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Evaluation of Physicochemical and Microbiological Parameters of Chiller Dam, Shajapur, M.P., India

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Abstract

Chiller dam is a major source of irrigation, fish culture and drinking water for inhabitants of Shajapur region. For the assessment of water quality, certain physicochemical and microbiological parameters were analyzed. The values of the pollution indicator parameters like dissolved oxygen (2.8 to 8.4mg/l) conductivity (192 to 460 µmhos/cm), TDS (180 to 810 mg/l), total hardness (102 to 430 mg/l), chloride (31.92 to 250.9mg/l), nitrate-nitrogen (0.9 to 10.6 mg/l), phosphate (0.20 to 3.20 mg/l) and dissolved organic matter (1.18 to 6.4 mg/l), indicates trophy status of water particularly at down stream. Higher values of BOD (12.8 to 41.6 mg/l), COD (22.6 to 112.4 mg/l), Faecal Coliform (2 to 106 X 10^2 CFU/100ml) and Total Coliform (6 to 162 X 10^2 CFU/100ml) further indicate that the eutrophication has been at a faster rate Downstream the river, where higher amount of domestic sewage, cloth washing and anthropogenic activities are observed. Based on the findings of the study and pollution status, Chiller dam can be divided into three zones, are as – slightly polluted zone (Upstream site), polluted zone (Dam site) and extremely polluted zone (Downstream site).

Keywords: Chiller Dam, Physicochemical, Water Pollution, Coliform, Microbiological Parameters.

Introduction

The quality of freshwater ecosystem are deteriorating rapidly due to increase in population, industrialization, development, lack of proper sanitary facilities and treatment of wastes. Water may be contaminated by various means, chemically or biologically and may become unfit for drinking and other uses. In our country, 70% of water is seriously polluted and 75% illness and 80% of the child mortality is attributed to water pollution (Raja *et al*. 2008). The quality of water is usually determined by its physicochemical, microbiological and biological characteristics. The Chiller river, which was earlier called Chandralekha river, flows from south to north splitting Shajapur city into almost two parts eastern and western Shajapur. Chiller dam is constructed on this river about 6 km south from the Shajapur city. Downstream of the dam (i.e. Chiller river) is regularly getting damaged due to human intervention. There is an immediate need for management and conservation of this valuable water body to save it from further degradation. Chiller dam is totally neglected in any scientific studies regarding to its water quality. Therefore, the present study aims to make a better understanding about the existing level of physicochemical and microbiological parameters with relation to water quality of Chiller dam which will be useful for the management and conservation of water body.

Materials and Methods

Chiller dam is located at latitude of 23.42ºN and longitude of 76.27ºE in Shajapur district of Madhya Pradesh about 6 km away from the Shajapur city. Three study sites were selected viz. Upstream, Dam site and Downstream. The investigation was carried out for a period of twelve months from January 2015 to December 2015. Water samples were collected from each study sites once in a month between 8AM to 11AM at on regular interval of 30 days. Samples were collected in sterile containers and were kept in ice packs and were then transported to the base laboratory for further analysis. Some parameters like temperature, dissolved oxygen, pH, carbonate, bicarbonate, total alkalinity and transparency were analyzed in the field immediately after the collection of samples. The analysis of physicochemical parameters were made following the standard methods given in APHA (2005). The microbiological parameters like total Coliform and faecal Coliform were analyzed by using methods of APHA (2005). These samples were diluted to 10^2 and were

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subjected to the membrane filtration technique after filtration membranes were placed on different media and then incubated at 37ºC for 24 hours. Maconkey Agar and Brilliant Green media were used for obtaining faecal and total Coliform count.

Results and Discussion

The results of physicochemical and microbiological parameters of water at different study sites are given in table 1. The water temperature ranged from a minimum of 15.6ºC in December to a maximum of 31.1ºC in June. The present observation revealed that the the seasonal air temperature cycle maintained a close parallel relationship with seasonal cycle of water temperature. This observation was also in agreement with findings of Hidetoshi (2002) and Kolo and Oladimeji (2004). The Secchi disc transparency was found to be highest of 123 cm in January at Dam site while lowest of 24 cm in August at Downstream site. Reduced transparency during rainy season might be due to the erosion of soil by precipitation and the transport of silt particles through run off whereas higher transparency values during winter season were due to the setting effect of suspended solids in the absence of flood inputs and low wind velocity. Some scientists believe that wind velocity and oxygen influence transparency (Sreenivasan 1972, Shrivastava *et al.*2003) while the others have considered the plankton as an important factor (Swaroop and Singh 1979). In the present study, fluctuation in the transparency could be assigned mainly to the dissolved organic matter, decaying vegetation and mixing of agricultural runoff in the dam. Mirza *et al.* (2013) and Shrivastava *et al.* (2003) also made similar observations.

The pH was in the alkaline, ranged from 7.9 to 9.0 with minimum in winter and maximum in summer months. The increase in pH during summer months may be due to the increase of $CaCO_3$ in stagnant waters and increase amount of nitrates, phosphates and ultimately eutrophication in summer. Kamble *et al.* (2009) has also reported that HCO_3 ions formed during summer due to reduced photosynthesis also increased pH. Araoye (2009) and Mustafa (2009) had also reported the similar findings. Conductivity values exhibited between 190 to 460 µmhos/cm. Minimum conductivity value was observed in December and January months at Upstream site while maximum in August at Downstream site, whereas the Conductivity values at Downstream site were higher than permissible limit. TDS ranged between 190 to 810 mg/l with maximum in August at Downstream site and minimum in winter months at Upstream site. Maximum values of TDS during in summer was observed due to the addition of dead organic substances contributed by the decomposition of aquatic plants and animals and water evaporation in high temperature. The rain water may have gradually decreased the TDS concentration during monsoon and lowest values recorded during winter due to settlement of organic and inorganic substances in bottom sediment and lower rate of decomposition activities in low temperature. Kumbar *et al.* (2014) recorded TDS values range of 46-919 mg/l in lake water. The maximum limit for TDS as suggested by WHO (1984) is 500 mg/l which indicated that recorded TDS signifies the polluted water at Downstream site. A comparisons of the pH, conductivity and TDS values of Upstream site and Dam site with the Down stream, clearly indicates the higher contamination of ionic pollutants in Downstream due to continuous disposal of huge amount of sewage and domestic wastes of Shajapur city.

Dissolved oxygen is one of the most important parameters in water quality studies, It influences the distribution and abundance of algal and macrophytic population and is important in bringing about various bio-chemical changes. In Chiller dam dissolved oxygen ranged between 2.8 to 8.4 mg/l. Low dissolved oxygen at downstream site confirms the pollution due to addition of wastes. Trivedi *et al.* (1990) have also observed decline in dissolved oxygen due to addition of waste water in river Krishna. Low concentration of oxygen in summer can be attributed to the decreasing solubility level of oxygen during increase temperature in summer months, along with the increasing decomposition ratio in warm days. Similarly higher concentration of oxygen during winter months may be due to increasing solubility of oxygen during winter along with the decrease in decomposition ratio in winter months. Similar observations were recorded by Janjua *et al.* (2009) and Morrison *et al.* (2001).

Total hardness means the concentration of cations which is mainly concerned with the concentration of calcium and magnesium ions. Total hardness values varied between 100 to 430 mg/l with highest in summer at Downstream and lowest in winter at Upstream. High values of hardness in summer are mainly due to rising temperature, increasing the solubility of calcium and magnesium salts and due to reduction of water volume. Similar trends have been reported by Hussain *et al.* (2013) and Bhasin *et al.* (2015). The water having higher hardness value causes heart diseases (Peter 1976). The carbonate and bicarbonate alkalinity ranged from 5 to 32 mg/l and 116 to 234 mg/l respectively at Chiller dam. The highest value of alkalinity reported during summer due to the accumulation of organic matters produced by decay and decomposition of vegetation and in turn, added carbonate and bicarbonate concentrations in the Dam water content (Jain *et al.* 1997). The lowest alkalinity concentration was noticed during winter season and can be related to the inflow of freshwater and dissolution of calcium carbonate in the water column (Padma and Periakali, 1999). Same trends in alkalinity variations were observed by Kumar and Sharma (1991) at Pichhola and Fatehsagar lakes.

Chloride concentration in the Chiller dam water exhibited great variation throughout the study period. It ranged from 31.9 to 250.9 mg/l with maximum in downstream site, which was higher than the permissible limit, and indicates the pollution due to sewage wastes. The chloride concentration indicates the presence of organic matter presumably of animal origin. The calcium ranged from 32.2 to 148.6 mg/l with maximum in June and minimum January. Awadellah (1990) observed the calcium range of 17.6 to 24.39 mg/l at Aswan reservoir. Thus the Chiller dam showed higher concentration of calcium specially at downstream site which may be due to dissolution of more calcium from the underlying predominately calcium stones in the Dam bed.

The values of phosphate in the Chiller dam were fairly high and varied from 0.17 to 3.89 mg/l. The highest amount of phosphate was recorded during summer season which is associated with the entry of domestic sewage at the downstream of dam. The lowest amount of phosphate was recorded during winter season due to increased uptake of phosphate by living organisms. Hastler (1947) pointed out that the constant addition of even low levels of nitrogen and phosphorus to an aquatic environment could greatly stimulate algal growth. The phosphate concentration is also beyond permissiable limit at Downstream site as suggested by WHO (1984), which is responsible for enhanced eutrophication. Silicate ranged from 12.2 to 39.5 mg/l with maximum at Downstream and minimum at Upstream site. Nitrate-nitrogen ranged between 0.90 to 10.6 mg/l with maximum in summer months and minimum in winter months. The higher concentration of nitrate-nitrogen at Downstream are due to high nitrification activities at this site. However, besides the rainwater, soil collides, decomposition of organic matter and conversion from insoluble to soluble salts also appeared to have contributed to the rise of phosphate and nitrate-nitrogen. Tamot and Awasthi (2012) recorded nitrate ranged between 0.6-2.2 mg/l in Shahpura lake Bhopal. The dissolved organic matter exhibited between 1.18 to 6.4 mg/l with maximum in June at Downstream study site and minimum in January at Upstream study site, while Dam site showed intermediate position. Singh *et al.* (1980) reported dissolved organic matter ranged from 0.5 to 11.2 mg/l with maximum in June at Rihand reservoir.

During the present study the chemical oxygen demand (COD) ranged from 22.6 to 112.4 mg/l. The maximum COD values were observed at Downstream site in summer months, which clearly indicates contamination in water. The biological oxygen demand was found within the range of 12.8 to 41.6 mg/l. Lower values of BOD in Upstream site and Dam site may possibly due to lower bacterial population in respect of Downstream study site. The higher BOD and COD values were recorded during summer season which can be attributed to the high bacterial acitivity and heavy input of organic matter while lowest BOD and COD was estimated in winter season due to less decay of organic matter at low temperature. Bhasin *et al.* (2015a) recorded higher BOD and COD values in summer and lowest in winter season from Kshipra river.

Fecal coliform (FC) and Total coliform (TC) the biological characteristics of water and waste water are of fundamental importance to human health, because of role they played in decomposition of waste (Metcaff and Eddy, 2003). Faecal Coliform (FC) is associated with bacteria in gut, because of their large number and long survival in water, they are easily detected. They are also considered as indicator of several intestinal bacteria. Count of FC and TC are influenced by various anthropogenic activities (Bhasin *et al.* 2015b). In the present study values of FC ranged from 2-11 X 10^2 CFU/100ml at Upstream site, 5-22 X 10^2 CFU/100ml at Dam site and 42-102 X 10^2 CFU/100ml at downstream site. TC values ranged between 6-20 X 10^2 CFU/100ml at Upstream and 10-30 X 10^2 CFU/100ml at Dam site and 69-162 X 10^2 CFU/100ml at Downstream site. Maximum TC and FC values were recorded during summer at Downstream and minimum during winter at Upstream site. Higher count in summer may be due to favorable conditions for bacterial growth in rich nutrient medium, higher temperature whereas, lower count are reported during winter due to decrease in temperature and low nutrient concentration at the Upstream site. FC and TC counts are higher in Downstream which may be due to addition of city sewage and higher anthropogenic activities in this site like cattle bathing, flower dumping near Rajrajeshwari temple and cloth washing etc. Such activities contribute to increase FC and TC count (Bhasin *et al.* 2015c). Shawkey and Robeh (2007) reported high counts of FC and TC in summer from Nile river, Egypt.

Conclusion

On the basis of present investigation the Chiller dam can be divided into three zones, as based on pollution load 1- slightly polluted zone (Upstream), 2- polluted zone (Dam site) and 3- extremely polluted zone (Downstream site). Physicochemical and microbiological parameters vary from site to site depending upon the ecological conditions, quality and quantity of agricultural run-off, domestic and industrial wastes. The values of physicochemical and microbiological parameters indicate that the eutrophication had been at a faster rate in down stream site of the Dam which indicates that water is not suitable for consumption directly without proper treatment. Following precautions are recommended to make Chiller dam water free from pollution, 1- Integrated planning and programs of water resources and distributions, rehabilitations as well as sanitation should be thoughtfully adapted with a wide ecological sconsiderations, 2- Soil, domestic and industrial waste disposal in the dam area including downstream should be strictly stopped. 3- A continuous monitoring of the dam water for various, physical, chemical and biological parameters should be done.

Table 1
Details of Physicochemical and Microbiological Parameters at Chiller dam

S. No.	Parameters	Up stream			Dam site			Down stream		
		Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
1.	Air Temperature ºC	18.0-23.2	30.4-40.2	25.9-30.4	18.2-23.1	30.1-41.5	25.4-39.3	18.5-23.8	30.9-39.1	25.5-30.6
2.	Water temperature ºC	15.6-22.6	23.7-31.9	24.2-27.1	15.9-23.0	23.1-32.8	24.8-27.6	16.2-23.1	24.2-32.1	24.6-27.9
3.	Transparency cm.	90-107	51.0-81.0	44.0-78.0	99.0-123.0	78.0-96.0	56.0-90.0	46.0-63.0	30.0-54.0	24.0-42.0
4.	pH	8.0-8.3	8.4-8.7	8.1-8.5	7.9-8.7	8.2-8.5	8.1-8.4	8.2-8.3	8.4-9.0	8.4-9.0
5.	Conductivity µ mhos/cm	190.0-210.0	220.0-270.0-	220.0-288.0	210.0-232.0	230.0-278.0	230.0-292.0	230.0-300.0	390.0-446.0	310.0-510.0
6.	Total Dissolved Solids mg/l	190.0-210.0	230.0-290.0	210.0-300.0	180.0-310.0	240.0-460.0	270.0-540.0	480.0-506.0	510.0-616.0	580.0-810.0
7.	Dissolved Oxygen mg/l	7.8-8.4	6.0-7.2	6.8-7.8	7.2-8.0	5.8-7.0	6.2-7.6	4.2-5.2	2.8-4.0	3.2-4.8
8.	Total Hardness mg/l	100.0-106.0	126.0-172.0	136.0-172.0	102.0-120.0	132.0-176.0	132.0-170.0	280.0-300.0	330.0-430.0	320.0-415.0
9.	Carbonate mg/l	5.0-8.0	10.0-20.0	8.0-20.0	6.0-8.0	12.0-22.0	12.0-20.0	10.0-16.0	20.0-32.0	16.0-26.0
10.	Bicarbonate mg/l	116.0-130.0	142.0-172.0	136.0-170.0	120.0-134.0	146.0-180.0	142.0-178.0	142.0-158.0	172.0-234.0	170.0-206.0
11.	Total Alkalinity mg/l	121.0-138.0	152.0-192.0	144.0-190.0	126.0-142.0	158.0-202.0	154.0-198.0	160.0-174.0	192.0-276.0	186.0-232.0
12.	Chloride mg/l	31.0-36.9	40.9-63.9	40.9-61.9	31.9-37.9	43.9-58.9	41.9-60.9	102.9-144.9	186.9-256.9	180.9-230.9
13.	Calcium mg/l	32.2-36.4	42.6-63.6	40.6-61.4	33.2-38.6	46.6-66.6	44.4-62.2	60.6-79.8	84.8-148.6	89.4-140.2
14.	Phosphate mg/l	0.20-0.30	0.40-0.50	0.30-0.40	0.30-0.40	0.60-0.80	0.40-0.80	1.10-1.40	2.10-3.90	1.70-3.20
15.	Nitrate-nitrogen mg/l	0.90-1.1	1.2-2.0	1.4-2.0	1.0-1.2	1.6-3.4	1.5-3.0	3.0-4.6	6.9-10.6	5.1-9.2
16.	Dissolved organic matter mg/l	1.2-1.3	1.8-2.3	1.4-2.2	1.2-1.4	1.8-2.4	1.4-2.3	2.2-2.9	3.5-6.4	3.8-6.2
17.	Biological Oxygen Demand mg/l	12.8-14.2	16.4-19.6	14.6-16.8	13.4-15.6	18.2-21.4	15.4-17.6	20.6-24.8	36.2-41.6	25.6-29.8
18.	Chemical Oxygen Demand mg/l	22.6-29.4	33.8-38.2	28.2-33.4	27.4-32.6	35.2-41.6	29.6-34.4	42.8-49.2	83.6-112.4	59.4-64.2
19.	Faecal Coliform X 10^2 CFU/100ml	2-8	8-11	6-10	5-13	14-22	10-18	40-48	76-102	64-82
20.	Total Coliform X 10^2 CFU/100ml	6-13	14-20	10-14	10-16	19-30	14-23	69-76	92-162	80-124

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