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An Investigation on Soil Quality and Heavy Metal Levels in Soil of Rajbandh Waste Disposal Site at Khulna, Bangladesh

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A B S T R A C T

The principle objective of this study was to evaluate the soil quality and the level of contamination of soil by heavy metals adapting various developed index in a selected waste disposal site at Rajbandh, Khulna, Bangladesh. To theses endeavor, ten soil samples were collected from the selected locations and then the relevant elements of Al, Fe, Mn, Cr, Cu, Pb, Zn, Ni, Cd, As, Co, Sb, Sc and Hg were measured and monitored using standard method. To estimate the contamination situation of soil, contamination factor (CF), enrichment factor (EF) and geo-accumulation index (Igeo) and potential ecological risk index (PERI) were computed using geological background values. In addition, for assessing soil quality, Pearson's correlation coefficients analysis was also performed. Furthermore, this study revealed that the values of CF and Igeo in soils around the waste disposal area affected from the contamination of heavy metals mostly by Pb, Cd and Sb. In contrast, Pearson's correlation indicated that the sources of metals are almost the same and these heavy metals might be derived from the waste accumulation activity. Dump sites have great potential for energy extraction if the high valued compounds to be extracted.

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INTRODUCTION

Heavy metals became a serious environmental threat towards the world basically in developing countries not having appropriate facilities and funds to deal with the multiplying quantity of waste daily produced. As a consequence of industrialization and urbanization, the rapid growing number of industries makes the natural environment vulnerable for all living creatures on earth creating indiscriminate disposal of solid waste, effluents consisting toxic chemicals [1].

Nowadays, practice of ‘landfill’ is widespread, which defines as an unit operation for the ultimate dumping of municipal solid waste (MSW) on a certain land designed and constructed focusing the least effect to the surrounding atmosphere [2]. Though, long lasting and continuous retention of heavy-metal elements might affect the defending ability of soil in and around the landfill area [3]. The complex biological and physicochemical processes of the huge amount of waste makes the adjacent areas vulnerable caused by the constant release of toxic heavy metal compounds from the decomposed waste, leachate and soil from the waste disposal sites [4]. Besides, most of the ecological and human health problems originate from the release of heavy metal from the leachate and soil in waste landfill, landfill gas holding hazardous air pollutants [5].

Serious environmental pollution due to heavy metal is increasing day by day in whole world. Moreover, change in soil condition has been occurred for centuries but its extent has amplified prominently since the period of technological developments due to gradually increasing the use of materials containing these metals by consumers [6]. According to the soil system, heavy metal pollution occurs owing to both metallurgical and natural processes involving weathering of mineral deposits and anthropogenic activities related to industry, agriculture, burning of fossil fuels, vehicular emission, mining etc. [7].

Undoubtedly, waste is turning into the most noticeable, latest, significant source of environmental hazards in developing country like Bangladesh [8, 9]. Continuous damping of waste in land creates two major issues, (i) contamination of surface and ground water by leachate and (ii) bioaccumulation of toxic heavy metals in soil, consuming these heavy metals by plants and involving these metals into the food chain [10]. Analyzing the toxicity and detrimental effects of heavy metals on living entity, researchers have given importance in the source and fate of these elements in the environment [11].

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Among ten metropolitan cities of Bangladesh, Khulna is the third largest city.Total rate of waste generation in Khulna is 420 to 520 ton per day collected from residences, whole and retail sale market places including shopping places, streets, hotels and restaurants, hospitals and private clinics, educational institutions, cinemas, bus, railway and launch/steamer ghats, slaughter houses, etc.[3]. At the present time, all collected SW is directly disposed at Rajbandh waste disposal site which is the only official dumping site over 25 acres in area. The dumpsite is 10 kilometers far from City Corporation headquarter in the direction of west. Considering aforementioned disputation, a detailed study was necessary to determinesoil contamination by heavy metal in the surrounding area of the Rajbandh municipal dumpsite specifically to define the magnitude of soil contamination. Hence, this study was conducted to examine the soil quality on the basis of heavy metal concentration, which is considered around the waste dumping site at Rajbandh, Khulna. The means of the inspectionare the metal contamination Factor (CF), enrichment factor (EF), geo-accumulation index (I_{geo}) and potential ecological risk index (PERI). Generally, these pollution or contamination indices are indicators used to calculate the occurrence and intensity of anthropogenic pollutant on topsoil. The purposes of this study are (i) to assess the level of heavy metal pollution (Al, Fe, Mn, Cr, Cu, Pb, Zn, Ni, Cd, As, Co, Sb, Sc and Hg)(ii) to perform correlation between heavy metals.

MATERIAL AND METHODS

The total research procedure and materials utilized in this study are described in the following articles.

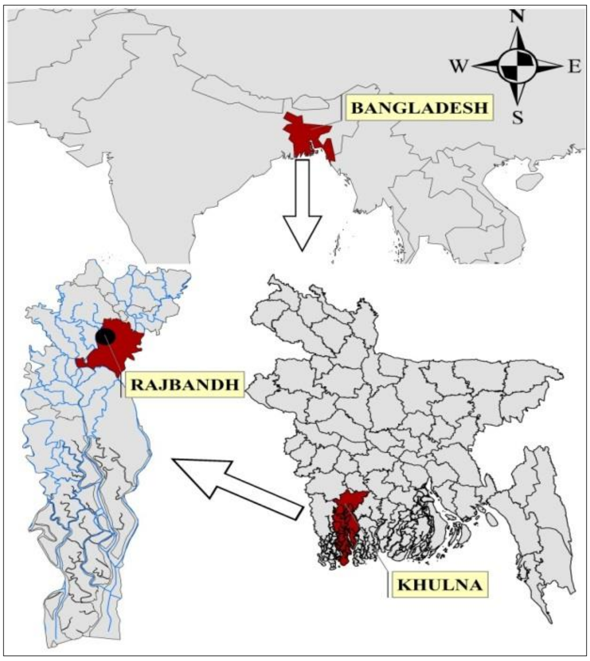
Study area and sampling

Khulna is a district among total sixty four districts in Bangladesh. Besides, the Khulna city is in the northern part of the district, acknowledged as third largest among ten metropolitan cities of Bangladesh. Geographically, Khulna lies between $22^0 47´16´´$to $22^0 52´0´´$north latitude and $89^0 31´36´´$ to $89^0 34´35´´$ east longitude. This city situated on the Rupsha and Bhairab river-banks. At present, the city covers an area of 45.65 km^2 with a population about 1.5 million.

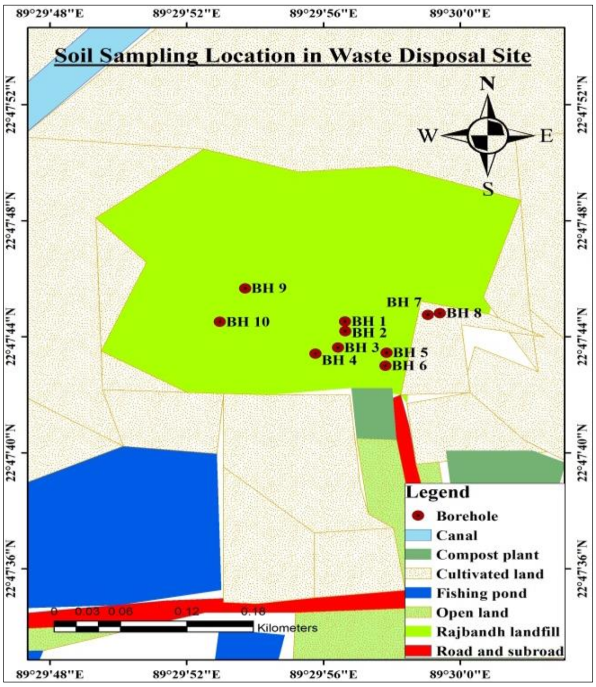
The municipal solid waste of Khulna city is dumped in the Rajbandh disposal site in order to accumulate and dispose in the landfill. So this waste disposal site was chosen as sampling place to explore and assess the soil quality and the contamination stage. The location of selected disposal site as well as ten soil sampling points is shown in Figure 1.

Sampling

In this study, ten soil samples were collected from different selected locations of waste disposal site as shown in Figure 1 (b). The samples were collected at a depth of 0-30 cm from the existing ground surface. Moreover, the sampling points were selected maintaining gradual increase of about 10 m distance from the 1st borehole (BH-1) by the subsequent boreholes. Since, the first sampling point, BH-1 is located at the center of the waste disposal site.



(a)



(b)

Figure 1. (a) Location map of Rajbandh waste disposal site and (b) Soil sampling points in the site.

Laboratory investigations

To measure the concentration of different metal content in soil laboratory work was done following standard method. In laboratory investigation, at first 10 g of each soil sample was taken into a 100 mL conical flask. Already, the flask was washed by deionized water prepared by addition of 6 mL $HNO_3/HClO_4$ acid in ratio 2:1 and left overnight. Each sample was heated at temperature of 150°C for about 90 minutes.Later, temperature was raised to 230°C for 30 minutes. Subsequently, HCl solution was added in ratio 1:1 to the digested sample and re-digested again for another 30 minutes. The digested sample was washed in 100 mL volumetric flask and the mixture obtained was cooled down to room temperature. After performing the digestion procedure, Heavy metals in this digested solution were determined using atomic absorption spectrophotometer (AAS) and the amount of each heavy metal was extrapolated from the calibration graph prepared. The relevant concentrations of Al, Fe, Mn, Cr, Cu, Pb, Zn, Ni, Cd, As, Co, Sb, Sc and Hg were measured in the laboratory. All the concentrations of elements presented here are in mg per kg is provided in Table 1.

Assessment of soil contamination

The average concentrations of different metal elements were compared with allowable limit of that specific metal of different countries to identify the soil quality of landfill. Besides, laboratory results were subjected to geo-statistical analysis, in order to facilitate interpretation. Correlations between pairs of metals were also obtained.

Determination of contaminant factor

The CF of individual metal is the ratio of metal concentration in the soil and the background value of the same metal (concentration of the metal in unaltered granodioritic rocks). The CF is computed using the Equation (1).

$$CF = \frac{C_{metal}}{C_{background}} \quad (1)$$

CF values were interpreted as recommended by Hakanson (1980), where: CF<1 indicates low contamination; 1 < CF < 3 is moderate contamination; 3 < CF < 6 is considerable contamination; and CF > 6 is very high contamination.

Determination of enrichment factor

Enrichment factor (EF) is used to determine the level of pollution based on heavy metal accumulation by soil [12]. The EF is computed using the Equation (2).

$$EF = (\frac{C_x}{C_{ref}})_{sediment} / (\frac{C_x}{C_{ref}})_{background} \quad (2)$$

where, C_x is the concentration of element x, and C_{ref} is the concentration of the reference element in soil and the earth's crust, respectively [13]. By the normalization, one metal concentration with respect to a reference element concentrationin soil, EF is calculated. In addition, a reference element is almost stable compared to other elements based on anthropogenic effect in the soil [14]. Al, Fe, Mn and Rb are typically used as elements in many studies. According to [15], significance of EF is tabulated in Table 2.

TABLE 2. Seven enrichment factor classes (Taylor, 1964)

EF value	Designation of quality
>50	Extremely severe enrichment
25 - 50	Very severe enrichment
10 - 25	Severe enrichment
5 - 10	Moderately severe enrichment
3 - 5	Moderate enrichment
1 - 3	Minor enrichment
< 1	No enrichment

Determination of geo-accumulation index

The geo-accumulation index is used to evaluate the degree of soil contamination by metals. The geo-accumulation index (Igeo) is defined in Equation 3 as describes by [16].

$$I_{geo} = Log_2(\frac{C_i}{1.5\, B_i}) \quad (3)$$

TABLE 1 Metal element concentrations of collected samples.

Sampling Points	Metal elements													
	Al	Fe	Mn	Cr	Cu	Pb	Zn	Ni	Cd	As	Co	Sb	Sc	Hg
BH-1	490.67	1602.55	90.55	5.65	53.55	230.76	133.6	3.02	4.67	3.88	5.51	2.92	8.98	8.87
BH-2	510.22	1709.77	88.93	5.88	60.13	243.88	127.93	5.44	3.26	4.09	7.78	3.02	9.04	9.2
BH-3	550.87	1678.66	90.76	7.09	65.77	255.5	130.73	7.44	4.26	5.09	6.66	3.02	10.77	8.32
BH-4	606.12	1708.23	87.65	8.83	70.12	267.93	165.93	6.88	6.11	4.11	5.03	4.12	12.03	8.59
BH-5	707.98	1809.23	98.87	8.88	90.77	289.87	178.87	7.11	5.98	4.88	3.99	4.09	14.11	7.22
BH-6	767.43	1987.76	109.77	8.77	100.87	305.6	187.93	5.63	4.08	3.02	7.14	5.09	15.93	8.01
BH-7	800.87	1786.77	110.12	7.93	109.77	387.88	198.92	5.77	3.3	4.93	8.79	6.72	15.88	7.65
BH-8	874.5	1786.8	120.7	8.0	110.7	402.7	200.8	6.1	4.8	3.6	10.8	7.1	16.9	7.1
BH-9	765.8	1345.8	130.8	7.3	87.66	380.9	187.9	6.1	5.1	4.11	8.88	6.9	16.8	6.1
BH-10	657.8	1550.6	120.8	5.2	90.8	308.9	155.8	5.6	4.6	5.04	8.77	8.9	14.8	4.8

where, C_i is the measured concentration of a specific metal element and B_n is the geochemical background value (average shale value) of the same element. 1.5 as constant value is used in the index calculation to account the natural variations in the environment and small anthropogenic influences. Table 3 briefly classifies the values for Igeo for the soil quality.

Determination of potential ecological risk index

To assess the probable ecological threat due to heavy metals, Potential Ecological Risk Index (PERI), which is proposed by [17], was used in this research. This index is a combined method to consider the susceptibility of metals, toxicity level and concentration of the heavy metals [18-20]. PERI is calculated using three basic

TABLE 3. Seven enrichment classes (Abrahim and Parker, 2008).

I_{geo}	Value I_{geo}	Class designation of soil quality
>5	6	Extremely contaminated
4-5	5	Strongly to extremely contaminated
3-4	4	Strongly contaminated
2-3	3	Moderately to strongly contaminated
1-2	2	Moderately contaminated
0-1	1	Uncontaminated to moderately contaminated
0<	0	Uncontaminated

TABLE 4. Toxic-response factor (TR) for several metals

Reference	**Hakanson, 1980**						**Ajah et al., 2015**		
Elements	Zn	Cr	Cu	Hg	Pb	Cd	As	Ni	Co
TR	1	2	5	10	5	30	10	5	5

TABLE 5. Classification based on ecological risk index(ER) and potential ecological risk index (PERI)

ER	**Pollution Degree**	**PERI**	**Risk Level**	**Risk Degree**
ER < 30	Slight	< 40	A	Slight
30 ≤ ER < 60	Medium	40 ≤ RI < 80	B	Medium
60 ≤ ER < 120	Strong	80 ≤ RI < 160	C	Strong
120 ≤ ER < 240	Very Strong	160 ≤ RI < 320	D	Very Strong
ER ≥ 240	Extremely Strong	RI ≥ 320	-	

TABLE 6. Values of maximum allowable limit of heavy metals in different countries and present average concentration of metal in samples.

Metals	Allowable limt							Avg. conc. in soil samples
	Austria	Canada	Poland	Japan	UK	Germany	U.S.A	
Cd	5	8	3	-	3	-	0.7	**4.61**
Co	50	25	50	50	-	-	40	7.33
Cr	100	75	100	-	50	200	1000	7.36
Cu	100	100	100	125	100	50	100	**84.01**
Ni	100	100	100	100	50	100	500	5.90
Pb	100	200	100	400	100	500	200	**307.38**
Zn	300	400	300	250	300	300	300	166.85

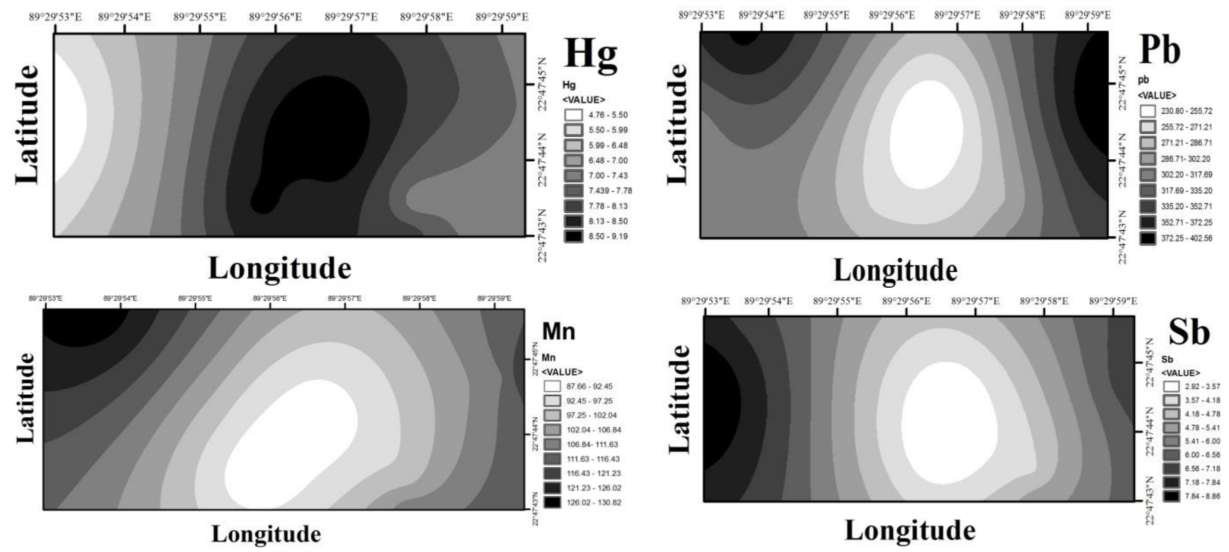


Figure 2. Surface spatial distribution of Fe, Hg, Pb, Mn and Sb concentration in soil samples.

components: contamination factor (CF), toxic-response factor (TR) and potential ecological risk factor (ER). Thus, the following equations are used to evaluate potential ecological risk index of a single element (ER) and comprehensive potential ecological risk index (PERI):

$$ER = TR \times CF \quad (4)$$

$$PERI = \sum ER \quad (5)$$

where, CF is measured by Equation (1), TR is the toxic-response factor of a single element, which is shown in Table 4. Generally, classic PERI method considers eight pollutants including PCBs, Hg, Cd, As, Pb, Cu, Cr andZn. However, we did not consider PCBs but Ni and Co in this paper. The significance of ER and PERI is tabulated in Table 5.

RESULTS AND DISCUSSION

Spatial Variation of Metal Contents in Soil

Figure 2 illustrates the distribution pattern of 4 different metal elements in soil using ArcGIS. In these patterns dark to light color represents the highest to lowest value of concentration in soil. It was observed that the distribution patterns of Pb, Mn and Sb concentrations in soil of the selected area were almost the same. But, pattern for Hg distribution was different than that of other parameters. Additionally, comparing with map of soil sampling location at study area (Figure (b)), all these patterns depict, the highest concentration lies around BH-1 and BH-2, which point toward centre of the waste disposal site. But, the distribution pattern for Hg depict, the highest concentration lies around BH-9 and BH-10.

Comparison with allowable limit

Table 6 shows the average concentration of Cd, Co, Cr, Cu, Ni, Pb and Zn in present study compared with allowable limits of different countries. In this table, average concentrations of Cd, Cu and Pb were greater than the allowable limit of one or more countries.

Figures 3, 4 and 5 show the graphical representation (bar chart) of available allowable limits and metal concentration present in soil of the selected study area for Cd, Cu and Pb, respectively. The average concentration of Cd in soil exceeded the allowable limits of Poland, UK and USA but within the limit for Canada and Austria (Figure 3). Moreover, the average concentration of Cu in the study was only greater than the safe limit for USA (Figure 4). Similarly, the average concentration of Pb in soil showed the higher allowable limits of Austria, Canada, Poland, UK and USA but within the limit for Japan and Germany (Figure 5).

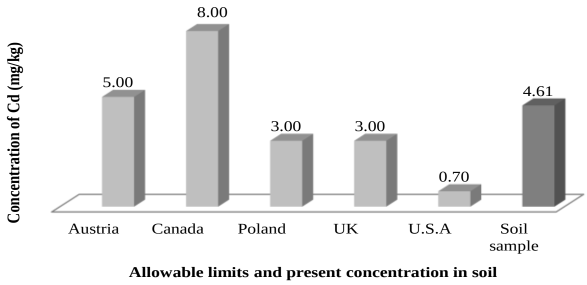


Figure 3. Comparison of allowable limits and present concentration of Cd in sample.

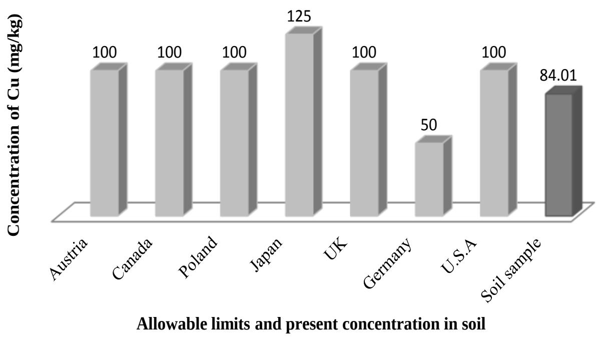


Figure 4. Comparison of allowable limits and present concentration of Cu in sample.

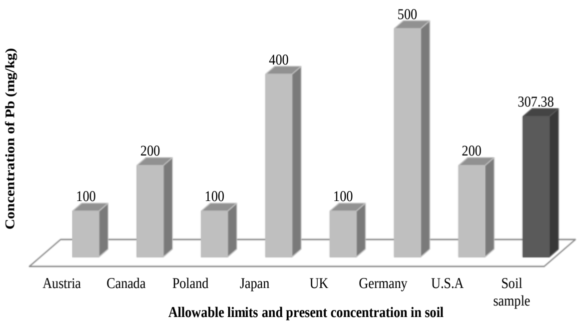


Figure 5. Comparison of allowable limits and present concentration of Pb in sample

Contaminant Factor (CF)

Figure 6 represents the values of CF for Al, Fe, Mn, Cr, Ni, Co, Sc and Hg were found to be less than 1 and hence indicated the low level of contamination in soil. The values of CF for Cu, Zn and As were between 1 to 3 belongs to the moderate level of contamination. Accordingly, the entire values of CF for Pb, Cd and Sb in soil indicated the high level of contamination (CF 6). The statistics for the computed values of contamination factor (CF) in soil are presented in Figure 6.

Enrichment Factor (EF)

Aluminum (Al) was used as the reference element because it is assumed that reference element should be least enriched in consequence of regional contamination condition. As Al is selected as reference element hence

EF of Al was found to be 1. In the present work, the values of EF varied across the sites following the sequence of Cd>Sb>Pb>As>Zn>Cu>Hg>Sc>Co>Mn> Cr>Ni>Fe>As an illustration, Figure 7 shows the EF values of 13 elements of the mean value of EF computed for 10 boreholes according to Taylor (1964) classification. The EF values of some metals as Cu, Pb, Zn, Cd, As, Sb, Sc and Hg are large in class of extremely sever enrichment. As the same manner, the EF value for other metals varies within five different classes (Very severe enrichment to minor enrichment). Figure 8 depicts the spatial distribution of EF values for six heavy metals of Sb, Cd, Pb, As, Hg and Mn in soil by the method of interpolation of Kriging method using ArcGIS. As illustrated by Figure 8, the spatial variations of EF for Cd, Hg and As were found to be similar but different from the distribution of EF of others.

Geo-accumulation index

To measure the degree of pollution quantitatively in soil sample this index is used, which is classified seven grades ranging from unpolluted to very extremely polluted. Figure 9 shows the overall statistics of Igeo in soil of selected waste disposal site. Moreover, Table 7 represents allocated class of Igeo values for different metals in different boreholes according to Abrahim and Parker, 2008. From Figure 9 and Table 7, compared to Table 3, results depicted that the value of Igeo in case of Al, Fe, Mn, Cr, Ni, Co, Sc and Hg showed the uncontaminated level, the value of Igeo in case of Cu showed the uncontaminated to moderately contaminated level. In consideration of the metal of Cd, the value of Igeo for Cd showed the strongly contaminated when for Pb it showed moderately to strongly contaminated in soil [1]. Correspondingly, the mean value of Igeo for the metal of Sb indicated the strongly to extremely contaminated and strongly contaminated level along the boreholes. These suggest that the soil of the study area have background concentrations for Al, Fe, Mn, Cr, Ni, Co, Sc and Hg. Therefore, these elements are nearly unaffected by anthropogenic impacts, while Pb, Cd and Sb concentration exceeded the background value or average shale value of metals. The main sources of these dangerous metals are industrial waste and gasoline used in the different chemical factories and motor vehicles .

Potential ecological risk index

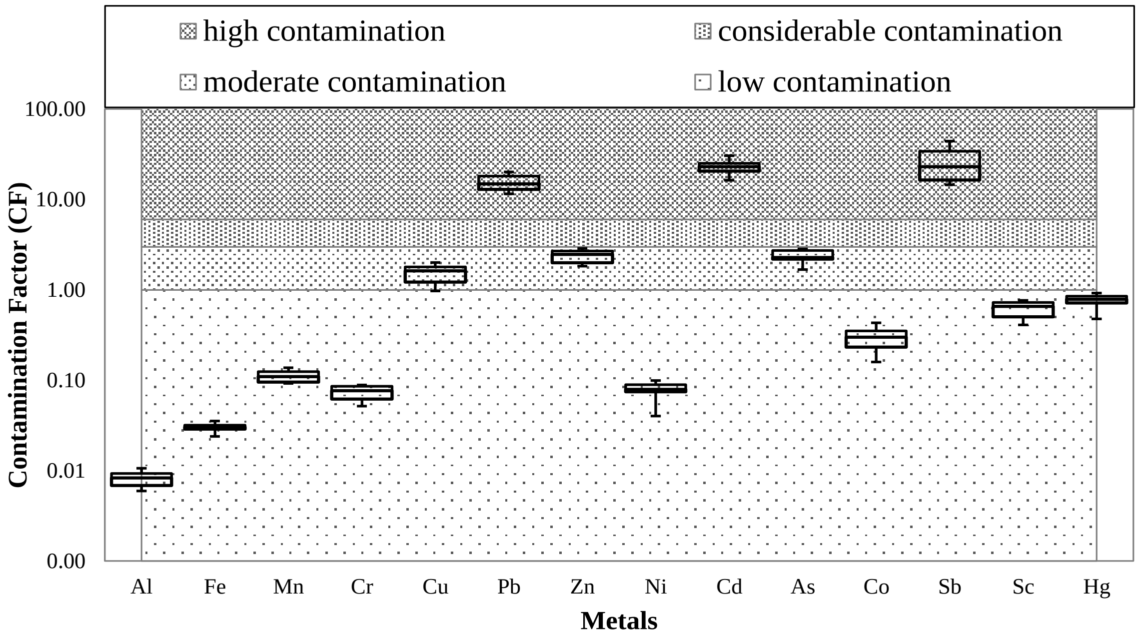


Figure6. Statistics of contamination factor (CF) of metals in collected soil samples.

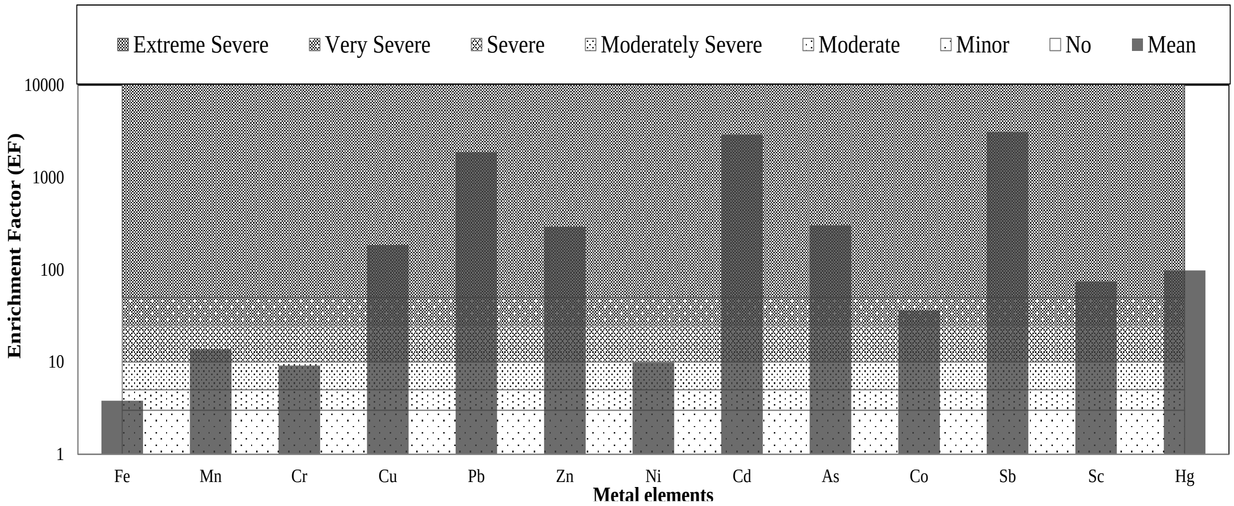
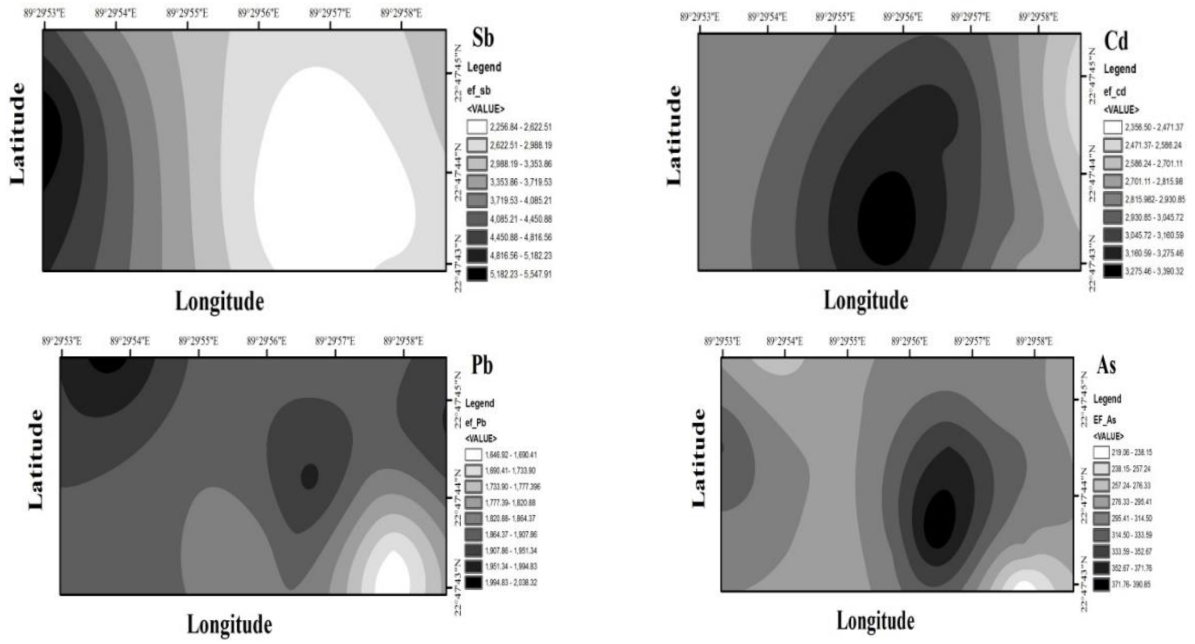


Figure 7 Classification of mean EF values of studied soil.

TABLE 7. Allocated class for different metals in different boreholes according to I_{geo}.

Sample	Al	Fe	Mn	Cr	Cu	Pb	Zn	Ni	Cd	As	Co	Sb	Sc	Hg
BH-1	0	0	0	0	0	3	1	0	4	1	0	4	0	0
BH-2	0	0	0	0	0	4	1	0	4	1	0	4	0	0
BH-3	0	0	0	0	0	4	1	0	4	1	0	4	0	0
BH-4	0	0	0	0	0	4	1	0	4	1	0	4	0	0
BH-5	0	0	0	0	1	4	1	0	4	1	0	4	0	0
BH-6	0	0	0	0	1	4	1	0	4	1	0	5	0	0
BH-7	0	0	0	0	1	4	1	0	4	1	0	5	0	0
BH-8	0	0	0	0	1	4	1	0	4	1	0	5	0	0
BH-9	0	0	0	0	1	4	1	0	5	1	0	5	0	0
BH-10	0	0	0	0	1	4	1	0	4	1	0	5	0	0



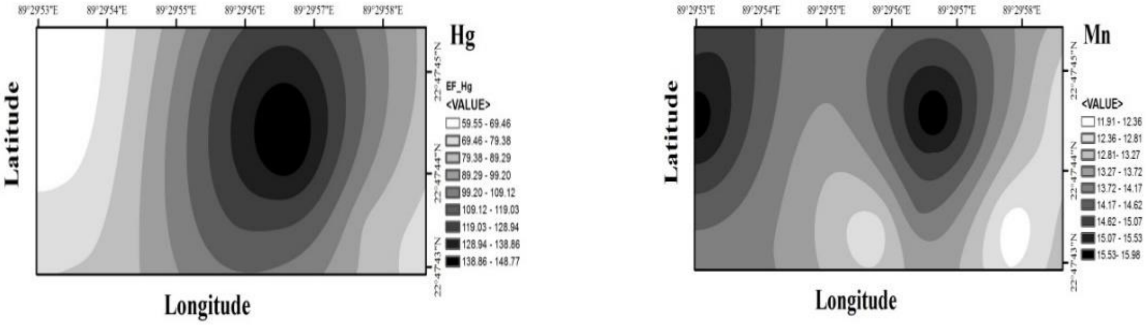


Figure 8. Spatial distribution of EF for Sb, Cd, Pb,As, Hg and Mn.

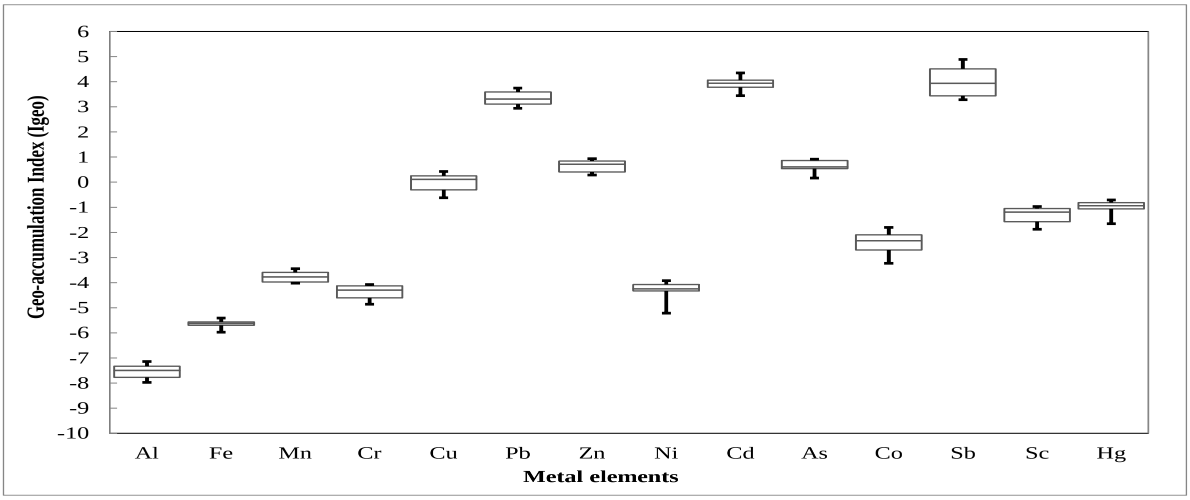


Figure 9. Statistics of Igeo for different metals in studied soil sample.

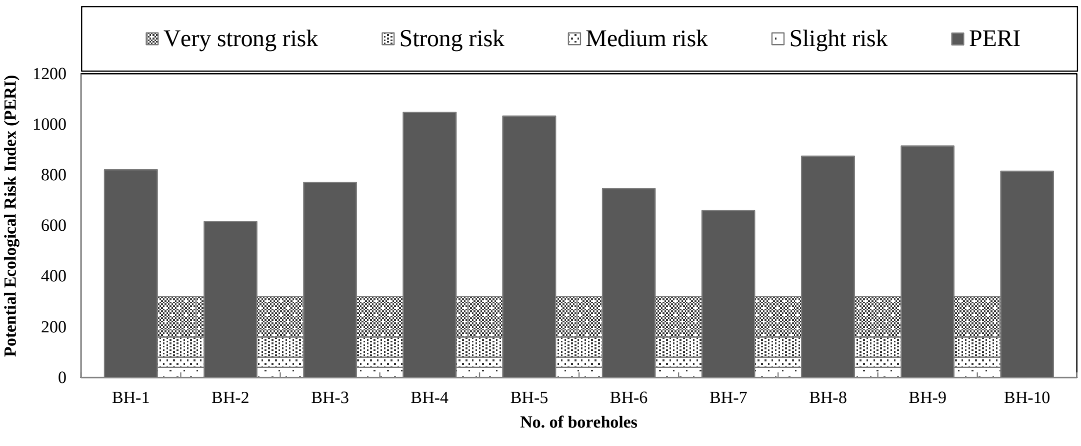


Figure 10. PERI values of studied soil in different boreholes.

TABLE 8. Variation on ecological risk index (ER) and potential ecological risk index (PERI)

No. of BH	ER									PERI
	Cr	Cu	Pb	Zn	Ni	Cd	As	Co	Hg	
BH-1	0.11	1.95	57.69	1.91	0.20	700.50	21.56	1.10	35.48	820.50
BH-2	0.12	2.19	60.97	1.83	0.36	489.00	22.72	1.56	36.80	615.54
BH-3	0.14	2.39	63.88	1.87	0.50	639.00	28.28	1.33	33.28	770.66
BH-4	0.18	2.55	66.98	2.37	0.46	916.50	22.83	1.01	34.36	1047.24
BH-5	0.18	3.30	72.47	2.56	0.47	897.00	27.11	0.80	28.88	1032.76
BH-6	0.18	3.67	76.40	2.68	0.38	612.00	16.78	1.43	32.04	745.55
BH-7	0.16	3.99	96.97	2.84	0.38	495.00	27.39	1.76	30.60	659.09
BH-8	0.16	4.02	100.66	2.87	0.41	715.50	20.05	2.15	28.56	874.39
BH-9	0.15	3.19	95.22	2.68	0.41	763.50	22.83	1.78	24.56	914.31
BH-10	0.10	3.30	77.22	2.23	0.37	682.50	28.00	1.75	19.04	814.51

TABLE 9 Pearson's product moment linear correlation coefficients of metal elements in soil samples (n = 14).

	Al	Fe	Mn	Cr	Cu	Pb	Zn	Ni	Cd	As	Co	Sb	Sc	Hg
Al	1													
Fe	0.232	1.000												
Mn	0.774	-0.312	1.000											
Cr	0.558	**0.551**	0.012	1.000										
Cu	0.963	0.341	0.729	0.483	1.000									
Pb	0.928	-0.060	0.843	0.328	0.871	1.000								
Zn	0.964	0.248	0.680	**0.666**	0.912	0.875	1.000							
Ni	0.281	0.150	0.021	0.580	0.267	0.191	0.242	1.000						
Cd	0.052	-0.176	-0.029	0.418	-0.067	-0.070	0.168	0.329	1.000					
As	-0.197	-0.311	-0.092	-0.245	-0.074	-0.061	-0.236	0.377	0.016	1.000				
Co	0.554	-0.180	0.722	-0.238	0.541	0.730	0.387	-0.086	-0.506	-0.139	1.000			
Sb	0.705	-0.234	**0.890**	-0.064	0.746	0.781	0.624	0.047	-0.034	0.109	**0.704**	1.000		
Sc	0.961	0.071	0.870	0.468	**0.932**	**0.902**	**0.924**	0.295	0.112	-0.121	0.536	**0.807**	1.000	
Hg	-0.501	0.414	-0.822	0.162	-0.542	-0.552	-0.408	-0.155	-0.193	-0.323	-0.437	-0.879	-0.677	1.000

Using the assessment method introduced by Hakanson et al. [17], ecological risk index of an individual element (ER) and potential ecological risk index (PERI) of all metals were calculated.The obtained PERI and RI values are shown in Table 8. In terms of the maximum ER of these eight metals, the metals arrayed is in the order of ER(Cd) > ER(Pb) > ER(Hg) > ER(As) > ER(Cu) > ER(Zn) > ER(Co) > ER(Ni) > ER(Cr). Cd was the key influence factor to cause the potential ecological risk, and the maximum value of ER was up to 916.50 for Cd. All of the sampling points have strong potential ecological risk of Cd, whereas PERI of other metals only show slight potential ecological risk to the environment except Pb and Sb with slight to strong ecological risk. Therefore, Cd, Pb and Sb were the key elements to be further studied. In addition, Figure 10 depicts potential ecological risk indexes (PERI) for all BHs are above 320. Hence, from PERI point of view risk degree is very strong.

Correlation of metals

In this study, Pearson's correlation coefficients were calculated for metal concentration present in soil of study area for soil quality assessment. The interrelationship analysis concerning different variables is significant tool in advanced research . The correlation analysis is a primary technique to estimate the level of association among the variables involved in particular research. Such association is possibly drive to perceptive about underlying relationship between the variables. Moreover, the study of correlation decreases the hesitation related to making a proper decision [21]. So, it is easy to select proper treatment analyzing the values of correlation coefficients to minimize soil contamination. In addition, correlation matrix between various metal parameters in soil of selected waste disposal site for dry season is shown in Table 9. Some of the metal elements had statistically significant correlation with each other indicating close association of them. Correlation matrix of the metal data indicates positive correlations (r2 >0.5) among most of the elements. Based on the results of Pearson's correlations matrix on metal elements in soil, it was observed the most significant viz. high positively correlated values between Fe and Cr (0.551), Mn and Sb (0.890), Cr and Zn (0.666), Cu and Sc (0.932), Pb and Sc (0.902), Zn and Sc (0.924), Co and Sb (0.704),Sb and Sc (0.807). Such a significant correlation between metals might indicate similar pollution level and similar pollution sources of these heavy metals.

CONCLUSION

Result reveals that the computed values of EF in soils were extremely sever enriched by the element of Cu, Pb, Zn, Cd, As, Sb, Sc and Hg, varied across the sites following the sequence of Cd>Sb>Pb> As> Zn> Cu> Hg> Sc. Moreover, the values of CF for Pb, Cd and Sb were indicated the high level of contamination. Pb, Cd and Sb were higher than average shale value according to Igeo, which indicates risk to environment. As reported by ER, the metal elements of Cd, Pb and Sb were the key elements to be further studied. In addition, PERI point of view risk degree was very strong. Based on Pearson's correlation analysis, is can be observed that most of the metals in soil were significantly correlated with each other which indicated their source was almost the same and these metals might be derived from the waste accumulation activity. This study demonstrations that there is environmental contamination around dumping area and put emphasis on the need for a comprehensive public health approach to address environmental extortions in local communities. Finally, it can be concluded that it is obvious a systematic and constant monitoring for heavy metal pollution should be instituted and certain remediation steps should be carried out to minimize the rate and extent of pollution problems in future.

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Persian Abstract

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چکیده

هدف اصلی این مطالعه ارزیابی کیفیت خاک و میزان آلودگی خاک با فلزات سنگین منطبق با شاخص های توسعه یافته مختلف در یک محل دفن زباله در بنگلادش می باشد. به منظور انجام این پژوهش ده نمونه خاک از محل های انتخاب شده جمع آوری شد سپس عناصر مربوط Al, Fe, Mn,Cr, Cu, Pb, Zn, Ni, Cd, As, Co, Sb, Sc, and Hg با استفاده از روش های استاندارد اندازه گیری شد. برای برآورد وضعیت آلودگی خاک عامل آلودگی (Cf), عامل غنی سازی (EF), و شاخص خطر زیست محیطی (PERi) با استفاده از مقادیر زمین شناسی محاسبه شد. علاوه بر این، برای ارزیابی کیفیت خاک، تجزیه و تحلیل ضرایب همبستگی پیرسون نیز انجام شد. بعلاوه این مطالعه نشان داد که مقادیر CF و Lgeo در خاک های اطراف منطقه تخلیه زباله از آلودگی فلزات سنگین مانند Cd, Pb, Sb تاثیر گرفته است. در مقابل رابطه پیرسون نشان داد که منابع فلزات تقریبا یکسان هستند و این فلزات سنگین ممکن است از تجمع ضایعات مشتق شده باشد. اگر ترکیبات با ارزش محل های تخلیه زباله استخراج شوند پتانسیل بالایی برای استخراج انرژی دارند.