Research Article

Status of heavy metals in water and sediments of canals and rivers around the Dhaka city of Bangladesh and their subsequent transfer to crops

Abstract

The study was carried out to observe the present status of heavy metals in water, sediment, soil and plant in the Tejgaon-Rampura-Shitalakhya water channel and the adjacent areas of the Dhaka city as well as to evaluate the heavy metal transfer in the water-soil-plant systems. Water, sediment, soil and plant samples were analyzed to know about lead, cadmium, copper and zinc contents. The findings show that heavy metal concentrations in water, sediment, soil and plant in the study area had the trend: Tejgaon Khal>Rampura canal>Shitalakhya river. Different water quality parameters such as pH, DO, BOD, COD, TDS, and NH3 shows that most of the values are higher than the DoE (Bangladesh) recommended irrigation water standards. The heavy metal concentrations in water varies and are well below the recommended values except for Cd and the trend follow the order Pb>Cd>Zn>Cu. The concentrations of the investigated heavy metals in sediment samples are found higher than the USEPA recommended sediment standards and follow the trend Zn>Cu>Pb>Cd. Similar trends are observed for the heavy metals in soil. The accumulation of heavy metals in plants followed the trend Zn>Pb>Cu>Cd in the Tejgaon and Rampura area while the trend are Zn>Cu>Pb>Cd in plants from Shitalakhya. In most of the cases the results of the tested parameters shows significant variations (at 1% level) from Tejgaon river samples with others.

Keywords: wastewater, heavy metals, soil, plant, sediment

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Introduction

Waste water disposal is a growing concern in developing countries as large quantities of municipal waste and industrial effluent are being produced due to increased urbanization and industrialization.[1] Application of wastewater to cropland could be an alternative source of nutrients because it can improve physical properties and increase nutrient contents of soils;[2] e.g., wastewater irrigation provides N, P and organic matter to the soils.[3] Nevertheless, there is a risk of potentially toxic elements such as Cd, Pb, Cu, Zn, Fe and Mn accumulation from domestic and industrial sources.[4] The occurrence of heavy metals in industrial wastewater is often present at significant levels and if discharged into surface waters can have severe effects on the environment and public health. Therefore, their high concentration in plant tissues brings about poisoning problems in human beings and some other animals feeding on specific plant tissues.[1] Trace metal composition of soil varies widely depending on the sources, industrial waste type and geographical location.[5]

A number of studies are reported on the heavy metal contamination of soil and plants in industrial sites around Dhaka city.[6–9] However, these are no extensive and conclusive findings reported. The wastes from various industries contain a variety of heavy metals, organic and inorganic components and the physical quality of this water is very bad and creates various types of diseases with common skin diseases in the nearby localities. Tejgaon Khal receives the industrial as well as domestic wastes from the densely habited industrial site now located in the mid of the capital city of Dhaka. Thus, there is a possibility of the presence of large amount of heavy metals in water of Tejgaon Khal to Shitalakhya River which is the sink of these wastes.

The water of Balu River and Shitalakhya River are extensively used for irrigation in the agricultural lands of the associated area which also causes a threat of heavy metal contamination in the agricultural products grown in this region and consequent human health problems. Therefore, this research objective is to identify the level of Cu, Zn, Pb and Cd in water, sediment, soils and vegetables from canal of Tejgaon Khal-Rampura Canal-Shitalakhya River.

Material and methods

To complete the comprehensive study of the proposed research, the study area was selected from Tejgaon-Rampura canal to Shitalakhya River–a span of 30km (Figure 1). The whole area was divided into three small parts viz., Tejgaon Khal (T), Rampura Khal-Balu River (R) and Shitalakhya River (S) closed to Balu River. Ten points from each part were selected and water, sediment, soil and plant samples were collected from each point. Water samples were collected by using 500ml plastic bottles; pH and DO were tested instantly. Two sets of water samples were collected from each point: one set was used to determine BOD and COD and the other set was preserved with 2-3 drops of concentrated HCl in refrigerator for further analysis. The collected sediment samples were dried appropriately and then passed through a 0.5mm sieve. The sieved samples were stored in plastic pots for chemical analysis. The soil samples were collected from the surface 0-15cm depth, samples were air dried and visible roots and debris were removed and discarded and preserved as described by Imamul Huq et al.[10]

Plant samples were collected from the respective field from where the soil samples were collected. The plant samples were washed first

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with tap water and then again with deionized distilled water. The fresh weights of collected samples were taken. For chemical analysis, the samples were first air dried and then oven dried at 80°C±5°C for 48hours and then dry weight of the plant samples were taken. The samples were ground with an electrical grinder and passed through a 0.2mm sieve. Various chemical and physico-chemical properties of the water, sediment, soil and plant samples were analyzed in the laboratory as described by Imamul Huq and Alam.[10] Results were calculated on oven dry basis. The data are subjected t statistical analysis for pair test using Minitab-16 software.
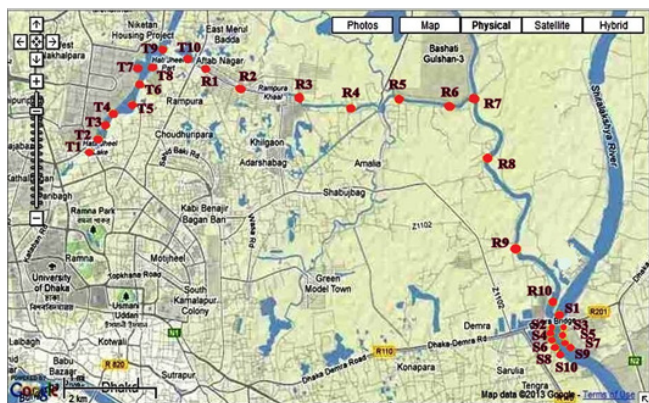

Figure 1 Sampling points of the studied area.

Results and discussion

Physicochemical characteristics of water

Different water quality parameters like pH, Dissolved oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Ammonia-N, along with some heavy metals Zinc (Zn), Copper (Cu), Lead (Pb) and Cadmium (Cd) were analyzed and the results are given in the Table 1. Color and odor are important characteristics of water for physical characterization and it was observed from the study that the color of the water of Tejgaon Khal and Rampura Canal was black or dark black. The pH values of collected water sample ranges from 6.62 to 7.46, which is slightly acidic to slightly alkaline in nature and it increased with increasing distance towards the Tejgaon Khal to Shitalakhya River (Table 1). The pH of Shitalakhya River and Rampura Khal showed significant (at 5% level) difference with Tejgaon Khal. It might be due to higher amount of industrial effluent discharge in Tejgaon Khal.

Dissolved oxygen is an important parameter for water quality assessment. The DO at different sampling points ranged from 0.29 to 3.08mgL^{-1} and showed an increasing trend from Tejgaon Khal to Shitalakhya River (Figure 2). It might be due to dumping of untreated waste materials from industrial sources of Tejgaon area and these pollution levels became comparatively higher than Rampura Khal and Shitalakhya River. The DO values of Shitalakhya River showed highly significant difference (at 1% level) with the DO values of Tejgaon and Rampura Khal. Rahman and Hadiuzzaman[11] also found lower levels of DO in industrially polluted water. It has been noticed that the BOD and COD values of the studied area represented a sharp decreasing trend from the Tejgaon Khal to Shitalakhya River (Figure 2). The values were ranged from 650 to 30mgL^{-1} for BOD and 510 to 130mgL^{-1} for COD. The BOD and COD values recorded from

Tejgaon and Rampura Khal was higher than the standard value which is 50mgL^{-1} and 200mgL^{-1}.[12] The BOD and COD values of Shitalakhya river was varied significantly (at 1% level) in comparison with the BOD and COD values of Tejgaon and Rampura Khal while Tejgaon and Rampura Khal also showed significant variation for BOD (at 5% level) and COD (at 1% level) values. This might be due to the huge amount of industrial discharge in Tejgaon Khal which contain large amount of organic and inorganic load. Rahman and Hadiuzzaman[11] also found higher levels of BOD and COD in industrially polluted water.

Results followed a slight detrimental trend of total TDS at different sampling points, Tejgaon Khal to Shitalakhya River and ranged from 743 to 1158mgL^{-1}, respectively. The lowest TDS values were found in water of Shitalakhya River and highest value found in Tejgaon and Rampura and the results was varied significantly (at 1% level). Water that contains less than 500mgL^{-1} of dissolved solid is generally satisfactory for the domestic use and the other industrial purposes and water containing more than 1000mgL^{-1} of DS (dissolved solid) usually contains minerals that give it a distinct taste or make it unsuitable for human consumption,[13] whereas DoE[12] recommended permissible limit (2100mgL^{-1}) for irrigation water. The concentration of NH$_3$-N at different sampling points ranges from 2.79 to 0.45mgL^{-1} and highest concentration is found in T10 point in Tejgaon Khal. The concentration of ammonia in water sample found to be lower than the standard value 5mgL^{-1}.[12] The ammonia concentration of Shitalakhya River showed a highly significant difference (at 1% level) with Tejgaon and Rampura Khal. It might be due to the Industrial discharge in Tejgaon Khal which contain large amount of organic and inorganic loads. Rampura Khal also showed the higher ammonia concentration which might be due to the closeness to Tejgaon Khal but with distance it was found a sharply decreasing trend (Figure 2).

Heavy metals in wastewater

The results shows that the concentration of heavy metals in different water samples ranges from 0 to 0.20mg L^{-1} for Zn, 0 to 0.032mgL^{-1} for Cu, 0 to 0.61mgL^{-1} for Pb and 0.09 to 0.31mgL^{-1} for Cd, respectively. The highest concentrations of Zn, Cu Pb and Cd were found in Tejgaon Khal and Rampura Khal. However, the concentrations in Shitalakhya River were found lower than the Tejgaon and Rampura channel. The allowable limit of Zn, Cu, Pb and Cd in irrigation water is 2mgL^{-1}, 0.2 mgL^{-1}, 5mgL^{-1} and 0.01mgL^{-1}.[10] The concentrations of Zn, Cu and Pb in wastewater found lower than the allowable limit although continuous application of this water might increase the concentration of these metals in soil and plant. The concentration of Cd was found very high than the normal level. The trend of Zn, Cu and Pb concentration was found in the study area Tejgaon Khal> Rampura Canal> Shitalakhya River and incase of Cd, it was found Rampura Canal>Tejgoan Khal> Shitalakhya River (Figure 2). The concentrations of Zn, Cu, Pb in Shitalakhya River varied significantly (at 1% level) and Cd showed insignificant result with Tejgaon Khal. Meanwhile, the concentration of Zn, Cd, Pb and Cd in Shitalakhya River varied significantly with the Rampura Khal (Zn, Cd at 1% and Cu, Pb at 5% level of significance). On the contrary, the Zn, Cu concentration at Rampura Khal did not show any significant difference and Pb, Cd varied significantly (at 1% level) with Tejgaon Khal. Blom[14] also reported a decrease in metal concentration away from the source point.

Status of heavy metals in sediments

Sediments represent a potential source of contaminants to the

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overlying water and hence can influence water quality. For the present study, the collected sediment samples were analyzed for pH (Table 2). The lower limit of pH of the sediment was found 6.37 at point-T1 and highest pH 7.39 found at point-S5 (Table 2). The acidic pH at point-T1 in Tejgaon Khal may be due to the acidic discharge of effluent from nearby industrial area as well as a result of high oxidation of organic carbon in this area which produced large volumes of carbon dioxide that dissolved in the water to produce carbonic acid which lowered the pH. Alkaline pH in Shitalakhya River might be due to the deposition of tremendous amount of sediments which might contain much calcium carbonate, magnesium carbonate. On hydrolysis of these calcium carbonate and magnesium carbonate releases OH- ion which contributes alkalinity in sediment. There is a sharp decreasing trend of Zn, Cu, Pb and Cd concentration found from Tejgaon Khal to Shitalakhya River (Figure 3). The maximum concentration of Zn (347.33mg kg^{-1}), Cu (203mg kg^{-1}), Pb (120mg kg^{-1}) and Cd (35.80mg kg^{-1}) were found in Tejgaon Khal and minimum concentration of Zn (21.67mg kg^{-1}), Cu (28.90mg kg^{-1}), Pb (6mg kg^{-1}) and Cd (0.53mg kg^{-1}) were found in Shitalakhya River (Table 2). According to USEPA[15] guideline, the concentration of Zn, Cu, Pb and Cd in heavily polluted sediment is >200mg kg^{-1}, >50mg kg^{-1}, >60mg kg^{-1} and >6mg kg^{-1}. This indicated that Tejgaon and Rampura Khal were highly polluted by industrial discharge and the concentrations of heavy metals in Shitalakhya River were found below the standard limit which is far away from the Tejgaon and Rampura Khal. The concentration of Zn, Cu and Pb in sediment sample from Shitalakhya River showed significant difference (at 1% level) with the sediments of Tejgaon Khal and Rampura Khal. The concentration of Cd in sediment sample from Shitalakhya River showed insignificant results with the sediments of Tejgaon Khal and significant results (at 5% level) with the Rampura Khal. Meanwhile, the concentration of Zn, Pb, Cd in Sediment from Rampura Khal showed no significant difference with Tejgaon Khal and Cu showed significant difference (at 5% level).

PH of the soil

The study revealed that the pH of soil samples collected from associated cultivated land of Tejgaon Khal was acidic and Rampura Khal showed more acidic than Tejgaon Khal (Table 3). Shitalakhya River showed slightly acidic pH. The pH of Tejgaon and Rampura soil showed that this area might be polluted with industrial effluent and municipal waste. Lower pH may be due to battery industry, dyeing industry and electrical industry in that area. It also might be due to the genetically formation of soil from acidic parent material in this area.

Heavy metals in soil

The concentrations of Zn, Cu, Pb and Cd ranges from 62 to 508mg kg^{-1} for Zn, 20 to 131mg kg^{-1} for Cu, 13 to 52mg kg^{-1} for Pb and 0.04 to 1.40mg kg^{-1} for Cd, respectively (Table 3). The maximum permissible limit of Zn, Cu, Pb and Cd in soil is 64mg kg^{-1}, 26mg kg^{-1}, 32mg kg^{-1} and <1mg kg^{-1}, respectively.[10] The results showed that soil samples from Tejgaon Khal contain higher concentration of Zn, Cu, Pb and Cd which are several times higher than the permissible limit. The concentrations of metals in soils are found to decrease with distance away from the disposal point Tejgaon (Figure 4). The concentrations of Zn, Cu, Pb and Cd in soils from Shitalakhya River are found below the standard limit. This implies that the soils from Tejgaon Khal and Rampura Khal is contaminated with heavy metals which may comes to the food chain and may cause toxic effect to human health. The concentration of Zn in soil samples from associated area

of Shitalakhya river are varies significantly (at 1% level) with the soils of Tejgaon Khal and insignificantly with the soils of Rampura Khal. Cu, Pb and Cd concentrations in soils from Shitalakhya river area significantly different (at 1% level) with the soils of Tejgaon Khal and Rampura Khal area. Soils from Rampura Khal are also significantly differing for Cu (at 1% level), Zn, Cd (at 5% level) and insignificant difference for Pb with the soils of Tejgaon Khal area. Total Cd, Pb, Zn and Cu contents of surface soil in waste water irrigated locations are above the normal ranges of these metals for soils.[2,16]

Heavy metals in plant

The concentrations of Zn, Cu, Pb and Cd in plant ranges from 460 to 77mg kg^{-1} for Zn, 60.50 to 11.50mgkg^{-1} for Cu, 84.50 to 0mg kg^{-1} for Pb and 5.95 to 1.45mg kg^{-1} for Cd, respectively. The critical limit of Zn, Cu, Pb and Cd in plant is 20mg kg^{-1}, 6mg kg^{-1}, 2mg kg^{-1} and 0.7mg kg^{-1}.[10] The plants grown on Tejgaon River area shows high concentrations of Zn, Cu, Pb and Cd in Rampura and Shitalakhya area, is much higher than the permissible limit (Figure 4). The high concentration of Zn, Cu, Pb and Cd in plant grown on Tejgaon and Rampura Khal area might be due to high concentration of metals in the soil as caused by irrigation with metal contaminated water released from industries. The concentration of Zn in plants grown on Shitalakhya river area varies significantly with the plants grown on Tejgaon Khal (at 1% level) and Rampura Khal (at 5% level) area. The concentrations of Cu, Pb and Cd in plants grown on Shitalakhya river area varies significantly (at 1% level) with the plants grown on Tejgaon Khal and Rampura Khal area. Zn, Cu and Cd in plants grown on Rampura Khal area are insignificantly different with plant samples from Tejgaon Khal area and the concentration of Pb varies significantly (at 1% level). Several studies have indicated that vegetables grown in heavy metals contaminated soils have higher concentrations of heavy metals than those grown in uncontaminated soils.[8,17,18] Elevated levels of Cd, Cu, Pb and Zn in plants in industrially polluted area have been demonstrated by other researchers.[8,16]

Correlation between heavy metals in soil and plant

The correlation between soil and plant for all the heavy metals were positive (Table 4). The results revealed that the relations of soil and plant for Zn and Cu were significant at 5% level (r=0.456 and r=.451) and significant at 1% level for Pb and Cd (r=0.582 and r=0.479). The correlation pattern indicated that the heavy metal concentrations of Zn, Cu, Pb and Cd in plants were associated with the concentration in the soil.

On the other hand, the metal concentrations present in soil and plant were positive but related differently. The relationship of soil Zn and plant Pb and was significant (r=0.461) but not significant for soil Zn and plant Cu and Cd (r=0.080 and r=0.51). Correlation among soil Cu and plant Zn, Pb and Cd were significant at 1% level. For soil Pb, it showed a significant relationship with plant Zn, Cu and Cd (r=0.540, r=0.365 and r=0.814). The concentration of soil Cd were significantly related with plant Zn and Pb (r=0.552 and r=0.617) but not significant with plant Cu (r=0.306). The correlation data showed positive relationship between metals in plant and soil which revealed that the increasing concentrations of heavy metals in soil will increase in the concentrations in plant. As a result plant uptake nutritional elements through the root from the soil.

From the above discussion, an elevated level of heavy metal was found in wastewater collected from the study area. The concentration

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of Cd in wastewater was found higher than the recommended irrigation standards which may cause serious impacts on soil-plant system. Although the concentrations of Zn, Cu and Pb were low, however the heavy metal contamination of Tejgaon Khal was high than Shitalakhya river. DO content of the water collected from Tejgaon Khal was only 0.29mgL^{-1}. The value is several times lower than the permissible limit. Meanwhile, the BOD and COD of the tested water were found higher than the DoE recommended irrigation water standards. The heavy metal concentration in the sediments was found in the order Zn>Cu>Pb>Cd. The trend of contamination in the three different riches are Tejgaon Khal>Rampura Canal>Shitalakhya River. The heavy metal concentration in soil followed the similar trend like that of sediment. Plant samples collected insitu revealed that the contaminants present in the environment do enter into them. The accumulation of heavy metals followed the trend Zn>Pb>Cu>Cd in Tejgaon and Rampura while the trend of accumulation in plants from Shitalakhya was Zn>Cu>Pb>Cd. The present study reveals the fact that the effluents discharged from the industries around the study area are not treated before these are released to the environment. The relevant authority needs to take care.

Table 1 Physicochemical properties of water sample (mg L^{-1}) collected from the studied area

Point	pH	BOD	COD	DO	TDS	Ammonia	Zn	Cu	Pb	Cd
T1	6.69	650	510	0.29	1131	2.57	0.05	0.032	0.61	0.095
T2	7.46	560	500	0.33	1153	2.56	0.01	0.016	0.53	0.097
T3	7.3	520	480	0.34	1122	2.54	0.2	0.015	0.12	0.13
T4	6.62	490	480	0.35	1110	2.52	0.15	0.014	0.09	0.09
T5	6.82	510	450	0.38	1108	2.55	0.08	0.017	0.16	0.09
T6	7.06	520	420	0.34	1107	2.5	0.1	0.014	0.1	0.13
T7	7.06	490	350	0.37	1106	2.51	0.06	0.016	0.26	0.17
T8	7.06	482	350	0.38	1093	2.56	0.04	0.01	0.32	0.133
T9	7.15	470	450	0.35	1090	2.71	0.12	0.011	0.56	0.13
T10	7.08	520	430	0.33	1158	2.79	0.09	0.008	0.42	0.133
R1	7.1	530	400	0.44	1108	2.66	0.12	0.01	0.6	0.28
R2	6.9	480	300	0.37	1108	2.65	0.15	0.032	0.07	0.17
R3	7.08	480	290	0.33	1105	2.64	BDL*	BDL*	BDL*	0.187
R4	7.21	470	260	0.38	1106	2.65	0.1	0.008	0.001	0.223
R5	7.25	490	240	0.35	1103	2.69	0.15	BDL*	BDL*	0.133
R6	7.32	490	220	0.34	1101	2.67	0.08	0.01	BDL*	0.3
R7	7.32	480	220	0.37	1015	2.68	0.05	BDL*	0.06	0.31
R8	7.32	220	270	1.21	1010	2.37	0.03	0.006	BDL*	0.31
R9	7.3	180	250	1.66	1006	2.25	BDL*	BDL*	BDL*	0.27
R10	7.28	160	230	2.12	982	2.24	0.02	0.01	0.03	0.21
S1	7.32	140	280	2.32	858	2.15	BDL*	BDL*	0.004	0.133
S2	7.22	120	260	2.36	827	2.15	0.01	0.003	BDL*	0.127
S3	7.29	130	170	2.34	821	2.1	BDL*	BDL*	BDL*	0.11
S4	7.31	90	220	2.62	820	1.97	BDL*	BDL*	BDL*	0.12
S5	7.3	110	190	2.69	781	0.53	0.02	0.001	BDL*	0.13
S6	7.31	80	200	2.56	775	0.57	0.008	BDL*	BDL*	0.17
S7	7.3	60	180	2.76	766	0.45	BDL*	BDL*	BDL*	0.15
S8	7.31	50	160	2.74	747	0.46	0.005	0.002	0.001	0.13
S9	7.31	30	150	2.96	744	0.5	0.006	BDL*	0.001	0.15
S10	7.29	30	130	3.08	743	0.52	BDL*	BDL*	BDL*	0.14

* BDL, below detection limit

Table 2 Status of heavy metals in sediments collected from the studied area

Point	pH	Zn (mgkg-1)	Cu	Pb	Cd
1	6.37	174.67	170	62	10.37
T2	7.3	174.33	168	41	9.53
T3	7.05	272.33	112	36	10.07
T4	6.42	197	117	31	28.27
T5	6.67	164.67	186	42	8.6
T6	6.79	126	100	28	52.27
T7	6.8	273	203	88	10.23
T8	6.7	347.33	134	78	10.2
T9	6.87	192.33	147	60	11.03
T10	6.79	64.33	198	120	35.8
R1	6.99	28.67	161	53	11.13
R2	6.87	102	147	33	12.37
R3	7.05	176.33	151	64	12.6
R4	7.14	218.33	87	12	10.23
R5	7.1	253.33	92	15	12
R6	7.2	179.33	107	55	10.27
R7	7.2	304.67	92	41	11.4
R8	7.3	286.33	99	22	10.13
R9	7.25	313.33	99	33	12.4
R10	7.3	136.67	86	28	10.97
S1	7.28	69	90	13	10.53
S2	7.14	88.33	81	11	28.07
S3	7.32	57	71	8	4.9
S4	7.3	57.67	101	10	5.5
S5	7.39	45.67	49	6	1.33
S6	7.31	75	50	8	1
S7	7.32	50.67	49.8	9	1.23
S8	7.36	56.67	28.9	7	0.87
S9	7.3	46.33	59.4	8	0.53
S10	7.32	21.67	28.9	6	0.6

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Table 3 Status of heavy metals in soil and plant (mg kg^{-1}) collected from the studied area

Points	Soil					Plant			
	pH	Zn	Cu	Pb	Cd	Zn	Cu	Pb	Cd
T1	5.65	95	98	40	0.6	172	14.5	84.5	4
T2	5.71	143	131	51	0.28	378	15.15	71	5.95
T3	5.56	382	82	45	1.4	263	18	66	4.65
T4	5.6	210	81	52	0.84	412.5	45.75	37.5	5.3
T5	5.56	358	82	40	0.72	425	24.75	13	5.4
T6	5.71	395	95	35	0.3	393	30.5	57	4.3
T7	5.55	139	115	50	0.32	253	53.75	25	3.65
T8	5.81	115	122	30	1.24	289	28.55	34	2.95
T9	5.9	508	110	35	0.52	111	23.55	24.5	2.6
T10	5.71	407	118	25	0.92	380	33	61.5	2.8
R1	4.45	255	80	26	0.56	460	43	73	4.1
R2	4.84	87	63	28	0.6	263.5	57.8	18.5	2.95
R3	4.5	67	81	30	0.32	86.5	60.5	16	3.05
R4	5.01	70	74	26	0.28	267	43	29.5	3.2
R5	4.66	67	65	40	0.52	345	28.5	34.5	3.3
R6	4.7	78	57	45	0.48	241.5	33.5	32	4.2
R7	4.5	127	56	39	0.28	179.5	18.55	14	5.4
R8	5.04	115	54	40	0.28	178	23.55	10	2.45
R9	4.4	71	55	30	0.16	149	18.55	6.5	2.6
R10	4.66	75	50	28	0.24	143.5	16.5	3.5	3.05
S1	6.6	64	37	20	0.2	81.5	12.35	3	2.15
S2	6.35	123	35	22	0.24	77	15	3	2.05
S3	6.55	95	36	17	0.16	142.5	24.5	BDL*	2.3
S4	6.08	102	29	15	0.2	112.5	14.45	2.5	2.65
S5	6.24	86	21	17	0.12	217.5	13.5	BDL*	2.05
S6	6.46	111	26	13	0.04	123.5	11.5	1.95	1.85
S7	6.6	62	26	15	0.04	137.5	13.55	BDL*	2.05
S8	6.5	89	20	19	0.08	132	15.15	0.95	1.85
S9	6.55	115	21	16	0.04	123	14.35	BDL*	2.2
S10	6.62	83	26	15	0.04	93.5	15.15	1.05	1.45

* BDL, below detection limit
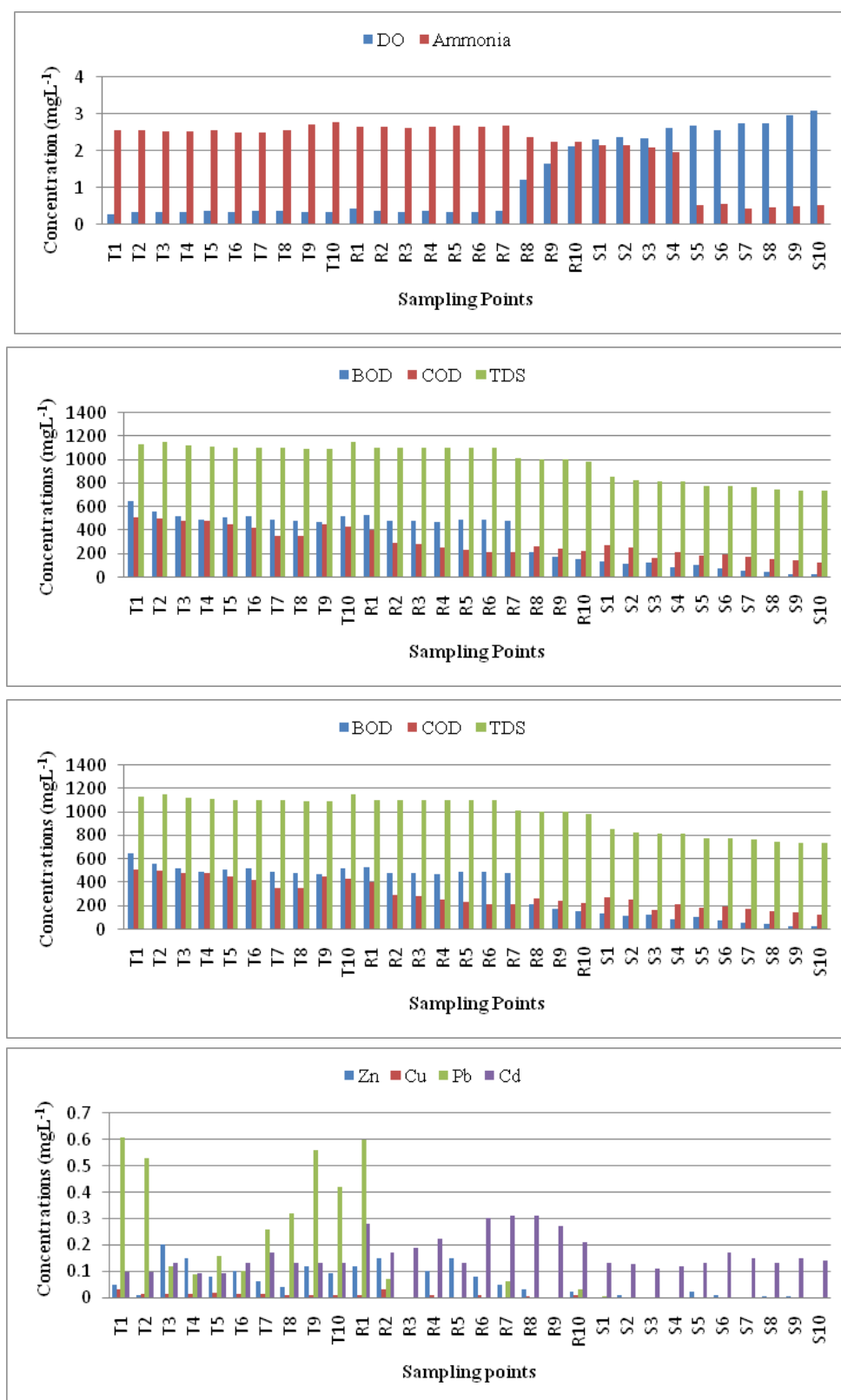
Figure 2 The changing of different physicochemical parameters in water with distances.

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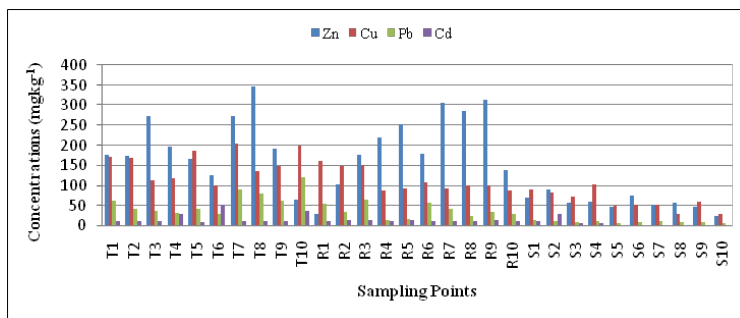©2016 Uddin et al. **600**

Figure 3 The changing of heavy metal concentrations in sediments with distances.
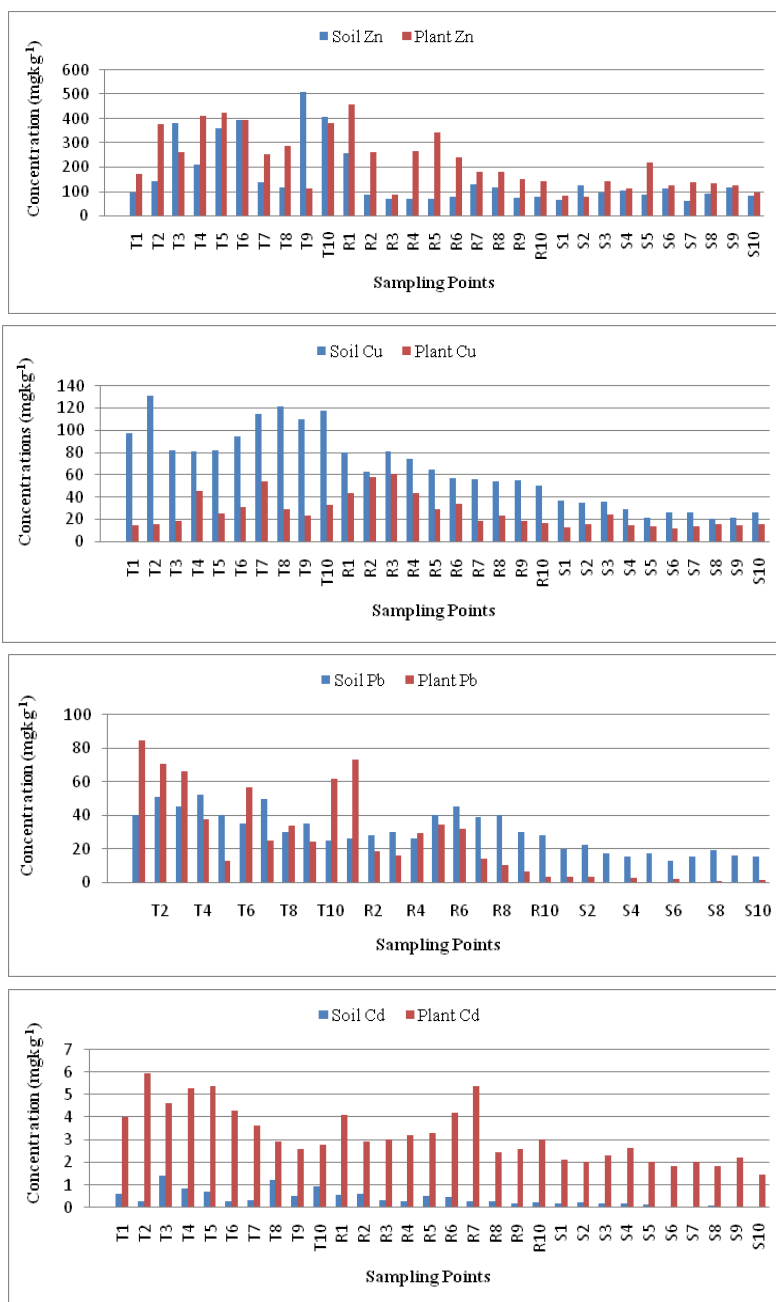
Figure 4 The relation between soil and plant based on presence and uptake of heavy metals with distance

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Conflict of interest

Author declares that there is no conflict of interest.

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