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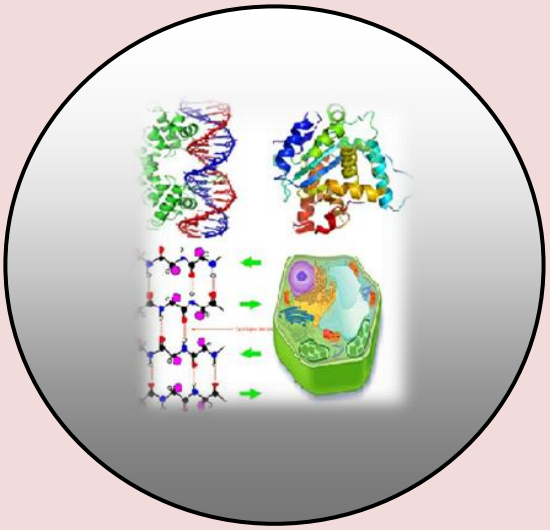

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RESEARCH PAPER

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Assessment of Physico-Chemical and Microbiological Parameters of Drinking Water and Determination of Water Quality Index (WQI) from Kolar reservoir, (M.P) India

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ABSTRACT
Kolar reservoir is one of the most important sources of irrigation and drinking water for the Bhopal city. The present study was aimed at to calculate water quality index (WQI) in relation to human health. The Physico-Chemical and Microbiological parameters were analyzed at 4 sampling sites during January 2016 to December 2017. The results obtained on WQI ranged from 0-25 at, Thus depicting the excellent water quality.
Keywords: Kolar Reservoir, Microbiological status and Water Quality Index (WQI).

INTRODUCTION

Life on the globe is impossible without freshwater. Water is one of the most necessary constituent of the earth. Less than 1% water is present in reservoir, ponds, lakes, rivers, etc., which is used by man for drinking, industrial, domestic and agricultural purposes. Water quality in an aquatic ecosystem is determined by many physical, chemical and biological factors (Sargaonkar and Deshpande 2003). Unsafe water and sanitation account for almost one tenth of the global burden of disease (Fewtrell et al., 2007). Total 768 million and 2.5 billion people in the world are living without access to clean water and proper sanitation, respectively (WHO, 2002). Total 80% of the water in India has become polluted due to the discharge of untreated domestic sewage and partially-treated industrial effluents into the natural water source (CPCB 2007). In developing countries about 1.8 million people, mostly children, die every year as a result of water related diseases (WHO 2004). Nowadays, surface water quality became a critical issue in many countries; especially due to the concern that freshwater will be a scarce resource in the future, therefore, water quality monitoring program is necessary for the protection of freshwater resources (Pesce and Wunderlin 2000). World Health Organization (WHO) (2002). Quantifying selected major risks to health. In: The World Health Report 2002: Reducing Risks, Promoting Healthy Life. Geneva: World Health Organization, 47-97. Madhya Pradesh, with its 0.46 million ha of reservoirs, has the maximum water spread under man-made lakes of all Indian States. Description of 32 reservoirs comprising 6 small, 21 medium and 5 large, covering a total area of 173 901 ha, is available. The average size of these small, medium and large reservoirs is 350, 2 527 and 23 661 ha respectively (R.F.I: M.P.).

The study area selected is Kolar reservoir near Lawakhedi village in Sehore District. Kolar Dam, a major masonry dam, is located about 32 km from Bhopal. This reservoir (latitude 22° 57' 37" and longitude 77° 20' 24") has a catchment area of 240 km^2. The gross storage capacity is 270 Mcm and live storage capacity is 265 Mcm and did storage level is 5 Mcm. The Dam is used for supplying drinking water to Bhopal city.

Collection of water samples

The water samples for the present study were collected at a monthly interval for a period of January 2016 to December 2017. Samples were collected every month from the surface of the reservoir at 8.00 am - 10.00 am in order to maintain uniformity. Water samples were collected from the selected stations in sterilized screw capped polyethylene bottles of one liters capacity and analyzed in laboratory for their physicochemical parameters. The collected samples were transported to the laboratory within 4 to 5 hrs for analyzing various physicochemical and microbiological parameters. For each sampling air temperature, water temperature, transparency, Turbidity, pH, TDS, Conductivity, dissolved oxygen, Free CO_2, TH, TA, Calcium hardness, Chloride, Sodium, Potassium, Calcium, Nitrate nitrogen, Phosphate phosphorous and coliform were monitored at 4 sampling sites, while other parameters were analyzed in the laboratory by adopting the procedures outlined by standard methods of APHA (2005); Adoni (1985) and WHO (2011).

RESULTS AND DISCUSSION

Minimum, maximum, mean and their standard deviation values of the analyzed variables of Kolar reservoir in two years 2016 to 2017 and drinking water standard World Health Organization (WHO) 2011 Table 1.

Air temperature ranged from 14.2 to 35.1^{o}C (2016) and 12.1 to 34.1 ^{o}C (2017) Table 1. Minimum air temperature values were recorded during winter season and maximum during summer season. A Similar trend was also documented by Wanganeo et al., (2007) in Sarangpani pond and Khan et al., (2016) in lower Lake. Wanganeo et al., (2007), reported that a close relationship exists between atmospheric temperature and surface water temperature, besides this atmospheric temperature plays a crucial role in physico-chemical and biological behavior of aquatic systems. Water temperature ranged from 10.1 to 17.2 ^{o}C (2016) and 9.1 to 17.1 ^{o}C (2017) Table 1. Minimum water temperature was observed during winter season and maximum during summer season during the entire study period. Similar trend was also documented by Garg et al., (2010) in Ramsagar reservoir and Surve et al., (2005) in Kandhar dam, Nanded. During summer the high water temperature may be due to reduction in water level and high solar radiation while low temperature was recorded in winter which may be due to short day period Pawar and Pandarkar, (2011) and low intensity of solar radiation (Wanganeo, 2010). The Transparency ranged from 20 to 35 cm (2016) and 19 to 37 cm (2017) with an average value of 27.5 recorded both the years (Table 1). The water transparency was low in rainy months, while maximum values were observed in winter months during both the years. Similar trend was also documented by Jaybhaye et al., (2008) in a reservoir, Sawsana and Lendhe and Yergi (2004) in Phirange Kharbav Lake. pH values in Kolar reservoir samples varied from 7.1 units to 8.3 units with an average value of 7.7 units in 2016 and 7.6 units to 9.3 units with an average value of 8.42 units in 2017 (Table 1). The minimum pH in Kolar reservoir under the study was rescored in winter months and maximum in summer month. Similar observations were recorded by Verma and Mohanty (1995) in Danmukundpur pond and Shobha et al., (1996) in Kolar dam. pH indicates that the water is slightly alkaline in nature. The turbidity ranged from 4 to 15 NTU in 2016 and 6 to 15 NTU in 2017 (Table 1). In the present study, Minimum values were observed in winter months and maximum in rainy month. During winter season settlement of silt and clay resulted in decline of turbidity values. Similar results were observed by Garg et al., (2006) in Harsi reservoir and Thirupathaiah et al., (2012) in Manair reservoir. The total dissolved solids varied from 115 mg/l to 156 mg/l in 2016 and 129 mg/l to 160 mg/l in 2017 (Table 1). In general maximum TDS was recorded during summer months in comparison to winter months. Similar results were observed in Tigra reservoir by Uchchariya (2012) and Minor Keenjhar Lake by Korai et al., (2008). It may be on account of concentration of nutrients as the water level drops down on account of evapotranspiration.

According to WHO (2011) guidelines the safe value of TDS for drinking purpose is 500 mg/l (Table 1). The specific conductivity ranged from 177 to 240 µS/cm 2016 and 198 to 246 µS/cm in 2017. Minimum value was observed in winter month compression to summer month. Similar results were observed in Almatti reservoir (Hulyal and Kaliwal, 2011). Specific conductivity is an indicator of the presence of ions and concentrations of dissolved components and has a direct relationship with TDS. Conductivity was under the permissible limit as prescribed by WHO (2011). According to Wanganeo (2010) dissolved oxygen is most essential and critical factor for water bodies. Dissolved oxygen during the two years observation ranged from 4.4 to 7.6 mg/l and 5.2 to 8.4 mg/l within an average 6.37 to 7.32 (Table 1). Higher DO content in the Kolar reservoir observed in two years was during summer months. In Kolar reservoir, free CO_2 content ranged from ND to 2.6 mg/l and ND to 2.4mg/l in 2016 to 2017 respectively with an average value of 1.79 mg/l and 1.57 mg/l (Table 1). Free CO_2 higher in polluted water bodies as compared to fresh water. Higher values were recorded in summer months possibly due to the low photosynthetic activity. Similar observations were made by Jemi and Balasingh (2011) in Temple ponds in Kanyakumari; Ubharhande and Sonawane (2012) in Paintaakli Dam. Total hardness in Kolar reservoir fluctuated between 39 mg/l to 62 mg/l (2016) and 43 mg/l to 61 mg/l during (2017) with an average values 51.25 mg/l to 53.92 mg/l (Table 1). Minimum values of total hardness were observed in winter month and maximum in summer months throughout the period of investigation. Similar results were observed in Wanganeo et al., (2007) in Sarangpani pond and Patil et al., (2011) in Shivaji University lake Kolhapur. In the present study of Kolar reservoir 2016 and 2017 calcium hardness ranged from 28 to 43 mg/l and 29 to 47 mg/l within an average of 35.5 to 38.9 mg/l (Table 1) during the year 2016 and 17 respectively. In general maximum calcium hardness values were recorded during summer months in comparison to winter and monsoon months at all the sites. Similar observations for calcium hardness have been reported by Kumar et al., (2005) in Ayyanakere tank. Total alkalinity in Kolar reservoir recorded from 100 mg/l to 132 mg/l in 2016 and 98 mg/l to 140 mg/l in 2017 within an average value of 119.25 mg/l to 120.83 mg/l (Table 1). The minimum values of TA were observed in winter months and maximum in summer months. Similar results have been observed by Mahajan and billore (2014) in Nagchoon pond; Gupta et al., (2016) in Jamawa Ramgarh reservoir. The chloride content ranged from 9 to 19 mg/l (2016) and 10 to 21mg/l (2017) within an average value of 14.5 mg/l to 14.7 mg/l (Table 1). Similar observations have been made by Wanganeo et al., (2007) in a Tropical pond and Uchchariya (2012) in Tighra reservoir. Chlorides play an important function in water quality determination. Chloride values fall under the permissible limits (250 mg/l) an prescribed by WHO (2011). The sodium ranged from 4.31 to 7.22 mg/l and 5.15 to 7.56 mg/l within an average of 5.72 to 6.17 mg/l in the year of 2016 and 2017 respectively (Table 1). Sodium values were also under the permissible limits of 200 mg/l as prescribed by WHO (2011). The minimum value of sodium was recorded in winter months and maximum in rainy months. Similar observations were made by Uchchariya (2012) in Tighra reservoir and Mohan & Zafar (1986) in reservoirs of Hyderabad. The sodium concentration is generally low compared to calcium. The potassium ranged from 0.12 to 2.35 mg/l and 0.22 to 2.42 mg/l within an average value of 1.04 to 1.15 mg/l in the year of 2016 and 2017 respectively (Table 1). On over all bases higher values of potassium were observed during rainy season in comparison to winter season (Table 18). Similar observations were also recorded by Mohan & Reddy (1987) in freshwater Lake of Hyderabad and Kaushik & Saksena (1999) in Suraj kund Gwalior. The calcium ranged from 26.11 to 29.65 mg/l and 26.72 to 30.12 mg/l within an average value of 27.47 to 27.9 mg/l in the year of 2016 and 2017 respectively (Table 1). Calcium values fall under the permissible limit of 75 mg/l as prescribed by WHO (2011). Higher values of during monsoon month are on account of surface runoff from surrounding weathering rock material. Similar observations were recorded by Uchchariya (2012) in Tighra reservoir, Gwalior and Ganesan and Sultan (2009) in Chrompet Lake of Chennai. The nitrate nitrogen ranged from 0.008 to 0.53 mg/l and 0.008 to 0.59 mg/l with an average value of 0.13 to 0.22mg/l in the years of 2016 and 2017 respectively (Table 1). Nitrate nitrogen values fall under the permissible limit of 45 mg/l as prescribed by WHO (2011). Minimum values of nitrate nitrogen were observed in winter months and maximum to rainy months. Similar observations were made by Mahajan and Billore 2014 in Nagchoon pond in Khandwa and Ramkrishana (2003) in Pallakkothukulam and Sonatheertham in Tiruvannamala.

The phosphate phosphorous ranged from 0.0005 to 0.173 mg/l and 0.0004 to 0.212 mg/l within an average value of 0.107 to 0.108 mg/l in the years of 2016 and 2017 respectively (Table 1). In the present study, higher concentration of phosphate phosphorus was observed during monsoon months and low during winter months. Similar observations made by Kumar et al., (2009) in Jawahar Sagar of Rajasthan; Manimegalai et al., (2010) in Walayar reservoir of Kerala.

The coliform ranged from 20 to 93 (MPN/100 ml) and 15 to 120 (MPN/100 ml) within an average value of 42.67 (MPN/100 ml) to 57.42 (MPN/100 ml) in the years of 2016 and 2017 respectively (Table 1). During the two year observation minimum coliform was recorded in winter months and maximum in monsoon months. Similar trend was observed by Jotwani et al., (2014) in Kolar reservoir and upper lake and Gogoi and Sharma (2013) in pond water in Dibrugarh of Assam.

Table 1.

Parameters	year	Minimum	Maximum	Avg.	SD	WHO Standard
Air temperature(^{o}C)	2016	14.2 (December)	35.1 (June)	23.12	6.61	-
	2017	12.1 (January)	34.1 (May)	23.51	6.37	
Water temperature(^{o}C)	2016	10.1 (December)	17.2 (April)	13.69	2.05	-
	2017	9.1 (January)	17.1 (May)	13.17	2.45	
Transparency (cm)	2016	20 (August)	35 (January)	27.5	5.3	-
	2017	19 (July)	37 (December)	27.58	5.45	
Turbidity (TUR)	2016	4 (January)	15 (July)	9.57	3.42	-
	2017	6 (January)	15 (July)	10.35	2.39	
pH (units)	2016	7.1 (December)	8.3 (May)	7.7	0.36	6.5-8.5
	2017	7.6 (November)	9.3 (March)	8.42	0.53	
TDS (mg/l)	2016	115 (January)	156 (April)	135.75	13.11	500
	2017	129 (November)	160 (May)	144.42	10.04	
Conductivity (µS/cm)	2016	177 (November)	240 (April)	208.92	20.19	500
	2017	198 (November)	246 (March)	222.67	15.87	
DO (mg/l)	2016	4.4 (May)	7.6 (January)	6.37	1.18	-
	2017	5.2 (June)	8.4 (December)	7.32	0.9	
Free CO_2 (mg/l)	2016	ND (Jan-Dec)	2.6 (April)	1.79	0.85	-
	2017	ND (Jan-Feb-Dec)	2.4 (June)	1.57	0.95	
TH (mg/l)	2016	39 (January)	62 (April)	51.25	7.58	-
	2017	43 (February)	61 (May)	53.92	6.12	

TA (mg/l)	2016	100 (November)	132 (May)	119.25	8.32	-
	2017	98 (January)	140 (May)	120.83	12.7	
CaH (mg/l)	2016	28 (August)	43 (June)	35.5	5.65	-
	2017	29 (November)	47 (April)	38.93	5.66	
Chloride (mg/l)	2016	9 (December)	19 (April)	14.5	3	250
	2017	10 (January)	21 (April)	14.75	3.28	
Na (mg/l)	2016	4.31 (December)	7.22 (August)	5.72	0.97	200
	2017	5.15 (December)	7.56 (July)	6.17	0.7	
K (mg/l)	2016	0.12 (December)	2.35 (August)	1.04	0.87	12
	2017	0.22 (January)	2.42 (July)	1.15	0.84	
Ca (mg/l)	2016	26.11 (December)	29.65 (August)	27.47	1.17	75
	2017	26.72 (December)	30.12 (July)	27.9	1.07	
N (mg/l)	2016	0.008 (February)	0.53 (July)	0.13	0.14	45
	2017	0.008 (February)	0.59 (August)	0.22	0.23	
P (mg/l)	2016	0.0005 (January)	0.173 (August)	0.107	0.071	-
	2017	0.0004 (January)	0.212 (August)	0.108	0.085	
Coliform (MPN/100 ml)	2016	20 (January)	93 (July)	42.67	19.84	-
	2017	15 (January)	120 (July)	57.42	30.85	

Table 2. Showing WQI 2016 in Kolar reservoir.

Parameter	Result	Permissible Limit (WHO)	1/permissible limit Relative weight (wi)	(Result-0)/(Limit-0) Quality Rating (Qi)	Wi*Qi Weighted value	Wi*Qi/ Wi Wqi
pH	7.7	8.5	0.117647059	5.13	0.603921569	5.133333
TDS	135.75	500	0.002	0.2715	0.000543	0.2715
Conductivity	208.92	500	0.002	0.41784	0.00083568	0.41784
Chloride	14.5	250	0.004	0.058	0.000232	0.058
Na	5.72	200	0.005	0.0286	0.000143	0.0286
K	1.04	12	0.083	0.087	0.007222222	0.086667
Ca	27.47	75	0.013	0.366	0.004883556	0.366267
N	0.13	45	0.022	0.0029	6.41975E-05	0.002889
						6.365096

Table 2 and 3 revealed the water quality index at different sites during 2016 and 2017. In general the water quality indexes at all the sites lies within the permissible limits on observed by. Thus, the water quality of Kolar reservoir is of excellent quality as per (Table 4).

Table 3. Showing WQI 2017 in Kolar reservoir.

Parameter	Result	Permissible Limit	1/permissible limit Relative weight (wi)	(Result-0)/(Limit-0) Quality Rating (Qi)	Wi*Qi Weighted value	Wi*Qi/ Wi Wqi
pH	8.42	8.5	0.117647059	5.613	0.660392157	5.613333
TDS	144.42	500	0.002	0.28884	0.00057768	0.28884
Conductivity	222.67	500	0.002	0.44534	0.00089068	0.44534
Chloride	14.75	250	0.004	0.059	0.000236	0.059
Na	6.17	200	0.005	0.03085	0.00015425	0.03085
K	1.15	12	0.083	0.0958	0.007986111	0.095833
Ca	27.9	75	0.013	0.372	0.00496	0.372
N	0.22	45	0.022	0.0049	0.000108642	0.004889
						6.910086

Table 4. Showing WQI.

Ranges	Water Quality Status (WQI)
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unfit for drinking

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