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Use of Geo-Accumulation Index and Enrichment Factor in Assessing Pollution of Some Heavy Metals in KEEA, Ghana Tidal Flat

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Abstract**-**In environmental pollution studies, assessment of elevated levels of heavy metals as toxic pollutants has significant importance since it has detrimental consequences on the environment, which translates into damaging effects on humans. An evaluation was carried out to determine the concentrations of seven heavy metals (As, Cd, Cr, Cu, Hg, Pb, Zn) in soil sediments collected from 12 different stations within the Benya Lagoon in Komenda Edina Eguafo Abrem Municipality (KEEA) in Ghana using a fast sequential hydride generation atomic absorption spectrophotometer. In this study geo-accumulation index (Igeo) and Enrichment Factor (EF) were computed and compared in different sites. The range of the concentration in the sediments areas are as follows: (As: 14.4-105.6 mg/kg), (Cd: 3.6-26.4 mg/kg), (Cr: 30.8-100.8 mg/kg), (Cu: 4.8-217.6 mg/kg), (Hg: 0.4-8.8 mg/kg), (Pb: 40.8-309.2 mg/kg) and (Zn: 2.0-177.2 mg/kg). The geo-accumulation index (Igeo) gave the extent of contamination in the order Cd > Pb > As > Hg > Cu > Cr > Zn with Station 1 as the most polluted. The EF values all show very high human influence. These high levels of heavy metals pose individual potential risks and point to a possible detrimental effect on the health of inhabitants that use resources directly from the lagoon without treatment, and therefore the need for education to curtail any unanticipated disasters.

Keywords- *Benya Lagoon, Heavy Metal, Pollution, Igeo, EF*

I. INTRODUCTION

Exposure to heavy metals has been linked to several human diseases such as development retardation or malformation, kidney damage, cancer, abortion/miscarriage, effect on intelligence and behaviour, and even death in some cases of exposure to very high concentrations [1]. High concentrations of heavy metals in soils can be of a grave health concern as they have adverse effects on the environment and all living things therein. Such health risks occur as living organisms, including humans, breathe in dust coming from soils laden with heavy metals or eat plants tainted with them. The plants may be contaminated through normal uptake when cultivated on affected soils or when irrigated with polluted water [2]. Heavy metals have high densities and are toxic, exposure to which have been linked to negative effects on our intelligence and behaviour and diseases such as development retardation or malformation, kidney damage, cancer, abortion/miscarriage, and even death in cases of extreme exposure [1, 3]. Heavy metals could get into water bodies through the inappropriate disposal of domestic waste, agricultural runoff and the direct channelling of industrial and mining wastes into drainage systems that lead to such water bodies.

Ghana, a country in the West-African sub-region, shares its southern boundary with the Gulf of Guinea, which is part of the Atlantic Ocean. The Benya Lagoon and its environs which was investigated and located in the Komenda, Edina, Eguafo, Abrem (KEEA) District of the Central Region of Ghana, maintains contact with the Gulf of Guinea throughout the year [4]. This lagoon is of utmost importance to the natives because aside serving as their only source of water for domestic chores, they carry out fishing activities in the lagoon and uses the water to irrigate their farms. All products from the lagoon (foodstuffs from farms irrigated using the water, fishes, salt and other edible organisms) are transported and sold within the environs and beyond the KEEA District. Indeed, all activities in the KEEA District are woven around the Benya Lagoon. Sanitation in the KEEA municipality is poor, resulting in serious environmental problems. Treatment and disposal facilities for solid and liquid wastes are rare, resulting in wastes being directly poured into the lagoon without any form of treatment, resulting in atmospheric pollution [5]. The coast line and the lagoon are considered to be “the mother and final destination” of all the drainage systems within the district to the extent that all wastes are emptied directly into it lagoon which virtually enters the sea during high tides. Typically in this district, fishermen keep their treated wood meant for boat construction in the open close to the lagoon, and therefore after rains, the chemicals used to treat the wood wash straight into the lagoon. Fishermen also attach lead-ingots to their fishing nets to help sink their nets to the bottom of the lagoon. Despite such practices, the lagoon still serves as the principal source of water and its products a source of livelihood to the inhabitants of the KEEA District. The Environmental Protection Agency (EPA) of Ghana has reported the pollution of lagoons and beaches in the country. Lagoons are drying up as a result of heavy pollution [6], [7], and this threatens the livelihood of the fishermen. Anthropogenic impact on our lagoons and beaches has long been identified, but so far, no actions have been taken [8]. Different elements, mineral species and organic debris are the many components that makeup sediments. This forms one of the final sinks for heavy metals to discharge into the environment [9]. The study of sediments has become an excellent means of understanding effects natural and anthropogenic processes on depositional environments [10]. Although there are many sediments pollution indices that can be used to assess the level of contamination by heavy metals, the index of geo accumulation index (Igeo) is one method mostly used. The enrichment factor can also be used to talk about the level of minerals in soil [11]. In other words EF can tell us how many times these heavy metals are greater than their standard background value in the environment. Or EF explains the contamination of these heavy metals in sediments.

The aim of this study is therefore to carry out a pollution assessment using Geo accumulation index (Igeo) and Enrichment factor (EF) of sediments of seven selected heavy metals (Arsenic As, Cadmium Cd, Chromium Cr, Copper Cu, Mercury Hg, Lead Pb and Zinc Zn) and determine if the soil at the coastline can support an activity like farming at the coastline of KEEA, Ghana.

II. MATERIALS AND METHODS

A. Study Area

Elmina, is a town located within the Komenda Edina Eguafo Abrem (KEEA) municipality, south-facing bay on the Atlantic Ocean coast of Ghana, about 12 km west of Cape Coast. The Benya Lagoon is located within the KEEA, (05°05′N, 01°21′W) as shown in Figure 1.

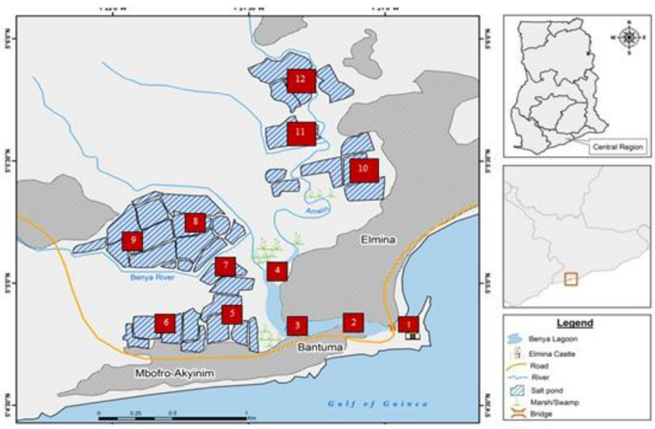

Figure 1. A map of Benya lagoon showing the 12 sampling stations [12]

B. Sample Collection

Fishermen were used throughout the sampling period as they aided us with their boats and skills in reaching some of the not-easily-accessible stations investigated. Twelve fixed sampling stations were selected and marked along the Benya Lagoon as shown in Figure 1.

Superficial (upper 10cm) sediment samples were randomly sampled using sediment coring device at a speed not more than 0.3m/s near the banks of the lagoon in all the sampling stations. Overlying water was siphoned. Upper 5 cm of sediment from surface grab samples were removed with a pre-cleaned plastic spoon and placed in a plastic bowl. The process was repeated for three (3) areas within each sample station and placed in the same bowl to form a composite sample. The composite sediment samples were mixed using plastic spoon until a uniform colour and consistency was achieved. The composite sediments samples from each station were placed in a plastic container, coded with indelible pen, and place in a labeled Ziploc bag to avoid cross contamination. They were then stored in a refrigerator before the laboratory analysis. Sediments were then place on ice in an ice chest and then transported to the Ghana Atomic Energy Commission (GAEC) Preparation Laboratory for digestion and analyses.

C. Heavy Metal Composition

Calibration and concentration measurements of elements in the samples were carried out using a PC－based Varian AA240 fast sequential hydride generation atomic absorption spectrophotometer (AAS). AAS was the preferred choice due to its simplicity in sample preparation and handling, high sensitivity, detection limit, degree of accuracy and reproducibility and its general advantage over flame photometry and colorimetry methods. Each prepared solution was taken to the AAS instrument for readings with standards from Fluka Analytical (Sigma－Aldrich Chemie GmbH, Switzerland), to serve as internal positive controls.

Working standard solutions of Cd, Cr, Cu, Pb, and Zn were prepared from the stock standard solutions. About 1.0 g of the soil sample was weighed and quantitatively transferred into a 10 mL test-tube. It was wet ashed with 3 mL aqua regia and placed on a hot plate (95^{o}C) to heat for an hour until all brown fumes ceased. The solution was cooled, filtered and topped to the 10 mL mark with deionised water. It was then sent for hydride generation AAS analysis. The calibration curves were prepared for each element individually by applying a linear correlation least square method. A blank reading was taken and the necessary correction made during the determination of the concentrations of the various elements. The quantitative analysis involved the calculation of the final concentrations from the identified elements initial concentrations and converting them into the final concentrations using Equation 1.

$$\text{Final concentration} = \frac{\text{Initial Concentration} \times \text{Normal Volume}}{\text{Sample Weight in Grams}} \qquad (1)$$

Nominal volume was given as 20 ml and the sample weight for soil was 1.5 grams.

Determination of Hg using cold-vapour AAS and As were also measured using Varian AA 240 fast sequential hydride generation AAS.8 The instrument was set up according to the manufacturer’s specifications. It was equipped with argon to drive the hydride system. HCl (6 M) and sodium borohydride (NaBH4) (0.6%) generated the hydride. The data was statistically analysed using the software Microsoft Excel 2010.

III. RESULTS AND DISCUSSIONS

A. *Assessment According to Heavy Metal Concentrations*

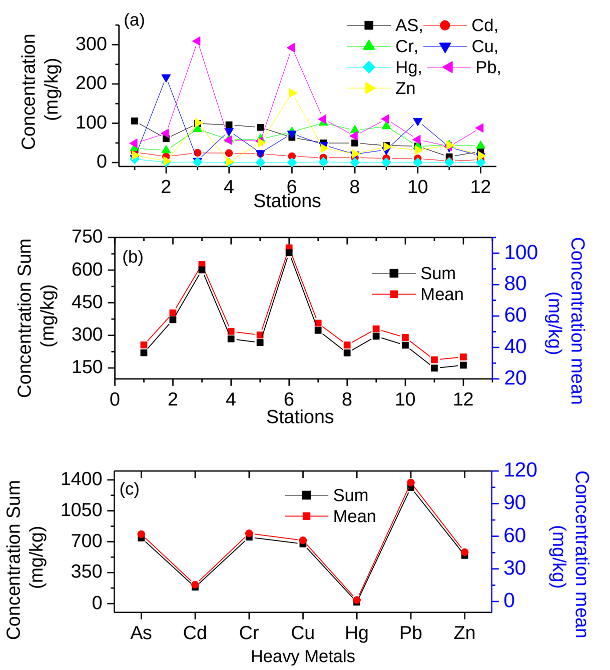

Figure 2. (a) Concentrations of the individual metals at the various Stations, (b) Accumulated metal concentration (left) and mean concentration (right) at the various Stations, (c) Sum (left) and mean (right) of the heavy metals considering all 12 Stations investigated

TABLE I. SUMMARY CONCENTRATION OF HEAVY METALS (MG/KG)

	As	Cd	Cr	Cu	Hg	Pb	Zn
Min	14.4	3.6	30.8	4.8	0.4	40.8	2.0
Max	105.6	26.4	100.8	217.6	8.8	309.2	177.2
Mean	61.9	15.5	62.6	56.2	1.3	109.4	45.4
SD	29.6	7.4	24.0	59.5	2.4	92.2	49.1

Figure 2 (a) shows the concentrations of the individual metals at the various Stations; (b) is a double y-axis graph that shows the accumulated metal concentration (on the left) and mean concentration (on the right) at the various Stations; (c) is a double y-axis graph that shows the sum (on the left) and mean (on the right) of the individual heavy metals considering all the 12 Stations investigated. It can be deduced from (b) that cumulatively the Stations with the highest and lowest metal concentrations are Stations 6 and 11 respectively, with the mean concentration following a similar trend. From (c) it can be deduced that considering all the 12 Stations studied, Pb recorded the highest concentration while Hg recorded the lowest. The mean concentrations followed a similar pattern. Mean concentration of the heavy metals from higher to lower mean content in this area showed that: Pb > Cr > As > Cu > Zn > Cd > Zn. Cumulatively the station with the highest metals concentration to the lowest is such that: 6 > 3 > 2 > 7 > 9 > 4 > 5 > 10 > 1 > 8 > 12 > 11, (figure 2). The highest metal concentration values for As, Cd and Hg was found at Station 1. Stations 2 and 3 were the locations of highest metal concentration for Cu and Pb respectively. It is not surprising since situated within these sample stations are where most of the activities are concentrated; the fish market, repair and fabrication shops, fuel shops etc. Zn and Cr had their highest metal concentration values at Station 6 and 7 respectively where most homes and settlements are. The very high standard deviation (SD) between the concentrations of heavy metals at different stations in this study is an indication in the spatial distribution of metal contamination not uniform.

An important source of nutrients, trace elements, contaminants, and low salinity water to many types of coastal ecosystems can be from groundwater discharge [13]. The high levels of these seven heavy metals in the sediments of Benya Lagoon could be attributed to the following activities in around the KEEA: From 1482 to 1486 the Portuguese built a fort on the strategically local end of a narrow bounded by the ocean and the Benya River. The River provided a natural shelter harbour. This river feeds the Lagoon with water. The fort was built to protect the gold-rich land of ‘’El Mina’’, the mine [14]. The geographical factor of Benya Lagoon gives the distinction of heavy metal concentration in the area. Due to the activities around the bed of the Lagoon there is a transfer slowly for decades through dynamic equilibrium process of erosion and accretion of heavy metals. Nature has its own way of contributing and distributing heavy metals in an environment but it has been established that heavy metals can also be released into the system from anthropogenic sources:

1) *Arsenic (As)*

Arsenic, a metalloid and naturally occurring element, is one of the most abundant elements in the earth’s crust and is found throughout our environment. Arsenic can attach to very small particles in the air, stay in the air for many days, and travel long distances [15]. An activity of mining for Gold around the Lagoon was stopped in 2012 by the Ghana government. During those mining periods, there is a high probability of the Lagoon being contaminated by As [2]. Guidelines to keep the concentration of arsenic in drinking water to 50 µg/L or lower has not been found to be protective, and the World Health Organization has decreased their recommendation to 10 µg/L. Because ground water can contain high concentrations of arsenic, hence, drinking water sources should be tested for arsenic and carefully monitored [15].

2) *Cadmium (Cd)*

Very good sources of Cd in the Lagoon can be from spillages from several products like old Cd batteries, detergents, paints, inks, boating activities, domestic garbage dumps, phosphate fertilizers in agricultural runoff, mining activities and sewage treatment plant, impurities from electroplating steel, urban runoff, industrial effluents and wastewater and refined petroleum products [2].

3) *Chromium (Cr)*

Cr is metal used in cements, pigments for paints, paper, rubber, metal alloys, and through the many human activities around the Lagoon might have been washed into it, [16].

4) Copper (Cu)

A very frequent source of copper in aquatic environment is through wet and dry depositions, mining activities, and storm water runoffs, industrial, domestic, and agricultural waste disposal. Among industrial sources include copper plating, pulp and paper mills, e-waste, sewage and other forms of waste waters [7]. Around the bed of Benya Lagoon are a lot metal repair shops, mending copper, iron, lead, etc for the fishermen.

5) Mercury (Hg)

Two primary forms of mercury are ethylmercury (inorganic mercury) which is primarily from dental amalgams and methylmercury (organic mercury), which is the type found in fish. In terms of toxicity, ethylmercury rates the highest. Methylmercury penetrates your body very well, but is slightly less toxic than the inorganic form, which is what you absorb from your dental amalgams [17]. Mining activities for Gold around the Lagoon stopped in 2012 by the Ghana government may be the probable cause of Hg around the Lagoon and the shores [2].

6) Lead (Pb)

The principal source of Pb in the marine environment appears to be the exhaust of vehicles which run with leaded fuels reaching the sea by rain and wind blowing dust [18]. Pb registered the highest concentration and there may be a good explanation as to why. Until the late 1980's fuel in Ghana had been laced with Pb. Considering the fact that outboard motors used on the lagoon are propelled by such fuels, one will expect the fuel leakage to boost Pb concentration [2]. Lead ingots are normally attached to fishing nets to serve as sinks for the net and this may be one major way for lead to end up in the lagoon. The lead ingots used for fishing are prepared along the bed of the Lagoon.

The KEEA District, which happens to be a very old district, used to be the hub for the Portuguese and the Dutch in the 15th and 17th century and therefore boasts of some really old castles and buildings. The periodic renovation of such buildings which includes painting also causes the lead-pollution of the lagoon as most of the paints are lead-tainted and therefore get washed-up into the lagoon as runoffs after rains [2].

7) Zinc (Zn)

Oysters contain more zinc per serving than any other food [19]. Other sea foods like lobsters also contain zinc. Sea foods like lobsters, shrimps are a delicacy of the people in KEEA, so some of the fishermen in the area engage in catching them. You can see their shells scattered around the whole of KEEA.

B. Assessment According to Geo-accumulation Index (Igeo)

Comparing studied concentrations in soil sediments with pre industrial levels can be calculated by applying the geo-accumulation index (Igeo) and is mathematically expressed as:

$$\text{Igeo} = \log_2\left(\frac{Cn}{1.5 \times Bn}\right) \quad (2)$$

The degree of pollution in sediments is also assessed by the determination of Igeo. This criterion was originally defined by Muller in 1979. It is able to evaluate the heavy metal pollution in sediments [20].

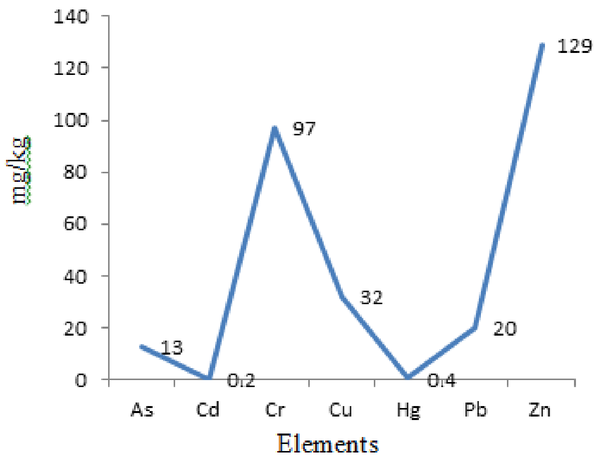

Figure 3. Bn values of the seven elements under investigation

Cn is the concentration of element 'n' and Bn is the geochemical background value (world surface rock average) [21]. The factor 1.5 is incorporated in the relationship to account for possible variation in background data due to lithogenic effect. The geo-accumulation index (Igeo) scale consists of seven grades (0 – 6) ranging from unpolluted to highly polluted (Table 2).

TABLE II. POLLUTION GRADES OF GEO-ACCUMULATION INDEX OF METALS IGEO CLASS

I_{geo} Class	I_{geo} Value	Sediment Quality
0	$I_{geo} \leq 0$	Unpolluted
1	$0 < I_{geo} \leq 1$	Unpolluted to moderately polluted
2	$1 < I_{geo} \leq 2$	Moderately polluted
3	$2 < I_{geo} \leq 3$	Moderately to heavily polluted
4	$3 < I_{geo} \leq 4$	Heavily polluted
5	$4 < I_{geo} \leq 5$	Heavily to extremely polluted
6	$5 <$ Igeo	Extremely polluted

The Igeo values calculated for each sampling Station is presented in Figure 4. Figure 4 (a) presents the Igeo values for the individual metals calculated for the Stations. (b) Represents the sum (on the left) and mean (on the right) of Igeo values for the individual Stations. (c) Presents the sum (on the left) and mean (on the right) of the heavy metals taking into consideration all the 12 Stations investigated. The Igeo scale consists of seven grades (0 – 6) ranging from unpolluted to highly polluted as presented in Table 2. With reference to Table 2 and Figure 4 (a) it can be deduced that all the Stations investigated did not show any sign of pollution for Cr and Zn, while they were all either heavily or extremely polluted with Cd. The overall effect of the heavy metals at the individual stations, as depicted in (b), shows that for Stations 11 and 12, both the cumulative (sum), and means show that they were unpolluted.

The results of Igeo values indicated that Pb sediment quality be considered as moderately polluted ($1 <$ Igeo ≤ 2) at

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stations 2, 7, 8, 9 and 12 but stations 3 and 6 were heavily polluted. For Hg, station 7 is in the moderately polluted sediment quality while station 1 is in the heavily polluted range, stations No 2, 3 and 11 are in the range of unpolluted to moderately polluted with the rest of the stations showing no sign of pollution. Moderately polluted and moderately to heavily polluted situation was recorded Cu at stations 10 and 2 respectively. From unpolluted to moderately polluted situation was recorded for Cu at station 6 and 4 while the remaining stations indicated no sign of pollution (Igeo ≤ 0).

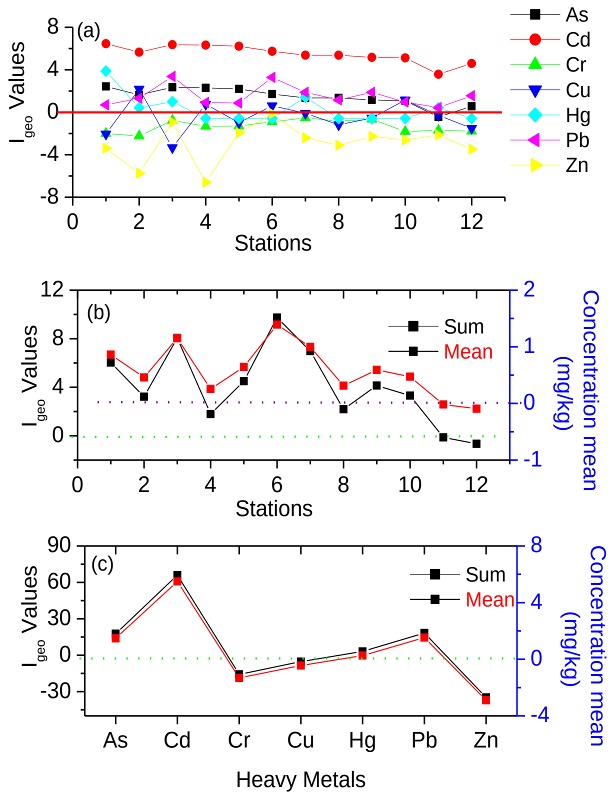

Figure 4. (a) Igeo values for the individual metals calculated for the Stations. (b) Sum (left) and mean (right) of Igeo values for the individual Stations. (c) Sum (left) and mean (right) of the heavy metals considering all 12 Stations investigated.

The Highest Igeo values are showed for all the stations (extremely polluted) except station No 11 which is in the range of heavily polluted sediment quality.

From Figure 4 (a), the Igeo values for As shows that 50% of the samples fall in the range of moderately to heavily polluted, 33.3% in the moderately polluted class, while the remaining 16.7% is divided class 0 and class 1. On the basis of the mean values of Igeo, sediments are enriched for metals in the following order: Cd > Pb > As > Hg > Cu > Cr > Zn. It is generally known that rivers and related urban environments have been severely contaminated with metals (eg. Cd, Cu, Pb and Zn) as a result of historic and modern mining and industrial operations [22–24].

C. Assessment According to Enrichment Factor (EF)

Enrichment factor (EF) is commonly used to distinguish metals originating from anthropogenic and natural sources [25]. Anthropogenic origins or contamination of the KEEA, Ghana and its surrounding marine environment to determine the levels of the seven heavy metals in sediments was calculated. The enrichment factor (EF) was calculated as the following in reference to Buat-Menard and Chesselet (1979) [26]:

$$EF = \frac{\left(\frac{Cn}{Cref}\right)_{sample}}{\left(\frac{Bn}{Bref}\right)_{background}} \quad (3)$$

Cn – content of the examined element in the examined environment,

Cref – content of the examined element in the reference environment,

Bn – content of the reference element in the examined environment,

Bref – content of the reference element in the reference environment.

This procedure is also called “normalization”. The EFs can be used to differentiate crustal from non-crustal origins of a given element. Reference (or conservative) elements are those whose concentrations are so abundant in the earth’s crust that anthropogenic influences do not change them substantially, or else they are inert in biogeochemical cycles. The most often used reference elements are: Si, Al, Fe, Sc, Cs, and Ti. It is worth mentioning that sometimes total organic carbon (TOC) and granular composition of solid samples are used in normalization procedure, by analogy with conservative elements [27].

The average crustal abundance data can be used to select background metal values, although regional background values have been suggested to be more appropriate [28–31].

Seven pollution categories were recognized on the basis of the enrichment factors (Table 3). If the EF value of heavy metals is less than 1, it means that metal may be entirely from crustal materials or natural weathering processes. If enrichment factor of samples is more than 1.5, it suggests that a considerable portion of the trace metals were introduced as a result of human activities while EF > 50 indicates an extremely severe enrichment [32].

TABLE III. ENRICHMENT GRADES OF EF [25]

EF Value	Sediment Quality
EF < 1	No enrichment (No human influence)
1 < EF < 3	Minor enrichment (Minor human influence)
3 < EF < 5	Moderate enrichment (Moderate human influence)
5 < EF < 10	Moderately severe enrichment (Moderately severe human influence)
10 < EF < 25	Severe enrichment (Severe human influence)
25 < EF < 50	Very severe enrichment (Very severe human influence)
50 < EF	Extremely severe enrichment (Extreme human influence)

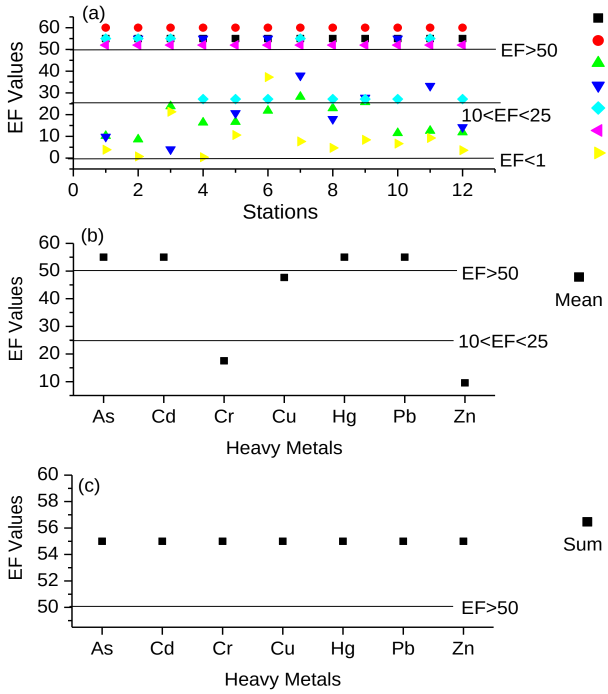

Figure 5. The mean EF value of metals in sediments stations

In Figure 5 (a) it can be determined that As, Cd, Hg and Pb showed extremely severe enrichment in the sediments from all the Stations; Cr and Cu showed between severe and very severe enrichment while Zn showed between minor and moderately severe enrichment. Considering the effect of the heavy metals at all the Stations, it can be deduced from (b) that the mean EF values for Cr and Zn showed moderately severe to severe enrichment; Cu showed very severe enrichment while As, Cd, Hg and Pb showed extremely severe enrichment in the sediments. The cumulative effect all the heavy metals in all the Stations is that of extremely severe enrichment as depicted in (c).

IV. CONCLUSION

Soil is a vital resource for humans because its chemical and physical conditions affect agricultural production and the quality of its products that constitute one of the fundamental factors of the life cycle of the earth. Depending on their concentration in the soil, the heavy metals may determine a potential toxicity to plants and for their consumers. Their entrance in the food chain represents a geochemical risk because of their toxicity to human health, especially to the occurrence of bioaccumulation phenomena. Heavy metals can be present in the soil as a product of the weathering of the natural rocks, or because they come as part of pollution loads generated by human activities. It is very important to distinguish between the natural background values and anthropogenic inputs, and to recognize that the background values change from area to area and with the scale of the area investigated. For these reasons the geochemical monitoring of soil is important in the aim of evaluating the natural content of heavy metal in soils, related to parental materials and possible enrichment due to human activities.

Results from the Igeo and EF showed that the human activities there are the contributing factors to high levels of contamination in KEEA but all these human activities mentioned can be controlled so as to curb down the concentration levels of the seven metals worked-on at the KEEA. Certain pathways have been found to result in humans' exposure to heavy metals, such as from drinking water, foods, cigarettes, certain residential areas, occupational environment, and cosmetics [15]. Breathing of contaminated air and ingestion of contaminated foods have been known to be the main cause of heavy metals entering the human body. There is the hope that people would be more careful as there are more write-ups and education about heavy metals and are the possible sources of related health hazards in humans, Table 4.

ACKNOWLEDGMENT

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TABLE IV. SUMMARY OF THE EIGHT ELEMENT AND HOW THEY FUNCTION AND AFFECT THE HUMAN BODY

Element	Function	Adverse Effect of Deficiency	Adverse Effect of Excessive Consumption
As	As may be found in the human body to control gene expression, support reproductive health and treat digestive problems	Abnormal growth, problems with heart and bones.	Anaemia, risk of cancer in the liver, bladder, kidneys, prostate, and lungs, inflammation of the skin. Causes depression, gastrointestinal problems and even death
	[33, 34]		
Cd	Cd has no known beneficial function in the human body. Cd is a cumulative toxin. Greatest contributors to Cd exposure are industrial fumes and cigarette smoking.	The greatest Cd concentrations are found in the kidneys and the liver. Due to slow excretion, Cd accumulates in the body over a lifetime and its biologic half-life may be up to 38 years.	Diarrhoea, Nausea, Excessive salivation, Abdominal pain, Increased bone fractures, Low back pain, Chest pain, anaemia, hypertension, and hepatitis
	[35, 36]		
Cr	Chromium is an essential mineral that plays a role in how insulin helps the body regulate blood sugar levels. Insulin is a hormone your body uses to change sugar, starches, and other food into the energy you need for daily activities.	Increase blood sugar, triglycerides (a type of fat in the blood), cholesterol levels, and increase the risk for a number of conditions, such as diabetes and heart disease.	Reduce how effective insulin is at controlling blood sugar and cause stomach irritation, itching, and flushing, fast and irregular heart rhythms, liver problems, and kidney damage.
	[37]		
Cu	Cu is required to fix calcium in the bones and to build and repair all connective tissue. This includes the tendons, ligaments, skin, hair, nails, arteries, veins and a few other tissues.	Low libido in women and men is also linked to copper imbalance. Deficiency of Cu increases the lipid peroxidation in the heart in 2-folds.	Vomiting, nausea, abdominal pain, menstrual cramps weakness, and metallic taste in the mouth. It can cause damage to the liver and kidney. Dr. Paul Eck found that elevated tissue Cu is associated with homosexual desire.
	[38]		
Hg	Vaccines would come underneath that, though they're slowly removing the mercury from the vaccines. So, it depends if you get a lot of vaccines or not. Now if you're going in for flu shots routinely, you might be exposed to a fair amount of mercury	Methylmercury from fish consumption, dental amalgam, and thimerosal-containing vaccines are routes mercury enters body system.	Harms thyroid and kidney functions, Insomnia, neurological and behavioural problems, harms the development of the unborn baby's brain. Some studies suggest that small increases in exposure may affect the heart and circulatory system.
	[17]		
Pb	Pb is one of the commonest elements in the environment. Low levels in adults are not harmful. However, low levels in children are a cause for concern. Pb is not known to help in any body function. Pb poisoning usually occurs over a period of months or years	Pb is a highly toxic metal and a very strong poison found in lead-based paints, including paint on the walls of old houses and toys. It is also found in: art supplies, contaminated dust and gasoline products.	Abdominal pain and cramps, fatigue, aggressive behaviour, constipation, loss of appetite, sleep problems, headaches, irritability, high blood pressure, anaemia, numbness or tingling in the extremities, memory loss, kidney dysfunction loss of developmental skills in children.
	[39]		
Zn	Found in cells throughout the body. Needed for the body's defensive (immune) system to properly work, cell division, cell growth, wound healing, and the breakdown of carbohydrates and for the senses of smell and taste.	Hair loss, frequent diarrhoea, impotence, and eye and skin lesions. Affects cell growth and immune function and the proper function of the sense of taste and smell.	Weakens immune function. High doses of zinc may also lower HDL ("good") cholesterol and raise LDL ("bad") cholesterol.
	[40]		

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