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HEAVY METAL CONTAMINATION AND POLLUTION LOAD INDEX IN ESTUARINE ENVIRONMENT OF TAPI RIVER, INDIA

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Key words*: Tapi estuary, Heavy metal, Contamination factor, Pollution load index.*

Abstract – Investigation was carried out on water quality in terms of heavy metals contamination and its concentration using to compute the pollution load index and contamination factor in estuarine environment of Tapi River, Gujarat (India). The water samples were collected at monthly interval during January 2014 to September 2014 from Hazira estuary of the Tapi river and heavy metals such as cadmium, chromium$^{(Hexa)}$, lead and cobalt were analyzed. The heavy metals Cd (0.096±0.014), $Cr^{(Hexa)}$ (0.094±0.014), Pb (0.713±0.041) and Co (0.132±0.019) were observed during the study which revealed that the estuarine area of Tapi river is heavily contaminated by heavy metals and were verified by contamination factor of Pb (139.80) < Co (12.00) < Cd (8.73) < $Cr^{(Hexa)}$ (0.94) and pollution load index (10.83). The possible sources of such contamination in Tapi estuary water are direct discharges of industrial effluents. To conserve these water resources, it is advised that entry of such pollutants should be stopped, need to implement the appropriate management policy and strictly follow the rules & regulation to discharge effluents.

INTRODUCTION

Rivers are considered as lifeline for human beings but now a days these are polluted by different natural as well as anthropogenic activity like industrial effluents, domestic sewage and agricultural components. The increased industrial activities and other activities like agricultural and domestic sources increase the pollution stress (Ajayi and Osibanjo, 1981). Industrial development and discharged effluents are the major threats to the surface water (Moorthy and Jeyabalan, 2012) and input of these pollutants are responsible to increase the contamination of heavy metals in the river water (Reza and Singh, 2010). The heavy metal also increased by atmospheric releases from fossil fuels burning, land run-off and releases from industrial operations such as mining, canning and electroplating (Fostner and Wittman, 1979; Marr and Creasser, 1983). It reached toxic after accumulation in the body of flora and fauna which passes through the food chain of fish to man (Ayodele and Abubakar, 2001). Although some of these metals may be essential for human and some of our hazardous for human metabolism especially when their concentration is high (Sheriff *et al.*, 1979). The higher concentration of metals causing damage to nervous system and internal organs (Lee *et al.*, 2007; Lohani *et al.*, 2008). The current state of the river is serious concern and in order to address the pollution crisis effectively, it is important to first understand the causes of pollution (Malik *et al.*, 2014) so the many researcher worked on the heavy metal pollution in different resources (Malik and Sawant, 2013; Ghorade *et al.*, 2014; Reza and Singh, 2010; Singh and Singhchandel, 2006; Edokpayi *et al.*, 1996; Dubey and Ujjania, 2014; Pandey *et al.*, 2014 and Venkatesharaju *et al.*, 2013). These metals are hazardous for human life so it is essential to assess the heavy metal contamination and management of aquatic resources. Accordingly, present study entitled "Heavy metal contamination and pollution load index in estuarine environment of Tapi river, India" was conducted.

MATERIALS AND METHODS

Water sample collection, preservation and analysis

Water samples for the present study were collected from Hazira estuary of Tapi river (Fig. 1) in 1L

capacity of sterilized bottles at every three months during January 2014 to September 2014. These collected water samples were preserved and digested with HNO_3 acid method to follow the APHA (2005). Analysis of processed water samples were carried out by Atomic Absorption Spectrophotometer (AAS) at Department of Biosciences, VNSGU, Surat.

Statistical analysis

Contamination factor (CF): A contamination factor (CF) to describe the contamination of a given toxic substance in water sources (Håkanson, 1980). The contamination factor is the ratio of observed concentration and background value of each metal which was obtained by dividing the observed concentration of metal in the water by the background value of metals (Moor, 1991 and NEBR, 1994).

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

Where,

CF = contamination factor

C metal = observed metal concentration in water samples

C Background value = background value of the metal

Pollution Load Index (PLI): Indicate the degree of pollution "n" of at the estuarine environment (Håkanson, 1980). It is the root of "n" number powered by the multiplication of contamination factor values (Tomilson *et al.*, 1980).

$$PLI = (CF1 \times CF2 \times CF3 \times \cdots\cdots \times CFn)^{1/n}$$

Where,

n = is the number of metals and CF = is the contamination factor.

RESULTS AND DISCUSSION

Heavy metals concentration

Cadmium is found in water from geochemical processes such as chemical composition of rock, minerals (Alloway, 1995) and it formed in waste water from chemical industries, electroplating, mining waste, nickel-cadmium batteries, certain pigments used for plastics stabilizing and pesticides. In present study, it was observed 0.096±0.014 mg/l (Table 1) in estuarine water which was beyond permissible limits of (Moor, 1991 and NEBR, 1994).

Chromium$^{(Hexa)}$ is one of the most naturally distributed heavy metal in crust of the earth. It is normally found in two oxidation states as trivalent and hexavalent (Goel, 2006). Chromium$^{(Hexa)}$ is highly toxic to the organisms and its concentration was observed 0.094±0.014 mg/l (Table 1) which was below to the recommended standards.

Lead is a toxic element and mostly found in the natural environment in the form of minerals and sparingly soluble in water even when present in extremely low concentration. An anthropogenic source such as industrial waste discharge from metal processing industries, electric equipment's, plastics, chemical industries, dye works etc. may contribute to increase the pollution in water body (Trivedy and Goel, 1986). In this study, value of lead concentration 0.713±0.014 mg/l (Table 1) higher than the permissible limits of Moor (1991) and NEBR (1994).

Cobalt is generally found in the earth crust and environmentally it is attributed by natural and anthropogenic sources. Its natural sources are erosion, weathering of rocks and soil, seawater spray, volcanoes and forest fires while the anthropogenic sources such as mining, sewage

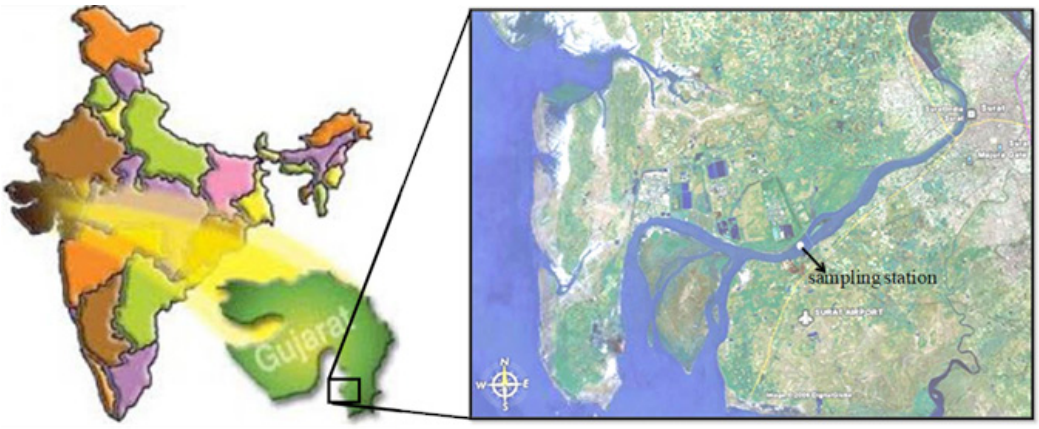

Fig. 1. Map of study site in estuarine region of Tapi River

Table 1. Contamination factor (CF) & Pollution load index (PLI)

Heavy Metals	C ± SE	Ci	CF	PLI
Cadmium	0.096±0.014	0.01*	8.73	**10.83**
Chromium (Hexa)	0.094±0.014	0.10*	0.94	
Lead	0.713±0.041	0.01*	139.80	
Cobalt	0.132±0.019	0.01*	12.00	

C=conc. of real value, Ci=Background value, CF=Contamination factor and PLI=Pollution load index *Moor (1991) and NEBR (1994).

sludge, phosphate fertilizers, fossil fuels processing of cobalt alloys and petroleum industries wastes (Smith and Carson, 1981) and it observed 0.132±0.019 mg/l (Table 1) which was beyond the permissible limits in estuarine water.

Contamination Factor (CF) and Pollution Load Index (PLI)

The level of contamination can be expressed by the contamination factor and index value give the status of pollution (Håkanson, 1980) so they are correlated to each other. Among the heavy metal's concentration the CF values of chromium(Hexa) (0.94) which was (CF<1) and considered low contamination whereas CF values of cadmium (8.73), cobalt (12.00) and lead (139.80) were (CF ≥ 6) considered highly contaminated and fall under the category (IV). The standard values of contamination factor (CF) are described in Table 2. The metals like Co, Cd and Pb are higher (>1) due to the influence of external various sources like industrial activities, agricultural runoff and other anthropogenic inputs (Adel *et al*., 2011).

Pollution load index (PLI) was found 10.83 (Table 1) which shows that studied area was polluted because resulted value is >1 (Table 3). The possible sources of contamination were industrial pollutants. The estuarine environment of Tapi river is facing industrial pollutants especially with heavy metals (Co, Cd and Pb) possibly that were increased from non-treated industrial waste which discharged to Tapi river. Similar observation was obtained by Withanachchi *et al.* (2018) in Mashavera River, Georgia.

Table 2. Contamination Factor (CF) and its value reference values

Category	Contamination Factor (CF)	Value of CF
I.	Low contamination factor	<1
II.	Moderate contamination factors	1 ≤ - <3
III.	Considerable contamination factors	3 ≤ - <6
IV.	Highly contamination factor	≥ 6

Table 3. Pollution load index (PLI) and under the categories of observer value

S. N.	Pollution load index (PLI)	Value
1.	Non-Polluted	<1
2.	Polluted	>1

CONCLUSION

The results of heavy metal concentrations (chromium (Hexa), cadmium, cobalt and lead) and contamination factor (CF) both are found the similar increasing order Pb < Co < Cd < Cr(Hexa) and pollution load index (PLI) also shows that heavily polluted due to direct discharges of industrial effluents. The sources of heavy metals are industrials effluents which were contributing to environment pollution in the estuary of Tapi River, India.

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