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Study of Nutrients and Trophic Status of Tighra Reservoir, Gwalior (Madhya Pradesh), India

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Abstract

In the present study, transparency (128.70±4.44 cm), total dissolved solids (113.90±4.25 mg L^{-1}), electrical conductivity (138.7±3.51µS/cm), pH (8.47±0.02), free carbon dioxide (0.26±0.05 mg L^{-1}), total alkalinity (28.69±2.28 mg L^{-1}), total hardness (50.10±1.92 mg L^{-1}), chlorides (26.96±0.92 mg L^{-1}), nitrate-nitrogen (0.032±0.0017 mg L^{-1}), inorganic phosphorous (0.009±0.001 mg L^{-1}), calcium (16.70±0.44 mg L^{-1}), magnesium (3.58±0.16 mg L^{-1}), sodium (4.22±0.15 mg L^{-1}) and potassium (2.92±0.07 mg L^{-1}) were analyzed to assess the trophic status of Tighra reservoir. When various physico-chemical characteristics of Tighra reservoir have been compared with the range values and categories of trophic status as provided by various authors, then Tighra reservoir can safely be placed under the category of oligo-mesotrophic water bodies.

1. Introduction

Water is an essential requirement for life and has been put to diverse uses including human and domestic consumption, irrigation, industry, and aquaculture and is also a basic requirement for sustaining a high quality of life for economic and social development. It forms the liquid constituent of all living matter and is used by both the animals and plants for their metabolic activities. 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 purpose etc. The demand of freshwater has increased many folds and at the same time sewage, industrial wastes, agriculture runoff, varieties of synthetic chemicals and other anthropogenic activities degrade the quality of large share of this limited quantity of water. The water characteristics of any water body depend manly on geographical location, climate, seasons, topography and demographic pressure. The reservoirs located near the cities and towns receive a good amount of sewage load altering their physico-chemical characteristics. Oligotrophic water bodies are relatively less productive and receive comparatively small amount of nutrients and support few aquatic plants and animals while eutrophic water bodies experience high influx of nutrients and are highly productive in term of plants and animals. In Madhya Pradesh, there are many freshwater bodies in the form of rivers, lakes and man-made reservoirs in the state. The small, medium and large reservoirs in this state are estimated to be 1,72,575; 1,67,502 and 1,18,307 ha respectively with a total of 0.458 million ha (Sugunan 1997), contribute to the maximum water spread of all Indian states under manmade lakes. Gwalior and Chambal divisions are rich in water resources and have approximately 54,839 ha water area falling under reservoirs. The physico-chemical characteristics play an important role in assessment of the water quality and trophic status of a water body. However, information on the ecology especially the trophic status of the reservoirs is scanty. Only a few workers have attempted to study some of reservoirs for their nutrients status. Therefore, this paper aims at the study of nutrients characteristics and trophic status of Tighra reservoir along with its suitability as habitat for aquatic organisms.

2. Materials and Methods

2.1 Study Area:

Tighra reservoir constructed on Saank river in the year 1917, situated near Tighra village in Gwalior district, Madhya Pradesh, was selected for the study. The catchment area of this reservoir is 412.25 Sq km with maximum depth 18 m. Geographically, Tighra reservoir lies on $78^0$01'30" E to $77^0$57'54" E longitude and $26^0$11'42" N to $26^0$14'08" N latitude an altitude of 218.58 m from mean sea level (fig. 1 and 2).

2.2 Sampling Procedure:

Water samples were collected from four sampling stations, viz., A, B, C and D during April, 2007 to March, 2009 from Tighra reservoir. The samples were drawn in to iodine treated double stoppered polyethylene bottles without any air bubbling. Estimation of various physico-chemical characteristics of monthly samples was carried out in the first week of every month in the early hours of the day, i.e., between 7.00 am to 10.00 am.

2.3 Analytical Techniques

Analytical techniques as described in standard methods for examination for water and waste water (APHA 1985 and Trivedy & Goel 1986) were used for the physico-chemical analysis. The physico-chemical parameters viz., transparency were determined by Secchi disc, electrical conductivity by conductivity meter, total dissolved solids by gravimetric method, pH by digital pH meter, free carbon dioxide by titration method using phenolphthalein solution as an indicator, total alkalinity by titration method using strong acid and methyl orange and phenolphthalein solutions as indicators, total hardness and calcium hardness by ethylene diamine tetra acetic acid (EDTA) titration method using eriochrome black-T and murexide indicators, chlorides by argentometric method, nitrate-nitrogen by colorimetric method using brucine sulfanilic acid, inorganic phosphorous by using stannous chloride method, magnesium by indirect method and sodium and potassium were estimated with the help of Flame Photometer were analyzed. Physico-chemical characteristics of water, like transparency, pH, free carbon dioxide, total alkalinity, total hardness, chlorides, calcium and magnesium 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 six hours after the collection of water samples.

3. Results and discussion

The results of physico-chemical characteristics of Tighra reservoir water are summarized in table 1 and have been given in fig. 3 and the trophic status of Tighra reservoir has been given in table 2.

Transparency or light penetration followed a direct relationship with nutrients, and is chiefly affected by the algal growth and turbidity. High Secchi disc transparency values indicate low primary productivity of phytoplankton and consequent low fish production in the reservoirs. In the present investigation on Tighra reservoir, transparency was reported from 91.75 to 165.63 cm with an average value of 128.70±4.44 cm. Low values of transparency were observed in rainy season due to accumulation of suspended matter (silt, clay and organic matter) and human activities into the water body and high values in the winter season when suspended matter get settled and deposited in the bottom or became stagnant as has also observed by several workers (Abohweyere 1990, Garg *et al.* 2006a, Dan-Kishiya & Chiaha 2012). Dagaonkar & Saksena (1992) have observed that the transparency of Kailasagar tank fluctuated between 14 cm and 181 cm was high in winter season, and had a negative correlation with turbidity. Kaushik & Saksena (1991) and Kumar *et al.* (2007) have reported high transparency in winter season. The transparency in Tighra reservoir is quite high.

The total dissolved solids are affected by geographical location of the water body, drainage, rain-fall, organic material deposited at the bottom level, incoming water and nature of biota. According to Klein (1972) the excess amount of total dissolved solids in water disturbed the ecological balance in the water due to osmotic regulation and suffocation caused in aquatic fauna. In present study, total dissolved solids in Tighra reservoir were fluctuating between 81.90 and 141.75 mg L^{-1} with an average value of 113.90±4.25 mg L^{-1}. Lower values of total dissolved solids were recorded in winter season and higher in rainy seasons throughout the period of investigation. High values of total dissolved solids during rainy seasons may be attributed to the runoff and catchments watershed and also due to leaching of substances from rocks in surrounding area. Dissolved salts coupled with other ions are utilized by macrophytes and phytoplankton for their growth can be adduced for the lower total dissolved solids values in winter season. Almost same observations were obtained from Minor reservoir (Rajashekhar *et al.* 2007), Keenjhar lake (Korai *et al.* 2008), Mansagar lake of Jaipur (Singh *et al.* 2010) and three dams in Nanded (Pawar & Kanvate 2010).

The amount of ionized material in the water contributes to the electrical conductivity, which is known as an important measure of total dissolved solids. Olsen (1950) has classified water bodies having conductivity values less than 300.0 µS/cm as oligotrophic. Vollenweider & Frei (1953) have also used specific conductivity as indicator for assessing trophic status the lake. The value of electrical conductivity in Tighra reservoir ranged between 108.82 and 164.79 µS/cm with an average value of 138.70±3.51 µS/cm, which was well within the range observed from various water bodies like in Oyun reservoir (Mustapha, 2008) and in Harsi reservoir (Garg *et al.* 2006a, b). The criterion of Olsen (1950) when applied to the nature of Tighra reservoir, this reservoir falls under the category of oligotrophic water bodies. Low conductivity might be responsible for the soft nature of water bodies. Increased concentration of cations such as calcium, magnesium and sulphates during the summer might be responsible for higher electrical conductivity of water during this period. Utilization of these minerals by plankton and macrophytes might be reason for the decrease in the ionic concentration. The present results are in conformity with the earlier workers in this regions and elsewhere (Kaushik & Saksena 1991, Ahmed & Sarkar 1997, Chaurasia & Pandey 2007, Telkhade *et al.* 2008).

Almost all the biological processes and reactions are dependent upon pH and are affected not only by the reaction of carbon dioxide with water and by organic and inorganic solutes present in water. In the present investigation, pH was observed to fluctuate from 8.29 to 8.68 with an average value of 8.47±0.02. Venkateswarlu (1983), has classified reservoirs into five categories, viz., acidobiontic (pH less than 5.5), acidophilus (pH between 5.5 and 6.5), indifferent pH (between 6.5 and 7.5), alkaliphilous (pH between 7.5 and 9.0), and alkalibiontic (pH more then 9.0). If this criterion is applied to Tighra reservoir, then this water body is classified under the category of alkaliphilous water bodies. Kaushik & Saksena (1991), Dagaonkar & Saksena (1992), Dhakad & Chaudary (2005), Korai *et al.* (2008) and Kumar *et al.* (2009) have also observed pH variation from 7.7 to 9.3 in Suraj Kund and Kailasagar (Gwalior), Natnagra pond (Dhar), Keenjhar lake (Sindh, Pakistan) and Jawahar Sagar lake (Rajasthan) respectively. During the present study, the pH was low during winter months and maximum during the summer months. The low value of pH might be due to accumulated organic matter and decomposition of macrovegetation and other organic matter which on biological oxidation gives up carbon dioxide. Similar results were observed by Verma & Mohanty (1995), Shobha *et al.* (1996) and Verma *et al.* (2012). High pH in summer is due to high respiratory rate, decomposition activities and temperature exposure. These results were also obtained by Chaudhary *et al.* (2004) and Solanki (2007).

The respiration activities of aquatic plants, animals and decay of organic matter produce carbon dioxide, which is highly soluble in natural waters. It is essential raw materials for the photosynthesis of green plant. Free carbon dioxide remains high in polluted waters as compared to freshwater bodies. It is also evident that carbon dioxide acts as a limiting factor in the process of photosynthesis when the density of phytoplankton is high. The free carbon dioxide values of Tighra water was ranging from its absence to 1.22 mg L^{-1}. Higher values were observed in the summer months possibly due to the decomposition of organic matter, low photosynthetic activity and low precipitation of free carbon dioxide as carbonates. Khatawkar *et al.* (2004), Salve & Hiware (2006), Islam & Pramanik (2009), Kumar *et al.* (2009) have also reported free carbon dioxide ranging from its absence to 14.0 mg L^{-1}. Higher concentration of free carbon dioxide in summer season in the present study agrees with the observations made by Sultan *et al.* (2003), Kumawat & Jawale (2004) and Kumar *et al.* (2009).

Total alkalinity is the sum of total carbonate and bicarbonate alkalinity. Alkalinity of water is a measure of its capacity to neutralized acids. It is generally imparted by the salts of carbonates, bicarbonates, phosphates, nitrates, borates, silicates etc. along with hydroxyl ions available in free state. Spence (1964) has classified water bodies into three major categories based on the values of alkalinity. They are (i) nutrient poor (from 1.0-15.00 mg L^{-1}), (ii) moderately rich nutrient (from 16.0-60.0 mg L^{-1}), and (iii) nutrient rich (>60.0 mg L^{-1}). Total alkalinity during two years observations ranged from 11.90 to 48.10 mg L^{-1} with an average of 28.69±2.28 mg L^{-1}. If Spence's classification is appeared to that of Tighra reservoir, it has moderately good productive nature. The minimum total alkalinity in Tighra reservoir under study was recorded in the month of November (winter season) and maximum in the month of August (monsoon season). Like other Indian water bodies (Garg *et al.* 2006a & 2009, Jayabhaye *et al.* 2008, Telkhade *et al.* 2008), in Tighra reservoir also the minimum total alkalinity was recorded during winter and maximum during monsoon.

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 mg L^{-1}), moderately hard (from 75.0-150.0 mg L^{-1}), and hard (from 151.0-300.0 mg L^{-1}). In the present work, average total hardness was observed as 50.10±1.92 mg L^{-1}. 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 Korai *et al.* (2008), Kumar *et al.* (2009), Singh *et al.* (2010), Verma *et al.* (2012) and Makode (2012). According to Sawyer (1960), Tighra water is adjudged as soft throughout the period of study. This was due to the fact that there is neither much anthropogenic activity nor any kind of pollutants are being poured into the reservoir.

Chlorides are always present in natural waters and the source of chlorides can be attributed to dissolution of salt deposits or due to discharges of effluents from chemical industries, sewage discharge, irrigation, drainage and contamination from refuge etc. Chlorides play an important role in water quality determination. Increased concentration of chlorides is always regarded as an indicator of eutrophication (Hynes 1963) and pollution due to sewage discharge (Chourasia & Adoni 1985). Unni (1983) have designated less domestic pollution with chlorides from 17.9-57.6 mg L^{-1}, moderate domestic pollution with chlorides from 50.9-129.9 mg L^{-1} and high domestic pollution with chlorides ranging from 92.4-206.4 mg L^{-1}. In Tighra reservoir, the chloride contents ranged from 18.59 to 35.56 mg L^{-1} with an average of 26.96±0.92 mg L^{-1}. High chloride content in this reservoir were observed during summer months and monsoon months which was due increased temperature and consequent evaporation of water from the water body especially in summer and runoff water brought salts from catchment area in monsoon. Similar observations have also been made by Lendhe & Yeragi (2004), Garg *et al.* (2006a) and Babar & Raje (2009). If the classification of Unni (1983) is applied to the chloride contents in the water of Tighra reservoir, this reservoir is categorized as unpolluted water body.

Nitrogen does not occur naturally in water and soil minerals, but is a major component of all organic matter of both the plant and animal origin. Some bacteria convert nitrate back to nitrogen gas under anaerobic conditions when soluble organic matter is present. This process (denitrification) is one of the main ways by which nitrogen is lost from water and soil. According to Sylvester (1961), the domestic sewage is mainly responsible for greater concentration of nitrates in freshwaters. Good amount of nitrates are useful for irrigation but their entry into the water resources increases the growth of nuisance algae and triggers eutrophication and pollution load (Trivedy & Goel 1986). In Tighra reservoir, nitrate-nitrogen in water was estimated between 0.019 and 0.048 mg L^{-1} with a mean of 0.032±0.0017 mg L^{-1} during the entire period of study. In the present study, high concentration of nitrate-nitrogen was observed during monsoon seasons and low in winter season. The high nitrate concentration during monsoon might be due to influx nitrogen rich water that brings about large amount of contaminated sewage water, leaching of nitrate bearing rocks and decaying macrophytes. Decrease in nitrate content during winter months was probably due to its utilization as nutrient by the algal community as evidenced by the luxuriant growth of algae particularly in the winter months. These observations are conformity with the work of (Blomqvist *et al.* 1994, Anderson *et al.* 1998, Kaushik & Saksena 1999, Thilaga *et al.* 2005, Deshmukh & Pingle 2007, Mustapha 2008, Verma *et al.* 2012).

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, bottom fauna, dead eggs of aquatic animals and excreta of other animals etc. Lee *et al.* (1981), on the basis of phosphorus contents have classified the water bodies into five categories, viz., oligotrophic less than 0.007 mg L^{-1}, oligo-mesotrophic between 0.008 and 0.011 mg L^{-1}, mesotrophic between 0.012 and 0.027 mg L^{-1}, meso-eutrophic between 0.028 and 0.039 mg L^{-1}, eutrophic more than 0.040 mg L^{-1}. Inorganic phosphorous in Tighra reservoir had a range from 0.002 to 0.017 mg L^{-1} with an average of 0.009±0.001 mg L^{-1} during the study period. The maximum value of phosphorous was obtained in monsoon and the minimum in winter. These results were also confirmed by the observations of Kaushik & 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 their growth 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 inorganic phosphorus content in water of Tighra reservoir, this reservoir can be placed under oligo-mesotrophic water body.

Calcium is essential element for all organisms, being an important constituent of cell wall and also in, regulating various physiological functions. The water bodies, on the basis of calcium level (Ohle 1934) are poor (less than 10.0 mg L^{-1}), medium (from 10.0-25.0 mg L^{-1}), and rich (more than 25.0 mg L^{-1}). The order of the major cations in waters is generally in a progression of Ca>Mg>Na>K (Rhode 1949). In the present study on Tighra reservoir, it was observed that the range of variation in calcium contents in water was from 13.68 to 22.85 mg L^{-1} with an average of 16.70±0.44 mg L^{-1}. The calcium ions were always higher than that of magnesium ions and reached to a maximum of 22.85 mg L^{-1} in June and a minimum of 13.68 mg L^{-1} in November in this reservoir. During the monsoon season, the weathering of rocks, surface runoffs from surrounding water having high amount of calcium cation, and less utilization of calcium by plankton and other aquatic organisms for their activity contribute to high calcium level. However, high production rate and physiological activity of plankton are at their maximum in the winter season and utilization of the calcium by them makes it at less in amount. These results are identical to those reported by Kamble *et al.* (2008) for Khadakwasala reservoir, Jayabhaye *et al.* (2008) for Sawana reservoir, Ganesan & Sultan (2009) for Chrompet lake, Jalilzades *et al.* (2009) for Hebbal lake, Jayashankara *et al.* (2010) for Temple tank, Karnataka and Verma *et al.* (2012) for Chandola lake of Ahmadabad. On the basis of the level of calcium in water, Tighra reservoir may be placed under medium productive water body as suggested by Ohle (1934).

Magnesium is often associated with calcium in all kinds of water due to its similar chemical properties but its concentration remains generally lower than calcium. Dagaonkar & Saksena (1992) suggested that the magnesium is essential for synthesis of chlorophyll and acts as a limiting factor for the growth of phytoplankton. In the present study, the magnesium during entire period of investigation ranged from 2.47 to 5.13 mg L^{-1} with a mean value of 3.58±0.16 mg L^{-1}. Magnesium content was maximum during the summer season and low during winter season but was always lesser than calcium. This may be due to the uptake of magnesium by macrophytes and algae in the formation of chlorophyll-magnesium-perphyrin-metal complex and is also used in enzymatic transformations (Wetzel 1975). These results are consistence with those observations obtained in Harsi reservoir (Garg *et al.* 2006a), in Khomph-Niwari lake (Khare *et al.* 2007), in Sawana reservoir (Jayabhaye *et al.* 2008), in Jawahar Sagar lake (Kumar *et al.* 2009) and in Gundolav lake (Sharma *et al.* 2010).

The sodium is one of the important cations occurring naturally, and is a highly soluble monovalent alkaline ion present in the natural water. The concentration of sodium in freshwater is generally lower than the calcium and magnesium. In the present investigation, the average value of sodium in Tighra reservoir was 4.22±0.15 mg L^{-1}. The lower value of sodium recorded in winter season in the present study is due to utilization by plankton and other aquatic organisms, while the higher values were experienced in rainy season due to the fact that rain water brings good quantities of sodium from the catchment area of the reservoir. Above observations get support from the earlier findings of Munawar (1970), Jhingran (1982), Mohan & Zafar (1986), Ganesan & Sultan (2009) and Sharma *et al.* (2010) on various Indian reservoirs.

Potassium in nature is obtained from the weathering of the potassium bearing rocks, potassium also tends to form plates of mica, which are insoluble and becomes unavailable to aquatic ecosystems. Due to low potassium concentration, the growth rate and photosynthesis of algae especially blue green algae become poor and respiration is increased (Provasoli 1958, Wetzel 1983). An average potassium value during period of investigation was 2.92±0.07 mg L^{-1}. The potassium content in the present study was also higher during rainy and lower during the winter season as shown by Mohan & Reddy (1987), Kaushik & Saksena (1999) and Garg *et al.* (2006a & 2010).

In conclusion, the various physico-chemical characteristics of Tighra reservoir like transparency, electric conductivity, pH, free carbon dioxide, alkalinity, hardness, chlorides, calcium, nitrate and inorganic phosphorous have been compared with the trophic status as suggested by various authors (Lee *et al.* 1981, Olsen 1950, Venkateswarlu 1983, Reid & Wood 1976, Spence 1964, Sawyer 1960, Unni 1983, Ohle 1934, Vollenweider 1968, Lee *et al.* 1981), then this reservoir, can safely be placed under the category of oligo-mesotrophic water bodies with moderate quantity of nutrients to support relatively good biota in the reservoir. This is 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 anthropogenic activities by local village people at present but if the similar conditions continue for the long, Tighra reservoir may soon become oligo-mesotrophic to eutrophic water body.

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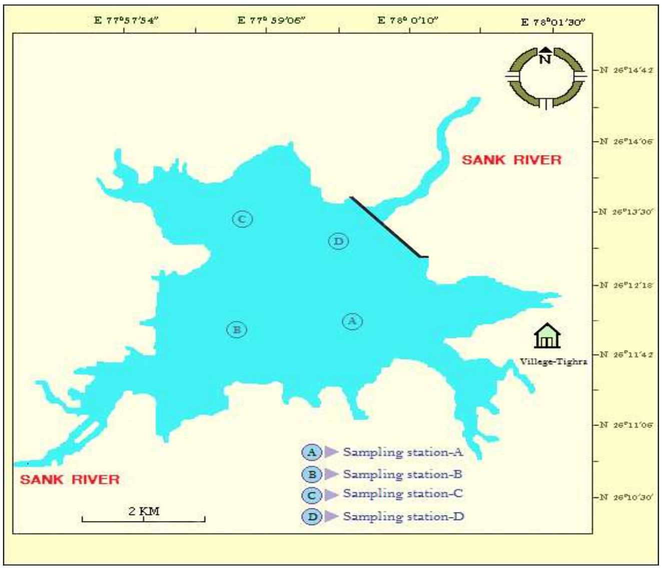
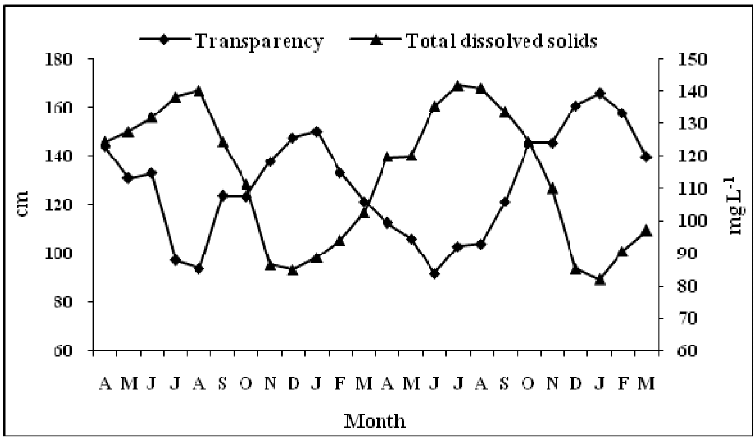


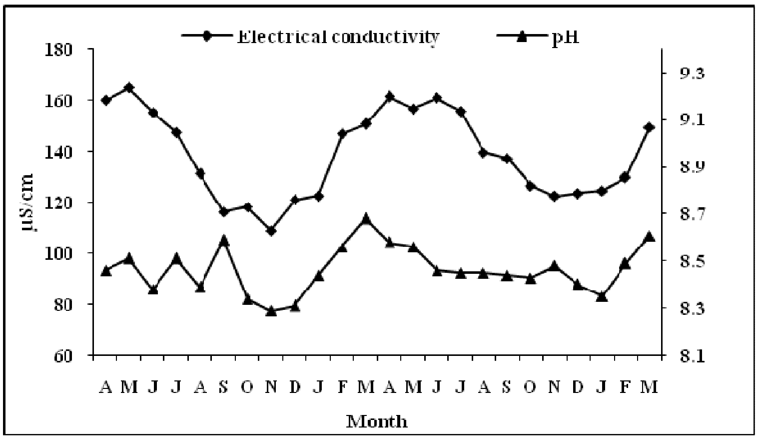
Fig. 1 Sketch of Tighra reservoir, Gwalior

Fig. 2 Satellite image of Tighra reservoir (www. google.com)

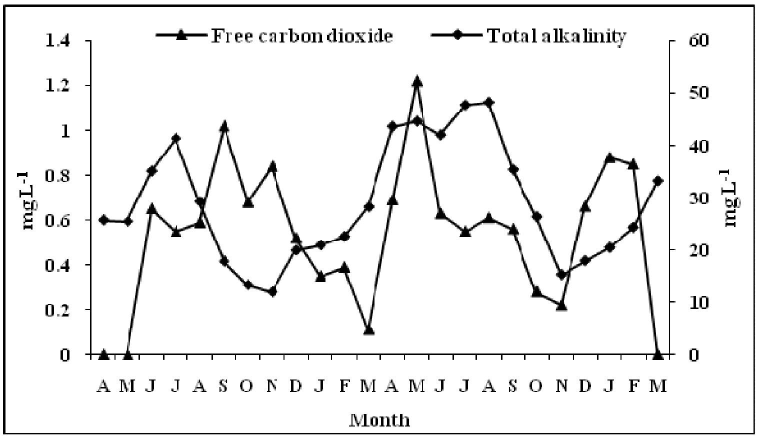
3a



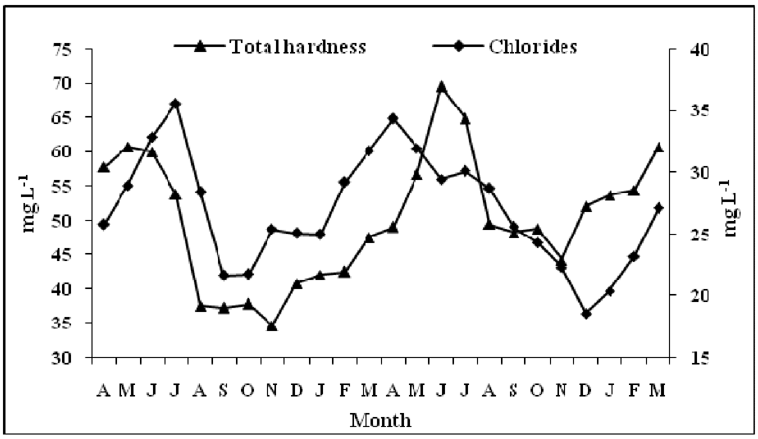
3b


Electrical conductivity
pH
180
160
140
120
100
80
60
µS/cm
9.3
9.1
8.9
8.7
8.5
8.3
8.1
A M J J A S O N D J F M A M J J A S O N D J F M
Month

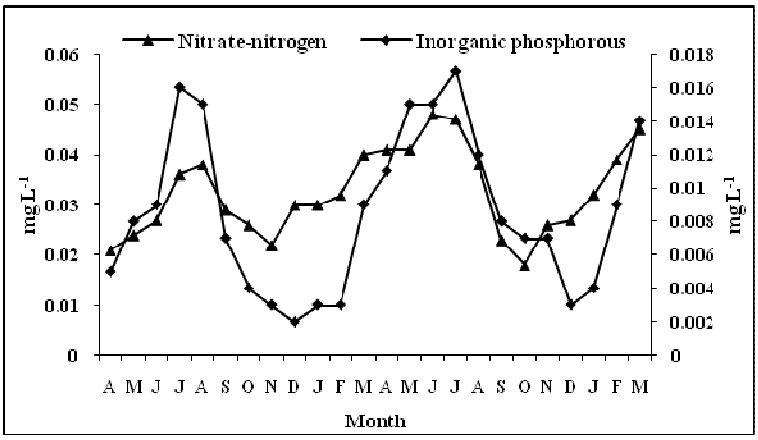
3c


Free carbon dioxide
Total alkalinity
1.4
1.2
1
0.8
0.6
0.4
0.2
0
mgL-1
60
50
40
30
20
10
0
mgL-1
A M J J A S O N D J F M A M J J A S O N D J F M
Month

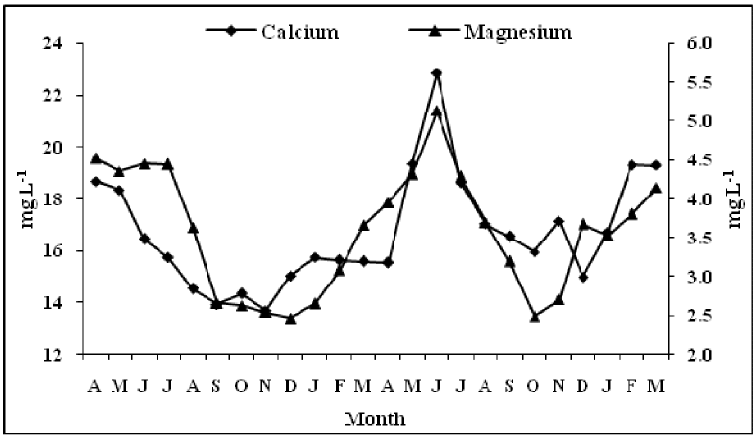
3d


Total hardness
Chlorides
75
70
65
60
55
50
45
40
35
30
mgL-1
40
35
30
25
20
15
mgL-1
A M J J A S O N D J F M A M J J A S O N D J F M
Month

3e


Nitrate-nitrogen
Inorganic phosphorous
mgL-1
Month
A M J J A S O N D J F M A M J J A S O N D J F M

3f


Calcium
Magnesium
mgL-1
Month
A M J J A S O N D J F M A M J J A S O N D J F M

3g

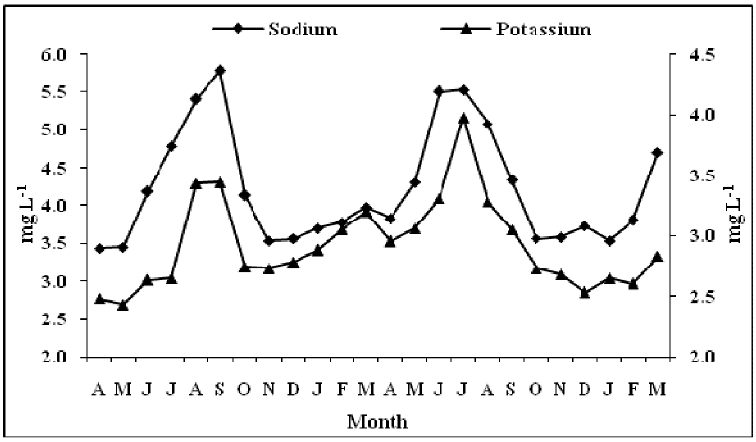

Sodium
Potassium
mgL-1
Month
A M J J A S O N D J F M A M J J A S O N D J F M

Fig. 3: Monthly variation in transparency and total dissolved solids (3a); electrical conductivity and pH (3b); free carbon dioxide and total alkalinity (3c); total hardness and chlorides (3d); nitrate-nitrogen and inorganic phosphorous (3e); calcium and magnesium (3f); sodium and potassium (3g) of water of Tighra reservoir during 2007-2009

Table 1 Range of variation, average with standard error of physic-chemicals characteristics of water of Tighra reservoir during April, 2007 to March, 2009

S.No	Parameters	2007-2008				2008-2009			Average		
		Range of variation			Mean ±SE	Range of variation		Mean ±SE	Range of variation		Mean ±SE
		Unit	Min	Max		Min	Max		Min	Max	
1.	Transparency	Cm	93.56	150.0	127.9±5.15	91.75	165.63	29.4±7.48	91.75	165.63	128.70±4.44
2.	Total dissolved solids	mg L^{-1}	84.79	40.14	112.87±6.0	81.90	141.75	115.04±6.27	81.90	141.75	113.90±4.25
3.	Electrical conductivity	µS/cm	108.82	164.79	136.86±5.57	122.44	161.33	140.60±4.45	108.82	164.79	138.7±3.51
4.	pH	-	8.29	8.68	8.46±0.03	8.35	8.61	8.48±0.02	8.29	8.68	8.47±0.02
5	Free carbon dioxide	mg L^{-1}	Nil	1.02	0.48±0.09	Nil	1.22	0.60±0.09	NIL	1.22	0.26±0.054
6.	Total alkalinity	mg L^{-1}	11.90	41.19	24.21±2.45	15.25	48.10	33.16±3.47	11.90	48.10	28.69±2.28
7.	Total hardness	mg L^{-1}	34.53	60.75	45.95±2.77	44.25	69.50	54.25±2.14	34.53	69.50	50.10±1.92
8.	Chlorides	mg L^{-1}	21.63	35.56	27.59±1.24	18.59	34.33	6.32±1.38	18.59	35.56	26.96±0.92
9.	Nitrate-nitrogen	mg L^{-1}	0.021	0.040	0.029±0.0018	0.018	0.048	0.035±0.0028	0.019	0.048	0.032±0.0017
10.	Phosphates	mg L^{-1}	0.0015	0.0157	0.007±0.0014	0.003	0.017	0.01±0.0013	0.002	0.017	0.009±0.001
11.	Calcium	mg L^{-1}	13.68	18.68	15.64±0.46	14.98	22.85	17.77±0.64	13.68	22.85	16.70±0.44
12.	Magnesium	mg L^{-1}	2.47	4.52	3.42±0.24	2.49	5.13	3.74±0.21	2.47	5.13	3.58±0.16
13.	Sodium	mg L^{-1}	3.43	5.78	4.14± 0.23	3.53	5.53	4.29±0.22	3.43	5.78	4.22±0.15
14	Potassium	mg L^{-1}	2.43	3.44	2.87±0.10	2.53	3.98	2.97±0.12	2.43	3.98	2.92±0.07

Table 2Trophic status of Tighra reservoir

S.N.	Parameters	Unit	Mean± SE	Trophic status of reservoir	References
1.	Transparency	cm	128.70±4.44	Eutrophic	Lee *et al.* (1981)
2.	Electrical Conductivity	µS/cm	138.70±3.51	Oligotrophic	Olsen (1950)
3.	pH	-	8.47±0.02	Alkaliphilous	Venkateswarlu (1983)
4.	Free carbon dioxide	mg L^{-1}	0.26±0.054	Soft	Reid and Wood (1976)
5.	Total alkalinity	mg L^{-1}	28.69±2.28	Moderately	Spence (1964)
6.	Total hardness	mg L^{-1}	50.10±1.92	Soft	Sawyer (1960)
7.	Chlorides	mg L^{-1}	26.96±0.92	No Pollution	Unni (1983)
8.	Calcium	mg L^{-1}	16.70±0.44	Medium	Ohle (1934)
9.	Nitrate-nitrogen	mg L^{-1}	0.032±0.0017	Meso-eutrophic	Vollenweider (1968)
10.	Inorganic phosphorous	mg L^{-1}	0.009±0.001	Oligo-mesotrophic	Lee *et al.* (1981)
	Trophic status of reservoir			**Oligo-mesotrophic**	