Temporal variation in the nutrient fluxes in Narmada estuary

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Present study consists the temporal changes in the fluxes of the macronutrients in Narmada estuary between the years 2005 and 2010. Temperature, salinity, nitrogen and phosphates were studied. One way ANOVA test was performed and the results suggest difference over the period of time in the parameters like temperature, salinity, nitrates, phosphates and total Phosphates at different level of significance. There is noted increase in certain nutrients over the period of time. The study infers that the effluent flow, sewage drainage, catchment runoff and the tides are having great influence on the macronutrient fluxes.

[Keywords: Narmada Estuary, Nitrogen, Phosphates, Physico-chemical, Nutrients, Gulf of Khabhat]

Introduction

Estuaries are among the most productive ecosystems and the nutrients are constantly maintained in the sediment and water column. Estuaries play an important role in the biogeochemical cycling of nutrients and are important regions of research between land-ocean interactions and for quantifying fluxes of materials from terrestrial sources anthropogenic activities. Over recent decades, due to the changing agricultural practices and increased wastewater inflow the concentration of nutrients in some rivers have increased resulting in the eutrophication of estuarine ecosystems world wide. Further, the increase in near shore activities has escalated the addition of nutrients into the estuaries. The estuaries of the Indian subcontinent have a different pattern as these are under profound influence of monsoons which adds to its dynamic nature. Despite being under intense demographic, economic and ecological pressures, estuarine areas provide highly valuable ecosystem benefits for humans.

Gujarat is blessed with the longest coast line and two Gulfs: The Gulf of Kachchh and The Gulf of Khabhat. The main rivers that drain into the Gulf of Khabhat are the Sabarmati, the Mahi, the Narmada, the Tapti and the Shetrunji. Of these, Narmada being the longest west-flowing river, with large catchment area and is subjected to many stages during its course in terms of macronutrient fluxes. Out of the various nutrients Nitrogen (N) and phosphorus (P) are the key nutrient substances as these play an important role in controlling the primary productivity of natural waters.

Due to rapid industrial development along the banks of Narmada River there is increased input of domestic and industrial waste into the estuarine region. In the present paper the change in the macronutrients levels of Narmada estuary over a period of five years is attempted. The outcome of the paper would aid the stakeholders and the managers to understand the behavior of the ecosystem over the years and facilitate them to develop plans aimed at preventing their further degradation and preserving the unique ecosystem which supports breeding ground of giant prawns and hilsa.

Materials and Methods

The Narmada River originates at the Maikal hills of the Vindhya near Amarkantak in Madhya Pradesh and flows down till the Gulf of Khabhat covering an area of 1312 kms. River Narmada flows through the most fertile plains of Gujarat and carries a large volume of suspended sediment. In Gujarat it has sinuous meandering pattern and continues to flow its sinuous course till it meets the sea downstream Bharuch.
The estuarine region stretches from the mouth at Luhara Point to varying distances inland during different seasons of the year. Narmada estuary is influenced by semi-diurnal tides with unequal variability. It receives the maximum pollution load from the industries located at Ankleshwar, Panoli and Jhagadiya. Apart from these there are industrial establishment at Dahej, which release their effluents near the estuary. The study area and sampling station is indicated in Fig. 1.

Analysed during the present study. The water temperature was noted in the field and samples were immediately fixed for dissolved oxygen. The nutrients (Nitrites, Nitrates, Phosphates, and Total Phosphates) were estimated in the laboratory following the standard methods prescribed by Grasshoff. Statistical analysis (One way ANOVA) was performed with the help of Software Graphpad prism 3.017 to show the level of significance in temporal variation of various parameters. Correlation between various physico-chemical parameters was carried out with the help of SPSS windows version 12.

Result and Discussion

The same stations were monitored in various years and therefore in the present paper the mean for the year of study is taken and the standard error of mean considered.

The water temperature of the Narmada estuary remained high with maximum temperature in the year 2005 (28.0 ± 0.4°C). Being a tropical region the warmer waters is expected in the region. One way ANOVA showed a highly significant temporal variation in the temperature ($F_{2,28}$ 48.33 $P < 0.0001$). This significant variation could be attributed to the changes in the water currents of the region.

Narmada estuary is a fresh water estuary under the tidal effect which influences the salinity regimes. In the present study the salinity increased from 5.9 ± 2.8 ppt (2005) to 20 ± 2.6 ppt (2007) with moderate level of significance ($F_{2,32}$ 5.90 $P < 0.001$). Studies have shown that the freshwater runoff influences the salinity of the estuarine region and the gradient depends on the ratio of incursion of saline water to fresh water runoff. In case of Narmada estuary a decline in the flow of fresh water flow due to Narmada dam from 33,600 Mm$^3$ in 1996 to 6196 Mm$^3$ in 2007 was observed. This reduction in flow of fresh water has resulted in increase in salinity in the estuarine region.

Among the other parameters the dissolved oxygen content fluctuated during the study period and a gradual increase was noted from 2005(4.52 ± 0.25 mg/l) to 2010 (7.18 ± 0.21 mg/l). Increase in dissolved oxygen could be attributed to general improvement in the water quality of the estuarine system.
Nutrients

The Nitrogen\textsuperscript{14} and Phosphates\textsuperscript{21} are the essential nutrients that limit the growth of primary productivity in the ecosystem. Among these nutrients nitrites are important and in the present study the nitrite levels remained constant during 2005 and 2007 with 0.013 ± 0.005 mg/l and 0.012 ± 0.006 mg/l respectively. However, the Nitrite values increased in 2010 (0.02 ± 0.001 mg/l) but the variation was not significant (ANOVA values $F_{2,33} = 1.82 \, P > 0.05$ Fig. 2). At present the value might be insignificant but an increasing trend indicate the input of nitrite into aquatic system from terrestrial sources through runoff. Major sources of nitrites are urban wastewater, farmland fertilizer and animal manure that enter the river system through runoff and leaching and finally enter the estuarine system\textsuperscript{22,23,24}.

Nitrates showed the oscillatory pattern during the study years. A highly significant temporal variation ($F_{2,32} = 182.0 \, P < 0.001$) in nitrate was noted. It was as low during 2005 0.009 ± 0.002 mg/l, then increased to 0.52 ± 0.027 mg/l during 2007 and declined in 2010 (0.41 ± 0.01 mg/l). It is known that the availability of Oxygen facilitate the conversion of NO\textsubscript{2} into NO\textsubscript{3}\textsuperscript{25}. In the present study the nitrite conversion into nitrates is very well observed. Compared to the other estuaries in India like the Godhavari estuary\textsuperscript{26} and Cochin Estuary\textsuperscript{27} the nitrite and nitrate value were low in Narmada estuary. The values were comparable with the Mandovi Estuary\textsuperscript{28}.

Phosphorus is an essential element in life processes\textsuperscript{29}. In present study Phosphates had shown a gradual increase during these years. This variation was highly significant at the level of $P < 0.0001$ ($F_{2,36} = 10.74$). Phosphorus levels was 0.037 ± 0.011 mg/l during 2005, then increased to 0.067 ± 0.011 mg/l in 2007 and further increased in 2010 (0.076 ± 0.002 mg/l) (Fig. 2). Total Phosphates also shows similar pattern.

![Graphs showing temperature, salinity, nitrite, nitrate, phosphate, and total phosphate levels over the years 2005, 2007, and 2010.](image)

**Fig. 2**—The Variation in various Physico-Chemical parameters during the year 2005, 2007 and 2010.
Table: 1: Nutrient levels during three year study period

<table>
<thead>
<tr>
<th>Parameters</th>
<th>unit</th>
<th>2005</th>
<th>2007</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>28 ± 0.44 (26-29)</td>
<td>27.7 ± 0.31 (26-29.5)</td>
<td>23.5 ± 0.37 (21-25)</td>
</tr>
<tr>
<td>Salinity</td>
<td>ppt</td>
<td>5.9 ± 2.8 (0.2-31.6)</td>
<td>20 ± 2.67 (11.6-35.9)</td>
<td>13.03 ± 2.5 (5.1-38.1)</td>
</tr>
<tr>
<td>DO</td>
<td>mg/l</td>
<td>4.52 ± 0.25 (3.3-6.7) (3.2-5.9)</td>
<td>4.91 ± 0.37 (6.6-8.1)</td>
<td>7.18 ± 0.21</td>
</tr>
<tr>
<td>Nitrite</td>
<td>mg/l</td>
<td>0.01 ± 0.005 (0.0007-0.02)</td>
<td>0.01 ± 0.005 (0.003-0.06)</td>
<td>0.02 ± 0.001 (0.01-0.03)</td>
</tr>
<tr>
<td>Nitrate</td>
<td>mg/l</td>
<td>0.009 ± 0.002 (0.001-0.01)</td>
<td>0.52 ± 0.02 (0.41-0.69)</td>
<td>0.41 ± 0.016 (0.25-0.48)</td>
</tr>
<tr>
<td>Phosphate</td>
<td>mg/l</td>
<td>0.03 ± 0.01 (0.007-0.1)</td>
<td>0.066 ± 0.002 (0.06-0.09)</td>
<td>0.07 ± 0.002 (0.06-0.08)</td>
</tr>
<tr>
<td>Total Phosphate</td>
<td>mg/l</td>
<td>0.07 ± 0.009 (0.03-0.14)</td>
<td>0.32 ± 0.02 (0.22-0.45)</td>
<td>0.33 ± 0.06 (0.16-1.1)</td>
</tr>
<tr>
<td>Silicates</td>
<td>mg/l</td>
<td>0.023 ± 0.001 (0.01-0.02)</td>
<td>0.026 ± 0.000 (0.021-0.03)</td>
<td>0.020 ± 0.001 (0.01-0.026)</td>
</tr>
</tbody>
</table>

pattern as that of phosphate-phosphorus with 0.075 ± 0.009 mg/l during 2005, 0.32 ± 0.024 mg/l in 2007 and marginal increase in 2010 (0.33 ± 0.067 mg/l). The yearly variation was highly significant at the level of $P < 0.0001$ ($F_{2,35}$ 10.07). Significant rise in the phosphates can be attributed to the release of phosphates from the catchment and the river.

It is also estimated that the nutrient levels will increase in near-future due to the human interventions, and changes in the freshwater fluxes. Further, it is also known that the phosphates are very much reactive with the suspended particles. In the present study lowering in the inorganic phosphates value can be attributed to its absorption and conversion into organic phosphates by various organisms. Silicates values remained similar during the tenure of the study period with value of 0.023 ± 0.001 mg/l during 2005, 0.026 ± 0.000 mg/l during 2007 and 0.020 ± 0.001 mg/l during 2010. This indicates no discharge of external silicates into the system through the industrial effluents.

Acknowledgments

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References


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