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Analysis of physicochemical water quality parameters of Buckingham Canal, Chennai, Tamil Nadu, India

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Abstract
Water is a renewable natural resource essential for all life sustaining systems on earth. Fresh water becomes a scarce commodity due to its over exploitation and pollution. The causative factors for the pollution of water are industries, agriculture and domestic activities. Further, the industrial growth and consequent pollution let into the freshwater system in the form of sewage are a challenge to this fragile ecosystem. Therefore, keeping in view of the above mentioned factors, the physicochemical parameters of the Buckingham canal were investigated in the present study. The water samples were collected on a monthly basis from the study site from March 2011 to February 2012. The samples thus collected appeared to be brownish/blackish in colour and the odour was found to be with a fishy sewage smell. The mean minimum and maximum water temperature were recorded as 21.1 and 32.5˚C and the atmospheric temperature was 22.5 and 34.7˚C respectively. The average pH of the water samples was found to be a minimum of 7.24 and a maximum 8.36. Electrical conductivity varied from a minimum of 1546.0 to a maximum of 2215.0µmhos/cm. The turbidity values ranged from 150.0 to 258.0NTU and total alkalinity was high in summer (1396mg/L) while the minimum values fell during monsoon (175.0mg/L) and winter (150.0mg/L). Total suspended solids level ranged from a minimum of 280.0 to a maximum of 360.0mg/L. Total dissolved solids level ranged between a minimum of 1422.0 and a maximum of 4250.0mg/L. Total hardness values ranged from 270.0 to 1265.0mg/L respectively. The mean dissolved oxygen value of the water samples ranged from 3.5 to 5.9mg/L. For biological oxygen demand, the values ranged from 146.0 to 511.0mg/L, and for chemical oxygen demand it varied between 640.0 and 1572.0mg/L. Changes in the water quality affect the biotic community of the aquatic ecosystem which ultimately reduces the primary productivity thus affecting the entire aquatic ecosystem.

Keywords: Buckingham Canal, physicochemical, water quality parameters

Introduction
Since the industrial revolution, industries have been booming and, consequently, millions of anthropogenic compounds have entered our environment. Persistent organic pollutants have been found even in remote areas of the world [1]. Pollution may be defined as the presence of undesired natural or anthropogenic substances in our environment or a chemical that exceeds normal background level and has the potential to cause harm. Harm is taken to include biochemical or physiological changes that adversely affect an individual, organism's ability to breed, grow or survive [2]. Water is the renewable natural resource essential for all life sustaining systems on the earth. Majority of water available on earth is saline in nature. Only a small quantity exists as fresh water. Fresh water becomes a scarce commodity due to over exploitation and pollution of water. Increasing pollution and its necessities healed to the deprivation of surface and sub-surface water. The causative factors for the pollution of water are industries, agriculture and domestic activities. Further, the industrial growth and consequent pollution let into the freshwater system are a challenge to this fragile ecosystem. The ability of water bodies to clean themselves has been affected by the sheer quantity of waste generated by ever increasing population [3]. The quantity of utilizable water decreases due to over exploitation and also by pollution. Wise and restrained use of the earth's resources, especially water being the most vital one is emphasized [4]. For the quantification of the effects of aquatic habitats contamination, analysis of the composition of aquatic constituents, physicochemical and biological parameters are needed. Therefore, keeping in view of the above mentioned factors, the physicochemical water quality parameters of the Buckingham canal were investigated in the present study.

2. Materials and Methods

2.1 Study Area

Chennai (Madras) the capital of Tamil Nadu is situated on the eastern coast of India (13.0827° N, 80.2707° E). There are three waterways that flow through the city, *viz*., Cooum river, Adayar river and Buckingham canal. The Buckingham canal is a man-made water canal linking the two rivers, Cooum and Adayar. The portion north of the Cooum is known as the north Buckingham canal, and the portion south of the Cooum as the south Buckingham canal. The canal extends from Nellore in Andhra Pradesh to Marakkanam near Puducherry. The length of this canal in Andhra Pradesh is 257km, and 163km is in Tamil Nadu. Approximately, 31km is within the city limits of Chennai (Figure 1). The canal was known as Lord Clive's canal and later as Buckingham canal. However, the section in Chennai was known as Cochrane's canal for much of the 19th century. The Cooum connects the canal to the Bay of Bengal in the center of Chennai.

Within the city of Chennai, the canal is badly polluted from sewage and industrial effluents, and the silting up of the canal has left the water stagnant, creating an attractive habitat for mosquitoes. The North Chennai Thermal Power Station (NCTPS) discharges hot water and fly ash into the canal as well. Within the city limits of Chennai much of the canal has been used as the railway route of the elevated Mass Rapid Transport System (MRTS). MRTS stations, *viz*., Kotturpuram, Kasturbai Nagar and Indira Nagar have encroached the canal and narrowed its width to less than 50m in few places. Buckingham canal is the most polluted of the three major waterways in the city with nearly 60% of the estimated untreated sewage being let into it daily, including Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) [5] (Figure 2). The three waterways are severely polluted in Chennai city, particularly the Buckingham canal by sewage, sullage, industrial wastes, storm water drainage and garbage, as urbanization has occurred (Figure 3). The water quality is considered to be highly toxic and completely non-potable. Hence, for the present study Buckingham canal was selected to ascertain the physicochemical characteristics of water.

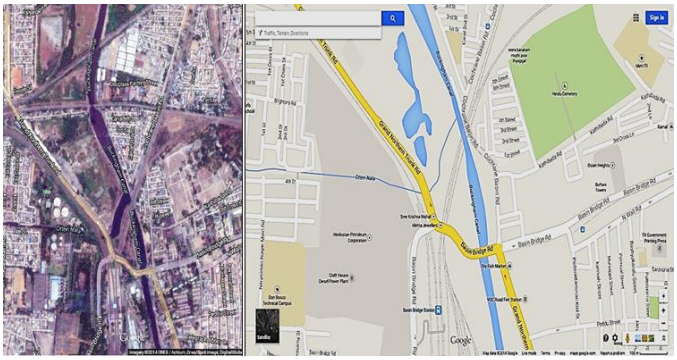

Fig 1: Study area-Buckingham canal

Fig 2: Study site – Buckingham canal.
A, **B**, **C** & **D:** Discharge of industrial wastes;
E, **F**, **G** & **H:** Pollution from slum habitations;
I, **J**, **K** & **L:** Degradable and non-degradable wastes disposal;
M, **N**, **O** & **P:** Point and non-point wastes disposal

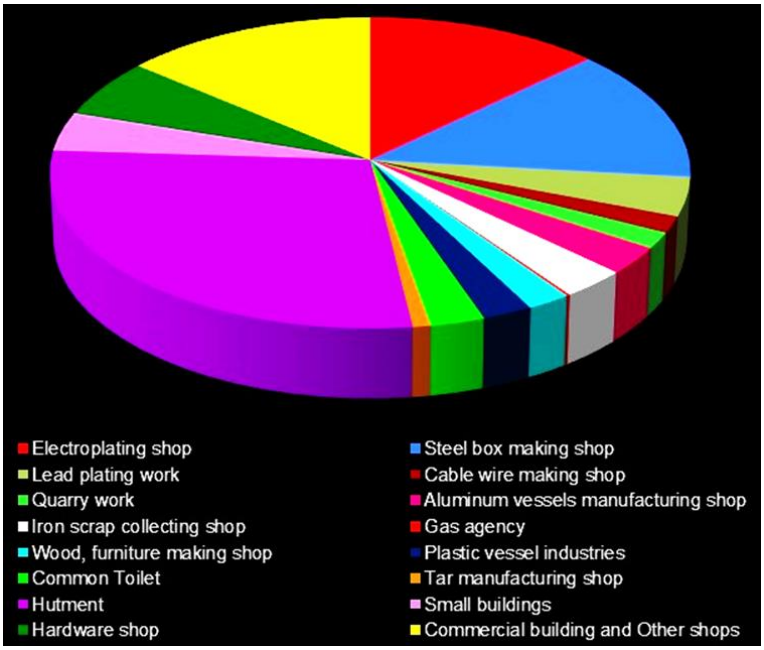

Fig 3: Types of municipal, industrial wastes and sewage discharged into Buckingham canal

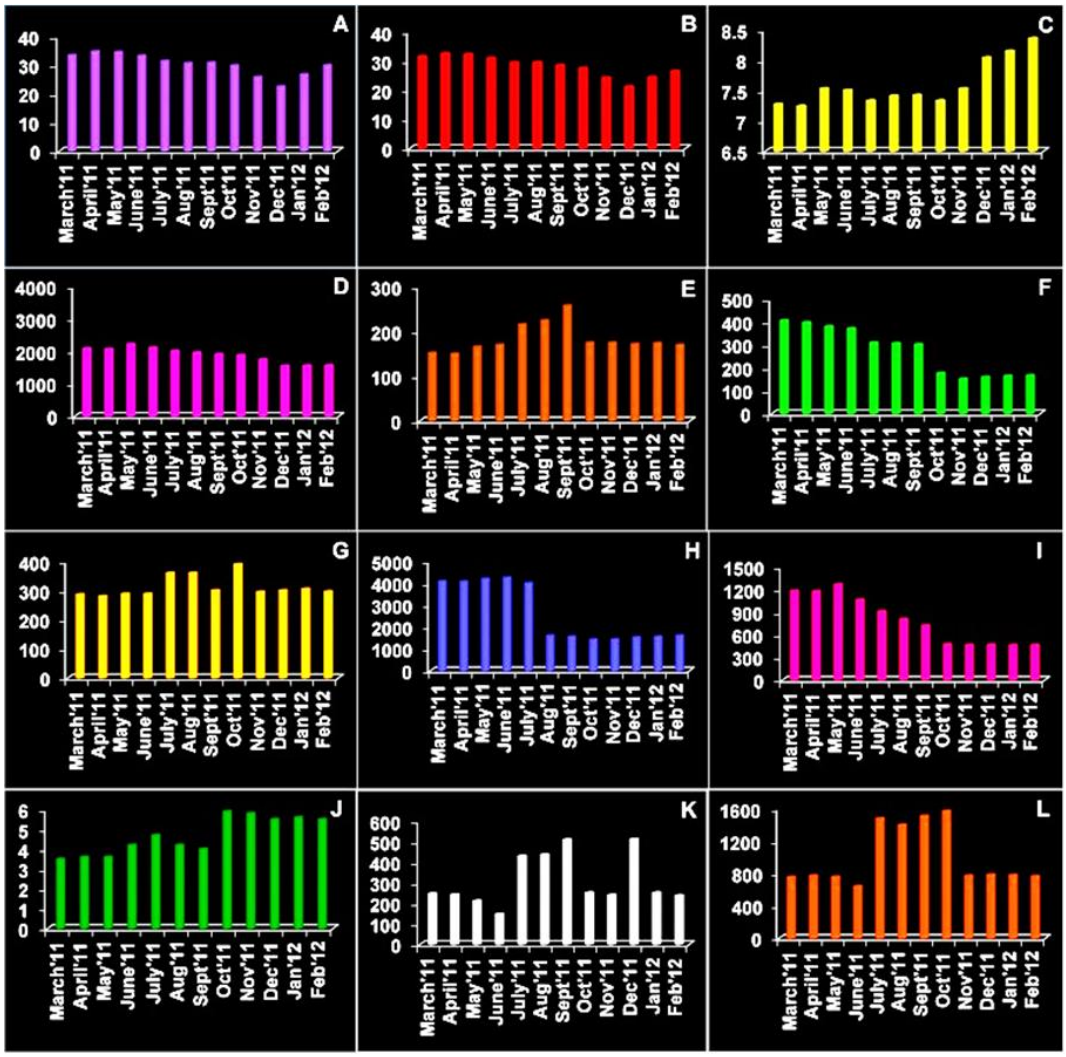

Fig 4: Physicochemical parameters of Buckingham canal.
A: Atmospheric temperature; **B:** Water temperature; **C:** pH; **D:** EC; **E:** Turbidity; **F:** TA; **G:** TSS; **H:** TDS; **I:** TH; **J:** DO; **K:** BOD; & **L:** COD

2.2 Collection and analysis of water samples

The water samples were collected on a monthly basis in triplicate from the study site from March 2011 to February 2012. On the canal side, the water samples were collected at a depth of 2 to 4m from site. The water samples were analyzed for various physical and chemical parameters based on the procedures described in APHA [6]. The physicochemical parameters, *viz*., colour, odour, atmospheric temperature, water temperature, pH, Electrical Conductivity (EC), turbidity, Total Alkalinity (TA), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Hardness (TH), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were studied. Temperature, pH, EC and turbidity were measured using digital thermometer, pH meter, conductivity meter and Nephelometer, respectively.

3. Results

The values for physical and chemical parameters of Buckingham canal during the study period from March 2011 to February 2012 are presented in Figure 4. The water samples collected from the Buckingham canal for the present study appeared to be brownish/blackish in colour and the odour was found to be with a fishy sewage smell. The mean minimum and maximum atmospheric temperature was 22.5 and 34.7˚C and for water temperature it was 21.1 and 32.5˚C respectively. The average pH of the water samples was found to be a minimum of 7.24 ±0.03 and a maximum 8.36 ±0.04. EC varied from a minimum of 1546.0 to a maximum of 2215.0µmhos/cm. High values of EC were recorded in summer (2011) during the present study. The turbidity values ranged from 150.0 to 258.0NTU. TA showed marked seasonal variation and was high in summer (1396.0 ±9.16mg/L) while the minimum values fell during monsoon (175.0 ±6.42mg/L) and winter (150.0 ±1.66mg/L). TSS levels ranged from a minimum of 280.0 to a maximum of 360.0mg/L. TDS levels ranged between a minimum of 1422.0 and a maximum of 4250.0mg/L. TH values varied from 270.0 ±14.0 to 1265.0 ±9.01mg/L respectively. The mean DO value of the water samples ranged from 3.5 ±0.1 to a maximum of 5.9 ±0.1mg/L. For BOD, the values were found to be from 146.0 ±0.72 to 511.0 ±1.22 mg/L, whereas for COD it ranged between 640.0 ±1.05 and 1572.0 ±1.23mg/L.

4. Discussion

Pollution is a gift of rapid industrial revolution and excessive exploitation of natural resources. Majority of the industries are water dependent and a huge volume of wastewater emanates from them which generally is discharged into water courses either untreated or inadequately treated causing water pollution. The impairment of water bodies by unrestricted disposal of industrial effluent makes it imperative for short term and prompt monitoring of the aquatic ecosystem [7]. Water pollution is a global issue; industrialization in developing countries affects the faunal diversity of water because waste water from industries are directly dumped into the water bodies. Increased industrialization, urbanization, population growth and overall man's greed to over exploit nature has created a serious threat to all kinds of life in the form of pollution which has now become a global problem. Not only the industries be responsible for the pollution of air but also for the contamination of water [8]. Water pollution is due to the alteration in physical, chemical and biological characteristics which may lead to harmful effect on human and aquatic biota.

It is generally believed that temperature is one of the important factors in aquatic ecosystems. The mean atmospheric temperature ranged from 22.5 to 34.7˚C and the water temperature of the Buckingham canal from 21.1 to 32.5˚C. pH of natural water is an important environmental factor, the fluctuation of which are linked with the chemical changes, species composition and life processes. It is generally considered as an index for suitability of environment. In the present work, pH ranged between 7.24 and 8.36 and was favorable for an increase in photosynthetic activity. pH of water is regulated by carbon dioxide and bicarbonates. In the present study, alkaline pH observed could be due to evaporation of water of Buckingham canal and therefore is not conducive for aquatic life. The pH was found to be higher than the permissible range recommended by WHO [9]. Similar variations in pH was observed in the water samples of study area by Saha and Pandit [10], Sultana *et al*. [11] and Dheenadayalamurthy and Sultana [12].

EC denotes the measurement of total soluble ions present in the water which is confirmed by the presence of other metals and fluoride as well as other parameters. Generally 0.5 to 1µmhos/cm EC are found suitable for cultivation of crops, however if the range is between 1.0 and 2.0µmhos/cm, only salt resistant crops can be grown. The observed EC values of the water samples of Buckingham canal were found to be very high (ranging from 1546.0 to 2215.0µmhos/cm) and it is detrimental to biotic growth. High EC in dry season represents water with high electrolyte concentration due to evaporation, the 12 to 15 fold higher EC is attributed to high salinity and high mineral content in the water samples of Buckingham canal. The high level of major cations (Na^+, Ca^+ and Mg^+) and concentration of anions (Cl^- and SO_4^-) in lake water was found to increase EC and is in consistent with other studies [12, 13].

Alkalinity is considered as an indicator of productivity. In the present study, high TA indicates the productive nature of the Buckingham canal and it varied between 150.0 and 1396.0mg/L. High TA values are also indicative of the eutrophic nature of the water body. Kambalae and Nnaware [14] also reported that the addition of wastes from organic matter leads to high alkalinity in the aquatic systems. TA increased in summer and decreased in monsoon. This supports the observations of Saha and Pandit [10], Sultana *et al*. [11] and Munawar [15] that the accumulation of bicarbonate in summer is due to increased rate of decomposition. They have discussed the interrelation among pH, carbon dioxide, alkalinity, calcium, carbonate and bicarbonate. This work confirms that similar generalization is true for the Buckingham canal under the present study.

TSS level ranged from a minimum of 280.0 to a maximum of 360.0mg/L. TDS concentration fluctuated between 1422.0 and 4250.0mg/L. Majagi *et al*. [16] studied the heavy metal concentration of Karanja reservoir, Bidar, Karnataka for one year and reported that TDS concentration varied between 89.3 and 422.2mg/L. Wagh [17] observed the total solid value in the range from 221.0 to 235.0mg/L from Harsul lake. Swarnalatha

and Rao [18] studied the water quality of Banjara lake and observed that TDS varied between 168.0 and 462.0ppm.

TH is a measure of capacity to precipitate soap. It is the sum of the polyvalent cations present in water. The untreated domestic sewage and industrial wastes are considered to be important source of calcium and magnesium [19] and is responsible for hardness of water. The ions (Ca^+ and Mg^+) in combination with bicarbonate, carbonate, sulphate, sulphide and other anions make the water hard. Hard water is believed to be more productive than soft waters. Hardness of water affects human health. Hardness of water samples of Buckingham canal varied between 270.0 ±14.0 and 1265.0 ±9.01mg/L whereas in Chromepet lake it varied between 439.25 and 565.38mg/L [20]. Hardness of water is not a pollution parameter but indicates water quality [21]. During monsoon, the hardness was low indicating influence of dilution of water caused by inflow due to monsoon. Similar trend of total hardness was reported in lakes of Bannur, Lingambadi and Hebbal in a study by Jalilzadeh *et al.* [22] as the calcium and magnesium were found to range from 60.0 to 282.0mg/L and 24.0 to 150.0mg/L respectively. Low levels of calcium and magnesium were observed in rainy and winter seasons (68.0 and 125.0mg/L). Similar trend of calcium and magnesium variation (72.33 ±4.93 to 179.3 ±14.97mg/L and 21.33 ±3.05 to 66.66 ±4.16 respectively) was seen in Arakkonam lake [12].

DO is essential for growth of algae and fish production. It did not show any definite annual pattern. A higher concentration during winter and early monsoon are correlated by its inverse correlation with water temperature [23]. In the present study, DO concentration was observed from 3.5 to 5.9mg/L. DO is needed for living organisms to maintain their biological process and it plays a vital role for supporting aquatic life. It is susceptible to the environmental changes as it is evident from the present status of Buckingham canal water [24]. The introduction of oxygen demanding materials, either organic or inorganic, into water caused depletion of DO in Arakkonam lake water [12]. Similar trend was recorded in the Buckingham canal and this poses a threat to higher forms of aquatic life, if the concentration falls below critical point. DO being minimum in summer and maximum in winter showed an inverse relationship with water temperature, which may be due to two reasons. In summer, at high temperature, rate of oxidation of organic matter in water increases and oxygen is consumed in this process. Secondly, at higher temperature, water has lesser holding capacity and oxygen is lost to the atmosphere [10, 15].

BOD is an important parameter to assess the pollution of waters, where the contamination occurs due to disposal of domestic and industrial effluents. BOD of Buckingham canal was recorded as 146.0 ± 0.72 to 511.0 ± 1.22mg/L, in the month of June and December respectively. Similar trend of variation was recorded in the Arakkonam lake in a study by Dheenadayalamurthy and Sultana [12]. It showed relatively higher values in summer, whereas during monsoon, a high biochemical oxygen demand was observed. This observation also falls in line with study of Tiwari *et al.* [25]. However, Parashar *et al.* [21] reported the lowest (1.85mg/L) BOD in Kolar reservoir in their study.

COD is a measure of oxygen equivalent to the requirement of oxidizing organic matter contents by a strong oxidizing agent. The COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances and also estimates the carbonaceous fraction of organic matter. In the present study, COD was found to be 640.0 ±1.05 to 1572.0 ± 1.23mg/L and was well above the permissible limit.

Good quality of water is essential for living organisms. The quality of water can be known by studying its physical and chemical characteristics as well as phytoplankton and other hydrophytes growing in it. Due to vast population and negligence of human beings, the quality of water is deteriorated. Limnology plays an important role in decision making processes for problems like dam construction, pollution control, fish and aquaculture practices [26]. Changes in the water quality affect the biotic community of the aquatic ecosystem which ultimately reduces the primary productivity. Without the knowledge of water chemistry, it is difficult to understand the biological phenomenon fully; the chemistry of water reveals much about metabolism of the ecosystem and explains the general hydro-biological interrelationship [27].

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