IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 11, Issue 1 Ver. I (January. 2018), PP 90-99
www.iosrjournals.org

Spatial distribution and contamination assessment of heavy metalsin urban road dusts from Dhaka city, Bangladesh

M.D.H. Khan[1,*], A. Talukder[2], M. Safiur. Rahman[3]
[1] *Department of Microbiology, Stamford University Bangladesh, Dhaka, Bangladesh[22]Department of Chemistry, University of Dhaka, Bangladesh*
[3] *Atmospheric and Environmental Chemistry Laboratory, Chemistry Division, Atomic Energy Centre,P.O. Box 164, Dhaka 1000, Bangladesh*Corresponding author: dulal.hossain@stamforduniversity.edu.bd*

Abstract : *Street dusts were collected from twenty two road side locations in Dhaka City, Bangladesh. Dusts samples were sieved below 90 µm and analyzed by Energy Dispersive X-ray Fluorescence (EDXRF) for eight toxic heavy metals (Pb, Cr, Cu, Cd, Ni, As, Zn and Mn). This study revealed that the concentrations of these metals were higher than that of the background value of the respective metals in soil. For the assessment of pollution level in the street dusts in Dhaka City, several important indices: enrichment factor (EF), pollution index (PI), pollution load index (PLI), and geo-accumulation index (I_{geo}) were followed in this study. ArcGIS software is used to generate the spatial distribution map for the heavy metals, which specifies high and low concentrated zone of toxic heavy metals in the study area. Enrichment factors analysis indicated the anthropogenic and natural sources of metal contamination. Pearson's correlation coefficients analysis show that Cu, Pb, Cd, Ni, Zn, As and Mn which are significantly positively correlated, likely originate from common anthropogenic sources. Chromium was found at high concentrations in all the samples that seems also to have anthropogenic sources, but not the same ones as for the other contaminants. All the models agreed that contamination levels is in increasing order of Mn>Zn >Cr>Cu>Ni>Pb>Cd>As.*

Keywords -*Street dusts; Enrichment factor; Heavy metals; Chromium, Contamination factor; Dhaka city.*

I. Introduction

Air pollution today is a major problem for modern societies. It has long been recognized as a potentially lethal form of pollution. In recent times, studies of air pollution especially in the urban environment have focused largely on road deposited dust [1], [2], [3], [4], [5], [6], [7], [8], [9]. The particles of dust that deposit from the atmosphere and accumulate along roadside are called road dust or road deposit dust[10]. Road dust represents complex chemical composition and originates from the interaction of solid, liquid and gaseous materials produced from different sources and activities [11], [12]. However, heavy metals of the different sources accumulate in top soils from atmospheric deposition by sedimentation, impaction, and interception [13],[14]. Accumulations of heavy metals on urban surfaces arise from vehicle exhausts, industrial discharges, oil lubricants, automobile parts, corrosion of building materials, and atmospheric deposition [13], [15]. Thus, the heavy metals are good indicators of contamination in surface environments, especially in the urban areas. Street dust acts as recipient of pollutants from different sources and makes a significant contribution to the pollution in the urban environment [15]. With the increase of population, the tightly packed buildings limit air circulation, leading to increase of heavy metal accumulations in the street dust [16]. Many studies of concentrations of heavy metals in street dusts in large cities have been conducted in developed countries ([17], [18], [19], [13], [20]) but little has been done in less developed countries. At present, air pollution has become a main environmental issue in many nations, including Bangladesh [15]. Subsequently, heavy metal pollution in urban road dusts in Bangladesh becomes serious with the rapidly urbanization and industrialization during the last two decades. Ahmed et al. [20] reported that total numbers of vehicles and auto-rickshaws (two-stroke engine vehicles) in Dhaka City of Bangladesh have been increased several folds in the last decade. According to Bangladesh Road Transport Authority (BRTA, 2016), the number of registered motor vehicles in 2011 was 72,377, which has been increased to 93,934 in 2015 (BRTA, 2016).Numerous studies have tried to ascertain various aspects of this problem: especially potential health effects of exposure to this materials through inhalation, ingestion and dermal contact ([19], [20], [21]). But unfortunately quite a few studies associated with the health risk assessment for the toxic metals in urban road dust samples in the capital city of Bangladesh (Dhaka), especially in the smelting district have not been carried out during the past decade/s. In the present study, an attempt has been made to generate and evaluate levels of trace heavy metals, As, Cu, Cr, Pb, Mn, Cd, Ni and Zn in road deposited dust in the Dhaka city. The study would form the basis of establishing baseline data regarding heavy metals in road dust of the city and identifying the patterns spatial distribution of Pb, Cr, Mn, Ni, Cu, Zn, As, Zn using geographical information system method. The study is also important in that it can be used as basis for planning management strategy to achieve better environmental quality and substantial development of the district.

II. Materials and methods

2.1 The study site: Dhaka City, Bangladesh: Bangladesh is located in the eastern part of south Asia. It is surrounded by India to the west, north, and northeast, by Myanmar to the southeast, and by the Bay of Bengal to the south. Dhaka City, the capital city, is almost in the middle of Bangladesh (Fig. 1). Total area of the city is about 150 km^2. In 1950, the population of Dhaka City was only 0.43 million ([20], [22])and now the present population in Dhaka is above 158million [23] with a rate of increment of about 7% per year [24]. Numbers of vehicles and industries are also multiplying rapidly, and recent observation of smog in the Dhaka City indicates the onset of air pollution [25]. On the other hand, there are many different types of industries (i.e., textile, glass, ceramic, pharmaceutical) have been established in Dhaka City.

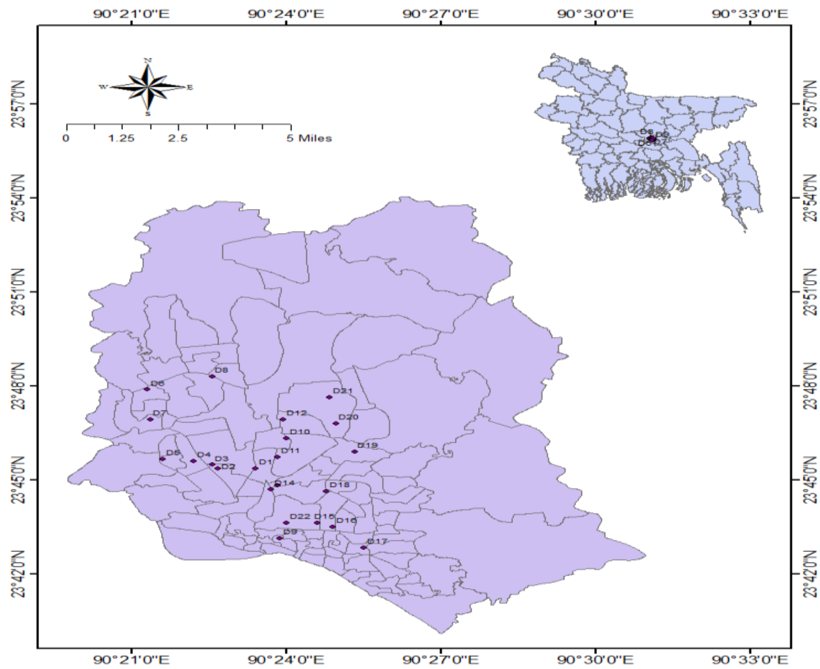


Fig. 1: Map of Dhaka City showing the sampling location

2.2. Sample collection and processing: In this study, 22 road dust samples from Dhaka Capital City, Bangladesh have been collected, which cover all most 25 km circle. A detailed description for each sampling site is presented in Table 1.The sampling sites within each unit were selected at random, and approximately 300 g street dust samples were collected using polyethylene brush on impervious surface (road, pavement, and gutter) in dry monsoon (January, 2016). All collected dust samples were stored in sealed polyethylene bags, labeled and then transported to the laboratory. All samples were air-dried naturally in the laboratory for one week, then sieved through a 1.0 mm (16 US mesh) nylon mesh (USA Standard Testing Sieve, W.S. Tyler Inc., USA) to remove refuse and small stones. Subsequently, the samples were dried for 24 hr at about 85 ºC in an oven; Vinci Technologies SA - 27 B, France) and sieved through a 74 µm (200 US mesh) nylon mesh; USA Standard Testing Sieve, W.S. Tyler Inc., USA). This size was selected in this study for elemental analysis as those particles of street dusts with diameters below 100 µm are easily re-suspended (as opposed to bigger particles which move mainly by “saltation” and “creep”) ([26], [27]), and they can be inhaled through the nose or mouth during breathing ([15],[28]). For making fine grain size and homogeneous mixture, each of the sieved samples was ground with an agate mortar and pestle, Finally, a pellet maker having approximately 10 tons of hydraulic pressure; Specac, UK) was applied for 2-5 min onto the dust samples to prepare 25 mm pellet for elemental analysis by EDXRF; Epsilon 5, PAN analytical, The Netherland) following the method for same matrix published in literature ([15], [29], [30]).

Table 1. Description of road dust samples collected from DhakaCity

SampleS ID	Latitude	Longitude	Sampling locations in capital city Dhaka, Bangladesh
D1	23°45´24´´N	90°23´25´´E	Farmgate Bus Stoppage (close to Anando Cinema Hall)
D2	23°45´24´´N	90°22´46´´E	Manik Mia Avenue (close to NAAM Buildings)
D3	23°45´32´´N	90°22´36´´E	Manik Mia Avenue (close to Parliament House)
D4	23°45´38´´N	90°22´20´´E	Asad Gate Bus Stoppage (close to Parliament House)
D5	23°46´41´´N	90°21´37´´E	Kallyanpur Bus Stoppage (close to Residential Model College)
D6	23°46´57´´N	90°21´21´´E	Technical Bus Stoppage (close to Asia Cinema Hall)
D7	23°47´55´´N	90°21´22´´E	Mirpur-1 Buss Stoppage.
D8	23°48´19´´N	90°22´34´´E	Mirpur-13 Buss Stoppage.
D9	23°46´45´´N	90°23´54´´E	Mohakhali Flyover Bridge Bus Stoppage.
D10	23°46´24´´N	90°24´2´´E	Mohakhali Central Bus Terminal (close to ICDDRB Hospital)
D11	23°45´46´´N	90°23´51´´E	BG Press (close to Bangladesh University of Textile Engineering)
D12	23°45´51´´N	90°23´60´´E	Tibbet Nabisco, Industerial area
D13	23°44´52´´N	90°23´48´´E	FDC Rail Crossing (close to Pan Pacific Shonargaon Hotel).

D14	23°44´44´´N	90°23´41´´E	Bangla Motor Bus Stoppage.
D15	23°43´39´´N	90°24´38´´E	GPO round square.
D16	23°43´31´´N	90°24´54´´E	Bangabhaban. (close to President House)
D17	23°42´53´´N	90°25´30´´E	Saidabad Rail Crossing (Saidabad Inter District Bus Stoppage)
D18	23°44´38´´N	90°24´50´´E	Malibag(close to Hosap Tower under flyover)
D19	23°45´56´´N	90°25´19´´E	Rampura Bus Stopage (close to Bangladesh Television Station)
D20	23°46´49´´N	90°24´59´´E	Gulshan Round Square-1 (Diplomatic Zone)
D21	23°47´39´´N	90°24´52´´E	Gulshan Round Square-2 (Diplomatic Zone)
D22	23°43´40´´N	90°24´01´´E	Doel Chatter, (in Dhaka University Campus)

2.3. Elemental analysis in road dust sample using EDXRF: The concentrations of Pb, Cr, Mn, Ni, Cu, Zn, As, Cdin dust samples were measured by energy dispersive X-ray fluorescence spectrometry (Epsilon 5, PAN analytical, The Netherland). For getting the elemental concentration in road dust samples, all the sample pellets were irradiated by X-raysfrom Gd tube under a vacuum equipped with a liquid nitrogencooled PAN-32 Ge X-ray detector having a Be window thicknessof 8 µm. The power, current and high voltage of the instrumentwas 600 W, 6 mA and 100 kV, respectively. The system's software(Epsilon 5 software) automatically analyzed the sample spectrumsand determined the net intensities of element peaks as soon asthe measurement was completed ([30], [6]). The standard materials of similar matrices were also irradiated under similar experimental conditions for the construction of calibration curves for quantitative elemental analysis in the respective samples. The generated X-ray spectra of the materials were stored into the computer. Detection limits (DLs**)** were calculated using three times the square root of the background [31]. One standard reference material from IAEA 433 (marine sediment) was used for the construction of calibration curves for carrying out elemental analysis in the road dust samples. The calibration curve for each element was constructed based on the K X-ray and L X-ray intensities calculated for the respective elements present in standard samples. The curves were constructed by plotting the sensitivities of the elements as a function of their atomic number. The validation of calibration curves constructed for elements present in the standards was checked through analysis of standard reference materials. All results in respect of certified known values were found to vary within the acceptable range (< 7%) of error (SI 1).

2.4 Pollution assessment

Enrichment factor (EF): Enrichment factor (EF) was used to assess the degree of metal pollution and probable natural or anthropogenic sources. EF is defined mathematically as:

$$EF=\frac{[C_x/C_{ref}]_{Sample}}{[B_x/B_{ref}]_{Background}} \qquad \text{…………………………….(2.1)}$$

Where, $(C_x/C_{ref})_{sample}$ is the ratio of concentration of a target metal and the reference metal in the road dust samples and $(B_x/B_{ref})_{background}$ refer to the ratio of concentration of a target metal and the reference metal in the background material. Mn or Fe was used as normalizer and concentrations of elements in the crust were taken as background. EF can also give an insight into differentiating an anthropogenic source from a natural one[15].In general, EF values much higher than 10 are mainly considered to have anthropogenic sources while values less than 10 predominantly originate from background soil material. Moreover, EF also assists in determining the degree of metal contamination. Five contamination categories are recognized on the basis of the enrichment factor. Bellow 2 is deficiency to minimal enrichment, 2-5 is Significant enrichment, 5-10 is Significant enrichment, 20-40 is Very high enrichment, Above 40 is Extremely high enrichment[32].

Contamination Factor: To assess the extent of contamination of heavy metals in road dust and also provide a measure of the degree of overall contamination along a particular road, contamination factor and pollution load index has been applied [33].The contamination Factor (CF) parameter is expressed as:

$CF = C_{metal} / C_{background}$------------------------------- (2.2)

Where CF is the contamination factor, C_{metal} is the concentration of heavy metals in dustand$C_{background}$ is the background value for the metal. The CF reflects the metal enrichment in the dust. The geochemical background values in continental crust averages of the trace metals under consideration reported by Taylor and McLennan [34] was used as background values for the metal. The CF are classified into four groups [35].CF < 1 refers to low contamination; 1 ≤ CF < 3 means moderate contamination; 3 ≤ CF ≤ 6 indicates considerable contamination and CF > 6 indicates very high contamination.

Pollution Load Index: Each roadway site was evaluated for the extent of metal pollution by employing the method based on the pollution load index (PLI) developed by [36]follows:

$PLI = n\sqrt{(CF_1 \times CF_2 \times CF_3 \times .... CFn)}$ ………………………(2.3)

where*n* is the number of metals studied (seven in this study) and *CF* is the contamination factor calculated as described in an earlier equation. The PLI provides simple but comparative means for assessing a site quality, where a value of PLI < 1 denote perfection; PLI = 1 present that only baseline levels of pollutants are present and PLI >1 would indicate deterioration of site quality [15].

Geoacumulation index (*I_{geo}*): The index of geoaccumulation (I_{geo}) is widely used in the assessment of contamination by comparing the levels of heavy metal obtained to a background levels originally used with bottom sediments [37]. It can also be applied to the assessment of road dust contamination [13]. It is computed by the following equation:

$$I_{geo} = \log_2 \left[\frac{C_n}{1.5B_n}\right] \quad \text{……………………………………………………………….(2.4)}$$

Where Cn is the measured concentration of the heavy metal in road dust and Bn is the geochemical background concentration of the heavy metal (crustal average). The constant 1.5 is introduced to minimize the effect of possible variations in the background values which may be attributed to litho logic variations in the sediments [21].The following classification is given for geoaccumulation index [37], [38]: <0 = practically unpolluted; 0-1 = unpolluted to moderately polluted; 1-2 = moderately polluted; 2-3 = moderately to strongly polluted; 3-4 = strongly polluted; 4-5 = strongly to extremely polluted and > 5 = extremely polluted.

III. Results and discussion

3.1 Heavy metal contents in street dust: The concentration of the studied heavy metals (Pb, Cr, Mn, Ni, Cu, Zn, As and Cd) in street dust samples compared with the background values for soil [39] are presented in Table 2. However, the mean heavy metal concentrations in the investigated street dust samples are shown in Box and Whisker plot (Fig. 2), which are varied from 9.07 to 43.19, 108.09 to 199.42, 194.37 to 415.07, 25.44 to 56.58, 30.23 to 74.44, 107.56 to 683.23, 5.16 to 11.74 and 6.08 to 21.52 mg/kg for the concentrations of Pb, Cr, Mn, Ni, Cu, Zn, As, and Cd respectively. In the layout in Fig. 2, the tri linear symbol in the box represents the median value and the vertical bars display the range of the data for 25 to 75 percentile. Fig. 2 also shows that the highest concentration in the street dust samples was found for Zn followed by Mn, Cr, Cu, Ni, Pb, Cd and As respectively. The finding of this study is consistent with the observations of previous researchers[21], who found that Zn, Mn, Cd, Pb, Ni, Cr etc. are the predominantly present in the street dust samples. On the other hand, the percentage of relative standard deviation data (Table 2) showed that abundances for Mn, Cr, As, Ni and Cu do not vary over a long ranges among the different sampling sites in Dhaka City, whereas rest of the studied heavy metals (i.e., Cd, Pb and Zn) vary significantly. It might be happened due to the reason that the main source of Cd, Pb and Zn are battery. Every year a good number of electrical vehicles (operated by battery) are running in Dhaka City but the used batteries are not properly collected for recycle and dumping here there. Therefore, the variation for the concentrations of Cd, Pb and Zn are significant in different sampling sites.

Table 2. Statistical analysis of heavy metal concentrations (mg/kg) in street dust samples.

Element	Mean	Median	SD	VC	Min	Max	GM	China, B CNEMC.	95% UCL
Pb	18.99	16.19	8.97	0.47	9.07	43.19	17.28	21.4	22.73
Cr	144.34	138	26.14	0.18	108.09	199.42	142.24	62.5	155.26
Mn	261.53	266.45	44.88	0.17	194.37	415.07	258.26	557	280.28
Ni	37.01	34.67	8.75	0.23	25.44	56.58	36.05	28.9	40.67
Cu	49.68	49.72	12.61	0.25	30.23	74.44	48.16	21.4	54.95
Zn	239.16	196.89	143.92	0.60	107.56	683.23	210.79	69.4	299.3
As	8.09	8.21	1.75	0.21	5.16	11.74	7.92	11.09	8.83
Cd	11.64	9.215	4.98	0.42	6.08	21.52	10.73	0.108	13.72

SD = Standard Deviation; GM = Geometrical Mean; VC = Variance of Coefficient; CNEMC = China Environmental Centre. In this study we used background value from CNEMC, because we have no available background value.

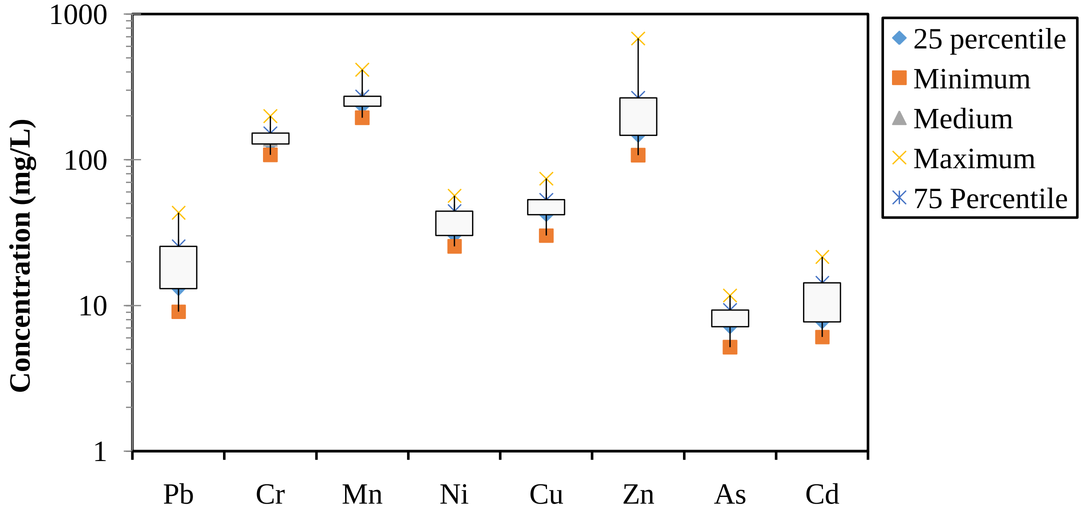
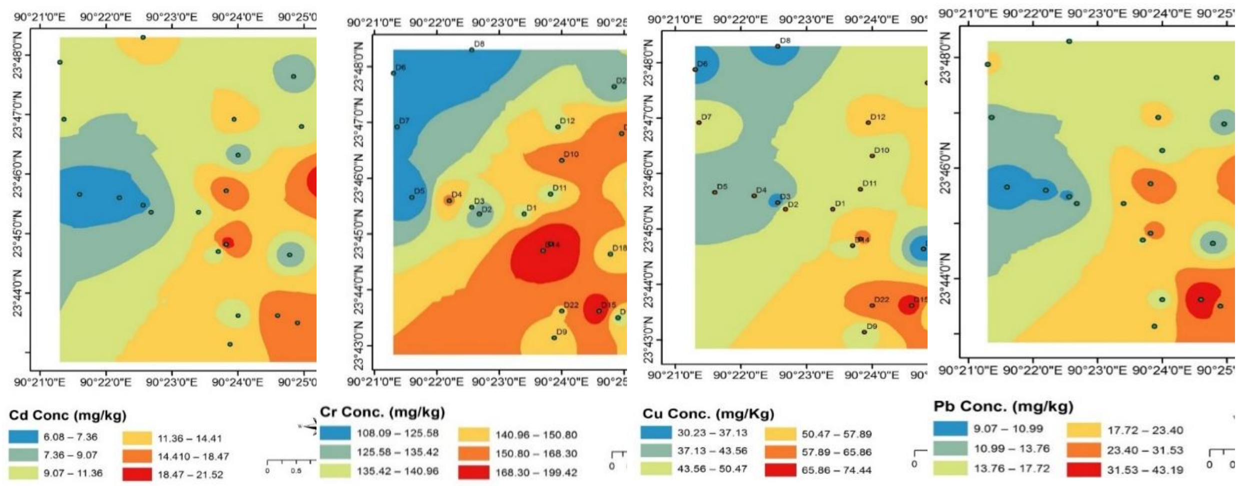
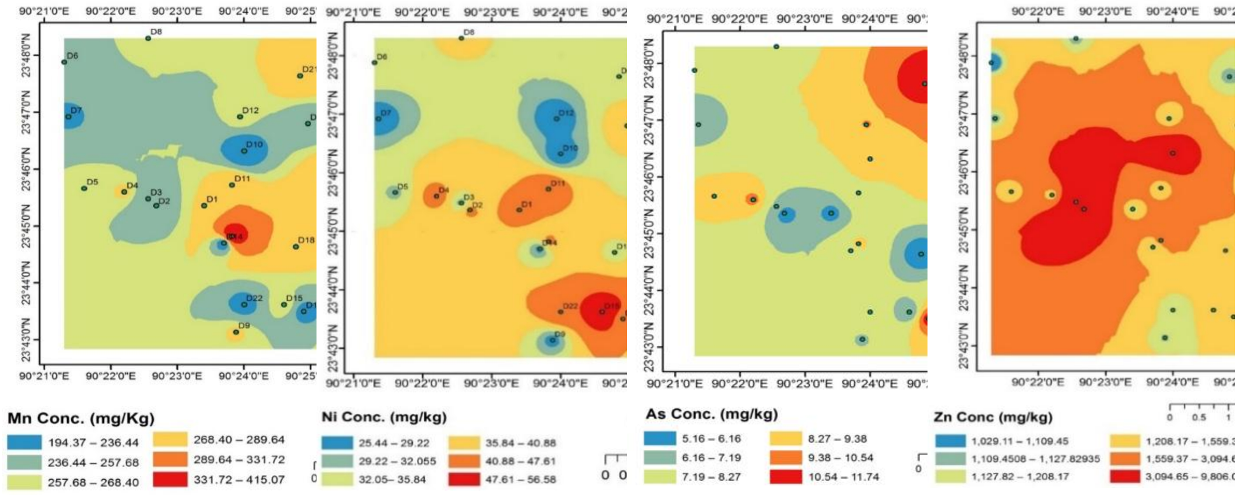


Fig. 2. Box-Whisker plot for the heavy metal concentrations in street dust samples

3.2 Spatial distribution of metals in street dust: The spatial distributions of Pb, Cr, Mn, Ni, Cu, Zn, As and Cdin dust samples of Dhaka City were obtained based on their concentrations using ArcGIS software (Version 10.2, Esri, California, USA), which has been shown in Fig. 3. The results of spatial distribution pattern showed that the high concentrated zones of Cd were found at the sampling sites of D15, D16, and D19 respectively (i.e. GPO, Bangabhabon and Rampura TV station respectively), which is shown in Fig. 3(a). This study revealed that the concentration of Cd was very much higher than the soil background value of 0.108 mg/kg [39] in all the sampling sites. The maximum concentration of Cd was 200 times higher than the soil background value. The highest concentration zone for Cr was found in the sampling sites of D13, D14, and D15 (i.e., Rail crossing at F.D.C., Banglamotor and GPO) respectively (Fig. 3(b)), which was three times higher than its background value in soil (CNEMC, 1990). The highest concentrated zone of Cu, Pb and Ni were found at the sampling site of D15 (GPO), which is shown in Figs. 3(c), 3(d) and 3(f) respectively. From this study, it was observed that the concentrations of Pb and Ni were two and three times higher, while the concentration of As was slightly higher compared to the background values in soil [39].On the other hand, the higher concentration Zn in street dust samples was found at the sampling sites of D1, D3, D4 to D5 and D9 to D12 respectively (Farmgate, Manikmia Avenue, Asadgate to Kalynpur and Mohakhali to Tejgaon industrial area). Subsequently, this study also revealed that the concentration of Zn in street dust samples in most of the sampling sites of Dhaka City was almost higher than its background value of 69.9 mg kg^{-1} in soil [39].However, the sampling site of D15 (GPO round square) was found to be significantly contaminated site for most of the heavy metals (Cd, Ni, As, Cu and Cr). It might be happened due to the reasons that GPO is the high traffic density area, and there are several metal smelting workshops are also established there. It should be noted here that heavy metals come into road dust due to anthropogenic activities especially from the industries of motor-vehicle and smelting. For instance, (i) nickel is used as body and parts of car and copper is often used in car lubricants [16], (ii) Cd is used for preparation of special alloys and solders, metal plating, pigments in yellow or brown paints (for coloring plastics, glass, and enamels), nickel-cadmium



(a) (b) (c) (d)



(e) (f) (g) (h)

Fig. 3 . Spatial distribution for heavy metals concentration for (a) Cd, (b) Cr, (c) Cu, (d) Pb, (e) Mn, (f) Ni, (g) As, and (h) Zn in street dust sample of Dhaka City, Bangladesh.

rechargeable batteries, and electronic waste [14]. Subsequently, chromium is used in motor parts and motor's body, (iii) Zn is added to tire tread rubber mostly as zinc oxide (ZnO), and in lesser quantities as a variety of organo-zinc compounds, to facilitate vulcanization of the rubber. Zinc is common in car lubricants, tires and carburetors [16]. Therefore, it has been suggested that the contamination of heavy metals in street dust mainly from traffics and metal smelting workshops in some places.

3.3 Pollution assessment

3.3.1 Geoaccumulation index: Average Geoaccumulation index (**I_{geo}**) of heavy metals shown in fig.4while fig 5 represents the sampling pointwise **I_{geo}** values. The average I_{geo} for Cd belong to extremely contaminated level (shown in fig. 4). This high index is caused mainly by the metallurgical industry; hence its content in the areas affected by industrial activity may be elevated. I_{geo} values for Cr ranged from 0.21 to 1.1 and the sampling point Rail crossing (F.D.C), Banglamotro, GPO show moderately contaminated level. The mean value of Cr is 0.62 which is shown in fig.4. TheI_{geo} value of Cu ranged from -.05-1.21. The sampling point at Saidabad, GPO show moderately contamination level with mean value 0.68 (unpolluted to moderately polluted). The value of I_{geo} of Zn ranged from 0.05 – 2.71.The sampling point Saidabad and Gulshan fall on moderately to strongly contaminated level with mean value 2.1.

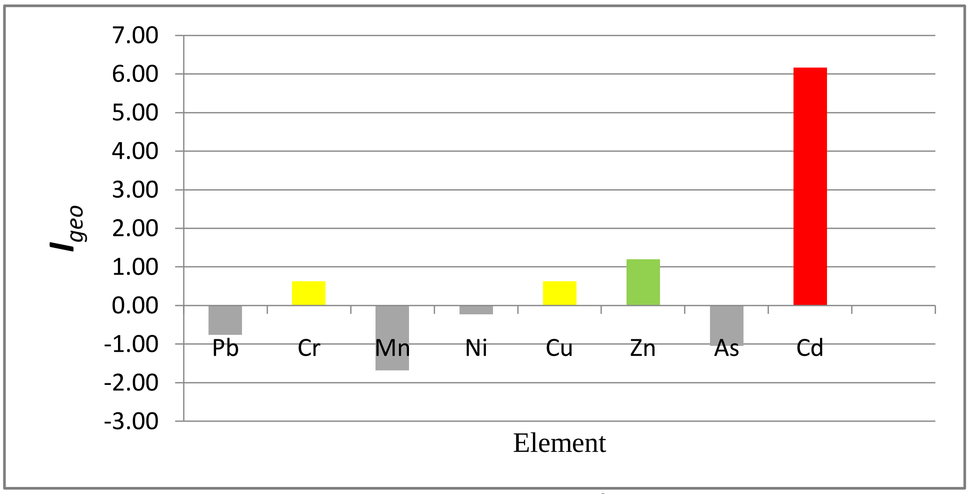
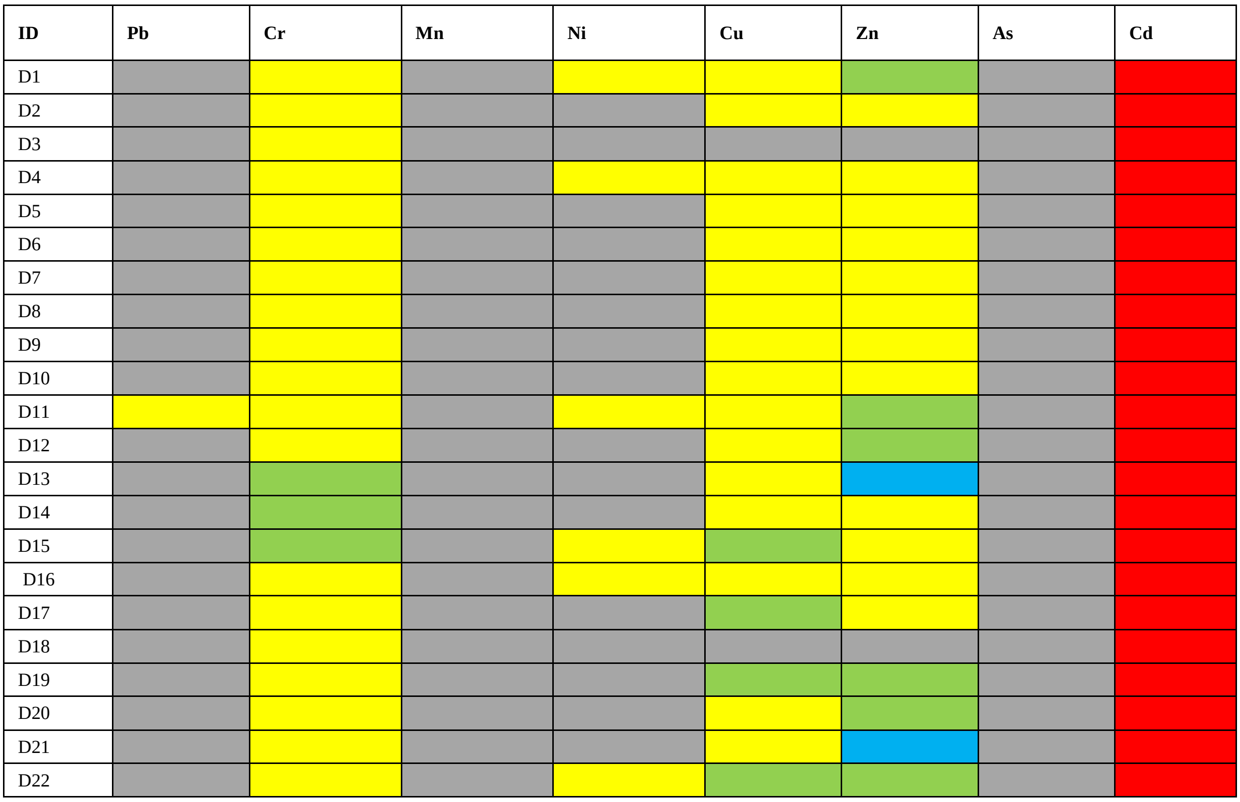


Fig. 4 Average Geoacumulation Index (I_{geo}) of metals in Dhaka City

Table 3. Contamination level of different toxic heavy metal in Dhaka city.

Element	MeanI_{geo}value	Contamination level
Pb	-0.76	Uncontaminated
Cr	0.62	Uncontaminated to moderately contaminated
Mn	-1.68	Uncontaminated
Ni	-0.23	Uncontaminated
Cu	0.63	Uncontaminated to moderately contaminated

Zn	1.20	Moderately contaminated
As	-1.04	Uncontaminated
Cd	6.17	Extremely contaminated



<0 = practically uncontaminated
0-1 = uncontaminated to moderately contaminated,
1-2 = moderately contaminated
2-3 = moderately to strongly contaminated
3-4 = strongly contaminated,
4-5 = strongly to extremely contaminated and
>5 = extremely contaminated

Fig. 5 Representation of *Igeo* of metals at different sampling points

Fig. 5 represents the sampling point wise I_{geo}value. I_{geo} is distinctly variable and suggests that street dust of Dhaka city ranged from uncontaminated to strongly/extremely contaminated with respect to the analyzed metals. I_{geo} revealed that all the samples examined in respect of Pb, As and Mn fell into class 0—uncontaminated. In all sampling point Cd fall on extremely contaminated level.

3.3.2 Contamination factor and pollution Load Index (PLI): While computing the contamination factor (CF) for pollution load index (PLI) of street dust of the study area, average shale value for each heavy metal described by Turekian and Wedepohl, 1961 [40], were considered as background concentration because there are no geochemical background data available for the studied region. To effectively compare whether the 22 roadways suffer contamination or not, the Pollution Load Index (PLI) described earlier was applied. The PLI is aimed at providing a measure of the degree of the overall contamination at the sampling sites along the various roadways. Fig. 6 shows results of the PLI for the nine metals studied at the various roadways.

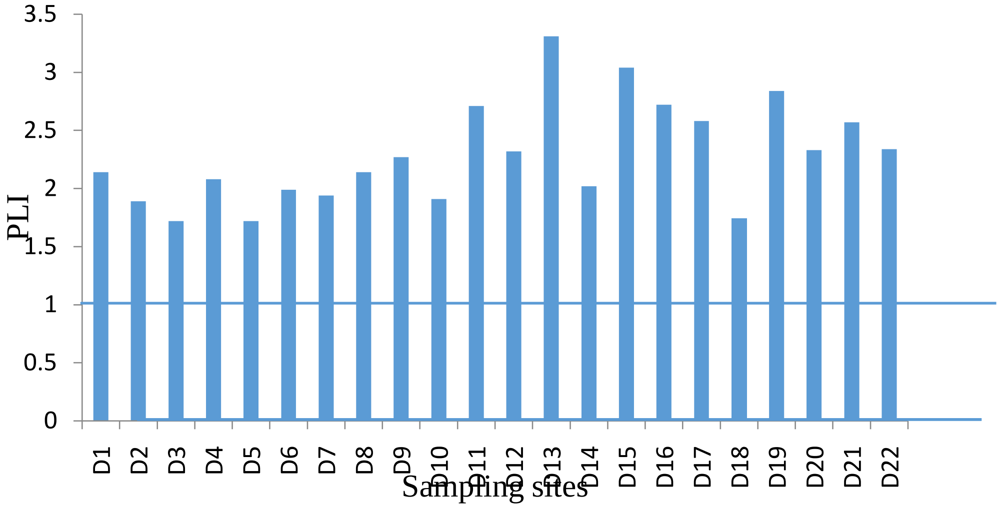


Fig. 6. Pollution Load Index (PLI) values of different sampling sites

The concept of a baseline is a fundamental issue to the formation of a PLI [36]. The PLI values ranged from 1.74 - 3.34 for street dust of 22 locations of different streets of Dhaka city (Fig. 6). The index as presented provides a simple and comparative means for assessing a site or estuarine quality: a value of zero indicates perfection, a value of one that only baseline levels of pollutants are present, and values above one would indicate progressive deterioration of the site and estuarine quality [36]. However, all of the locations, have the value >1.0 indicates pollution load in the respective sites.Based on the results presented in Figure 3.13, D13(Rail crossing at F.D.C) show strong signs of pollution or deterioration of site quality, whereas D5 (Kallynpur bus stand) exhibited signs of less pollution comparatively. All road sides dust show PLI values above 1, indicates strong signs of pollution or deterioration of site quality. Relatively, high PLI values at all roads dust suggest input from anthropogenic sources attributed to human activities and/or vehicular emissions.

3.3.3 Enrichment factor: Heavy metals enrichment factors were calculated for each road dust sample relative to the background value in the upper crust. In this regard, Mn was taken as the reference element [15]. The average EF of Cd, Pb, Zn, Cu Cr Ni, V and As are 229.49, 1.89, 7.34, 4.94, 4.92, 2.73, 6.14 and 1.55 respectively. Heavy metals with average EF higher than 10, revealed that Cd in road dust of Dhaka mostly originate from anthropogenic sources. Pb, Ni and As with mean EF values of 1.89, 2.72 and 1.55, respectively, are considered to originate primarily from natural sources such as wind-blown soil minerals. The mean EF values displayed the following decreasing trend: Cd> Zn > V > Cu > Cr> Ni > Pb > As. From the I_{geo} and EF analyses, we concluded that Pb, Cu Cr Ni and As in road dust were mainly influenced by crustal materials; for Zn, V and Cd, they were influenced by both crustal materials and anthropogenic sources; while for Cd, anthropogenic sources may be dominating.

3.3.4 Correlation coefficient analysis: Pearson's correlation coefficients are presented in Table 4 for metals in 22 street dust samples of Dhaka. Significant positive correlations were found for some elemental pairs; Pb–Ni, Pb-Cu, Pb-Cd, Mn–Zn, Mn-Cd, Cu–Cd, Zn-As. Cr and Fe show no significant positive correlation with any of the other contaminants studied. These results indicate that Cu, Pb, Cd, Ni, Zn, As and Mn which are significantly positively correlated, likely originate from common anthropogenic sources. Chromium, found at high concentrations in all samples, seems also to have anthropogenic sources, but not the same ones as for the other contaminants. This indicates that there might be a different source for Cr other than local anthropogenic sources such as traffic and urban industries. Since none of contaminants were strongly correlated with Fe but it has high concentrations in all samples. So it may have different anthropogenic sources it can be inferred that the major sources of the metals studied are anthropogenic.

Table 4. Pearson's correlation coefficient for metals concentrations of street dusts in Dhaka city

	Pb	Cr	Mn	Fe	Ni	Cu	Zn	As	Cd
Pb	1								
Cr	0.307	1							
Mn	0.360	0.157	1						
Fe	-0.293	-0.017	-0.329	1					
Ni	0.476*	0.212	0.238	-0.170	1				
Cu	0.669**	0.405	0.238	-0.220	0.390	1			
Zn	0.355	0.247	0.602**	-0.288	0.289	0.421	1		

As	0.085	-0.023	0.104	-0.241	-0.083	0.177	0.559**	1	
Cd	0.903**	0.263	0.585**	-0.319	0.304	0.654**	0.420	0.147	1

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

IV. Conclusion

Total twenty two street dusts samples collected in Dhaka city were analyzed for As, Cr, Cu, Mn, Ni, Pb, Cd and Zn using EDXRF. This study revealed that Ni, Pb, Cd and As concentrations were slightly higher in different degree than that of soil background level. The graphical representation of the special distribution of heavy metals concentration in street dust samples suggested that the hot-spot areas for Pb, Zn, Cu, Co and Cr might be mainly associated with industrial activities and heavy traffic density considering the sampling sites. Four contamination indexes namely, enrichment factor (EF), geo-accumulation index (I_{geo}), contamination factor (CF) and pollution load index (PLI) were used in the assessment level of metal contamination. The results of all the contamination indexes used agreed well in explaining the contaminated levels and possible sources of the metals present in the road soil dust samples. For instance, EF proved to be an effective tool in differentiating a natural origin from anthropogenic source of contamination for the various elements investigated under the study. Correlation coefficients, CA and ratio analyses results suggest that (Cu, Pb, Zn and to some extent Ni) have some common anthropogenic origins where Cr has different anthropogenic origin.

Acknowledgements

References

[1] Ahmed, F. Bibi, M.H. Ishiga, H, Environmental assessment of Dhaka City (Bangladesh) based on trace metal contents in road dusts. *Environ Geol. 51:* 2007, 975–985

[2] Binggan Wei, Linseng yang, A review of Heavy Metal Contaminations in Urban Soils, Urban Road Dusts and Urban Agricultural Soils from China. *Microchemical Journal 94*; 2010, 99–107.

[3] Banerjee, A. D. K. , "Heavy metal levels and solid phase speciation in street dusts of Delhi, India" *Environmental Pollution, 123,* 2003, 95-105.

[4] De Miguel, E., Llamas, J. F., Chacon, E., Berg, T., Larssen, S. Røyset, O., and Vadset, M. (1997). "Origin and patterns of distribution of trace elements in street dust: unloaded petrol anf urban lead", *Atmos Environ.,31,* 2733-2740

[5] Domingo, J. L., "Metal-induced developmental toxicity in mammals: a review" J Toxicological *Environment and Health, 42,* 1994, 123-141

[6] Lu, Y., Gan, H., Zhang, B., Shi, Z., Concentration and chemical fractionation of heavy metals in soils of urban green space in Shenzhen City (In Chinese). *Environ Chem*.28: 2010, 284–8.

[7] Shinggu, D. Y., Ogugbuaja, V. O., Toma, I. and barminas, J. T, "Determination of heavy metals in street duct in Yola, Nigeria" *African journal of Pure and Applied Chemistry, Vol. 4 (1),* 2010, 17-21.

[8] Turer, D., "Effect of non-vehicular sources on heavy metal concentrations of roadside soils" *Water, Air, soil pollution 166,* 2005, 251-264.

[9] Yongming, H., Peixuan, D. and Junji, E. S. , "Multivariate analysis of heavy metal contamination in urban dusts of Xi'an, Central China" *Science of the Total Environment, 355,* 2006, 176-186.

[10] Faiz Y., Tufail, M., Javed M.T., Chaudhry M.M. and Siddique N. , "Road dust pollution of Cd, Cu, Ni, Pb and Zn along Islamabad Expressway, Pakistan", *Microchemical Journal, 92,* 2009, 186–192.

[11] Hjortenkrans, D., Bergboak, B. and Haggerud, C., "New metal emission pattern in road traffic environment" *Environmental Monitoring and Assessment, 117*, 2006, 85-98

[12] Akhter, M. S. and Madany, L. M. ,"Heavy metals in street and house dust in ahrain" *Water, Air and soil Pollution, 66,* 1993, 111-119

[13] Li, X.D., Poon, C., Liu, P.S., Heavy metal contamination of urban soils and street dusts in Hong Kong. *Appl. Geochem. 16(11-12):* 2001, 1361–1368

[14] Rahman, M.S., Saha, N., Molla, A.H., Potential ecological risk assessment of heavy metal contamination in sediment and water body around Dhaka export processing zone, Bangladesh. *Environ Earth Sci. (USA),* ***71****(5):* 2014, 2293-2308.

[15] Addo, M.A. E.O. Darko, C. Gordon, B. J. B. Nyarko, J. K. Gbadago, Heavy Metal Concentrations in Road Deposited Dust at Ketu-South District, Ghana. *International Journal of Science and Technology*. *Volume 2 No.1,* January 2012, ISSN 2224-3577.

[16] Al-Khashman, O.A. (2004). Heavy metal distribution in dust, street dust and soils from the work place in Karak Industrial Estate, Jordan. *Atmos Environ. 38:* 6803–6812.

[17] Madany, I.M., Akhter, M.S., Al Jowder, O.A., The correlations between heavy metals in residential indoor dust and outdoor street dust in Bahrain. *Environ Int. 20:* 1994, 483–492.

[18] Chen TB, Wong JWC, Zhou HY, Wong MH , Assessment of trace metal distribution and contamination in surface soils of Hong Kong. *Environ Pollut 96(1):* 1997, 61–68.

[19] Wang WH, Wong MH, Leharne S, Fisher B., Fractionation and biotoxicity of heavy metals in urban dusts collected from Hong Kong and London. *Environ Geoch Health 20:* 1998, 185–198.

[20] Sezgin N, Ozcan HK, Demir G, Nemlioglu S, Bayat C, Determination of heavy metal concentrations in street dusts in Istanbul E-5 highway. *Environ Int 29:* 2003, 979–985.

[21] Ahmed, F. and Ishiga, H. "Trace metal concentration in street dusts of Dhaka City, Bangladesh, *Atmospheric Environment, 40* , 2006, 3835-3844.

[22] Hossen, M., Bangladesh environment facing the 21st century, second ed. Society for Environment and Human Development (SEHD), Dhaka, pp. 2002, 207–216.

[23] BBS (2017), Bangladesh Bureau of Statistics. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Dhaka.

[24] Karim, M.M., Islam, M., Hoque, M.S., Current status, comprehensive management tool, and state-of-art solution for air quality in Bangladesh. Bangladesh environment 2000 (an outcome of ICBEN-2000). Bangladesh PoribeshAndolon (BAPA), Dhaka, pp. 2000, 1–28.

[25] BRTA. (2016). Bangladesh Road Transport Authority. Air pollution in Bangladesh. BRTA associated with Greater Dhaka Metropolitan Area Integrated Transport Study, working paper no. 23.

[26] Nicholson, K.W., A review of particle resuspension. Atmospheric Environment 22: 1988, 2639–2651.

[27] Sehmel, G.A., Particle resuspension: a review. *Environment International* 4: 1980, 107–127.

[28] Ferreira-Baptista, L., De Miguel E., Geochemistry and risk assessment of street dust in Luanda, Angola: A tropical urban environment. *Atmospheric Environment* 39: 2005, 4501–4512.

[29] Islam, G.M.R., Habib, M.R., Waid, J.L., Rahman, M.S., Kabir, J., Akter, S., Jolly, Y.N., Heavy metal contamination of freshwater prawn (*Macrobrachiumrosenbergii*) and prawn feed in Bangladesh: A market-based study to highlight probable health risks. *Chemosphere* 170: 2017, 282-289.

[30] Tamim, U., Khan, R., Jolly, Y.N., Fatema, K., Das, S., Naher, K., Islam, M.A., Islam, S.M., Hossain, S.M., Elemental distribution of metals in urban river sediments near an industrial effluent source. *Chemosphere* 155: 2016, 509-18.

[31] Curie, L. , Nomenclature in evaluation of analytical methods including detection and quantification capabilities. *Pure and Applied Chemistry* 67(10): 1995, 1699–1723.

[32] NaghmehSoltani, Behnam Keshavarzi, Farid Moore, Ecological and human health hazards of heavy metals and polycyclicaromatic hydrocarbons (PAHs) in road dust of Isfahan metropolis, Iran.*Science of the Total Environment 505,* 2015, 712–723.

[33] Hakanson, L., Ecological risk index for aquatic pollution control. *A sedimentological approach. Water Res., 14(5),* 1980, 975-1001.

[34] Taylor, S.R., Abundance of chemical elements in the continental crust: a newtable. Geochim. *Cosmochim. Acta, 28,*1985, 1273–1285.

[35] Mmolawa, K.B., Likuku, A.S., Gaboutloeloe, G.K., Assessment of heavy metal pollution in soils along major roadside areas in otswana" *African J. Environmental Science and Technology Vol. 5(3)*, pp. 2011, 186-196.

[36] Thomilson DC, Wilson DJ, Harris CR, Jeffrey DW, Problem in heavy metals in estuaries and the formation of pollution index" *HelgolWissMeeresunlter. 33(1–4):* 1980, 566–575.

[37] Muller, G., "Index of geoaccumulation in sediments of the Rhine River", *Geological J 2*: 1969, 108118.

[38] Hovmand, M.F., Kemp, K., Kystol, J., Johnsen, I., Riis-Nielsen, T., Pacyn,, J.M., *Environmental Pollution 155,* 2008, 537−541.

[39] CNEMC, China National Environmental Monitoring Center. The Backgrounds of Soil Environment in China, *Environment Science Press of China,* 1990.

[40] Turekian, K.K.; Wedepohl, K.H. Distribution of the elements in some major units of the earth's crust. *Geological Society of America Bulletin, 72,* 1961, 175-192.