Assessment of Heavy Metal Pollution in Sediment for Thamiraparani River, India

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Abstract – An investigation of sediment characterization was led along a stretch of the Thamiraparani Stream, Tamilnadu, India, during September, 2020 to assess the effect of anthropogenic actions. Ten locations were chosen from Athoor to Punnakayal for the examination. Sediments were analysed with ICP-OES instrument. From the obtained results (stated in mg/kg of dry weight) revealed that Fe wide-ranging from 1623.95 to 53003.83, Pb ranged between 0.02 to 0.3, Zn varies from 0.2 to 2.08, Cu from 0.02 to 0.83, Ni from 0.41 to 2.8, and Mn from 2.01 to 17.39. Assessed Pollution Load Index (PLI) and geo-accumulation index (Igeo) discovered the sediments at all places were almost not affected by metallic element. The obtained results were compared with heavy metal Guidelines for Sediments (EPA).

Keywords - Sediment, Pollution Load Index, Geo-accumulation Index, Thamiraparani River

1. Introduction:
Sediment encapsulates basic components of aquatic biological systems. In the aquatic system heavy metals are removed from the water column by interacting with organic matter or particulate matters eventually deposited as sediments [1,2]. Due to the distribution of heavy metals in sediments presents in surface water drastically increasing adsorption to suspended particulate matter. In general sediments are sinks for the heavy metals especially in the aquatic environment [3] and it is found in different grain sizes such as fine, medium, and coarse at the lower part of ponds, rivers, narrows, river mouth, and seas [4]. However, some of the heavy metals from the sediments might be released through the various processes. Sediment goes about as both transporter and possible wellsprings of impurities in an oceanic climate and can fill in as a lake that can hold or delivery toxins to the water segment by different cycles of remobilization [5].

Due to their built-in characteristics such as persistence, bio-geochemical recycling and non-degradability, it is considered as series pollutant to the aquatic systems [6]. Considering environmental monitoring activities, it is essential to determine the heavy metal levels in the surface water and also it should be within the national standards [7,8]. The determined heavy metal in sediments from the surface water studies used to identify hot spot of heavy metal contamination in the region [9,10]. Thus, it is inevitable to analysis the distribution of heavy metals in sediments from the surface water body such as River and stream, which is convenient
to understand the vulnerability associated with releasing of wastes into river system and its impacts on the ecosystem [11] by the decision maker for better decision making.

There are many multi-element determination techniques are available to found the heavy metals presented in the sediments such as X-ray fluorescence, flame atomic absorption spectrophotometer [12], Atomic Fluorescence Spectrometer, Inductively Coupled Plasma-Mass spectrometry [13], inductively coupled Plasma-Atomic Emission Spectrometry [14], Transmission Electron Microscopy [15], and Neutron activation. Various geochemical analysis techniques are used to determine the heavy metals in the sediments such as Enrichment factor, sediment quality guideline, potential ecological risk index [16], Pollution load index, geoaccumulation Index [17] and mean-effects range medium-quotient [18].

The present study considered very important because Thamirabarani River is sources of domestic purposes for both Tirunelveli and Tuticorin district. Due to the untreated waste water from the suspending businesses are released into the waterway, and it's utilized for home grown doing by individuals residing in the catchment area. This examination identifies the degrees of the substantial metals of the silt in Thamirabarani River with the point of assessing the contamination grade of the Stream [19]. In order to fulfil the intention of the research, heavy metals in sediment were examined by ICP-OES instrument suggested in the different literatures and sediment quality assessment was done by Pollution load Index and geoaccumulation index.

2. Study Area:
The examination was led laterally an around 6.5 km in downstream side of Thamiraparani River located in the South portion of Tamilnadu (Lat. 8°37'37.440"N Long. 78°7'30.566"E)

![Figure 1. Sampling Location Map](image)
The current investigation was led in the stretch of Authoor to punnakayal. Ten locations were explored along the stretch in the study area. Numerous human exercises inside and around this waterway consist of digging, fishing, sailing, washing clothes, and bathing.

3. Materials and Methods

Sediments were collected from 10 different locations keeping the standard strategy portrayed by APHA. Sediment samples are collected with the help of hand shovel at various locations of Thamiraparani river for the tests. The gathered samples were placed into the polythene pack (dregs). The sediments were dried in a muffle furnace at 100°C. The accompanying metals specifically Fe, Cu, Pb, Mn, Ni and Cr were checked utilizing procedures implemented from APHA. Heavy metals in sediment were checked by inductively coupled plasma-mass spectrometry after microwave assimilation of sediment on a CEM Corporation. All chemical substances were of investigative reagent grade used.

4. Data Analysis

To decide the greatness of metal defilement in the silt, PLI and Igeo were utilized. Contamination load in sediment for study area was assessed utilizing the methodology of Anthony et al.

\[
PLI = \left( \prod_{i=1}^{n} CF_i \right)^{1/n}
\]

Where, \( n \) = number of metals
CF = contamination factor.
CF = Metal concentration in sediment / Background values of the metal

As per Chakravarty the PLI > 1 is contaminated while PLI value < 1 specifies no contamination. The Igeo values were determined for various metals using the formula.

\[
Igeo = \log_2 \left( \frac{C_{\text{sample}}}{1.5C_{\text{background}}} \right)
\]

Based on Igeo value pollution of sediment categorised as Igeo <0 (undirtied),

\[0 < Igeo < 1 \] (slightly dirtied), \[1 < Igeo < 2 \] (moderately dirtied).

In this study background value taken as world typical value of Cr 90, Fe 47600, Zn 95, Cu 50, Pb 20, Mn 900 and Ni 68.

5. Results

The following table 1 shows the amount metals in deposits for the investigated area during September 2020.

Chromium arrives at streams principally from the release of industries and discarding of items comprising the metal. Significant amount of copper involved in paleness, liver and kidney harm, stomach and abdominal aggravation. The presence of manganese in sediment is very low. Lead is poisonous to people and its source mainly the utilization of lead as a petroleum added substance, overflow from the urban communities, release of inappropriately treated leftover wastes, sewage muck and the utilization of insecticides comprising lead mixes. The high convergence of lead noted in location 1 may be because of anthropogenic activities related with oil-based goods.

**Heavy metals**

Heavy metals are very dangerous to living beings when its accumulated. Heavy metals presence in water and sediments due to industrial and domestic discharge as well acid rain. Sometime acid rain broken the rocks and releasing of heavy metals into water body and its deposited in sediments. Heavy metals in
sediments are not migrate easily because of their their long residual time, strong concealment and toxicity. Its affect the health of people and animals when the metals absorbed by crops, enter the food chain, or migrate into water and atmosphere.

### Table 1. Heavy metals of Sediments in Thamiraparani River

| Sl. No | Location | Latitude       | Longitude      | Chromium | Iron   | Manganese | Copper | Lead | Nickel | Zinc |
|--------|----------|----------------|----------------|----------|--------|-----------|--------|------|--------|------|
| 1      | Sample 1 | 8°37'37.440"  | 78°4'4.456"E  | 0.8      | 1623.95| 10.58     | 0.44   | 0.3  | 1.5    | 0.6  |
| 2      | Sample 2 | 8°37'42.441"  | 78°4'11.896"E | 0.72     | 2076.85| 13.47     | 0.22   | 0.2  | 1.7    | 0.5  |
| 3      | Sample 3 | 8°38'1.00"N   | 78°4'44.27"E  | 0.27     | 2310.3 | 6.49      | 0.02   | 0.05 | 2.47   | 0.2  |
| 4      | Sample 4 | 8°38'9.06"N   | 78°5'3.90"E   | 0.4      | 2663.86| 17.39     | 0.37   | 0.2  | 0.42   | 1.35 |
| 5      | Sample 5 | 8°38'12.213"N | 78°5'19.898"E| 0.91     | 1973.41| 14.34     | 0.03   | 0.04 | 0.48   | 0.82 |
| 6      | Sample 6 | 8°38'12.687"N | 78°5'33.237"E| 0.24     | 53003.82| 9.74      | 0.02   | 0.02 | 0.42   | 0.83 |
| 7      | Sample 7 | 8°38'23.93"N  | 78°6'27.66"E  | 0.43     | 2613.39| 4.94      | 0.2    | 0.21 | 0.98   | 1.56 |
| 8      | Sample 8 | 8°38'14.38"N  | 78°6'43.59"E  | 0.41     | 1685.89| 5.97      | 0.2    | 0.26 | 0.41   | 0.67 |
| 9      | Sample 9 | 8°38'15.738"N | 78°7'7.266"E  | 0.08     | 1994.21| 2.01      | 0.83   | 0.07 | 0.53   | 1.7  |
| 10     | Sample 10| 8°38'11.175"N | 78°7'30.566"E| 0.68     | 3806.87| 10.9      | 0.04   | 0.2  | 2.8    | 2.08 |

The investigated heavy metals are iron, chromium, zinc, copper, manganese, lead and nickel. The difference in their qualities are appeared in figure 2. The estimations (in mg/kg) of iron ran between 1623.95 to 53003.82, while the chromium was most elevated (0.91) in location 5 and least (0.08) in site 9. The zinc esteem went from 0.2 (location 3) to 2.08 (location 10). The copper was maximum (0.83) in location 9 and least (0.02) in location 3 and 6, while the manganese focus was lower most (2.01) in location 9 and peak (17.39) in location 4. The extreme centralization of Pb (0.3) was noted at location 1, while the least (0.02) was noticed at location 6. The mean convergence of nickel went from 0.41 in location 8 to 2.8 in location 10.

![Figure 2: Presence of metals in sediments](image-url)
PLI was determined for every one of examination locations as per the techniques for Tomlinson et al. (1980). Value of PLI > 1 indicates contamination, whereas PLI < 1 shows no contamination. The PLI noted for all the locations were under one except location 6 (figure 3). Accordingly, the sediment of the examination stretch of Thamiraparani Stream is uncontaminated.

**Figure 3.** Differences in the PLI Values

**Figure 4.** Differences in the Igeo values
The determined Igeo values are mentioned in table 3 and the differences are indicated in figure 4. From the figure, it's observed that Igeo values are below 0 at sampling location for all the metals. So, there is no contamination from these metals in deposited sediments of Thamiraparani River.

**Table 2. Pollution Load Index (PLI)**

| Locations | PLI Values |
|-----------|------------|
| 1         | 0.72661309 |
| 2         | 0.73074079 |
| 3         | 0.71976339 |
| 4         | 0.7364738  |
| 5         | 0.7041027  |
| 6         | 1.01931901 |
| 7         | 0.73002704 |
| 8         | 0.69290865 |
| 9         | 0.70983823 |
| 10        | 0.77863434 |

**Table 3. Geo-accumulation Index (Igeo)**

| Cr         | Fe        | Mn         | Cu          | Pb          | Ni          | Zn          |
|------------|-----------|------------|-------------|-------------|-------------|-------------|
| -7.3987437 | -5.45834  | -6.995476  | -7.41324    | -6.64386    | -6.08746    | -7.89178    |
| -7.5507468 | -5.10346  | -6.6470657 | -8.41324    | -7.22882    | -5.90689    | -8.15482    |
| -8.9657843 | -4.94977  | -7.7005252 | -11.8727    | -9.22882    | -5.36791    | -9.47675    |
| -8.3987437 | -4.74433  | -6.2785577 | -7.66322    | -7.22882    | -7.92396    | -6.72186    |
| -7.2128771 | -5.17716  | -6.5567706 | -11.2877    | -9.55075    | -7.73132    | -7.44112    |
| -9.1357093 | -0.42983  | -7.1148219 | -11.8727    | -10.5507    | -7.92396    | -7.42363    |
| -8.294407  | -4.77193  | -8.0942327 | -8.55075    | -7.15843    | -6.70157    | -6.51327    |
| -8.3631198 | -5.40434  | -7.8210128 | -8.55075    | -6.85031    | -7.95873    | -7.73259    |
| -10.720672 | -5.16203  | -9.3915482 | -6.49764    | -8.74339    | -7.58836    | -6.38928    |
| -7.6332089 | -4.22925  | -6.9524875 | -10.8727    | -7.22882    | -5.187      | -6.09823    |

Heavy metals in sediments are threaten the health of aquatic animals and humans, so it’s necessary to measure and reduce the source of pollution. There is a complex relationship between metals present in sediments. Heavy metal substance of rocks and parent materials, cycles of soil formation, pollution by human exercises, and other anthropogenic components. [20]
The PLI and Igeo have been utilized broadly in the valuation of residue contamination by metals. The outcome of the current assessment discovered that the dregs of the investigation stretch of the Thamiraparani River is uncontaminated by heavy metals.

Table 4. Guidelines for Sediments (EPA) (mg / kg)

| Sl. No | Metals | Not Polluted | Study Area |
|--------|--------|--------------|------------|
| 1      | Chromium | <25          | 0.08 to 0.9 |
| 2      | Iron    | ND           | 1623.95 to 53003.83 |
| 3      | Manganese | <300         | 2.01 to 17.39 |
| 4      | Copper  | <25          | 0.02 to 0.83 |
| 5      | Lead    | <40          | 0.02 to 0.26 |
| 6      | Nickel  | <20          | 0.41 to 2.8 |
| 7      | Zinc    | <90          | 0.2 to 2.08 |

The PLI was under 1 for all locations apart from location 6 and the Igeo values are under 0 for different metals, hence overall sediments are uncontaminated. These outcomes were validated by the way that the estimations of metals in the dregs were underneath the EPA rules for sediment limit, a sign that the silt of the Thamiraparani Waterway was not dirtied by metallic element.

6. Conclusion

Heavy metals in the surface residue were estimated, pollution load index and geo-accumulation index were determined, the potential wellsprings of contamination were dissected. The heavy metal fixations in the silt were higher than those in the water. Relationship investigation that heavy metals (Zn, Cr, Pb) in sediment may start from metal preparing, electroplating ventures, modern wastewater, and homegrown sewage. Ni might be gotten from nature, and Cu got from nature and anthropogenic exercises.

The nature of surface water and silt is valuable for sustainable use of waterway. The huge variety noted in convergences of certain parameters utilized in portraying the dregs superiority is an impression of effects of human caused movement on nature of this stream. Be that as it may, the degree of these metals in environment has expanded massively in the ancient time because of human contribution and exercises. The inference of this heavy metal’s present danger of contamination of the residue and overlying surface water. So, incessant testing is crucial to limit the potential wellbeing threats of occupants in catchment territories who depend of the waterway water for domestic usage, rural and fishing activities.

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