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APPRAISING THE WATER POLLUTION INDEX OF AN ESTUARIAL ENVIRONMENT

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***Abstract*— The WPI is an important tool to summarize a large number of water quality data into simple terms which is one of the most effective ways to interrelate information on water quality trends. The information generated can help to guide policy makers on effective restoration, conservation and management of water resources. In this technique the weightage for various water quality parameters is assigned to be inversely proportional to the recommended standards for the corresponding parameters. Estuaries represent productive aquatic habitats and are characterized by dynamic biogeochemical processes. Water quality loss in estuaries is, therefore, one of the worst forms of water pollution. For the analysis of water parameters, the water samples were collected and preserved in pre-rinsed plastic bottles at monthly intervals during June 2011–May 2013 for the period of two years from the Dumas vicinity of Tapi estuary. Temperature and pH were analyzed in situ and other parameters were analyzed as per standard references. The WPI in the studied area in the first year ranged between 1.2334 to 7.8266 whereas it varied from 1.797 to 6.439 in second year of the study. The higher value of WPI was observed during the month of December and January in the first year and in the month of December in the second year indicating high polluted nature of the estuary. The overall study revealed the polluted nature of the water ranging from mild to severe during different months in the studied area. It was observed that estuarine environment was polluted by the impact of anthropogenic as well as industrial activities. This study is important as understanding the ecological status of the estuarine habitats is imperative for successful environmental management and sustainable development.**

***Keywords*— Pollution, Water quality, Aquatic bodies, harmful effect**

I. INTRODUCTION

Estuaries represent productive aquatic habitats and are characterised by dynamic biogeochemical processes. They provide some of the most invaluable ecosystem resources and services. Besides that, estuaries have drawn much attention as they support the livelihood of a large majority of the human population globally and hence are constantly exposed to anthropogenic perturbations [1]. Various factors such as the geophysical locations, riverine fluxes and other man-made developments influence the environmental status of an estuaries. The estuaries along the west coast of India are largely influenced by intense monsoonal precipitation during the southwest monsoon season and hence experience significant seasonal variations in the physicochemical parameters [2].The WPI is helpful to summarize a large number of water quality data into simple terms which is one of the most effective ways to interconnect information on water quality trends to guide policy makers on effective restoration, conservation and management of water resources.

Earlier studies in the Mandovi and Zuari estuaries showed that due to the rapid increase in anthropogenic activities, the level of terrigenous material entering these estuarine environments along the river discharge has been rising at an alarming which are considered to be the lifeline of Goa [3,4]. Likewise, rivers and estuarine systems around the world are affected by changes in land use, hydrological and biogeochemical cycles mainly driven by the continuous increase in population [5-10]. Land use and climate, in conjunction with geology, are the ultimate determinants of hydrology and water quality, thereby acting as the primary drivers of change in structure and function of rivers [11,12,13]. Thus, predicting response of estuarine system to global changes and local impacts is critical to protect or restore good water quality and ecosystem functioning [10,14]. The importance of time series in aquatic system has been recognized long ago to better understand the long-term changes [5,15,16].

Water quality loss in estuaries is, therefore, one of the worst forms of water pollution [17]. The main causes of decline in quality of the estuarine aquatic bodies are related to water subtraction and releases of agricultural, domestic and industrial effluents [18], altering the physical, chemical and biological properties of water [17,19,20].

Keeping in view the impact of different activities on estuarine environment this study was conducted with an aim to find out WPI of Tapi estuary in Gujarat. The assessment would be helpful to deal with the estuary management to conserve this important ecosystem as Tapi estuary is one of the major estuaries of west coast river systems of India and situated at21^0 40'N and 72^0 40'E.

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II. MATERIAL AND METHODS

For the analysis of water parameters, the water samples were collected and preserved in pre-rinsed plastic bottles at monthly intervals during June 2011–May 2013 for the period of two years from the Dumas vicinity of Tapi estuary. Temperature and pH were analysed in situ and other parameters like dissolved oxygen (DO) conductivity, turbidity, nitrate, nitrite, phosphate, biochemical oxygen demand (BOD), chemical oxygen demand (COD), chloride and TPHC were analysed in the Research Laboratory, Department of Aquatic Biology, VNSGU, Surat. For the preservation and analysis of the water samples, the standard methods were followed [21,22].

Figure 1: Sampling site

As WPI represents the sum of the ratio between the observed parameters and regulated standard values, the WPI was calculated from the observed values of water quality parameters following the equation developed by Milijašević [23].

$$WPI = \sum_{n=1}^{n} \frac{Ai}{T} \times \frac{1}{n}$$

where Ai represents the concentration of the analysed water parameters, T represents the standard values of the water quality and n indicates the number of analyses. Data analysis and graphical presentations were done with Microsoft Excel 20019 and SPSS,2016.

Table 1. Water quality classification according to WPI [24]

Class	Characteristics	WPI
I	Very pure	≤0.3
II	Pure	0.3-1.0
III	Moderately polluted	1.0-2.0
IV	Polluted	2.0-4.0
V	Impure	4.0-6.0
VI	Heavily impure	>6.0

III. RESULT AND DISCUSSION:

The mean temperature among the three sampling sites in the two years of study did not vary much. Mean value of turbidity registered an increase during the second year of study (2012-2013) compared to the first year (2011-2012). The mean concentration of pH increased marginally in the second year in comparison to first year of the study. The fluctuation of average value of sodium was least between two years. The average value of chloride showed fluctuation having higher concentration in the second year of sampling compared to first year. Values of COD fluctuated very significantly during the entire study period. The average value of COD was higher at Dumas in the year 2011-2012. The average concentration was higher in the year 2011-12 compared to 2012-2013 for the nitrite. The average concentration of potassium showed fluctuation with higher value in the year 2012-13 (Fig.2&3).Most of the water quality parameters exceeded the standard limit(Fig. 2 & 3)

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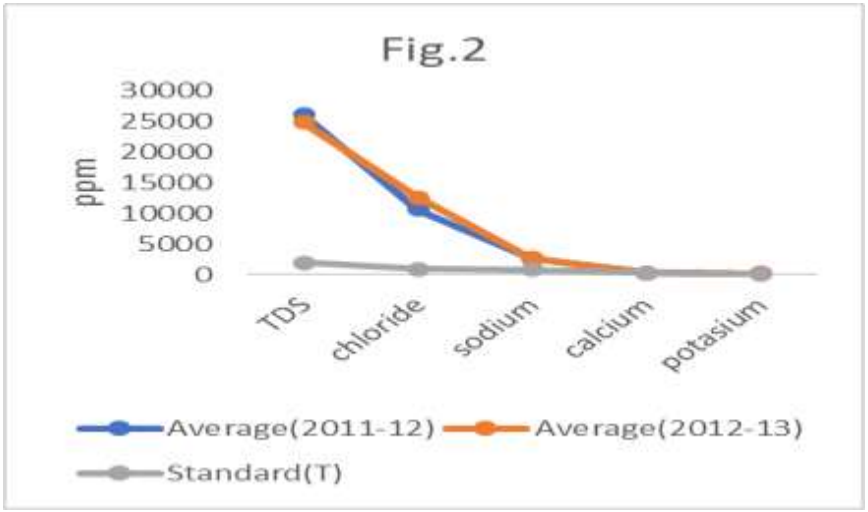

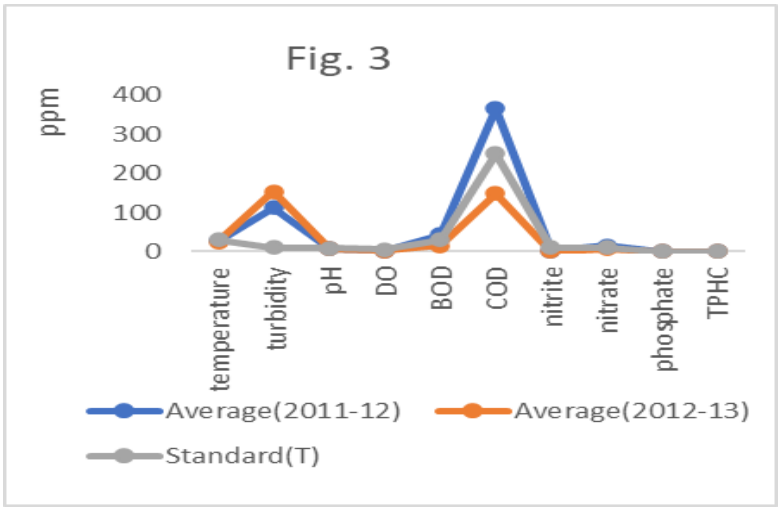

Table 1: Pooled values of water quality parameters and Water Pollution Index(WPI) of estuarine environment for two consecutive years

Parameters	Pooled (2011-12)	Standard(T) [Reference]	A/T*1/n	Pooled Values (2012-13)	A/T*1/n
Temperature	27.417	30 [25]	0.061	26.167	0.058
Turbidity	111.500	10[25]	0.743	153.833	1.026
TDS	26031.250	2000[26]	0.868	24729.417	0.824
pH	7.608	8.5[25]	0.060	7.867	0.062
DO	2.987	5 [27]	0.040	3.003	0.040
BOD	43.560	30[25]	0.097	15.844	0.035
COD	364.500	250[25]	0.097	147.833	0.039
Nitrite	1.977	10[25]	0.013	0.726	0.005
Nitrate	15.538	10[25]	0.104	7.345	0.049
Phosphate	0.164	0.1[25]	0.109	0.136	0.091

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Calcium	405.817	400[26]	0.068	348.716	0.058
Chloride	10594.050	1000[28]	0.706	12570.083	0.838
Sodium	2663.750	920[26]	0.193	2745.875	0.199
Potassium	216.933	15[26]	0.964	249.050	1.107
TPHC	0.635	0.3[29]	0.141	0.254	0.056
WPI=∑ A/T*1/n			4.264		4.487

n=15(Number of parameters studied)

According to the obtained WPI values, the estuarine water is classified into different classes (Table 1). If the value of WPI < 1, the water site is marked as pure, if WPI > 2, the water area is polluted, and if WPI > 6, the water in that area belongs to the group of heavily impure waters [24].

The WPI in the studied area in the first year ranged from 1.2334 to 7.8266 whereas it varied from 1.797 to 6.439 (Fig. 4 and 5). The higher value of WPI was observed during the month of December and January in the first year and in the month of December in the second year. The study revealed the polluted nature of the water in the study area.

A lower value of WPI would indicate a better Water Quality whereas high values indicate poor quality of water. The traditional WPI take into consideration DO, BOD, pH, faecal coliforms, nitrate, phosphate, turbidity, temperature and total solids [30]. The water of this estuary was less poor in monsoon season compared to post monsoon period. The reason behind might be the dilution of water through the heavy rain water during monsoon, while during pre and post monsoon period the flowing rate of water decreased hence the organic and inorganic component contamination was increased. These Water quality index ranks revealed that the estuarine water of the Tapi River was affected by increasing anthropogenic activities as well as agricultural and industrial runoff occurred in surrounding area. Hence, this area can degrade the water quality and making it unfit for public use and aquatic life.

According to Table 2, it can be concluded that water pollution index ranked higher in 2012-13 compared to 2011-12. However, no significant difference was found between two years as revealed by Mann-Whitney Test($p > 0.05$)

The outcomes of this investigation revealed the quality assessment of the estuarine water body of Tapi River from Dumas areas for two consecutive years. This study highlighted poor water quality conditions of estuary in association with various physico-chemical parameters. The water quality variables showed fluctuations. Higher contaminations of components were found during pre and post monsoon then monsoon season. This might be due to the dilution of pollutants during monsoon season. This monitoring field study provides an informative preliminary data about water quality variables and helps to understand the quality status of water bodies. The Water quality index revealed that the estuarine water of the Tapi River was affected by increasing anthropogenic activities as well as agricultural and industrial runoff occurred in surrounding area. Hence, this area can degrade the water quality and making it unfit for public use.

Similar findings on water quality of Tapi estuary were described earlier and it was considered as polluted with input sources from industries, domestic and anthropogenic activities [31-35]. Many reports are also available on the polluted aspect of physico-chemical features of various estuaries from India [36,37,38]. Water quality of Damanganga and Par Estuary was also found to be of poor quality and exhibited polluted nature of the estuary [39,40].

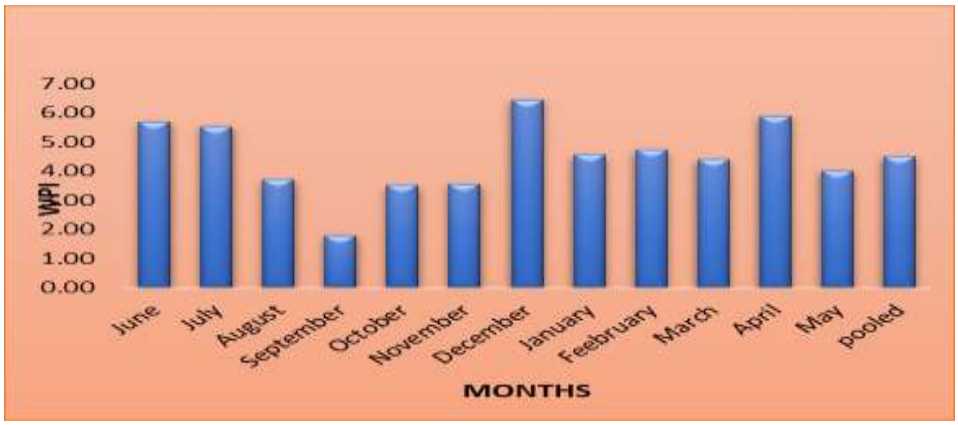

Fig. 4: WPI for the year 2011-12

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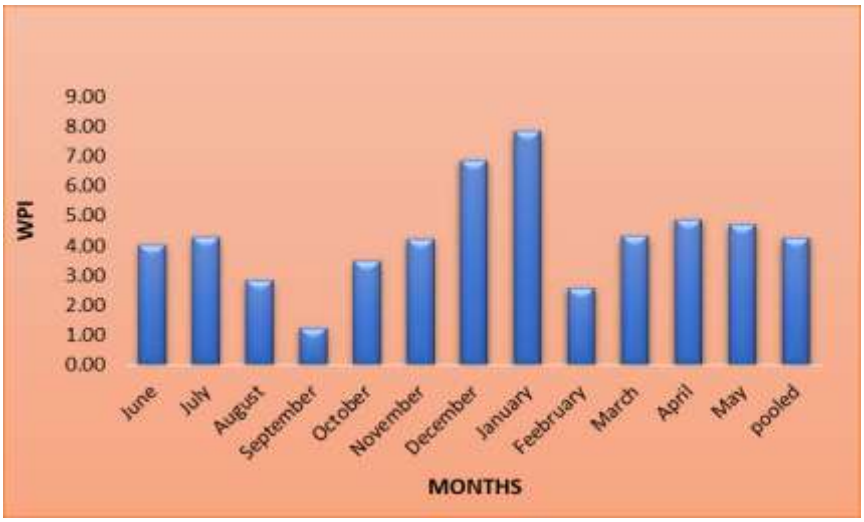

Fig. 5: WPI for the year 2012-13

Table 2. Mann-Whitney Test

	2011-2012	N	Mean Rank	Sum of Ranks	Test statistics	
WPI	2011-2012	12	11.58	139.00	Mann-Whitney U	61.000
	2012-2013	12	13.42	161.00	Wilcoxon W	139.000
	Total	24			Asymp. Sig. (2-tailed)	.525

IV.CONCLUSION

This study summarized the pollution status of the Tapi estuary with reference to physico-chemical parameters and evaluated the pollution status through the computed values of WPI. Water quality index of the studied area revealed that the estuarine water of the Tapi River was affected by increasing anthropogenic activities as well as agricultural and industrial runoff occurred in surrounding area. Hence the poor water quality can make it unfit for public use and aquatic life.

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