Physico-chemical Assessment and heavy metal accumulation pattern in sediment and water of Kosasthalaiyar river near Ennore Estuary, Tamilnadu using Geo-spatial Techniques.

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Abstract

This research to analyze the heavy metals sediment from the Kosasthalaiyar river using sophisticated Atomic Absorption Spectrometer, subsequently pollution indices like Geo-accumulation Indices (IGeo), Contamination Factor (CF), Enrichment Factor (EF) and Pollution Load Index (PLI) to determine the intensity of heavy metal in sediment. Eventually, Geospatial technique was used, Factor analysis that was used to evaluate the heavy metals revealed that the sources of the toxic substances in the study area's sediments were both natural and human. In this research Geo accumulation Index showed that Fe, Mn, Cr, Cu, Ni, Pb, and Zn were severely contaminated in the surface resulting of the Coast. When the Enrichment Factors were calculated, they revealed the enrichment component with the dropping trend among average contents. The influence of various foreign factors, including farm runoff, industrial processes, and other human inputs, resulted in higher (41) values for the PLI values of the CD. This study helpful Control Board to understand the trend of heavy metal pollution in sediment and further to carry out the remedial action to refrain the pollution at the study area.

Keywords: Sediments; Heavy metal; Pollution; Kosasthalaiyar river; Analysis

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1. Introduction

Around 97% of the Earth's freshwater is accessible from the subsurface, and it is a crucial part (Delluer, 1999). It contributes to maintaining, marshes, and addition to serving as a supply of drinkable water for agriculture, business, and residential usage (Oladeji et al., 2012).

According to Qiu (2010), Water quality makes up roughly 70% and 40% of all the water supplies used in China for irrigation and private usage, respectively (Nickson et al. (2005)).

In Ghana, the population's main reliable water source for drinking in remote regions and recently developed urban areas is subterranean (Duah and Xu, 2006). For such people, having water of sufficient quality is essential because it acts as their main water supply both drinking and home usage. Usually, anthropogenic activities have a substantial direct or indirect impact on groundwater resources, including farming, careless sewage disposal, and miners (Teaf et al., 2006).For instance, overburden, fines, and industrial discharges are produced during in the different mineral processing phases and each of these items has the possibility of polluting water via leaking thru the ground (Johnson and Hallberg, 2005). As an observed of groundwater quality by mine effluents, a colliery in the Nigerian town of Enugu damaged deep) Quality of water and sea water with excessive pH, iron, and sulphate, according to Obiadi et al. (2016). According to studies by Mallo, these wastewaters from mines often have an exceptionally high pH level, which causes acid mine drainage and ends in bodies of water, especially aquifer (2011). Similarly to this, Oladipo et al. (2014) found proof of heavy metal poisoning of water quality.

Similar evidence of contamination with heavy metals of), Water quality operations in Zamfara State, Nigeria, was discovered by Oladipo et al. (2014). Ghana is recognised as one of the world's top gold exporters, and it is thought that the mining industry contributed significantly to the nation's total foreign profits. Informal gold has indeed been expanding across the country and is thought to be a substantial contributor of metals in groundwater because of the unregulated use of mercurial (Hg) and other dangerous chemicals inside the mining activities (Donkor et al., 2006). Since most small scale mining businesses lack their own permits, they mostly operate illegally. Due to their innate stealth and clandestine character, they work uncontrollable inside the concessions of big mining enterprises or in locations where mine is prohibited, such as near to reserve forests, water bodies, or ecologically endangered regions (Appiah, 1998). Their operations are frequently not controlled as a result, which results in the usage of dangerous chemicals to recover the gold. According to Meech et al. (1998), these chemicals are typically released uncontrollably into to the biosphere, which contaminates the ecosystem.

The quality of soil and water at locations with considerable mining activities has been examined using a variety of techniques. By correlating the level of heavy metals in the soil to their crustal levels using the geo-accumulation (Igeo) index, Awadh (2013) determined that the levels in the soil exceeded the crustal values, indicating that the soil had been polluted. On the other hand, Likuku et al. (2013) employed the weighting factors, pollution load index, level of pollution, and geo concentration benchmark to assess the amount of heavy metals in the soils.

The attempt to quantify the amounts of heavy metals in the sediment of India's southeast coast is reflected in this publication. Studies on heavy metals found in the sediment of the current research region are few and far between. A few research projects have focused on specific topics, like physical traits and marine mouth shape (Sreenivasulu et al., 2015, Karthikeyan et al 2020, Vasanthi et al 2013, 3.Mitha et al 2021,4. de Melo Albuquerque et al 2023, 5. Balachandar et al 2023). Nanda Kumar and colleagues, 2009, 2010. Understanding the location of the metals and their concentrations inside the research area is vital. The Location Index (Igeo) (Muller, 1960, 1979; Rubio et al., 2000; Satpathy et al., 2011; Yu et al., 2008), the Analytics And insights (EF) (Abrahim & Parker, 2008); Ra et al., 2013; Present in small amounts et al., 2014); and the Contaminant Benchmark (PLI), as well as other environmental impact study indices, were used by the authors (Goher et al., 2014; Ozseker & Eruz, 2011; Rabee et al., 2011, Menon et al 2023, Savurirajan et al 2022, Saraswati et al 2022, Akila et al 2022).

The findings from this investigation would pave the way for additional work inside the study area and assist the relevant authorities in ensuring that the local water bodies have a satisfactory and suitable hard rock condition. The study makes an effort to clarify coastal management by giving judgment consumers access to primary sources of information. Additionally, the baseline data will be presented in a flat form for the participants to use in managing and conserving the study region from additional pollution concerns as well as monitoring coastal contamination via affordable biomarkers. Additionally, the research area's levels of pollution can be continuously checked to protect the fishing industry and bio - diversity.

2. Study area

Kosasthalaiyar is a 136 km (83 mi) long river that rises in the Thiruvallur district near Pallipattu and empties into the Bay of Bengal. Its northern branch, the Nagari river, rises in Andhra Pradesh's Chitoor district and merges with the main river at the Poondi reservoir's backwoods. The districts of Vellore, Chitoor, North Arcot, Thiruvallur, and Chennai are all included in its catchment region. Its watershed region is in the North Arcot District, where it splits off near Kesavaram Anicut and flows as the Cooum River to Chennai, with the main river continuing on to the Poondi lake. The stream travels from Poondi Reservoir via Thiruvallur District, the Chennai Metropolitan Area, and Ennore Creek before joining the sea.

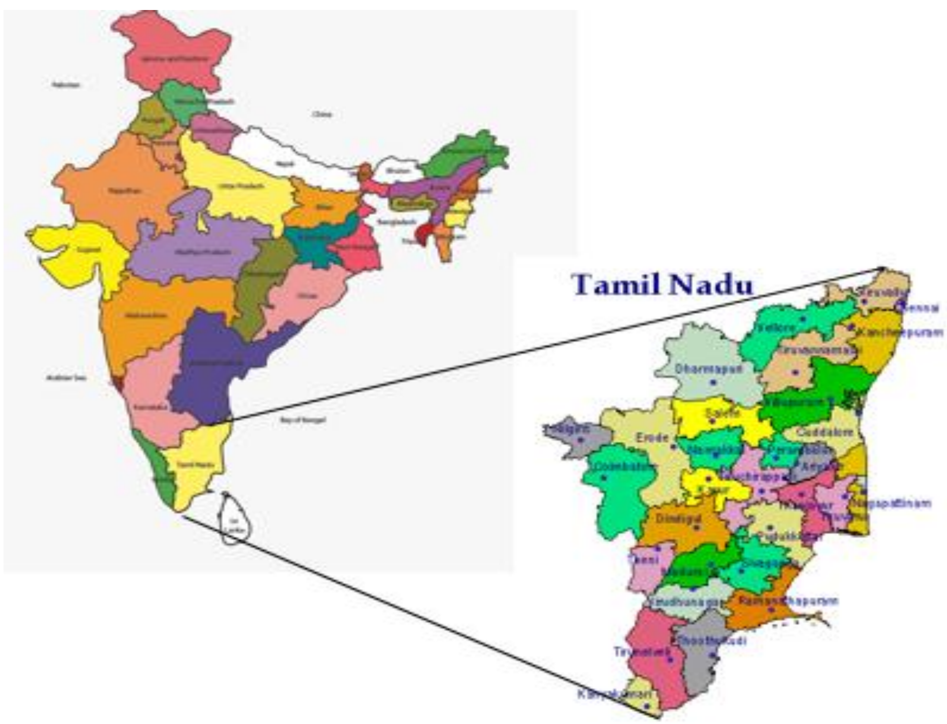
Nine check barriers line the river. Two check ponds are located at Vallur and Tamaraipakkam across the river. The Tamarapakkam Anicut, which is situated across the river and upstream of Poondi reservoir, regulates the excess flow into the river. A tiny check dam called Vallur Anicut was built across the river near Minjur to regulate levels of water and provide irrigation channels nearby. It flows through the Chennai metropolitan area for a stretch of 16 kilometres (10 mi). The river's catchment is 3,757 km2 (2,334 mi), and its bed width is between 150 and 250 m. (490 to 820 ft).As during monsoon, the river can discharge flood water at a rate of up to 50,000 cubic feet per second (1,400 m3/s) into the sea at Ennore Stream. To feed water to the Krishna River from Srisailam Lake in the Nagari basin of the Chitoor district, the Galeru Nagari irrigation project is currently being implemented. Every year, a sizable amount of water is released into the sea via the Kosasthalaiyar River close to Ennore Creek once the floodgates of Poondi reservoir are opened. At the a cost of million, construction on the 10th check dam across the river is anticipated to be finished by the end in 2018. The bridge would span the 100-meter-wide river and be 1.5 metres high. For more than two kilometres, the stream would be filled with water.

Ennore estuary is located at 13^{0}13’58”N 80^{0}19’52”E located in Ennore, Chennai along the Coromandel coast of Bay of Bengal. As Kosasthalaiyar river water get mix with Ennore estuary, the part of the river from North Chennai Thermal Power Station (NCTPS) to Ennore Thermal Power station comes under study area.Part of Kosasthalaiyar river near North Chennai Thermal Power Station (NCTPS) is located at 13^{0}15’16”N 80^{0}18’53”E and southern part of the river near Ennore Thermal Power station is located at 13^{0}12’05”N 80^{0}18’23”E.

Flooding water from the river flows into the ocean at a rate of up to 50,000 cubic feet per second (1,400 m3/s) through Ennore Creek. Birimian deposit meta-sedimentary and meta-volcanic rocks are used to define the region. The morpho rocks, which make up the northwest half of the region, are reduced metamorphic rocks connected to mica-rich granitoid of the "basin" type (Kesse, 1985; Nude et al., 2011, Naik et al 2022, Mukherjee et al 2022, Khadanga et al 2022). Basalts agglomerated with kilometres dominate the morpho group, which is separated from the morpho group by the main Obuasi mineralized shear zone.kind high-sulfide The region's gold ore is composed of gold mineralization, and the pathfinder minerals are pyrites and arsenopyrites (Osae et al., 1995). Fe, As, Pd, Sb, Cu, Zn, S, and Au are the main geochemical fingerprints of the mineralization and are used to categorise the ore (Oberthu et al., 1994). Structure in the region regulates mineralized zones.

2.2 Surveying and mapping

A Geographic Positioning System was used to map the community's sources of water, including boreholes, hand dug wells, springs, and streams (GPS). The variety of water points of supply within a 100 m, 200 m, 300 m, and beyond 400 m radial distance of a active mine site was determined by laying out these supply locations on the region's topographic map in accordance with federal rules and rigs regarding the minimum distance from energizing mining to water points. The drainage map was also used to plan the sampling sites for the investigation shown in Figure 1, as well as to establish the flow direction and its connection to the mineral processing facilities where discharges are discharged directly into the river.



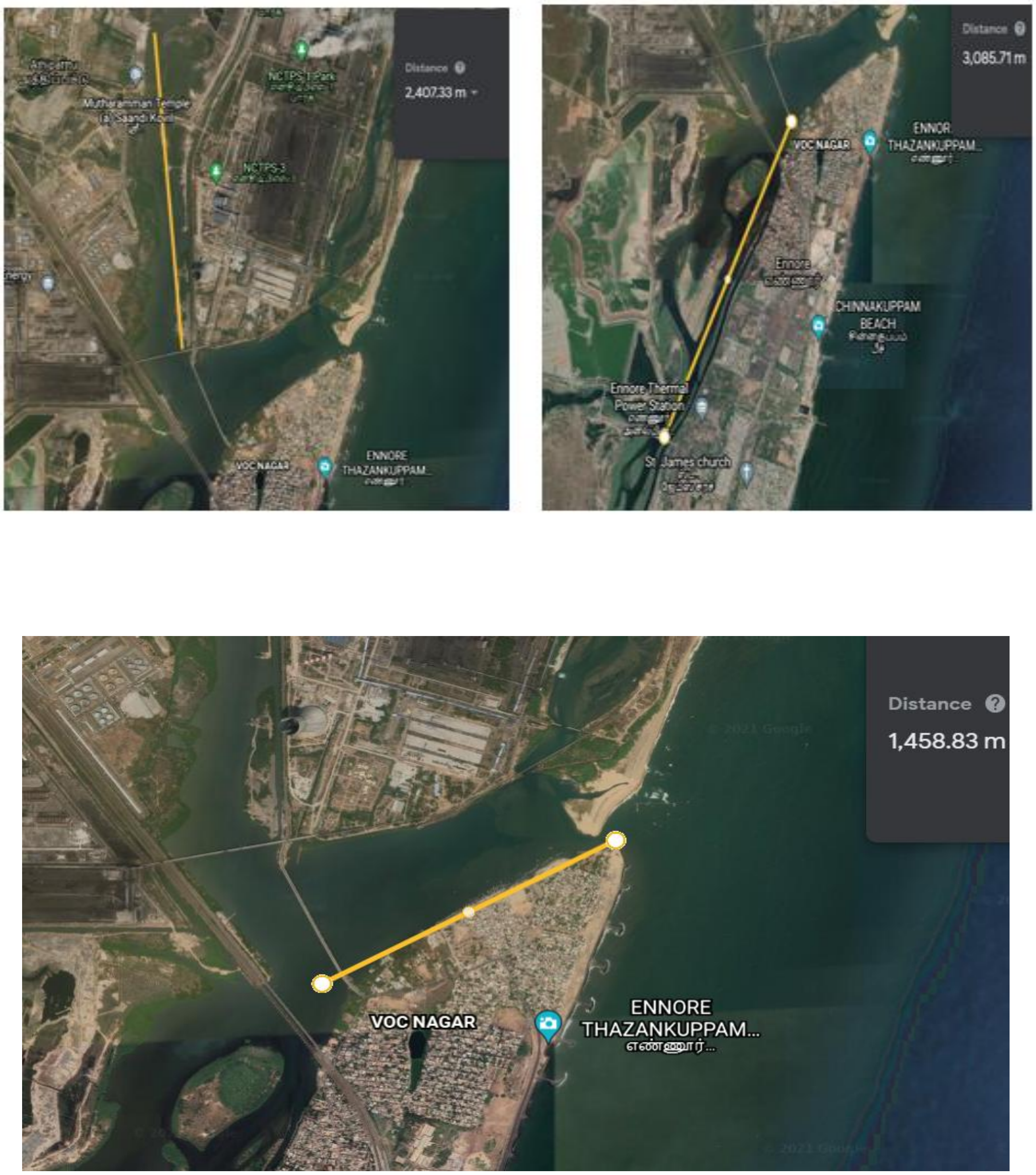


Figure 1 Sampling location map of the study area

3. Materials and methods

Ten samples have been at random taken with a mud grab from the unbroken bottom sediment's upper 0 to 2 cm, and the precise coordinates of the sampling spots were noted utilizing a GPS tracker (Shaari etal., 2015). Figure 1 displays the sampling sites. After that, sediment samples were stored for later analysis in pristine self-sealing bags (Obaidy etal.,2014). Approximately 1g of dried surface sediments were digested with 14ml of aqua-regia solution at 110 °C for 90 minutes (HNO_3:HCl). 14 ml of aqua-regia were poured and warmed at 110 °C for

30 minutes after chilling. Particle emissions spectrometry after the digestion samples are passed through with a 0.45 m filter (Alomary &Belhadj,2007; Ashrafetal.,2012; Moukhchan etal.,2013; Ali etal.,2014). To study the silt quality, maps of digitised contour lines were created using ArcGIS9.1 software. As a result, the most polluted areas were identified (Saadet etal.,2014, 2016, Supriya et al 2020, Selvaraj et al 2019, Neelavannan et al 2021).

Other ways should be used in order to comprehend the current environmental problem and the level of contamination by heavy metals with regard to the natural ecosystem. The metal enrichment relative to baseline values can be utilized to determine the human impact to a selected heavy metals in marine sediment. The Geo-accumulation Index (Igeo), which has been completing the initial by Muller (1979) to detect trace metals in sediment, is a standard concept to evaluate pollution from heavy metals in sedimentary rocks. It may be calculated using the equation that follows.

$$Igeo = log_2\left[\frac{C_n}{1.5B_n}\right]$$

where Bn is the geological baseline value and Cn is the component 'n' content.

To evaluate trace metals was investigated sediment in a much more thorough manner (Tesfamaria.,2016). With regard to a standard metal, this approach normalises the measured concentration of heavy metals (Veerasingam etal.,2012, Vinothkannan et al 2020, Yogeshwaran et al 2022, Khadanga et al 2022). Nirmala et al. (2016) state that there doxsensitive ferrous hydroxyl (Fe(OH)3) and oxides under oxidizing conditions are major sinks of heavy metals in aquatic ecosystems in the instance of iron. Even a small can alter how heavy metals are distributed. In order to distinguish between natural and anthropogenic elements, Fe was utilised as a conservative trace.

$$\mathrm{EF} = M_x \times \mathrm{Fe}_b / M_b \times \mathrm{Fe}_x$$

where Mx is the percentage of the hard rock in the soil sample, Fe_x is the concentration of iron in the sediment, and Mb and Fe_b are the percentages of the metals in acceptable backdrop / baseline reference materials

4. Results and discussion

These information were conducted with XLSTAT2016 in order to analyses the levels of heavy metals' contents in sand from the Kosasthalaiyar River, south east coast of India. to ascertain connection and the variations in concentration between several sites. The most popular multidimensional analysis tool used in environmental research is principal component analysis. It is used to minimize data and extract a limited number of latent variables for examining relationships among observable. Table 1 lists the varying levels of heavy metals

Table 1 Heavy metal concentrations(ppm) for the study area

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	
METALS	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	MEAN
Mn	0.063	0.082	0.068	0.046	0.091	0.065	0.091	0.081	0.065	0.027	0.0679
Cu	0.54	0.63	0.52	0.36	0.59	0.49	0.82	0.63	0.49	0.09	0.5160
Zn	0.52	0.56	0.49	1.1	0.84	0.76	0.59	0.81	1.2	0.12	0.6990
Cr	0.21	0.32	0.25	0.19	0.23	0.21	0.41	0.28	0.23	0.06	0.2390
Pb	0.034	0.041	0.036	0.022	0.043	0.028	0.021	0.019	0.032	0.013	0.0289
Ni	0.72	0.91	0.86	0.57	0.79	0.68	1.02	0.61	0.56	0.21	0.6930
Cd	0.91	1.12	0.86	0.67	0.91	0.87	1.14	0.81	0.92	0.09	0.8300
Fe	0.37	0.26	0.44	0.1	0.2	0.24	0.5	0.06	0.33	0.29	0.2790
Al	0.061	0.048	0.052	0.036	0.039	0.058	0.041	0.032	0.028	0.0025	0.0398
Ca	84.5	92.2	80.6	80.6	84.5	92.2	88.3	84.5	76.8	88.3	85.2500

These findings suggest that Fe, Mn, and Cr concentrations varied more between sampling locations than other elements, which exhibited a steady trend. Ca > Mn4 > Zn4 > Cr4 > Ni4 > Pb4 >Cu4 > Cd was the average amount of heavy metals that was on the decline.At every station, Fe had the greatest value while Cd had the lowest.

These levels were comparable to those found in the Obuasi region by earlier researchers who dug 50 cm into the sediment (Antwi-Agyei et al., 2009; Boateng et al., 2012, Suyatna et al

2019, Kondo et al 2021). Hg, on the other side, was extremely low in the soil (below the detection), despite being the chemical employed by artisanal miners in the region to separate gold from concentrated ore. This could be due to the miners repeatedly reusing the Hg until it is exhausted before releasing the effluents into the ecosystem.According to Martin and Meybeck's (1979) classification system, the CF for Cu, Fe, Mn, and Zn in the sediment were low since they were less than 1 (Fig. 3(c)). Nevertheless, Pb and As contamination levels in the soil were moderate and high, correspondingly. The high CF values for As are attributable to its relationship with the ore extracted in the study area and are consistent with work done by Boateng et al. (2012) in the Obuasi area. Sedimentationmay result from its quick weathering as a result of the ore's exposure to the environment during mining operations. At a depth of 20 cm compared to a depth of 40 cm, the As concentration was greater.

Table 2 The pollution load index for sampling stations in the sediment

	SEDIMENT SAMPLES		**ENNORE**	**(in ppm)**						
METALS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Mn	102	106	110	78.9	89.7	80.5	95.7	78.6	97.4	92.4
Cu	15.2	14.3	12.7	18.9	13.4	10.5	8.65	11.3	12.5	15.6
Zn	18.6	42.3	29.6	27.8	25.4	26.9	34.6	36.7	38.9	34.2
Cr	80.7	54.8	76.9	75.8	34.8	25.8	30.5	46.2	72.3	94.5
Hg	BDL (DL-0.3)	BDL (DL-0.3)	BDL (DL-0.3)	BDL (DL-0.3)	BDL (DL-0.3)	BDL (DL-0.3)	BDL (DL-0.3)	BDL (DL-0.3)	BDL (DL-0.3)	BDL (DL-0.3)
Pb	38.6	42.5	54.2	28.6	21.7	26.8	35.6	47.8	42.5	55.4
Ni	16.5	22.1	24.6	18.2	15.1	12.3	10.5	22.4	15.8	9.8
Al	1.24	1.12	0.98	0.75	0.87	0.65	0.73	0.89	1.24	0.62
Ca	120	158	142	163	125	175	89.6	107	134	168
Si	5.2	5.4	6.2	5.8	6.1	5.9	5.8	4.9	5.5	4.1
Ti	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)
Ag	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)	BDL(DL-0.02)
Co	0.12	0.14	0.11	0.08	0.07	0.09	0.05	0.06	0.11	0.06

Cd	1.45	1.68	1.55	2.21	1.75	1.34	2.66	2.78	1.25	1.69
Mo	0.62	0.54	0.57	0.69	0.42	0.34	0.38	0.41	0.35	0.46
Chloride	4800			5500	5900	5400	6100	5200	5400	3800

The EF levels for the toxic substances recorded in the coastal sediments are represented by the enrichment factor (EF). Cd, Pb, Zn, Cu, Cr, Ni, Mn, Fe represented the decreasing trend of enrichment factors for average contents. Cd indexed extraordinarily high level at stations TP-7 and TP-8 using the above contamination parameters, with 42% of the stations demonstrating really high saturation. For 50% of the sites, Pb content was noticeable. The considerable enrichment was present in the other 50% of a stations. At the TP-7 site, Zn showed significant concentration, and at 70% of the places, it showed moderate richness. 70% of the locations indicated a moderate enrichment in Cu. 25% of the sites displayed a moderate concentration of Cr and Ni. The additional heavy metals (Fe and Mn) also showed little or very little enrichment everywhere.

PLI readings from across all sampling sites were below one, suggesting that all examined toxic metals at all sites were in the basal values, as according Tomilson et al. (1980). The zone's PLI value varies from 0.05 to 2.30. (Fig. 9). Because of the influence of indirect foreign factors including fertilizer runoff, industrial processes, and other human inputs, Cd showed higher(41) values. According to the GESAMP (1985), Cd is produced by the erosion of sulfur-bearing ores, phos- s.n, thermally mineralized rocks, and black shale deposits, as well as industrial wastes, municipal wastewater effluents, and sludge. When contrasted to their concentrations in the global sediment. The disparity in indices arises from the varying sensitivity of the these indicators to certain sediment contaminants (Praveena et al.,2007).

5. Conclusions

The investigation of total heavy metal contents and their distribution reveals that sediment from the Kosasthalaiyar river is polluted with heavy metals, which is a result of the area's intense anthropogenic strain. The largest levels of the analyzed, which is linked to Buckingham Canals and other farm and aquatic effluents and is located at the third intake (northern side of the research region). The use of confirmation factors and correlation research, both of which were employed in this study, is essential for a deeper comprehension of the complexities of the pollutants. The association of the percentage data showed connections between the components Fe, Mn, Cr, Cu, Ni, Pb, Zn, and Cd that were both beneficial and detrimental. Also it showed that these ions had intricate geochemical properties. These normal data were broken down into three primary components using factor analysis, each of which was linked to a separate potential source of contributions. Three components, Mn, Fe, Cr, Zn, Ni, and Cu in the first component, Cd in the next, and Pb in the third, together accounted for 92% of the overall variation.Hence, it can be seen that small - scale mining in the region contaminates a surface river; as a result, it must be controlled in order to minimize pollution, protect waterways from much further contaminating it, and lessen its negative effects on human health.

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