Eco. Env. & Cons. 28 (February Suppl. Issue) : 2022; pp. (S300-S306)
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ISSN 0971–765X

**DOI No.: http://doi.org/10.53550/EEC.2022.v28i02s.050**

# Evaluation of Heavy Metals Contamination in Suspended Sediments of Dikrong River, Assam, India

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(Received 31 May, 2021; Accepted 30 June, 2021)

## ABSTRACT

This study is a comprehensive monitoring survey to assess the environmental pollution status of the river Dikrong –was carried out in 2020. Samples were taken at 10 different positions along the river from the foot hill of Arunachal Pradesh down to the Brahmaputra river. Besides other biological and chemical parameters, concentrations of Fe, Al, Ti, Pb, Zn, Cu, Ni, Co, Mn and Cr. Very high element concentrations were determined at only a few stations of the river Dikrong. The mean concentration exhibits positive correlations among Fe, Al, Ti, Mn, Zn, Pb, Ni, and Co. The relative distributions of the contamination are: Al > Fe > Ti > Mn > Cu > Cr > Zn > Pb > Ni > Co. An evaluation of the pollution status of the river was carried out by enrichment factors (EFs), contamination factors (CFs), geo-accumulation indexs ($I_{geo}$) and pollution load indexs (PLIs) calculated using adapted background concentrations of heavy metals in the sediments. The investigating factors suggest the significant contamination for Dikrong river sediments are Al and Fe. The mean concentrations of heavy metals in the sediments were found to be below the geochemical background level of world surface rock average. The elemental correlation is indicative to the metamorphosed pyrophanite ($MnTiO_3$) deposition.

***Key words**: Heavy metals contaminantion, Sediment, Dikrong river, etc.*

## Introduction

Stream sediments act as each supply and sink for serious metals. Several serious metals like-cobalt, chromium, manganese, nickel, zinc, copper and selenium are essential components for traditional growth of plants and living organisms (Saikia, *et al*., 2014). Heavy metals like lead, mercury, iron, cadmium, aluminium and magnesium are gift in water sources. If these metals are gift within the sediment, these reach the organic phenomenon through plants and aquatic animals. This causes serious metal poisoning just in case the extent within the water is incredibly high. Sediments are detrital product of rocks and bear the mineralogical properties of the initial rock formation. Geochemical studies of sediments are useful in understanding the various sediment sources, component distribution pattern and evaluating the environmental conditions existing in a region. The mineralogical properties of sediments mirror the geologic history of transport and sorting method. The sediments are contaminated by serious metals once rocks are disintegrated through natural and anthropogenetic method. As per Mohiuddin *et al.* (2010), Hassan *et al.* (2021) and Buragohain *et al.* (2020), the buildup and distribution of serious metals ar the foremost common environmental pollutants, and their incidence in waters and biota indicate the presence of natural or anthropogenetic sources. The estimation of salt distribution in sediments is very important as a result of the overall dioxide consumption by salt weathering is approximated by the overall molar charge equivalents of all cations generated by salt weathering. In several weathering surroundings, the chemical weathering of salt minerals leads to the formation of secondary clays. gift study is confined within the stream Dikrong one in all the most significant sediment carrying tributary of Brahmaputra River. The rock composition is poor that causes additional erosion within the basin. As stream sediments act as each supply and sink for serious metals so contaminants might eventually experience the organic phenomenon and lead to several adverse environmental effects. This qualitative analysis study is conducted to guage the concentration of serious metals (iron, aluminium, titanium, lead, zinc, copper, nickel, cobalt, manganese, chromium, etc.) due to the natural and anthropogenetic activities of the stream Dikrong that helps to assess the eco harmful potential of the stream sediments.

## Materials and Methods

### Study Area

The study area, Dikrong river (Fig 1), originating near the Senkeng mountains at an altitude of 2579 m in the Lesser Himalayan ranges of Arunachal Pradesh, is a tributary of the Subansiri river lying on the north bank of the river Brahmaputra. The river basin comprises the Bomdila Group (Precambrian), the Gondwanas, the Siwaliks and the Quaternaries. The Gondwanas are thrusted over the Siwaliks along the Main Boundary Thrust. The study area is bounded by latitudes 26⁰56′15′′ N and 27⁰08′12′′N and longitudes 93⁰45′10′′E and 94⁰57′02′′E. Samples were collected from the river bed along the seventh order segment of the Dikrong river flowing through the Kimin Formation (Upper Siwaliks) and the Quaternaries comprising the Pleistocene and Recent deposits.

### Sample collection and preparation

The suspended sediment samples were collected from ten locations of the Dikrong river. Suspended samples were collected at a depth of 2 to 3 ft. from the surface of each sampling locations. To eliminate the possibility of bank materials of the local origin, special care is taken on the sample collection by collecting the mass far away from the banks as possible (Table 1). The suspended particles were separated by gravimetric method using Whatman filterpaper (40μ). The wet samples were allowed to dry and the moisture contents were removed by heating the samples at temperature 110 °C for 10 min. The heavy metals (Al,Co,Cr,Cu,Fe,Mn,Ni,Pb,TiandZn) in sediment samples were determined using a Philips Magi XPRO wavelength dispersive X-ray spectrometer with arhodium anodeX-ray tube was used, which may operate upto 60kV and current upto125mA, at a maximum power level of 4kW. The precision and accuracy of the data is ±2%, and average values of three replicates were taken for Each determination.

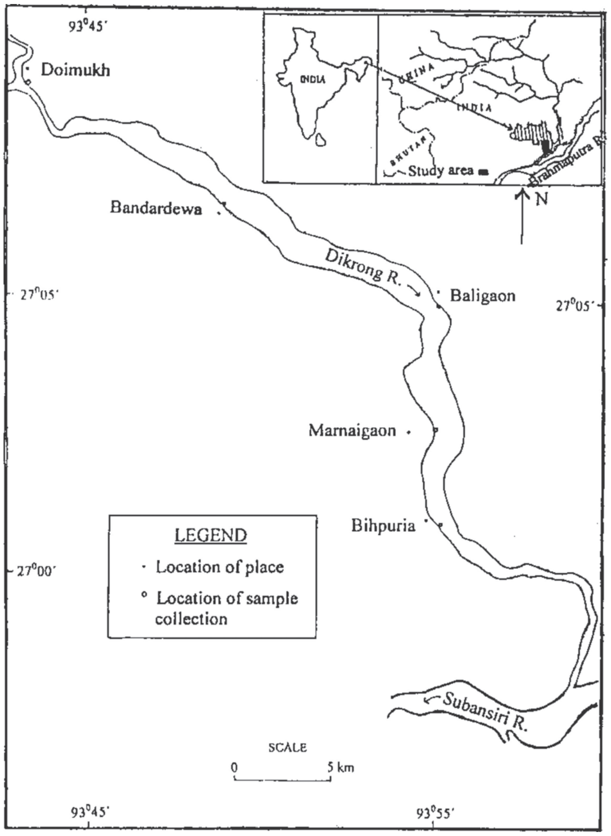

**Fig. 1.** Location of sampling sites

### Index of geo-accumulation

The index of geo-accumulation (Igeo) is used to assess the accumulation of contamination in sediments (Muller, 1969). The index of geo-accumulation is defined as:

**Table 1.** Sampling code and number of collected samples

| Sl No. | Sampling Code | No of Samples |
|---|---|---|
| 1 | SD1 | 5 |
| 2 | SD2 | 3 |
| 3 | SD3 | 3 |
| 4 | SD4 | 3 |
| 5 | SD5 | 4 |
| 6 | SD6 | 3 |
| 7 | SD7 | 5 |
| 8 | SD8 | 3 |
| 9 | SD9 | 5 |
| 10 | SD10 | 7 |

$$I_{geo} = log_2 \frac{C_n}{1.5B_n}$$

Where, Cn is the measured concentration of element and Bn is the geochemical background value. The constant 1.5 allowed to analyze the possible natural fluctuations in background data due to lithologic effect. The seven grades or classes profile of the geo-accumulation index proposed by Muller (1981) and according to this classification the value of sediment quality is considered as unpolluted (Igeo is ≤0, class 0); from unpolluted to moderately polluted (Igeo is 0-1, class1); moderately polluted (Igeo is 1-2, class 2); from moderately to strongly polluted (Igeo is 2-3, class 3); Strongly polluted (Igeo is 3-4, class 4); from strongly to extremely polluted (Igeo is 4-5, class 5) and Extremely polluted (Igeo is >6, class 6). The total geo-accumulation index (Itot) is defined as the sum of Igeo for all trace elements obtain from the site (Ya *et al.,* 2007).

### Enrichmentfactor

The contamination or enrichment factorb (EF) is based on the standardization of the analysed element against a reference. It is used to assess the level ofcontamination and the possible anthropogenic impact in sediments. The element which has low occurrence variability is considered as a reference element. Generally geochemical normalization of the heavy metals data to a conservative element, such as Al, Si and Fe is employed.In this study Fe is considered as reference element of normalization because natural sources (1.5%) vastly dominate its input (Tippie, 1984). The EF is defined as follows:

$$EF = \frac{C_{n(sample)}/C_{ref(sample)}}{B_{n(background)}/B_{ref(background)}}$$

Where, Cn (sample) and Cref (sample) are the content of the examined and reference element in the examined environment respectively; Bn (background) and Bref (background) are the content of examined and reference element in the reference environment respectively. Due to the unavailability of metal background values for the study area, we used the values from world surface rocks (Martin and Meybeck, 1979) for analysis.We used categories of enrichment factor described by Mmolawa *et al.* (2011) that is, deficiency to minimal enrichment (EF<2); moderate enrichment (2≤EF<5); significant enrichment (5≤EF<20); very high enrichment (20≤EF<40) and extremely high enrichment (EF≤40) for our investigation.

### Contamination factor (CF)

The level of contamination of sediment by metal is expressed in terms of CF calculated as:

$$CF = C_{Sample}/C_{Background}$$

Where, C Sample is the concentration of the given metal in river sediment, and C Background is value of the metal equals to the worldsurface rock average given by Martin and Meybeck (1979). The CF and level of contamination proposed by Hakanson (1980) is used (Table 4) for describing the contamination level of this study. According to Hakanson the classifications are:low contamination (CF<1); moderate contamination (1≤CF<3); considerable contamination(3≤CF<6) and very high contamination (CF>6).

### Pollution load index (PLI)

Pollution load index(PLI) for a particular site can be estimated using the method proposed by Tomilson *et al.* (1980).

$$PLI = (CF_1 \times CF_2 \times CF_3 \times \dots\dots\dots \times CF_n)^{1/n}$$

Where, CF is the contamination factor and n is the number of metals.

## Results and Discussion

### Metal contaminations

The world surface rock average prescribed by Martin and Meybeck (1979) isused as background value for investigation. The concentration of heavy metals in the sediments samples of Dikrong river is presented in the Table 2.

The concentration of Cu and Pb varied from 81.1 to 204.52 ppm with mean value 35900 ppm, 12.9 to 41.6 ppm wit hmean value 28 ppm respectively. This value is more than the world surface rock average as background level. The concentration of Fe, Al,

**Table 2.** Concentration of heavy metals (ppm) in the Dikrong river sediments and world surface rock average

| Elements | Concentration of elements for site SD1 to SD10 | | | World surface rock average* | Indian river sediment average** |
|---|---|---|---|---|---|
| | Min | Max | average ± standard deviation | | |
| Fe | 20850 | 30290 | 23812±3150 | 35900 | 29000 |
| Al | 48060 | 60324 | 53320 ± 4094 | 69300 | — |
| Ti | 2310 | 3324 | 2649 ± 322 | 3800 | — |
| Pb | 12.9 | 41.6 | 28 ± 9 | 16 | — |
| Zn | 27.7 | 41.2 | 35 ± 1.3 | 127 | 16 |
| Cu | 81.1 | 204.52 | 138.30 ± 38.45 | 32 | 28 |
| Ni | 12.5 | 25.8 | 18.63 ± 4.16 | 49 | 37 |
| Co | 9.8 | 18.6 | 13.73 ± 2.93 | 13 | — |
| Mn | 598 | 786 | 659.10 ± 56.70 | 750 | 605 |
| Cr | 29.2 | 71.6 | 46.86 ± 13.73 | 71 | 87 |

Ti, Zn, Ni, Co, Mn and Cr varied from 20850 to 30290 ppm, 48060 ppm to 60324 ppm, 2310 ppm to 3324 ppm, 27.7 to 41.2 ppm, 12.5 to 25.8 ppm, 9.8 to 18.6 ppm, 598 to 786 ppm and 29.2 to 71.6 ppm with mean value 23812 ppm, 53320 ppm, 2649 ppm, 35 ppm, 18.63 ppm, 13.73 ppm, 659.10 ppm and 46.86 ppm respectively. These values are less than or near about the world surface rock average as background level. The comparison of average concentration of heavy metals (ppm) with world surface rock average concentration is presented in Fig 2 and the result of geochemical accumulation (Igeo) is presented in Table 3.

The Igeo values of majority elements in sampling sites were less than 0(<0), except the elements Pb and Cu. The Igeo values of Pb in sites SD1, SD2, SD4, SD5, SD8 and SD9 were less than 1 (<1) respectively, in case of Cu the Igeovalues of sampling sites SD1SD2, SD3, SD5, SD6, SD7, SD8, SD9, and SD10 were greater than 1(>1). The Igeo values of Cu in

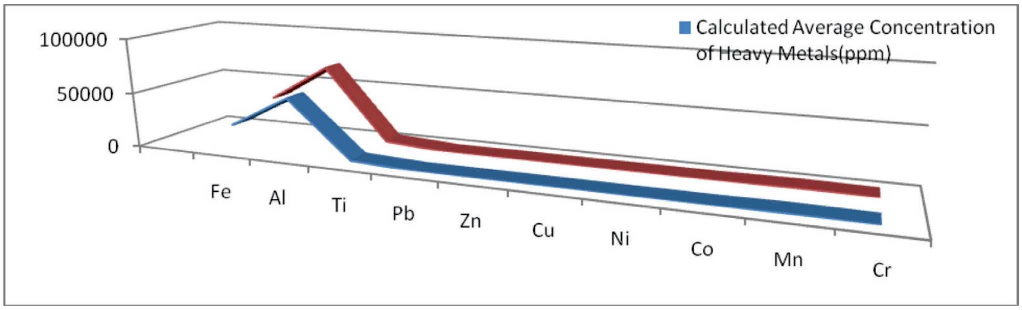

**Fig. 2.** Comparison of average concentration of heavy metals (ppm) in sediment with world average surface rock

**Table 3.** The geochemical accumulation (Igeo) of heavy metals in the sediment of Dikrong river

| Sample Code | Fe | Al | Ti | Pb | Zn | Cu | Ni | Co | Mn | Cr |
|---|---|---|---|---|---|---|---|---|---|---|
| SD1 | -1.3688 | -1.1130 | -1.2867 | 0.4536 | -2.4883 | 1.2305 | -1.8156 | -0.7618 | -0.8770 | -1.0390 |
| SD2 | -0.8302 | -1.0814 | -1.2352 | 0.7924 | -2.4628 | 2.0906 | -2.3278 | -0.2352 | -0.6813 | -1.2351 |
| SD3 | -1.3353 | -1.0208 | -0.7782 | -0.0283 | -2.4851 | 1.4026 | -1.5558 | -0.4208 | -0.5191 | -1.4076 |
| SD4 | -1.2012 | -0.9653 | -1.0444 | 0.5715 | -2.4550 | 0.7561 | -2.1327 | -0.1589 | -0.7820 | -0.6533 |
| SD5 | -1.1468 | -0.7851 | -1.2166 | 0.3074 | -2.4084 | 1.0135 | -1.6711 | -0.8614 | -0.8974 | -1.8528 |
| SD6 | -1.3793 | -0.8807 | -0.9869 | -0.6370 | -2.3822 | 1.7822 | -2.5284 | -0.7493 | -0.9081 | -0.5937 |
| SD7 | -0.9499 | -1.0523 | -0.9638 | -0.0825 | -2.3908 | 1.7460 | -1.9412 | -0.4849 | -0.6790 | -1.3326 |
| SD8 | -1.3276 | -0.8861 | -1.3029 | 0.4667 | -2.4540 | 1.8959 | -1.7053 | -0.6186 | -0.7099 | -1.0623 |
| SD9 | -1.1936 | -0.8539 | -1.2076 | 0.2697 | -2.5624 | 1.4879 | -2.3557 | -0.9683 | -0.8317 | -1.4977 |
| SD10 | -1.1468 | -1.0308 | -1.1249 | -0.9250 | -2.4077 | 1.3422 | -2.1021 | -0.0943 | -0.8792 | -1.7066 |

site SD4 was less than 1 (<1). According to Muller's classification, the calculated Igeo values for Pb indicate sediment quality be considered as unpolluted. The calculated Igeo values of Cu indicates sediment quality be considered as moderately except the site SD4 which is unpolluted. The result of Enrichment Factor (EF) is presented in Table 4.

The EF values for Cu in Dikrong River sediments ranged from 3.8195 to 9.6323. The EF values for Cu were found to be greater than 4 in nine samples out of 10 sampling sites, suggesting that these sites are classified as moderate enrichment for Cu. The stations SD1, SD2, SD3, SD6, SD7, SD8, SD9 and SD10 are significant enrichment for Cu. In case of Pb, the EF values were ranged from 1.1910 to3.9167. The result of Contamination Factor(CF) is presented in Table 5. The CF values for Cu in Dikrong River sediments varied from 2.5333 to 6.3890. For Pb the CF varies from 0.7900 to 2.5979. Most sampling sites had the CF greater than 1 and less than 6 for the elements Cu and Pb except SD2(Cu). The remaining elements had the CF values less than 1. It was found that most sampling sites were moderately contaminated by Pb except sampling sites SD6 and SD10. It was found that most sampling sites face considerable contaminated by Cu except SD4 was moderately contaminated. The site SD2 has very high contamination of Cu. Metal wise and sampling site wise, the Pollution Load Index (PLI) values are presented in Table 6 and Table 7.

The contaminations of various sampling sites were compared by determining the PLI. PLI values of the analyzed samples ranged from 0.7461 at SD10 to 0.9103 at SD2 with a mean value of 0.8230 (Table 7). All sampling site ssuggest has no overall pollution, whereas SD2 shows signs of pollution.

**Table 4.** Enrichment Factor (EF) value

| Sample Code | Fe | Al | Ti | Pb | Zn | Cu | Ni | Co | Mn | Cr |
|---|---|---|---|---|---|---|---|---|---|---|
| SD1 | 0.8756 | 1.0456 | 0.9269 | 3.0970 | 0.4030 | 5.3066 | 0.6424 | 1.3337 | 1.2314 | 1.1005 |
| SD2 | 1.2720 | 1.0687 | 0.9607 | 3.9167 | 0.4102 | 9.6323 | 0.4504 | 1.9213 | 1.4103 | 0.9607 |
| SD3 | 0.8963 | 1.1146 | 1.3187 | 2.2175 | 0.4039 | 5.9787 | 0.7692 | 1.6893 | 1.5781 | 0.8524 |
| SD4 | 0.9836 | 1.1583 | 1.0965 | 3.3608 | 0.4124 | 3.8194 | 0.5157 | 2.0257 | 1.3151 | 1.4379 |
| SD5 | 1.0214 | 1.3124 | 0.9731 | 2.7986 | 0.4260 | 4.5653 | 0.7101 | 1.2448 | 1.2141 | 0.6261 |
| SD6 | 0.8693 | 1.2282 | 1.1410 | 1.4542 | 0.4338 | 7.7785 | 0.3920 | 1.3453 | 1.2051 | 1.4985 |
| SD7 | 1.1707 | 1.0905 | 1.1594 | 2.1358 | 0.4312 | 7.5853 | 0.5889 | 1.6159 | 1.4125 | 0.8979 |
| SD8 | 0.9010 | 1.2237 | 0.9166 | 3.1252 | 0.4127 | 8.4161 | 0.6935 | 1.4729 | 1.3826 | 1.0830 |
| SD9 | 0.9888 | 1.2512 | 0.9792 | 2.7263 | 0.3828 | 6.3431 | 0.4418 | 1.1559 | 1.2706 | 0.8008 |
| SD10 | 1.0213 | 1.1068 | 1.0370 | 1.1910 | 0.4262 | 5.7338 | 0.5268 | 2.1184 | 1.2295 | 0.6928 |

**Table 5.** Contamination Factor (CF) value

| Sample Code | Fe | Al | Ti | Pb | Zn | Cu | Ni | Co | Mn | Cr |
|---|---|---|---|---|---|---|---|---|---|---|
| SD1 | 0.5808 | 0.6935 | 0.6148 | 2.0542 | 0.2673 | 3.5198 | 0.4261 | 0.8846 | 0.8167 | 0.7300 |
| SD2 | 0.8437 | 0.7088 | 0.6372 | 2.5979 | 0.2721 | 6.3890 | 0.2988 | 1.2744 | 0.9354 | 0.6372 |
| SD3 | 0.5945 | 0.7393 | 0.8746 | 1.4708 | 0.2679 | 3.9656 | 0.5102 | 1.1205 | 1.0467 | 0.5654 |
| SD4 | 0.6524 | 0.7683 | 0.7273 | 2.2292 | 0.2736 | 2.5333 | 0.3420 | 1.3436 | 0.8723 | 0.9537 |
| SD5 | 0.6775 | 0.8705 | 0.6454 | 1.8563 | 0.2825 | 3.0281 | 0.4710 | 0.8256 | 0.8053 | 0.4153 |
| SD6 | 0.5766 | 0.8147 | 0.7568 | 0.9646 | 0.2877 | 5.1594 | 0.2600 | 0.8923 | 0.7993 | 0.9940 |
| SD7 | 0.7765 | 0.7233 | 0.7690 | 1.4167 | 0.2860 | 5.0313 | 0.3906 | 1.0718 | 0.9369 | 0.5956 |
| SD8 | 0.5976 | 0.8116 | 0.6080 | 2.0729 | 0.2738 | 5.5823 | 0.4600 | 0.9769 | 0.9171 | 0.7183 |
| SD9 | 0.6558 | 0.8299 | 0.6495 | 1.8083 | 0.2539 | 4.2073 | 0.2931 | 0.7667 | 0.8428 | 0.5312 |
| SD10 | 0.6774 | 0.7341 | 0.6878 | 0.7900 | 0.2827 | 3.8031 | 0.3494 | 1.4051 | 0.8155 | 0.4596 |

**Table 6.** Metal wise PLI value

| Fe | Al | Ti | Pb | Zn | Cu | Ni | Co | Mn | Cr |
|---|---|---|---|---|---|---|---|---|---|
| 0.6584 | 0.7674 | 0.6927 | 1.6288 | 0.2746 | 4.1690 | 0.3715 | 1.0350 | 0.8757 | 0.6359 |

**Table 7.** Sampling sitewise PLI values

| Sample Code | PLI value |
|---|---|
| SD1 | 0.8002 |
| SD2 | 0.9103 |
| SD3 | 0.8527 |
| SD4 | 0.8576 |
| SD5 | 0.7754 |
| SD6 | 0.7893 |
| SD7 | 0.8537 |
| SD8 | 0.8794 |
| SD9 | 0.7651 |
| SD10 | 0.7461 |

## Conclusion

The investigation of Dikrong River sediments shows the order of the mean concentrations of tested heavy metals as :
Al > Fe > Ti > Mn > Cu > Cr > Zn > Pb > Ni > Co, which is depicted in Fig 3.

The comparisons of the mean concentration of the heavy metals of all the sampling sites are shown in Fig 4.

The correlation analysis of mean concentrations showed good to strong positive correlations among Fe, Al, Ti, Mn, Zn, Pb, Ni and Co, suggesting that these metals have common sources. The correlation is shown in Table 8. The elements Fe and Zn expressed a strong positive correlation with Pb, Zn, Cu, Co, Mn and Al, Ti respectively at 0.05 level. The other element such as Cu have strong positive correlation with Pb and Zn. Ni has strong positive correlation with Al, Ti and Zn. Co has strong positive correlation with Fe, Ti and Zn. Mn has strong positive correlation with Fe, Ti, Pb, Ni, Co and Cu at this level of significance. Cr has strong positive correlation with Ti, Pb, Zn, Co and Cu.

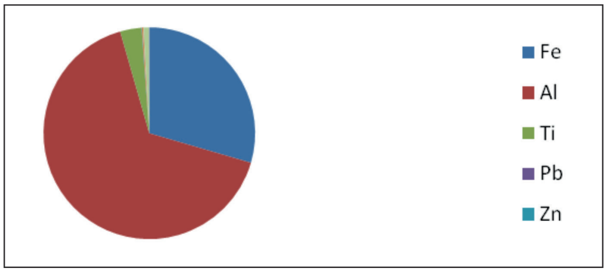

**Fig. 3.** Mean Concentration of the tested heavy metals (ppm)

The EF values counsel that Dikrong river sediments were considerably enriched by studied heavy metals having important contribution by copper and lead. The CF values counsel that sample sediments of Dikrong river moderately show contaminated and primarily contributed by copper. Some sites suffer low contamination due to lead. The Igeo values show that the sediments quality of Dikrong river is moderately contaminated by copper and from uncontaminated to moderately contaminated by lead. PLI of all sites counsel sampling sites counsel has no overall pollution, only sampling site SD2 shows signs of pollution. The concentration of Fe metal is found comparatively higher than the other metals, which may be due to of iron industry in the locality. On the other hand, the heavy metals Cu, Ni, Pb and Zn have been reported by Geological Survey of India in 1974 and 1983 (GSI, 1974 and GSI, 1983) from the metamorphic belt lying in the study area catchment. Therefore, these diment are contaminated with Cu and Pb that is due to dispersion from the mineralized zone of the upper catchment area. But the effects of anthropogenic factors cannot be ignored due to the gradually developing industries and habitats in the adjacent areas of the sampling locations. The very strong positive correlations of Ti with Fe are indicative to their association with clay. The observed positive correlation between Ti and

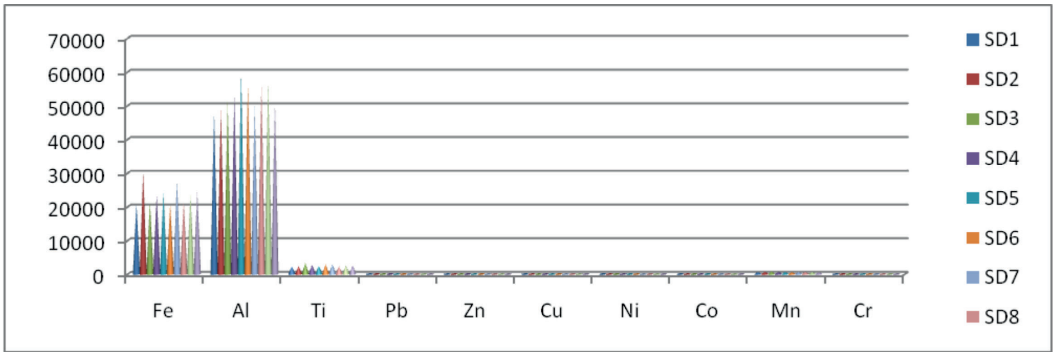

**Fig. 4.** Comparison of mean concentration of heavy metals (ppm)

**Table 8.** Pearson's correlation coefficient between the heavy metal elements of the Dikrong river sediments

| Elements | Fe | Al | Ti | Pb | Zn | Cu | Ni | Co | Mn | Cr |
|---|---|---|---|---|---|---|---|---|---|---|
| Fe | 1.0000 | | | | | | | | | |
| Al | -0.3004 | 1.0000 | | | | | | | | |
| Ti | -0.1235 | -0.1702 | 1.0000 | | | | | | | |
| Pb | 0.3100 | -0.0831 | -0.4870 | 1.0000 | | | | | | |
| Zn | 0.1483 | 0.0375 | 0.2169 | -0.4826 | 1.0000 | | | | | |
| Cu | 0.4039 | -0.1762 | -0.1193 | 0.1010 | 0.0965 | 1.0000 | | | | |
| Ni | -0.2857 | 0.0004 | 0.1428 | 0.0953 | -0.0268 | -0.2915 | 1.0000 | | | |
| Co | 0.3992 | -0.5604 | 0.2449 | -0.0226 | 0.2404 | -0.0099 | -0.1232 | 1.0000 | | |
| Mn | 0.2087 | -0.3730 | 0.5509 | 0.2105 | -0.2115 | 0.3174 | 0.4311 | 0.2981 | 1.0000 | |
| Cr | -0.3405 | -0.0616 | 0.1252 | 0.1077 | 0.1428 | 0.0708 | -0.4025 | 0.0632 | -0.1166 | 1.0000 |

Mn is indicative to the presence of pyrophanite ($MnTiO3$) mineral from the metamorphosed manganese deposition in the adjoin areas.

## Acknowledgements

Authors thank the Assam down town University, Guwahati, the Directors, National Geophysical Research Institute (NGRI-CSIR), Hyderabad and North East Institute of Science and Technology (NEIST-CSIR), Jorhat for their cooperation during his work.

## References

Buragohain, M. Kakoti, N. Mahanta, S. R., Sarmah, P., Pegu, B. K. and Dutta, M. P. 2020. Spatial Assessment of Arsenic and Iron Content in Water Sources of Lakhimpur District, Assam, India. *Pollution Research.* 39 (3): 769-777

Hassan, Y. Buragohain, M., Sarmahbezboruah, M. and Buragohain, I. 2021. Assessment of Arsenic and Fluoride content in different drinking Water Sources of Secondary schools in greater Guwahati of Assam, India. *Pollution Research*. 40 (1) : 211-216.

Martin, J. M. and Meybeck, M. 1979. Elemental mass balance of materials carried by major world rivers. *Mar Chem.* 7: 173-206.

Mohiuddin, K.M., Zakir, H.M., Otomo, K., Sharmin, S. and Shikazono, N. 2010. Geochemical distribution of trace metal pollutants in water and sediments of downstream of anurban river. *Int. J. Environ. Sci.Tech.* 7 (1) : 17-28.

Muller, G. 1969. Index of geoaccumulation in sediments of the Rhine River. *J. Geol.* 2 : 108-118

Muller, G. 1981. The heavy metal pollution of the sediments of Neckars and Its Tributary, A Stocktaking Chemische *Zeit.* 150: 157-164.

Saikia, B. J., Goswami, S. R. and Borah, R. R. 2014. Estimation of heavy metals contamination and silicate mineral distributions in suspended sediments of Subansiri River. *International Journal of Physical Sciences.* 9 (21) : 475-486.

Tippie, V. 1984. An environmental characterization of Chesa-peak Bayanda Frame work for Action, The Estuaryasa Filter, Academic Press, New York. 467-487.

Xu, Q. 2007. Facing up to invisible pollution. *Journal of Environmental and Public Health* In Press.

Ya, Z.G., Zhou, L.F., Bao, Z.Y., Gao, P. and Sun, X.W. 2007. High efficiency of heavy metal removal in mine water by limestone. *Chin. J. Geochem.* 28 (3) : 293-298.

Yang, C.Y., Chiu, H.F., Cheng, M.F.,Tsai, S.S., Hung, C.F. and Tseng, Y.T. 1999. Magnesium in drinking water and the risk of drafts Area diabetes mellitus. *Magnes Res.* 12(9): 894-899.

Yaron, B., Dagon, G. and Goldsmith. J. 1984. Pollutants in porous media. *Ecol. Studies* vol. 47. Berlin.

Yunker, M.B., Macdonald, R.W., Mitchell, R.V. and Goyette, R. H. 2002. *Orgnic Geochemistry*. 33 : 489–515.

Yousef, Y.A., Hvitved-Jacobsen, T., Harper, H. H. and Lin, L. Y. 1990. Heavy metal accumulation and transport through detention ponds receiving highway runoff. *Sci. Total Environ.* 93 : 433-440.

Yi, Zhang, M.K., Wang L.P., Ying Yong Sheng and Tai Xue Bao, 2007. Impact of heavy metal pollution on soil organic matter accumulation. 8(7) : 1479-83.

Yamamoto, N., Takahashi, Y., Yoshinaga, J., Tanaka, A. and Shibata, Y. 2006. Size distributions of soil particles adhered to children's hands. *Archives of Environmental Contamination and Toxicology*. 51 : 157-163.

Zimmermann, J., Dierkes, C., Göbel, P., Klinger, C., Stubbe, H. and Coldewey, W.G. 2005. *Water Science and Technology*. 51 (2).

Zhang, M.K., Liu, Z.Y. and Wang, H. 2010. Use of single extraction methods to predict bioavailability of heavy metals in polluted soils to rice. *Communications in Soil Science and Plant Analysis*. 41(7) : 820–831.