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A brief study on the physicochemical parameters and the microbial flora of an eutrophic lake: Perungalathur Lake (Peria Eri), Chennai, Tamil Nadu, India

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Abstract
Water is a critical resource in the lives of people who both benefit from its use and who are harmed by its misuse and unpredictability (flooding, droughts, salinity, acidity, and degraded quality). Water is a finite and vulnerable resource. Consequently, consumption of polluted water puts lives and livelihoods at risk because water has no substitute. There are many ways in which water intended for human consumption can get polluted. These include wastes from industries like mining and construction, food processing, radioactive wastes from power generating industries, domestic and agricultural wastes and by various microbiological agents. Water pollution is a serious threat all over the world in the light of limited fresh water availability and increasing generation of waste water being discharged either on land or into rivers, lakes, water bodies or sea thereby polluting the fresh water available in rivers, lakes, water bodies, and groundwater. The water pollution scenario in India is equally critical posing great threat to human health, aquatic life, vegetation and ecological balance. In this paper, the effects of polluted lake water and analyzed by various analytical tests that this lake water was highly contaminated by the open defecation activities and mixture of domestic wastes which has been confirmed by the presence of microbial agents like *Escherichia coli* and *Staphylococcus aureus* hence it's not suitable for human consumption has been proved.

Keywords: water pollution, aquatic life, domestic wastes, open defecation, *Escherichia coli*, *Staphylococcus aureus*

Introduction

Water covers about 70% of Earth's surface. Safe drinking water is a basic need for all humans. The WHO reports that 80% of diseases are waterborne. Lakes contain 50.01% of all the water on the Earth's surface, they hold 49.85% of the liquid surface fresh water. (Rachna and Disha, 2016) [62]. Industrialization, discharge of domestic waste, radioactive waste, population growth, excessive use of pesticides, fertilizers and leakage from water tanks are major sources of water pollution. Organic manuring also leads to severe depletion of dissolved oxygen, high biological and chemical oxygen demand, and high ammonia levels. (Boyd, 1982). Heavy metals released from domestic, industrial and other man-made activity may contaminate the natural aquatic system extensively (Velez, 1998) [84]. Contamination of fresh water with a wide range of pollutants has become a matter of concern over the last few decades (Vutukuru, 2005) [87]. In order to evaluate the adverse effects of the pollutants on aquatic organisms, there is a worldwide trend to complement physical and chemical parameters with biomarkers in aquatic pollution monitoring (Abdel *et al.* 2012) [3]. In the last few decades, an increase in population density, heavy industrialization and agricultural activities have resulted in more and more waste entering freshwater resources (Chavan and Muley, 2014) [18].

Aim & Objectives of Present Study

To assess some of the physico-chemical parameters such as pH, Alkalinity, Total Hardness, Calcium, Nitrates, Fluorides, Phosphates, etc.
To identify the microbial flora of the lake.
To identify the Aquatic plant varieties growth in the lake.
To isolate and identify the microbes.

The water samples were collected from the Perungalathur Lake (Periya Eri) during the period between October 2020 - February 2021 during and after the monsoon period.

Materials and Methods
Materials
Collection of Water Samples: Water samples were collected from three different sampling sites (Site I, Site Il and Site II) in plastic containers and were brought to the laboratory with due care and were stored at 20 °C for further analysis. Water samples of about 10 litres were collected for a period of 5 months from October 2020 – February 2021. The sampling sites were designated as follows:

Site I: Water samples collected from the first entrance of Perungalathur Lake.

Site II: Water sample collected from the second entrance located on the opposite side of the first entrance of Perungalathur Lake.

Site lll: Water sample collected from the peripheral side located on the central art of the Perungalathur Lake.
Water Samples for isolation and identification of microbes (Bacteria): Water samples of about 3 litres were collected from site I, site II and site III in sterile bottles and were brought to the laboratory. Microbial analyses were carried out on the same day of collection for a period of 5 months from October 2020 to February 2021.

Collection of Phytoplankton: Phytoplankton were collected by using phytoplankton net from Site I, Site II and Site III of Perungalathur Lake (Periya Eri), Perungalathur.
Collection of Macro flora (Aquatic Plants): Aquatic plants were collected by hand picking method from site I, site II and site III of Perungalathur Lake (Periya Eri), Perungalathur and identified.

Collection of Macro fauna: Crabs and Snails are collected by hand picking. Fishes, Prawns and aquatic insects were collected using a casnet of 2 metres diameter and mesh size 14 of inch. The fishes were collected randomly from the sampling sites I, II and II and identified.

Methods
Physico - Chemical Characteristics of water samples from site I site II and site III of Perungalathur Lake Periya Eri) were determined by following the standard methods outlined by APHA (2010).
The bacterial species isolated and identified by the Spread Plate Method and identification of gram positive or gram negative done by using Gran's Method.

Results
Results of the analyses of Physico-Chemical parameters of water samples from Site I, Site II and Sata III of Peria Eri, Perungalathur for a period of 5 months (October 2020 - February 2021).

Physical Parameters
Colour: Colour of the water samples collected from Site I of Perungalathur Lake (Periya Eri) is slightly yellow. Site II of Perungalathur Lake (Periya Eri) is also slightly yellow and whereas Site III the colour of the water sample is yellow.

Odour: Samples collected from Site I and Site II have a faint smell, whereas the sample has sewage smell in Site III.

Water Temperature: Water temperature from Site I shows a minimum of 26 °C (October 2020), Site II shows an optimum temperature of 30 °C (December 2020) and whereas in site III water temperature shows a maximum of 31°C in (February 2021).

pH: The pH value of water samples recorded in Site I and Site II has alkaline in nature whereas Site III has highly alkaline (9.0) in nature (February 2021).

Chemical Parameters
Electrical Conductivity (EC): The electrical conductivity of water decreased in Site I and Site II during (October to November 2020) where the electrical conductivity increases Site III during (January to February 2021).
Turbidity: Turbidity from Site I and II shows a slightly turbid where as in site III shows highly turbid.

Total Dissolved Solid (TDS): Total dissolved solids in the water Samples in the Site I ranges from 828 g/L (October 2020), in Site II the total dissolved solids range from 848 g/L and whereas in Site III the total dissolved solids range from 858 g/L (February 2021) revealing that TDS level in both sites are normal than the permissible limits (900 g/L) of W.H.O. (1995).
Total Suspended Solid (TSS): Total suspended solids in the water samples in the Site I range from 924 g/L (October 2020), in Site II, the total suspended solids range from 929 g/L (December 2020) and whereas the total suspended solids range from 995 g/L (February 2021) revealing that TSS level in both sites are normal than the permissible limits (1200 g/L) of APHA (2010).

Dissolved Oxygen (DO): Dissolved oxygen levels in the water samples in the Site I range from 2.10 mg/L (October 2020), in Site II, the dissolved oxygen levels from 2.50 mg/L (December 2021) and where as in Site III ranges from 2.51 mg/L (February 2021) revealing that the dissolved oxygen level in both sites are less than the permissible limits (50 mg/L) of BIS (1991) [16].

Biological Oxygen Demand (BOD): In site I, biological oxygen demand levels from 1.12 mg/L (October 2020) in Site II the values range from 1.15 mg/L (December 2020) and whereas in site III the values range from 2.0 mg/L (February 2021) revealing that the BOD level is normal than the permissible limits (2.0 mg/L) Singh *et al*., (2007).

Chemical Oxygen Demand (COD): In Site I, Chemical Oxygen demand levels from 1.10 mg/L (October 2020), in Site II the values range from 1.15 mg/L (December 2020) whereas in Site III it ranges from 1.17 mg/L (February 2021) revealing that the COD level in less than the permissible limits (2 mg/L) (Singh *et al*., (2007).

Total Alkalinity: The total alkalinity levels in Site I ranges from 198 mg/L (October 2020), in Site II the values range from 201 mg/L (December 2020) whereas in Site III the values range from 228 mg/L (February 2021) revealing that the alkalinity level is lesser than the permissible limits 20 (µmol/L) (October 2021), In Site II the values range from 230 (µmol/L) (December 2020). Whereas the values range from 240 (µmol/L) in the Site III. (February 2021) revealing that the total hardness level is lesser than the permissible limits 350 (µmol/L) (Singhal RN, 1986) [72].

Calcium: The amount of calcium in the water sample of Site I ranges from 72 (µmol/L) (October 2020), In Site II, the values range from 82 (µmol/L) December 2020). Whereas the values range from 84 (µmol/L) (February 2021) in Site I revealing that the Calcium level is lesser than the permissible limits (150 (µmol/L) (Angadi SB, 2005) [8].

Nitrate: The amount of nitrate in the water sample of site I ranges from 18.72 (µmol/L) (October 2020), in Site II the values range from 18.92 (µmol/L) (December 2020). Whereas in Site III values range from 19.2 (µmol/L) (February 2021) in Site I revealing that the nitrate level is lesser than the permissible limits (200 (µmol/L)) (Anderson *et al*, 1998) [7].

Phosphate: The amount of phosphate content in Site I ranges from 118 (µmol/L) (October 2020), in Site II it ranges from 125 (µmol/L) (December 2020). Whereas in Site III it ranges from 131 (µmol/L) (February 2020) revealing that the phosphate level is normal than the permissible limits (400 (µmol/L) (Moss B, 1989) [53].

Fluoride: Fluoride levels in the water samples in Site I ranges from 116 (µmol/L) (October 2020), in Site II the Fluoride level ranges from 128 (µmol/L) (December 2020). Whereas in Site III the Fluoride level ranges from 130 (µmol/L) (February 2021) revealing that the Fluoride level in both sites is lesser than the permissible limits (500 (µmol/L) of CPCB (1995) [24].

Salinity: Salinity levels in the water samples in Site I ranges from 1.28% (October 2020), In Site II the Salinity level ranges from 2.21% (December 2020). Whereas in Site Ill the salinity level ranges from 2.31% (February 2021) revealing that salinity levels in both sites are less than the permissible limits (36%) of WHO (1995).

Silicates: The amount of silicate in the water samples of Site 1 ranges from 20.19 (µmol/L) (October 2020), In site II, the values range from 22.10 (µmol/L) (December 2020). Where as in site the values range from 23.15 (µmol/L) (February 2021) revealing that the Silicate level is lesser than the permissible limits 200 (µmol/L) (Singhal, 1986) [72]

Table 1: Physio-Chemical Parameters of Perungalathur Lake During Oct 2020- Feb 2021.

S. No	Parameters	Site I	Site II	Site III
	Physical Examination			
1.	Colour	Slightly yellowish	Slightly yellowish	Yellowish
2.	Odour	Faint smell	Faint smell	Sewage smell
3.	pH	8.1	8.5	9.0
4.	Temperature (℃)	26	30	31
	Chemical Examination			
5.	Electrical Conductivity (µmol/cm)	1300	1300	1400
6.	Turbidity	Slightly turbid	Slightly turbid	Highly turbid
7.	TDS (g/L)	828	848	856
8.	TSS(g/L)	924	929	935
9.	DO (mg/L)	2.10	2.50	3.0
10.	BOD (mg/L)	1.12	1.41	1.42
11.	COD (mg/L)	1.10	1.15	1.17
12.	Salinity (%)	1.28	2.21	2.31
13.	Alkalinity (mg/L)	198	201	228
14.	Calcium (µmol/L)	72	82	84
15.	Total hardness(µmol/L)	220	230	240
16.	Phosphate(µmol/L)	11.8	12.5	13.1
17.	Nitrate(µmol/L)	18.72	18.92	19.2
18.	Fluoride(µmol/L)	116	128	130
19.	Silicate(µmol/L)	20.19	22.10	23.15

Isolation and Identification of Microbes (Bacterial Species) from water samples of Perungalathur Lake (Peria Eri), Perungalathur.

Bacterial Species: The results of isolation and the identified species were Escherichia Coli
(Site I), Staphylococcus aureus (Site II) and *Staphylococcus aureus* (Site III).

Identification of Phytoplankton from water samples of Perungalathur Lake (Peria Eri), Perungalathur: The results of identification of phytoplankton from Site I, Site II and lII of water samples of Perungalathur Lake. The identification of phytoplankton is represented by three classes such as Bacillariophyceae. Chlorophyceae and Cyanophyceae.

Identification of Macrofauna from water samples of Perungalathur Lake (Peria Eri), Perungalathur: The results of the study revealed that only one species of crab namely *Paratelphusa* (Oziotelphusa) *hydromus* alcocu was identified in Site II. Whereas 2 species of snails namely Bithynia, Helisoma were recorded only in Site II. 2 Species of fishes namely *Gambusia affinis* and *Tilapia mossambica* were identified from both sites I and II of water samples collected from Perungalathur Lake (Peria eri), Perungalathur.

Identification of Microflora from water samples of Perungalathur Lake (Peria Eri), Perungalathur: The results of the study revealed that 4 species of aquatic plants namely Pistia. Lantana, Water Lily, Hydrilla, Vernonia, etc.

Statistical Analysis

$$\text{Bacteria Enumeration} = \frac{\text{Bacterial sp. (no. of colonies)}}{\text{Number of totals}} \times 360$$

S. No	Bacterial Sp.	No. of Colonies
1.	*Escherichia coli* (A)	212
2.	*Staphylococcus aureus* (B)	209
3.	*Staphylococcus aureus* (C)	199
	Total	620

Discussion

Water is an essential thing for living organisms. Rapidly developing countries like India were facing severe problems of pollution of rivers and lakes use of unplanned urban, industrial and agricultural growth in the catchment, lack of concern for the environment and ineffective regulatory control mechanism (Wani *et al*., 2002) [88]. Not only there was an increasing concern rapidly deteriorating supply of water but the quality of utilizable water is also fast diminishing. The wide array of pollutants being discharged into the aquatic environment may have Physico-Chemical, biological and pathogenic effect (Goel, 2000) [35]. Hence, it was an imperative that proper monitoring and control of pollution of various aquatic bodies following strict enforcement standards. Lake pollution was a serious water pollution problem, it affects the abiotic and biotic factors of different aquatic systems in different degrees and its ultimately effect on man remains quite drastic in medical, aesthetic and economic sense (Augustin, 1969). Excessive nutrient levels in aquatic system can also cause ecological problems, they may lead to extensive growth of aquatic weeds such as *Eurasion milfoil*, water hyacinth, water chestnut etc. Excessive growth of these weeds can impair fishing, bathing, fish spawning, shellfish production and even navigation (Sculthorpe, 1967). Oil spills have tilled water birds, mammals, fish and vegetation which were present in the water. (Hunt, 1965). The untreated effluents of different industries might be highly dangerous when discharged into open water bodies (Murugesan and Kalaichelvan, 2003). The essential resource was becoming increasingly scare in impairment of water quality (Dwivedi and Pandey, 2002). Hosmani & Bharathi (1977). Naganandini & Hosmani (1990), Sreenath (1994) and Anil Kumar (1998) have stressed the importance of alkalinity, dissolved oxygen, phosphate, and nitrate in the abundance of Euglenophyceae. Zafar (1959) has emphasized the importance of alkalinity in the abundance of euglenoids and states that a higher pH favors their growth. Analysis of different Physico-Chemical parameters of water bodies helps to evaluate its pollution load and whether it is suitable for drinking or not. Quality of drinking water, which was declared as potable is set against certain standards like WHO (1996), APHA (2010).

Greenish colour of the Lake water might be due to presence of impurities and phytoplankton presence of floating and suspended materials make the water turbid and non-transparent.

The results of this study revealed that the turbidity of water samples from site I & site II is slightly turbid and highly turbid in site III which is mainly caused by suspended particles such as clay, silt, finely divided organic and inorganic matters, plankton and other microscopic organisms, decaying vegetation, organic matter and high planktonic growth and it is in accordance with the findings of Iqbal and Kataria (1995) [40] and Radhika *et al*. (2004) [61]. A decrease in the conductivity in sites I, II and III of water samples might be due to the absorption of settled minerals by the submerged macrophytes, which were present in abundance. The above findings were in accordance with the observations of Kaushi and Saksena (1999) [46] and Radhika *et al*. (2004) [61]. High values of alkalinity in this study in sites I, Il and III of water samples was due to evaporation and entry of more domestic water when the rate of flow of water is low (Sankar *et al*., 2002). The results of this study revealed that the turbidity of water samples from site I & site II was slightly turbid and highly turbid in site III which was mainly caused by suspended particles such as clay, silt, finely divided organic and inorganic matters, plankton and other microscopic organisms, decaying vegetation, organic matter and high planktonic growth and it was in accordance with the findings of Iqbal and Kataria (1995) [40] and Radhika *et al.* (2004) [61].

A decrease in the conductivity in sites I, II and III of water samples might be due to the absorption of settled minerals by the submerged macrophytes, which were present in abundance. The above findings were in accordance with the observations of Kaushi and Saksena (1999) [46] and Radhika *et al.* (2004) [61], In the present study TDS of sites 1, II and III was high from October 2020 to December 2020. Higher values of TDS were due to the addition of sewage with the lake water (Mamta Tiwari, 2005) [50] and low level of TDS in January and February 2021 might be influenced by physical forces such as evaporation (Radhika *et al*, 2004) [61].

TSS consists of particles of different sizes ranging from coarse to fine colloidal particles of various organic complexes and plankton (Radhika *et al*, 2004) [61]. TSS in the present study were found to be within the permissible limits in both sites I and II of water samples.

The dissolved oxygen is one of the important parameters in water quality assessments (Solanki *et al*, 2006) [76]. Decrease allochthonous in the dissolved oxygen level in sites I, II and III in this study might be the result of utilization of dissolved oxygen for the decay of autochthonous and materials that get dumped (Radhika *et al*., 2004) [61]. A low value of dissolved oxygen was also due to the increased microbial activity in the water. (Naga Prapurna and Shashikanth, 2002) [55] and (Mamta Tiwari. 2005) [50]. A low content of dissolved oxygen was a sign of organic pollution (Bhatt *et al*. 1999) [14]. Dissolved oxygen depiction could also be attributed to the phytoplankton respiration and sediment oxygen demand (Wani *et al*, 2002) [88].

Values of Biological oxygen demand directly given the extent of pollution in water samples. Biological oxygen demand values of the site I, II and III in the present analysis were above the permissible level as suggested by CPCB for drinking, bathing and swimming (Radhika *et al*, 2004) [61]. Higher value of Biological oxygen demand might be due to higher rate of organic decomposition (Bhatt *et al*, 1999) [14]. Low chemical oxygen demand values recorded in sites I, I and III in the present study might be the result of sedimentation of organic materials to the bottom, which was in the agreement with the findings of (Dakshini and Soni 1979: Ajmal *et al*, 1988 and Radhika *et al*, 2004) [61].

Calcium was a very important element influencing the flora of ecosystem which played a potential role in metabolism and growth and in the present study calcium level in sites I, II and II were below the permissible limit of CPCB (1995) [24]. Very low concentration of nitrate in sites 1. II and III in this study might be due to the utilization of nitrate for the luxuriant growth of macrophytes (Radhika *et al*. 2004) [61].

The presence of fluoride concentration in a water source was used as an indicator of organic pollution by domestic sewage (NEERI, 1979; and Chandrashekar *et al* 2003) [57, 19]. There was a direct relation between fluoride concentration and pollution level. Low fluoride values (October 2020 to February 2021) in both the sites in the present study coincide with the findings of Kaushik *et al,* (1991) [47] and Trivedi (1993) and this high concentration of fluoride given an undesirable taste of water (Mamta Tiwari, 2005) [50]. Low concentration of fluoride ion (January to February 2021) in this study in the lake water indicated the low amount of organic waste of animal origin which was supported by the work of Prithwiraj Jha and Sudip Barat, (2003).

Increase of phosphate in sites I, II and III in this study might be due to decayed phytoplankton and concentration of zooplanktons. Lower concentration of phosphate in this study might be a clue to higher consumption of phosphates by macrophytes. (Bhatt. *et al,* 1999 and Prithwiraj Jha and Sudip Barat, 2003) [14]. From the analysis of physicochemical characteristics from three sites of water samples of Perungalathur Lake, Perungalathur. TDS, BOD, Alkalinity were found to be higher than the permissible limits for drinking water standards prescribed by CPCB (1995) [24] indicated high pollution goal of the water samples. The study was further extended to analyse the microbes. microflora and macro fauna of water samples of Perungalathur Lake as they act as bio indicators of pollution of water.

The present study revealed the presence of prominent bacterial forms in the Perungalathur lake were *Escherichia coli* and *Staphylococcus aureus* which was in accordance with the work of Sultana (2002) [79]. The presence of bacteria in the present study indicated the contamination of water with the fecal matter, because it was very clear that people of this area defecate, discharge and wash in the same area, which includes definitely discharge of diverse micro flora of bacterial taxa like *Escherichia coli* and *Staphylococcus aureus* which were pathogens as stated by Goel (2000) [35]. In the present study *E. coli* fulfills the condition to the best possible extent which acts as an ideal indicator of fecal pollution. The advantage of testing E. coli rather than specific pathogens which would be present in both healthy as well as diseased human intestines in large numbers and billions of them are excreted daily by an average person. (Goel, 2000 and Sengupta, 2002) [35]. In general, for every pathogen in contaminated water, there are billions of *Escherichia coli*, which survive longer in water than most pathogens. Hence, it could detect recent and earlier pollution.

Among the phytoplanktons, Chlorophyceae and Bacillariophyceae were dominant followed by Cyanophyceae in the both sites of water samples of Lake and data indicated that the lake was tending towards eutrophication (Abbasi, 1996) [1]. Variation in the phytoplankton population in this study might be a clue to temperature variation (Bhatt *et al*., 1999) [14]. Presence of aquatic plants in three sites I, II and III of Perungalathur Lake indicated the pollution level of the lake (Sultana, 2002) [79]. There was a lack of diversity in the fish found in the lake in this study which was supported by the work of Abbas (1996) [1]. The presence of crabs, snails act as bioindicators of the pollution of Perungalathur Lake.

Though the water samples from sites I, II and III of Perungalathur Lake are polluted, the water of site III was highly polluted than site I & II of Perungalathur Lake. Thus, from various analyses that were carried out in the water of Perungalathur Lake such as Physico-Chemical characteristics, abundance pattern of microbes, phytoplankton, the investigated lake appears to be nutritionally rich. High habitational influence due to dumping of garbage. Fecal contamination, rich growth of macrophytes and macrofauna enrich the nutrient contents of water thereby raising the trophic level of the lake (Jeelani el al, 2005) [41] indicated the pollution status of the Perungalathur Lake, Perungalathur.

Summary and Conclusion
This study was designed to evaluate the pollution status of Perungalathur Lake called "Periya Eri". The lake when it was observed between the period of October 2020 - February 2021 shows more eutrophic in nature which was an alarming situation and if this continuous, for a longer period of time the underground water channels will in turn supply only polluted water to the surrounding locality, and safe groundwater will become a distant dream.

Recommendations
Continuous monitoring of the pollution level is a must in order to promote better living conditions around the lake along with improvement of aquatic life in the lake. The government organizations are to plan for time-to-time monitoring of the water quality along with a check on the influences, standards, with a view to reduce the external contribution into the pollution levels of Perungalathur Lake (Periya Eri), Perungalathur.

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