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Physico-chemical properties of Barua Sagar lake water, Jhansi, Uttar Pradesh India

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ABSTRACT

Jhansi is located in the plateau of central India, an area dominated by rocky reliefs and minerals underneath the soil. Barua Sagar is a historical place located about 25 km from Jhansi in Uttar Pradesh, India. It is situated on the bank of the Betwa River; the place is named after the Barua Sagar Taal, a large lake created about 260 years ago when Raja Udit Singh of Orchha built the embankment. Present study has been undertaken to investigate the physico-chemical properties of Barua Sagar lake water to assess the utility of lake water for fish production, irrigation, drinking and aesthetic purposes etc. Water Quality Index (WQI) was applied in Barua sagar Lake, using different water quality parameters (Temperature, pH, Dissolved Oxygen, Turbidity, Conductivity, Hardness, Alkalinity, Sodium, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand(COD), Nitrate, Chloride, Iron, Free residual Chlorine, Fluoride, TS, TDS and TSS). The water body is divided in to five sites for proper sampling and collection of water sample from whole lake. The impact of various anthropogenic activities was evident on some parameters such as the EC, BOD and DO. It is suggested that regular monitoring of the lake water quality is necessary for proper management.

Introduction

Water is vital natural resource which forms the basis of all life. Further, water is a key resource in all economic activities ranging from agriculture to industry. With ever increasing pressure of human population, there is severe stress on global water resources. not only developing nation but developed nations too.

It is fact that the lack of water that limits food production which threatens human survival. Water also play key role in the development of earth's surface, moderating climate and diluting pollutants. In fact, without water, life as we know it, cannot exist as for all the physiological activities of plants, and animal and microorganisms, it is an essential raw material in the process of photosynthesis of green plant which become food use by various living system in all trophic levels. Atmospheric humidity which consist water is highly essential for all terrestrial life to protect from dehydration.

Atmospheric water is the key factor in combination with temperature in the influencing the global ecology and in a function of hydrological cycle covering 70% of land surface, it influences weather and global climate and flora and fauna. In view of the above it is significantly linked with social economic, political and ecological intricacies. Approximately 97.2% water lies in oceans as salt water. While 2.15% in frozen ice form and the remaining 0.65% remain as fresh either on surface or ground water. Therefore, available fresh water resources on Earth are very limited.

The problem of water quality deterioration is mainly due to human activities such as disposal of dead bodies, discharge of industrial and sewage wastes and agricultural runoff which are major cause of ecological damage and pose serious health hazards (Meitei et al., 2004a; Kumar et al., 2010). The degree of pollution is generally assessed by studying physical and chemical characteristics of the water bodies (Duran and Suicnz, 2007). The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Faecal pollution of drinking water causes water -borne disease which has led to the death of millions of people both in cities and villages.

Concerns about lake water quality are directly related to the use (s) of the lake. As with all lake management decision, consider the primary use of lake to determine with water parameters are of greatest concern. Listed below (Table – 1) are some of the common use of lake and the water quality parameters of greatest concern.

The purpose of the study was to investigate the water quality of the Barua Sagar Lake and try to examine the physicochemical composition of Barua Sagar and to assess the utility of lake water for fish productions, irrigation, drinking and recreation purposes, etc.

Material and Methods

Study Area

Jhansi is located in the plateau of central India, an area dominated by rocky reliefs and minerals underneath the soil. Barua Sagar is a historical place located about 25 km from Jhansi in Uttar Pradesh, India. It is situated on the bank of the Betwa River, the place is named after the Barua Sagar Taal, a large lake created about 260 years ago when Raja Udit Singh of Orchha built the embankment. Area is 4.64 sq. Km; altitude is 210 mtrs above MSL. Monthly water sample have been collected from 5 different point of Barua Sagar Lake as fallow: Site1- East; Site 2– South; Site 3– West; Site 4– North and Site 5–Center respectively (Figure – 1).

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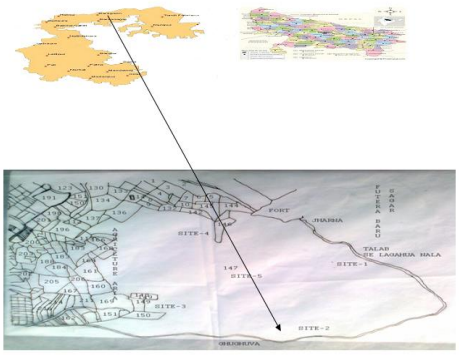

Figure – 1: Location of study area

Analytical techniques

The analytical work of the collected samples was done by the HIMEDIA (WTO-23) Octo Aqua Test Kit (multi-parameter) as well as laboratory testing- used to APHA guideline 2005. Different type of testing and their range are summarized (Table – 2) below.

Results and Discussion

The physico-chemical characteristics provide a fair idea of the water quality in any water body. The result of the physico-chemical characteristics of Barua Sagar lake water are summarized in Table -3 and discussed below. A standard guidelines for best uses of different types of water has been given by Central Pollution Control Board, New Delhi has been presented in Table – 4.

Temperature

Temperature is most important for fish and other aquatic life in lake. Temperature can vary greatly throughout the lake, with surface water affected more by air temperature than deeper water. Thus the top of the pond will be slightly warmer in the summer and colder in the winter than deeper portions of the pond.

Coldwater fish like trot prefer maximum water temperature below 21.11^0C, while warm water fish like bass and bluegill prefer summer temperature in 70s and 80s.Water temperature is also important when using aquatic herbicides to treat plant or algae growth. Most aquatic herbicides are most effective when water temperatures are between 15.55^0C and 23.8^0C. In Barua sagar lake temperature was recorded 10.3^0C in winter and 25.5^0C in summer.

pH

Ellis (1937) has observed that a pH range of 6.7 to 8.4 is suitable for the growth of aquatic biota. The pH of lake water is important for a number of lake uses. Different type of fish tolerates different pH levels but in general, most fish will do better in ponds with a pH near 7.0. Lake with a pH less than 6.0 may result in stunted or reduced fish population. Lake with a pH less than 5.0 or above 9.0 should not be used for dairy cows. In investigation barua sager lake pH was recorded range from 6.8 to 8.6.

Electrical Conductivity

Electrical conductivity (EC) is a measure of how well a solution conducts electricity and is correlated with salt content. Conductivity is typically reported in units of mSiemens/cm (microsiemens per centimetre). Freshwater fish generally thrive over a wide range of electrical conductivity. Some minimum salt content is desirable to help fish maintain their osmotic balance. The upper range varies with fish species. Channel catfish, for example, can withstand salinities up to 1/2-strength seawater. Seawater has a conductivity of around 50,000 to 60,000 mSiemens/cm. Electrical conductivity (EC) also can be used to give a rough estimate of the total amount of dissolved solids (TDS) in water. Typically, the TDS value in mg/l is about half of the EC (mSiemens/cm). In present study conductivity recorded higher amount in December 125.2 (µs/m) and lower in april 97.7 (µs/m) respectively.

Alkalinity

Total alkalinity (TA) is a measure of the concentration of bases (typically carbonate and bicarbonate) in the water that provide buffering capacity. The units are milligrams per liter (mg/l) as calcium carbonate. TA below 20 mg/l limits primary productivity in water. Application rates of copper sulfate for algae control are based on the TA of the water, and copper sulfate should not be used at all in waters with fish if the TA is less than 50 mg/l. In present investigation, alkalinity was recorded higher in December 52.5 ppm and lower in April 67.6 ppm respectively.

Hardness

Hardness is a measure of calcium and magnesium concentration in water and is controlled by the source of the lake water. The hardness of lake water is usually unimportant except when using some aquatic herbicides. Hardness concentrations about 50mg/l can reduce the effectiveness of some copper-based herbicides. Consult the label of aquatic herbicides to see if water hardness needs to be considered to determine application rate or herbicide effectiveness. During investigation of barua sager lake hardness was recorded minimum in December 104.5 ppm and maximum in April 112.4 ppm.

Cl (Chloride)

Chloride (Cl^-) together with sodium (Na) forms common salt (sodium chloride). Chloride should not be confused with the gas, chlorine (Cl_2). *Chlorine* is a highly reactive compound and is used as a disinfectant. *Chloride* is the same element in the form of a salt. Chlorine and chloride have dramatically different chemical properties. Chloride is a common component of most waters and is beneficial to fish in maintaining their osmotic balance. In commercial catfish production, chloride (in the form of salt) is often added to waters to obtain a minimum concentration of 60 mg/l. This is done because catfish are susceptible to "brown blood" disease, caused by excess nitrite in the water. A ratio of chloride to nitrite of 10:1 reduces nitrite poisoning. High chloride levels (above 100 mg/l) are a concern only if the water is also used to irrigate sensitive land-based crops. . In study, the amount of chloride recorded higher amount in December 46.6 ppm and lower in April 50.2 ppm respectively.

NO_3 (Nitrate)

Nitrate levels in drinking water for humans and livestock are a major concern. Typical levels in surface waters range from 0.005 to 0.5 mg/l nitrate. However, nitrate is relatively nontoxic to fish and is not a health hazard except at high levels (above 90 mg/l NO_3-N). Nitrate and nitrate-nitrogen are two ways of expressing the same parameter. Nitrate-nitrogen expresses the concentration of nitrate based only on the weight of the nitrogen in the nitrate (to convert nitrate-nitrogen concentrations to nitrate, multiply by 4.43). In present study nitrate recorded lower in December 1.5 ppm and higher in April 2.4 ppm respectively.

Dissolved Oxygen

The amount of oxygen that is dissolved in the water is critical for fish and other pond life. The maximum amount of oxygen that can be dissolved is controlled by the water temperature. Warmer water can hold less oxygen then colder water. In general, most pond water can hold less dissolved

oxygen then colder water. In general, most pond water can hold about 10 to 12 mg/l of oxygen. Dissolved oxygen is reduced by the biological decay of organic material such as decaying plants and animals or animal and human wastes. Dissolved oxygen level below about 5mg/l can begin to have detrimental effects on pond life. During investigation of Barua sager lake dissolved oxygen was recorded maximum in December 8.5 ppm and minimum in April 6.4 ppm.

Turbidity

Muddy or turbid lake water is usually an aesthetic problem. It is frequently caused by runoff from disturbed area around the pond. This might include planning grass or other vegetation on exposed areas, putting allayer of rocked over exposed bank, or removing muskrats or bottom-dwelling fish. Persistent muddy water problem can be treated with addition of ground limestone, hydrated lime, gypsum, or alum. Ponds that are only turbid or coloured during the summer are probably experiencing zooplankton blooms. Zooplanktons are small animal that serve as a food source for fish and other aquatic life. These zooplanktons bloom can be eliminated with copper sulphate, but in, most cases the health of the pond is best served if they are left untreated. Muddy water is very common in new pond and usually disappears as vegetation grows around the pond in established pond. In our study, the amount of turbidity recorded higher amount in April 10 NTU and lower in December 7 NTU respectively.

Total solid (TS)

Total solids are a measure of the suspended and dissolved solid in water suspended solids are those that can be retained on a water filter and are capable of settling out of the column into the stream bottom when stream velocities are low. They include silt, clay, plankton, drainage. Dissolved solid are those that pass through a water filter. They include some organic material, as well as salt, inorganic nutrients, and toxins. The amount of Total Solid recorded minimum 254 mg/l in December and maximum 323 mg/l in April month .

Total Dissolved Solids (TDS)

In natural water dissolved solids are consists of inorganic salts, small amount of organic matter and dissolved material in natural water. Dissolved solids are mainly due to carbonates, chlorides, sulphates, nitrates, phosphates, Ca, Mg, Na, K, Fe, Mn, etc. The amount of Total Dissolved Solid recorded minimum 210 mg/l December and maximum 249 mg/l in April month.

Total Suspended Solid (TSS)

The suspended solids determination is particularly useful in the analysis of sewage and other waste waters and is as significant as BOD determination. It is used to evaluate the strength of domestic wastewaters and efficiency of treatment units. Suspended solids are objectionable in river for many reasons. Suspended Solids containing much organic matter may cause putrefaction and consequently the stream may be devoid of dissolved oxygen. The amount of Total Suspended Solid recorded minimum amount 45 mg/l in Desembar and maximum 74 mg/l in April.

F (Fluoride)

Fluoride is a trace element typically present in water at levels of 0.1 to 1.5 mg/l. It may be added to water as a measure to prevent tooth decay in humans (0.7 to 1.2 mg/l). Levels at or above 3 mg/l are reported to cause losses of some fish species, depending upon complex water conditions. . In our study, the amount of fluoride recorded higher amount in April 0.73 ppm and lower in December 0.55 respectively. Which are water permissible limits.

Biochemical Oxygen Demand (BOD)

A pollution indicator showed its level in barua Sagar Lake from 4.6 ppm in December to 3.5 ppm in April. Low BOD content indicated that the lake stretch was free from organic pollution. Fokmare and Musaddiq (2002) recorded high value (BOD) as 20.00 mgl^{-1} in river Purna and said that this river is highly polluted due to organic enrichment, decay of plants and animal matter in the river.

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand gives us a reliable parameter for judging the extent of pollution in water (Shrivastava and Patil, 2002). COD is the measure of the oxygen required for chemical oxidation of organic matter. In Barua sagar lake maximum value was recorded 34.6 ppm in April and minimum 34.2 in December has been recorded. This also provides a direct measure of state of pollution in water bodies (Kulshrestha and Sharma, 2006).

Conclusion

This area comes under semi arid region of Bundelkhand with low precipitation (900 mm/yr) and higher evaporation (1800 mm/yr). Therefore, ground water is in small quantity and ground water table goes down during summer month (mid April to June). Ground water is taken out from wells tube-well and pumps.

Surface water is main source of water in Jhansi. Betwa River, Pahuj River, Barua Sagar lake, Lakshmi Tal, Atiya Tal etc. are the source of surface water . After treatment, the surface water is supplied to various areas through pipelines for municipal uses. So, surface water is a very much valuable resource for this region. Both the quality and quantity of this resource should be maintained for better future of the local people.

After compare from water quality standard we find that Barua Sagar is slightly polluted and the main source of pollution is the bathing, laundering and agricultural runoff from the catchments areas. Without proper treatment it may not be useful directly for drinking purposes. From the present investigation it was found that Barua sagar lake water quality index recorded 59 which is (ranges between 50-70) come under medium quality.

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Table – 1: Some important water quality parameters and uses

Lake use	Important water quality parameters
Animal drinking water	Bacteria, pH, metals, nitrate, blue-green algae, and pesticides
Swimming	Bacteria, turbidity, parasite
Fishing	Temperature, dissolved oxygen, pH, pesticides'
Irrigation	Aquatic herbicides, pH, metale
Aesthetic beauty	Turbidity

Table – 2: Hi-Media (wt 023) kit and their specific range for water analysis.

S. No.	Type of test	Range	Reagent Provided
1	pH	pH test strips of range 2.0 to 10.5	-----
2	Turbidity (visual comparison method)	0-25 NTU standards	5 Bottles: bottle marked sample bottle for standards of 0, 5, 10, and 25 NTU for turbidity comparison.
3	Chloride (Titration method)	----	4 reagent bottles: marked CHL-A, CHL-B, CHL-C (2 bottles)
4	Total hardness (Titration method)	25-600 mg/l (ppm) CaCo3	4 reagent bottles: marked TH-A, TH-B, TH-C (2 bottles)
5	Fluoride (visual colour comparison method)	0-2.5 mg/l (ppm)	2 Reagent bottles: marked reagent FL-A, FL-B
6	Nitrate (visual colour comparison method)	0-100 mg/l (ppm)	One reagent bottle : marked reagent N
7	Iron (visual colour comparison method)	0-2 mg/l (ppm)	One reagent bittle: marked reagent Fe
8	Residual free chlorine (Titration method)	0-3 mg/l (ppm)	4 Reagent bottles: marked reagent RCL-A, RCL-B, RCL-C

Table – 3 : Analytical Characteristics of Barua Sagar Lake water

S.No.	Parameter	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL
1	Temperature ^{0}C	10.3±0.11	13.5±0.70	18.5±0.88	20.1±0.43	25.5±0.79
2	p^H	8.6±0.17	8.3±0.26	7.8±0.65	7.2±0.26	6.8±0.34
3	Conductivity (µs/m)	125.2±1.00	117.4±0.57	110.6±1.5	101.1±1.4	97.7±0.60
4	Alkalinity (PPM)	52.5±1.22	55.7±1.66	58.5±1.4	62.2±0.87	67.5±0.90
5	Total Hardness (PPM)	104.5±1.82	108.6±1.24	110.6±1.15	112.3±0.92	112.4±0.90
6	Chloride (PPM)	46.6±1.00	47.1±1.32	48.4±1.64	49.8±1.7	50.2±0.88
7	Nitrate (PPM)	1.5±0.11	1.8±0.11	2.1±0.23	1.6±0.11	2.4±0.17
8	Dissolved Oxygen (PPM)	8.5±0.23	7.6±0.20	7.2±0.23	6.9±0.23	6.4±0.17
9	Turbidity (NTU)	7±1.15	9±0.57	9±1.00	9±1.15	10±1.15
10	Total solid (PPM)	254±2.64	255±2.64	280±2.88	306±1.73	323±2.3
11	Total Dissolved Solid (PPM)	210±1.52	201±1.73	217±2.88	249±3.05	249±2.08
12	Total Suspended Solid (PPM)	45±1.52	54±2.30	63±1.15	57±2.08	74±2.08
13	Fluoride (PPM)	0.55±0.015	0.59±0.023	0.63±0.03	0.68±0.02	0.73±0.02
14	BOD (PPM)	4.6±0.17	4.3±0.11	4.1±0.21	3.8±0.17	3.5±0.20
15	COD (PPM)	34.2±0.72	35.8±0.85	36.2±0.98	34.4±1.01	34.6±1.13

Table – 4: CPCB-Guideline for Best uses of Water

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	Total Coliforms Organism MPN/100ml shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organised)	B	• Total Coliforms Organism MPN/100ml shall be 500 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 5mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	• Total Coliforms Organism MPN/100ml shall be 5000 or less • pH between 6 to 9 • Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	D	• pH between 6.5 to 8.5 • Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	• pH between 6.0 to 8.5 • Electrical Conductivity at 25°C micro mhos/cm Max.2250 • Sodium absorption Ratio Max. 26 Boron Max. 2mg/l
	Below E	• Not Meeting A, B,C, D & E criteria.

Source-Central Pollution Control Board. New Delhi-2009