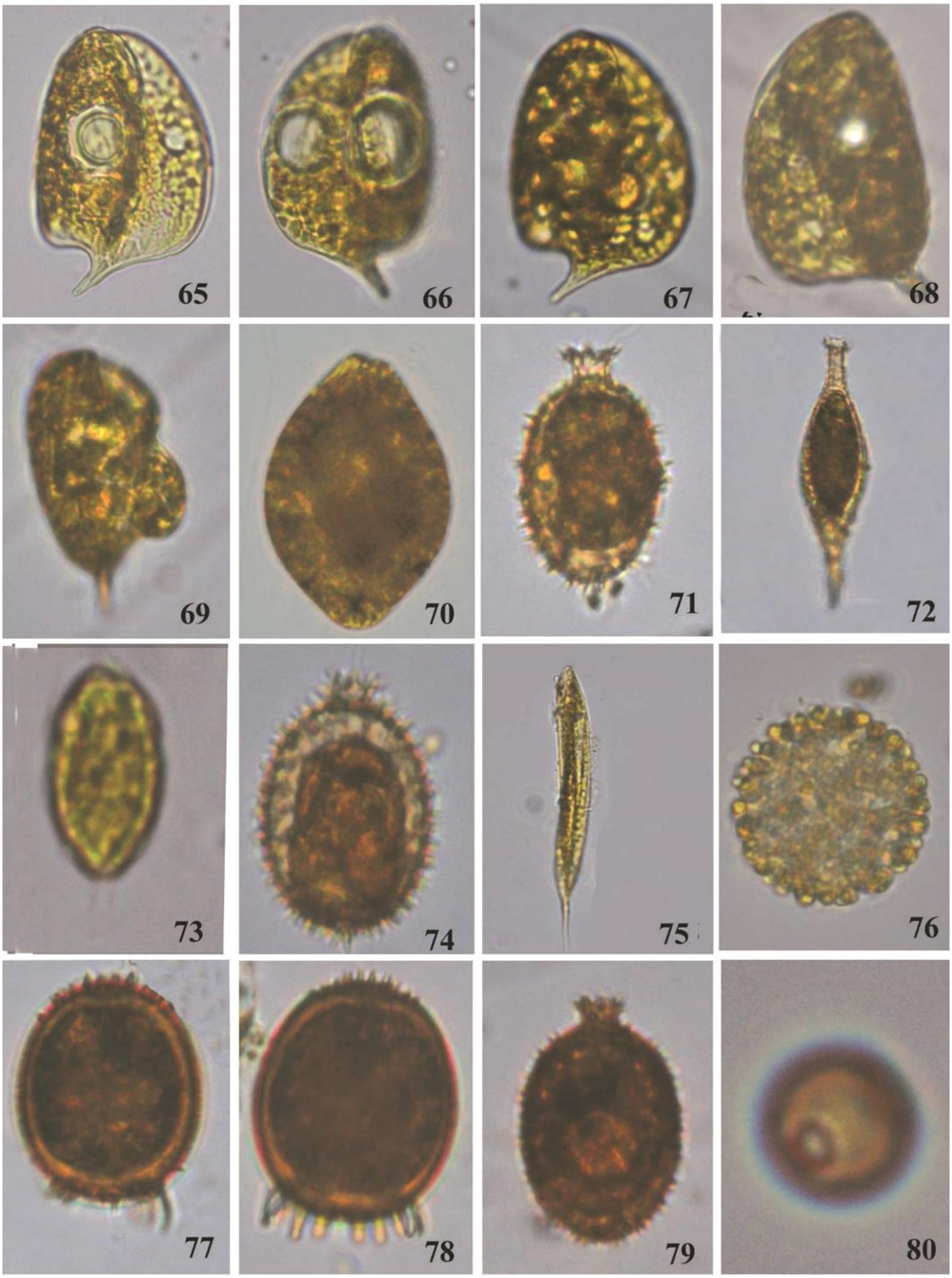


Plate 6

Fig. 81-83, 92. *Phacus*

Fig. 84, 86-87, 89-91. *Euglena* sp

Fig. 85, 88, 93. *Lepocinclis*

Fig. 94, 96. *Trachelomonas*

Fig. 95. *Dinobryon*

Plate- 6

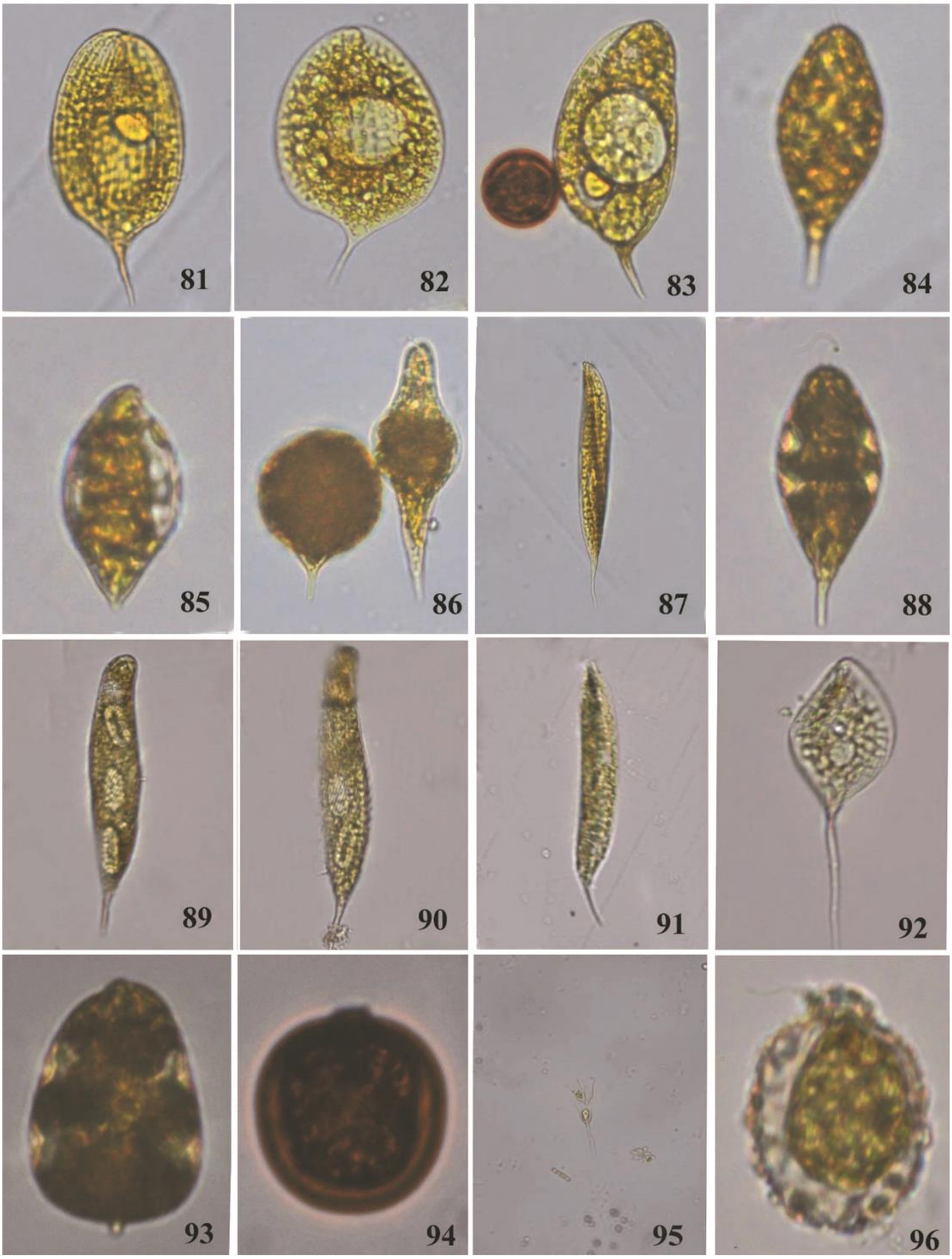


Plate 7

Fig. 97-100. *Phacus*

Fig. 101, 105, 107. *Euglena* sp

Fig. 102-104. *Mallomonas*

Fig. 106. *Scenedesmus*

Fig. 108. *Pelonema*

Fig. 109-111. *Trachelomonas*

Fig. 112. *Fragilaria*

Plate - 7