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RESEARCH ARTICLE

PHYSICO-CHEMICAL CHARACTERISTICS OF BALAGALA KERE AND PURALI KERE OF SHIMOGA DISTRICT, KARNATAKA, INDIA

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Abstract

The present study deals with the physico-chemical and biological characteristics of two water bodies of Shimoga district. Determination of Physical parameters (pH, EC, Turbidity and Total dissolved solids), Chemical parameters (Total hardness, Calcium hardness, Magnesium hardness, Total Alkalinity, DO, Sodium, Potassium, Chloride, Sulphates, Nitrate nitrogen and Phosphate), Bacteriological parameter (*E-coli*) and the concentrations of 7 heavy metals (Cadmium, Nickel, Lead, Iron, Manganese, Zinc and Copper) were carried out to identify the nature and quality of the water of the two lakes. The obtained results reveal that the values of all the physico-chemical parameters (except Turbidity) were well with in the permissible limit; however Bacteriological parameter (*E-coli*) and concentrations of two heavy metals (Iron and Manganese) were exceeding the permissible limit of drinking water standards prescribed by BIS (1998).

Introduction

The life on earth's surface is inconvincible without water. Water is one of the most important resources which human being has exploited than any other resource for sustenance of their life. The quality of utilizable water is very much limited on the earth. Though water is continuously purified by evaporation and precipitation, pollution of water has emerged as one of the most significant environmental problem in recent past.
The quality of water is now the concern of experts in all countries of the world. The decision of WHO's 29th session (May 1976) emphasizes that water delivered to the consumer should meet the high requirements of modern hygiene and should at least be free from pathogenic organisms and toxic substances. Also, the quality of water depends on the location of the source and the state of environmental protection in a given area. Therefore, the quality and the nature of water are determined by physical and chemical analysis (Voznoya, 1983). The purpose of this study was to know the physico-chemical and biological characteristics and also to identify distribution of several trace metal contaminants in the two lakes and these findings would raise significant ecological and public health concerns.

It is evident from the above mentioned facts that assessment of two water bodies is of prime importance at this junction which not only helps in generating valuable information pertaining to the pollutant levels, but also helps in formulating effective concentration strategies to reduce the pollutant levels. This inturn helps to protect and conserve the depleting biological resource of the water bodies for the posteriority. With this background, Balagala Kere on Holehonur road and Puralikere on Pillenagere to Shimoga road (Table 1) were selected and monitored for 3 seasons, viz., Monsoon (August 2006), Post-monsoon (December 2006) and Pre-monsoon (April 2007) and the obtained results were compared with drinking water standards prescribed by BIS (1998).

Materials and Methods

Water samples were collected at 30 cm depth, using polyvinyl chloride bottle. These water-samples bottles were then taken in dark condition for further analysis in the laboratory. The physico-chemical and biological parameters were determined according to the standard methods described in APHA, (1998). pH was measured at the spot using pH meter, for DO estimation, the samples were fixed at the spot and carried in icebox to laboratory and the analysis was taken up positively within 24 hours of collection.

Bacteriological sampling and Enumeration techniques

The water samples are collected from 30 cm depth, prior to taking the samples from the same in properly sterilized neutral glass bottles of 120 ml capacity. To each of these sampling bottles, 0.1 ml of 30% sodium thiosulphate solution was added prior to subjecting it to the process of sterilization. Care was taken while collecting samples; it was not collected up to the top. On the contrary, some space was left for the bacteria to survive. The collected water samples were then brought to the laboratory from the field in the packed sampling icebox and the analysis was taken up positively within 24 hours of collection.

E. coli enumerations were performed with spread plate method, using appropriate medium. The number of CFU's (colony forming units) was counted. *E. coli* were enumerated on a selective MENDO agar medium. Plates were incubated at 37°C for 24 hours, and then the numbers of CFU's with red, greenish, metallic fuchsine sheen were counted (Wcislo and Chrost, 2000).

Sample preparation for heavy metal analysis

Water samples (500 ml) were filtered using Whatman No. 41 (0.45 µm pore size) filter paper for estimation of dissolved heavy metal content. Filtrate and as collected water samples (500 m each) were preserved with 2 ml nitric acid to prevent the precipitation of metals. Both the samples were concentrated to ten folds on a water bath and subjected to nitric acid digestion (Clesceri, 1998 and Anton Paar, 1998). Heavy metal analyses were carried out using atomic absorption spectrophotometer (Model: GBC Avanta PM 8 lamps). The instrument was set zero by running the respective reagent blanks. Average values of three replicates were taken for each determination. The detection limits for Fe, Zn, Cd, Cu, Ni, Pb and Mn were 0.05, 0.008, 0.025, 0.04, 0.06 and 0.000 (mg l-1) respectively (Athanasopoulos, 2002).

Results and Discussion

Physico-chemical characteristics

The physico-chemical parameters are considered as the most important principles in the identification of the nature, quality and type of the water (fresh, brackish, saline) for any aquatic ecosystem. Water analysis is a statement of the kind and amount of impurities contained in the water. The form of statement will depend on the point of view from which the water being tested, that is to say, whether it is being examined for its suitability for drinking, domestic or its suitability for industrial processes (Rayan, 2000).

Physical parameters

pH

The pH of T1 and T2 was also observed to be on the alkaline side (Tables 3 and 4) during the investigation period and ranged from a minimum of 7.51 during Monsoon to a maximum of 7.60 in T1 during Pre-monsoon. Where as, in T2 a minimum of 7.30 were recorded during Monsoon to a maximum of 7.40 during Pre-monsoon (Tables 3 and 4). These results agree with that reported by Abd-Ella, (2003), who studied the Abu Za'baal Ponds during November-December 2002. The higher values of pH were recorded during Pre-monsoon season, while the lower values were found during monsoon season. Krumgalz *et al.,* (1980) and Ezz El-Din, (1990) reported that the seasonal variation in pH was mainly affected by temperature, salinity, carbonate and bicarbonate system, rather than the photosynthetic activity of the primary producers.

Electrical conductivity (EC)

Conductivity is the ability of a substance to conduct electricity. The conductivity of water is a more or less linear function of the concentration of dissolved ions. Conductivity itself is not a human or aquatic health concern, but because it is easily measured, it can serve as an indicator of other water quality problems. Therefore, conductivity measurements can be used as a quick way to locate potential water quality problems. The values of EC were high during Pre-monsoon season (189.20 µmohs/cm in T1 and 199.25 µmohs/cm in T2), while a lower value of 97.16 µmohs/cm in T1 and 91.00 µmohs/cm in T2 were recorded during Monsoon season respectively (Tables 3 and 4). The conductivity increased with the increase in total dissolved solids and water temperature (Entz, 1973).

Turbidity

Turbidity is another indicator of the amount of material suspended in water; it measures the amount of light that is scattered or absorbed. Suspended silt and clay, organic matter, and plankton can contribute to turbidity. It decreases the light penetration, limits the production of phytoplankton, which in consequence decreases the photosynthetic activity and depletion of oxygen content. It restricts the light penetration in water, resulting in reduced primary production. Turbidity will fluctuate before, during and after rains.

The turbidity values ranged from a minimum of 85.80 NTU in T1 during Pre-monsoon to a maximum of 120.00 NTU during Monsoon season respectively. However in T2 a minimum of 96.00 NTU was recorded during pre-monsoon to a maximum of 122.00 NTU during Monsoon season respectively (Tables 3 and 4). Seasonally, Monsoon months showed higher turbidity as a result of surface runoff from agricultural land and bank erosion at two lakes. The turbidity values in both the lakes crossed the maximum permissible limit prescribed by BIS (1998) in all the season reaching its maximum in monsoon season during the entire course of the study.

Total Solids

Solids refer to suspended and dissolved matter in water. They are very useful parameters describing the chemical constituents of the water and can be considered as a general of edaphic relations that contribute to productivity within the water body (Goher, 2002). In the present study, only TDS were measured and found in the same trend of the EC. The higher values of TDS were recorded during Pre-monsoon season (226.40 mg/l in T1 and 238.56 mg/l in T2). The lower values were measured during Monsoon season (109.00 mg/l in T2 and 97.16 mg/l in T2). The higher values observed during hot periods, may be due to the elevation of the water temperature which lead to the increase in the evaporation rates and the accumulation of the dissolved salts in water (Tables 3 and 4).

Chemical parameters

Calcium and magnesium

The distributions of calcium and magnesium concentrations in the water of two lakes were fluctuating during different seasons (Tables 3 and 4). However, the high calcium contents were recorded during summer and autumn may be related to the relative increase in the DO during these periods (Cole, 1979). Generally, the calcium contents in the water is affected by the adsorption of the calcium ion on the metallic oxides (Wilson, 1975) in addition to, the effect of the microorganisms which play an important role in the calcium exchange between sediment and overlying water (Elewa, 1988). On the other hand, the slight variations in the distribution patterns of the magnesium during summer and autumn. This is mainly attributed to its minor biotic demand and high solubility characteristic of these salts that keeps a homogenous distribution and mass balance for magnesium contents during these seasons (Wetzel, 1983).

Sodium and potassium

Sodium salts are highly soluble in water and hence all natural waters contain a little amount of sodium (Robert and Marsh, 1987). The present results show a slight variation in the sodium distribution patterns during Monsoon, Post-monsoon and Pre-monsoon. This is mainly attributed to the high solubility of these salts that keep a homogenous distribution and mass balance for sodium (Wetzel, 1983), as shown in Tables 3 and 4. However, the high values of the sodium contents ranged from 45.00 mg/l during Post-monsoon in T1 and 39.99 mg/l during Pre-monsoon in T2 may be due to the release and the dissolution of the sodium ions from sediment and rocks into the overlying water.

Potassium occurs in far lesser concentration in natural waters than calcium, magnesium and sodium. It behaves in the water as does sodium and found in small amounts. It plays a vital role in the metabolism of fresh water environment and considered being an important macronutrient. The slight seasonal variations in the potassium of the two lakes, indicate that the conservative nature of K. The ranges of K^+ were found to be from 12.80, 14.80 and 18.80 mg/l in T1 and 11.60, 13.60 and 20.80 mg/l in T2 during Monsoon, Post-monsoon and Pre-monsoon respectively. The higher concentrations during pre-monsoon season may be due to evaporation leading to low water level or due to the geomorphological nature of the catchment area.

Chloride and Sulphates

The seasonal variations of chloride and sulphates concentrations are represented in Tables 3 and 4. The distribution of sulphates during Monsoon, Post-monsoon and Pre-monsoon are similar to each other. However, the highest values were recorded during Post-monsoon season (8.40 mg/l of chloride and 40 mg/l of sulphates in T1 and 13.20 mg/l of chlorides and 40.0 mg/l of sulphates in T2 respectively). The relative increase in the chloride and sulphates concentrations during hot period may be due to the increase in the air and water temperatures followed by the high evaporation rate (Abdel-Satar, 2005). On the other side, the high values in the sulphates and chloride concentrations unexpected during Post-monsoon. This is mainly attributed to the dissolution of some ions especially Cl-, SO_4-- from the surrounding rocks and sediment which release into the water of the two lakes.

Total alkalinity

The results of total alkalinity are represented in Tables 3 and 4. It is clear from the tables that the total alkalinity values were decreased in Monsoon season (15.0 mg/l in T1 and 20.0 mg/l in T2) and increased during Pre-monsoon season (60.0 mg/l in both T1 and T2 respectively). The increase in the total alkalinity during Pre-monsoon may be attributed to the decrease in air and water temperatures, leading to a decrease in the reaction rate of carbonate direction and vice versa (Ali, 2002).

Dissolved oxygen (DO)

Dissolved oxygen is essential for the self-purification process in natural water systems. The DO level may indicate the effects of oxidisable wastes on receiving waters. It also indicates the capacity of a natural body of water for maintaining aquatic life. The oxygen dissolved in water may be derived from the atmosphere or from the photosynthetic activity of aquatic plants. Many a times, the concentration of dissolved oxygen is depleted due to the pollution load and this renders the water unsuitable for consumption by living beings. The temperature of water influences the amount of DO present; less oxygen dissolves in warm water than cold water.

The results of DO are represented in Tables 3 and 4, show slight seasonal variations ranging from 6.88, 7.29 and 6.48 mg/l in T1 and 6.08, 6.48 and 5.27 mg/l in T2 during Monsoon, Post-monsoon and Pre-monsoon respectively. This means that the water column was oxygenated in the two lakes during the investigation period. The distribution of DO is affected by the solubility of many inorganic nutrients, which are governed by seasonal shifts from aerobic to anaerobic environments in some regions of the ponds (Benson and Krause, 1980). Generally, the value of DO was lowest during Pre-monsoon months due to higher temperature and higher rate of microbial decomposition of the organic matter.

Nutrients

Nutrients such as phosphorous and nitrogen are essential for the growth of algae and other plants. Aquatic life is dependent upon these photo-synthesizers, which usually occur in low levels in surface water. Excessive concentrations of nutrients, however, can over stimulate aquatic plant and algae growth. Bacterial respiration and organic decomposition can use up DO, depriving fish and invertebrates of available oxygen in the water (eutrophication). Nutrient salts (NO_2-, NO_3-, NH_3-, PO_4---, T.P and SiO_2-) are plays an important roles in the productivity of the aquatic ecosystems supporting the food chain for phyto and zooplanktons as well as fish (Abdo, 2004).

Nitrate Nitrogen

The productivity of natural waters in terms of algal growths is related to the fertilizing matter that gains entry in to them. Also, reduced forms of nitrogen are oxidized in natural waters, thereby affecting the DO resource. For these reasons nitrogen data are often regarded as part of the information needed in water pollution control programs.

The results of the nitrate are represented in Tables 3 and 4, the higher values recorded during Pre-monsoon seasons (0.046 in T1 mg/l and 0.040 mg/l in T2 respectively). Ganapathi and Sreenivasan (1965) and Sreenivasan (1964, 1968, 1974) failed to detect nitrates in their studies. However, Birsal *et al.* (1985) while working on Supa reservoir and Pathak (1979) on Nagarjunasagar reservoir (Andhra Pradesh), and Mathew (1985) on Govindgrah lake (Madhya Pradesh) recorded relatively higher concentration of nitrate that ranged between 0.2 to 0.8 mg/L and pointed out that the higher concentration of nitrate is due to the inference of agricultural run-off from paddy fields and flood water during monsoon season.

Phosphate

Phosphate is one of the essential nutrients for the growth and development of flora in any ecosystem. Like nitrogen, phosphorous is also an essential to all forms of terrestrial life as nutrient element and sustaining primary productivity in the ecosystem. The cycling of phosphorus within lakes and river is dynamic and complex, involving adsorption and precipitation reactions, interchange with sediments and uptake by aquatic biota (Borberg and Persson, 1988). The seasonal variations of phosphates were fluctuated in the ranges from 0.014, 0.026 and 0.034 mg/l in T1 and

0.043, 0.055 and 0.063 mg/l during Monsoon, Post-monsoon and Pre-monsoon respectively. The high values of the phosphate content noticeable during summer especially, lake T2 (0.063 mg/l) was probably, due to the increase in the evaporation rate under rises of the air and water temperatures leading to the facilitating of phosphorus release from the decay organisms (Abdo, 2002).

Bacteriological Parameter

Bacteria and viruses from human and animal wastes carried to streams can cause disease. Fecal coliform, found in the intestines of warm-blooded animals, is the bacteria for which many countries surface water quality standards are written. Fecal coliform bacteria do not cause disease but are used as an indicator of disease causing pathogens in the aquatic environment.

Coliforms

Biological indicators of water quality are important since, they have the unique characteristics of survival and proliferation in water bodies. Under optimal conditions, even a single cell can grow in to millions in a short span of few hours and are more resistant than pathogens to the stresses of the aquatic environment and disinfection process (chlorination). Various indicator organisms include total coliform, fecal coliforms, fecal *E-coli*, fecal streptococci, bacteriophages and sulphite reducing clostridia (Arora, 2003 and WHO, 1998). Aquatic bacteria play a vital role in carrying water born diseases, which cause epidemics. These pathogenic bacteria enter in to water through external pollutants mostly by domestic contaminants such as human and animal excreta. Hence, importance of microbial analysis of water has been emphasized from time and again. Coliforms particularly *E coli* are present in large numbers in the normal intestinal flora of humans and animals, where it generally causes no harm. However, in other parts of the body *E. coli* can cause serious diseases, such as urinary tract infections, bacteraemia and meningitis.

In the current investigation, both lakes recorded moderately high count of coliform bacteria (>200 CFU's), which can be attributed to anthropogenic activity, sewage disposal and agricultural runoffs. In monsoon season coliform count in both the lakes was relatively less when compared to other two seasons due to high inflow from the surrounding area leading to dilution. The total coliform count recorded during the study period is presented in tables 3 and 4.

Heavy metals

Toxic heavy metals in air, soil, and water are global problems that are a growing threat to humanity. Metals, a major category of globally distributed pollutants, are natural elements that have been extracted from the Earth and harnessed for human, industry and products for millenia. Metals are notable for their wide environmental dispersion from such activity; their tendency to accumulate in select tissues of the human body, plants; and there overall potential to be toxic even at relatively minor levels of exposure. Some metals, such as copper and iron, are essential to life and play irreplaceable roles, for example, the functioning of critical enzyme systems. Other metals are xenobiotics, i.e., they have no useful role in human physiology (and most other living organisms) and, even worse, as in the case of lead and mercury, may be toxic even at trace levels of exposure. Even those metals that are essential, however, have the potential to turn harmful at very high levels of exposure, a reflection of a very basic tenet of toxicology-- "the dose makes the poison" (Howard, 2002).

The concentrations of Cd, Ni, Pb, Zn and Cu were well below detectable level (BDL) and only Fe, and Mn was detected in both the lakes samples. Concentrations of Fe in both lakes T1 and T2 are exceeding the permissible limit of drinking water standards prescribed by BIS (1998) during Post-monsoon and Pre-monsoon. However in both the lakes Fe and Mn were well below detectable level during Monsoon. The high concentration of iron may be due to the rock unit, rock water interaction and nature of the soil (Warrin *et al.,* 1971).

Table 1. Showing sampling points location with Latitude and longitude.

Sl No.	Sample ID	Lake Name and location	Lat	Long
1	T1	Balagala Kere (Holehonur Road)	13^0 55'500"	75^0 43'088"
2	T2	Puralikere on Road from Pillenagere to Shimoga	13^0 55'986"	75^0 36'817"

Table 2. Analytical methods used for physico-chemical analysis of water

Sl No.		Method (APHA 1998, BIS 1998, NEERI, 1998)	Instrument used
Physical			
1	Turbidity	Photometric	Digital Nephelo-Turbidity meter model 132 (Systronics)
2	Total dissolved Solids	Electrometric method	EC-TDS analyser – Microprocessor based (ELICO-CM 183)
3	EC		
4	pH	Electrometric	pH pen
Chemical			
5	Dissolved Oxygen	Wrinklers Iodometric method	Titration
6	Total hardness	Titrimetric	Titration
7	Calcium		
8	Magnesium		
9	Chloride		
10	Total Alkalinity		
11	Sulphate	Colorimetric	UV-Visible Spectrophotometer
Nutrients			
12	Phosphate	Colorimetric	UV-Visible Spectrophotometer
13	Nitrate Nitrogen		
14	Sodium	Flame photometry	S-Systronics, Mediflame 127
15	Potassium		
Bacteriological			
16	*E. coli*	Membrane filter technique	Membrane filters

Table 3. Physico-chemical, bacteriological and heavy metal concentrations in T1.

Sl No.	Parameters	Units	BIS (1998)		Results		
			P	E	August 2006	December 2006	April 2007
1	pH	pH	7.0-8.5	6.5-9.2	7.51	7.55	7.60
2	Electrical Conductivity	µmho/cm	1000	2250.0	97.16	174.20	189.20
3	Turbidity	NTU units	5	25	120.00	110.30	85.80
4	Total Dissolved Solids	mg/L	500	2000	109.00	193.84	226.40
5	Total hardness	mg/L	300	600	25.00	50.00	80.00

6	Calcium hardness	mg/L	75	200	15.00	35.00	70.00
7	Magnesium hardness	mg/L	30	100	10.00	15.00	10.00
8	Total Alkalinity	mg/L	200	600	15.00	45.00	60.00
9	Sodium	mg/L	-	-	29.98	45.00	39.99
10	Potassium	mg/L	-	-	12.80	14.80	18.80
11	Chloride as Cl	mg/L	250	1000	7.20	8.40	5.20
12	Sulphates	mg/L	200	400	20.00	40.00	35.00
13	Phosphate	mg/L	-	-	0.01	0.03	0.03
14	Nitrate nitrogen	mg/L	10	45	0.00	0.03	0.05
15	Dissolved oxygen	mg/L	3	9	6.88	7.29	6.48
16	E-coli	CFU/ 100 ml	Nil	Nil	200.00	257.00	285.00
17	Cadmium (Cd)	mg/L	0.01	0.01	BDL	BDL	BDL
18	Nickel (Ni)	mg/L	-	-	BDL	BDL	BDL
19	Lead (Pb)	mg/L	0.05	0.05	BDL	BDL	BDL
20	Iron (Fe)	mg/L	0.30	1.0	BDL	0.320	0.60
21	Manganese (Mn)	mg/L	0.10	0.30	BDL	0.035	0.15
22	Zinc (Zn)	mg/L	5.0	15.0	BDL	BDL	BDL
23	Copper (Cu)	mg/L	0.05	1.50	BDL	BDL	BDL

Note: All the parameters are in mg/L except pH, Electrical conductivity (µmohs/cm) and Turbidity (NTU).
P = Permissible limit, E = Excessive limit.
BDL - Below Detectable level.

Table 4. Physico-chemical, bacteriological and heavy metal concentrations in T2.

Sl No.	Parameters	Units	BIS (1998)		Results		
			P	E	August 2006	December 2006	April 2007
1	pH	pH	7.0-8.5	6.5-9.2	7.30	7.35	7.40
2	Electrical Conductivity	µmho/cm	1000	2250.0	91.00	121.50	199.25
3	Turbidity	NTU units	5	25	122.00	105.20	96.00
4	Total Dissolved Solids	mg/L	500	2000	97.16	185.56	238.56
5	Total hardness	mg/L	300	600	30.00	55.00	90.00

6	Calcium hardness	mg/L	75	200	20.00	40.00	70.00
7	Magnesium hardness	mg/L	30	100	10.00	15.00	20.00
8	Total Alkalinity	mg/L	200	600	20.00	45.00	60.00
9	Sodium	mg/L	-	-	15.00	34.19	39.99
10	Potassium	mg/L	-	-	11.60	13.60	20.80
11	Chloride as Cl	mg/L	250	1000	7.20	13.20	3.60
12	Sulphates	mg/L	200	400	20.00	40.00	35.00
13	Phosphate	mg/L	-	-	0.04	0.06	0.06
14	Nitrate nitrogen	mg/L	10	45	0.00	0.03	0.04
15	Dissolved oxygen	mg/L	3	9	6.08	6.48	5.27
16	E-coli	CFU/ 100 ml	Nil	Nil	205.00	222.00	301.00
17	Cadmium (Cd)	mg/L	0.01	0.01	BDL	BDL	BDL
18	Nickel (Ni)	mg/L	-	-	BDL	BDL	BDL
19	Lead (Pb)	mg/L	0.05	0.05	BDL	BDL	BDL
20	Iron (Fe)	mg/L	0.30	1.0	BDL	0.300	0.50
21	Manganese (Mn)	mg/L	0.10	0.30	BDL	0.030	0.15
22	Zinc (Zn)	mg/L	5.0	15.0	BDL	BDL	BDL
23	Copper (Cu)	mg/L	0.05	1.50	BDL	BDL	BDL

Note: All the parameters are in mg/L except pH, Electrical conductivity (µmohs/cm) and Turbidity (NTU).
P = Permissible limit, E = Excessive limit.
BDL - Below Detectable level.

Conclusions

Based on the results of the present studies and synthesis of the available information, it can be concluded that both the water bodies are oligotrophic lakes with a unique ecosystem. The result shows that, all the parameters (except Turbidity) are well within the desirable limits of drinking water standards prescribed by BIS (1998). The main factors affecting in the distribution and the concentrations of the different physical, chemical and bacteriological parameters of lake are;

1. The changes in the environmental conditions.
2. The water storage in the each lake and
3. Anthropogenic activities in and around the lake.

The present investigation and data generated can form support to develop policies and measures to improve our aquatic environment.

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