

Spatial Distribution of Heavy Metals in Surface and Sub Surface Sediments of the Coastal Area of Kutubdia Island, Cox's Bazar, Bangladesh

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Abstract

Concentrations of selected heavy metals (Zn, Cu, Pb, Cd, Fe, Mn, and Ni) in surface and sub-surface sediments were studied with an attempt to establish a base-line data of their concentration in the sediments of the coastal area of Kutubdia Island, Cox's Bazar, Bangladesh. Sediment sample of twelve different sites were collected and taken for open plate digestion technique (HNO₃). The concentration of heavy metals was analyzed using Flame Atomic Absorption Spectrophotometer (FAAS). The concentration of Cu, Fe, Mn, Pb and Ni in the sediment samples was higher than the proposed Threshold Effect Level (TEL). The observed concentrations of the metals varied in different sampling sites and also in surface to sub-surface. The decreasing trend of metals were observed in surface and sub-surface sediments as Fe>Mn>Ni>Cu>Pb>Zn>Cd. Geoaccumulation Index (I-geo) indicates that the sediment in the studied stations were unpolluted (grade 0) with respect to Cu, Pb, Fe, Zn and Cd whereas concentration of Mn indicated slight pollution in three stations. Contamination Factor (CF) values showed low to moderately pollution in studied stations. The values of Pollution Load Index (PLI) for the samples collected from all the stations were found less than one, indicating perfection except one study area was the hot spot. The Enrichment Factor (EF) indicates that the metal in the sediment of studied stations were entirely from crustal minerals whereas the sources of Mn are may be anthropogenic. However, the elevated level of some toxic elements was found in this investigation alarming about the natural balance of the area. Constant monitoring of the coastal area of Kutubdia Island, Cox's Bazar, Bangladesh is needed with a view to minimize the health risk of the population as well as the detrimental impacts on the aquatic ecosystem.

Keywords: Contamination factor; Crustal materials; Enrichment factor; Geoaccumulation index; Heavy metal; Pollution load index

Introduction

Sediments act as sink of heavy metals can become immediate source of metal pollution of the water bodies [1]. Data from sediments can provide information on the impact of distant human activity on the wider ecosystem. The composition of sediment sequences provides the best natural archives of recent environmental changes. It acts as both carrier and potential sources of contaminants in an aquatic environment and can serve as a pool that can retain or release contaminants to the water column by various processes of remobilization [2]. Heavy metals accumulate in the sediments through complex physical and chemical adsorption mechanisms depending on the nature of the sediment matrix and the properties of the adsorbed compounds [3]. Heavy metals undergo a global ecological cycle in which natural water are the main pathways [4]. Exposure to heavy metals has linked to several human diseases such as development retardation or malformation, kidney damage, cancer, abortion, effect on intelligence, behaviour and even death in some cases of exposure to very high concentrations. The most toxic heavy metals Cr, Ni, Pb, Cd and As. Cr (VI), Ni and Cd are carcinogenic; As and Cd are teratogenic and the health effects of Pb include neurological impairment and malfunctioning of the central nervous system.

Although some heavy metals such as Fe, Mn, Co, Cu and Zn are essential micronutrients for fauna and flora, they are dangerous at high levels. Geochemistry offers various methods for assessing anthropogenic influences. One of them is the use of geochemical calculations. When conducting studies on trace element concentrations in different environmental samples, several geochemical parameters such like I-geo, CF, PLI, EF may be established [5-9]. The coastal areas of Cox's Bazar region have the largest contribution to alive healthy of mass people in Bangladesh. The marine ecosystem therefore plays a very important role in both marine and terrestrial environment, but until no significant studies have been undertaken to investigate the heavy metal pollution condition of the coastal areas of Kutubdia. The mass concentration of heavy metals in the components of marine ecosystem will be an important study to know the present condition of the marine environment and also an attempt to establish a base-line data of their concentration in the sediments of the coastal areas of Kutubdia Island, Cox's Bazar.

Materials and Methods

Description of study area

Kutubdia is the Island in the Bay of Bengal is famous for the only lighthouse in Bangladesh which was built by the British during the British rule.

Kutubdia has the only Windmill in Bangladesh named as “Hybrid Power Plant”. Kutubdia is rich in producing salt and dried fish, locally known as 'Shutki'. It contains all the mysteries of the creation. Kutubdia is located at 21.8167°N 91.8583°E. Sediment samples were collected from twelve different locations of the coastal area of Kutubdia Island, in mid-March, 2016. This sites were chosen, because they

receive huge amount of alluvium from the downstream of Shngo river and Mathamuhuri river. It was also under consideration that several major industrial plants are under construction located at surroundings of this island. The sampling locations are shown in Table 1 and Figure 1.

Site name	Station number	Latitude (N)	Longitude (E)
North East site of Kutubdia (North Durung) nearest to Gandamara, Bashkhali	01	21°55'11.61"	091°52'45.55"
Char Dhurung, Akbor boli para, North Dhurung	02	21°55'0.74"	091°52'52.90"
Noya Ghona, Lemsikhali	03	21°51'51.70"	091°53'36.06"
Darbar Ghat, Lemsikhali	04	21°51'23.50"	091°53'27.55"
Dakshin, Lemsikhali	05	21°50'35.36"	091°53'14.07"
Malam Char, Kaiyarbil	06	21°50'0.80"	091°52'57.40"
Azam Colony, Baragop	07	21°49'25.39"	091°52'40.22"
Omzakhali, Baragop	08	21°48'59.25"	091°52'30.94"
Maddym Omzakhali Baragop	09	21°48'28.49"	091°52'15.46"
Ali Akbor dayle Ghat (Nearest to mathar Bari, Moheshkhali)	10	21°46'50.56"	091°51'45.76"
Tablar Char, new wind mill area (Ali Akbar dayle)	11	21°46'29.93"	091°51'25.56"
Naya Ghona, (Ali Akbar dayle)	12	21°46'15.30"	091°50'59.84"

Table 1: Sampling locations.

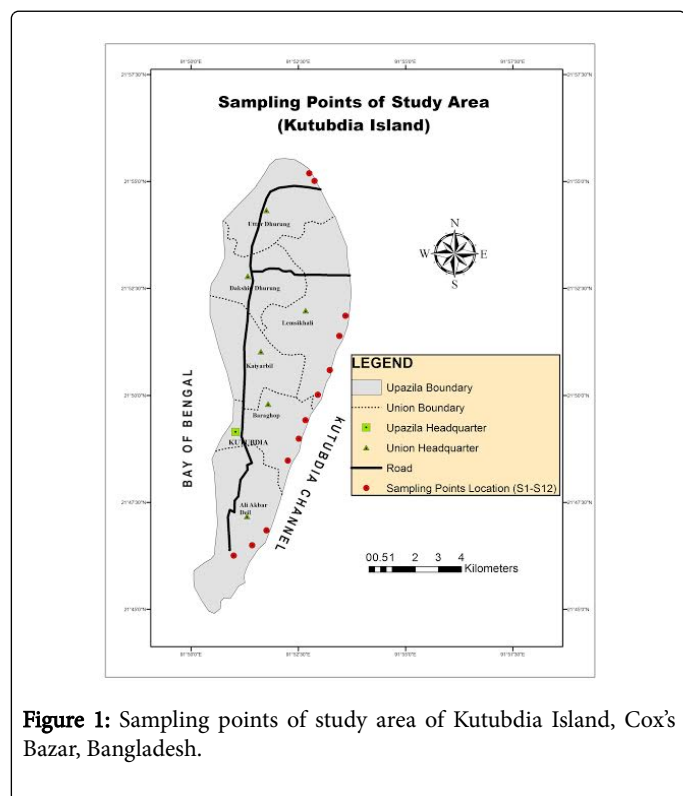


Figure 1: Sampling points of study area of Kutubdia Island, Cox's Bazar, Bangladesh.

Sediment sampling, preparation and measurement

The sediment samples were collected from surface and sub-surface sediments of the coastal area of Kutubdia, Cox's Bazar, Bangladesh in mid-March, 2016. The collected samples were stored into separate plastic container and stored at ambient temperature prior to treatment. The sediment samples were homogenized by manual mixing, air-dried for 72 h, oven-dried for 72 h, disaggregated using a pestle and mortar made by porcelain to pass through a 2 mm mesh sieve. An aliquot of 0.200 g of powdered sediment of each sample was taken in a silica crucible (150 cm³), then 11M concentrated Nitric acid (15 cm³) was added. The content of the crucible was carefully heated in sandbath nearly to dryness in fumehood. After cooling the crucible at room temperature, deionized water was added to the sample and was filtered through a filter paper (Whatman No. 42). The filtrate was collected in a measuring flask and was preserved for the determination of Pb, Cd, Zn, Cu, Ni, Fe and Mn [1-3]. All reagents used were Merck, Analytical Grade (AR) including standard stock solutions of known concentrations of different heavy metals. The samples were analysed for heavy metals in the sediment samples using an Atomic Absorption Spectrophotometer (HITACHI Z- 2000) [10]. The digested samples were directly aspirated into the flame (Air-Acetylene fuel mixture). Using the absorption mode, the concentration corresponding to the absorption in the digest was determined.

Quality Control

The analytical data quality was guaranteed by quality assurance and quality control methods, including the use of standard operating procedures, reagent blanks, and three sub-samples determination

through the implementation of laboratory. The relative standard deviations (%RSDs) of the sub-samples were <10%, indicating excellent reproducibility of the equipment and operation procedures.

Results and Discussion

Sediment analysis is a good proxy for the assessment of the “geochemical status” and “environmental qualities” in such marine environment [11]. The quality and potential environmental implication(s) of trace metals were evaluated using contamination indices such as; CF, geoaccumulation indices, pollution load indices and EF. These parameters have been used successfully by various workers to determine the quality of various environmental media [12-14].

Threshold Effect Level (TEL), Probable Effect Level (PEL)

The concentrations of Cu, Fe, Mn, and Ni in the sediment samples were higher than the proposed Threshold Effect Level (TEL) [11,12,15]. Study area was not contaminated with Cd, Pb and Zn. The concentration of Fe and Mn in the surface and sub-surface sediments has exceeded Probable Effect Level (PEL). The mean concentration of selected heavy metals in the surface and sub-surface sediments is given in Tables 2 and 3. Generally, the metal concentrations exhibit fluctuations between different stations and also in surface to sub surface. Elemental concentration of Fe was highest in the coastal area of Kutubdia. The decreasing trend of metals was observed in surface and in sub surface sediments were same as: Fe>Mn>Ni>Cu>Pb>Zn>Cd (Cd was below detection level). TEL-Threshold Effect Level, PEL-Probable Effect Level, BDL-Below Detectable Level. All values are mean of triplicate \pm S

Sample ID	Cu	Mn	Pb	Cd	Fe	Zn	Ni
NSD-1	30.97	1343.16	22.63	BDL	44245.18	13.24168	42.28
NSD-2	24.28	640.20	20.68	BDL	33782.11	BDL	54.56
NSD-3	39.36	1437.97	18.75	BDL	47467.09	48.7877	48.01
NSD-4	30.99	1138.83	17.96	BDL	41524.6	BDL	45.72
NSD-5	36.61	1373.10	21.71	BDL	45896.83	24.43673	50.61
NSD-6	35.24	1189.07	21.89	BDL	44181.24	BDL	49.42
NSD-7	34.95	1132.43	6.16	BDL	42174.32	32.83	32.06
NSD-8	35.98	1349.05	6.72	BDL	48380	42.27	38.60
NSD-9	34.39	828.66	13.71	BDL	33188.32	BDL	49.85
NSD-10	17.16	545.56	9.80	BDL	25902.49	27.12	25.22
NSD-11	18.50	480.55	12.05	BDL	25388.79	36.59	34.47
NSD-12	24.93	865.99	18.13	BDL	42916.87	105.84	40.97

Minimum	17.16	480.55	6.165	BDL	25388.79	BDL	25.22
Maximum	39.36	1437.97	22.63	BDL	43380	105.85	54.56
Average	30.28	1027.05	15.85	BDL	39587.32	11.07	42.65
SD	0.36	0.89	1.04	-	0.4616	3.63	0.85
TEL	31.6	460	35.8	0.99	20000	121	35
PEL	149	1100	128	4.98	40000	459	91.3

Table 2: Mean concentration of heavy metals (ppm) in sub surface sediments of coastal area of Kutubdia Island, Cox's Bazar, Bangladesh.

Sample ID	Cu	Mn	Pb	Cd	Fe	Zn	Ni
NSSD-1	18.09	734.17	13.38	BDL	22325.41	BDL	25.91
NSSD-2	28.63	740.45	18.11	BDL	35567.55	50.81	45.06
NSSD-3	40.95	874.25	24.13	BDL	42353.98	BDL	64.93
NSSD-4	23.29	787.13	15.83	BDL	42730.07	38.37	60.67
NSSD-5	31.03	1072.11	22.00	BDL	46359.72	11.50	55.11
NSSD-6	29.68	978.43	22.94	BDL	39649.80	58.60	69.11
NSSD-7	40.21	1140.09	23.06	BDL	45006.46	48.79	72.96
NSSD-8	34.86	1420.41	19.25	BDL	48662.69	BDL	35.62
NSSD-9	29.07	1249.81	18.46	BDL	43692.54	BDL	36.23
NSSD-10	4.91	231.22	3.92	BDL	13535.13	17.75	22.28
NSSD-11	20.60	1559.85	17.18	BDL	34570.31	BDL	31.71
NSSD-12	24.00	1042.28	13.99	BDL	40850.17	7.1898	29.28
Minimum	4.91	231.22	3.92	BDL	13535.13	BDL	22.28
Maximum	40.95	1559.85	24.13	BDL	48662.69	58.60	72.96
Average	27.11	985.85	17.69	BDL	37941.99	9.10	45.74
SD	0.59	3.01	2.36		0.6775	11.48	1.86
TEL	31.6	460	35.8	0.99	20000	121	35
PEL	149	1100	128	4.98	40000	459	91.3

Table 3: Mean concentration of heavy metals (ppm) in surface sediments of coastal areas of Kutubdia Island, Cox's Bazar, Bangladesh.

Geoaccumulation Index (I-geo)

Geoaccumulation Index was determined by the following equation according to Muller [16] which was described by Boszke [17],

$$I\text{-geo} = \log_2 (C_n / 1.5 B_n)$$

Where,

C_n=Measured concentration of heavy metal in the sediment.

Bn=Geochemical background value in average shale [18-20] of element n. The factor 1.5 is used for the possible variations of the background data due to lithological variations.

I-geo was classified into seven grades:

I-geo ≤ 0 (grade 0), unpolluted;

0 < I-geo ≤ 1 (grade 1), slightly polluted;

1 < I-geo ≤ 2 (grade 2), moderately polluted;

2 < I-geo ≤ 3 (grade 3), moderately severely polluted;

3 < I-geo ≤ 4 (grade 4), severely polluted;

4 < I-geo ≤ 5 (grade 5), severely extremely polluted;

I-geo > 5 (grade 6), extremely polluted [16].

The I-geo showed (Tables 4 and 5) that all heavy metals are in grade zero except study area NSD-1, NSSD-8 and NSSD-11 were slightly polluted. This suggests that surface and sub-surface sediments of the coastal area of Kutubdia are having background concentrations for these elements and practically unchanged by anthropogenic influences.

Sample ID	Cu	Mn	Pb	Cd	Fe	Zn	Ni
NSD-1	-1.124	0.076	-0.407	0	-3.988	-3.426	-1.268
NSD-2	-1.475	-0.994	-0.537	0	-4.381	0	-0.903
NSD-3	-0.778	-0.174	-0.678	0	-3.899	-1.544	-1.086
NSD-4	-1.124	-0.163	-0.742	0	-4.083	0	-1.158
NSD-5	-0.881	-0.107	-0.466	0	-3.944	-2.539	-1.012
NSD-6	-0.938	-0.1	-0.456	0	-3.988	0	-1.044
NSD-7	-0.949	-0.172	-2.286	0	-4.035	-2.114	-1.671
NSD-8	-0.907	-0.082	-2.158	0	-3.857	-1.756	-1.403
NSD-9	-0.974	-0.624	-1.129	0	-4.411	0	-1.035
NSD-10	-1.977	-1.224	-1.613	0	-4.756	-2.388	-2.017
NSD-11	-1.867	-1.407	-1.315	0	-4.796	-1.961	-1.565
NSD-12	-1.438	-0.558	-0.725	0	-4.012	-0.428	-1.315
Mean	-1.20267	-0.46075	-1.04267	0	-4.17917	-1.34633	-1.28975

Table 4: Geoaccumulation index of heavy metals (ppm) in sub surface sediments of coastal area of Kutubdia Island, Cox's Bazar, Bangladesh.

Sample ID	Cu	Mn	Pb	Cd	Fe	Zn	Ni
NSD-1	0.688147	1.580192	1.13159	0	0.947434	0.139386	0.621773
NSD-2	0.539504	0.753182	1.03446	0	0.723386	0	0.802346
NSD-3	0.874718	1.691732	0.93793	0	1.016426	0.513555	0.706
NSD-4	0.688644	1.339806	0.898075	0	0.889178	0	0.67231

Sample ID	CF(Cu)	CF(Mn)	CF(Pb)	CF(Cd)	CF(Fe)	CF(Zn)	CF(Ni)
NSD-1	0.688147	1.580192	1.13159	0	0.947434	0.139386	0.621773
NSD-2	0.539504	0.753182	1.03446	0	0.723386	0	0.802346
NSD-3	0.874718	1.691732	0.93793	0	1.016426	0.513555	0.706
NSD-4	0.688644	1.339806	0.898075	0	0.889178	0	0.67231

NSSD-1	-1.89	-0.796	-1.165	0	-4.966	0	-1.977
NSSD-2	-1.238	-0.783	-0.727	0	-4.293	-1.49	-1.178
NSSD-3	-0.721	-0.544	-0.315	0	-4.035	0	-0.653
NSSD-4	-1.535	-0.696	-0.922	0	-4.035	-1.894	-0.749
NSSD-5	-1.124	-0.249	-0.446	0	-3.922	-3.626	-0.886
NSSD-6	-1.185	-0.383	-0.386	0	-4.158	-1.279	-0.563
NSSD-7	-0.746	-0.162	-0.381	0	-3.966	-1.544	-0.484
NSSD-8	-0.955	0.156	-0.639	0	-3.857	0	-1.518
NSSD-9	-1.214	-0.027	-0.702	0	-3.988	0	-1.494
NSSD-10	-3.776	-2.458	-2.933	0	-5.718	-3.035	-2.197
NSSD-11	-1.713	0.292	-0.803	0	-4.339	0	-1.685
NSSD-12	-1.491	-0.292	-1.102	0	-4.108	-4.293	-1.801
Mean	-1.466	-0.495	-0.877	0	-4.282	-1.43	-1.265

Table 5: Geoaccumulation index of heavy metals (ppm) in surface sediments of coastal area of Kutubdia Island, Cox's Bazar, Bangladesh.

Contamination Factor (CF)

The ratio of the measured concentration to natural abundance of a given metal had been proposed as the Contamination Factor (CF) being classified into four grades for monitoring the pollution of one single metal over a period of time [10], low degree (CF < 1), moderate degree (1 ≤ CF < 3), considerable degree (3 ≤ CF < 6) and very high degree (CF ≥ 6). Thus, the CF values can monitor the enrichment of a given metal in sediments over a period of time.

$$CF = C(\text{metal}) / C(\text{background value})$$

Where,

CF=Contamination Factor

C metal=metal concentration in polluted sediments.

C Background value=background value of that metal.

Result of the present study (Tables 6 and 7) showed that the CF values of the metals Cu and Zn in the most study area are low (<1), but CF values of the metals like Mn, Ni, Fe and Pb shows values {CF ≥ 1} due to the influence of external discrete sources like windmill power generation activities, agricultural runoff and other anthropogenic inputs.

NSD-5	0.81362	1.615416	1.085905	0	0.982801	0.257229	0.744217
NSD-6	0.783027	1.398908	1.094835	0	0.946065	0	0.726825
NSD-7	0.776753	1.332271	0.308292	0	0.90309	0.345605	0.471505
NSD-8	0.799498	1.587119	0.335972	0	1.035974	0.444951	0.567739
NSD-9	0.764144	0.974901	0.68558	0	0.710671	0	0.73303
NSD-10	0.381358	0.641839	0.490317	0	0.554657	0.285501	0.370827
NSD-11	0.411127	0.565362	0.602655	0	0.543657	0.385223	0.506953
NSD-12	0.554073	1.018815	0.90691	0	0.918991	1.114194	0.602454

Table 6: Contamination Factor of heavy metals in sub-surface sediments of coastal area of Kutubdia Island, Cox's Bazar, Bangladesh.

Sample ID	CF(Cu)	CF(Mn)	CF(Pb)	CF(Cd)	CF(Fe)	CF(Zn)	CF(Ni)
NSSD-1	0.402169	0.86373	0.66943	0	0.47806	0.534863	0.38103
NSSD-2	0.636376	0.87112	0.905885	0	0.761618	0	0.662674
NSSD-3	0.9101	1.028539	1.206625	0	0.906937	0.403992	0.954928
NSSD-4	0.517707	0.926044	0.79173	0	0.914991	0.121141	0.892309
NSSD-5	0.689709	1.261342	1.1003	0	0.992713	0.616867	0.81054
NSSD-6	0.659702	1.151095	1.14747	0	0.849032	0.513656	1.016384
NSSD-7	0.893656	1.341288	1.153305	0	0.963736	0	1.07306
NSSD-8	0.774698	1.671078	0.96254	0	1.042028	0	0.523932
NSSD-9	0.646073	1.470373	0.92319	0	0.9356	0.186903	0.53293
NSSD-10	0.109153	0.272033	0.196162	0	0.289831	0	0.327654
NSSD-11	0.457856	1.835128	0.859375	0	0.740264	0.075683	0.466386
NSSD-12	0.533491	1.226213	0.699855	0	0.874736	0	0.430601

Table 7: Contamination Factor of heavy metals in surface sediments of coastal area of Kutubdia Island, Cox's Bazar, Bangladesh.

The Pollution Load Index (PLI)

The environmental impact of metals and the pollution level in the sediments can be determined with the help of two parameters; the I-geo and EF. The PLI of the studied area are calculated by obtaining the n-root from the n- CFs that was obtained for all the metals. Generally PLI as developed by Tomlinson [14] is as follows:

$$PLI = \sqrt[n]{CF_1 \times CF_2 \times CF_3 \times \dots \times CF_n}$$

Where,

CF=Contamination Factor,

n=number of metals.

The PLI value of >1 is polluted, whereas <1 indicates no pollution [21,22].

The values of PLI (Figure 2) were found to be generally low (<1) in all the studied stations except station NSSD-7 was the hot spot.

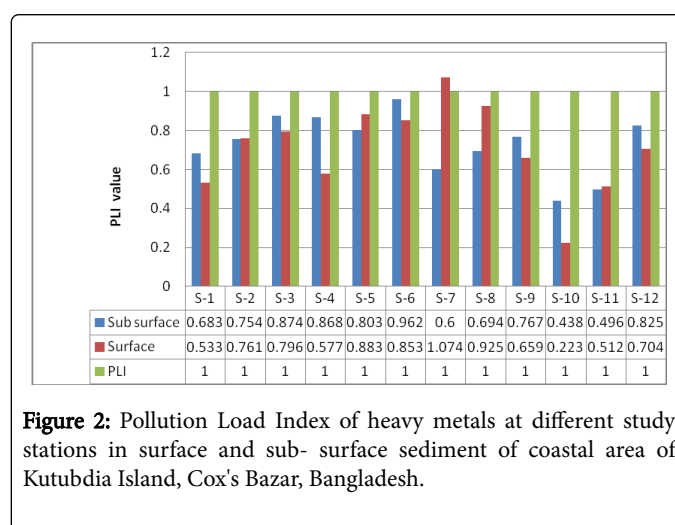


Figure 2: Pollution Load Index of heavy metals at different study stations in surface and sub- surface sediment of coastal area of Kutubdia Island, Cox's Bazar, Bangladesh.

Enrichment Factor (EF)

The Enrichment Factor (EF), due to its universal formula, is a relatively simple and easy tool for assessing the enrichment degree and comparing the contamination of different environmental media [23]. The EF is a normalization method proposed by Simex [24] to assess the concentration of the metals. It normalizes metal concentration as a ratio to another constituent of the sediments. Rubio [25] stated that there is no consensus about the most appropriate sediment constituent to be used for normalization. The constituent chosen for this purpose should also be associated with finer particles (related to grain size) and its concentration should not be anthropogenically altered [26]. Therefore, in the present study, it has been chosen to normalize metal concentrations using Fe. The EF is defined according to Ergin [27] as follows-

$$EF = \frac{(M/Fe)_{\text{Sample}}}{(M/Fe)_{\text{Background}}}$$

Where,

(M/Fe) Sample=the ratio of metal and Fe concentrations in the sample,

(M/Fe) Background= is the ratio of metal and Fe concentrations of the background.

The world average shale and the world average soil are among the materials often used to provide background metal levels. Thus, the background concentrations of Cu, Mn, Zn, Pb, Cd, Ni, and Fe in the average shale obtained from Turekian and Wedepohl are used in this study [28]. An element qualifies as a reference one if it is of low occurrence variability and is present in the environment in trace amounts [29]. Elements which are naturally derived have an EF value of nearly unity, while elements of anthropogenic origin have EF values of several orders of magnitude [30]. A value of unity denotes no enrichment or depletion of elements relative to earth's crust.

Six categories are recognized: <1 background concentration, 1-2 depletion to minimal enrichment, 2-5 moderate enrichment, 5-20 significant enrichment, 20-40 very high enrichment and >40 extremely high enrichment [31]. According to S. Olivares-Rieumont [32], EF values between 0.5 and 1.5 indicate the metal is entirely from crustal materials or natural processes, whereas EF values greater than 1.5 suggest that the sources are more likely to be anthropogenic. Measuring EF is an essential part of geochemical studies and is generally used to differentiate between the metals originating from anthropogenic and geogenic sources, and to assess the degree of metal contamination [31]. The EF (Tables 8 and 9) indicates that the metal in the sediment of studied stations were entirely from crustal materials or natural process whereas the sources of Mn are may be anthropogenic.

Sample ID	Cu	Mn	Pb	Cd	Zn	Ni	Fe
NSD-1	0.726327	1.667864	1.194374	0	0.14712	0.65627	1
NSD-2	0.745805	1.04119	1.430028	0	-0.83422	1.109155	1
NSD-3	0.860582	1.664393	0.922773	0	0.505255	0.694591	1
NSD-4	0.774473	1.506792	1.010007	0	-0.17031	0.756103	1
NSD-5	0.827858	1.643685	1.10491	0	0.26173	0.75724	1
NSD-6	0.827667	1.47866	1.157254	0	-0.79954	0.768261	1
NSD-7	0.860106	1.475235	0.341374	0	0.382691	0.522102	1

NSD-8	0.771735	1.532006	0.324306	0	0.4295	0.548024	1
NSD-9	1.075244	1.371804	0.964695	0	-0.81019	1.031463	1
NSD-10	0.687556	1.157182	0.883999	0	0.514733	0.66857	1
NSD-11	0.756224	1.039923	1.108521	0	0.708577	0.932486	1
NSD-12	0.602915	1.108624	0.986855	0	1.21241	0.655561	1
Max.	1.075244	1.667864	1.430028	0	1.21241	1.109155	1
Min.	0.602915	1.039923	0.324306	0	-0.83422	0.522102	-
Mean	0.793041	1.390613	0.952425	0	0.128979	0.758319	1

Table 8: Enrichment Factor of heavy metals (ppm) in sub-surface sediments of coastal area of Kutubdia Island, Cox's Bazar, Bangladesh.

Sample ID	Cu	Mn	Pb	Cd	Zn	Ni	Fe
NSSD-1	0.841252	1.806739	1.4003	0	-0.41463	0.797034	1
NSSD-2	0.835558	1.143776	1.189424	0	0.702273	0.870087	1
NSSD-3	1.003487	1.134079	1.330436	0	-0.24007	1.052914	1
NSSD-4	0.565805	1.01208	0.865286	0	0.441526	0.975211	1
NSSD-5	0.694771	1.270601	1.108374	0	0.122031	0.816489	1
NSSD-6	0.777005	1.355773	1.351506	0	0.726553	1.197109	1
NSSD-7	0.927283	1.391759	1.196704	0	0.532984	1.113438	1
NSSD-8	0.743452	1.603679	0.92372	0	-0.13764	0.5028	1
NSSD-9	0.690544	1.571582	0.986736	0	-0.73515	0.569613	1
NSSD-10	0.376608	0.93859	0.676811	0	0.644866	1.130498	1
NSSD-11	0.618503	2.47902	1.160904	0	-0.075	0.630027	1
NSSD-12	0.609888	1.401809	0.800074	0	0.08652	0.492264	1
Max.	1.003487	2.47902	1.4003	0	0.726553	1.197109	1
Min.	0.376608	0.93859	0.676811	0	-0.73515	0.492264	-
Mean	0.72368	1.425791	1.082523	0	0.137855	0.845624	1

Table 9: Enrichment Factor of heavy Metals (ppm) in surface sediments of coastal area of Kutubdia Island, Cox's Bazar, Bangladesh.

Conclusion

The effects of environmental pollution on aquatic ecosystem and its safety for human use are serious worldwide public issues. The result revealed the metals distribution and concentration in sediment varied among sampling points and also in surface to sub surface.

The concentrations of Cu, Fe, Mn and Ni in the sediment samples were higher than the proposed Threshold Effect Level (TEL). The concentrations of Fe and Mn in the sediment samples were higher than the proposed Probable Effect Level (PEL) in some study stations. Study area was not contaminated with Cd, Pb, Ni and Zn. The I-geo showed that all heavy metals in surface and sub-surface sediments of the coastal area of Kutubdia are having background concentrations except

three study stations. The CF values of the metals Cd, Cu and Zn in the most study stations are low (<1), but CF values of the metals like Ni, Mn, Fe and Pb shows values >1 due to the influence of external discrete. The values of PLI were found to be generally low (<1) in all the studied stations except station NSSD-7 was the hot spot. The EF indicates that the metal in the sediment of studied stations were entirely from crustal materials or natural process whereas the sources of Mn are may be anthropogenic. The results suggest that special attention must be given to the issue of element remobilization, because a large portion of elements in sediments are likely to release back into the water column. Therefore, constant monitoring of the water quality is needed to record any alternation in the quality and mitigate outbreak of health disorders and the detrimental impacts on the aquatic ecosystem.

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Author's Contributions

Nazim-Ud Doulah: Wrote the article as a leading author. Designed the research plan, participated in all experiments, calculations and coordinated the data analysis and contributed to the writing of the paper.

M. Rezaul Karim: Supervision and contributed to the writing of the paper. Critically reviewed the manuscript.

Shahadat Hossain: Designed the research plan, supervision and reviewed the manuscript.

Nipa Deb: Designed experiment, instrumentation and participated in the data analysis.

Bijoy Sonker Barua: Designed research plan.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that the other author has read and approved the manuscript and no ethical issues involved.

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