PHYSICOCHEMICAL PROFILE OF THE GODAVARI RIVER AT NASHIK IN CONTEXT OF POLLUTION

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INTRODUCTION
The water quality and human health are closely related. The quality of water is now being recognized in India as a major crisis is getting deteriorated by human activities. Rivers are getting contaminated due to waste disposal from with the rapid development in agriculture, urbanization and industrial development. The river water contamination with domestic and municipal sewage disposal, leaching of fertilizers, agricultural runoff and industrial effluents is becoming a common phenomenon. The Godavari River is one of the longest rivers flowing through Maharashtra, Andhra Pradesh and empties in Bay of Bengal. It originates from Brahmagiri hills of Trimbakeshwar, 29 km. from Nashik and flows through various parts of the city. The river is approximately 1465 km. long flows in eastward direction through the state of Maharashtra and joins Bay of Bengal in Andhra Pradesh. Godavari is sometimes also referred as the Ganga of the South. It has a catchment area of 3, 12 and 812 Sq.km. of which 69.3% lies in Maharashtra. The Godavari River is receiving huge quantities of wastes daily thereby resulting in reduction in quantity of flow of water in river, in turn quality of water affected due to diminishing levels of flushing within the system. The present investigation was carried out by exploring five stations S1 to S5 of Godavari River at Nashik city to study physico-chemical parameters based on Standard Deviation, Coefficient Correlation and Water Quality Index. Water quality index (WQI) may be defined as rating that reflects the composite influence of a number of water quality factors on overall quality of water. Water Quality Index was first formulated by Horton (1965) and then by Ott (1978). Method given by Horton (1965) was later on followed, with slight modifications by Tiwari and Mishra (1985), Trivedy and Goel (1986). A new mathematical formulation has been prepared with some modifications to the mathematical designs given by Horton (1965) and Ott (1978) to calculate WQI of Godavari river of Nashik city.

MATERIALS AND METHODS
Study area
Nashik a major industrial town situated at Latitude 19º – 33’ and 20º – 53’ North and Longitude 73º – 16’ and 75º – 6’ east is located in Northern Maharashtra on Western edge of the Deccan Plateau on the banks of the Godavari River. Five sampling stations S1-S5 of Godavari River were selected with purpose to collect water samples for Physico chemical parameter analysis at seasonal intervals during Nov. 2008 to Oct. 2009. Water samples were collected once in a month during Nov. 2008 to Oct. 2009 and were subjected to physico-chemical analysis following the method given by APHA (1989), Trivedy and Goel (1986). The investigation period was divided into three seasons i.e. winter (Nov. 08 – Feb. 09), summer (Mar. 09 – June 09), Monsoon (July 09 to Oct. 09).

Water Quality Index

ABSTRACT
The Godavari River in Nashik is being over exploited due to overpopulation, urbanization and industrialization, therefore requires monitoring of water quality parameters. In the present work various physicochemical parameters i.e. temperature, pH, turbidity, conductivity, total dissolved solids, nitrates, chlorides, phosphates, sulphates, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand were analyzed at five locations S1 to S5 of Godavari river at Nashik during Winter, Summer, Monsoon in the year Nov. 2008 – Oct. 2009 with reference to Mean values, Standard Deviation, Coefficient Correlation and Water Quality Index. Results showed that the physico-chemical parameters determined were higher in summer than in winter and Monsoon and WQI value of the water samples at various sampling sites is 60-95, indicating the pollution status of Godavari River at Nashik.
In order to calculate Water Quality Index six chemical factors of water have been selected. These factors are pH, Nitrates, Chlorides, Sulphates, Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD). The steps followed in the calculation of WQI are as follows:

**Weighting**

The word weighting implies relative significance of each of the factor in overall water quality and is dependent on the permissible levels in drinking water as suggested by ICMR. Factors having low permissible limit can harm the quality of water to a large extent even on a slight increase. Such factors have high weightings. On the other hand, factors which have higher permissible limits are less harmful and have low weightings.

Therefore

\[
W_i \propto \frac{1}{V_i} \quad \text{or} \quad W_i = \frac{K}{V_i} \quad \text{(1)}
\]

Where \(W_i\) = unit weight of the chemical factor.

\(V_i\) = maximum permissible limit as recommended by ICMR

\(K\) = constant of proportionality.

Value of \(K\) can be calculated as

\[
K = \frac{1}{6} \sum_{i=1}^{6} \frac{1}{V_i}
\]

The weights of all the chemical factors are calculated on the basis of this equation. The values are depicted in the Table 3

**Rating scale**

Each chemical factor has been assigned a rating value (Vr) to calculate WQI. The values fall between 0 and 100. To assign rating value to a factor, range of its concentration in water has been divided into five intervals (Table 4). The rating Vr = 0 implies that chemical factor exceeds standard maximum permissible limits and water is highly polluted while Vr = 100 implies that chemical factor has the most desirable value and water is absolutely clean. The other ratings falling between these two extremes are Vr = 40, Vr = 60 and Vr = 80 representing intermediate conditions of water (Table 4).

**Calculation of water quality index**

To calculate water quality index, the products of rating (Vr) and unit weights (Wi) of all the six chemical factors were summated.

\[
WQI = W_i \times V_r
\]

Where,

\[
W_i \times V_r = W_i (pH) \times V_r (pH) + W_i (NO_3^-) \times V_r (NO_3^-) + W_i (Cl^-) \times V_r (Cl^-) + W_i (SO_4^{2-}) \times V_r (SO_4^{2-}) + W_i (DO) \times V_r (DO) + W_i (BOD) \times V_r (BOD)
\]

Water quality indices were calculated in this way for three seasons at all the five sites from Nov. 2008 to Oct. 2009. Water quality falling within the range of 0 – 39.99 stands for severely polluted water, between 40 – 59.99 for excessively polluted water, between 60 – 79.99 for moderately polluted water, between 80 – 99.99 for slightly polluted and 100 for absolutely clean water. This scale is modified version of rating scale given by Tiwari and Mishra (1985).

**Standard deviation**

\[
\sigma = \frac{\sqrt{\sum x^2}}{N} - \left(\bar{x}\right)^2
\]

Where \(\bar{x}\) = Arithmetic mean and is denoted by \(\Sigma x\)

\(N\) = Number of values of x variable

\[
SD = \frac{\left[\sum(x_i - \bar{x})^2 + (x_i - \bar{y})^2\right] - (\text{Mean})^2}{3}
\]

Coefficient correlation (r) = \(\frac{\text{Cov}(x, y)}{\sigma_x \sigma_y}\)

\[
\text{Cov}(x, y) = \frac{\sum xy - x \cdot y}{N}
\]

Where x = X – Y and Y = y – y, x and y represent two different parameters.

x = mean value of x, y = mean value of y

The correlation among the different parameters will be true when the value of correlation coefficient (r) is high and approaching to one. Correlation, the relationship between two variables, is closely related to prediction. It reduces the range of uncertainty associated with decision making.

**RESULTS AND DISCUSSION**

![Table 1: Location of sampling stations S1 to S5 in the study stretch of the Godavari river during Nov.2008-Oct 2009.](image)

![Table 2: Classification of Water Quality](image)

The water quality of Godavari river is analyzed during Winter, Summer and Monsoon seasons at stations S1-S5 in the year Nov. 2008 to Oct. 2009 and the statistical analysis has been performed in calculating Mean values, Standard Deviation, Correlation Coefficient between different pairs of parameters, the calculated values of WQI are presented in Table No. 5-8.
Temperature
The fluctuation in river water temperature usually depends on the season, geographic location, sampling time and temperature of effluents entering the stream (Ahipathy, 2006). Water temperature is recorded lower (20.05ºC) during Winter and higher (28.85ºC) during Summer at all stations S1 to S5. In polluted water, temperature can have profound effect on Dissolved oxygen (DO) and Biological Oxygen Demand (BOD). Temperature showed negative significant correlation with Nitrates (R = - 0.944 at S1 – S2, r = - 0.977 at S3 – S5) and Dissolved oxygen DO (r = - 0.969 at S1 – S2, r = - 0.470 at S3 – S5) and positive correlation with other parameters as given in Table 5 - 8.

pH
is an important parameter is determining acid base balance of river water. pH of water varied between 8.38 at S1 in winter to 8.80 at S5 in summer indicating the alkalinity of water throughout the year. Jerome and Pius (2010) found pH in the range of 6 - 8.5. pH showed negative correlation with Nitrates (r = - 0.605 at S1 – S2, r = - 0.186 at S3 – S5), Dissolved oxygen (r = - 0.111 at S1 – S2) and positive correlation with other physico – chemical parameters are given in table 5 - 8. Similar trend has been observed by Sharma et al., 2011.

Turbidity
Turbidity ranged from 94.75 NTU in winter at S1 to 163.15 NTU in summer at S4. (Bhalla and Sekhon, 2010 a) showed the same results. During Summer the turbidity was due to less flow of water, enriching organic matter. Turbidity showed negative correlation with Nitrates (r = - at S1 – S2, r = - 0.970 at S3 – S5), DO (r = - 0.978 at S1 – S2, R = - 0.605 at S3 – S5), as also shown by Venkatesharaju et al. (2010) and showed significant positive correlation with other parameters as given in Table 5 - 8. The discharged effluents decomposed organic matter increases the turbidity of water, which interferes with the penetration of light.

Conductivity
Conductivity is measure of dissolved salts in water. Minimum values of conductivity observed were 218 μs/cm in winter at station S1 and maximum values observed were 332.23 μs/cm. Maximum values observed were 218 μs/cm in winter at station S1 and maximum values observed were 332.23 μs/cm. in summer at station S3, denoting a changing composition of water is indicative of more polluted water at station S3. Conductivity showed negative correlation with Nitrates (r = - 0.917 at S1 – S2, r = - 0.992 at S3 – S5), DO (r = - 0.972 at S1 – S2, r = - 0.415 at S3 – S5) as also indicated by Sharma et al. (2011) and given in Table 5 - 8.

Total dissolved solids (TDS)
Maximum values of TDS observed were 269 mg/L in summer
at station S5 and minimum values were 173.75 mg/lit in winter at station S1 during the study period. Yogendra and Puttiah (2007) observed the same results. High values of TDS found to be high during summer may be due to increased decaying of vegetation leading to more accumulation of dissolved solids in water. TDS showed strong positive correlation with Temperature ($r = 0.986$ at S1 – S2, $r = 0.975$ at S3 – S5), pH ($r = 0.318$ at S1 – S2, $r = 0.395$ at S3 – S5), Turbidity ($r = 0.880$ at S1 – S2, $r = 0.937$ at S3 – S5) Conductivity ($r = 0.944$ at S1 – S2, $r = 0.959$ at S3 – S5) as given in Table No. 5 – 8.

Nitrates

Concentration of Nitrates was minimum 0.63 mg/L in summer at station and maximum 2.87 mg/L at station S3 during the study period. This may be due to increased amount of domestic sewage and agricultural runoff that enter into river water indicative of more polluted water at station S3. The use of Nitrate as a fertilizer is major source of aquatic pollution. Excessive amount of Nitrates in water cause eutrophication which lowers DO, leading to killing of fish and retardation in plant growth and hinders the self purification process of rivers. Nitrates in drinking water are significant for public health as concentration greater than 10 mg/L as NO$_2$ - N can cause serious medical problem in blood of babies less than six months of age called Infant Cyanosis, Blue Baby Syndrome or Methaemoglobinemia. Nitrates showed strong significant negative correlation with Temperature ($r = -0.944$ at S1 – S2, $r = -0.977$ at S3 – S5), pH ($r = -0.605$ at S1 – S2, $r = -0.186$ at S3 – S5), Turbidity ($r = 0.865$ at S1 – S2, $r = 0.26$ at S3 – S5) Conductivity ($r = -0.917$ at S1 – S2, $r = -0.992$ at S3 – S5), TDS ($r = -0.931$ at S1 – S2, $r = -0.996$ at S3 – S5) Chlorides ($r = -0.804$ at S1 – S2, $r = -0.946$ at S3 – S5) Sulphates ($r = -0.929$ at S1 – S2, $r = -0.912$ at S3 – S5) Biological Oxygen Demand ($r = -0.825$ at S1 – S2, $r = -0.827$ at S3 – S5) Chemical Oxygen Demand ($r = -0.523$ at S1 – S2, $r = -0.662$) Nitrates only showed positive correlation with DO ($r = 1.03$ at S1 – S2, $r = 1.29$ at S3 – S5) as given in Table No. 5 - 8.

Chlorides

Maximum values of Chlorides observed where 26.15 mg/L in summer at station S3 and minimum values were 13.23 mg/L in winter at station S1 during the study period. The rise of chloride in summer was due to rise in temperature and evaporation thereby affecting the process of photosynthesis. The dumping of effluents of municipal as well as industrial sources, human activities, weathering and leaching of sedimentary rocks and soils increase the degree of eutrophication may be due to increased level of Chlorides. Chlorides showed negative correlation with Nitrates ($r = -0.935$ at S1 – S2, $r = -0.978$ at S3 – S5) Phosphates ($r = -0.804$ at S1 – S2, $r = -0.946$ at S3 – S5) Sulphates ($r = -0.929$ at S1 – S2, $r = -0.912$ at S3 – S5) Biological Oxygen Demand ($r = -0.825$ at S1 – S2, $r = -0.827$ at S3 – S5) Chemical Oxygen Demand ($r = -0.523$ at S1 – S2, $r = -0.662$) Nitrates only showed positive correlation with DO ($r = 1.03$ at S1 – S2, $r = 1.29$ at S3 – S5) as given in Table No. 5 - 8.

Phosphates

Maximum values of phosphates observed 1.52 mg/L in Summer at station S3 and minimum values observed 0.83 mg/L in Winter at station S1 during the study period. Bhalla et al. (2006) observed similar findings. Increased concentration of
Phosphates is due to increased application of fertilizers, use of detergents and domestic sewage leads to eutrophication. Phosphates bear negative correlation with Nitrates \((r = -0.804\) at \(S1 - S2\), \(r = 0.946\) at \(S3 - S5\)) only and shows strong positive correlation with all other physico-chemical parameters \((r = 1.01\) at \(S3 - S5\)) as given in Table 5 - 8.

Sulphates

Maximum values of Sulphates observed were 53.00 mg/L in summer at station S4 and minimum values observed were 30.09 mg/L in Winter at station S5. The presence of Sulphates in drinking water results in noticeable taste. Sulphates may be present in natural waters but increased Sulphate level in water may be due to human activities. Sewage disposal, leaching from fertilizers and irrigated agricultural land. Sulphates showed positive correlation with TDS \((r = 1.00)\), Chloride \((r = 1.01)\) at \(S1 - S2\) and Phosphate \((r = 1.01)\) at \(S3 - S5\). Sulphates bear negative correlation with Nitrate \((r = -0.929\) at \(S1 - S2\), \(r = -0.942\) at \(S3 - S5\)), DO \((r = -0.848\) at \(S1 - S2\), \(r = -0.504\) at \(S3 - S5\)) as presented in Table No. 5-8.

Dissolved oxygen

Maximum values of DO observed were 7.48 mg/L. in Winter at station S1 and minimum values observed were 3.88 mg/L in Summer at station S4 during the study period. High values of DO during winter could be due to greater solubility of oxygen in water at lower temperature and low oxygen content during summer may be due to low water level, high temperature and decay of macro vegetation. DO showed positive correlation with pH \((r = 0.275\) at \(S3 - S5\), NO\(_3\) \((r = 1.03\) at \(S1 - S2\), \(r = 1.29\) at \(S3 - S5\)), PO\(_4\) \((r = 0.353\) at \(S1 - S2\)), DO bears negative correlation with temperature \((r = 0.969\) at \(S1 - S2\), \(r = -0.470\) at \(S3 - S5\)).
at S3 – S5), pH (r = -0.111 at S1 – S2), Turbidity (r = -0.978 at S1 – S2, r = 0.605 at S3 – S5), Conductivity (r = -0.972 at S1 – S2, r = -0.415 at S3 – S5), TDS (r = -0.895 at S1 – S2, r = -0.464), Chloride (r = -0.869 at S1 – S2, R = -0.0766), Phosphate (r = -0.544 at S3 – S5) and Sulphate (r = -0.848 at S1 – S2, r = -0.504) as given in Table 5 – 8.

Biochemical oxygen demand

Maximum values of BOD were 11.35 mg/L in Monsoon at station S3 and minimum values were 3.75 mg/L in winter at station S1 during the study period. BOD values assess the organic load in a water body. Low BOD values in winter may be due to suspended solids settle in the bottom. Samantray et al. (2009) showed the same results. BOD shows negative correlation with DO (r = -0.950 at S1 – S2, r = -0.840 at S3 – S5), as also observed by Joshi et al. (2009). Conductivity (r = -1.35 at S1 – S2), TDS (r = -0.825 at S1 – S2), Phosphates (r = -0.975 at S1 – S2). BOD bears positive correlation with all other physico chemical parameters as given in Table 5 – 8.

Chemical oxygen demand (COD)

Maximum values of COD were 75.88 mg/L in Monsoon at station S3 and minimum 49.05 mg/L in winter at station S1 during the study period. Higher values of COD indicate the higher microbial activities and presence of oxidizable organic matter. Bhalla and Yadav (2010) have reported the similar findings. COD bears negative correlation with NO3 (r = -0.523 at S1 – S2, r = -0.662 at S3 – S5), DO (r = -0.738 at S1 – S2, r = -0.338 at S3 – S5) and bears strong positive correlation with other parameters as given in Table 5 – 8.

REFERENCES


