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RESEARCH MANUSCRIPT

Physico-chemical and Bacteriological Assessment of Water Quality of Kaliasote Dam of Bhopal, Madhya Pradesh

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Abstract

Deterioration in quality of water is major concern among developing countries nowadays. Industrialization, urbanization and modern agriculture practices using fertilizers and pesticides have direct impact on the water bodies and quality of water and influence the water resources quantitatively as well as qualitatively. This study deals with the physico-chemical and bacteriological parameters of water of Kaliasote dam of Bhopal, MP. Monthly change in water quality parameters such as temperature, pH, electrical conductivity, total alkalinity, chloride, nitrate, total hardness, fluoride, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and most probable number (MPN) were monitored for a period of three months from Oct 2013 to Dec 2013. It has been found in the analysis that the values of most of the parameters of tested water samples fall within the permissible limits as prescribed by WHO. The values of COD and MPN coliforms per 100 mL of water were found beyond the maximum permissible limits as prescribed by WHO standards. The findings indicate that the water of the dam is less polluted and can be used for domestic and irrigation purposes after proper treatment.

Keywords: Water quality, Kaliasote dam, most probable number, permissible limit, WHO standards.

Introduction

Water is a very precious resource as it is essential for existence of life. There would be no life on Earth without water. Although 71% of Earth's surface is covered with water, only 0.003% of Earth's total volume of water is available for us as fresh water. Human beings, animals and crops need good quality water for their survival. Most people in the world have no access to save drinking water and this has led to increase in water-borne diseases which kill more than six million children every year (TWAS, 2002). Water used for drinking purpose should be potable. Potable water is the water that is free from disease producing microorganisms and chemical substances that are dangerous to health (Lamikanra, 1999). Water consist different soluble salts and drinking water quality is affected by the presence of these different soluble salts (Sonawane and Khole, 2010). The surface water quality is principally influenced by the natural and the anthropogenic processes particularly in the urban areas and agricultural activities around the rural areas (Ayeni *et al*., 2011). These anthropogenic processes lead to the contamination of water. The contaminated water not only affects the health of the public but also the consumption of polluted water may cause various water-borne diseases such as diarrhea, dysentery and complaints of skin, teeth and other abdominal diseases (Bhardwaj, 2005). The transmission of disease through drinking water is therefore, one of the primary concerns for safe water supply (Ahmed *et al*., 2004).

Investigations on drinking water quality have been continuously done by various Researchers around the world. Considerable work has been done on the physico-chemical characteristics of water of different water bodies by various researchers. The studies of water quality of rivers in India are well documented by Sangu and Sharma (1985), Das and Sinha (1993), Jameson and Rana (1996), Sharma and Agarwal (1999), Mohanta and Patra (2000) and Parashar *et al*. (2006). Dattar (1991) studied physico-chemical characteristics of Betwa River in Vidisha district. Deepak (1999) studied hydro-chemical and environmental studies of Hathaikheda Dam with special emphasis on heavy metal contamination. A comparative study on physico-chemical characteristics of water quality of Betwa River, Kolar Dam and Upper Lake of Bhopal was conducted by Shukla (1996). Shrivastava (1998) had done comparative hydro-chemical study and pollution load assessment of Kervan, Kolar and Kaliyasote Dam water flow to evaluate its versatile potentiality. Present study deals with the analysis of physico-chemical and bacteriological parameters of water of Kaliasote Dam, Bhopal, MP.

Materials and methods

Study area: The Kaliasote water reservoir (latitude 25° 11' 45' N and longitude 77° 24' E) was constructed near village Chuna Bhatti about 4 km downstream of the Upper Lake across the river Kaliasote, a tributary of Betwa River (Yamuna Basin) in Huzur Tehsil of Bhopal District (Fig. 1).

Fig. 1. Aerial view of Kaliasote water reservoir, Bhopal, MP.

Kaliasote dam is nearest to Bhopal city. The major intake of water source for this Dam is Upper Lake. The Kaliasote dam is 1080 m long with maximum height of 34.25 m having gross storage capacity of 35.387 m. The Dam water is capable to irrigate an area of about 10.425 ha annually in Bhopal and adjoining agricultural land. The sampling stations chosen in this study were:

1. Spill way
2. East of Kaliasote dam
3. Near Shiv Mandir
4. Backside of Shiv Mandir
5. West of Kaliasote dam

Water sample collection and analysis: Water samples were collected from five different sampling stations for a period of three months during Oct 2013 to Dec 2013 and analyzed for parameters such as temperature, pH, electrical conductivity, total alkalinity, chloride, nitrate, total hardness, fluoride, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and most probable number (MPN) by using standard methods prescribed by APHA, AWWA, WEF (1998) and NEERI (1991). The results were carefully analyzed and compared with WHO Standards (1993) with special reference to drinking suitability.

Statistical analysis: Arithmetic mean, standard deviation, coefficient variation, median of the lower half, median, median of the upper half were calculated from the experimentally determined values of various water quality parameters of surface water samples.

Results and discussion

The observations of the analysis of various physico-chemical and bacteriological parameters of the water samples of the Kaliasote Dam is summarized in Table 1. During the entire study period, water temperature ranged between 15°C and 30°C with the lowest temperature recorded in the month of Dec 2013. At all the five sampling stations, highest temperature was recorded in the month of Oct at all the five sampling stations. The mean values of water temperature were given in Table 2.

Temperature is known to influence pH, alkalinity and DO concentration in the water (Aggarwal and Arora, 2012). The temperature of stored water volume is of great significance in the regulation of various physico-chemical as well as biological activities. Metabolic rate and the reproductive activities of aquatic life are controlled by water temperature and vary with season, elevation, geographic location, climatic conditions and water effluent from industrial activities. Water temperature also increases when warm water is discharged into streams from industries. pH of water is a measure of the acid base equilibrium and in most natural water it is dependent on the carbon dioxide-carbonate bicarbonate equilibrium. pH was found to be slightly alkaline in nature in the range between 7.50-7.80. pH was maximum in the month of Oct and Nov at all the five sampling stations and minimum in the month of Dec. The mean pH value was 7.7. WHO has recommended maximum permissible limit of pH from 6.5 to 9.2. Thus, the reservoir has pH values within the desirable and suitable range as prescribed by WHO for domestic use.

Conductivity is directly proportional to concentration of ions present in solution. Higher value of conductivity indicates higher concentration of dissolved ions. Conductivity is measured in terms of conductivity per unit length and used is microsiemens/cm. Conductivity of water sample was found in the range of 310-330 micromhos per cm^2, which was much below the WHO standards. There was not much variation seen in the value of conductivity from Oct to Dec 2013. Electrical conductivity is an important criterion in determining the suitability of water for irrigation. Alkalinity is an estimate of the ability of water to resist change in pH upon addition of acid. The alkalinity of water is mainly due to presence of hydroxide, carbonate and bicarbonate ions. Alkalinity of water samples was found in the range of 62-140 mg/L with mean value 92 mg/L. The maximum value of 140 mg/L was observed at sampling stations 4 and 5 in Dec and minimum value of 62 mg/L was observed at sampling station 4 and 5 in Oct. Alkalinity of all the sampling stations is well within the desirable limits prescribed for drinking water which is 120 mg/L (WHO) except for sampling stations 4 and 5 in Dec which is slightly higher. The high values of alkalinity may be due to increase in free carbon dioxide in the water. Alkaline water may decrease the solubility of metals. Alkalinity itself has little public health significance, although highly alkaline waters are unpalatable and can cause gastrointestinal discomfort. Alkaline substance such as bicarbonates, carbonates and hydroxides removes hydrogen ions and thus, lower the acidity and increases pH of the water. Chloride occurs in all natural waters in widely varying concentrations. The study findings showed irregular variation in chloride content in water samples. The chloride concentration was found in the range of 28-54 mg/L with maximum value at sampling station 1 in Oct. The result reveals that the chloride content is within the permissible limit of WHO.

Table 1. Physico-chemical parameters of water samples of Kaliasote Dam.

Parameters	WHO std.	October 2013					November 2013					December 2013				
		Sampling stations					Sampling stations					Sampling stations				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Temperature (°C)	-	30	30	30	30	30	28	28	28	28	28	15	15	15	15	15
pH	7.0-8.5	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.5	7.5	7.5	7.5	7.5
Conductivity ($\mu\Omega^{-1}cm^{-2}$)	600	330	330	330	330	330	324	324	324	324	324	310	310	310	310	310
Total alkalinity (mg/L)	200	72	68	68	62	62	96	88	82	82	82	120	110	110	140	140
Chloride (mg/L)	250	54	40	28	28	28	38	36	30	30	30	44	40	42	42	42
Nitrate (mg/L)	45	5.4	4.0	3.2	3.2	3.2	6.0	5.4	3.8	3.8	4.2	4.6	4.4	4.4	4.8	6.5
Total hardness (mg/L)	100	222	206	196	180	180	218	200	190	182	186	200	196	180	160	160
Fluoride (mg/L)	1.0	0.22	0.20	0.16	0.16	0.16	0.20	0.18	0.14	0.14	0.14	0.18	0.14	0.10	0.10	0.10
BOD (mg/L)	6	3.2	3.0	2.8	2.8	2.8	3.6	2.8	2.8	2	2	4.6	4	2	1	1
COD (mg/L)	10	20	18	18	16	16	24	22	16	16	14	24	20	18	12	10
MPN/ 100 mL	0	200	310	160	120	60	300	210	180	110	80	180	140	30	20	40

Table 2. Statistical analysis of water quality parameters of surface water samples of Kaliasote Dam (values of all the sampling stations of three months from Oct-Dec 2013 are pooled).

Parameters	Water samples							
	Min	Max	AM	SD	CV	Q1	Med	Q3
Temperature (°C)	15	30	24	6.65	27.33	30	28	15
pH	7.5	7.8	7.7	0.14	1.83	7.8	7.8	7.5
Conductivity ($\mu\Omega^{-1}cm^{-2}$)	310	330	321	8.38	2.61	330	324	310
Total alkalinity (mg/L)	62	140	92	25.5	27.6	62	82	110
Chloride (mg/L)	28	54	37	7.4	20.1	28	30	40
Nitrate (mg/L)	3.2	6.5	4.5	0.98	21.9	3.2	3.8	4.4
Total hardness (mg/L)	160	222	190	17.3	9.11	180	190	196
Fluoride (mg/L)	0.10	0.22	0.2	0.04	24	0.16	0.14	0.14
BOD (mg/L)	1	4.6	2.7	0.96	35.6	2.8	2.8	4
COD (mg/L)	10	24	18	3.88	22	16	16	20
MPN/ 100 mL	20	310	143	87.3	61.2	120	180	140

Min-Minimum, Max-Maximum, AM-Arithmetic mean, SD-Standard deviation, CV-Coefficient variation, Q1-Median of the lower half, Med-Median, Q3-Median of the upper half.

Chloride in small amount is very essential for good health. The chloride content normally increases with the increase mineral contents. High chloride content affects taste and could cause corrosion and have deleterious effects on human being and plants. Nitrate is a naturally occurring form of nitrogen found in soil as well as in water which is essential for all plants and animals. Nitrate is harmless in moderate amount. Excessive concentration of nitrate causes algae bloom which leads to eutrophication. It is most important to monitor nitrate concentration in water because; it may be potentially hazardous to health if their maximum permissible limit is exceeded. The nitrate content of sample was found in the range of 3.2-6.5 mg/L with maximum value at sampling station 5 in Dec. Its concentration was found to be much below the permissible limit as prescribed by WHO for drinking water. Total hardness is an important parameter in decreasing the toxic effects of poisonous elements. It is defined as the sum of calcium hardness and magnesium hardness both expressed as equivalents of calcium carbonate in mg/L. The hardness was found to be in the range of 160-222 mg/L. Classification of the water samples of the study area on the basis of total hardness is shown in Table 3. Table shows that 15 water samples of all 5 sampling stations belong to moderately hard category and within desirable limit.

Table 3. Classification of water samples of the study area on the basis of total hardness.

Concentration (mg/L)	Degree of hardness	No. of samples
0-50	Soft	-
50-100	Moderate soft	-
100-150	Slightly hard	-
150-250	Moderately hard	15
250-350	Hard	-
350+	Excessively hard	-

The total hardness of water is not a pollution parameter but it indicates water quality mainly in terms of Ca^{2+} and Mg^{2+} expressed as $CaCO_3$. The water containing excessive hardness is not suitable for potable water. Fluoride occurs in all natural water bodies. Both low and high concentration of fluoride in drinking water creates problems. In the present study, the value of fluoride was found in the range of 0.10-0.22 mg/L. The fluoride concentration was maximum at sampling station 1 in the month of Oct. Its value is within the permissible limit as prescribed by WHO. Fluoride at a lower concentration at an average of 1 mg/L is regarded as an important constituent of drinking water. However, when present in much greater concentration, it becomes a pollutant. Consumption of water having excessive fluoride content causes dental fluorosis.

BOD means the amount of oxygen required by the microorganisms to oxidize the biologically degradable organic matter under aerobic conditions. Determination of BOD depends on the concentration of dissolved oxygen. Dissolved oxygen present in drinking water adds taste and it is highly fluctuating factor in water (Mishra and Bhatt, 2008). The value of BOD in the present study was found in the range of 1.0-4.6 mg/L. Its concentration is found maximum at sampling station 1 in the month of Dec. Its value is within the permissible limit as prescribed by WHO. BOD indicates the presence of microbial organisms, their activity and dead organic matter on which microbes can feed. BOD gives an idea about the extent of pollution. The higher value of BOD means the presence of more biodegradable organic material (ICMR, 1975). Chemical oxygen demand determines the oxygen required for chemical oxidation of organic matter. COD values convey the amount of dissolved oxidisable organic matter including the non-biodegradable matters present in it. The value of COD was found in the range of 10-24 mg/L. Its value is higher than the permissible limit prescribed by WHO. The COD value indicates that the water of Kaliasote dam is polluted and it should be treated properly before using it for drinking purpose. The most probable number (MPN) is most suitable and widely used method to determine the bacteriological contamination of water. In the present study, the values of MPN coliforms per 100 mL of water range from 20-310 per 100 mL. MPN is found maximum 310 per 100 mL at sampling station 2 in the month of Oct and minimum of 20 per 100 mL at sampling station 4 in the month of Dec. The MPN values at all the five sampling stations in all three months are more than the permissible limits recommended by WHO. This may due to discharge of sewage of faecal origin in Kaliasote dam water. Thus, measures should be taken to control the pollution of dam water. Kaliasote dam water is not suitable for human consumption due to faecal contamination. Therefore, it should be treated chemically and purified to make it suitable for human consumption. Faecal coliform bacteria do not cause disease but are used as an indicator of disease causing pathogens.

Conclusion

The present study provides information regarding the pollution status of Kaliasote reservoir. The study findings indicates that the water quality of Kaliasote dam with respect to physico-chemical parameters is good and well within the water quality standards recommended by WHO except for COD, which is very high than the prescribed limits. All the water samples contain significant amount of organic matter that provides nutrition for the growth and multiplication of microorganisms. Thus, by detailed analysis of data it can be concluded that the quality of water samples under study was acceptable for majority of physico-chemical parameters except for COD and as per the bacteriological standards, the water needs to be treated before using it for drinking purpose as the value of MPN is very high. Higher value of COD and MNP indicates that water is polluted and does not fit for drinking purpose. Thus, there is a potential risk of getting infected by water-borne diseases if water is used without treating it with proper disinfectant. The water can be used for various purposes only after treatment with suitable disinfectant.

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