6. OBSERVATIONS, RESULTS & DISCUSSIONS:

6.1. PHYSICO-CHEMICAL COMPONENTS:

Temperature

Temperature is one of the most important factors which influence the aquatic ecology (Huet,1986). In Eastern region, water temperature was found between 16 - 32^0 C while in Central and Western region its range was- 18 to 35^{0}C and 18 to 29^{0}C respectively. The minimum temperature was found in Kapilvan, Amarkantak in the month of January, 2009. Variations in the temperature at sampling locations is depicted in Fig-1

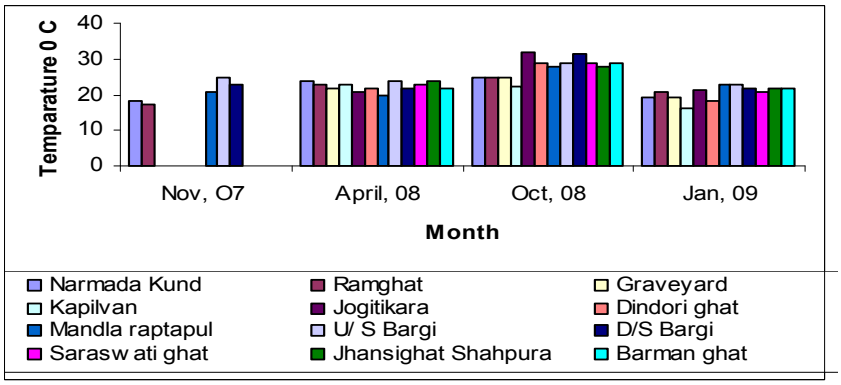

Fig. 1a: Variation of water temperature in Eastern region

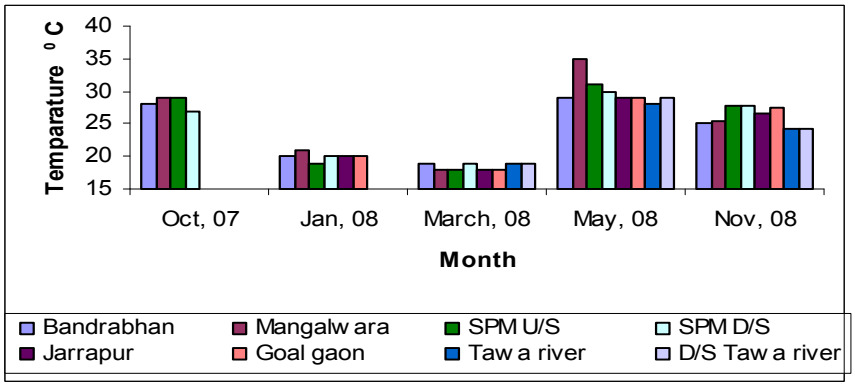

Fig. 1b: Variation of water temperature in Central region

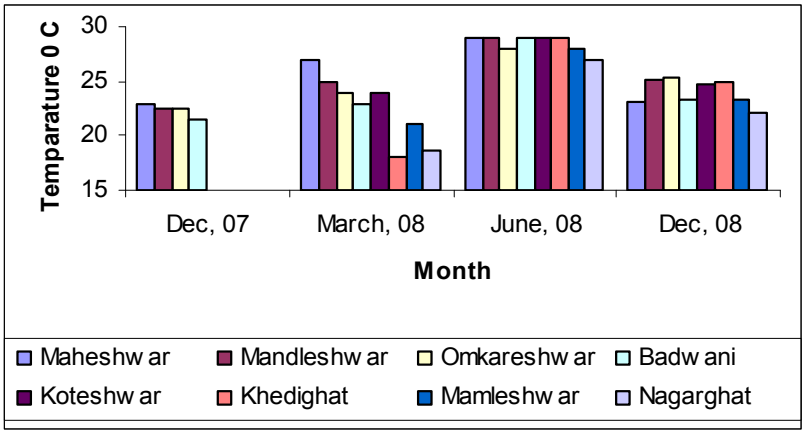

Fig. 1c: Variation of water temperature in Western region

Turbidity:

Turbidity of water is mainly due to suspended solids in the water, including silts, clays, industrial wastes, sewage and plankton. Such particles absorb heat in the sunlight, thus raising water temperature, which in turn lowers dissolved oxygen levels. They also prevent sunlight from reaching plants below the surface. This decreases the rate of photosynthesis, so less oxygen is produced by plants. Range of turbidity in eastern and western zone is in between 1-4 NTU and in Central region it is 1-5 NTU. Maximum turbidity was recorded in the month of November, 08 in Tawa River. Variations in the turbidity at sampling locations is depicted in Fig-2

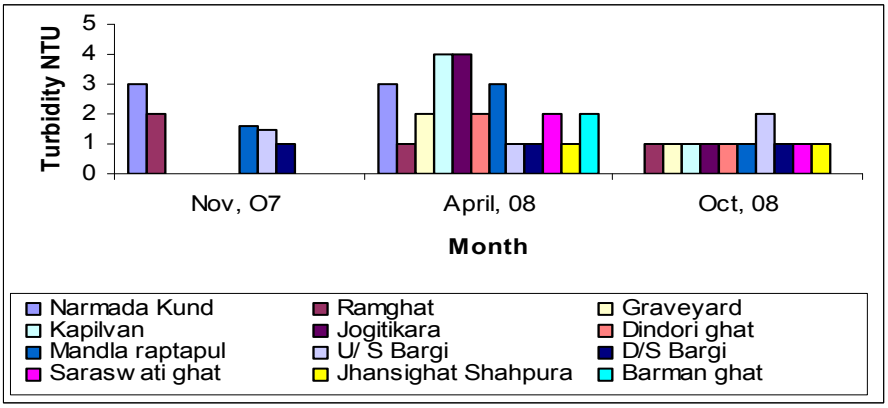

Fig. 2a: Variation of turbidity in Eastern region

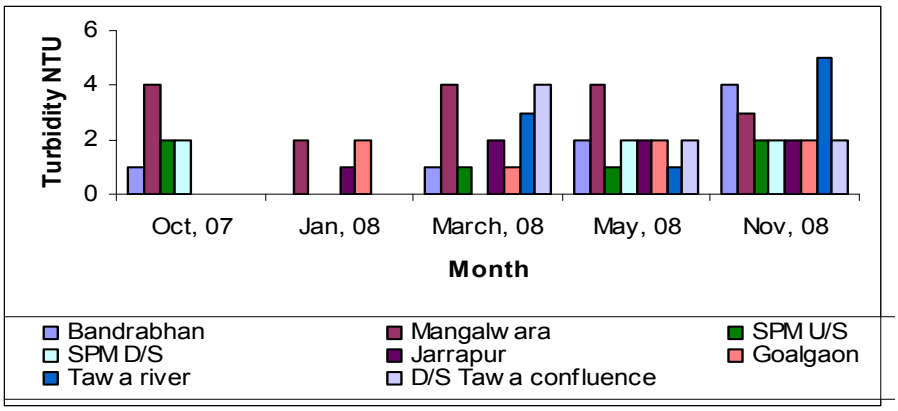

Fig. 2b: Variation of turbidity in Central region

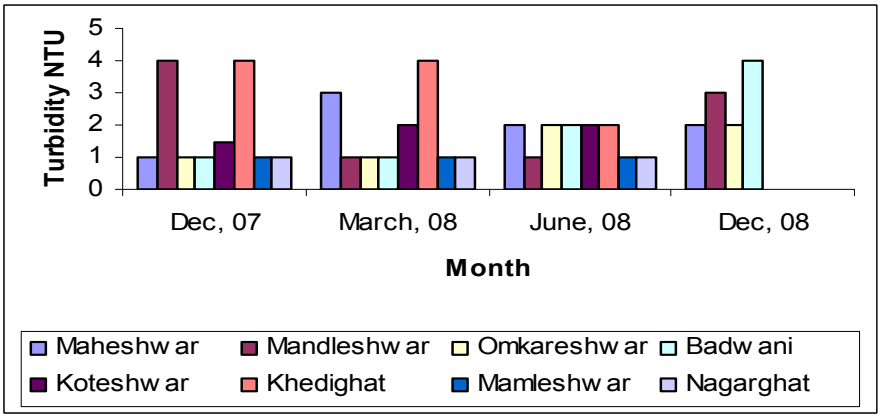

Fig. 2c: Variation of turbidity in Western region

pH:

pH plays a main role for biological life in order to ensure they may survive in water bodies. The concentration range of pH suitable for existence of most biological life quite narrow and crucial. Generally the desirable pH range for treated effluents either from municipal or industrial discharged into water streams usually varies from 6.5 to 8.5 pH (Metcalf and Eddy, 2004). pH of the entire stretch was observed in the range of 5.03 -9. In case of eastern zone the range was observed in between 5.03-9. Central and Western zone exhibit almost same pH range i.e. 6-9. The minimum pH was recorded in Narmada kund in the month of November, 07. Variations in the pH at sampling locations is depicted in Fig-3.

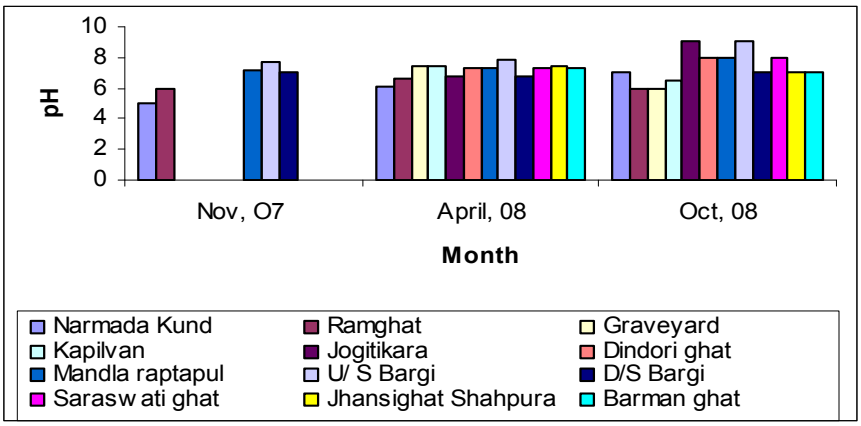

Fig. 3a: Variation of pH in Eastern region

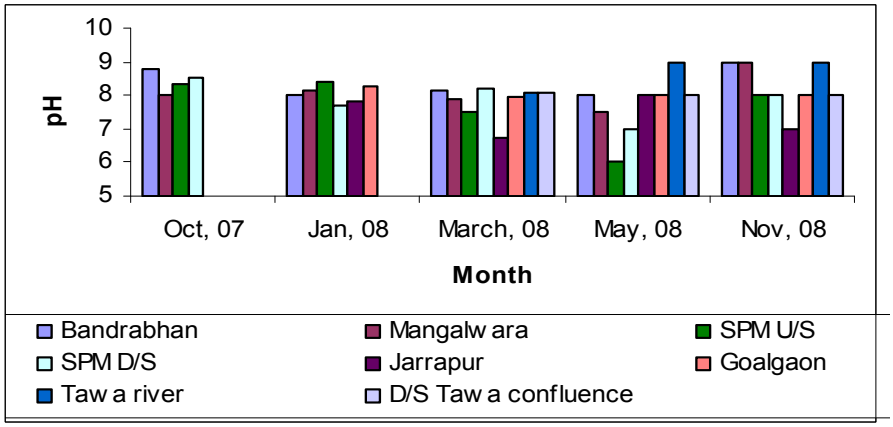

Fig. 3b: Variation of pH in Central region

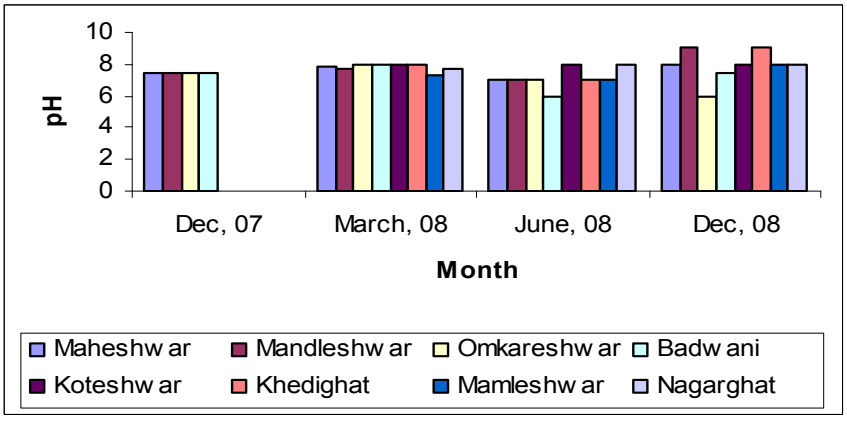

Fig. 3c: Variation of pH in Western region

Conductivity:

Conductivity, is a measure of the ability of an aqueous solution to carry an electrical current flow, it is expressed in microSiemens (uS). Because conductivity increases nearly linearly with increasing ion concentration, we can use conductivity measurements to estimate ion concentrations in solutions. The range of conductivity of the entire stretch was observed in the range of 60- 380 uS/cm showing minimum and maximum in the eastern region. Conductivity in Central and Western region were observed in between 110- 330 uS/cm and 140- 355 uS/cm respectively. Maximum was noted at Raptapul ghat, Mandla in the month of November, 07. Variations in the temperature at sampling locations is depicted in Fig-4

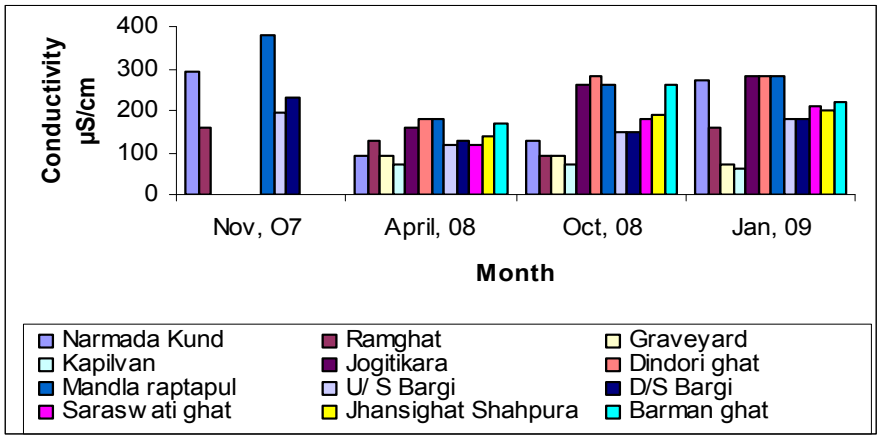

Fig. 4a: Variation of conductivity in Eastern region

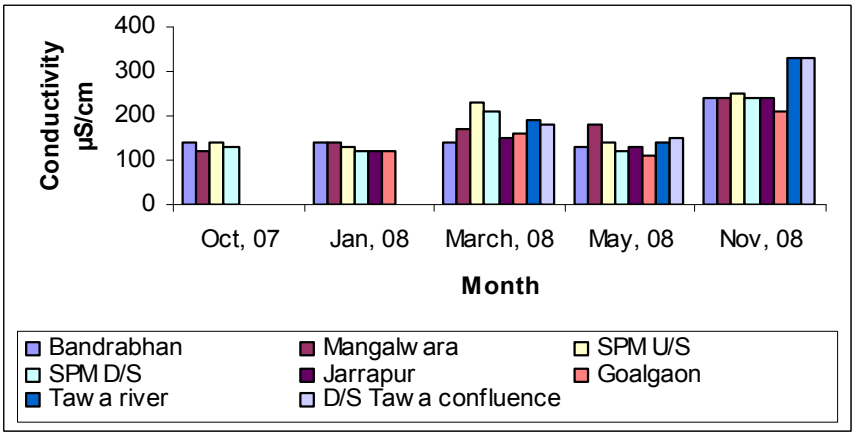

Fig. 4b: Variation of conductivity in Central region

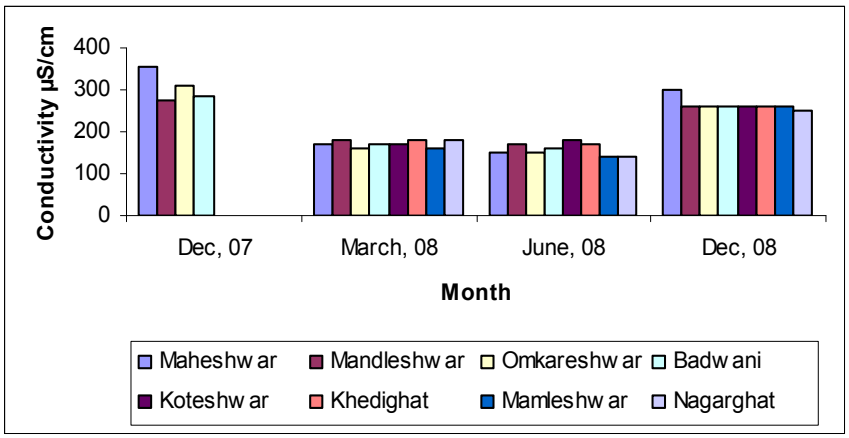

Fig. 4c: Variation of conductivity in Western region

Total Dissolved Solids (TDS):

Total solids content is the most vital physical characteristic of both water and wastewater, which is composed of colloidal matter, floating matter, settleable matter etc in solution. In Eastern zone range of TDS was observed in the range of 6-190 mg/l, in Central zone it was 18-220 mg/l and in Western zone it was 57-200mg/l respectively. Minimum TDS was recorded in downstream of Bargi reservoir in the month of October, 08. Variations in the TDS at sampling locations is depicted in Fig-5

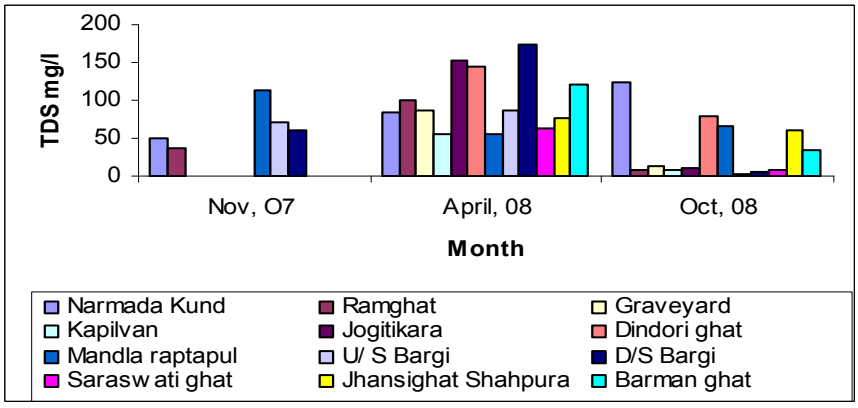

Fig. 5a: Variation of TDS in Eastern region

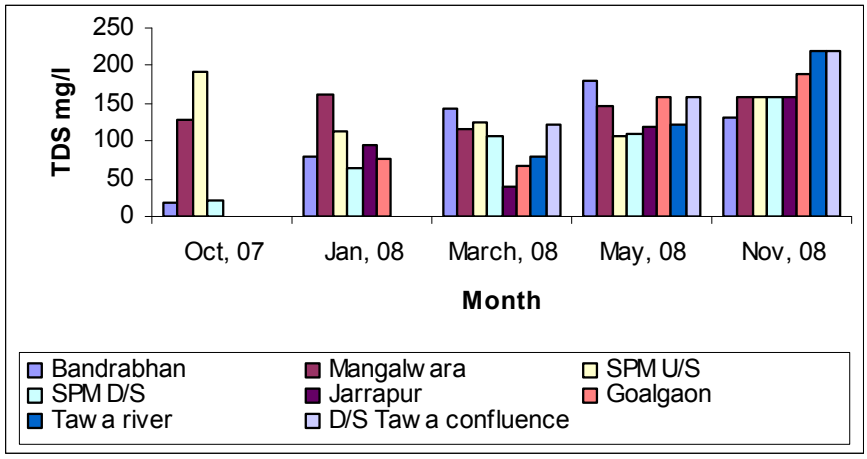

Fig. 5b: Variation of TDS in Central region

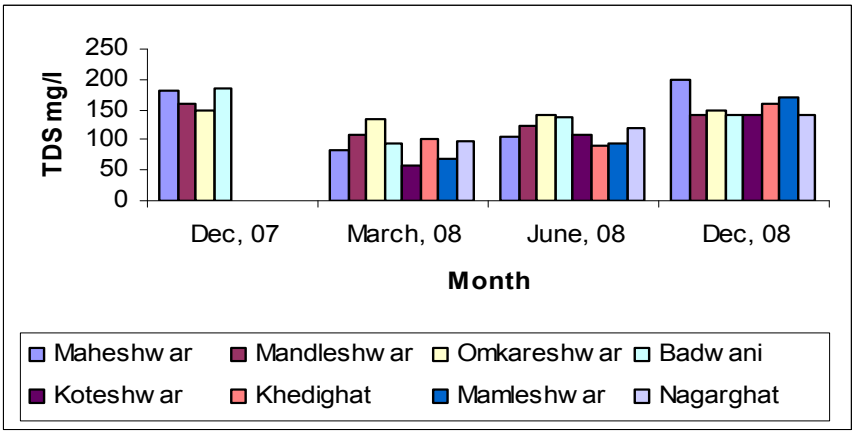

Fig. 5c: Variation of TDS in Western region

DISSOLVED OXYGEN (DO):

Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water. Oxygen enters the water as rooted aquatic plants and algae undergo photosynthesis, and as oxygen is transferred across the air-water interface. The amount of oxygen that can be held by the water depends on the water temperature, salinity, and pressure. Gas solubility increases with decreasing temperature (colder water holds more oxygen). Dissolved oxygen in Eastern zone varied between 4.2-11.8 mg/l showing maximum in Bargi reservoir upstream in the month of October, 08 and minimum in Saraswati ghat in the month of October, 08. The range of DO in Central and Western zone was 5.4-13.1 mg/l and 5.6-11.4. mg/l. Maximum DO was recorded in the month of November, 08 at Bandrabhan site, Hoshangabad. Variations in the DO at sampling locations is depicted in Fig-6

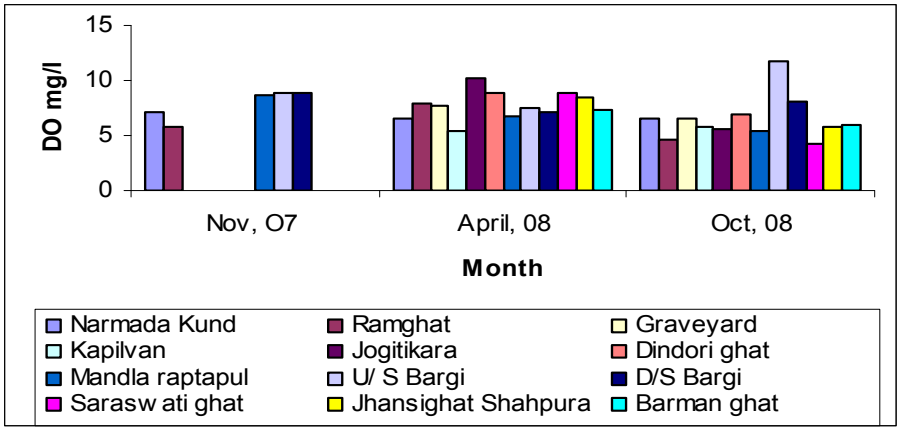

Fig. 6a: Variation of DO in Eastern region

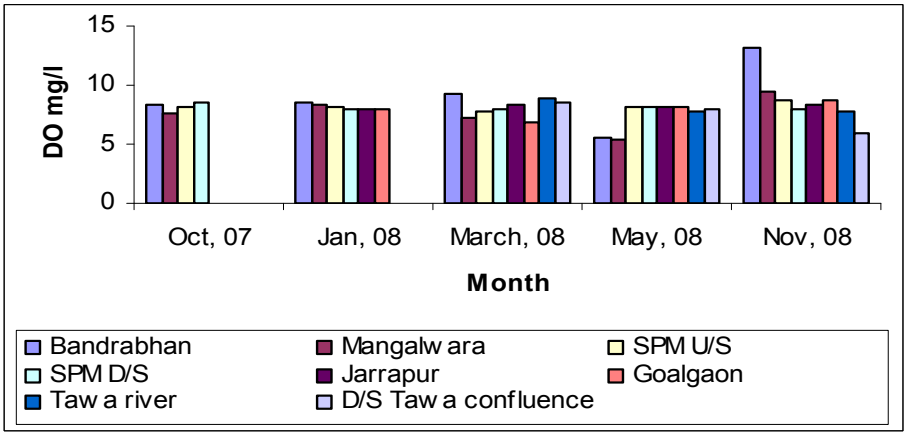

Fig. 6b: Variation of DO in Central region

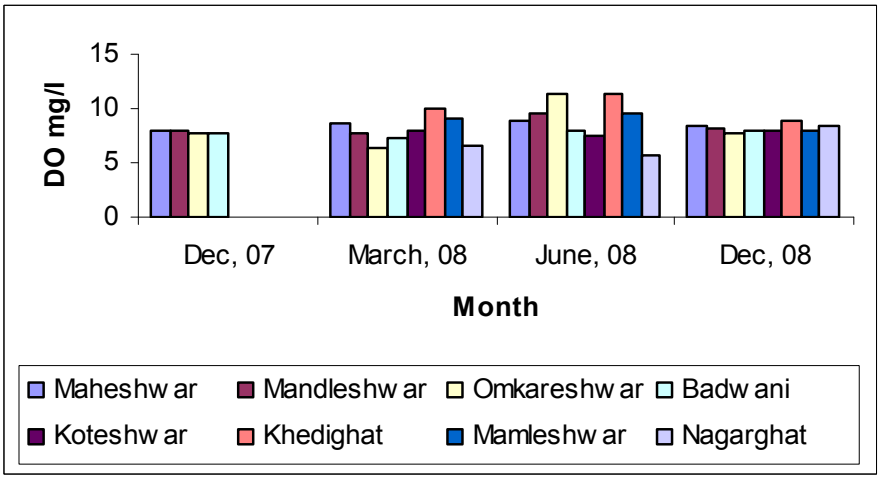

Fig. 6c: Variation of DO in Western region

Biochemical oxygen demand [BOD]:

Biochemical oxygen demand (BOD) is one of essential parameter in order to determine organic pollutant level as consequence of domestic wastes, agricultural. Minimum BOD of Eastern and Central zone was observed same 0.4 mg/l. The maximum BOD of Eastern zone was 7.6 mg/l while it was 4.1 mg/l in Central zone. The range of BOD in Western zone was in between 1.2- 4.1 mg/l. Maximum BOD was noted in the month of October, 08 at Bargi U/S. Variations in the BOD at sampling locations is depicted in Fig-7

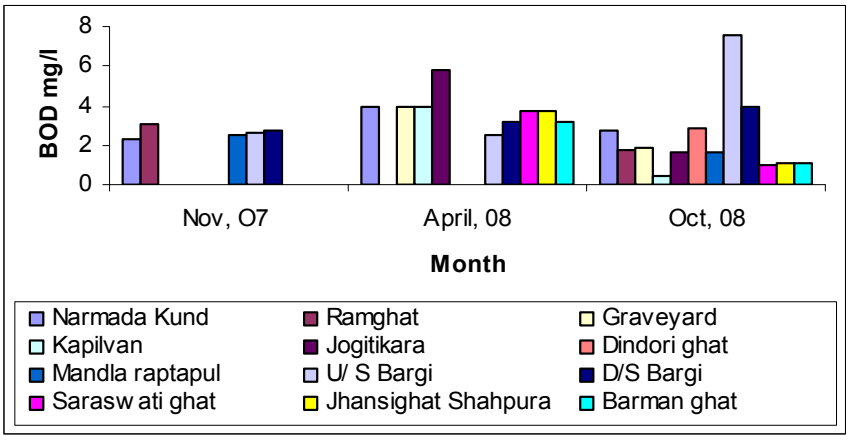

Fig. 7a: Variation of BOD in Eastern region

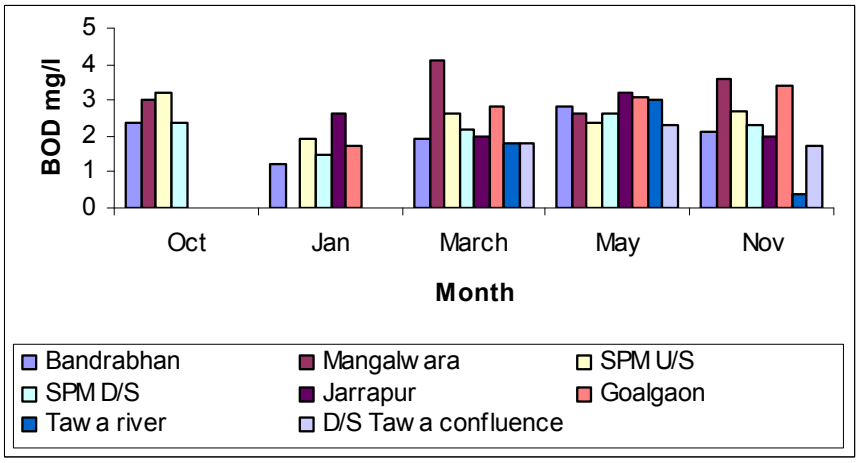

Fig. 7b: Variation of BOD in Central region

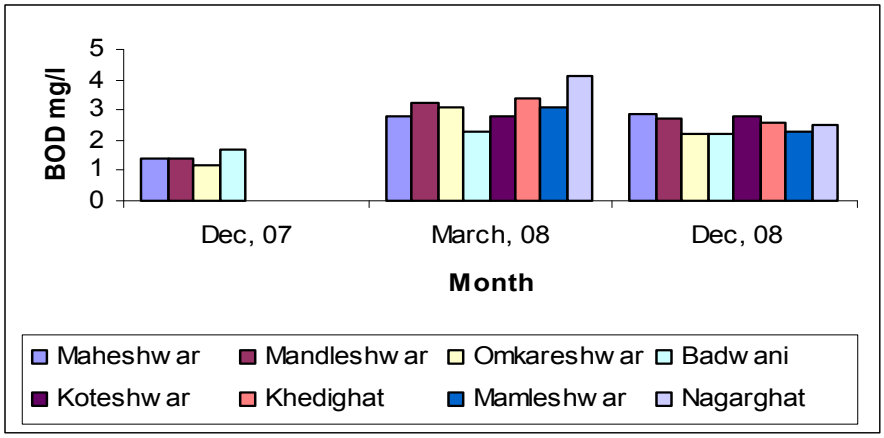

Fig. 7c: Variation of BOD in Western region

Chemical Oxygen Demand [COD]:

COD refer to the quantity of oxygen required to oxidize a complete organic substance chemically to form Carbon Dioxide (CO_2) and water (H_2O). The deteriorating of water quality can be measured with high value of COD. The minimum COD of the entire stretch of river under eastern to western zone was 10 mg/l while the maximum 110 mg/l. The range of COD in Eastern, Central and Western zone were 10-110 mg/l, 10-100 mg/l and 10 – 60 mg/l respectively. The maximum COD was found at D/S Bargi in the month of October, 08. Variations in the DO at sampling locations is depicted in Fig-8

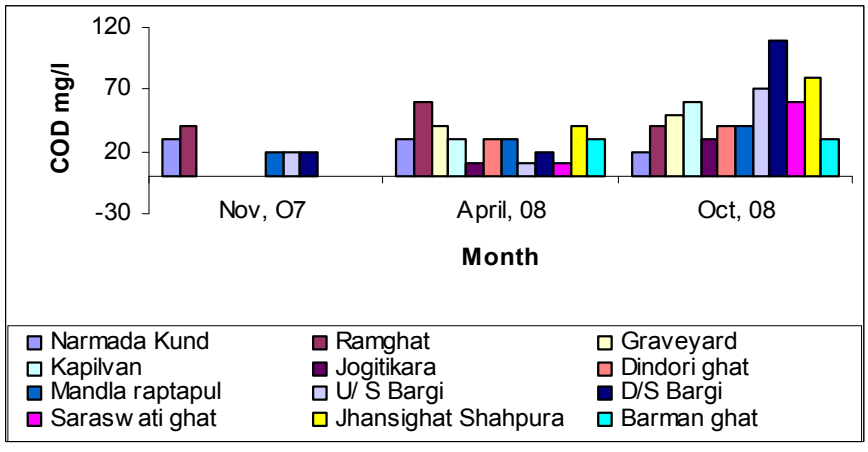

Fig. 8a: Variation of COD in Eastern region

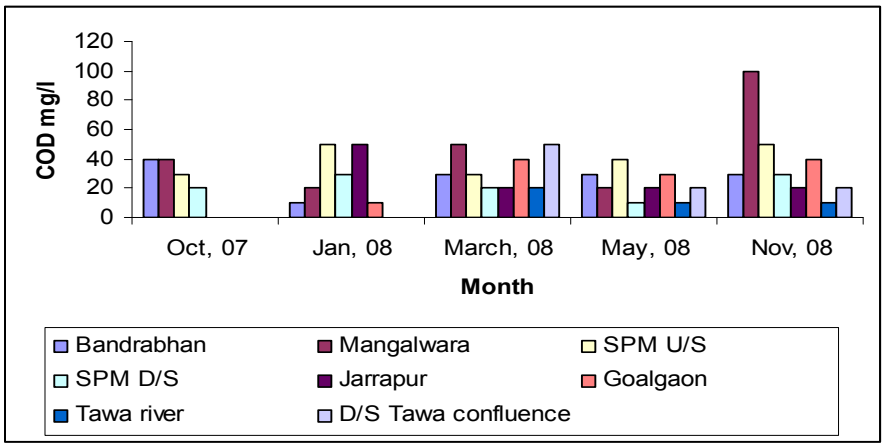

Fig. 8b: Variation of COD in Central region

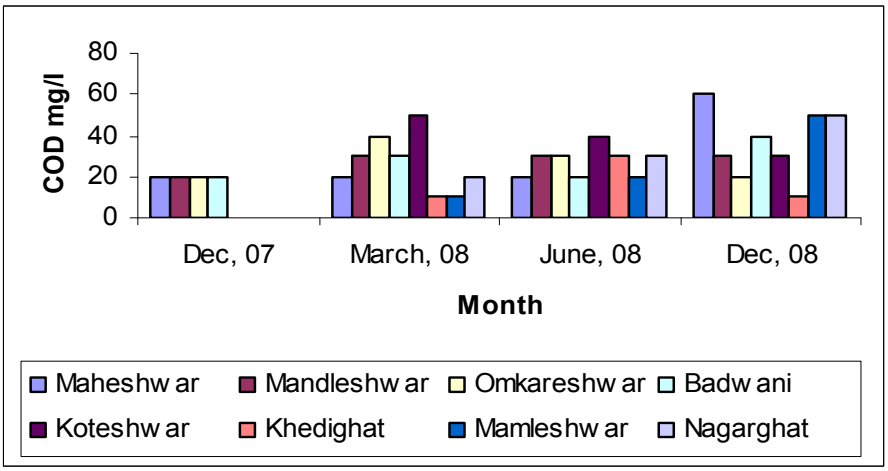

Fig. 8c: Variation of COD in Western region

Total Coliform:

Total coliform, fecal coliform, and *E. coli* are indicators of water quality. The total coliform group is a large collection of different kinds of bacteria. Total coliform bacteria are commonly found in the environment are generally harmless.Variations in the coliforms at sampling locations is depicted inFig-9

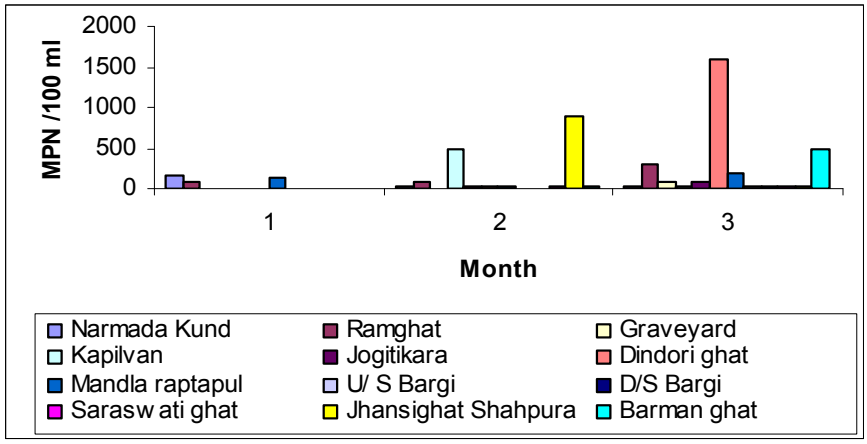

Fig. 9a: Variation of total coli form in Eastern region

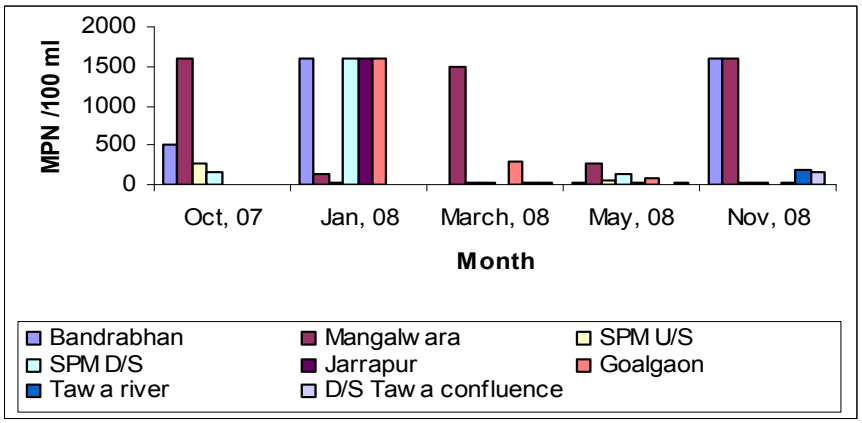

Fig. 9b: Variation of total coli form in Central region

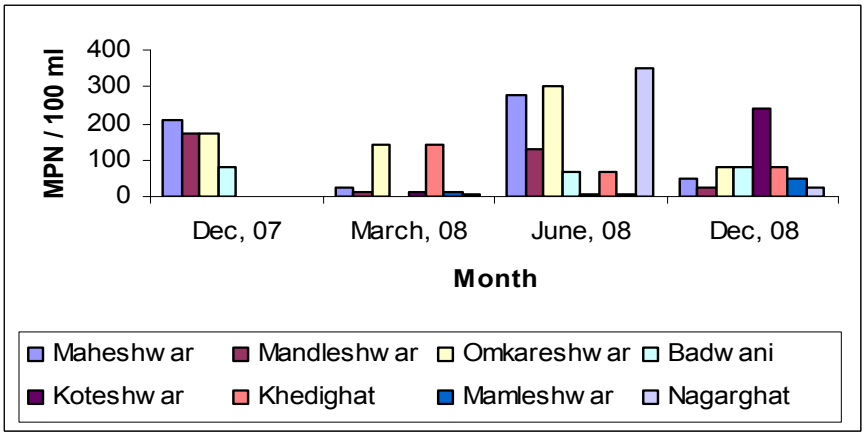

Fig. 9c: Variation of total coli form in Western region

Fecal Coliform:

Fecal coliforms are mostly exists in faeces. Fecal coliform bacteria are a sub-group of total coliform bacteria. They appear in great quantities in the intestines and faces of people and animals. The presence of fecal coliform in a drinking water sample often indicates recent fecal contamination meaning that there is a greater risk that pathogens are present than if only total coliform bacteria is detected. In most cases fecal coliform bacteria was absent in the sample. In Narmada kund (origin of Narmada river) fecal coliform was found maximum (9 MPN/100 ml) in the month of November, 07.

Ammonical nitrogen

The major sources of ammonical nitrogen are herbicide, pesticide and fertilizer from agricultural and farming activities, detergent from diurnal resident activities and animal manure from pig farm. The range of ammonical nitrogen in Eastern zone was observed in the range of 0.1- 1.17 mg/l. In Central zone and Western zone ammonical nitrogen ranged between 0.214- 0.979 mg/l and 0.008- 5018 mg/l showing maximum in Omkareshwar in the month of December, 08 and minimum in Maheshwar in the month of June, 08. Variations in the ammonical nitrogen at sampling locations is depicted in Fig-10

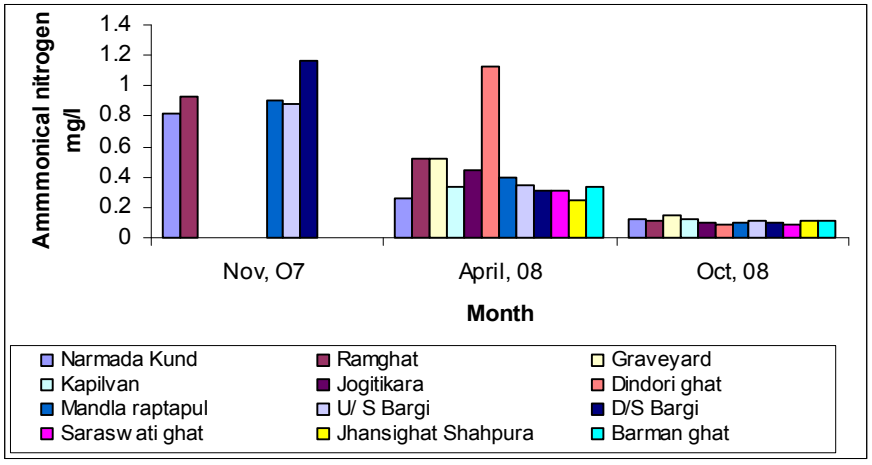

Fig. 10a: Variation of Ammonical nitrogen in Eastern region

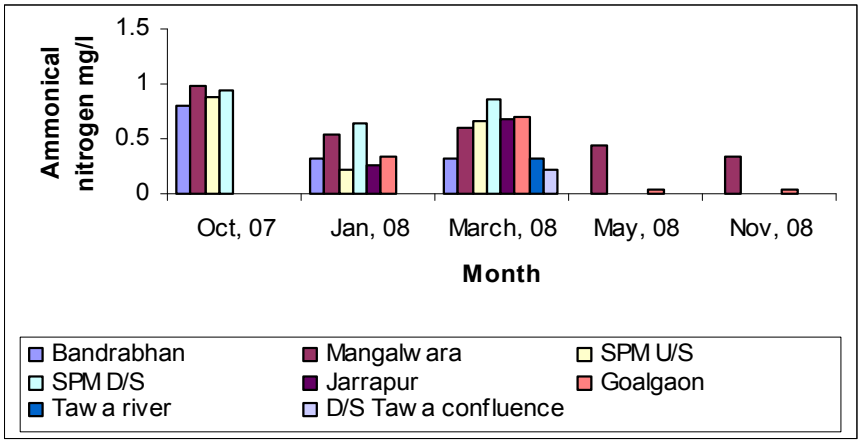

Fig. 10b: Variation of Ammonical nitrogen in Central region

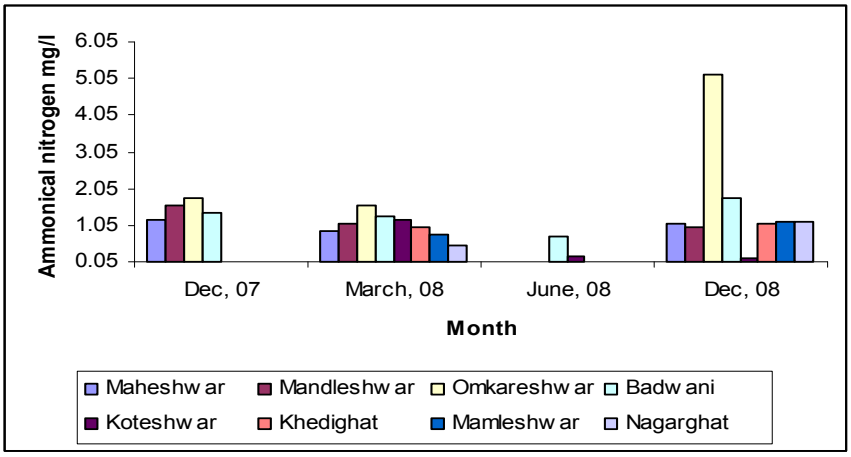

Fig. 10c: Variation of Ammonical nitrogen in Western region

Nitrate nitrogen :

Although nitrates occur naturally in soil and water, excess levels of nitrates can be considered to be a contaminant of ground and surface waters. Most sources of excess nitrates come from anthropogenic activities. The source of excess nitrates can usually be traced to agricultural activities, human wastes, or industrial effluents. Nitrate concentration in Eastern zone was observed in the range between 0.01- 1.0 mg/l while it was 0.003- 0.516 mg/l in Central zone and 0.085 – 0.809 mg/l in Western zone. Variations in the nitrate nitrogen at sampling locations is depicted in Fig-11

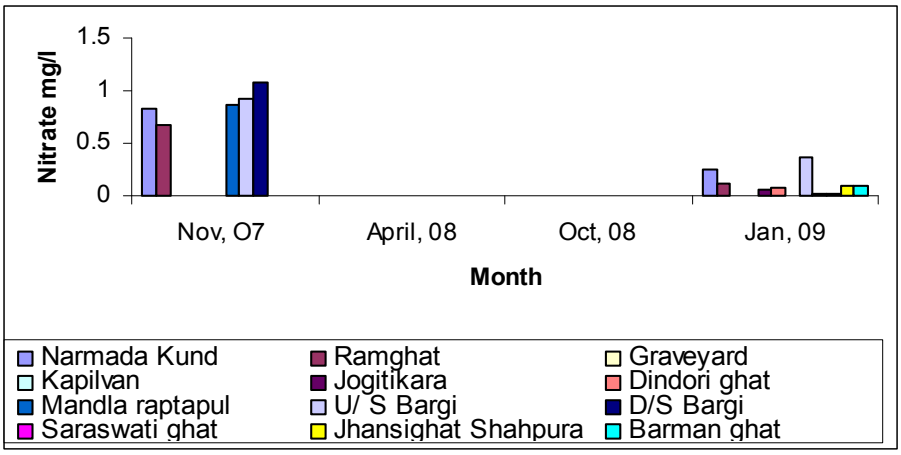

Fig. 11a: Variation of nitrate in Eastern region

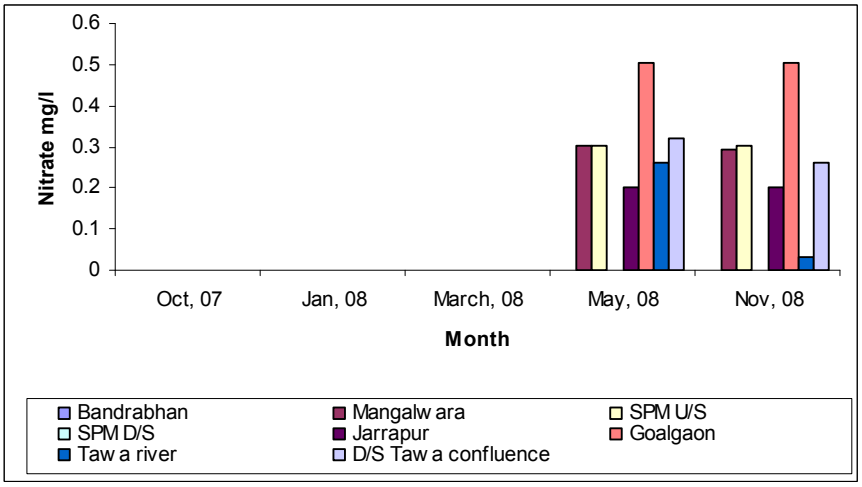

Fig. 11b: Variation of nitrate in Central region

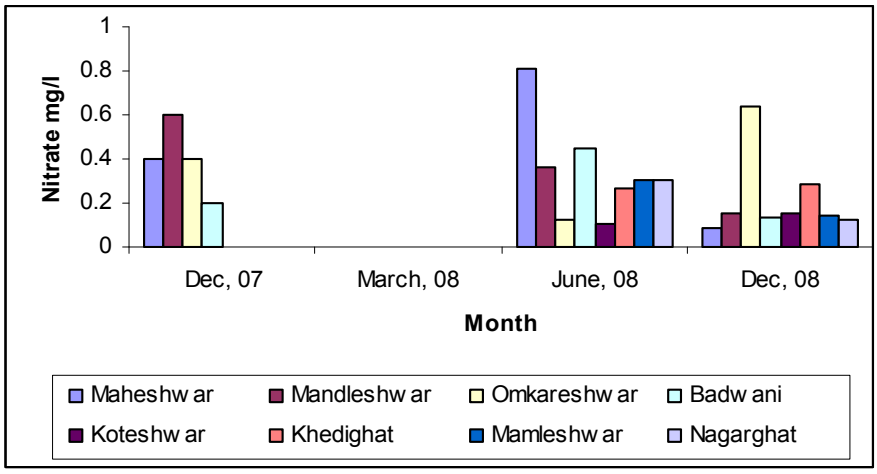

Fig. 11c: Variation of nitrate in Western region

Nitrite nitrogen :

Nitrite is an intermediate oxidation state of nitrogen. In aquaria and ponds, nitrites are produced by Nitrosomonas bacteria when ammonia is broken down. Nitrite concentration in the entire stretch observed in a range of 0.003- 20.52 mg/l. Maximum nitrite concentration was observed at SPM D/S in the month of October, 07. The ranges of nitrite in Eastern, Central and Western zone were 0.01-5.336 mg/l, 0.026 – 20.62 mg/l and 0.003 -.0.68 mg/l respectively. Variations in the nitrite nitrogen at sampling locations is depicted in Fig-12

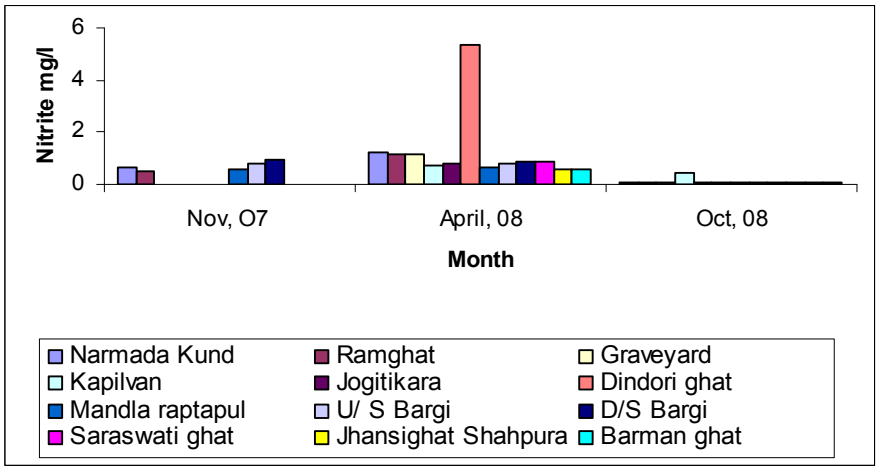

Fig. 12a:Variation of nitrite in Eastern region

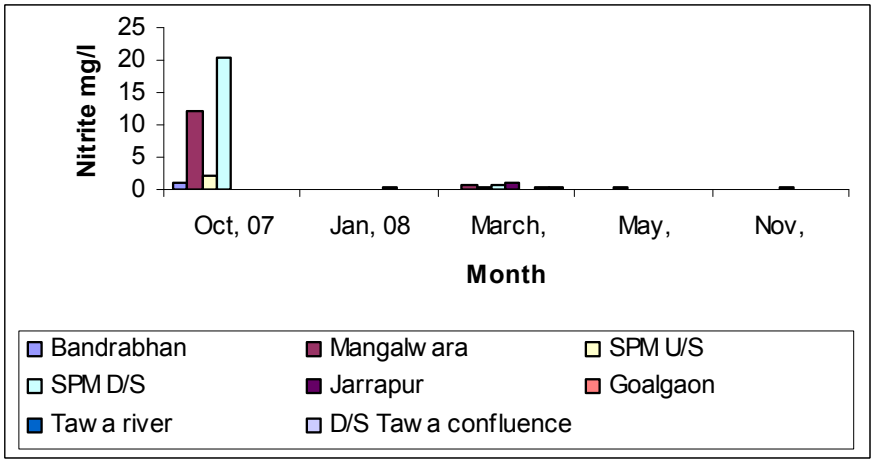

Fig. 12b:Variation of nitrite in Central region

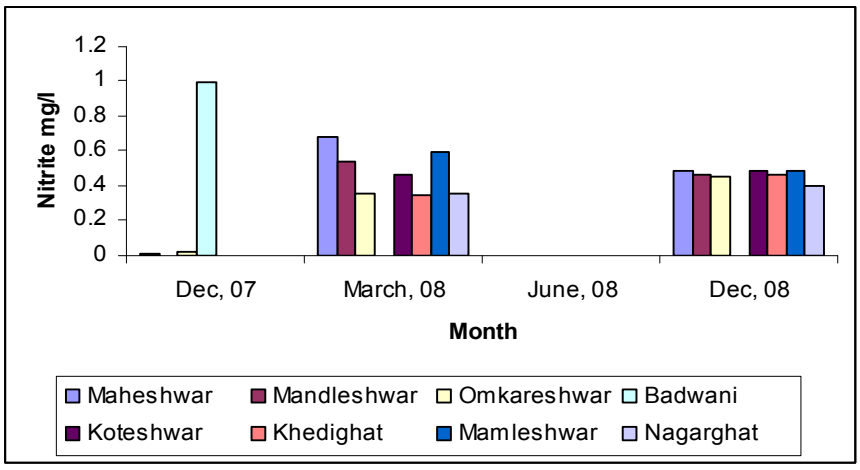

Fig. 12c: Variation of nitrite in Western region

Phosphate :

Phosphate deposits and phosphate-rich rocks release phosphorus during weathering, erosion, and leaching process. Phosphorus may also be released from lake and reservoir bottom sediments during seasonal overturns. Sewage treatment plants provide most of the available phosphorus to surface water bodies. The range of phosphate in Eastern zone was observed in between 0.222- 1.894 mg/l, in Central zone it was 0.021 – 1.5 mg/l and in western zone it was 0.036 – 2.5 mg/l. Variations in the phospates at sampling locations is depicted in Fig-13

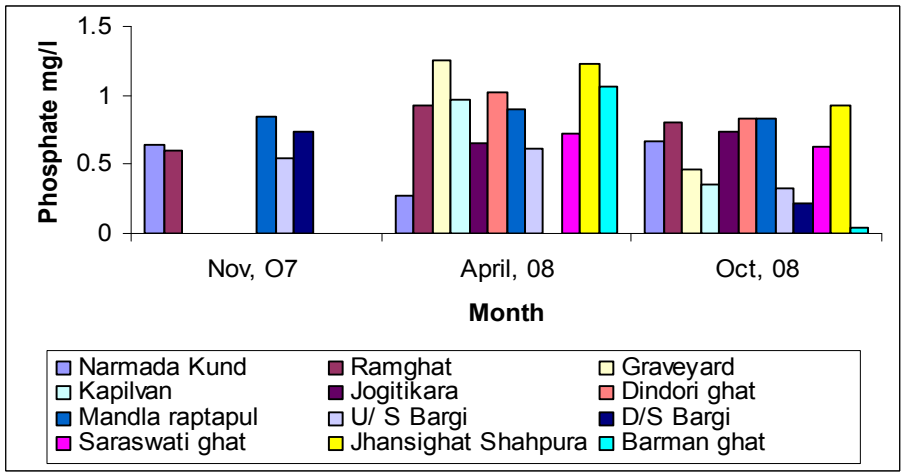

Fig. 13a: Variation of phosphate in Eastern region

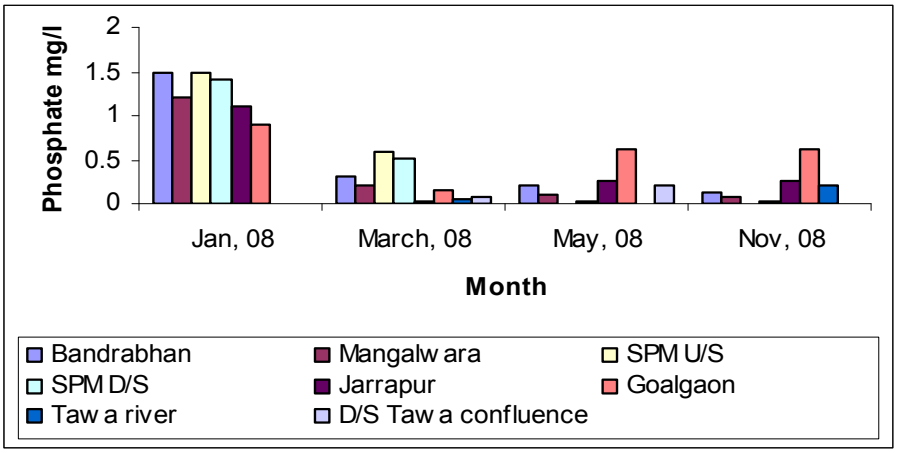

Fig. 13b: Variation of phosphate in Central region

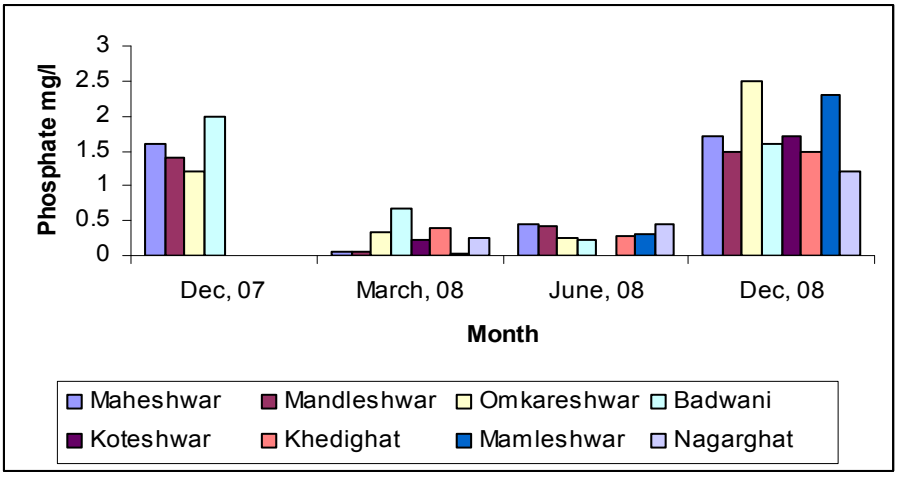

Fig13c. Variation of phosphate in Western region

The surface water quality of the Narmada river is also compared with BIS 2296 [1982]. It is observed that the quality of river water of the Eastern Zone classified under class A and B in most of the sampling sites and class C at Dindorighat. This reveals that the surface water in this region is suitable for outdoor bathing and used for domestic use after treatment and disinfection.

Surface water quality at Central Zone classified under class A-C. The surface water in this region is suitable for outdoor bathing and used for domestic use after treatment and disinfection.

In Western Zone the quality of water classified in class B in most of the sampling location which reveals that the water is suitable for out door bathing. Statistical details of the physico chemical components are as per table No- 1.7.1-1.7.4.

6.2. BIOLOGICAL PARAMETERS (BENTHIC MACRO INVERTEBRATES:

The status of any water quality can also be assessed by Biological Water Quality Criteria (BWQC) for water quality evaluation. This system is based on the range of saprobic and diversity score of the benthic macro invertebrate families with respect to water quality. To determine the changes in water quality to different grades of pollution level, the entire taxonomic groups, with their range of Saprobic score from 1-10, in combination with the range of diversity score from 0-1 has been classified into 5 different classes of water quality as specified below:

Sl. No.	Taxonomic Groups	Range of saprobic score	Range of Diversity Score	Water Quality	Water Quality Class	Indicator Colour
1.	Ephemeroptera, Plecoptera, Tricoptera, Hemiptera, Diptera	7 and more	0.2-1.0	Clean	A	Blue
2.	Ephemeroptera, Plecoptera, Tricoptera, Hemiptera, Planaria, Odonata, Diptera	6-7	0.5-1.0	Slight Pollution	B	Light Blue
3.	Ephemeroptera, Plecoptera, Tricoptera, Hemiptera, Odonata, Crustacea, Mollusca, Polychaeta, Coleoptera, Diptera, Hirudinea, Oligochaeta	3-6	0.3-0.9	Moderate Pollution	C	Green
4.	Mollusca, Hemiptera, Coleoptera, Diptera, Oligochaeta	2-5	0.4-less	Heavy Pollution	D	Orange
5.	Diptera, Oligochaeta, No animals	0-2	0-0.2	Severe Pollution	E	Red

In Eastern Zone, the analysis results indicated that biological water quality of River Narmada did not support establishment of benthic macro-invertebrates at the origin of river at Amarkantak due to lack of any substratum essential for the growth and survival of invertebrate macro benthos and the water quality of River Narmada on this site found to be moderately polluted (Class "C") due to various human activities related to religious and tourism. The water quality has changed to slightly polluted state (Class "B") at Mandala. In Jabalpur region, the biological water quality of River Narmada observed from slight to heavy pollution due to anthropogenic activities. The river water quality from Jabalpur onwards to Badwani observed moderate pollution.

In Central Zone, the results indicated that biological water quality of River Narmada is maintained as moderately polluted (Class "C") due to religious and recreational activities except at Bandrabhan after confluence of Tawa river which shows slight polluted water quality (Class "B").

In Western Zone, the results indicated that biological water quality of River Narmada is moderately polluted (Class "C") due to anthropogenic activities except at Nagar ghat, Omkareshwar and Khedi Ghat, Mortakka which shows slight polluted water quality (Class "B").

Hence, the entire study reveals that the quality of the Narmada River Based on BQC is observed to be in Class C as per standard saprobic and diversity score of the benthic macro invertebrate families. Except in few sampling sites i.e. Bandrabhan after confluence of Tawa river in central zone shows slight pollution i.e. Class "B" and Nagar ghat, Omkareshwar and Mortakka, Khedighat, in western zone observed slight pollution i.e. Class "B"

Summary of diversity and saprobic scores observed in eastern, central and western zone of River Narmada is depicted in Fig-14, 15 and 16 respectively and table 2.1.a, 2.2.a and 2.3.a.

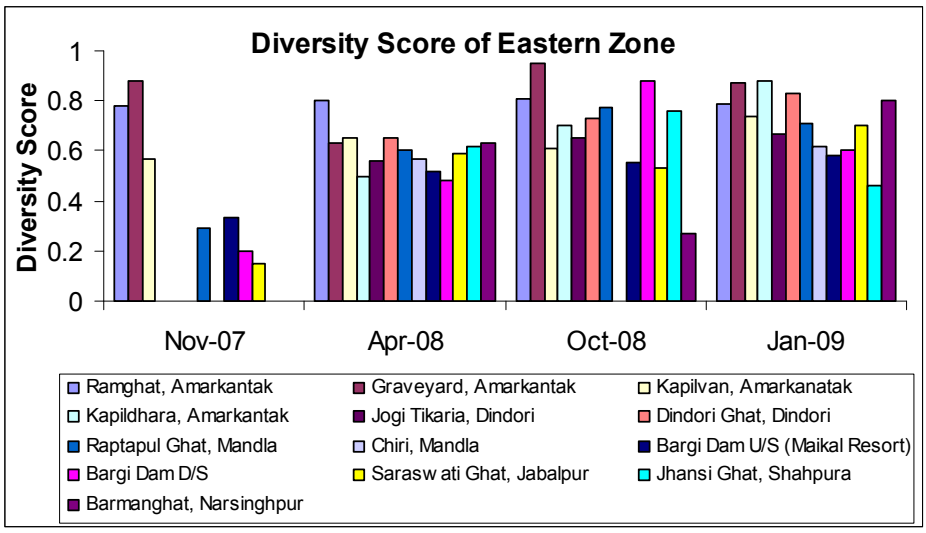

Fig. 14a: Variation of Diversity Score in Eastern region

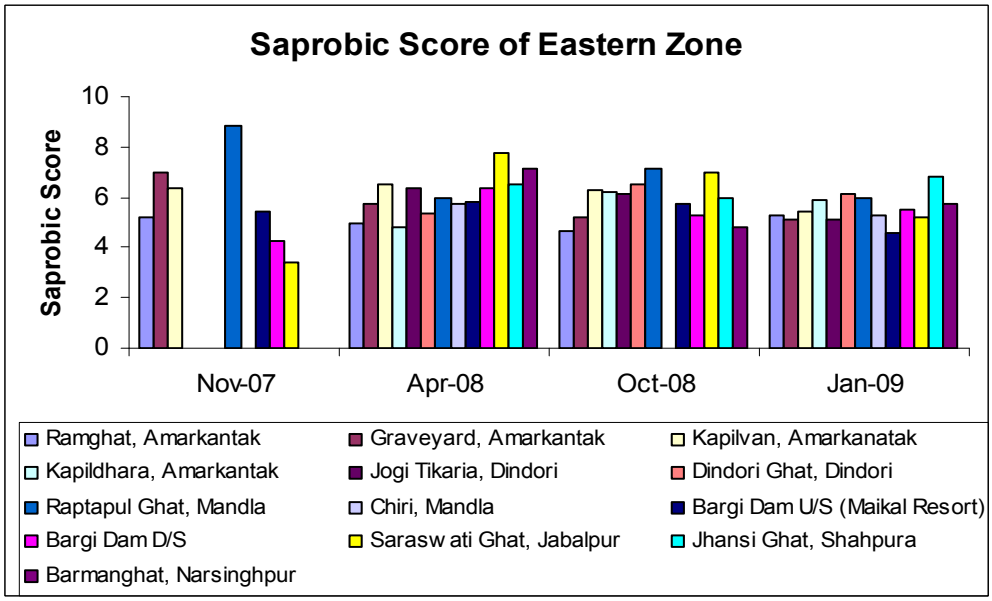

Fig. 14b: Variation of Saprobic Score in Eastern region

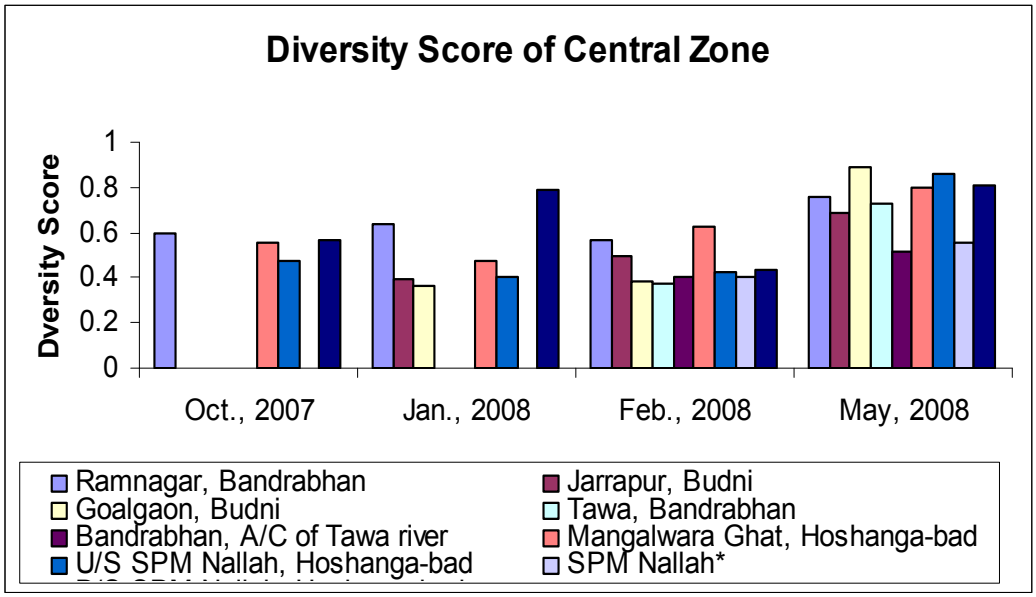

Fig. 15a: Variation of Diversity Score in Central region

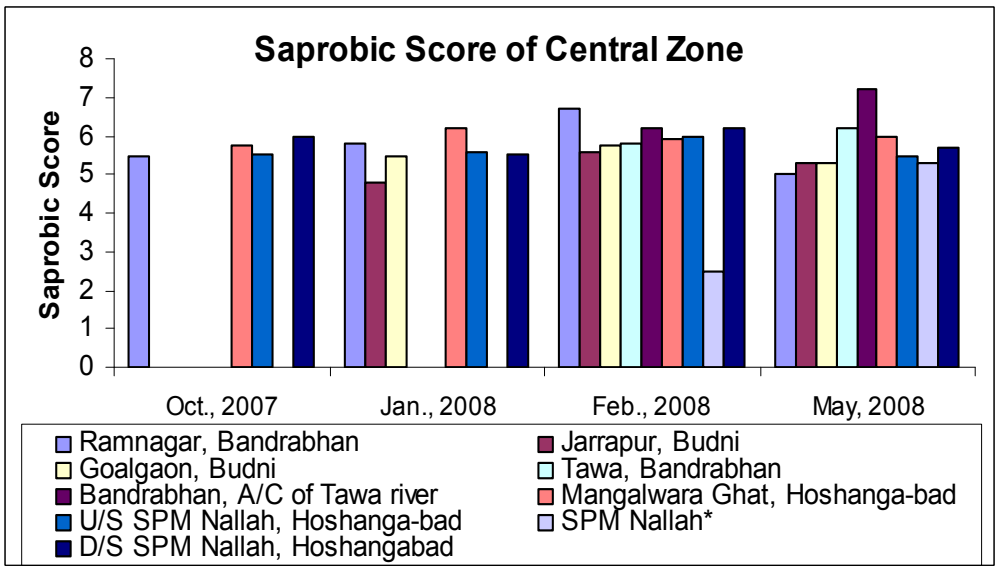

Fig. 15b: Variation of Saprobic Score in Central region

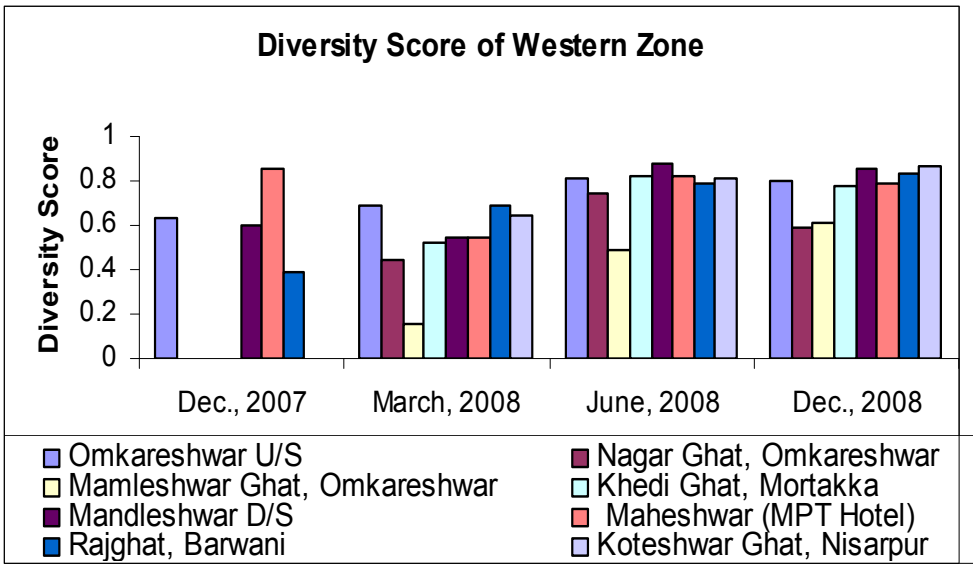

Fig. 16a: Variation of Diversity Score in Western region

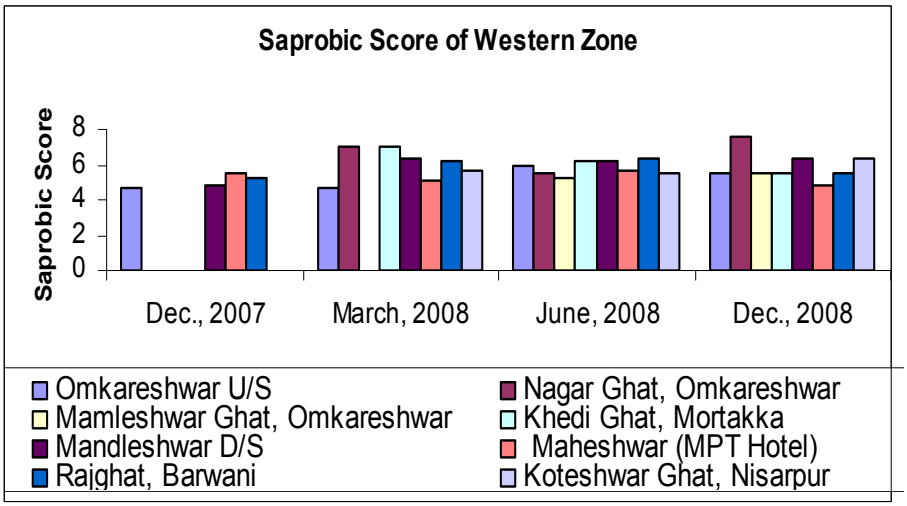

Fig. 16b: Variation of Saprobic Score in Western region