SEASONAL VARIATIONS IN SURFACE WATER QUALITY OF SENGAR RIVER DUE TO EFFLUENT FROM PETROCHEMICAL INDUSTRY


Environment Monitoring Section, Epidemiology Section, Indian Institute of Toxicology Research, Council of Scientific and Industrial Research, Lucknow (INDIA)

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ABSTRACT

All the surface water resources (river, pond and lakes) are getting indiscriminately polluted in India as well elsewhere. The present investigation highlights the adverse impacts of water quality of Sengar river (India) due to the discharge of effluent of a petrochemical plant. During summer season, the downstream water quality was significantly changed due to lean flow that tends to alter ecological niche, aquatic flora and fauna, benthos, other aquatic organisms and self purification of the river system. The objective of this investigation was to assess the impact of the petrochemical industry effluent on water quality of Sengar River near Phaphund, Auraiya, U.P. The Physico-chemical parameters viz pH, Dissolved oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids, Sulphide and Oil and Grease were tested for three seasons. During summer season, the downstream water quality was significantly changed due to lean flow that tends to alter ecological niche and self purification of the river system. The downstream water was also unfit for bathing and potable that could be categorized as E Class of water used for irrigation, industrial cooling and control waste disposal.

Key Word: Impact, Effluent, Petrochemical industry, Seasonal, Water quality

INTRODUCTION

Water is essential for survival of any form of life. Water accounts for about 70% of the weight of a human body. About 80% of the earth surface is covered by water\(^1\). On Earth, it is found mostly in oceans and other large water bodies, with 1.6% of water below ground in aquifers and 0.001% in the air as vapour, clouds (formed of solid and liquid water particles suspended in air) and precipitation. Oceans hold 97% of surface water, glaciers and polar ice caps 2.4%, and other land surface water such as rivers, lakes and ponds 0.6%. The increase in pollution in surface water is due to continuous increase in urbanization, industrialization and modern life style. Petrochemical industry is discharging its treated effluent into the Sengar River near village Phaphund, Auraiya, U.P. (India) at a 10 km distance from the plant. The fertile bank is extensively cultivated either for Rabi or kharif crops at all the seasons irrigated with Sengar’s water. The industrial effluent, agriculture run off and the domestic waste comes from the villages consists of organic and inorganic impurities. Therefore, the river becomes polluted and its water quality is affected.

AIMS AND OBJECTIVES

The purpose of this investigation was to characterize the petrochemical effluent and its possible adverse impacts on water quality of Sengar.

MATERIAL AND METHODS

Sampling and analysis

The effluent samples were collected at the outlet of effluent treatment plant near plant Fig. 1 boundary and the river water samples were
collected fortnightly from up stream and downstream of discharge point from March 2007 to February 2008 and important physico-chemical parameters were analyzed. The collected samples were preserved, stored and analyzed, using chemicals of analytical grade. Instantaneous Dissolved Oxygen and pH were measured at site and other parameters i.e. Total Suspended Solids, sulfide, Biochemical Oxygen Demand, Chemical Oxygen Demand, and oil and grease were analyzed in the laboratory.

\[ \text{Fig. 1 : Layout map showing Sengar river} \]

**Statistical methods**

Two way analysis of variance was carried out to analyse the significance in mean values of the parameters considering site and season as independent variables and each pollution parameter separately as dependent variable. Prior to analysis normality assumption of the data and homogeneity of variances were ascertained. Post hoc analysis between the groups was carried by calculating least significant differences. The level of significance was considered to be 5 per cent. SPSS version 14.0 was used to analyse the data.

**RESULTS AND DISCUSSION**

The summary of results of water quality of Sengar river and wastewater quality of petrochemical effluent for different seasons are presented in Table 1.

The pH values ranged between 7.2 to 7.6. The pH of downstream and effluent was found slightly
<table>
<thead>
<tr>
<th>Season</th>
<th></th>
<th>Summer (March-June 2007)</th>
<th>Monsoon (July-Oct. 2007)</th>
<th>Winter (Nov. 07- Feb. 08)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>Min</td>
<td>Max</td>
<td>Avg±SD</td>
<td>Min</td>
</tr>
<tr>
<td>pH</td>
<td>28</td>
<td>30</td>
<td>29±0.2</td>
<td>26</td>
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<tr>
<td>TSS</td>
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<td>172</td>
<td>169±1.9</td>
<td>158</td>
</tr>
<tr>
<td>DO</td>
<td>4.5</td>
<td>4.5</td>
<td>4.4±0.1</td>
<td>4.3</td>
</tr>
<tr>
<td>BOD</td>
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<td>20</td>
<td>19.5±1.0</td>
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<td>COD</td>
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<td>50</td>
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<td>44</td>
</tr>
<tr>
<td>Oil and grease</td>
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<td>5</td>
<td>5±0.0</td>
<td>5</td>
</tr>
<tr>
<td>Sulfide</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1±0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>CN</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01±0.0</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(i) Treated effluent of petrochemical industry

(ii) Upstream of Sengar river

(iii) Downstream of Sengar river
higher than upstream (Fig. 2). Maximum pH was recorded in the month of November and minimum in January, however no significant change was recorded in mean value in all three seasons \( (F_{2,63} = 0.8, p = 0.429) \). Significant site effect \( (F_{2,63} = 5.5, p = 0.006) \) is observed as the mean value of pH is found to be significantly higher in downstream \( (p = 0.002) \) and at effluent point \( (p = 0.023) \) compared to upstream however no significant differences are observed between downstream and at effluent point.

The Suspended Solids ranged between 56-150.5 mg/l. Significant site \( (F_{2,63} = 16.9, p = 0.000) \) and seasonal \( (F_{2,63} = 7.4, p = 0.001) \) effect was observed with respect to total suspended solids. The mean value of Total Suspended Solids was found to be significantly higher in monsoon season \( (p = 0.000) \) in comparison to summer season. This may be due to flood condition in monsoon which contributes suspended solids in river. During the monsoon season the range becomes low both in up and down stream due to the dilution process by flood. Mean TSS content has been found to be significantly higher in down stream (Fig. 3). However in the present study, the values were much lower than the standard values prescribed by various agencies i.e. 500-2100 mg/l and 1000 mg/l. The high TSS values are responsible for gastrointestinal irritations.\(^{3-5}\) The major source of dissolved solids was industrial effluent of petrochemical industry and improper sanitation in rural areas.

![Fig. 2: Concentration of pH in different season](image)

![Fig. 3: Concentration of TSS in different season](image)
Concentration of Dissolved Oxygen was found lowest in effluent (Fig. 4). No seasonal effect was observed with respect to Dissolved Oxygen concentration as mean values were not found to be significantly different in all season. It ranged between 1.8-6.4 mg/l. However, site effect was found to be significant ($F_{2,63}=74.0, p=0.000$) as mean value of downstream ($p=0.000$) and upstream ($p=0.000$) significantly higher compared to effluent but no statistical significance in mean value between downstream and upstream was observed. Therefore, Dissolved Oxygen level was low at the effluent site (mean=3.167mg/l) compared to other sites and hence the discharge is affecting the Dissolved Oxygen levels and are also below the standard values of 5-6 mg/l. The low Dissolved Oxygen values indicate the biodegradation of the organic matter and decay of vegetation\textsuperscript{7,8}.

Biochemical Oxygen Demand\textsuperscript{5} is the amount of oxygen utilized by microorganism in stabilizing the organic matter. On average basis, the demand for oxygen is proportional to the amount of organic waste to be degraded aerobically. Hence, Biochemical Oxygen Demand\textsuperscript{5} approximates the amount of oxidizable organic matter present and the Biochemical Oxygen Demand\textsuperscript{5} value can be used as a measurement of waste strength. Biochemical Oxygen Demand\textsuperscript{5} values are increased in summer and winter season but it lowers in monsoon due to aeration of surface water by flood water\textsuperscript{9} (Fig. 5). The average values ranged between 2.0 to 19.85 mg/l. The sources of Biochemical Oxygen Demand\textsuperscript{5} in the river are domestic discharge and the industrial
effluent from the petrochemical industry. At high Biochemical Oxygen Demand values the aquatic life both plants and animals will be adversely affected. Both seasons \( (F_{2,63}=6.8, p=0.002) \) and site \( (F_{2,63}=501.9, p=0.000) \) were significantly associated as far as when Biochemical Oxygen Demand is concerned. In monsoon season, mean Dissolved Oxygen concentration found to be significantly higher compared to summer \( (p=0.001) \) and winter \( (p=0.009) \) season. However, no significant change was observed between winter and summer season. Mean value of Biochemical Oxygen Demand at effluent was significantly higher compared to down stream \( (p=0.000) \) as well as up stream \( (p=0.000) \).

Chemical oxygen demand is the amount of oxygen required to decompose the organic and inorganic matter. The maximum values were recorded from the downstream when it compare with upstream values where the effluent mixes with river water. High values of Chemical Oxygen Demand and low levels of Dissolved Oxygen suggested that the chemicals were added to the river water which might have affected the Dissolved Oxygen levels and consequently the chemical degradation of the products. In the monsoon season, the range became low because of the dilution of river water due to rains. The range of Chemical Oxygen Demand was 7.1-89.35 mg/l. Presence of high level of Chemical Oxygen Demand was also one of the causes of the depletion of Dissolved Oxygen in the river water. Mean Chemical Oxygen Demand concentration was found to be significantly higher is winter season \( (p=0.001) \) compared to summer season. The mean Chemical Oxygen Demand content of the effluent found to be significantly higher compared to down stream \( (p=0.000) \) and up stream \( (p=0.000) \) however no significant change in mean Chemical Oxygen Demand were observed between downstream and upstream (Fig. 6).

The major source of oil and grease is the effluent of petrochemical complex. It is also one of the important parameter that affects the aquatic life. It decreases the penetrating power of the light and gaseous exchange. Thus the basic physiological processes of aquatic life such as photosynthesis and respiration are adversely affected. The range of oil and grease in up stream and in the down stream was less than 1.2 mg/l while in effluent it ranged between 3.9-9.4 mg/l. Sulfide comes from the industrial effluent and domestic sewage, produces \( \text{H}_2\text{S} \) and causes fouling smell. The fouling smell has harmful social impact on near by villagers. Sulfide ranged from 0.18 to 2.4 mg/l. It increases during summer because of reduced volume of water in river due to lean flow and evaporation. In downstream the range of sulfide was increased due to discharge of domestic and industrial effluent (Fig. 7). Only site effect was observed \( (F_{2,63}=25.1, p=0.000) \) with respect to sulphide concentration at the effluents point as the mean value were found to be significantly higher compare to downstream \( (p=0.000) \) as well as up stream \( (p=0.000) \), however no significant change in mean value was observed in different seasons.
CONCLUSION

Though monitored parameters were within the prescribed limit of general standards of effluent discharged but the presence of toxic chemicals in low concentrations in the complex industrial effluent can not be ruled out. It has been observed from the result that water quality directly depends on the quality and quantity of discharge from the plant and its dilution rate. During summer season, the downstream water quality was significantly changed due to lean flow that tends to alter ecological niche, aquatic flora and fauna, benthos, other aquatic organisms and self purification of the river system while in monsoon season, all the pollutants except Total Suspended Solids gets diluted. The downstream water was also unfit for bathing and potable that could be categorized as E class of water used for irrigation, industrial cooling and control waste, disposal. More extensive study is called for to conserve water resources from further deterioration and to protect the overall health of the river.

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REFERENCES


*When we heal the earth, we heal ourselves!*