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ENVIRONMENTAL ASSESSMENT OF TAPI ESTUARY, SURAT, GUJARAT WITH REFERENCE TO HEAVY METALS

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Abstract:

Heavy metals are natural constituents of the marine and freshwater environment, generally found in very low concentrations. Human activity has inevitably increased the levels of metal ions in many of these natural water systems. The dynamic coastal and marine waters are frequently polluted by metals that affect the biota. Concentrations of mercury (Hg), cadmium (Cd), lead (Pb) and zinc (Zn) were observed in water samples collected from Tapi estuary were monitored spatially for two years to understand their distribution in estuary. The average value of heavy metals distribution in water was in order Pb>Zn>Cd> Hg in both the sampling years (2011-12 and 2012-13) from all the studied three sites, Dumas, Magdalla and Hazira.The levels of heavy metals were higher than the permissible limits recommended by statuary bodies. The statistical analysis concluded that there was significant difference in the average values of mercury, cadmium, lead and zinc between different sites in water in the year 2011-2012, $P<0.05$ at the significance level of 95%. The statistical analyses also exposed significant difference in the average values of mercury, cadmium, lead and zinc in water between different sites. The result of the present study concluded that the Tapi estuary had higher pollutants that need to be monitored regularly and conservation actions required to be implemented by the agencies and responsible bodies.

Key Words: Pollution; Heavy Metals; Statistical Analysis & Monitoring

Introduction:

Coastal environments, especially estuaries are under serious threat due to urbanization and industrialization. Estuaries are characterized with high biological productivity, providing habitat to organisms either during the larval stage and/or for their entire life cycle. These productive ecosystems are constantly under stress from various pollutants such as metals, persistent organic compounds, pesticides and hydrocarbons. Heavy metals are natural constituents of the environment, but the increase in their concentrations has been reported extensively in many coastal environments. In the recent past, a great volume of scientific literature has been reviewed concerning the sources, fate and transport, toxicity, mode of action and bioaccumulation of metals in food chain organisms in the coastal realms (Tao et.al, 2012). Both natural and anthropogenic activities are responsible for the abundance of heavy metals in the environment (Khan et al., 2008).Effluents from mining, electroplating, metallurgy, machinery, automobile, refinery, combustion of coal/fuel oil, agriculture and domestic are discharging metals into coastal waters (Burakov et al, 2018). Metals tend to adsorb from water columns onto surfaces of particles and they are settled into the sediment. Metals can be accumulated in the tissues of marine organisms from the water, sediment, suspended particulate materials. Several studies have demonstrated metal contamination in seawater, sediments and bioaccumulation in coastal and estuarine ecosystems of India (Surana et al, 2019; Surana et. al, 2015; Dhanakumar et al, 2015; Bhuvaneshwari et al, 2012; and Gupta et al, 2009). The increasing pollution by heavy metals have a significant adverse health effects for invertebrates, fish, and humans (Martin et al., 2015). Bioaccumulation is the indication of bioavailability and it could be a biomarker of metal pollution. Bio-indicator organisms are able to bio-accumulate metals from contaminated ambient environments (Duarte et al, 2020). A comprehensive study of metal contamination during different period around India revealed that estuaries are affected by pollutants (Chakraborty et al, 2014). Padmini and Rani (2009) in their study of Ennoreestuary revealed that the influence of discharge from various industries and waste water from municipal sewage has adverse impact on estuarine environment. Priority metals viz. Cu, Cr, Cd, Pb and Ni are increasing globally in the inland and coastal waters especially regions of developing countries like India (Li et al, 2019). Thus, it is vital to explore the status of heavy metal pollution in estuarine samples. In view of the above facts, the present study was undertaken to monitor metal concentrations in water from three major locations of Tapi estuary with respect to the pollution sources.

Materials and Methods:

Study Area:

Dumas (Site 1) is the mouth of the estuary in the southern bank 16 Km away from Surat city at 21^{o} 06’ 21.71” N and 72^{o} 42’ 15.33” E. Magdalla (Site 2) is situated in the south of Gujarat about 15 km from Surat city at 21^{o} 08’47.13” N and 72^{o} 45’ 7.81” E. Hazira (Site 3) is located on the bank of Tapi River near the Arabian Sea at 21^{o} 08’ 10.53” N and 72^{o}” 39’ 46.33” E.

Sample Collection:

Water samples were collected every month in the morning during low tide from June 2011 to May 2013. Plastic containers used for water sample collection were cleaned with dilute HNO_3 and detergent followed by distilled water prior to sample collection. Containers were again rinsed with sampling water before collecting water samples. Samples for heavy metals analysis were collected and acidified with concentrated nitric acid. The collected samples were brought to the laboratory for further analyses.

Heavy Metals Analysis:

Four heavy metals viz. mercury, cadmium, lead and zinc in the water samples were estimated using Atomic Absorbance Spectrophotometer (AAS) after pre concentration by evaporation of unfiltered samples in the presence of HNO_3.

Procedure:

Acid preserved water sample (100 ml) was taken in a beaker and 10 ml of nitric acid was added. It was then brought to a slow boil and evaporated on a hot plate to the lowest volume possible (about 10 to 20 ml) before precipitation occurred. Heating was continued with the addition of concentrated nitric acid till digestion was completed indicating a light-colored clear solution. Care was taken not to let sample get dried during the digestion. Beaker wall was washed with distilled water and volume was made up to 100 ml by adding distilled water. The sample was then filtered and the filtrate was collected for AAS analysis.

Calculation:

The reading was noted against standard curve in mg/L.

Result and Discussion:

The descriptive statistics of the obtained result of the study is revealed in Table 1. The average variation of heavy metals concentrations in water samples are depicted in Figs. 1 to 4. Concentration of mercury was higher from Dumas in the year 2011-12 whereas from Hazira in 2012-13 (Fig.1). The average concentration of mercury was higher from Dumas showing less fluctuation between Magdalla and Hazira in the year 2011-12 whereas the fluctuation was higher between sites in 2012-13. The average concentration of cadmium was higher from Hazira showing less fluctuation between Magdalla and Dumas in the year 2011-12 whereas less fluctuation was observed between Magdalla and Hazira in 2012-13, fig. 2. The average concentration of lead was in the order Hazira>Magdalla>Dumas in year 2011-12 and Dumas>Hazira>Magdalla in the year 2012-13, fig. 3. The average concentration of zinc was in the order Hazira>Dumas>Magdalla in the year 2011-12 and in the sequence Dumas>Magdalla>Hazira in the year 2012-13, fig. 4. The average value of heavy metals distribution in water was in order Pb>Zn>Cd> Hg in both the sampling years (2011-12 and 2012-13, fig 5).

In an aquatic ecosystem heavy metals are the serious aquatic pollutants and their uptake and accumulation in the aquatic ecosystems, beyond safe limits, would cause direct consequences to the aquatic food chain and ultimately to the human beings. According to Anazawa et al. (2004) aquatic pollution has become more serious concern due to discharges of industrial wastes in aquatic habitats. Heavy metal accumulation affects the ecosystem, by imbibing the toxic chemicals into aquatic biota. The levels of heavy metals are higher than the permissible limits recommended by USEPA (1986). This might be attributed to the huge amounts of raw sewage, agricultural and industrial wastewater discharged into the water bodies and similar observations were revealed by Hardman et al., 1994; Abdel-Moati and El-Sammak, 1997and Mason, 2002. Hg, Cd and Pb are non-essential for living organisms and can pose serious threat in elevated concentrations. Mercury has well characterised toxic effects on both the physiological and the neurological systems of the human bodyPiscator, 1986. The relatively immediate effects of acute lead poisoning are ill defined symptoms, which include nausea, vomiting, abdominal pains, anorexia, constipation, insomnia, anaemia, irritability, mood disturbances and coordination loss. In more severe situations neurological effects such as restlessness, hyperactivity, confusion and impairment of memory can result as well as coma and death, Ferrier, 1986. Acute effects of inhalation are bronchitis and pneumonitis and toxaemia in the liver. Chronic inhalation of cadmium compounds as fumes or dust produces pulmonary emphysema, where the small air sacs of the lungs become distended and eventually destroyed reducing lung capacity. Both the chronic inhalation and oral intakes of cadmium affect the kidneys producing in the first instance proteinuria similar to proximal tubule proteinuria (Tsuchiya, 1981). The enrichment elements, such as, Pb and Cd in the study sites, are probably due to the anthropogenic activities and is associated with river runoff from agricultural and shipping activities. The surrounding study area support heavy industrial and fishing activities which might be among the reasons for elevated level of heavy metals in water samples.

Table 1: Descriptive statistics of the studied heavy metals (2011-2013)

Metals	N	Mean(mg/L)	Std. Deviation	Minimum(mg/L)	Maximum(mg/L)
Mercury	72	0.0039	0.00601	.00	0.04
Cadmium	72	0.0524	0.4139	.00	0.16
Lead	72	0.4255	0.39389	.00	1.49
Zinc	72	0.1220	0.17322	.00	1.26

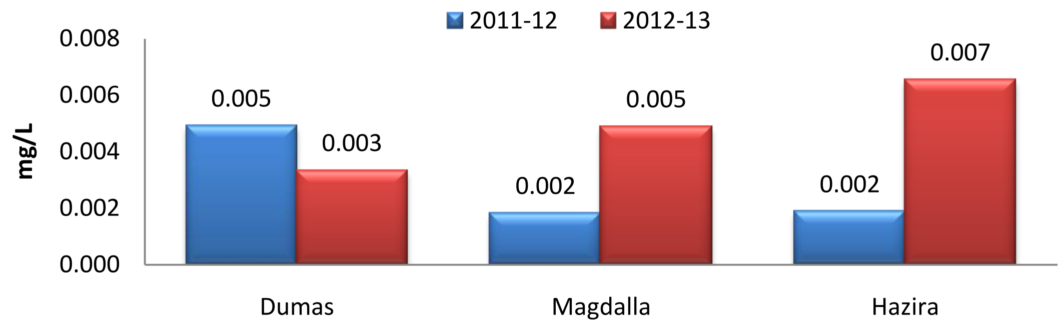

Fig. 1 Mercury in water

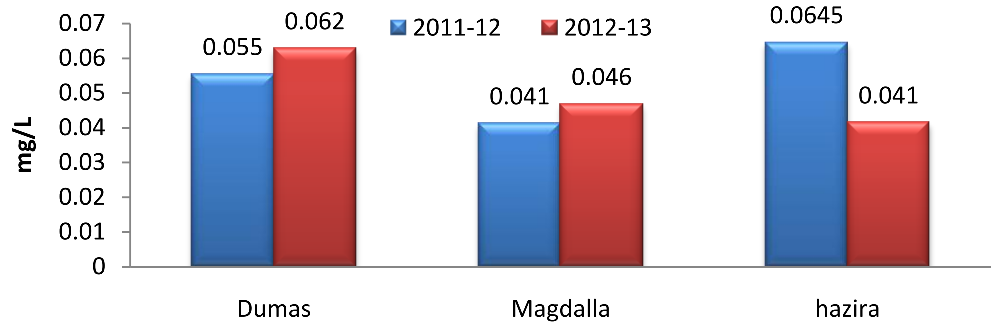

Fig. 2 Cadmium in water

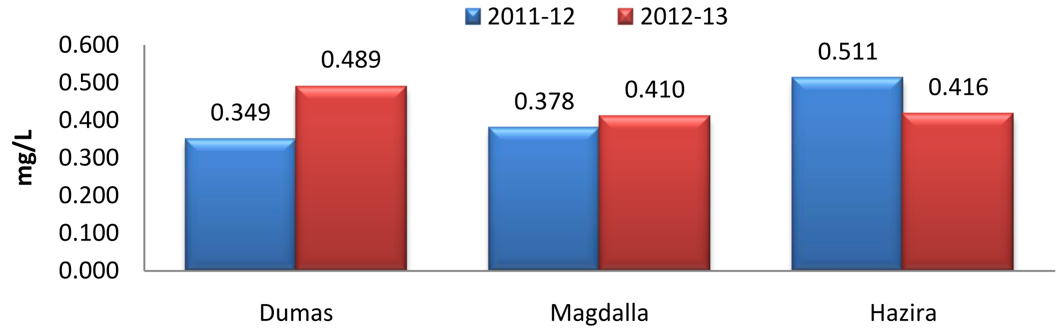

Fig. 3 Lead in water

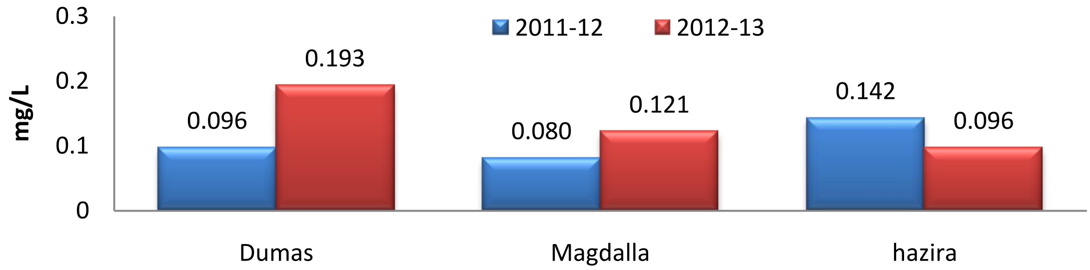

Fig. 4 Zinc in water

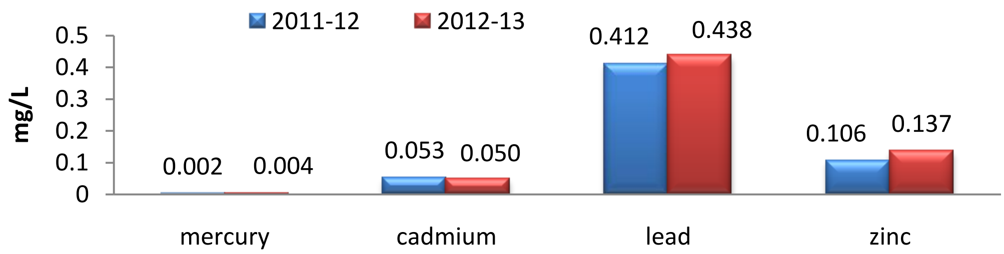

Fig. 5 Distribution of heavy metals in water

Statistical Analyses:

Normality test was run and the data were found non normal in distribution (Table 1). Non parametric test was applied for statistical analysis.

Statistical Analysis between Sampling Sites:

H_0: There is no statistically significant difference between the average values of different heavy metals in water, between the sampling sites.

H_1: There is statistically significant difference between the average values of different heavy metals in water between the sampling sites.

The statistical analysis concluded that there was significant difference in the average values of Mercury, Cadmium, Lead and Zinc between different sites in water in the year 2011-2012, $P<0.05$ at the significance level of 95%. The significant values are depicted in Table 2. The statistical analysis for the year 2012-2013 concluded that there was no significant difference in the average values of mercury, cadmium, lead and zinc between different sites in water $P>0.05$ at the significance level of 95%. The significant values are depicted in Table 2.

Statistical Analysis between Sampling Years:

H_0: There is no statistically significant difference between the average values of different heavy metals in water between the two sampling years.

H_1: There is statistically significant difference between the average values of different heavy metals in water between the two sampling years.

The statistical analysis between two sampling years for Dumas revealed significant difference in all metals whereas only mercury showed difference in Magdalla. The statistical analysis between two sampling years in Hazira showed significant difference in the average values of cadmium and zinc ($p < 0.05$) at the significance level of 95% confidence. Mercury showed no significant differences in the distribution of average concentration in water, $P>0.05$ at the significance level of 95%. The significant values are depicted in Table 3.

Table 1: Test of normality

Heavy metals	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Metals	Statistic	Df	Sig.	Statistic	Df	Sig.
Mercury	.258	72	.000	.634	72	.000
Cadmium	.492	72	.000	.119	72	.000
Lead	.140	72	.001	.902	72	.000
Zinc	.250	72	.000	.583	72	.000

Table 2: Kruskal- Wallis test of heavy metals in water between sites (Dumas,Magdalla and Hazira

Years		Mercury	Cadmium	Lead	Zinc
2011-12	Asymp. Sig.(2-tailed)	0.091	0	0	0
2012-13		0.176	0.317	0.767	0.963

Table 3: Mann-Whitney test for significant difference between sampling years (2011-12&2012-13)

Levels		Mercury	Cadmium	Lead	Zinc
Dumas	Asymp. Sig. (2-tailed)	0.005	0	0	0
Magdalla		0.042	0.862	0.791	0.861
Hazira		0.794	0.007	0.198	0

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