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EFFECT OF AUTOMOBILE EXHAUSTS ON NUTRITIONAL STATUS OF SOIL AND PLANT

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Abstract

For this research work, soil and plant samples were collected from the road side of Dhaka-Chittagong highway, Sample were analyzed after proper preparation for mineral nutrients especially nitrogen, phosphorus, potassium, sulfur and for heavy metals especilly lead, zinc, manganese, iron, copper and nickel. These were done to asses the amount of havey metals in soil and plant as well as their effect on the nutritional status of soil and plant. It was found that the emission of Pb, Zn and SO_2 from automobile exhaust/ wastes cause the contamination of soil plant along the highway. Lead, zinc and other heavy metals emitted from the motor vehicle wastes negatively affect the phosphorus uptake of the plants. Nitrogen uptake or accumulation by the highway side plants were not affected by automobile exhausts in this present analysis. The sulfur content of soil and plant was high in highway side soils and plants as SO_2 is emitted from the burning of fossil fuels and lubricants in the automobiles.

INTRODUCTION

Though Bangladesh is crisscrossed by many rivers, yet our comunication and transportation of goods are mainly dependent on metalled roads. Most of our agricultural lands are on the side of highways. There is a possibility that our land is polluted directly by the automobile exhausts.

One of the serious problem facing the modern technological society is the drastic increase in environmental pollution by the internal combustion engine of both the light and heavy duty vehicles. The major pollutants emitted by automobiles are carbon monoxide, hydrocarbons, nitrogen oxides, peroxy acetyl nitrate, sulfur dioxide, particulate zinc and lead and the minor pollutants are the aldehydes (Agarwal, 1991a). Different mechanisms are resposible for the occurrence of the above pollutants. The mechanisms are incomplete combustion, wall-quenching, scavenging, interaction of oxygen and nitrogen at high temperature, interaction of sulfur and oxygen, unburned carbon particles (Kachhawaha, 1991).

Automobiles supply heave metals (Pb, Ni, Zn, Cd) to the environment as lead is added to petrol, nickel is added to petrol and present in nickel containing parts; and zine and cadmium are added to lubricating oils and present in tyres and galvanized part of the vehicles (Ardakani, 1984). Lead compunds in form of tetraethyl lead is added during refining as an antiknocking agent in order to prevent the fuel from spontaneously exploding

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before its ignition by spark plug (Hirschler and Gilbert, 1964; Heichel and Hankin, 1972). Exhausted lead emissions occur in a variety of forms such as chlorides, bromides, chlorobromides, sulfates, oxides and as complexes with ammonia and phosphorus. The size of these particles varies between 0.001 to 10.0 micron. About two thirds of these particles become air borne after emission (Barsy and Harrison, 1972). The fraction of lead escaping from the petrol driving vehicles increases as the vehicle mileage increases. Lead compounds in the atmosphere near traffic zone as remain air borne for long periods of time. Other heavy metals remain in roadside-dust and it finally accumulates as sediment in the roadside lands. The transport of these heavy metals from automobile source through the environment follows a nework of paths by which the atmosphere, the hydrosphere and the biosphere are connected in a complex pattern (Agarwal 1991b).

The emitted heavy metals ultimately deposit on soil and plant surfaces and/or taken up by the plants. People living along the important highways of the country grow vegetables of various kinds in the depressions, basins and lands along the roadsides. There is a possibility of lead and other heavy metal pollution of these vegetables. The accumulation of these heavy metals in the soil and plant affect the normal nutritional status of soil and plant.

Crops vary considerably in their sensitivity to heavy metal toxicity. Most horticultural crops and root crops are more sensitive than cereals which in turn are more sensitive than the grasses. Although less sensitive than arable crops, the better grass species tend to be replaced by weed grasses (Davies *et at.*, 1993)

MATERIALS AND METHODS

Five sampling sites were selected covering the 32 kilometer of Dhaka-Chittagong highway from Shanir Akhra to North end of Meghna Bridge. Three sampling spots were selected from each sampling site except site V. Soil and plant samples were collected from each spot. Soils of 0-15cm depth and natural as well as cultivated plants were collected. A list of collected plant samples is shown in Table 1.

Soil samples were dried in air and sieved after grinding for chemical analysis. Plant samples were also dried, ground and stored in a dessicator. Soil samples were analyzed for physical, chemical and physico-chemical studies. Total nitrogen of soil was determined by Kjeldahl distillation method after acid digestion (Jackson, 1992). Available nitrogen was extracted by 2M KCl solution and then determined by Kjeldahl distillation method.

Avilable phosphorus of soil was determined colorimetrically by Chemito Visible Spectrometer following ascorbic acid blue color method after extracting by Bray-1 solution (Jackson, 1962) and 0.5 M $NaHCO_3$ solution (Page *et al.*, 1990). Exchangeable K was measured by Galenkamp Flame Photometer at 767nm wavelength after extracting with normal neutral ammonium acetate solution (Jackson, 1962). Available sulfur of soil samples was determined by turbidimetric method (Page *et al.*, 1990).

Available heavy metals as Pb, Zn, Fe, Mn, Cu, Ni of soils were extracted with 0.1N HCl and IN NH_4OAc (pH 3.0) and

Table 1. Sampling sites and collected plant samples

Sampling site	Spot	Plant samples	
		Local name	Botanical name
Site I	1	Halencha	*Enhydra Flactuans*
	2	Kalmi	*Ipomea aquatica*
	3	Halencha	*Enhydra flactuans*
Site II	1	Maricha	*Croton bonplandianum*
	2	Maricha	*Croton bonphlandianum*
	3	Halencha	*Enchydra flactuans*
Site III	1	Maricha	*Croton bonplandianum*
	2	Halencha	*Enhydra flactuans*
	3	Dhaincha	*Sesbania bispinosa*
Site IV	1	Maricha	*Croton bonplandianum*
	2	Dhaincha	*Sesbania bispinosa*
	3	Rice	*Oryza sativa*
Site V	1	Kalmi	*Ipomoea aqautica*

then the extract was analysed by Atomic Absorption Spectrophotometer (Perkin Elmer 3110) (Jackson, 1962).

Total nitrogen of plant samples was determined, similarly of soil after acid digestion (Jackson, 1962). Total phosphorus was determined colorimetrically after ternary acid digestion (IRRI, 1976). Sulfur in the plant sample was determined by turbidimetric analysis after digesting the sample by nitricperchloric acid mixture. Using the same nitric-perchloric acid digested extract sodium and potasium are determined by using Galenkamp Flame Photometer and using the ternary acid digested extract Calcium and magnesium were determined by EDTA method. Heavy metals (Pb, Zn, Fe, Mn, Cu, Ni) of plant sample were determined in Perkin-Elmer 3110 Atomic Absorption Spectrophotometer after digesting the plant samples by ternary acid mixture (Jackson, 1962).

Potassium and Na were determined by using a Galenkamp Flame Photometer after filtering, calcium and magnesium were determined by using EDTA method (Jackson, 1962). Sulfur was determined by turbidumetric method. Total phosphorus was determined follwing the ascorbic acid method after digesting it by HNO_3-$HClO_4$. Heavy metals were measured by using Perkin Elmer 3110 Atomic Absorption Sepectrometer after filtering the sample.

RESULTS AND DISCUSSION

Nitrogen

The highest concentration of total soil nitrogen (0.22%) was found in the spot 3 (500m away from the highway) of site II

(Table 2). Available nitrogen was also high in the same place. but the total nitrogen in plant sample (4.39%) was observed in the plant of truck stand (site V) though its soil nitrogen was not so high (0.08%). A sharp correlation (r=0.721**) was observed between soil nickel and soil nitrogen and a positive but no significant correlation was observed between soil zinc and soil nitrogen (Table 6). It is possible that zinc and copper might have come into soil from urbon activities or from vehicular exhausts (Tiller and Merry, 1981; Elsokkary, 1978).

A very significant correlation was observed (r=0.689**) between soil lead and plant nitrogen (Table 5). At the same time a significant correlation was also observed (r=0.671*) between plant lead and plant nitrogen (Table 7). It is possible that the accumulation of lead in soil due to motor vehicle exhausts could have formed compound like $Pb(NO_3)_2$ and it is known that lead uptake is enhanced by plant when $Pb(NO_3)_2$ is applied as dertilizer material than $PbCl_2$ (Chen *et al.*, 1997).

A positive but no significant correlation (r=0.551) was observed between plant zinc and plant nitrogen (Table 7). Rehman *et al.* (1988) observed that nitrogen concentration and uptake in straw and unhusked grain is enhanced when zinc concentration in soil and plant is increased.

Phosphorus

Phosphorus concentration in soil was the highest (93 ppm) in spot 2 (50m away from the highway) of site I, a stoppage of almost all the vehicles. It is interesting to note that, the plant phosphorus concentration in this spot was relatively low and the highest concentration was found in site IV. The low concentration of plant phosphorus in site I which contained the highest soil-phosphorus

Table 2. Results of soil sample analysis

Sampling site	Spot	pH	OC (%)	OM (%)	Total N (%)	NH_4-N (ppm)	NO_3-N (ppm)	Total Av. N (ppm)	Extra-P (ppm)	Extra-K (ppm)	SO_4-S (ppm)
Site I	1	7.15	0.64	1.11	0.07	18	41	59	9.73	200	108.56
	2	7.4	2.14	3.69	0.20	39	40	79	93.56	800	69.36
	3	6.58	0.81	1.41	0.07	30	18	48	12.15	250	123.6
Site II	1	6.71	0.90	1.55	0.07	12	37	49	12.08	150	186.16
	2	6.61	0.51	0.89	0.05	18	25	43	7.13	140	145.6
	3	6.97	2.06	3.55	0.22	45	36	81	4.86	100	65.6
Site III	1	7.0	0.26	0.44	0.03	17	25	42	3.44	40	54.64
	2	7.25	0.21	0.37	0.03	21	10	31	3.17	40	42.40
	3	6.45	0.47	0.81	0.04	21	42	63	2.72	60	166.96
Site IV	1	5.8	0.51	0.89	0.05	18	31	49	4.73	120	28.40
	2	6.7	0.30	0.52	0.03	33	15	48	2.61	40	51.21
	3	6.0	1.54	2.66	0.15	27	44	71	1.61	80	90.0
Site V	1	8.05	2.14	3.68	0.08	20	33	53	9.73	130	257.64

might be due to the interaction with heavy metals and their antagonistic effects. This soil contained the highest amount of zinc (Huq and Islam, 1999) and there is a possibility of phosphorus fixation with zinc.

On the other hand, the roadside plants of site IV accumulated the highest amount of phosphorus (6600ppm) whereas the soil-phosphorus was not so high (4.7ppm). The pH of this spot (5.8) cound be the reason for the availability of the element and its ultimate accumulation.

Table 3. Heavy metals in soil samples

Sampling site	Spot	HCl (0.1N) Extractable (ppm)						NH_4OAc (pH 3) Extractable (ppm)					
		Fe	Mn	Zn	Pb	Ni	Cu	Fe	Mn	Zn	Pb	Ni	Cu
Site I	1	175	119.3	15.1	5.3	1.5	5.8	153	95.4	15.8	6.8	2.1	14.7
	2	359	143.2	216	7.1	3.1	13.8	20	93.7	185.4	5.3	3.7	4.3
	3	218	50.3	66	8.8	1.7	9.5	124	27.5	57.4	9.5	1.9	4.5
Site II	1	156	130	14.4	8.4	1.8	6.3	17	60.0	15.4	9.2	3.9	3.9
	2	177	168.7	7.3	5.0	1.8	3.7	19	151.5	3.9	6.2	1.6	1.8
	3	399	78.5	6.5	4.1	2.7	11.9	197	51.0	3.4	4.0	2.8	3.4
Site III	1	359	34.2	4.2	1.8	1.2	1.8	86	15.4	1.7	1.5	2.3	1.5
	2	479	61.3	3.7	0.8	1.3	1.7	110	30.5	2.3	0.3	3.9	1.4
	3	319	157.6	22.3	1.4	2.1	4.8	76	33.5	1.3	0.9	1.5	2.8
Site IV	1	189	10.7	2.4	1.9	1.3	1.9	69	4.3	1.2	1.5	1.8	1.7
	2	379	77.7	5.5	1.3	1.5	2.5	22	25.3	0.7	0.4	1.2	1.4
	3	699	51	7.9	3.7	3.8	10.6	215	19.8	2.7	3.4	5.4	4.1
Site V	1	619	134.5	128	72	3.6	29.6	617	149.6	99.4	66	8.7	33.8

The interactions with heave metals particularly with zinc was also supposed to be low as its concentration of the lowest in the soil (2.4 ppm) (Table 3).

A high correlation was observed (r=0.866** for HCl extract and r=0.889** for NH_4OAc extract) between soil zinc and soil phosphorus. Positive but no significant correlation was observed between soil nickel and soil phosphorus (Table 6). There is a chemical relationship between zinc and phosphorus in soil. The pH at whcih zinc is soluble it can bind soil-phosphorus from solution (Jurinak and Inouye, 1962; Loneragan *et al.*, 1979).

It is obvious from the present investigation that, where soil zinc was high soil-phosphorus was also found to be higher (Tables 2 and 3). On the other hand that phosphorus is bound by zinc is proven by the fact that no positive correlation was observed with plant phosphorus and soil zinc. So it is clear that zinc addition from motor vehicle exhausts/sewage sludge affects negatively the phosphorus nutrition of plant (Schroop and Marschner, 1977). There was no appreciable relationship between plant-phosphorus and other heavy metals in soil.

Table 4. Results of plant sample analysis

Sampling site	Spot	N (%)	P (%)	S (%)	K (%)	Pb (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)	Ni (ppm)
Site I	1	2.56	0.33	0.89	2.45	62	104	314	5080	14	44
	2	3.25	0.34	0.30	4.03	8	28	152	1120	2	18
	3	1.83	0.29	0.45	3.5	2	106	252	1010	4	24
Site II	1	3.61	0.23	1.53	2.1	30	86	396	1360	4	50
	2	3.07	0.27	0.59	3.15	16	54	132	620	4	26
	3	2.45	0.29	0.53	4.03	34	44	754	5480	-	36
Site III	1	2.29	0.37	0.35	2.28	18	24	162	1080	4	30
	2	2.67	0.25	1.47	3.85	4	22	1418	3240	4	24
	3	3.35	0.24	0.68	2.98	13	50	86	1770	11	43
Site IV	1	2.10	0.66	0.53	2.8	16	52	194	600	4	34
	2	3.24	0.16	0.63	1.58	11	44	395	4550	15	33
	3	1.39	0.08	0.21	2.45	16	78	214	2270	26	43
Site V	1	4.39	0.32	0.61	4.55	162	290	162	1420	20	34

Sulfur

The highest value of soil-sulfur was found in the site V (257.64ppm). In most cases soil-sulfur increased with increasing distance which indicated that motor vehicle exhausts and wastes released SO_2 and other sulfur compounds in the atmosphere and that come into soil as air borne and deposited in the soil by cindensation and precipitation (Brady, 1988). Atmospheric sulfur become part of the soil-plant system in three ways some of it is absorbed directly from the atmosphere by growing plants, some is absorbed by the soil from the atmosphere and a similar amount is added in soil with precipitation (Brady, 1988).

Significant correlation was observed between soil lead (r=0.724** for HCl extract and r=0.746** for NH_4OAc extract)

Table 5. Correlation coefficient values between soil and plant parameters

Plant Parameters	HCl extractable heavy metals	
	Pb	Zn
N	0.689**	0.476
P	0.059	0.099
K	0.508	0.571*
S	-0.126	-0.380
Ca	0.137	-0.353
Mg	-0.098	-0.265

** significant at 1% level; * significant at 5% level

Table 6. Correlation coeficient between soil parameters

	HCl extractable heavy metals						NH_4OAc extractable heavy metals				
	Pb	Zn	Mn	Fe	Cu	Ni	Pb	Zn	Mn	Fe	Cu
N	0.049	0.470	0.102	0.321	0.485	0.721**	0.039	0.483	0.139	0.161	0.055
P	0.026	0.866**	0.334	-0.052	0.279	0.322	0.007	0.889**	0.284	-0.180	0.007
K	-	0.859**	-	-	-	-	-	-	-	-	-
S	0.724	0.266	0.660*	0.058	0.628*	0.398	0.746**	0.223	0.636*	0.553*	0.687**
pH	0.638*	0.559*	0.411	0.261*	0.601*	0.236	0.632*	0.555*	0.605*	0.529	0.658*
OM	0.530	0.662*	0.242	0.457	0.844**	0.876**	0.519	0.655*	0.407	0.554*	0.490

** sifnificant at 1% level; * significant at 5% level

Table 7. Correlation coefficient between plant parameters

	Pb	Zn	Mn	Fe	Cu	Ni
N	0.671*	0.551*	-0.029	-0.019	-0.079	-0.019
P	0.095	0.012	-0.150	-0.237	-0.476	-0.237
S	-0.057	-0.600	0.512	-0.019	0.165	0.488
Pb	-	0.916**	-	-	-	-

** significant at 1% level; * significant at 5% level

and soil-sulfur. A significant correlation (r=0.660* for HCl extract and r=0.636* for NH_4OAc extract) was also observed between soil Mn and soil sulfur. Similar significant correlations were also observed between soil Fe, Cu and soil sulfur (Table 6).

Positive but no significant correlations were observed between plant heavy metals (Mn and Ni) and plant-sulfur (Table 7) that indicated that the sulfur absorbed by plant from atmosphere and from soil by root.

Potassium

A high correlation was observed (r=0.859) between HCl extractable soil zinc and soil potassium. At the same time positive but no significant correlation was observed between soil Mn and soil potassium. A negative correlation was observed between soil Fe and soil potassium because when Fe solubility is increased the availability of potassium is decreased (Table 6).

A high correlation was observed (r=0.571*) between HCl extractable soil Zn and plant potassium. Positive but no significatn correlation was found between soil lead and plant potassium (Table 5).

Conclusion

Huq and Islam (1995) stated that lead, zinc and other heavy metals are emitted from the automobile exhausts which causes the contamination of road-side soil and plant and this contamination decreases with increasisng distance from the highway. The investigation showed that, lead, zinc which emitted from automobile exhausts affect the nutritional status of plant and soil especially phosphorus nutrition. Zinc negatively affects the phosphorus uptake by the plants and zinc can bind soil phosphorus from solution.

Sulfur content in soil and plant increased with increasing the automobile exhausts. Automobile emitted air borne sulfur as SO_2 or sulfur particles deposited on foliar surfaces of plant and on the soil. A significant correlation were observed between soil sulfur and soil Mn, Fe and Cu but no significant correlation was observed between plant heavy metals and plant sulfur.

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