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# Water quality and pollution status of Chambal river in National Chambal sanctuary, Madhya Pradesh

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***Abstract:*** *The physico-chemical characteristics of Chambal river water in National Chambal sanctuary (Madhya Pradesh) have been studied. The stretch of Chambal river contained in the National Chambal sanctuary (located at $25^0$ 23'-$26^0$ 52'N, $76^0$ 28'-$79^0$ 15' E) is extending up to 600 km downstream from Kota (Rajasthan) to the confluence of the Chambal with Yamuna river (Etawah). The river flow in Madhya Pradesh spans up to approximately 400 km. Three sampling stations viz., Station A-near Palighat, district Sheopurkalan, Station B-near Rajghat, district Morena and Station C-near Baraighat, district Bhind were established for the collection of water samples during April, 2003 to March, 2004. The water quality parameters namely transparency (12.12 - 110 cm), colour (transparent-very turbid), turbidity (1-178 TNU), electrical conductivity (145.60-884 $\mu S\ cm^{-1}$), total dissolved solids (260-500 $mgl^{-1}$), pH (7.60-9.33), dissolved oxygen (4.86-14.59 $mgl^{-1}$), free carbon dioxide (0-16.5 $mgl^{-1}$), total alkalinity (70-290 $mgl^{-1}$), total hardness (42-140 $mgl^{-1}$), chloride (15.62-80.94 $mgl^{-1}$), nitrate (0.008-0.025 $mgl^{-1}$), nitrite (0.002-0.022 $mgl^{-1}$), sulphate (3.50-45 $mgl^{-1}$), phosphate (0.004-0.050 $mgl^{-1}$), silicate (2.80-13.80 $mgl^{-1}$), biochemical oxygen demand (0.60-5.67 $mgl^{-1}$), chemical oxygen demand (2.40-26.80 $mgl^{-1}$), ammonia (nil-0.56 $mgl^{-1}$), sodium (14.30-54.40 $mgl^{-1}$) and potassium (2.10 $mgl^{-1}$-6.30 $mgl^{-1}$) reflects on the pristine nature of the river in National Chambal sanctuary. On the basis of various parameters studied, Chambal river in this stretch can be placed under the category of oligosaprobic. The water quality analysis, indicated that the river water in the sanctuary area is pollution free and can serve as a good habitat for many aquatic animals including endangered species.*

***Key words:*** *Chambal river, Water quality, Pollution status, Sanctuary area*
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## Introduction

River pollution in India has now reached to a point of crisis due to unplanned urbanization and rapid growth of industrialization. The entire array of life in water is affected due to pollution in water. The problem of water quality deterioration is mainly due to human activities such as disposal of dead bodies, discharge of industrial and sewage wastes and agricultural runoff which are major cause of ecological damage and pose serious health hazards ( Meitei *et al.,* 2004a). The degree of pollution is generally assessed by studying physical and chemical characteristics of the water bodies (Duran and Suicnz, 2007). Studies related to water pollution of rivers like Godavari, Krishna and Tungbhdra (Mitra, 1982), Cauvery (Somashekar, 1985; Batcha, 1997), Jhelum (Raina *et al.,* 1984), Kosi (Bhatt and Negi, 1985), Morar (Kalpi) (Saksena and Mishra, 1991), Alaknanda (Tiwari *et al.,* 1991), Brahamani (Panda *et al.,* 1991; Mitra, 1997), Betwa (Datar and Vashishtha, 1992), Ganga (Pandey, 1985; Singh *et al.,* 1999; Sahu *et al.,* 2000; Rao *et al.,* 2000), Godavari (Rao *et al.,* 1993; Rafeeq and Khan, 2002), Yamuna (Meenakshi *et al.,* 2002; Anand *et al.,* 2006), Pachin (Hussain and Ahmed, 2002), Irai (Sawane *et al.,* 2004), Tansa (Shaikh, 2004) and Purna (Meitei *et al.,* 2004a,b) have received greater attention from time to time and during recent years. An attempt has, therefore, been made to study water pollution in river Chambal in National Chambal Sanctuary area.

## Materials and Methods

River Chambal originated near the Janapao temple at about 24 km south-west away from Mhow iin Madhya Pradesh at an elevation of 854.35 m. At the origin, there are three Nallah which are 1.6 to 2.4 km in length around the temple. These Nallah meet the river Chambal. The Chambal is a perennial river in Madhya Pradesh. The stretch of river contained in the National Chambal sanctuary (25° 23'-26° 52'N, 76° 28'-79° 15' E) extends upto a distance of 600 km downstream from Kota (Rajasthan) to the confluence of the Chambal with the Yamuna river (Etawah) a major tributary of river Ganga. In fact, this river forms the boundary between Rajasthan and Madhya Pradesh and Madhya Pradesh and Uttar Pradesh. Within the sanctuary (river length of approximately 600 km), the river flows through the areas of deeply eroded alluvium. Stony rapid, sand banks and gravel bars are abundant, and there are many steeps banks and bends where the depth of water exceeds 10 m.

Three sampling stations were established almost equidistantly on the stretch of Chambal river flowing in the National Chambal sanctuary. Station-A was established at Palighat (near Pali village, district Sheopurkalan), Station-B was established at Rajghat (near Morena road bridge, district Morena) and Station-C was established at Baraighat (near Barai village, district Bhind).

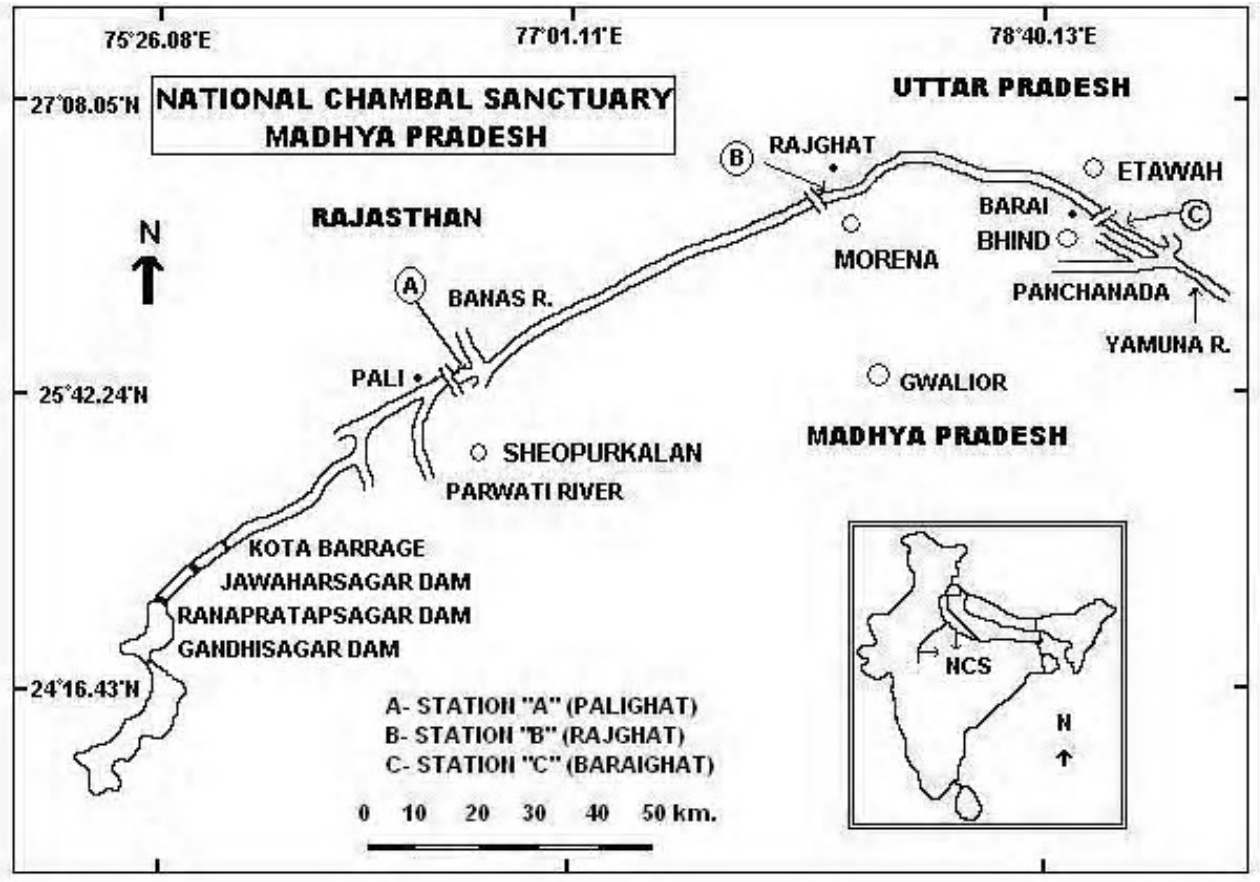



**Fig. 1:** National Chambal Sanctuary, Madhya Pradesh

Beyond this station river Chambal joins to the river Yamuna at Pachnada (Fig. 1). The water samples were collected from all the three sampling stations established on Chambal river from April, 2003 to March, 2004. The monthly samples of subsurface water were collected during first week of each month in the early hours of the day *i.e.* between 7 am to 9 am Utmost care was taken to avoid spilling of water and air bubbling at the time of sample collection. Iodine treated polyethylene double stoppard bottles were used for collection of sample. Some of the physico-chemical characteristics of water including water temperature, depth, color, transparency, flow rate, pH, dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, chloride, calcium and magnesium were determined at the sampling stations, while other parameters including turbidity, electrical conductivity, total dissolved solids, nitrate, nitrite, sulphate, phosphate, silicate, biochemical oxygen demand, chemical oxygen demand, ammonia, sulphide, sodium and potassium were analyzed in the laboratory within 4 to 6 hr of collection. The physico-chemical characteristics of water were analyzed according to the methods of APHA (2005) and Trivedy and Goel (1984).

## Results and Discussion

The physico-chemical characteristics provide a fair idea of the water quality in any water body. The result of the physico-chemical characteristics of Chambal river water are summarized in Table 1 and shown in Fig. 2 to 27.

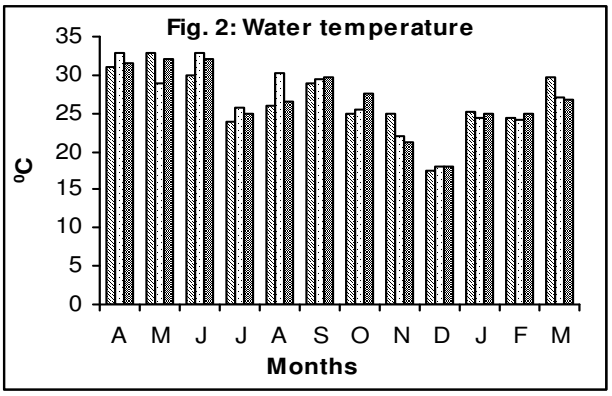
Temperature is basically important for its effects on certain chemical and biological reactions taking place in water and aquatic organisms (Shrivastava and Patil, 2002). It depends upon the season, time of sampling and also upon the temperature of effluents which are being added in to the river. Mean annual water temperature in Chambal river was given in Table 1. The low water temperature was recorded in winter, while highest was recorded in summer. Similar seasonal variation in water temperature was recorded by Batcha (1998) in river Cauvery, Singh *et al.* (1999) in river Ghaghara, Nath and Srivastava (2001) in river Narmada, Shrivastava and Patil (2002) in river Tapti and Meitei *et al.* (2004a) in river Purna.

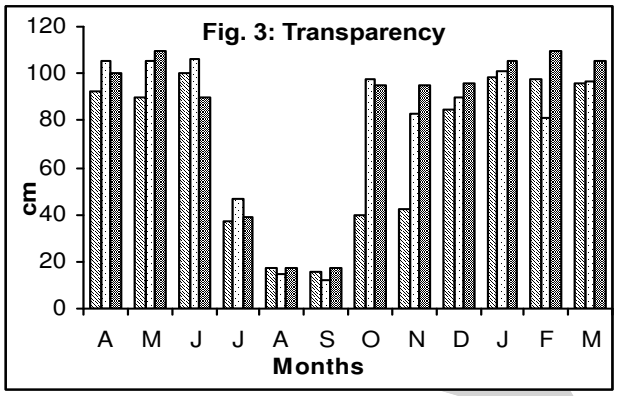
Transparency or light penetration depends on the intensity of sunlight, suspended soil particles, turbid water received from catchment area and density of plankton *etc.* (Mishra and Saksena, 1991; Singh, 1999; Kulshrestha and Sharma, 2006). Transparency of a river water is also affected due to total solids partly or fully decomposed organic matters, silts and turbulence caused by the currents, waves, human and cattle activities (Singh *et al.,* 1999). Seasonal impact was also seen on water transparency indicating higher values during winter and summer seasons, whereas lower values are evident in monsoon season. The transparency values were less in monsoon season due to high current which erodes the bank of the river and due to turbid flood water, suspended matter

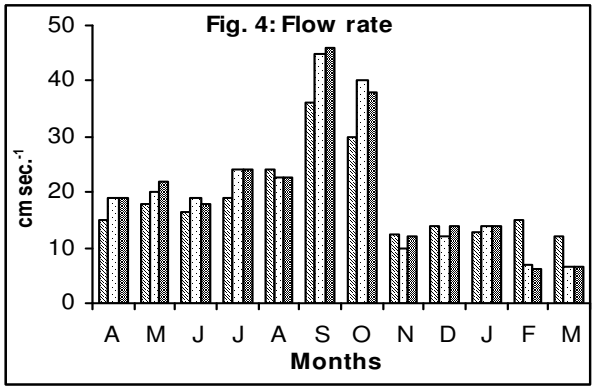
**Table - 1:** Analysis of physico-chemical parameters of Chambal river

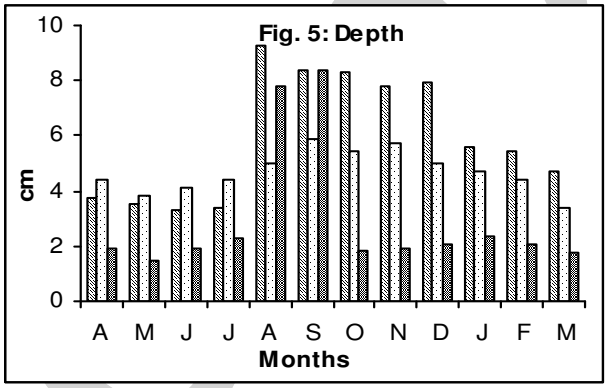
| Sl. No. | Parameter | Unit | Station-A (Palighat) | | | Station-B (Rajghat) | | | Station-C (Baraighat) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range of variation | | Mean and standard deviation | Range of variation | | Mean and standard deviation | Range of variation | | Mean and standard deviation |
| | | | Min. | Max. | | Min. | Max. | | Min. | Max. | |
| 1 | Water temperature | $^0$C | 17.60 | 31.00 | 26.47 ± 4.09 | 17.90 | 33.00 | 26.75 ± 4.44 | 18.10 | 32.10 | 26.69 ± 4.33 |
| 2 | Transparency | cm | 15.50 | 100.00 | 67.66 ± 33.93 | 12.12 | 106.20 | 78.13 ± 34.50 | 17.00 | 110.00 | 82.48 ± 35.38 |
| 3 | Flow rate | cm sec$^{-1}$ | 12.50 | 36.00 | 19.70 ± 7.58 | 6.00 | 45.00 | 19.80 ± 12.09 | 6.10 | 46.00 | 29.68 ± 11.83 |
| 4 | Colour | | V.T | Transp. | - | Transp. | V.T | - | Transp. | V.T. | - |
| 5 | Depth | m | 3.32 | 9.26 | 6.27 ± 2.25 | 3.40 | 5.88 | 4.79 ± 0.75 | 1.47 | 8.38 | 2.97 ± 2.40 |
| 6 | Turbidity | NTU | 1.60 | 86.30 | 20.15 ± 24.92 | 1.35 | 178.00 | 29.80 ± 53.38 | 1.00 | 107.00 | 19.70 ± 29.82 |
| 7 | Electrical conductivity | µS cm$^{-1}$ | 145.60 | 403.20 | 283.00 ± 91.98 | 100.00 | 666.40 | 370.60 ± 179.99 | 168.00 | 884.00 | 408.33 ± 248.69 |
| 8 | Total dissolved solids | mgl$^{-1}$ | 270.00 | 460.00 | 325.58 ± 61.13 | 260.00 | 450.00 | 315.58 ± 59.90 | 260.00 | 500.00 | 307.33 ± 64.64 |
| 9 | pH | - | 7.90 | 9.33 | 8.24 ± 0.38 | 8.10 | 8.92 | 8.30 ± 0.23 | 7.60 | 8.98 | 8.36 ± 0.34 |
| 10 | Dissolved oxygen | mgl$^{-1}$ | 4.86 | 10.33 | 7.66 ± 1.64 | 5.06 | 11.75 | 7.88 ± 2.03 | 5.37 | 14.59 | 8.22 ± 2.71 |
| 11 | Free carbon dioxide | mgl$^{-1}$ | Nil | 3.30 | 1.63 ± 0.57 | Nil | 6.60 | 3.02 ± 1.70 | Nil | 16.50 | 2.81 ± 5.46 |
| 12 | Total alkalinity | mgl$^{-1}$ | 72.50 | 275.00 | 145.83 ± 63.88 | 70.00 | 270.00 | 159.30 ± 60.32 | 75.00 | 290.00 | 171.04 ± 62.97 |
| 13 | Total hardness | mgl$^{-1}$ | 42.00 | 94.00 | 74.96 ± 16.95 | 52.00 | 134.00 | 104.31 ± 26.45 | 62.00 | 140.00 | 106.54 ± 26.12 |
| 14 | Chloride | mgl$^{-1}$ | 15.62 | 59.64 | 29.41 ± 15.14 | 16.33 | 39.76 | 28.87 ± 7.29 | 18.46 | 80.94 | 42.16 ± 23.68 |
| 15 | Calcium | mgl$^{-1}$ | 9.61 | 31.26 | 22.50 ± 5.73 | 17.63 | 44.08 | 27.98 ± 7.61 | 19.23 | 34.46 | 24.95 ± 5.07 |
| 16 | Nitrates | mgl$^{-1}$ | 0.008 | 0.024 | 0.014 ± 0.004 | 0.012 | 0.025 | 0.016 ± 0.003 | 0.010 | 0.021 | 0.0155 ± 0.003 |
| 17 | Nitrites | mgl$^{-1}$ | 0.002 | 0.022 | 0.014 ± 0.005 | 0.006 | 0.020 | 0.011 ± 0.003 | 0.010 | 0.017 | 0.012 ± 0.002 |
| 18 | Sulphates | mgl$^{-1}$ | 8.50 | 40.40 | 27.07 ± 8.85 | 14.00 | 42.00 | 31.11 ± 9.34 | 3.50 | 45.00 | 24.60 ± 13.59 |
| 19 | Phosphates | mgl$^{-1}$ | 0.005 | 0.030 | 0.018 ± 0.006 | 0.006 | 0.050 | 0.023 ± 0.012 | 0.004 | 0.045 | 0.018 ± 0.009 |
| 20 | Silicates | mgl$^{-1}$ | 2.80 | 13.80 | 8.03 ± 2.95 | 4.00 | 13.50 | 7.36 ± 2.43 | 3.80 | 12.60 | 7.00 ± 2.88 |
| 21 | BOD | mgl$^{-1}$ | 0.81 | 3.24 | 1.76 ± 0.83 | 1.01 | 5.67 | 2.12 ± 1.37 | 0.60 | 3.24 | 1.87 ± 0.78 |
| 22 | COD | mgl$^{-1}$ | 24.40 | 26.80 | 10.98 ± 6.76 | 4.00 | 22.50 | 11.60 ± 5.79 | 4.00 | 17.60 | 8.33 ± 4.60 |
| 23 | Ammonia | mgl$^{-1}$ | Nil | 0.56 | 0.09 ± 0.16 | Nil | 0.56 | 0.151 ± 0.14 | Nil | 0.54 | 0.15 ± 0.18 |
| 24 | Sulphides | mgl$^{-1}$ | Nil | 0.14 | 0.015 ± 0.00 | Nil | 0.28 | 0.058 ± 0.040 | Nil | 0.28 | 0.035 ± 0.00 |
| 25 | Magnesium | mgl$^{-1}$ | 2.43 | 8.28 | 461.00 ± 1.84 | 1.70 | 20.17 | 8.64 ± 5.79 | 1.08 | 14.13 | 10.92 ± 4.89 |
| 26 | Sodium | mgl$^{-1}$ | 15.20 | 52.80 | 4.56 ± 9.95 | 26.80 | 48.80 | 38.00 ± 6.30 | 14.30 | 54.40 | 39.02 ± 11.55 |
| 27 | Potassium | mgl$^{-1}$ | 3.10 | 6.10 | 4.22 ± 1.03 | 3.40 | 6.10 | 4.89 ± 0.97 | 2.10 | 6.30 | 4.51 ± 1.41 |

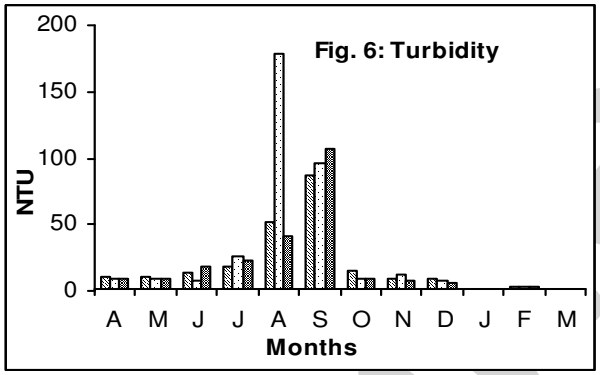
Transp. = Transparent, V.T. = Very turbid. n = 12

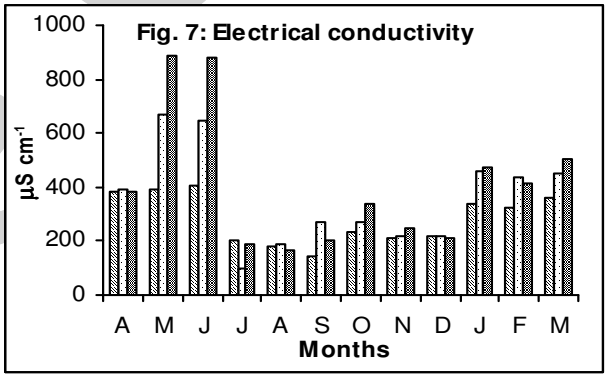


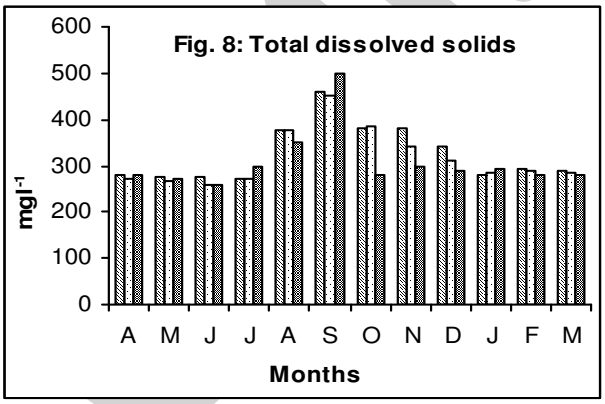



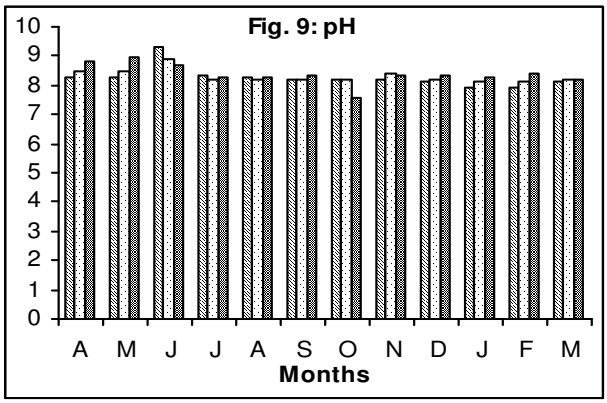
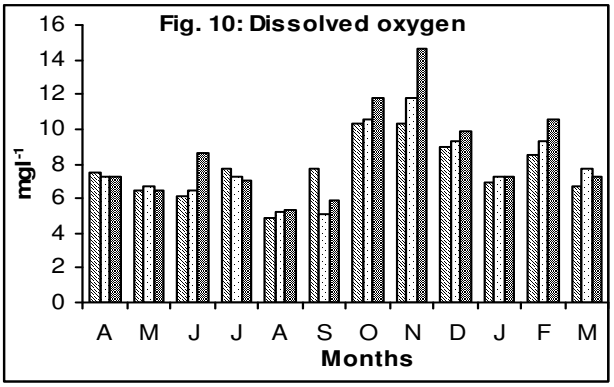
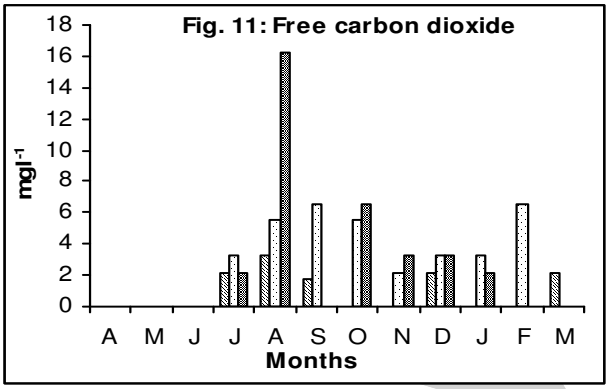
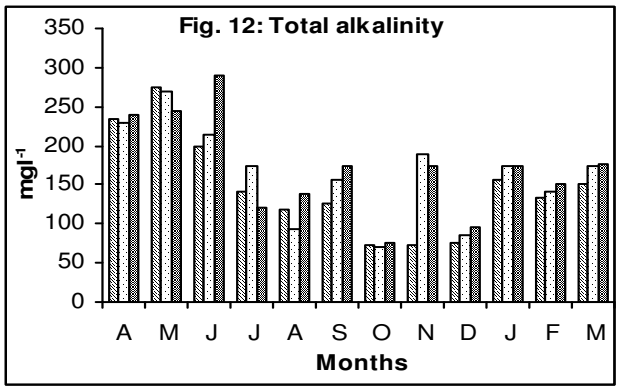



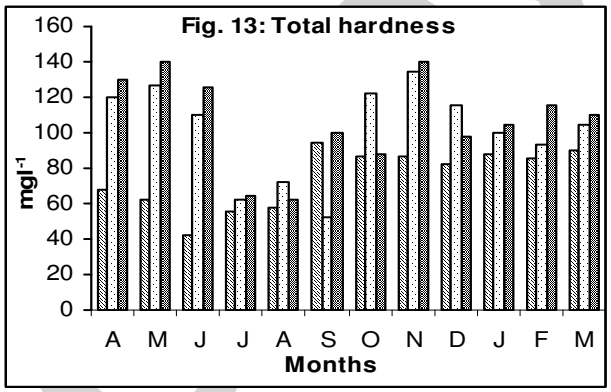


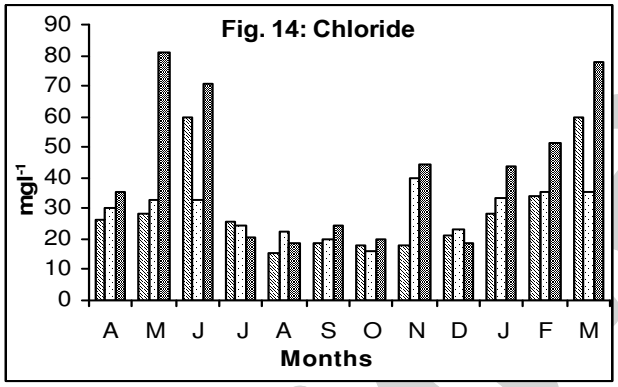
**Fig. (2-9):** Results of physico-chemical characteristics of river Chambal

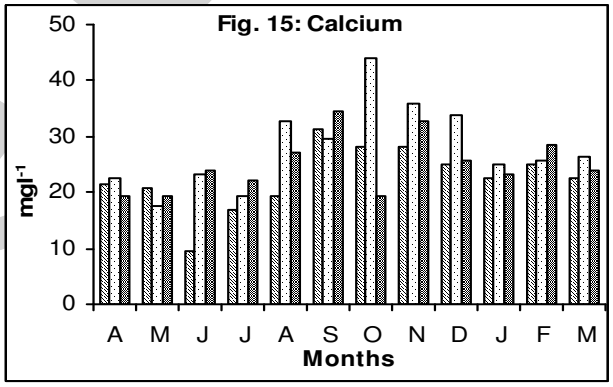


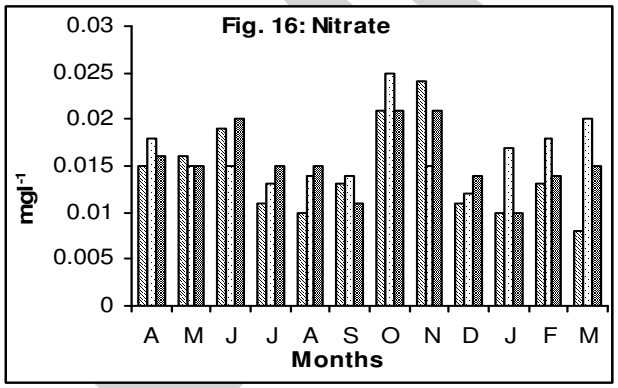



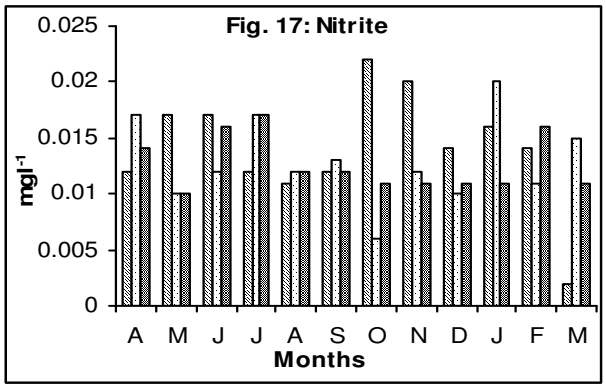
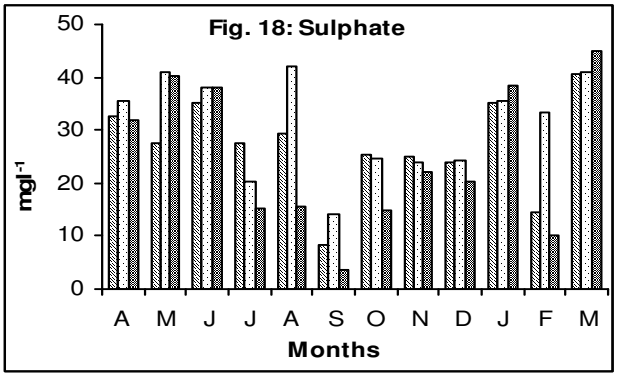
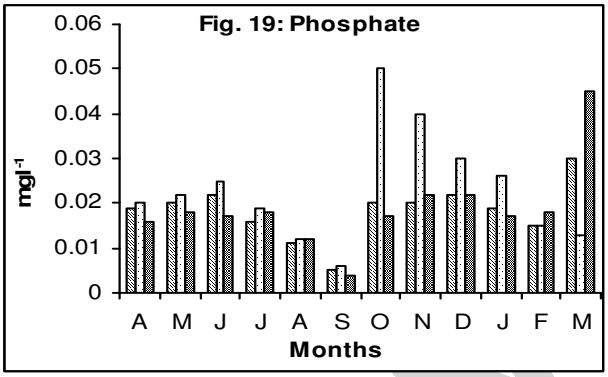
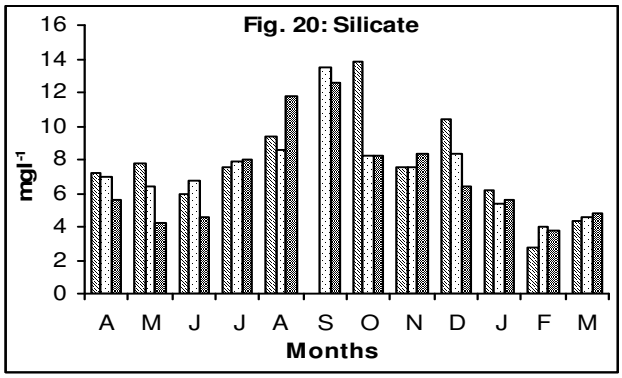



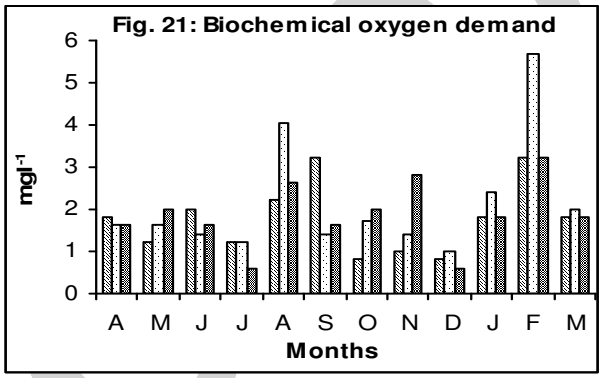


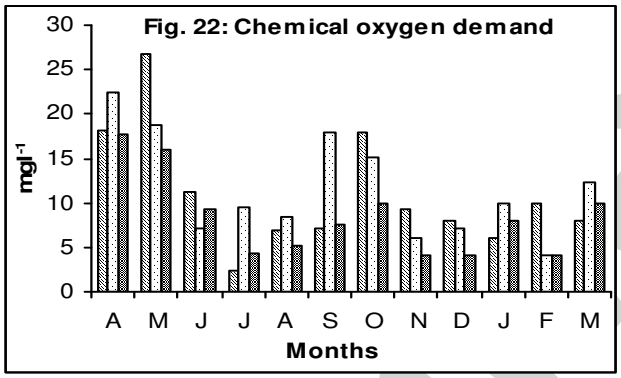
**Fig. (10-17):** Results of physico-chemical characteristics of river Chambal

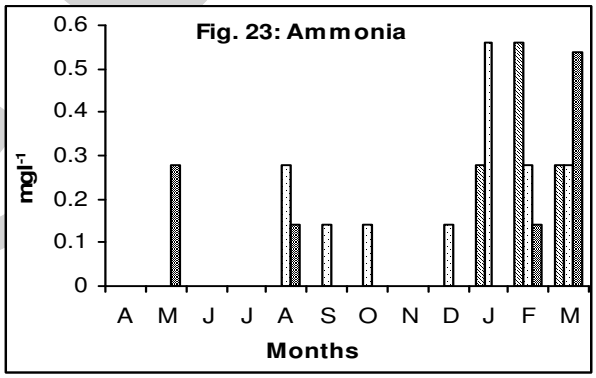


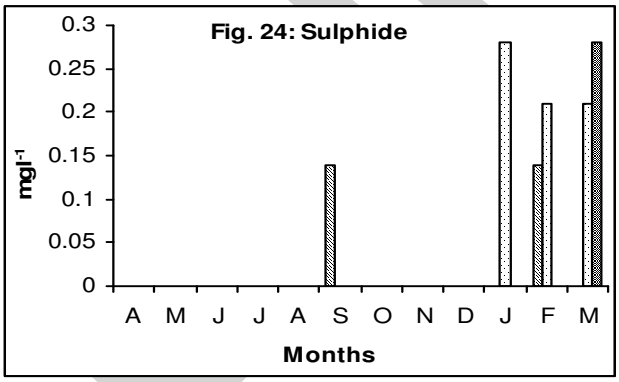



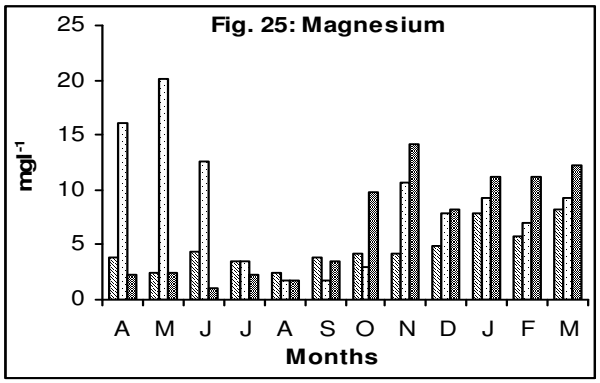





**Fig. (18-25):** Results of physico-chemical characteristics of river Chambal

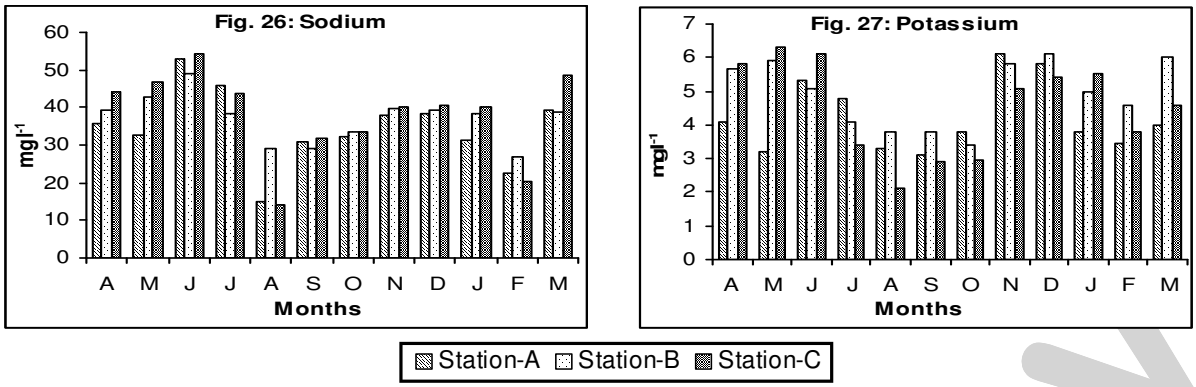



**Fig. (26-27):** Results of physico-chemical characteristics of river Chambal

and dissolved particles. High value of transparency was recorded in late post monsoon and winter months as has also been observed by Singh *et al.* (1999), Nath and Srivastava (2001) and Shaikh and Yeragi (2004). Flow rate of water bodies generally depends upon the amount of water available and on its depth. Mean annual flow rate in Chambal river was found to be minimum (6.0 cm $sec^{-1}$) at Station-B in the month of February and maximum (46.00 cm $sec^{-1}$) at Station-C in the month of September.

The colour of river water was very much turbid in monsoon season and except for monsoon season, the colour of water was transparent. The minimum depth (1.47 m) of river water was recorded at Station-C in the month of March while maximum depth (9.26 m) was recorded in the month of August at Station-A. The minimum turbidity (1.00 NTU) was recorded at Station-C in the month of March and maximum turbidity (178.00 NTU) was recorded at Station-B in the month of August.

Conductivity is the measure of capacity of a substance or solution to conduct electrical current through the water. In the present study, lowest conductivity value (145.60 µS $cm^{-1}$) was observed at Station-A in the month of September and highest value of conductivity (884 µS $cm^{-1}$) was observed at Station-C in the month of May. Total dissolved solids are composed of carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of Ca, Mg, Na, K, and Mn and organic matter, salts and others particles (Mishra and Saksena, 1991). Minimum total dissolved solids (260 $mgl^{-1}$) were recorded at Station-B and Station-C, while maximum value (500 $mgl^{-1}$) was recorded at Station-C in the month of September.

Ellis (1937) has observed that a pH range of 6.7 to 8.4 is suitable for the growth of aquatic biota. The water in Chambal River was always alkaline throughout the period of study. Alkaline pH was also observed by Shaikh and Yeragi (2004) in river Tansa during whole study period, while Varma (1998) have observed acidic nature of water of Subernarekha river due to discharge of copper industrial effluents in this river. The minimum pH value (7.60) was recorded at Station-C in the month of October and maximum pH (9.33) was recorded at Station-A in the month of June.

Dissolved oxygen is one of the important parameter in water quality assessment. Its presence is essential to maintain variety of forms of biological life in the water and the effect of waste discharge in a water body is largely determined by the oxygen balance of the system. Dissolved oxygen is regulator of metabolic activities of organisms and thus governs metabolism of the biological community as a whole and also acts as an indicator of trophic status of the water body (Saksena and Kaushik, 1994). Oxygen is generally reduced in the water due to respiration of biota, decomposition of organic matter, rise in temperature, oxygen demanding wastes and inorganic reductant such as hydrogen sulphide, ammonia, nitrites, ferrous iron, *etc.* (Sahu *et al.,* 2000). Inorganic reducing agents such as hydrogen sulphide, ammonia, nitrite, ferrous iron and certain oxidizable substances also tend to decrease dissolved oxygen in water. Tarzwell (1957) has suggested that a minimum of 3 $mgl^{-1}$ dissolved oxygen is necessary for healthy fish and other aquatic life. In the present study, the minimum value of dissolved oxygen was recorded as 4.86 $mgl^{-1}$ at Station-A in the month of August and maximum recorded as 14.59 $mgl^{-1}$ at Station-C in the month of November. This level of oxygen in the river should be able to support good fauna and flora. Similar observation was recorded by Singh and Rai (1999) in river Ganga, Hiware and Jadhav (2001) in river Manjar, Rafeeq and Khan (2002) in river Godavari. The pH, alkalinity and free carbon dioxide are interrelated in aquatic ecosystems. Most of the free carbon dioxide in water comes from the decomposition of organic matter and from respiration of organisms (Singh, 1999). In polluted water, the free carbon dioxide is generally high. In Chambal river, free carbon dioxide ranged from non traceable amount at all stations to the maximum value of 16.50 $mgl^{-1}$ at Station-C in the month of August. Good oxygen saturation and low free carbon dioxide indicate no pollution load in the river at all Stations.

Ganapati (1943) attributed that the changes in the values of bicarbonates are associated with the rate of photosynthetic activity. Klein (1959), Shrivastava and Patil (2002) suggested that the alkalinity is directly related to the abundance of phytoplankton which dissociate bicarbonate into carbonates and carbon dioxide. The carbon dioxide, thus, released is used in photosynthesis. George *et al.* (1966) have opined that with a pH range of 7.0 to 9.0 in water bodies, the bicarbonates concentration remains high. The lowest level of total alkalinity in the Chambal river was 70.0 $mgl^{-1}$ at Station-B in the month of October and highest level was 290.0 $mgl^{-1}$ at

**Table - 2:** Comparison of physico-chemical parameters of Chambal river with that of Indian standards

| S. No. | Parameters | Present study on Chambal river | IS-2296: 1974 | | |
|---|---|---|---|---|---|
| | | | Public water supply | Fish culture | Irrigation |
| 1 | Turbidity (NTU) | 1.00-178.00 | 10(IS: 10500:1991) | | |
| 2 | Electrical conductivity (μS $cm^{-1}$) | 100.00-884.00 | | 1000.00 | |
| 3 | Total dissolved solids ($mgl^{-1}$) | 260.00-500.00 | 500 | | 2100.00 |
| 4 | pH | 7.6-9.33 | 6.00-9.00 | 6.00-9.00 | 5.50-9.00 |
| 5 | Dissolved oxygen ($mgl^{-1}$) | 4.86-14.59 | >4.00 | >3.00 | |
| 6 | Free carbon dioxide ($mgl^{-1}$) | 0.00-16.50 | | 6.00 | |
| 7 | Total alkalinity ($mgl^{-1}$) | 70.00-290.00 | 200-600 (IS-10500:1991) | | |
| 8 | Total hardness ($mgl^{-1}$) | 42.00-140.00 | 300-600 (IS-10500:1991) | | |
| 9 | Chlorides ($mgl^{-1}$) | 15.62-80.94 | 600.00 | | 600.00 |
| 10 | Calcium ($mgl^{-1}$) | 9.61-44.08 | 74-200 (IS-10500:1991) | | |
| 11 | Nitrates ($mgl^{-1}$) | 0.008-0.025 | 50.00 | | |
| 12 | Nitrites ($mgl^{-1}$) | 0.002-0.022 | 0.020 | | |
| 13 | Sulphates ($mgl^{-1}$) | 3.50-45.00 | 200-400 (IS-10500:1991) | | 1000.00 |
| 14 | BOD ($mgl^{-1}$) | 0.60-5.67 | 3.00 | | |
| 15 | Ammonia ($mgl^{-1}$) | 0.00-0.56 | | 1.20 | |
| 16 | Sodium ($mgl^{-1}$) | 14.30-54.40 | 200 | | |

Station-C in the month of June. Similar seasonal variations have been recorded by Singh and Rai (1999) in river Ganga at Varanasi.

Cation of calcium, magnesium, iron and manganese contribute to the hardness of water (Shrivastava and Patil, 2002). Barrett (1953) has reported that the hard waters are more productive than the soft water from fisheries point of view. The minimum value of total hardness in the river was 42.00 $mgl^{-1}$ at Station-A in the month of June and maximum value was 140.0 $mgl^{-1}$ at Station-C in the month of November.

Chloride concentration in water indicates the presence of organic waste in water, primarily of animal origin (Thresh *et al.,* 1949). It increases with ammonical nitrogen which also owes itself mostly to animal excreta. Chloride in Chambal river varied from 15.62 $mgl^{-1}$ at Station-A in the month of August to 80.94 $mgl^{-1}$at Station-C in the month of May. The chloride concentration was quite low in this river which reflects that there is very less amount of organic waste of animal origin and practically no discharge of municipal and industrial wastes. The calcium is one of the most abundant substances of natural water being present in high quantities in the rocks. The disposal of sewage and industrial wastes are also important sources of calcium. The calcium level in the river varied from 9.61 to 44.08 $mgl^{-1}$ during April to March.

Alderfer and Lovelace (1977) believed that inorganic nitrogen above 0.03 $mgl^{-1}$ stimulates algal growth to such an extent that water may not be suitable for human consumption. In the river under study, nitrate from to 0.008 $mgl^{-1}$ at Station-A in the month of March to 0.025 $mgl^{-1}$ at Station-B in the month of October was recorded. Nitrate-N was found to be quite low during the present investigation which reflects that the river does not receive any waste water. Nitrite in the river varied from 0.002 $mgl^{-1}$ at Station-A in the month of March to 0.022 $mgl^{-1}$ at Station-A in the month of October, 2003. Sulphate in the river varies from minimum of 3.50 $mgl^{-1}$ at Station-C to maximum of 45.00 $mgl^{-1}$ at Station-C in the month of March.

Major source of phosphate in water are domestic sewage, agriculture effluents and industrial waste waters. The high concentration of phosphate is, therefore, indicative of pollution. In Chambal river, phosphate was recorded from 0.004 $mgl^{-1}$ at Station-C in the month of September to 0.050 $mgl^{-1}$ at Station-B in the month of October. Sinha *et al.* (1998) have reported higher phosphate content in lower stretch of Ganga river during monsoon season.

Silica is quite abundant on the earth but silicates remain meager in water. The major source of dissolved silica in river is the weathering of rocks and mineral in the catchments area. Silicate is an essential nutrient for growth of diatoms that are important food to fishes (Nath and De, 1998; Nath and Srivastava, 2001; Johnson, 2004). In Chambal river, silicates fluctuated from 2.80 $mgl^{-1}$ to 13.80 $mgl^{-1}$.

Biochemical oxygen demand (BOD), a pollution indicator, showed its level in river from 0.60 $mgl^{-1}$ at Station-C to 5.67 $mgl^{-1}$ at Station-B. Low BOD content indicated that the riverine stretch was free from organic pollution. Fokmare and Musaddiq (2002) recorded high value of biochemical oxygen demand (BOD) as 20.00 $mgl^{-1}$ in river Purna and said that this river is highly polluted due to organic enrichment, decay of plants and animal matter in the river. Chemical oxygen demand (COD) gives us a reliable parameter for judging the extent of pollution in water (Shrivastava and Patil, 2002). COD is the measure of the oxygen required for chemical oxidation of organic matter. In this river, maximum value of COD (26.80 $mgl^{-1}$) at Station-A during May and minimum value (2.40 $mgl^{-1}$) at Station- A in July have been recorded. This also provides a direct measure of state of pollution in water bodies (Kulshrestha and Sharma, 2006).

The presence of ammonia is an evidence of sewage inflow to a water body. However, free ammonia serves as an indicator of aquatic pollution was generally absent or found in traces during most occasions in Narmada river (Nath and Srivastava, 2001). Chambal river had a range of ammonia concentration between nil at all stations to 0.56 $mgl^{-1}$ at Station-A and B in the month of February, 2004. Ammonia in present case indicates no pollution at various stations in the river. Sulphide indicates the amount of organic matter present in water, degradable by sulphur bacteria. Chambal river water, however, showed a range from untraceable amount of sulphide at all stations to a maximum value of 0.28 $mgl^{-1}$ at Station-B and C in the month of March.

Magnesium in Chambal river varies from 1.70 to 20.17 $mgl^{-1}$ during the period of study. Sodium is one of the important cation occurring naturally. Sodium concentration in irrigation water and soil is of great interest as high sodium contents makes soil hard to plough and unsuitable for seedling emergence. Chambal water had sodium concentration from 14.30 $mgl^{-1}$ at Station-C in the month of August to 54.40 $mgl^{-1}$ at Station-C in the month of June and potassium level from 2.10 $mgl^{-1}$ at Station-C in the month of August to 6.30 $mgl^{-1}$ at Station-B in the month of December, suggesting their moderate but harmless concentration.

On the basis of various parameters studied, Chambal river in this stretch can be placed under oligosaprobic. When various parameters of our study are compared with that of Indian standards (IS,1974, 1991) for public water supply, fish culture and irrigation, it was revealed that all such parameters are well within the limits (Table 2). The water characteristics considered for the study indicate that the river water in the National Chambal Sanctuary is pollution free and can serve as a good habitat for many aquatic animals including endangered species.

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