

Studies of physicochemical and bacteriological characteristics of Bansagar Lake Shahdol (M.P.)

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Abstract

The piece of investigation is carried out to study the water quality and suitability of Bansagar Lake, Shahdol for irrigation and drinking purpose. This study is done during 2015-16 to assess seasonal variations in the water of the lake by observing different physicochemical and microbiological parameters viz. temperature, pH, total hardness, total dissolved solids, dissolved oxygen, biological oxygen demand, free CO₂, alkalinity, chloride, nitrate, SPC, TCC, and FCC in different seasons of the year. Out of them DO, BOD, Free CO₂, SPC, TCC and FCC were found to be very much greater than the amount recommended by WHO and ISI for drinking water. Some parameters viz. temperature, pH, Total hardness, and total dissolved solids were found within the optimal range. Hence, it can be concluded that Bansagar Lake is gradually tending towards eutrophication which leads to the lake water very unsafe for drinking, irrigation and fishery purposes can be used.

Keywords: bansagar lake, physicochemical, bacteriological characteristics

1. Introduction

The Bansagar project envisages constructed on a dam across the Son river. The dam site is situated near Deolond bridge on Rewa-Shahdol road, at a distance of 50.7 km from Rewa. The river Son originated from Amarkantak in Shahdol district at an elevation of about 1066.8 m. For about 508.54 km the river runs through Madhya Pradesh in the districts of Shahdol and Sidhi, and then for a length of about 96 km. it flows through Uttar Pradesh. There after it enters Bihar, before meeting the Ganga river on its right bank near village Banikpur 820.74 km from its source. The project Bansagar is a multipurpose, both for hydro-electric power generation and for irrigation. Bansagar dam is a multipurpose project which construction was began in 14 May 1978 and started in 25 Sept. 2006.

The study of Physico-chemical characteristics of water is an important aspect. It is difficult to understand the biological activities of water body without adequate knowledge of water chemistry. There are several abiotic factors, which directly or indirectly affect the growth and biodiversity of aquatic environments.

The Physico-chemical characteristics of water quality includes physical, chemical and biological parameters which determine its nutrient status and contamination level.

2. Materials and Methods

The proposed research work will be carried out in 2015-16 with the help of following methodologies: During the study, water samples will be collected at seasonal interval from 4 different places in the lake and mix them to make a

composite sample. Water temperature shall be recorded in the lake with the help of mercury thermometer. The pH will be recorded with pH meter in the laboratory. Salinity and total dissolved solids (TDS) will be measured with the titration method in laboratory. Total hardness of carbonate and bicarbonate, Chloride, and Alkalinity will be determined by titration with EDTA, Silver nitrate and hydrochloric acid in the laboratory. For fecal coliform bacteria examination, samples will be collected in 125 ml pre sterilized (at 121°C) borosil bottle and will be analyzed with multiple tube fermentation technique using Mc-Conkey broth media within 6 hours of sample collection. A standard plot will be made for counting and assessing the bacterial load by pure plate technique. Various statistical analyses like tabulation, Graph, correlation etc. will be performed with help of computer in order to ascertain the level of significance.

3. Results and Discussion

Temperature: The most common physical assessment of water quality is the measurement of temperature. Temperature impacts both the chemical and biological characteristics of surface water. All metabolic and physiological activities and life processes such as feeding, reproduction, movement and distribution of aquatic organisms are greatly influenced by water temperature (Gupta *et al.*, 2008)^[1]. The temperature of Bansagar Lake ranged from 16.9 (winter) to 31.8°C (summer) throughout the period of investigation. Temperature showed positive correlation with pH, TH, TDS, DO, BOD, free CO₂, alkalinity, nitrate and negative with Chloride and FCC in the lake.

Table 1: Physicochemical parameters of Bansagar Lake during 2015-16.

S. No.	Parameters	Summer season	Monsoon season	Winter season	Avg.	SD
1.	Temp. (°C)	16.9	31.8	22.8	23.83	±7.50
2.	pH	7.1	7.6	6.6	7.10	±0.50
3.	TH (mg/l)	234	252	198	228.00	±27.50
4.	TDS (mg/l)	1033	1442	794	1089.67	±327.70

5.	DO (mg/l)	5.0	10.6	8.2	7.93	±2.81
6.	BOD (mg/l)	9.5	35.9	18.3	21.23	±13.44
7.	Free CO ₂ (mg/l)	15.5	30.3	10.3	18.70	±10.38
8.	Alkalinity (mg/l)	443.1	548	578.3	523.13	±70.95
9.	Chloride (mg/l)	294.5	260.2	461	338.57	±107.41
10.	Nitrate (mg/l)	4.83	9.06	4.38	6.09	±2.58
11.	SPC	33000	54000	57000	48000	±13076
12.	TCC	746	1509	2450	1568	±853
13.	FCC	338	449	2296	1027	±1099

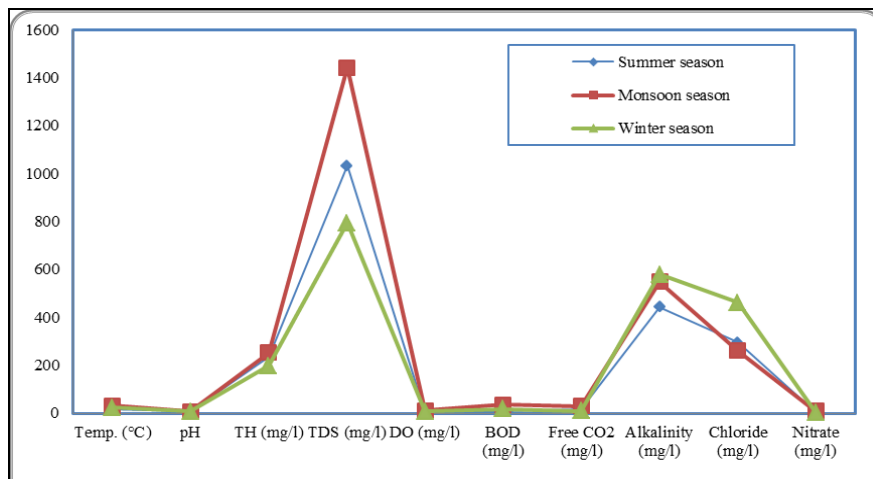


Fig 1: Physicochemical Parameters of Bansagar Lake during 2015-16.

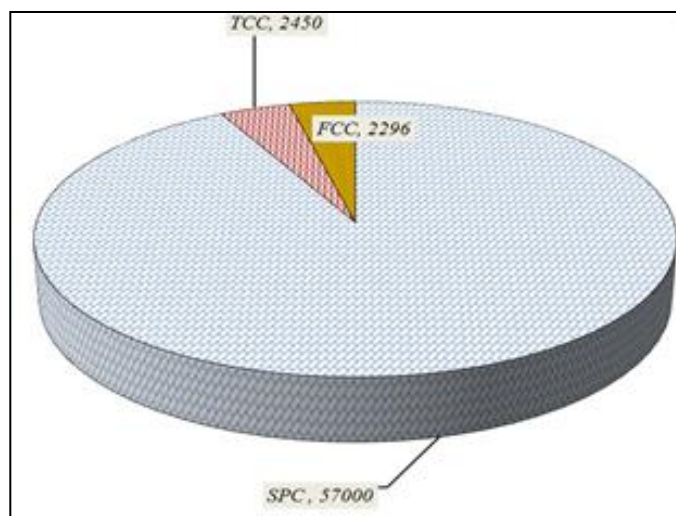


Fig 2: Graphics analysis of average SPC, TCC and FCC

Table 2: Coefficient of correlation of various parameters of the lake.

	Temp.	pH	TH	TDS	DO	BOD	Free CO ₂	Alkalinity	Chloride	Nitrate	SPC	TCC	FCC
Temp.	1.00												
pH	0.60	1.00											
TH	0.44	0.98	1.00										
TDS	0.71	0.99	0.94	1.00									
DO	0.98	0.43	0.25	0.56	1.00								
BOD	1.00	0.65	0.50	0.76	0.96	1.00							
Free CO ₂	0.79	0.96	0.90	0.99	0.65	0.83	1.00						
Alkalinity	0.65	-0.21	-0.39	-0.06	0.79	0.60	0.06	1.00					
Chloride	-0.28	-0.93	-0.99	-0.87	-0.08	-0.34	-0.81	0.55	1.00				
Nitrate	0.88	0.91	0.81	0.96	0.77	0.91	0.99	0.22	-0.70	1.00			
SPC	0.73	-0.11	-0.30	0.04	0.85	0.68	0.15	0.99	0.46	0.32	1.00		
TCC	0.34	-0.55	-0.70	-0.42	0.52	0.27	-0.31	0.93	0.81	-0.15	0.89	1.00	
FCC	-0.07	-0.84	-0.93	-0.75	0.13	-0.14	-0.66	0.71	0.98	-0.53	0.64	0.92	1.00

Higher temperature in the summer was probably due to greater solar radiations with scorching heat, longer day length, and clear atmosphere comparatively low water levels, increased load of suspended solids, soil particles of the lakes and decomposed organic matter in both the lakes water because suspended solids absorb more heat. Ammakiri (2006) ^[2]; Banerjee and Mandal (2009) ^[3] and Yadav *et al.*, (2012) ^[4] have observed similar trends while working on the limnology of different water bodies.

pH : pH gives an idea of the concentration of the ionized hydrogen which in turn yields indirect information of free CO₂ content, alkalinity, dissolved oxygen, dissolved solids and thus may serve as test of several environmental conditions (Sheeja, 2005) ^[5]. PH of water is an important environmental factor that influence the metabolism of all the aquatic organisms. Generally neutral or slightly alkaline water pH (7.5) proved to be more productive and suitable for biota. A number of published data showed that there are positive relationships among the water quality parameters (Gupta and Mahrotra, 1986) ^[6]. PH showed positive correlation with temperature, TH, TDS, DO, BOD, free CO₂, alkalinity, nitrate and negative with chloride, FCC, SPC and TCC in the lake.

The pH exhibit slightly acidic and alkaline nature of water and ranged between 6.6 (monsoon) and 7.6 (summer) in Bansagar Lake. Minimum pH was found in rainy season and maximum in summer season in lake. Data represent a clear cut indication of alkaline nature of the Lakes. Slightly acidic nature of lake water in monsoon and winter could be attributed to reduced photosynthetic activity of phytoplankton and other higher plants and higher value of pH in summer was due to more utilization of bicarbonate and carbonate buffer system. Similar trends were reported by Ansa (2005) ^[7] in Adani flats of the Niger Delta area.

Most of the biological processes and biochemical reactions are pH dependent. It is considered as an indicator of overall productivity that causes habitat diversity (Bhatnagar and Singh, 2010) ^[8]. PH is an important ecological factor. It is the result of the interactions of various substances in solutions and also of numerous biological phenomenon. The pH of water is very important indication of its quality and provides information in many types of geochemical equilibrium and solubility calculations (Hem, 1991) ^[9]. In water body's evaporation, amount of dissolved nutrients and gases, standing biomass of plants and animals, addition of organic matter from extraneous sources and influx of rain water are some of the important factors which determine pH in time and space. PH of water dependent upon the carbonates and bicarbonates. The water tends to be more alkaline if it possesses carbonates and it is much less alkaline when it possesses large quantities of bicarbonates, CO₂ and calcium.

Total hardness : The term 'hardness' is frequently used to assess the water quality and is governed principally by the concentration of calcium and magnesium and sometimes by iron and aluminum salts, which combined largely with bicarbonate and carbonate, sulphate, chloride and other anions of mineral acids. Iron and aluminum are generally present in negligible amount in water. Most of the calcium and magnesium were present in natural water as bicarbonate, sulphate and sometimes as chlorides and nitrates. Hardness producing substances react with soaps,

forming insoluble compounds before lather is produced. They are thus a measure of soap consuming power of water. Temporary hardness is due to the presence of bicarbonates of calcium and magnesium which can be removed by boiling. Permanent hardness is mostly due to calcium sulphate and magnesium sulphate and that remains even after boiling. TH showed positive correlation with temperature, TDS, DO, BOD, free CO₂, alkalinity, nitrate and negative with chloride, FCC, SPC and TCC in the lake.

The highest value of hardness was found in monsoon (252 mg/L) and lowest (198 mg/L) in summer in the lake. The permissible limit of hardness for drinking water is 600 mg/L as per Indian standard. Hardness as such, has got no adverse effect on human health. Water with hardness above 200 mg/L may cause scale deposition in the water distribution system and more soap consumption.

Total dissolved Solids (TDS): Water, the universal solvent has large number of salts dissolved in it, which is largely governed by physicochemical properties and in turn have an indirect effect on aquatic organisms. TDS are the solids that are in dissolved state in solution. Water with high dissolved solids generally is of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer. The total dissolved solids fluctuated between 794 and 1442 mg/L the lake which showed hard water character. Higher concentration of TDS might also due to discharge of sewage and organic matter by interference of man. Further total hardness exhibited a low value in monsoon season and high value in summer season. ISI has declared 500 mg/L as the permissible limit for TDS in drinking water. The lake TDS showed positive correlation with temperature, TH, DO, BOD, free CO₂, alkalinity, nitrate and negative with chloride, FCC, SPC and TCC in the lake.

Dissolved oxygen: Dissolved oxygen refers to the level of free, non-compound oxygen present in water. It is an important parameter for assessing water quality because of its influence on the organisms living within the water of lakes. A dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality. Dissolved oxygen is necessary to many forms of life including fish, invertebrates, bacteria and plants. These organisms use oxygen in respiration. Bacteria and fungi also require DO to decompose organic material at the bottom of the lakes. According to the study, the low value of DO in the lake was 5.0 mg/L in winter and the highest value was observed 10.6 mg/L in summer in Bansagar Lake. The low value during the winter may be due to high load of suspended particles, soil particles and decomposed organic matter which reach the water and reduce the penetration of light that in turn lowers the photosynthesis. In winter O₂ holding capacity of water increases therefore rise in O₂ content seen in the winters. DO showed positive correlation with temperature, TH, TDS, BOD, free CO₂, alkalinity, nitrate and negative with chloride only.

Biological Oxygen Demand: Biological oxygen demand (BOD) is the amount of dissolved oxygen demanded by aerobic biological organisms to break down organic material present in the water at certain temperature over a period of time. It is found to be more sensitive test for organic pollution. The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20°C and is often as a surrogate of the

degree of organic pollution of water. Most natural lake water contains small quantities of organic compounds. Aquatic microorganisms have evolved to use some of these compounds as food. Microorganisms living in oxygenated waters use dissolved oxygen to oxidatively degrade the organic compounds releasing energy which is used for growth and reproduction. Populations of these microorganisms tend to increase in proportion to the amount of food available. This microbial metabolism creates an oxygen demand proportional to the amount of organic compounds useful as food. Fish and aquatic insect may die when oxygen is depleted by microbial metabolism. The amount of oxygen require to completely oxidize the organic compounds to carbon dioxide and water through generations of microbial growth, death, decay and cannibalism is total biological oxygen demand (Total BOD). BOD values of the lakes were ranged from 9.5 to 35.9 mg/L in Bansagar Lake. The higher values of BODs were observed in summer and low in winter in the lake. BOD of the lake showed positive correlation with temperature, TH, TDS, DO, free CO₂, alkalinity, nitrate and negative with chloride and FCC.

Free CO₂: Carbon dioxide is highly soluble in water. The source of free carbon dioxide in water is not from the air phase because CO₂ is a product of aerobic and anaerobic decomposition of organic matter and it intimately bounds in the complex carbonate-bicarbonate equilibrium. CO₂ is an important component of the buffer system that influences carbonate and bicarbonate concentration in water. It is released during the decomposition of certain substances and metabolic activity of living organisms. The mean value of free carbon dioxide varied between 10.3 (Monsoon) and 30.3 mg/L (summer) in Bansagar Lake. Carbon dioxide exhibited an inverse relation with dissolved oxygen. A gradual rise in dissolve oxygen and fall of free carbon dioxide level had probably disrupted the equilibrium between these two gases. Higher level of free CO₂ concentration incommittant with increasing temperature during summer season might be due to the dumping of garbage in the lake and rapid decomposition of organic matter. This is strengthened by the observation of Joshi *et al.*, (1995) ^[10] and Sharma (2010) ^[11] who have observed the addition of drainage to be the main causal factor for increase in carbon dioxide in water bodies. Free CO₂ showed positive correlation with temperature, TH, TDS, DO, BOD, alkalinity, nitrate and negative with chloride, FCC, and TCC in the lake.

Alkalinity: Alkalinity of any water body is mainly due to carbonates, bicarbonates and hydroxide ions. It is an index of nutrients status in water body. The total alkalinity fluctuated between 443.1 and 578.3 mg/L with the highest value in the monsoon and lower values in winter season in Bansagar Lake. One important environmental consequence of alkalinity is the ability of a water body to withstand acidification due to acidic precipitation and atmospheric deposition. A water body may have a fairly neutral pH, but its alkalinity is low, it will readily be acidified. A body of water with same pH but with higher alkalinity will have greater buffer capacity and consequently, a greater resistance to acidification (APHA, 2005) ^[12].

Chloride: Chloride value ranged 260.2 (summer) to 461 mg/L (monsoon) in Bansagar Lake. The peak chloride values during the early monsoon tend to increase sharply till

the post monsoon approaches. The peak chloride value can be attributed to the surface run off, rich in animal origin and organic wastes. Chloride can be considered as one of the basic parameter of classifying water bodies polluted by sewage in to different categories. Chloride showed negative correlation with most of the physicochemical parameters but positive with microbiological ones.

Nitrate: Total nitrogen in the sediments comprises all types of organic nitrogen along with nitrates, nitrites and ammoniacal nitrogen. All dead animal and plant tissues release nitrogen to the soil and from the soil to the sediments. Nitrate is the oxidized form of nitrogen and is usually found in combined form of inorganic nitrogen in any water body. Nitrate is also an indispensable nutrient for aquatic flora as well as phytoplankton that establishes the productivity of ponds.

Nitrate concentration in the present study ranged from 4.38 (monsoon) to 9.06 mg/L (summer) in Bansagar Lake. Total nitrogen in the sediments comprises all types of organic nitrogen along with nitrates, nitrites and ammoniacal nitrogen. During present investigation maximum values of nitrogen were found in summer season probably due to decaying organic matter and depletion in water level of lakes while, minimum values were observed during winter season which may be due to dilution and stagnation of water level. These findings support to the observations of several workers (Majumdar *et al.*, 2006 and Manjare *et al.*, 2010) ^[13-14]. Nitrate showed positive correlation with temperature, pH, TH, TDS, DO, BOD, free CO₂, alkalinity and negative with chloride, FCC and TCC in the lake.

Bacteriological parameters: Coliform are bacteria that are always present in the digestive tracts of animals, including humans, and are found in their wastes. They are also found in plant, soil and water. Water pollution caused by faecal contamination is a serious problem due to the potential for spreading diseases from pathogens (disease causing organisms). Frequently, concentrations of pathogens from faecal contamination are small, and the number of different possible pathogens is large. As a result, it is not practical to test for pathogens in every water sample collected. Instead, the presence of pathogens is determined with indirect evidence by testing for an "indicator" organism such as coliform bacteria. Coliform come from the same sources as pathogenic organisms. Coliform are relatively easy to identify, are usually present in larger numbers than more dangerous pathogens, and respond to the environment, wastewater treatment, and water treatment similarly to many pathogens. As a result, testing for coliform bacteria can be a reasonable parameter for indicating the presence of other pathogenic bacteria in the lakes. All the bacteriological observations were recorded in MPN per 100 ml. of water sample.

Standard plate count: Standard plate count (SPC) for bacteria ranged from 33000 (winter) to 57000 (monsoon) in Bansagar Lake. It is observed that the trends indicate higher bacterial population with the commencement of monsoon and relatively lower bacterial density during winter. This is in conformity observation of Patralek (1992) ^[15] and Mohan *et al.*, (2007) ^[16]. The higher bacterial population was obviously due to transport of organic matter from various sources through surface run-off from hills around the lakes (Sharma *et al.*, 2008) ^[17]. It showed very high level from the permissible limit as suggested by ISI. SPC was positively

correlated with temperature, DO, BOD, alkalinity, chloride, and nitrate and negatively correlated with pH, TH and TDS in the lake.

Total coliform count: Total coliform count (TCC) ranged from 746 (winter) to 2450 (monsoon) in Bansagar Lake. It was also showed a very high level from the permissible limit as suggested by Pandey and Sharma (1999) [18] for drinking water. 100 MPN (most probable number) per 100 ml. presence of *E. coli* in the water indicates that it has been contaminated with faecal material that may contain disease

causing microorganism such as certain bacteria, virus and other parasites. TCC was positively correlated with temperature, DO, BOD, alkalinity, chloride and negatively correlated with pH, TH, TDS and nitrates in the lake.

Faecal coliform count: Faecal coliform count (FCC) ranged 338 (winter) to 2296 (monsoon) in Bansagar Lake. Qualities of lake water have been reported to be unsatisfactory with FCC and other bacterial count due to far exceeding level recommended by ISI and WHO for drinking water.

Table 3: Permissible limits for water as recommended by ISI and WHO.

S. No.	Parameters	ISI permissible limits	WHO limits
1.	Temperature	-	-
2.	pH	6.5-8.5	9.2
3.	Total hardness	300-600 ppm	500 ppm
4.	TDS	500-2000 ppm	1500 mg/L
5.	DO	3-7 ppm	-
6.	BOD	0-5.0 ppm	30 ppm
7.	Free CO ₂	<10 ppm (for surface water)	10 ppm
8.	Alkalinity	200-600 ppm	500 mg/L
9.	Chloride	250-1000 ppm	250 mg/L
10.	Nitrate	45-50 ppm	10 mg/L
11.	Standard plate count	10/100 MPN per 100 ml	100 MPN / 100 ml.
12.	Total bacteria	0-100 MPN	100 MPN / 100 ml.
13.	Coliform bacteria	0-100 MPN	100 MPN/ 100 ml.

Table 4: Suggested values of coliform MPN/100ml. for water (Pandey and Sharma, 1999) [18].

S. No.	Quality	Grade	Bathing and Swimming	Public water supply
1.	Excellent	I	<10	<100
2.	Good	II	4	200
3.	Satisfactory	III	250	800
4.	Poor	IV	1500	1000
5.	Unacceptable	V	>6000	>8000

4. Conclusion

The present study of physicochemical and bacteriological parameters of Bansagar lake reveals that DO, BOD, CO₂, SPC, TCC, and FCC were found in little higher amount in the lake. Temperature, pH, Total hardness, total dissolved solids, alkalinity, chloride and nitrates were within permissible limit as suggested by ISI and WHO in the lake. Hence, it can be concluded that lakes have become very little contaminated and eutrophicated which leads to the lakes safe for, irrigation and fishery purposes.

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