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Evaluation of physico-chemical and microbial parameters on water quality of Narmada River, India

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The present study was carried out to ascertain the quality of water at western zone of Narmada River of Madhya Pradesh (India). Due to heavy discharge of harmful and deleterious substances in river, the biological, chemical and physical characteristics of water have changed to a considerable extent. The objectives of this study were to find out the changes in physico-chemical nature as well as biological health of Narmada River. A thorough study was done on the basis of prevailing seasons. The deterioration of water quality was noticed at lower site of water body in a particular season as low temperature, dissolved oxygen and higher concentration of content of chlorine, etc., all pointing towards the nutrient enrichment. This evaluation will be immensely helpful to estimate the effect of impoundments on the quality of water, fisheries development and reservoir management policy. The microbial analysis was also conducted in terms of most probable number (MPN) of total coliforms in water sample and its highest value (1239) was reported from downstream of Omkareshwar dam site of Narmada River. Water quality index of all sites of Narmada River was calculated for three seasons, viz. summer, monsoon and winter and it was found to be highest (123) at Koteshwar dam site of river in monsoon season and the lowest (70) was observed in water of upstream of Omkareshwar dam during winter. The suitable correlation coefficients were calculated for 7 pairs of variables and correlation matrices were then established seasonally.

Key words: Impoundments, water quality index, dissolved oxygen, most probable number

INTRODUCTION

Water is the most indispensable natural resource in the world for the sake of existence of life. Narmada is the fifth largest river of India. It is commonly known as the Life line of Madhya Pradesh. Water quality is critical public health concern in India. Water pollution in Narmada River has come to alarming proportion in recent past. Thus, the estimation of water quality is very important for proper assessment of associated hazards (Warhate et al., 2006). Recently, several indigenous and useful species are dwindling day by day. To cope with these problems, there is need for application of oriented limnological research so that we can better utilize the most important resource of ours. In this context, change in several physico-chemical features of water of Narmada River was

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Table 1. Physico-chemical and microbial parameters and their methodology.

pH	-----	Digital pH meter
Alkalinity	mgl^{-1}	Titrimetry with H_2SO_4
Total hardness	mgl^{-1}	Titrimetry with EDTA
Chlorine content	mgl^{-l}	Argentometric method
Total Dissolved Solids	mgl^{-l}	TDS method
Dissolved Oxygen	mgl^{-1}	Winkler method
Biochemical Oxygen Demand	mgl^{-l}	BOD_5 method
Total coliform	Cfu/100 ml	Membrane filtration method

ascertained. These physico-chemical characteristics in many ways have significant influence and impact on aquatic life (Agarwal et al., 1976). Any alteration in these parameters may disturb the quality of water. Dissolved oxygen is of great importance to all the living organisms and is considered to be the sole parameter which to a large extent can reveal the nature of whole water body. Eutrophic water bodies have a wide range of dissolved oxygen and as such oligotrophic water bodies have narrow range of dissolved oxygen (Rucinski et al., 2010). Biological oxygen demand (BOD) also indicates the amount of organic compounds in water as measured by the volume of oxygen required by bacteria to metabolise it under aerobic condition. Biochemical oxygen demand is represented by the amount of organic matter present in water. For more organic matter, more oxygen is required by bacteria for its decomposition. This results in release of organic nutrients in water bodies resulting in death of organisms thriving on water (Rustum et al., 2008). The magnitude of BOD is related to the amount of organic material in waste water. The strength of waste water is expressed in terms of BOD level. Water pollution is generally indicated by the presence of harmful and harmless microbes. Microbial examination of water is a direct measurement of deleterious effects of pollution. Most probable number is the most common microbial parameter for the sanitary analysis of water. The test is used to detect coliforms, a group comprising of all the aerobic and facultative anaerobic, Gram negative, non spore forming and rod-shaped bacteria. These inhabit the intestines of all warm-blooded animals. The discharge of waste water from municipal sewers containing human faecal matter is hazardous to human health. Faecal contamination was routinely detected by microbiological analysis (Nogueira et al., 2003). The aim of this study was to ascertain the impact of several physico-chemical parameters on water quality of Narmada River and to assess further its nature in terms of microbial growth. Assessment of water quality is done to analyse the physical, chemical and biological characteristics of water (Kazi et al., 2009). Water quality index aims at giving a single value to the quality of a source reducing great amount of parameters into a simpler expression and enabling easy interpretation of monitoring data. In this study, water quality index (WQI) is used for assessing surface water quality. Water quality index is a tool used to determine conditions of water quality and, like any other tool, require knowledge on principles and basic concepts of water and related issues (Khan et al., 2003).

MATERIALS AND METHODS

Narmada River is the largest western flowing river in the Indian peninsula (Table 1). In the present investigation, water samples were collected from five different sites viz. Omkareshwar upstream, Omkareshwar downstream, Maheshwar dam site, Mandleshwar and Koteshwar sites (Figure 1). These study sites were situated in a stretch of 220 km of the western zone of Narmada River. The study was based on spatial analysis (Yusuf and Shah, 1986). Water samples were taken in plastic bottles in triplicates for all seasons such as winter, summer and monsoon and analysed onsite and offsite for selected physico-chemical parameters such as pH, alkalinity, total hardness, chlorine content, total dissolved solids, dissolved oxygen and biochemical oxygen demand (Pejman et al., 2009). Temperature and pH were noted onsite, while other parameters were analysed in the laboratory after the samples were properly transported using a pre-cleaned 1 L plastic container in an icebox (NEERI, 1986; APHA 2000)

Microbial analysis was performed in terms of most probable number (MPN)

MPN is performed sequentially in three stages: presumptive, confirmed and completed test.

Presumptive coliform test

It is used to detect coliforms in a water sample. In this lactose fermentation, tubes are inoculated with different water volumes and production of acid and gas from the fermentation of lactose in any of the tubes is a presumptive evidence of coliforms in water sample. The lactose broth (lactose- 5.0 g, peptone- 5.0 g, beef extract- 3.0 g and distilled water- 1 L) used in this test is selective for the isolation of coliforms. A pH indicator Bromocresol purple is also added to lactose broth for the detection of acid. The colour of indicator changed to yellow with the production of acid from lactose.

Confirmed coliform test

In this, water samples from all the positive presumptive lactose broth were inoculated into tubes of brilliant green lactose broth and incubated at 35°C for 48 h. This test is used to determine MPN. MPN = Number of coliforms per colony count x 100 / Volume of sample used

Water quality index

The calculation of water quality index was done using weighted

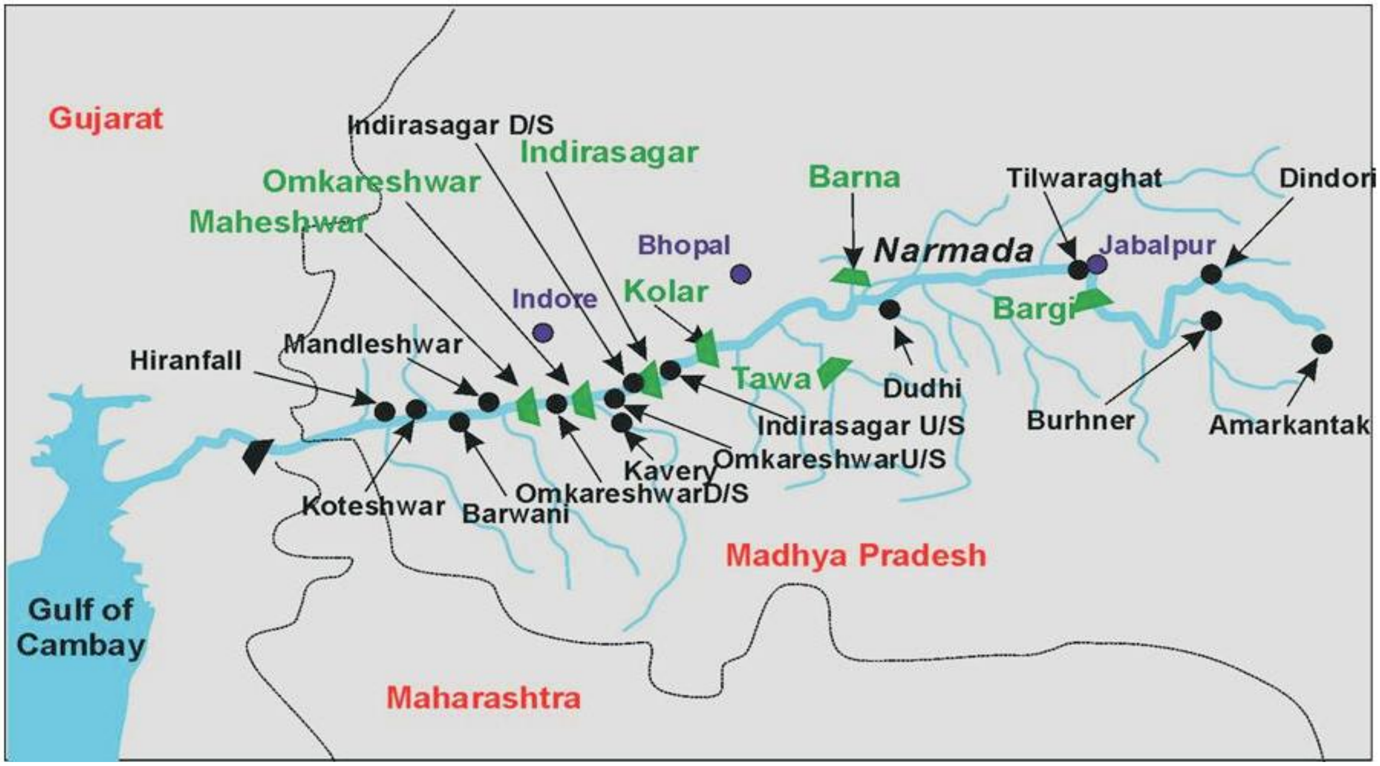

Figure 1. Map showing the exact location of different sites of Narmada river.

arithmetic index method (Brown et al., 1972). They proposed multiplicative form of the index where weights to individual parameters were assigned based on a subjective opinion based on the judgement and critical analysis of the author. The weight assigned reflected a parameter's significance for use and had considerable impact on the index. This index is based on the comparison of the water quality parameters to regulatory standards and gives a single value to the water quality of a source (Abbasi, 2002).

$$\text{WQI} \quad \sum_{n=1}^{n} q_n W_n \,/\, \sum_{n=1}^{n} W_n$$

Where, qn = 100 [V_n - V_{io}]/(S_n - V_{10})]

Where q_n = Quality rating for the n^{th} water quality parameter; V_n = estimated value of the n^{th} parameter at a given sampling station; S_n = standard permissible value of n^{th} parameter; V_{io} = ideal value of nth parameter in pure water (pH = 7, DO = 14 mg/l and for other parameter = 0); W_n = unit weight for n^{th} parameter; S_n = standard value for nth parameter; K = constant for proportionality.

RESULTS AND DISCUSSION

The present result depicted the true picture of water quality on the basis of seasonal variations. The pH of different water sample shows little variation from slightly acidic to slightly alkaline. The greater pH may be caused by increase in dissolved oxygen produced as a result of photosynthesis (Wetzel, 1975). The acidic pH is a characteristic of oligotrophic water bodies whereas the neutral and alkaline pH are shown by eutrophic and mesotrophic nature of water bodies, respectively (Kumar et al., 2008). The pH is directly dependent on the amount of CO_2 present and inversely proportional to the activity of photosynthesis (Pandit et al., 2001). At all sites of Narmada River, alkaline pH was reported and its value was found to be maximum (8.4) at Koteshwar dam during winter season. (Figure 2)

Alkalinity is total measure of the substances in water that have acid neutralizing ability (Hoko, 2008). Its level showed greater variation at all sites. The highest alkalinity (138 mgl^{-1}) was reported from the site of Koteshwar study site during monsoon season, whereas the lowest (115 mgl^{-1}) was found to be at Maheshwar dam site during the same season. The amount of alkalinity is dependent on the nature of materials discharged in water bodies (Figure 3).

The total hardness was found to be high in all water bodies. This is highest (172 mgl^{-1}) in Mandleshwa site during monsoon season and lowest (136 mgl^{-1}) at Omkareshwar downstream study in winter season. The hardness is due to dominance of salts of calcium and magnesium which indicated surge in eutrophication of river resulting to greater pollution level. The presence of lower pH and higher hardness may affect their continued use (Chatterjee and Raziuddin, 2002) (Figure 4).

Chloride that dissolves easily in water is toxic to most aquatic organisms because it reacts quickly with other substances in water (Padmanabha and Belagali, 2001).

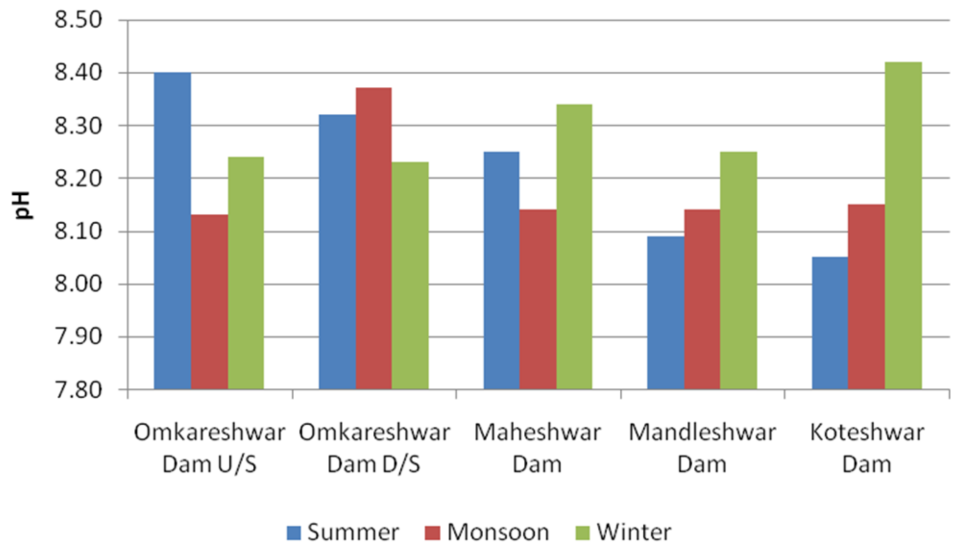

Figure 2. Fluctuation in the value of pH at different sites of Narmada River in different seasons.

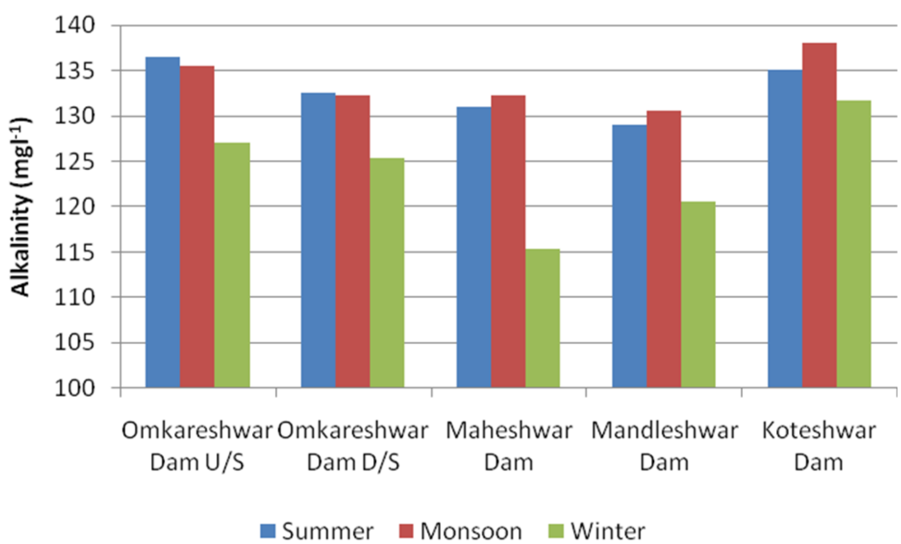

Figure 3. Fluctuation in the value of alkalinity at different sites of Narmada River in different seasons.

The amount of chloride in all water bodies was found to be higher in all sites. At Maheshwar dam site, the maximum content of chloride (26 mgl^{-1}) was noticed during monsoon season, while the minimum (18 mgl^{-1}) was reported from upstream of Omkareshwar dam in winter. The high amount of chloride is an indication of burgeoning anthropogenic pressure on water bodies. The increased chlorine is generally due to the salts of sodium, potassium and calcium (Figure 5). Chloride content showed negative correlation with pH (r = - 0.32) and positive correlation with alkalinity (r = + 0.35) and hardness (r = + 0.49) (Table 2).

The total dissolved solid (TDS) is the sum of the cations cations and anions concentration. A high content of solids elevates the density of water, reduces solubility of gases like oxygen and mitigates the utility of water for drinking, irrigation and other purposes. TDS was found to be highest (357 mgl^{-1}) at Mandleshwar dam site during monsoon season and the lowest (228 mgl^{-1}) was reported from downstream of Omkareshwar dam during winter season (Figure 6). TDS was found to be positively correlated with alkalinity (r = + 0.17), total hardness (r = + 0.73) and chloride contents (r = + 0.45).

The depletion of oxygen can result from a number of natural factors but is most often a concern as a result of pollution and eutrophication in which plant nutrients enter

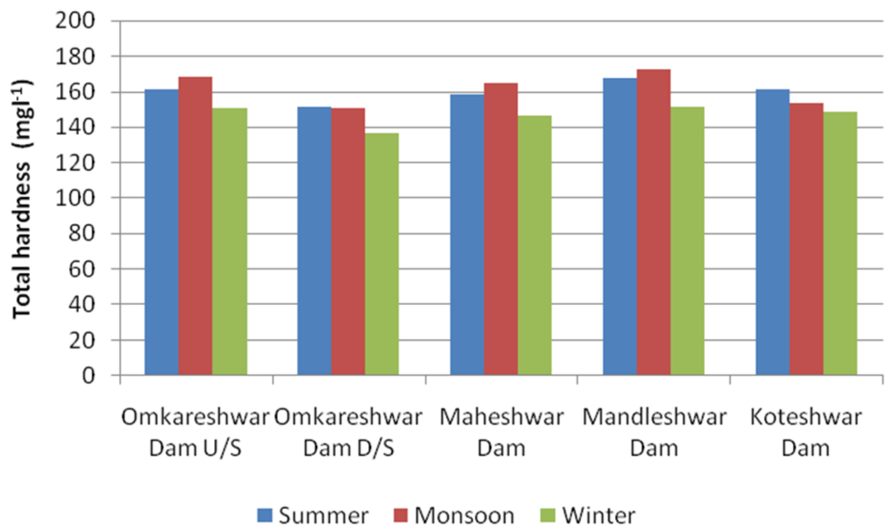

Figure 4. Fluctuation in the value of total hardness at different sites of Narmada River in different seasons.

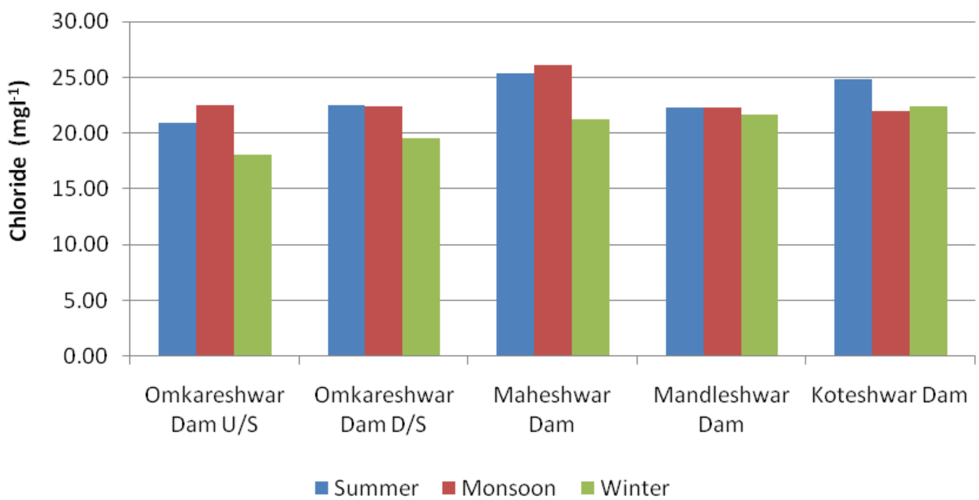

Figure 5. Fluctuation in the value of chloride contents at different sites of Narmada River in different seasons.

Table 2. Correlation matrices between different physicochemical and biological parameters.

	pH	Alkalinity	Hardness	Chloride	TDS	DO	BOD	MPN
pH	0.00							
Alkalinity	-0.20	0.00						
Hardness	-0.54	0.46	0.00					
Chloride	-0.32	0.35	0.49	0.00				
TDS	-0.36	0.17	0.73	0.45	0.00			
DO	0.28	-0.67	-0.56	-0.66	-0.32	0.00		
BOD	-0.51	0.59	0.43	0.48	0.47	-0.67	0.00	
MPN	0.13	0.40	-0.04	0.41	0.30	-0.42	0.57	0.00

a water source (Heinz et al., 1995).of same site showing the inverse relationship with temperature. This happens due to heavy amount of organic matter discharged which needs oxygen for decomposition. As such, low dissolved

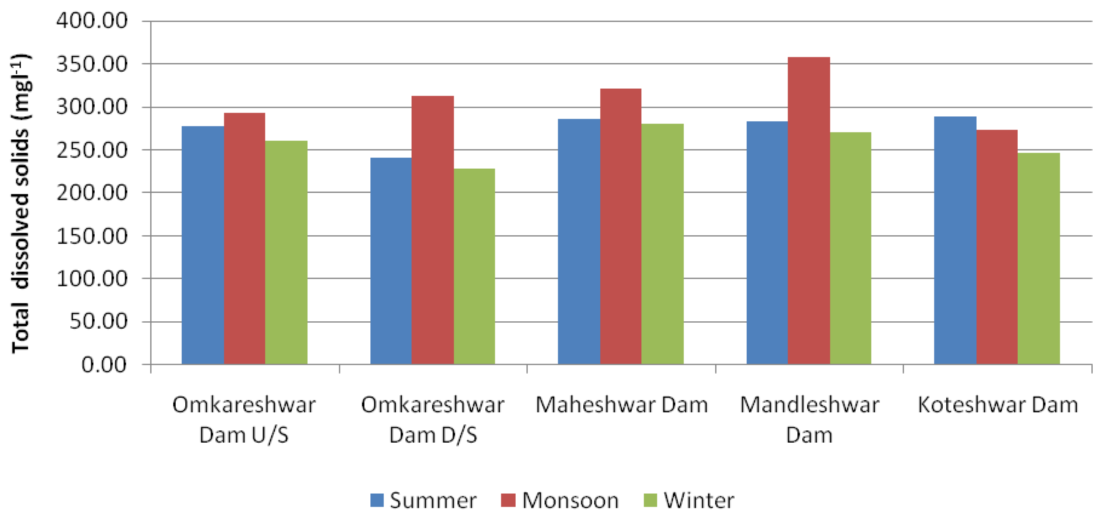

Figure 6. Fluctuation in the value of total dissolved solids at different sites of Narmada river in different seasons.

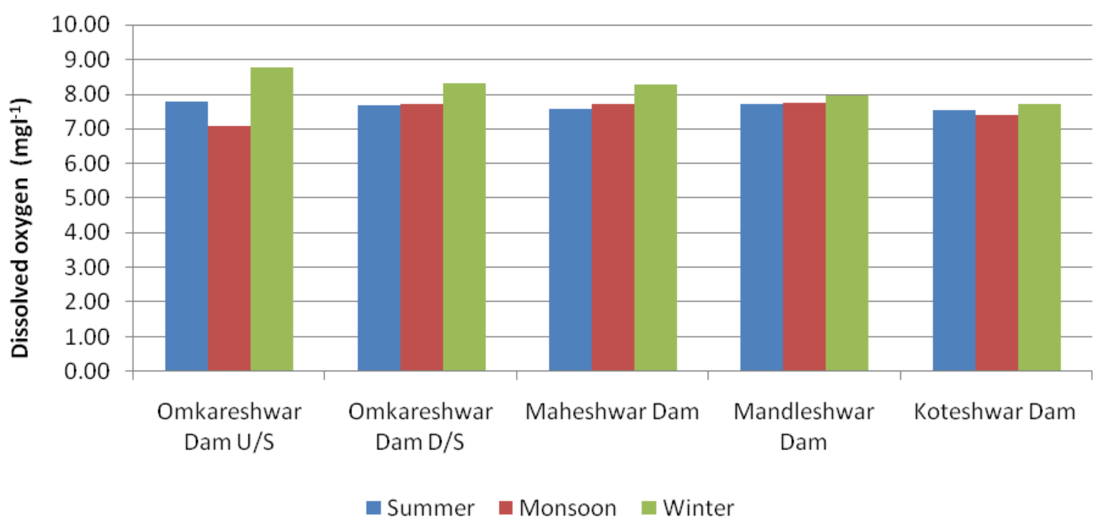

Figure 7. Fluctuation in the value of dissolved oxygen at different sites of Narmada River in different seasons.

oxygen indicates the biodegradation of organic matter (Abowei et al., 2010) (Figure 7).

Likewise, the biochemical oxygen demand also indicates the amount of organic compounds in water as measured by the volume of oxygen required by the bacteria to metabolise it under aerobic condition. For more organic matter, more oxygen is required by bacteria for its decomposition. This results in release of organic nutrients in water bodies resulting in death of organisms thriving on water (Jonasson et al., 2012). The highest degree of biochemical oxygen demand (10 mgl^{-1}) was reported from Koteshwar study site during monsoon season, while lowest level (4.0 mgl^{-l}) was observed from upstream of Omkareshwar dam during summer season (Figure 8). Dissolved oxygen was found to be positively correlated with pH (r = + 0.28) and showed negative correlation with chloride (r = - 0.66), alkalinity (r = - 0.67), hardness (r = - 0.56) and biochemical oxygen demand (r = - 0.67).

Water is considered safe for drinking if it contains less than four coliforms per 100 ml of water. The occurrence of coliforms detected in water is a direct measurement of deleterious effects of pollution of human health. In laboratory, to confirm the water quality to drinking water standards, the actual number of coliforms was not reported but they are mentioned as an approximate count-MPN. These dam sites are present in close vicinity of human settlements so the abundance of coliforms is immi-

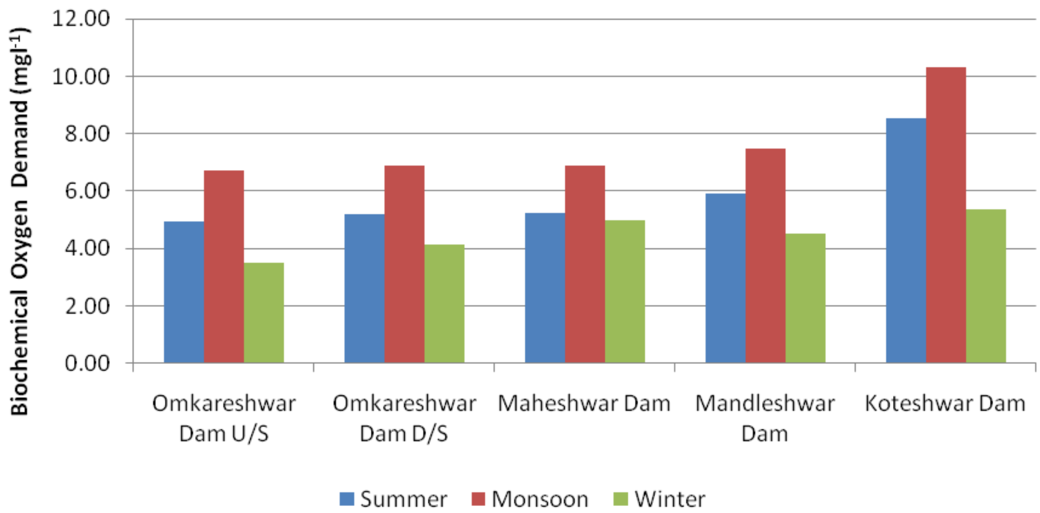

Figure 8. Fluctuation in the value of BOD at different sites of Narmada River in different seasons.

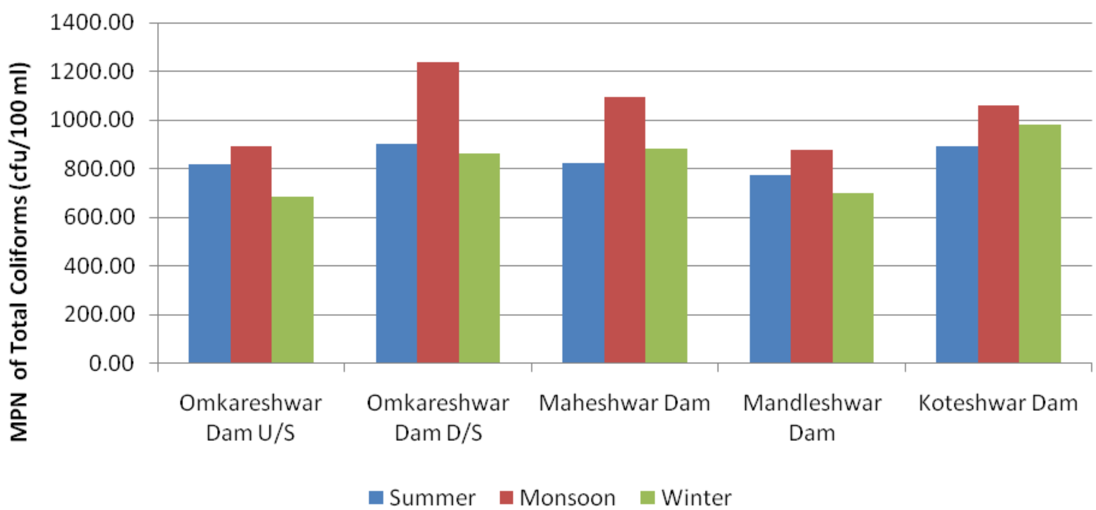

Figure 9. Fluctuation in the value of total coliforms (cfu/100 ml) at different sites of Narmada river in different seasons.

nent. In this study, the MPN value was found to be highest (1239 cfu/100 ml) at downstream of Omkareshwar dam site during monsoon season and lowest (682 cfu/100 ml) was reported at Mandleshwar dam site of Narmada River in winter (Karafistan and Arik-Colakoglu, 2005) (Figure 9). MPN showed negative correlation with DO (r = - 0.42) and positive correlation with BOD (r = + 0.57).

The expression of water quality that offers a stable and reproducible unit of measure which responds to changes in the principal characteristics of water was responded (Faisal et al., 2003; Kannel et al., 2007). Water quality index (WQI) is a mechanism for presenting a cumulatively derived numerical expression defining a certain level of water quality (Bordalo et al., 2006). In other words, WQI summarizes large amounts of water quality data into simple terms e.g., excellent, good, bad, etc. for reporting to management and the public in a consistent manner. In the present study, water quality index was found to be the highest (123 mgl^{-l}) at Koteshwar study site of Narmada River during monsoon season, whereas the lowest (70 mgl^{-l}) was observed at upstream of Omkareshwar dam of Narmada River during winter (Figure 10).

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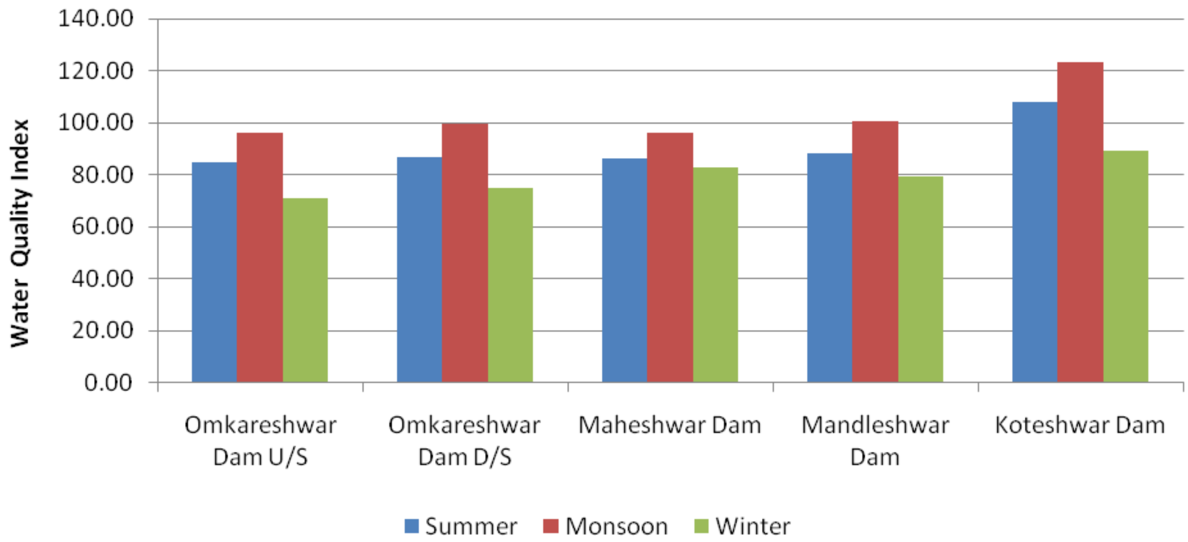

Figure 10. Fluctuation in the value of water quality index at different sites of Narmada River in different seasons.

REFERENCES

Abbasi SA (2002). Water quality indices, state of the art report, National Institute of Hydrology, scientific contribution no. INCOH/SAR-25/2002, Roorkee: INCOH. pp: 73.

Abowei JFN (2010). Salinity dissolved oxygen, pH and surface water temperature conditions in Nkoro River, Niger Delta, Nigeria. Adv. J. Food Sci. Technol. 2(1): 36-40.

Agarwal DK, Gour SD, Tiwari IC, Narayan Swami N, Narwash SM (1976). Physico-chemical characteristic of Ganga water in Varanasi. Ind. J. Environ. Health 18: 201-20

APHA (2005). Standard methods for examination of water and wastewater (21st ed). American Public Health Association, Washington D.C., USA

Bordalo AA, Teixeira R, Wiebe WJ (2006). A water quality index applied to an international shared river basin: The case of the Douro River. Environ. Manage. 38:910–920.

Brown RM, Mc Cleiland NJ, Deininger RA, O'Connor MF (1972). A Water Quality Index-crossing the psychological barrier (Ed Jenkis, S.H). Proc. Intl. Conf on water Poll, Jerusalem. 6:787-797.

Chatterjee C, Raziuddin M (2002). Determination of water quality index of a degraded river in Asansol industrial area, West Bengal. J. Environ. Pollut.1(2):181-189.

Faisal K, Tahir H, Ashok L (2003). Water quality evaluation and trend analysis in selected watersheds of the Atlantic region of Canada. Environ. Monit. Assess. 88:221-248.

Heinz G, Stefan, Xing Fang (1995). Stimulation of dissolved oxygen profiles in a transparent, dimictic lake. Limnol.Oceanogr.40 (1):105 – 118.

Hoko Z (2008). An assessment of quality of water from boreholes in Bindura District**,** Zimbabwe. Phys. Chem. Earth 33: 824–828.

Jonasson L, Hansen JLS, Wan Z, She J (2012). The impacts of physical processes on oxygen variations in the North Sea-Baltic Sea transition zone. Ocean Sci. 8: 37–48.

Kannel PR, Lee S, Lee YS, Kanel SR, Khan SP (2007). Application of water indices and dissolved oxygen as indicators for river water classification and urban impact assessment. Environ. Monit. Assess. 132:93–110.

Karafistan A, Arik-Colakoglu F (2005).Physical, chemical and microbiological water quality of the Manyas lake, Turkey. Migration and Adaptation Strategies for Global Change.10:127-143.

Kazi TG, Arain MB, Jamali MK, Jalbani N, Afridi HI, Sarfraz RA, Baig JA, Shah AQ (2009). Assessment of water quality of polluted lake using multivariate statistical techniques: A case study, Ecotox. Environ. Safe. 72(20): 301-309.

Khan F, Husain T, Lumb A (2003). Water quality evaluation and trend analysis in selected watersheds of the Atlantic region of Canada. Environ. Monit. Assess. 88:221–242.

Kumar J, Singh S, Pal A (2008). Water quality of Turamdih and Jaduguda uranium mines and adjacent areas, East Singhbhum, Jharkhand, J. Ecophysiol. Occup. Health 8 : 7-14

NEERI (1986). Manual on water and waste water analysis.National Environment Engineering Research Institute, Nagpur

Nogueira G, Nakamura VC, Tognim CBM, Filho AAB, Filho PDB (2003). Microbiological quality of drinking water of urban and rural communities, Brazil. Rev. Saude Publica. 37(2):232-236.

Padmanabha B, Belagali SL (2007). Water quality index of Kabini river in the kallahally village of Nanjangud Taluka of Mysore District, Karnataka. J. Environ. Sci. Eng. 49(1):48-50.

Pandit AK, Rathore SA, Bhat SA (2001). Limnological features of freshwater of Uri, Kashmir. J. Res. Dev. 1: 22-29.

Pejman AH, Bidhendi NGR, Karbassi AR, Mehrdadi N, Bidhendi EM (2009). Evaluation of spatial and seasonal variations in surface water quality using multivariate statistical techniques. J. Environ. Sci. Technol. 6(3):467-476.

Rucinski DK, Beletsky D, DePinto JV, Schwab DJ, Scavia D (2010). A simple1-dimensional, climate based dissolved oxygen model for the central basin of lake Erie. J. Great Lakes Res. 36: 465-476.

Rustum R, Adeloye AJ, Scholz M (2008). Applying Kohonen Self organising map as a software sensor to predict the BOD. Water Environ. Res. 80(1): 32-40

Warhate SR, Yenkie MKN, Chaudhari MD, Pokale WK (2006). Impacts of Mining Activities on Water and Soil. J. Environ. Sci. Eng. 48(2):81 - 88.

Yousuf, A.R and Shah, G.M (1988). Comparative Limnology of some fresh habitats of Kashmir. Geobios*,* 7: 58-61.