International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 4 Issue 5, May 2017

ISSN: 2394-4404

Assessment Of Water Quality Of Sasthamcotta Fresh Water Lake And Kip Canal Of Kollam District, Kerala

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***Abstract:** Sasthamcotta lake is Kerala's biggest fresh water lake and meets the drinking water needs of half a million people of Kollam district. The lake is facing degradation due to anthropogenic activities such as directing human waste, soil erosion due to destruction of vegetation etc. leading to the deterioration of environmental quality as well as a decrease in the surface area and depth. In the present study, we have compared physical and chemical parameters and two bacteriological parameters such as total coliform and Escherichia coli for Sasthamcotta lake water and Kallada Irrigation Project (KIP) canal water. Studies showed that both Sasthamcotta lake water and KIP canal water obeyed all the physical and chemical parameters of drinking water specification except pH. It was found that both samples contain total coli form and Escherichia coli (more in KIP water) and both samples are found to be unfit for drinking without sufficient purification.*

***Keywords:** bacteriological analysis, coliform, Escherichia coli, fresh water, irrigation, pH, sasthamcotta lake, water analysis*

I. INTRODUCTION

Water is the foundation of life. Therefore civilizations were flourished in the banks of river water sources. However, the scenario is fast changing as all around the world, far too many people spend their entire day searching for it. Clean, safe drinking water is scarce. Today, nearly 1 billion people in the developing world don't have access to it. Yet, we take it for granted, we waste it, and we even pay too much to drink it from little plastic bottles. NASA reported the detection of water molecules on moon by NASA's Moon Mineralogy Mapper and confirmed by ISRO's Chandrayan-1 space craft in September 2009.

Kerala is blessed with 44 rivers and is a big resource for the people for various uses. Almost all river water is used for irrigation purposes in Kerala. The only exception is Sasthamcotta fresh water lake which caters the drinking water need of entire Kollam District, (the map is shown in Fig.1). However, the situation is fast changing. The lake which all of us are proud of is slowly dying down. Shrinking area along with shallow water level makes the lake difficult to support the human population in Kollam district. Adding to this is the deteriorating water quality owing to anthropogenic interferences. As the facts became more evident especially during summer, authorities are now searching for alternates to the grand old fresh water lake.

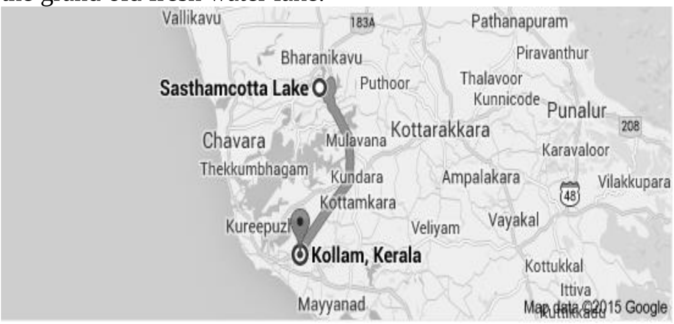

Figure 1: Map showing the position of Sasthamcotta lake in Kollam district

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During this summer India was under the grip of one of the worst drought situations in its history. Several southern and western parts of India were in the highest mercury levels. The districts of Telengana and Karnataka showed temperature hovering around 44 $^{\circ}$C. The surface water resources continue to be contaminated with runoff water from agriculture field containing pesticides, fertilizers, soil particles, waste chemicals from Industries and sewage from cities and rural areas. So a number of studies have been conducted on the various water quality aspects of lakes, rivers and wells. Ground water and surface water used by men are of different characteristics. Ground water contains dissolved minerals from the soil layers through which it passes.

Sasthamcotta lake is the largest freshwater lake in Kerala located at Sasthamcotta of Kollam District, Kerala, India on the South of the West coast. The lake is named after the ancient Sastha temple located on its bank. It meets the drinking water needs of half million people of the Quilon district and also provides fishing resources. The purity of lake water for drinking use is attributed to the presence of large population of larva called *cavaborus* that consumes bacteria in the lake water. The lake is a designated wetland of International importance under the Ramsar Convention since November 2002. The Lake water is reported to be free of common salt or other minerals and metals.

The quality of the lake environment is affected badly by the factors such as increasing anthropogenic pressure, encroachment on parts of the lake for agriculture, cultivation of tapioca which increases the soil loss by erosion, domestic and agrochemical wastes from surrounding areas disposed into the lake, soil erosion of the banks from the encroached land effluents from domestic sewage, reduction of ground water recharge to the lake due to increase in agriculture in the area around the lake, soaking of dry leaves of coconut palm before matting etc. Adding to this, is the harshest summer of this year with temperature reaching up to 38 $^{\circ}$C at Kollam. (Fig. 2) The water table has gone down substantially and lake became unable to cope up the requirement. It is likely that this might have impaired the water quality. It is therefore inevitable to monitor the water quality as it is directly linked to human health.

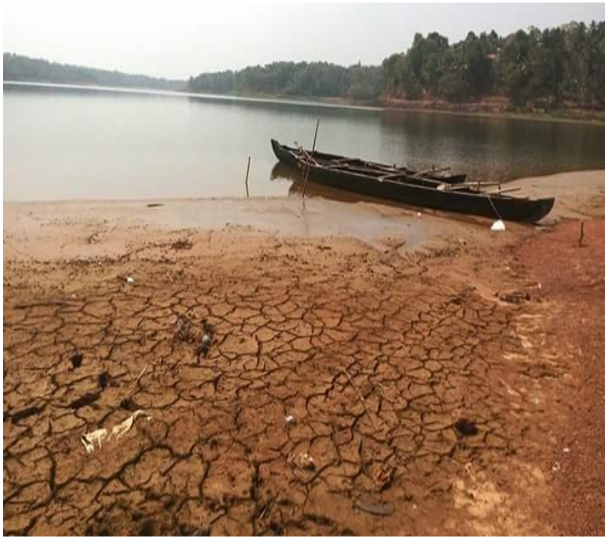

Figure 2: Photograph of Sasthamcotta Lake during March-April 2016

The ecology and pollution of Sasthamcotta fresh water lake was studied by Prakasham, Unnithan and Bhuvendran. Hydrology of Sasthamcotta lake with special reference to sediment water interaction was also conducted The water quality of the lake was assessed. Occurrence of multi antibiotic resistant E.coli in Sasthamcotta fresh water lake was studied by Jayachandran and Preetha G. P. Several studies have been conducted regarding the hydrological features of the lake.

It is in this context, authorities have identified this new source i.e., water from KIP (Kallada Irrigation Project) canal to reduce the pressure on the shrinking fresh water.

Kallada irrigation and Tree crop development scheme is the largest irrigation project in Kerala. The scheme was planned to irrigate net cultivable command area of 61630 Ha. Kallada irrigation is a unique project in Kerala where minor conveyance system consisting of a net work of PVC pipes introduced for supplying water from canal to crops. This is the most efficient system for conveying water to fields as the loss of water is least. In this system water is conveyed through buried pipe lines and hence compared to field channels land requirement is less. Kallada river is a west flowing river which originates from Kullathupuzha, Shenthuruni ranges of western ghats. The microbiological quality of the Kallada river water was assessed in a prevous study.

II. MATERIALS AND METHODS

Water samples from Sasthamcotta lake and KIP canal were collected during April 2016. Surface water samples were collected using clean bucket. The samples were stored and preserved as per the APHA standards.

Water samples were stored in pre-rinsed plastic bottles and that for bacteriological examinations were collected in sterilized bottles and the analysis was done on the same day.

III. ANALYSIS

All analysis were conducted using standard analytical methods (APHA, 1985).There is no single measure that constitutes good water quality. The water samples were analyzed for physico- chemical and biological parameters.

The physical parameters include colour, odour and taste. It is very important as good quality drinking water should be free from objectionable colour, taste and odour. Here both the samples obeyed all the physical parameters. The chemical parameters measured were pH, conductivity, total dissolved solids, dissolved oxygen, free carbon dioxide, alkalinity, chloride, salinity, sulphate, total hardness, calcium, magnesium, nitrite, bicarbonate and phosphates. In bacteriological examination, total Coliforms and Escheria coli in water samples were determined using Mac Conkey agar.

IV. CHEMICAL EXAMINATION OF WATER

The pH of the samples were measured by a digital pH meter standard instrument (Eutech pH Tutor) with an accuracy of ± 0.01 pH. The conductivity of samples were measured by Systronics conductivity meter (Type CD-10) with an accuracy of ± 0.1 conductivity. To determine total dissolved solid content a suitable volume of the filtered sample is evaporated in a water bath and dried the residue in an oven at 105° C to constant weight. The dissolved oxygen was measured by the Winkler method. For the determination of free carbon dioxide, the samples should be analyzed immediately after collection. 50 ml of sample is in a flask and add 2-3 drops of phenolphthalein indicator. If the color turns pink, free carbon dioxide is absent in the sample. If the sample remains colorless, titrate it against sodium hydroxide solution until pink color appears.

Alkalinity was estimated by the titration of a suitable sample volume with a 0.02 N H_2SO_4 solution with phenolphthalein and then methyl orange indicator. Chloride was estimated by argentometric method. The salinity of water may be calculated on the basis of its empirical relationship with chloride content.

Sulphate is estimated by gravimetric method. Hardness was determined by EDTA titration method. Calcium alone was determined by EDTA method using murexide (ammonium purpurate) indicator. Nitrite was estimated by potassium permanganate method.

Bicarbonate is estimated by the titration of 0.05 N standard H_2SO_4 with methyl orange indicator and phosphate is estimated complexometrically.

V. BACTERIOLOGICAL EXAMINATION OF WATER

In bacteriological examination, total Coliform and Escherichia coli in water samples were determined in triplicate and the average value was taken. For all estimations, pour plate method were employed. Nutrient agar with following composition was used. Peptone 5.0 g, Yeast extract 3.0 g, Beef extract 3.0 g, Agar 15.0 g and distilled water 1 litre. After sterilization, the pH was adjusted at 6.8+ or -0.2 and the samples were incubated at 37°C/24 hours. Total Coliforms were enumerated using MacConkey agar which enriched coliforms and intestinal pathogens giving pink to red colonies. Mac Conkey was a composition of Peptone, 17.0 g; Proteose peptone, 3.0g; Inositol 10g; Bile salts (No.3) 1.5g; Sodium Chloride, 5 g; Neutral red 0.03 g; Crystal violet, 0.001 g; Agar, 13.5 g and Distilled water, 1 litre. Final pH was adjusted at 7.1. Escherichia coli (EC) was enumerated on Mac Conkey agar plates with colony morphology 2-3 mm in diameter and red in colour.

VI. RESULTS AND DISCUSSION

The various physical chemical and bacteriological parameters of water studied are colour, odour, taste, pH, electrical conductivity, total dissolved solids, dissolved oxygen, free carbon dioxide, alkalinity, chloride, salinity, sulphate, total hardness, calcium, magnesium, nitrite, bi carbonate, phosphate, total Coliforms and E.coli. They are summarised in Table 1 and Table 2.

Parameter	Sasthamcotta Lake Water	KIP Canal Water
pH	6.59	5.80
Conductivity/µS	46	38
TDS (mg/l)	1.64	7.71
Dissolved Oxygen (mg/l)	7.1	10.6
Free CO_2 (mg/l)	5.0	7.5
Alkalinity (mg/l)	14.43	17.14
Chloride(mg/l)	21.2	28.3
Salinity(mg/l)	38.5	51.3
Sulphate (mg/l)	0.10	0.03
Total hardness (mg/l)	13	10
Calcium as Ca (mg/l)	2.94	2.52
Magnesium Mg (mg/l)	1.3	0.90
Nitrite (mg/l)	0	0
Bicarbonate (mg/l)	0.3	0.2
Phosphate (mg/l)	0.5	0.5

Table 1: Chemical parameters of the water samples

Sample	Total Coliforms (MNP/100 ml)	Escherichia coli (MNP/100 ml)
Lake	> 161	18
KIP canal	> 161	161

Table 2: Bacteriological analysis of samples

CHEMICAL ANALYSIS

pH

pH is a scale of intensity of acidity or alkalinity and measures the concentration hydrogen ions in water. pH of natural water varies around seven (6.5 to 8.5). A lower pH value below 4 produces sour taste and high value, above 8.5 a bitter taste.

The pH values of Sasthamcotta lake water and Canal water are found to be 6.59 and 5.80 respectively which shows that the lake water is slightly acidic and KIP water is more acidic. Also the pH of KIP water shows that it is not within the desirable limit of Indian standard specification for drinking water. Lowering of pH might be due to stagnation, decay of vegetable matters, discharge of domestic sewage and increase of carbon dioxide.

CONDUCTIVITY

Pure water is a poor conductor of electricity. Acids, bases and salts in water make it good conductor of electricity. Thus higher the concentration of electrolyte in water the more is its electrical conductance. The conductance of distilled water ranges from 0.5 to 3 µS and that of fresh water ranges from 150 to 500 µS. Standard value for drinking water given by BIS/WHO is below 700.

Conductivity of lake water is found to be greater than KIP canal water. The relatively low conductivity values of both samples indicate the presence of less dissolved salts.

TOTAL DISSOLVED SOLIDS

A large number of salts are found dissolved in natural water. The common ions are bicarbonates, chlorides, suphates, phosphates and nitrates of Ca, Mg, Na, K, Fe and Mn etc. A high content of dissolved solids reduces the solubility of gases and increases the utility of water for drinking and other purposes. It is especially an important parameter in the analysis of saline lake and marine water and is often expressed as ppt. Samples gave TDS values of 1.64 and 7.71 for Sasthamcotta lake water and Canal water respectively and the latter has the highest value. However the two values are within the permissible limit (ie; 500 mg/l).

DISSOLVED OXYGEN

Dissolved oxygen (DO) levels in the natural and waste water depend on the physical, chemical and biochemical activities of water body. In water pollution evaluation and waste water treatment, the determination of DO is a key component. DO is an important water quality parameter because for the self-purification of water bodies sufficient DO must be available. Most aquatic organism acquires oxygen from water. Oxygen is crucial to photosynthesis and respiration. The DO always affects the solubility of contaminants such as toxic heavy metals. Low DO levels are often the result of organic pollution.

Lake and KIP water showed DO level 7.1 mg/l and 10.6 mg/l respectively [is enriched with oxygen]. Water from both sources showed concentration of DO greater than 6 mg/l, the minimum concentration required for a contamination free water body.

FREE CARBON DIOXIDE

In natural waters most of the alkalinity is caused due to CO_2 respiratory activity of aquatic organisms and the process of decomposition are important sources of in bodies of surface water. Free CO_2 combines with water partly to form carbonic acid (H_2CO_3) which dissociates as follows.

$$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^- \rightarrow 2H^+ + CO_3^{2-}$$

The free CO_2 content is higher in KIP canal (7.5 mg/l) and lower in Sasthamcotta lake (5 mg/l)

ALKALINITY

Alkalinity of water is its acid neutralizing capacity. The alkalinity is an indication of the concentration of bicarbonate, carbonate and hydroxide ions. The measured values also include contributions from borates, phosphates, silicates or other bases. Alkalinity measurements are used in the interpretation and control of water and waste water treatment process. The alkalinity values showed by Lake and KIP canal water are 14.43 mg/l and 17.14 mg/l respectively. Compared to lake water KIP water showed a very high value. It may be due to contaminants added through washing of clothes and bathing of humans as well as animal during the harsh summer. Yet both values are within the desirable limit (200 mg/l).

CHLORIDE

Chloride is one of the major inorganic anions in water. A salty taste is produced when the chloride concentration is high. However it depends on the chemical composition of water. Presence of chloride is commonly considered as an indicator of human activity. In natural fresh waters high concentration of chloride is considered to be an indicator of pollution due to organic wastes of animal origin (animal excreta has high quantity of chlorides along with nitrogenous wastes).Industrial effluents may increase the chloride content in natural waters. Chloride content above 250 mg/l makes the water salty in taste. However a level of up to 1000 mg/l is safe for human consumption.

Chloride content is found to be greater in KIP canal (28.3 mg/l) water than the lake (21.2 mg/l). So the human activity may be greater in KIP canal water and hence it is more polluted. However, both the samples contain Cl^- ion within the desirable limit for drinking water specification (250 mg/l).

SALINITY

It is a critical factor in deciding about the suitability of water for consumption as well as irrigation. It therefore clear that KIP water (51.3 mg/l) is more saline than lake water (38.5 mg/l). Sea water normally contains 35000 mg/lit of Salt. Water containing more salt used for irrigation may eventually lead to secondary salanization. These values are also within desirable limit.

SULPHATE

In all natural waters sulphates are found. Water with about 500 mg/l sulphate has a bitter taste and those with 1000 mg/l or more may cause intestinal disorders. Values shows the sulphate concentration of the lake (0.1 mg/l) and KIP water (0.03 mg/l) are comparatively low and within the desirable limit of drinking water specification (150 mg/l).

TOTAL HARDNESS

Total hardness of water is the sum of concentration of alkaline earth metal cations present in it. Calcium and magnesium are the principal cations imparting hardness. However, to lesser extent cations like iron, manganese and strontium also contribute to hardness. Hardness of water prevents lather formation with soap and therefore hard water is not suitable for bathing and washing. Hard waters have high boiling point and hence it is not suited for cooking too. It is important in industrial use as well.

Total hardness of lake water (13mg/l) is found to be greater than KIP canal water (10mg/l). However both are within the permissible limit (500mg/l).

CALCIUM

It is found in abundance in all natural waters and its source lies in the rocks from which it is leached. Its concentration varies greatly in natural waters depending upon the basin. It is an important micro nutrient in an aquatic environment. Being an important contributor to hardness in water it reduces the utility of water for domestic use. From the table it is clear that calcium content in both the samples (2.94mg/l for lake water and 2.52mg/l for KIP canal water) is within permissible limit (75mg/l) of drinking water standard.

MAGNESIUM

The source of magnesium in natural waters is from chemical weathering of rocks and chemical fertilizers. It is generally found in low concentration than Calcium. Concentration of mg above 150 mg/l if present with sulphate may cause gastro intestinal problems and diarrhea. Determination gave very low values for lake (1.3mg/l) as well as KIP water (0.9mg/l) and it is well within the drinking water specification.

NITRITE

Nitrite is the partially oxidized form of nitrogen found in very low concentration in natural waters. It has no mineral source in water, but occurs as an intermediate form during dentrification and nitrification reactions. Presence of even minute quantity of nitrite in water is indicative of organic pollution and prevailing low oxygen concentration. Both samples of water have zero concentration of nitrite and obey drinking water specification. At high concentration it may cause blue- baby disease.

BICARBONATE

Water containing free CO_2 reacts with lime stone or chalk ($CaCO_3$) of soil or sediment producing calcium bicarbonate [$Ca(HCO_3)_2$] Calcium bicarbonate remains in solution if it is in equilibrium with a certain amount of free CO_2 in water.

It is found that lake water (0.3mg/l) contains slightly greater amount of bicarbonate than KIP water (0.2mg/l). But it is within the limits of drinking water specification.

PHOSPHATE

Phosphorous is one of the key elements necessary for growth of plants and animals. Phosphates are formed from this element. Organic phosphates are important in nature. Their occurrence may result from the breakdown of organic pesticides which contain phosphates. They may exist in solution, as particles. Lakes and rivers serve as phosphorous sink .Rainfall can cause varying amounts of phosphates to wash from farm soils into nearby water ways. Phosphates will stimulate the growth of phytoplankton and aquatic plants which provide food for fish. This may cause an increase of fish population and excess of phosphate causes eutrophication that leads to low amount of DO in water.

Phosphates are not toxic to people and animals unless they are present in very high levels. Phosphate levels greater than 1.0 mg/l may interfere with coagulation in water treatment plants. As a result organic particles that harbor in micro organisms may not be completely removed before distribution. It is found that phosphate level in lake water and KIP canal water are 0.5mg/l each. Their occurance may result from the breakdown of organic pesticides, detergents and soaps. Yet both of them obey Indian Standard for drinking water specification since the phosphate level is less than 1mg/l.

BACTERIOLOGICAL ANALYSIS

Contamination of water with coliforms makes water unsatisfactory for drinking. Faecal coliforms by themselves are not disease causing while some strains are known to cause diarrhoea. Human excreta are the main source of fecal pollution in the lake. The domestic sewage from the thickly populated belt around the lake contributes the drainage impurities especially during rainy season. The results are shown in Table 2.

Both samples show the presence of total coli forms and Escherichia coli. Hence from this point of view, water from the Sasthamcotta lake and KIP Canal are unfit for drinking purpose without sufficient purification. This dangerous situation may be due to the contamination of fecal matters released into the soil and water. But it is very important that treated water entering into distribution system shall not contain Escherichia coli and thermo tolerant coliform bacteria in any 100 ml sample.

VII. CONCLUSIONS

With the country reeling under severe dry spell during this summer the water level in our Sasthamcotta lake was lowest ever since. Sasthamcotta lake is the drinking water source of whole Kollam Distict and so, as a collective effort to save the lake, the Government of Kerala has decided to use water from KIP canals for this purpose in April 2016. In this context we have compared the water qualities of Sasthamcota lake and KIP canal. Also compared it with the standard insisted by Bureau of Indian Standard insisted for drinking water specification.

Here we have compared three physical parameters such as colour, odour and taste, fifteen chemical parameters such as pH, conductivity, total solid content, dissolved oxygen, free carbon dioxide, alkalinity, chloride, salinity, sulphate, total hardness, calcium, magnesium, nitrite, bicarbonate and phosphate and two bacteriological parameters such as Total coli form and Escherichia coli.

Studies showed that both Sasthamcotta lake water and KIP canal water obeyed all the physical and chemical parameters of drinking water specification except pH in the case of KIP water (5.8). The drinking water specification by BIS is (6.5 - 8). It might be due to the discharge of domestic sewage and increasing free carbon dioxide content in KIP water than in the lake. But from the bacteriological point of view both samples contain T.C and E.C (more in KIP water) and both samples are found to be unfit for drinking without sufficient purification.

Recommendation to mitigate the situations are discharge of human wastes sewage and other pollutants directly into the lake should be strictly banned, agricultural cultivation on the immediate vicinity of Sasthamcotta lake should be controlled, periodic evaluation of water quality should be conducted, bathing and direct washing of cloths in the lake should be prohibited and minimize the utility pressure of water from Sasthamcotta lake.

ACKNOWLEDGEMENT

The authors are thankful to Cashew Export Promotion Council (CEPC), Kollam, Kerala for doing the bacteriological analysis and KSMDB College for doing chemical analysis.

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