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Abstract

In Bhopal, the approximate population is 18 lakhs, total waste supply is 417.94 MLD and total sewage is 334.5 MLD per day. Sewage from 27 nallahas was released into the water bodies, resulting in deterioration of water quality of halali and tawa reservoir. Therefore, there is a need for continuous evaluation to save the reservoir from eutrophication. Present studies were carried out to determine Physico-chemical characteristics of Halali and Tawa reservoir located near Bhopal during three different seasons of the year 2008-2010. Ecological parameters like dissolved oxygen, PH, nitrate, phosphate, temperature, alkalinity, total hardness, conductivity, transparency and BOD were analysed. The study revealed that temperature varied from 16.3 to 41.2°C, pH value ranged between 7.6 and 8.9, mean value of dissolved oxygen ranged between 2.65 and 6.4 mg/l, nitrate, phosphate, transperancy, conductivity and BOD values ranged between 2.65 and 6.94 mg/l. Studies conducted on above parameters showed that halali and tawa reservoirs are suitable for aquaculture and irrigation purposes.

Keywords: Halali, Tawa, trophic status

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Introduction

The surface water and groundwater resources of the country play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, recreational activities etc. Due to unplanned management, tremendous development of industry and agriculture and disposal of untreated public sewage water, agricultural runoff and other human and animal wastes into rivers, lakes, reservoirs and other water bodies are continuously deteriorating the water quality and biotic resources (Venkatesan, 2007; Elmaci et al., 2008). These are the causative agents leading to eutropication (Chukwu and odunzeh, 2006; Shekhar et al., 2008). Health of the reservoir and biological diversity are related to almost every component of the ecosystem. As per the reservoir having a vast stretched area (Table 1), Selection of site for carrying out the investigations of present study figures 1 and 2 was based on the following criteria: Workability of variable site and morphometry of research, Ecologically variable conditions, Water current and Depth. The present investigation conducted on physio-chemical analysis of tawa and halali reservoir was to determine quality and tropic status of the water body. The physico-chemical characteristics play an importantrole in assessment of the water quality and trophic status of a water body. However, information on the ecologyespecially the trophic status of the reservoirs is scanty. Only a few workers have attempted to study some of reservoirsfor their nutrients status. Therefore, this study aims at the nutrients characteristics and trophicstatus of reservoir along with its suitability as habitat for aquatic organisms.

Fig. 1. Map showing sampling stations at Halali Reservoir

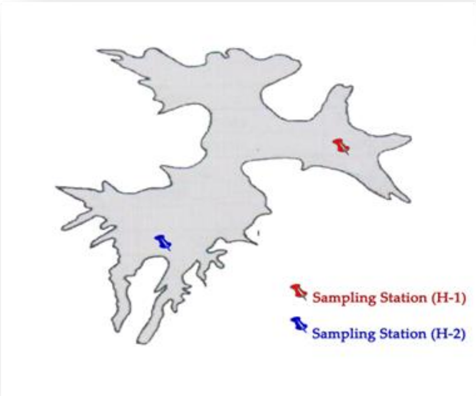
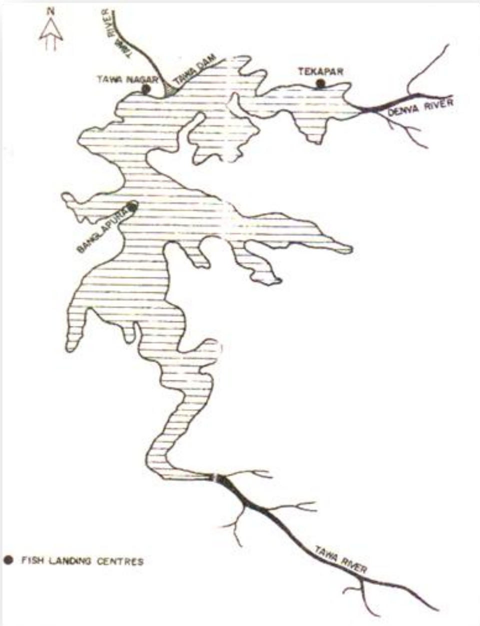


Fig. 2. Map showing sampling stations at Tawa Reservoir



Material and Methods

Water samples were collected from four selected sites (Tables 1 and 2) of Tawa and (H-1 and H- 2) of Halali reservoirs for a period of two years during August 2008 to July 2010 figures1 and 2. The sampling was usually carried out from 09.00 am to 11.00 am to avoid unpredictable change. The water samples were collected directly from the surface layer in acid washed 2 litre capacity plastic bottles monthly. The physio-chemical parameters such as temperature, conductivity, dissolved oxygen, pH, transparency, total hardness, phosphate, nitrate, biological oxygen demand, and total alkalinity were measured. All the parameters were analyzed as per the standard methods described in following the methods of APHA (2005) and Trivedi and Goel (1986). The atmospheric temperature and water temperature were recorded with the help of mercury filled centigrade thermometer. The specific conductivity was determined with the help of conductivity meter (DREL 2000 HACH, USA) and expressed as µmhos/cm.

The hydrogen ion concentration was recorded with the help of pH strips and digital pH meter. Total Alkalinity was analysed by titration method using strong acid and methyl orange and phenolphthalein solutions as indicators. Dissolved oxygen was determined by modified Winkler's method. Total hardness of water was determined by ethylene diamine tetra acetic acid (EDTA) titration method using erochrome black-T as indicator. Nitrite was determined by diazotization method.Phosphate was determined by inorganic phosphorous by using stannous chloride method.Biological oxygen demand was determined by Wrinkler's Iodometric method. Transparency of water samples were determined by using Secchi disc and colour by visual estimation. Physio-chemcial characters of air and water temperature, transparency, colour, pH, dissolved oxygen, total hardness, total alkalinity were determined at the sampling sites immediately after the collection of water samples, while rest of the parameters were analyzed in the laboratory within a period of 6 hrs after the collection of water samples.

Results and Discussion

During the period under study, each year, different physio-chemical parameters were analyzed as per standard methods for the examination of water.

Atmospheric temperature

Atmospheric Temperature followed seasonal climatic pattern. In Halali reservoir temperature varied between 18 and 37ºC from Aug’ 2008 to Jul’ 2010 (Tables 2 and 5). The atmospheric temperature was lowest in January and highest in June. Temperature started decreasing from October and became lowest in January. Atmospheric temperature in tawa reservoir varied between 15.5 and 41.2^{0}C from Aug’ 2008 to Jul’ 2010 (Tables 3 and 4). The atmospheric temperature was lowest in January and high in May. Similar range of variation has been shown by Ansari et al. (2008), Chinnaiah and Rao (2011), Khan et al. (2012), Meenakshi Saxena (2012).

Water Temperature

Water Temperature plays a very important role in some physiological processes like release of stimuli for breeding mechanisms in fish, both under natural and artificial conditions (Hora, 1945; Chaudhuri, 1964). In Halali reservoir water temperature varied between 19.9 and 32^{0}C from Aug’ 2008 to Jul’ 2010 (Tables 2 and 5). In Tawa reservoir water temperature varied between 18.5 and 26.8ºC from Aug’ 2008 to Jul’ 2010 (Tables 3 and 4). In the present study, in both the reservoir highest water temperature was noted during summer season and lowest was recorded during the winter season. This observation has been true for several water bodies in India (Narayana et al., 2008; Garg et al., 2009; Verma et al., 2011; Prabhakar et al., 2012; Meenakshi Saxena (2012).

Transparency

It is considered as an important parameter of trophic status of water bodies. It depends on the intensity of sunlight, suspended soil particles, turbid water received from catchment area and density of plankton (Mishra and Saksena, 1991). Transparency is inversely proportional to the amount of suspended organic and inorganic matter, density of the planktonic organisms and intensity of light. In Halali reservoir the transparency range varied between 20 to 154 cm (Tables 2 and 5). The highest value of transparency was recorded to be 60 cm (December, 2008), 140 (May, 2009) and 154 cm (May, 2010). The lowest values of transparency were recorded to be 22 cm (August, 2008), 20 (July, 2009) and 21 cm (July, 2010). In Tawa reservoir, the transparency range varied between 20 to 153 cm (Tables 3 and 4). The highest value of transparency was recorded to be 79 cm (December, 2008), 148 (March and April, 2009), 138 cm (May, 2010). The lowest value of transparency was recorded 22 cm (August, 2008), 20 cm (August, 2009) and 31 cm (July, 2010)

The transparency of water was low during monsoon period (July to August), while water was more transparent in May at Halali and March to May at Tawa reservoirs. The water transparency started decreasing in the mid of June with the start of rainy season. The rain water not only brings the silt from the catchment area but also turbulent water; which decreases the transparency, after the rains the silt starts settling down. The transparency was low during July-September and showed gradual increase from March-May. In June month it again showed a slight decrease due to the high winds. Low values of transparency were observed in rainy season due to accumulation of suspended matter (silt, clay and organic matter) into the water body and high value occurred during winter and summer due to absence of rain, runoff and flood water as well as gradual settling of suspended particles. This observation was also made by Meenakshi Saxensa (2012); Chaudhary Preeti (2012).

Colour

High turbidity value was observed during rainy season-which could be due to silt load. In Halali reservoir transparent colour of water was observed in winter season, light green to green colour was observed in the month of February and March, which means good growth of phytoplankton especially of green and blue green algae while green colour was observed in summer season (April, May and June) and brown to dark brown colour was observed in rainy season (July, August and September) suggesting depletion of algal community. Light green to green colour is imparted due to good algal growth of cyanophycean and cholorphycean algae and when their number was reduced, the colour of water became light green in colour (Tables 2 and 3). In Tawa reservoir the colour was found to be turbid in rainy season, green colour in winter season and transparent green colour of water was observed in summer season (Garg et al., 2006, 2009).

Hydrogen ion concentration

The pH indicates the intensity of the acidic or basic character of a solution and is controlled by the dissolved chemical compounds and biochemical processes in the solution. The pH>6.0 is indicative of low production, pH between 6.0 and 8.5 is of medium production and more than 8.5 is of high productivity in the water bodies. The largest fish crops are usually produced in water which is just on the alkaline side of neutral between pH 7.0 and 8.0. The limit above or below which pH has a harmful effect is given by Ohle (1938) as 4.8 and 10.8, while reviewing the work of German scientists remarks that categorically it can be said that a weak alkaline reaction (pH 7.0 to 8.0) has been found in most productive fish ponds and that very acid waters are distinctly undesirable. In halali reservoir the highest values of hydrogen ion concentration at surface level were 7.6 (November, 2008), 9.0 (May, 2009) and 8.9 (June, 2010) in Halali reservoir. The lowest values of hydrogen ion concentration was 7.2 (October, 2008), 6.9 (December, 2009) and 7.1 (January, 2010) the hydrogen ion concentration range varied from 6.9 to 9.0 (Tables 2 and 5). In Tawa reservior, the highest value of hydrogen ion concentration at surface level was 8.8 (May, 2008, 2009) and 9.1 (May, 2010). The lowest value of hydrogen ion concentration was 7.4 (November, 2008), 7.7 (December, 2009), 7.6 (February, 2010). Range of pH varied between 7.4 and 9.1 (Tables 3 and 4).

Halali and Tawa reservoirs were found alkaline in nature. The range of pH ranged from 6.9 to 9.0 for Halali Reservoir and from 7.4 to 9.1 for Tawa Reservoir. Higher values of pH were recorded during summer months. This may be due to increased photosynthetic activity and decomposition of allochthonous matter present in the reservoirs which increase the nutrient concentration at higher temperature, input of sewage and agricultural waste are also responsible for higher values of pH in water. The pH range from 6.4 to 8.3 is favourable for fish growth. In the present observation both the reservoirs showed alkaline pH range throughout the course of study. Similar observation has been found by Kaushik and Saksena (1991), Dagaonkar and Saksena (1992), Kumar et al. (2009), Sinha and Biswas (2011) and Meenakshi Saxena (2012) in Suraj Kund, Kailasagar, Keenjhar lake, Kalyani lake and Raipur Reservoir respectively.

High pH value observed during summer could be due to high photosyntentic activity of phytoplankton and macrophytes shifting the equilibrium towards alkaline. According to the pH value of water, Venkateswarlu (1983) has classified reservoirs into five categories, viz., acidobiontic, acidophilus, indifferent pH, alkaliphilous and alkalibiontic. If these criteria are applied to Halali and Tawa Reservoirs, then these reservoirs can be classified under the category of alkalliphious water bodies.

Electrical conductivity

In Halali reservoir during 2008, the maximum conductivity of water was recorded to be 210 μScm^{-1} in (December, 2008), 237 μScm^{-1} (May, 2009) and 253 $\mu S\ cm^{-1}$ in the month of (April 2010). Minimum conductivity of water was recorded to be 145 μScm^{-1} (August, 2008), 135 μScm^{-1} (July2009) and 173 μScm^{-1} (July 2010). Range of electrical conductivity varied between 135 and 253 μScm^{-1} (Tables 2 and 5). In Tawa reservoir, the maximum conductivity of water was recorded to be 230 μScm^{-1} (December, 2008) 257 μScm^{-1} (April, 2009), 272 μScm^{-1} (April, 2010) and minimum conductivity of water was recorded to be 165 μScm^{-1} (August, 2008), 140 (June 2009) and 190 μScm^{-1} (July, 2010). Range of electrical conductivity varied between 140 and 272 μScm^{-1} (Tables 3 and 4). The fluctuation in the values if conductivitycould be due to variations in the decomposition of organic matter.The values were high in summer seasons and was low in winter seasons. If criterion of Olsen (1950) is applied the reservoir can be placed under the categoriesof oligotropic water body.

Total alkalinity

Alkalinity of water is a measure of its capacity to neutralized acids and the total alkalinity is the total sum of carbonate and bicarbonate alkalinities. It is generally imparted by the salts of carbonates, bicarbonates, phosphates, nitrates, borates, silicates etc. along with hydroxyl ions available in Free State. The high alkalinity can be attributed to increased rate of organic decomposition during which free carbon dioxide is liberated and reacts with water to form bicarbonates thereby increasing the total alkalinity (Goel et al., 1984). According to Spence (1964), water bodies have been categorized into three major categories based on the values of alkalinity viz., (i) nutrient poor, (ii) moderately nutrient rich and (iii) nutrient rich.In general, calcareous water with alkalinities of more than 50 ppm are most productive of fish, waters with alkalinity of less than 10 ppm rarely produce large crops, water intermediate between these two groups may produce useful results (Ohle, 1938). All the ponds above 90.0 ppm of total alkalinity have been found to be productive. In Halali reservoir, the maximum value of the total alkalinity was recorded to be 104 mgl^{-1} (September, 2008) 122 mgl^{-1} (September, 2009) and 98 mgl^{-1} in the month of July 2010. The lowest value of total alkalinity at same depth was recorded to be 82 mgl^{-1} in (November, 2008), 70 mgl^{-1} (December, 2010) and 76 $mg\ l^{-1}$ (January 2010). Range of alkalinity varied between 70 and 122 mgl^{-1} (Tables 2 and 5). In Tawa reservoir, the highest value of the total alkalinity was recorded to be 112 mgl^{-1} (September, 2008), 121 mgl^{-1} (September, 2009) and 118 mgl^{-1} (July, 2010). The lowest value at the same depth was 62 mgl^{-1} (November, 2008), 57 mgl^{-1} December, 2009) and 60 mgl^{-1} (January, 2010) (Tables 3 and 4). The value of total alkalinity was ranging from 74 mgl^{-1} to 112 mgl^{-1} for Halali and 57 mgl^{-1} to 121 mgl^{-1} for Tawa Reservoirs.

In the present study, it was found, the that alkalinity ranged between 50 to 100 mgl^{-1} which has been found to be productive, which confirms nutrient rich and productive nature of the water reservoirs. Garg et al. (2006 and 2009) in Harsi and Ramsagar reservoirs, Verma et al. (2011) in Kankaria Lake, Verma et al. (2012) in Chandla lake and Meenakshi Saxena (2012) in Raipur Reservoir have found total alkalinity with its maximum value in summer and minimum in winter season. Similar results were observed in reservoir under study, the minimum alkalinity was recorded in winter and rainy seasons and maximum in summer season. During summer season it could be due to decrease in water level resulting death and decay of plants and living organisms. Lower value in winter and rainy seasons could be due to high photosynthetic rate.

Dissolve oxygen

The dissolved oxygen play a role of regulator of metabolic activities of organisms and thus governs metabolism of the biological community as a whole and as used as an indicator of trophic status of the water (Saksena and Kaushik, 1994). In Halali reservoir, the highest value of the Dissolve Oxygen was recorded to be 9.2 mgl^{-1} August 2008, 9.6 mgl^{-1} (August 2009) and 7.4 mgl^{-1} (April, 2010). The lowest value at the same depth was 6.9 mgl^{-1} (December, 2008), 6.1 mgl^{-1} (June, 2009) and 6.0 mgl^{-1} (July 2010). Dissolve Oxygen value ranged between 6.1 to 9.6 mgl^{-1} tables 2 and 5. In Tawa reservoir the highest value of the Dissolve Oxygen was recorded to be 8.6 mgl^{-1} in (August, 2008), 8.7 mgl^{-1} in (August, 2009) and 8.9 mgl^{-1} in (April, 2010). The lowest value at the same station was 6.3 mgl^{-1} in the month of December (2008), 6.0 mgl^{-1} in March (2009) and 6.4 mgl^{-1} in (July, 2010) Tables 3 and 4.

In the present study, dissolved oxygen was ranging from 6.0 to 9.6 mgl^{-1} for Halali reservoir and 6.0 to 8.9 mgl^{-1} is within the range reported by earlier workers. In both the reservoirs higher value of dissolved oxygen was found in the months of summer-this was due to the optimum water temperature regime enhances photosynthesis activities resulting into liberation of oxygen. Similar trends of results have been shown by various workers like Esmaelli and Johal (2005), Gonjari and Patil (2008) and Singh et al. (2010). During monsoon and the winter, the level of dissolved oxygen was quite satisfactory, perhaps due to good aeration caused by rain water.

Total hardness

Total hardness is defined as the concentration of multivalent metallic cations in solution. Bicarbonates and carbonates of calcium and magnesium impart temporary hardness, whereas, sulphates, chlorides and other anions of mineral acids produced as permanent hardness. Sawyer (1960) classified water bodies on the basis of hardness into three categories viz. soft (hardness less than 75.0 mgl^{-1}), moderately hard (from 75.0-150.0 mgl^{-1}) and hard (from 151.0-300.0 mgl^{-1}). The maximum value of the total hardness in Halali reservoir was recorded to be 108 mgl^{-1} in (August 2008), 104 mgl^{-1} in (July, 2009) and 102 mgl^{-1}

in (June, 2010). The lowest value of total hardness at same station was recorded to be 70 mgl^{-1} in (December, 2008), 68 mgl^{-1} in (December, 2009) and 72 mgl^{-1} in (January, 2010). The range of total hardness varied between 68 to 108 mgl^{-1} (Tables 1 and 4).

The highest value of the total hardness in the Tawa reservoir was recorded to be 154 mgl^{-1} in (August, 2008), 166 mgl^{-1} in (July, 2009) and 152 mgl^{-1} in (July, 2010). The lowest value at the same station was 88 mgl^{-1} in the month of December 2008, 106 mgl^{-1} in December 2009 and 108 mgl^{-1} (January, 2010) at Tawa reservoir. The range of total hardness varied between 88 and 170 mgl^{-1} (Tables 2 and 3). The total hardness attained maximum in rainy season, while minimum in winter season. High values of hardness during rainy season are probably due to the addition of large quantities of sewage and detergents in the reservoir from the nearby residential localities with surface runoff water. Similar results have also been obtained by Kumar et al. (2009); Singh et al. (2010); Verma et al. (2012); Sinha and Biswas (2011) and Khan et al. (2012). Halali and Tawa Reservoirs water is adjudged as moderately hard water throughout the study period.

Phosphate

Phosphorous is considered to be the most significant component among the nutrients responsible for eutrophication of a water body, as it is the primary initiating factor. High concentrations of phosphates can indicate the presence of pollution and are largely responsible for eutrophic conditions. Lee et al. (1981) have classified the water bodies on the basis of phosphorus contents into five categories viz., oligotrophic, oligo-mesotrophic, mesotrophic, meso-eutrophic; eutrophic. Phosphorus is rarely found in high concentrations in freshwaters as it is actively taken up by plants. Ecologically phosphorus is often considered as the most critical single element in the maintenance of aquatic productivity. The main source of phosphorous in water comes from the weathering of phosphorous bearing rocks, leaching from soils of nearby catchment areas and cattle dung. Other factors regulating the phosphorous are such as bacterial activity, sewage contamination, agriculture fertilizers, industrial effluents, depth of water body, aquatic vegetation, bottomfauna, dead eggs of aquatic animals and excreta of other animals etc. Lee et al. (1981), on the basis of phosphoruscontents have classified the water bodies into five categories viz., oligotrophic less than 0.007 mgl^{-1}, oligo-mesotrophic between 0.008 and 0.011 mgl^{-1}, mesotrophic between 0.012 and 0.027 mgl^{-1}, meso-eutrophicbetween 0.028 and 0.039 mgl^{-1}, eutrophic more than 0.040 mgl^{-1}. Inorganic phosphorous in halalireservoir had a range from 0.012 to 0.106 mgl^{-1} and average of 0.097±0.009 mgL^{-1} during the study period. The maximum valueof phosphorous was obtained in monsoon and the minimum in winter. These results were also confirmed by the observations of Kaushik and Saksena (1991), Jayabhaye et al. (2008), Kumar et al. (2009) and Manimegalai et al. (2010). Low values of phosphates during the winter season are due to their utilization by macrophytes and to theirgrowth as well, and higher values in rainy season are because of surface runoff, washing of agricultural fields and mixing with the incoming water to the reservoir.

When the classification of Lee et al. (1981) is applied to inorganicphosphorus content in water of reservoir, this reservoir can be placed under oligo-mesotrophic water body Moyle (1946) from a study of a large number of lakes and ponds, found good production of fish in the ponds having phosphorus concentration 0.02-0.05 ppm, while for the other ranges all ponds were found to be almost equally productive.The highest values of phosphate were recorded to be 0.104 mgl^{-1} (August, 2008), 0.106 mgl^{-1} (August, 2009) and 0.080 mgl^{-1} (July, 2010) in Halali reservoir. The lowest values of phosphate were recorded to be 0.043 mgl^{-1} (December, 2008), 0.012 mgl^{-1} (July, 2009) and 0.12 mgl^{-1} (June, 2010). Range of phosphate varied from from 0.012 to 0.106 mgl^{-1} (Table 1). In Tawa reservoir highest values of phosphate were recorded to be 0.010 mgl^{-1} (September, 2008), 0.014 mgl^{-1} (October, 2009) and 0.008 mgl^{-1} (July, 2010) at Tawa reservoir. The lowest values of phosphate were recorded to be 0.01 mgl^{-1} in December, 2008; June, 2009 and 2010 at Tawa reservoir. Range of phosphate varied from 0.001 mgl^{-1} to 0.014 mgl^{-1} (Tables 3 and 4).

In the present study, Halali reservoir the maximum value of phosphrous is 1.06 mgl^{-1} was obtained in monsoon and minimum is 0.12 mgl^{-1}. Low value of phosphate could be due to utilization by microphytes and macrophytes in their growth tables 2 and 5. Surface runoff from washings of agricultural fields and mixing with the incoming water to the reservoir made higher values of phosphorous in the reservoir. Similar reasons have been projected by Kaushik and Saksena (1999), Ganesan and Sultan (2009) and Prabhakar et al. (2012) in their studies. When the criterion of inorganic phosphorus is applied, Halali and Tawa reservoirs can be placed under eutrophic water body (Lee et al., 1981). From the above data, it can be concluded that high fish production can be expected as phosphorus concentration is above 0.02 ppm.

Nitrate

The nitrogen in water occurs as bound forms like nitrate, nitrite, ammonia and organic forms viz., urea, amino acids etc. Nitrates are products of oxidation of organic nitrogen by the bacteria present in soil and water where sufficient oxygen is present. High concentration of nitrates are useful in irrigation but their entry into water resources increase the growth of nuisance algae, macrophytes and trigger eutrophication and pollution (Trivedy and Goel, 1986). Of the dissolved nutrients, nitrogen and phosphorus have been widely studied and their role and importance in aquatic productivity is well recognized. As a constituent of protein, nitrogen occupies a highly important place in aquatic eco-system. Chu (1943) concluded from the results of laboratory experiments that nitrogen and phosphorus naturally occur in quantities far below the upper limit for optimal growth of plankton and often do not reach lower optimal concentrations, the optimal limit of nitrogen being given by him as 0.3 to 1.3 mgl^{-1}; these however, may not be applicable to natural conditions.The highest values of Nitrate in Halali reservoir were recorded to be 1.10 mgl^{-1} (August, 2008), 1.06 mgl^{-1} (August, 2009) and 0.68 mgl^{-1} (July, 2010) in Halali reservoir. The lowest values of nitrate were recorded to be 0.82 mgl^{-1} (December, 2008), 0.16 mgl^{-1} (May, 2009) and 0.17 mgl^{-1} (May, 2010) in Halali. Variation in Nitrate ranged between 0.16 mgl^{-1} and 1.10 mgl^{-1} (Tables 2 and 5). The highest values of nitrate were recorded as, 0.18 mgl^{-1}

Table 1. Seasonal variation of physio-chemical characteristic of Halali reservoir water during the year 2008-2010

Parameters	Summer Season			Rainy Season			Winter Season		
	Min	Max	Mean +SE	Min	Max	Mean +SE	Min	Max	Mean +SE
Ambient Temperature (C)	23.0	37.0	31.9 +5.04	28.0	31.5	29.7 +1.19	18.0	22.5	21.6 +3.29
Water Temperature (C)	23.4	29.8	26.4 +2.14	24.0	32.0	27.96 +2.6	19.9	26.2	22.7 +1.64
Transparency	120	154	130.0 +15.7	20	38	28 +6.91	40	94	72 +17.5
pH	8.2	9.0	8.5 +0.26	7.2	8.3	7.65 +0.38	6.9	8.2	7.5 +0.37
Electrical Conductivity	190	253	206.6 +33.6	135	190	158.3 +15.5	170	230	205.1 +19.7
Total Alkalinity	74	110	88.8 +9.6	93	122	115.4 +7.8	70	116	84.9 +10.6
Dissolved Oxygen	6.1	7.9	6.8 +0.49	6.0	9.6	8.09 +1.12	6.2	8.5	7.24 +0.61
BOD	4.24	7.12	5.68 ±0.44	3.79	6.02	4.90± 1.01	2.75	5.98	4.15 ±0.99
Total Hardness	86	102	93.31 +4.71	80	108	95.3 +8.05	68	98	79.25 +7.62
Phosphate	0.12	0.30	0.20 +0.5	0.10	0.98	0.51 +0.38	0.30	0.58	0.43 +0.08
Nitrate	0.16	0.63	0.37 +0.17	0.58	1.10	0.89 +0.16	0.49	0.86	0.69 +0.10
Colour			green			dark brown			Transparent-green

Table 2. Seasonal variation of physio-chemical characteristic of Tawa reservoir water during the year 2008-2010

Parameters	Summer Season			Rainy Season			Winter Season		
	Min	Max	Mean +SE	Min	Max	Mean +SE	Min	Max	Mean +SE
Ambient Temperature (C)	23.9	41.2	35.1 +5.78	31.6	39.2	34.8 +1.92	15.5	31.9	20.2 +4.43
Water Temperature (C)	22.5	26.8	24.8 +1.34	21.6	25.9	23.6 +1.16	18.5	23.5	20.9 +1.55
Transparency	104	153	137.5 +12.9	20	54	33.4 +9.69	61	126	84.9+18.62
pH	7.8	9.1	8.5 +0.39	7.6	8.4	8.1 +0.22	7.4	8.1	7.7 +0.173
Electrical Conductivity	140	272	217.1 +44.51	155	210	175.0 +15.9	180	242	218.8+17.24
Total Alkalinity	71	109	86.6 +14.44	68	121	97 +15.9	57	104	78.6 +17.87
Dissolved Oxygen	5.8	8.9	7.0 +0.8	6.4	8.5	7.77 +0.82	6.0	6.9	6.6 +0.25
BOD	4.2	6.94	5.07±0.26	3.4	5.66	4.78±0.34	2.65	5.98	4.65±0.88
Total Hardness	126	162	138.9 +10.92	102	170	137.4+22.02	88	124	105 +12.22
Phosphate	0.01	0.09	0.04 +0.01	0.04	0.14	0.08 +0.02	0.02	0.10	0.05 +0.02
Nitrate	0.01	0.19	0.05 +0.04	0.06	0.20	0.15 +0.04	0.04	0.09	0.07+0.15
Colour			transparent green			turbid			green

Table 3. Range of variations and mean with standard error of physio-chemical characteristics of water of Tawa Reservoir during 2008-2010

Parameters	Unit	2008-2010		
		Minimum	Maximum	Mean+SE
Ambient Temperature	C	15.5	41.2	32.6±1.43
Water temperature	C	18.5	26.8	24±1.22
Transparency	Cm	20	153	85±5.29
Colour		Light green	Brown	Green
pH		7.4	9.1	8.25±0.58
Electrical conductivity	$\mu S\ cm^{-1}$	162	260	217±9.7
Total Alkalinity	mgL^{-1}	57	121	94±3.98
Dissolved Oxygen	mgL^{-1}	6.3	8.9	7.86±0.15
Total Hardness	mgL^{-1}	88	170	129±4.87
Inorganic Phosphorous	mgL^{-1}	0.01	0.14	0.125±0.004
Nitrate-nitrogen	mgL^{-1}	0.01	0.21	0.16±0.03
BOD	mgL^{-1}	2.65	6.94	4.7+ 0.27

Table 4. Range of variations and mean with standard error of physio-chemical characteristics of water of Halali Reservoir during 2008-2010

Parameters	Unit	2008-2010		
		Minimum	Maximum	Mean+SE
Ambient Temperature	C	18	38	27.73±1.45
Water temperature	C	19.9	32.0	25.66±1.52
Transparency	Cm	20	154	86.4±4.23
Colour		Light Green	Green	Green
pH		6.9	9.0	7.88±0.67
Electrical conductivity	μS cm^{-1}	135	252	166.16±8.87
Total Alkalinity	mgL^{-1}	70	122	96.36±3.25
Dissolved Oxygen	mgL^{-1}	6.0	9.6	7.32±0.15
Total Hardness	mgL^{-1}	68	108	89.25±4.76
Inorganic Phosphorous	mgL^{-1}	0.22	0.56	0.47±0.009
Nitrate-nitrogen	mgL^{-1}	0.16	1.10	0.65±0.02
BOD	mgL^{-1}	3.2	6.8	4.9±0.33

(August, 2008), 0.20 mgl^{-1} (September, 2009) and 0.20 mgl^{-1} (July, 2010) at Tawa reservoir. The lowest values of nitrate were recorded to be 0.06 mgl^{-1} (December, 2008), 0.02 mgl^{-1} (June, 2009) and 0.01 mgl^{-1} (May, 2010) in Tawa reservoir. Variation in Nitrate ranged between 0.01 mgl^{-1} to 0.20 mg l^{-1} (Tables 2 and 3). From the above data it can be concluded that Tawa and Halali reservoirs, is found to be highly productive.

Biological Oxygen Demand: Biochemcial Oxygen Demand is a very important parameter in estimating the pollution status of sewage and industrial waste in the water body. In itself BOD is not a pollutant and exercises no direct harm but it may cause an indirect harm by reducing dissolved oxygen concentration levels inimical to fish life and other beneficial uses. BOD represents that fraction of Dissolved Organic matter which is degraded and easily assimilated by bacteria. The values of BOD provide information regarding quality of water and helps in deciding the suitability of water for consumption. It indicates the presence of biodegradable organic matter quantitatively, which consumes dissolved oxygen from water.The higher values of BOD produce obnoxious smell and unhealthy environment. Its range varied from 3.2 to 6.8 mg/l. The higher values of BOD were noted during summer months due to favourable environmental conditions for microbiological activities at higher temperature (Tables 1, 2 and 4). Biological oxygen demand is the amount of oxygen required by the living organisms engaged in the utilization and ultimate destruction or stabilization of organic water. It also indicates the presence of microbial activities and dead organic matter on which microbes can feed. In the present study the biochemical oxygen demand during entire period was ranging from 2.65 mgl to 6.94 mgl with an average of 4.7±0.27 mgl. The higher biochemical oxygen demand was recorded during rainy and summer season. A higher value of biochemical oxygen demand indicates maximum consumption of oxygen in mitigating higher organic pollution load. In the present investigation, the values of biochemical oxygen demand were obtained gradually increasing from pre-monsoon and becoming highest in monsoon. This may be due to presence of high amount of organic matter and entry of other allocthonous materials thereby increasing the respiratory activity of the heterotrophic organisms. In winter season, the biochemical oxygen demand values were low which may be due to lesser quantity of organic material in the form of solids and decreased microbial population. Similar observations have been made (Garg et al., 2006; Karne and Kulkarni, 2009; Verma et al., 2012) on various water bodies.

Tropical status of the water body

Nutrient level of any water body is directly related with their tropic status. Both natural and anthropogenic factors influence the productive status and water body's tropic status.There have been good number of parameters of water which are used to designate tropic status of water bodies.Harsi reservoir was considered to be oligo-mesotropic water body which was due to the fact thatno sewage is discharged to the reservoir and no agricultural practices are done in the vicinity of reservoir (Garg et al., 2006) .On the basis of physiochemical characteristics studytable 6 and 7 conducted on halali and Tawa reservoir and from the evaluation status assigned by various workers (Ohle, 1938; Olsen, 1950; Alikunhi, 1957; Sawyer, 1960; Spence, 1964; Vollenweider, 1968; Reid and Wood, 1976; Lee, 1981; Unni, 1983; Venkateshwarlu, 1983). It can be stated that Halali and Tawa reservoir could be placed under oligo-mesotrophic.

Conclusion

Colour of the reservoir water from light green to green could be due to good algal growth (Saxena and Saxena, 2009). Halali and Tawa Reservoirs can be classified under the category of alkalliphious and high fish production water bodies. High values of biochemical oxygen demand may be due to presence of high amount of organic matter and entry of other allocthonous materials thereby increasing the respiratory activity of the heterotrophic organisms. In conclusion, the various physico-chemical characteristics of like transparency, electric conductivity,pH, free carbon dioxide, alkalinity, hardness, chlorides, nitrate and inorganic phosphorous have beencompared with the trophic status as suggested by various authors (Ohle, 1934; Olsen, 1950; Sawyer, 1960; Spence, 1964; Vollenweider, 1968; Reid and Wood 1976; Lee et al., 1981; Venkateswarlu 1983; Unni, 1983). The reservoir can safely be placed under the category of oligo-mesotrophic water bodies withgood quantity of nutrients to support relatively good biota in the reservoir. This could be due to the fact that there is no municipal sewage and industrial waste discharge to the reservoir. Though it receives very little amount of pollution from anthropogenicactivities by local village people at present but if the similar conditions continue for the long, reservoir may soon become oligo-mesotrophic to eutrophic water body.

References

Alikunhi KH (1957). Fish culture in India. Farm Bulletin of Indian Council Agricultural Research, Dalwani R, Eds. 20: pp. 1687-1694.

Ansari MF, Ankalgi RF, Ankalgi SR (2008). Studies on physico-chemical aspects and plankton of Unkallake at Hubli, Karnataka, India. In: Proceedings of Taal (2007). The 12th world lake conference, Sengupta M, Dalwani R, Eds.) pp. 1687-1694.

APHA, AWWA, WEF (2005). Standard methods for the examination of water and waste water. 21st edition, Washington DC, USA.

Baskaya (2008). Evaluation of physical, chemical and microbiological properties of lake Ulubat, Turkey. Journal of Environmental Biology 29: 205-210.

Chukwu LO, Odunzeh CC (2006). Relative toxicity of spent lubricant oil and detergent against benthic macro-invertebrates of a West African estuarine lagoon. Journal of Environmental Biology 27: 479.

Chinnaiah B, Rao BD (2011). Physico-Chemical Characteristics of Pakhal and Ramappa Lakes, A.P, India. Nature Environment and Pollution Technology 10(1): 103-104.

Dagaonkar A, Saksena DN (1992). Physico-chemical and biological characterization of a temple tank Kailasagar, Gwalior, Madhya Pradesh. Journal of Hydrobiology 8(1): 11-19.

Esmaeili HR, Johal MS (2005). Study of physico-chemical parameters of water of Govindsagar reservoir, India. In: Proceeding of National Seminar on New trends in fishery development in India (Johal MS, Ed.), pp.173-177. Punjab University, Chandigarh, India.

Ganesan S, Sultana M (2009). A base line study of physico-chemical parameters and some trace metals in water of chrompet lake, Chennai, India. Journal of Aquatic Biology 24(2): 131-141.

Garg RK, Rao RJ, Saksena DN (2006). Studies on nutrients and trophic status of Ramsagar reservoir, Datia,Madhya Pradesh. Nature Environment and Pollution Technology 5(4): 545-551.

Garg RK, Rao RJ, Saksena DN (2009). Water quality and conservation management of Ramsagar reservoir,Datia, Madhya Pradesh. Journal of Environmental Biology 30(5): 909-916.

Goel PK, Gopal B, Trivedy RK (1984). Impact of sewage of freshwater ecosystem and General future of freshwater bodies and sewage. Journal of Ecology and Environment Science 6: 83-86.

Gonjari GR, Patil RB (2008). Hydrobiological studies on Triputi reservoir near Satara, Maharashtra. Journal of Aquatic Biology 23(2): 73-77.

Karne AV, Kulkarni PD (2009). Studies on physico-chemical characteristics of freshwater bodies in Khatavtahsil, Maharashtra. Nature Environment and Pollution Technology 8(2): 247-251.

Kaushik S, Saksena DN (1991). Water quality of Suraj kund, Gwalior and its management. In: Environmental pollution and resources of land and water. pp. 181-188. Academy Environmental Biology, Muzaffarnagar, India.

Kaushik S, Saksena DN (1999). Physico-chemical limnology of certain water bodies of Central India. Freshwater ecosystems of India (Vijaykumar K, Ed.), pp. 1-58. Daya Publishing House, New Delhi, India.

Khan RF, Jadhav MJ, Ustad IR. (2012). Physicochemical Analysis of Triveni lake water of Amravati district (Ms) India. Bioscience Discovery 3(1): 64-66.

Kumar NJI, Oommen C (2009). Variations in Hydrochemical characteristics of two distinct wetlands ofCentral, India. Nature Environment and Pollution Technology 8(2): 269-277.

Lee GF, Jones RA, Rast W (1981). Alternative approach to trophic state classification for water quality management. Occ. Pap 66: Dept. Civil Environ. Engg. Prog. Colorado State University, Fort Collins, Colorado, USA.

Meenakshi Saxena, Saksena DN (2012). Water quality and tropic status of Raipur reservoir in Gwalior, Madhya Pradesh. Journal of Natural Sciences Research 2(8).

Mishra SR, Saksena DN (1991). Pollutional ecology with reference to physico-chemical characteristics of Morar (Kalpi) river, Gwalior (MP). In: Current Trend in Limnology-I (Sastry NK Ed.), pp.159-184. Narendra Publishing House, New Delhi, India.

Narayana J, Puttaiah ET, Basavaraja D (2008). Water quality characteristics of Anjanapura reservoir near Shikaripur, District Shimoga, Karnataka. Journal of Aquatic Biology 23(1): 59-63.

Ohle W (1938). Die Bedeutung der anstanschvorgange zwischen Schlamn und Wasser Fur den stoffkrislauf der Gewasser, Vom Wasser.

Olsen S (1950). Aquatic plants and hydrosheric factors I. aquatic plants in Swjutland, Denmark. Svensk BotaniskTidskrift, 44: 1-34

Prabhakar C, Saleshrani K, Tharmaraj K, Kumar VM (2012). Seasonal variation in hydrological parameters of Krishnagiri dam, Krishnagiri district, Tamil Nadu, India. International Journal of Pharmaceutical and Biological Archieves 3(1): 134.

Reid GK, Wood RD (1976). Ecology of inland waters and estuaries. Second edition. D. Van. Nostrand.Corporation, New York, USA.

Saksena DN, Kaushik S (1994). Trophic status and habitat ecology of entomo fauna of three water bodies at Gwalior, Madhya Pradesh. In: Perspective in entomological research (Agarwal OP, Ed.). Scientific Publishers, Jodhpur, India.

Sawyer CH. (1960). Chemistry for sanitary Engineers. McGraw Hill Book Company, New York, USA.

Shekhar TRS, Kiran BR, Puttaiah ET, Shivaraj Y, Mahadevan KM (2008). Phytoplankton as index of water quality with reference to industrial pollution. Journal of Environmental Biology 29: 233-236.

Singh M, Lodha P, Singh GP (2010). Seasonal Diatom variations with reference to physico-chemical properties of water of Mansagar Lake of Jaipur, Rajasthan. Res. Journal of Agriculture and Science 1(4): 451-457.

Sinha SN, Biswas M (2011). Analysis of physico-chemical characteristics to study the water quality of a lake in Kalyani, West Bengal. Asian Journal of Experimental and Biological Sciences 2(1): 18-22.

Spence DHN (1964). The macrophytic vegetation of loaches, swamps and associated fens. In: The vegetation of scottland (Burnett JH, Ed.), pp. 306-425. Edinburgh, UK.

Trivedy RK, Goel PK (1986). Chemical and biological methods for water pollution studies. Environmental Publication, Karad, Maharashtra, India.

Unni KS (1983). Comparative water chemistry of a plankton dominated and macrophyte dominated lake in Chhindwara, M.P. Proceeding National Academy of Science India 53(B): 81-88.

Venkatesan J (2007). Protecting Wetlands. Current Science

93: 288-290.

Venkateswarlu V (1983). Taxonomy and ecology of algae in the river moosi, Hyderabad, India. II. Bacillariophyceae Bibliotheca: Phycology 66: 1-41.

Verma P, Chandawat DK, Solanki HA (2011). Seasonal variation in physico-chemical and Phytoplankton analysis of Kankaria Lake, Ahmedabad. Life science Leaflets: 19: 842-854.

Verma P, Chandawat D, Gupta U, Solanki H. (2012). Water quality analysis of an organically polluted lake by investigating different physical and chemical parameters. International Journal of Research in Chemistry and Environment 2(1): 105-111.

Vollenweider RA (1968). Scientific fundamentals of the eutrophication of lakes and flowing waters with particular reference to nitrogen and phosphorus. Organization for Economic Cooperation and Development. (OECD) report. Paris, France, DAS/CSI/68.27, pp.192.

Acien Fernandez FG, Garcıa Camacho F, Sanchez Perez JA, Fernandez Sevilla JM, Molina Grima E (1997). A model for Light Distribution and Average Solar Irradiance inside Outdoor Tubular Photobioreactors for the Microalgal Mass Culture. Biotechnol Bioeng 55: 701-714.

Bannister TT (1988). Estimation of absorption coefficient of scattering suspensions using opal glass. Limnol Oceanogr 33: 607-615.

Banuett F (1991). Life cycle determinants of the plant pathogen Ustilago maydis. In: Bennett JW, Lasure LL, editors. More gene manipulations in fungi. London: Academic Press, UK. pp. 217-23.