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Nutrient composition of Buckingham canal water, Chennai, Tamil Nadu, India

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Abstract
Population explosion, urbanization, industrialization and human apathy have all contributed towards increasing quantities of pollutants leading to an "ecological disaster". Pollution of water has emerged as one of the most significant environmental problem. About 60% of the untreated sewage gets into the Buckingham canal and the Adayar river takes the rest. Hence, the present study investigates the nutrients of Buckingham canal water from March 2011 to February 2012. The quantity of nutrients present in the Buckingham canal water samples varied widely. Free ammonia concentration ranged from 1.24 ±0.02 to 1.81 ±0.53mg/L. The nitrate and nitrite ranged from 40.75 ±1.06 to 80.65 ±4.25mg/L and 11.8 ±0.11 to 13.9 ±0.05mg/L respectively. Chloride content ranged from a minimum of 380 ±0.50 to a maximum of 1325 ±1.01mg/L and the fluoride content from 0.51 ±0.02 to 1.54 ±0.03mg/L. Potassium content in the water samples ranged from 38 ±3.51 to 88 ±4.72mg/L. The maximum calcium content in the water sample was 282 ±1.97 mg/L while the minimum ranged from 60 ±0.93 to 92 ±0.81mg/L. The magnesium values were also observed to be at a maximum of 150 ±0.16 and a minimum of 112 ±2.0mg/L. The silica content varied from 37.56 ±0.06 to 63.65 ±0.09mg/L. The phosphate content varied from 15.23 ±0.02 to 18.66 ±0.04mg/L. Sodium concentration was estimated as a minimum of 286 ±2.48 and a maximum of 453 ±8.15 mg/L and sulphate in water samples varied between 143.05 ±3.05 and 162.73 ±6.23mg/L. Presence of nutrients and oxygen is essential for the sustained proliferation of organisms. However, nutrients lead to undesirable change in the structure and function of ecosystems. Nutrients stimulate growth of aquatic plants which in turn decay and consume oxygen and emanate hydrogen sulphate. This accumulation exerts high biological demand on the ecosystem. In addition, with accumulation of nutrients, the organic biomass increases leading to pollution.

Keywords: buckingham canal, nutrients

1. Introduction
One of the major public health concerns in recent years has been environmental pollution and its effects on the living organism. Population explosion, urbanization, industrialization and human apathy have all contributed towards increasing quantities of pollutants leading to an "ecological disaster". Pollution of water has emerged as one of the most significant environmental problem. Not only there is an increasing concern for rapidly deteriorating supply of water, the quantity of utilizable water also fast diminishing. The wide array of pollutants discharged into the aquatic environment may have physicochemical, biological, toxic and pathogenic effects [1]. Nearly 30% of the estimated 55 million liters of untreated sewage is being let into the waterways of Chennai on a daily basis, including by Chennai Metropolitan Water Supply and Sewerage Board. About 60% of the untreated sewage gets into the Buckingham canal and the Adayar river takes the rest. Several tons of municipal solid waste being dumped every day makes its way through the Buckingham canal into the sea [2]. Presence of nutrients and oxygen is essential for the sustained proliferation of organisms. However, nutrient leads to undesirable change in the structure and function of ecosystems [3]. Therefore, in the present study, the nutrients of Buckingham canal water were ascertained.

2. Materials and methods
2.1 Study area
Chennai (Madras) the capital of Tamil Nadu is situated on the eastern coast of India, on 13 0 4' north latitude and 8 0 15' east longitude. There are three water ways that flows through the city, *viz*., the 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.

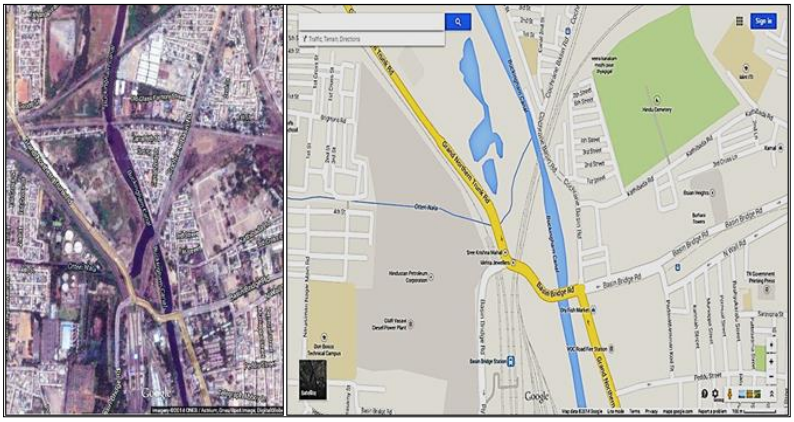

Fig 1: Study area Buckingham canal

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 55mL of untreated sewage being let into it daily, including Chennai Metropolitan Water Supply and Sewerage Board. 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 and the water quality is considered to be highly toxic and completely non-potable.

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 each site. The water samples were analyzed for nutrients, *viz*., free ammonia, nitrate, nitrite, chloride, fluoride, potassium, calcium, magnesium, silica, phosphate, sodium and sulphate. The ammonia content of Buckingham canal water samples was studied by the method of phenol hypochlorite [4]. Calcium, sodium and potassium were determined using flame photometer (Model-Chemito 1000) following the procedure of Jackson [5]. Chloride was analyzed as per the method of APHA [6]. Sulphate was measured using a Nephelometer.

3. Results

The values for nutrients present in the water samples of Buckingham canal during the study period from March 2011 to February 2012 are presented in Figure 2. Free ammonia concentration in the present study was observed between 1.24 ±0.02 and 1.81 ± 0.53mg/L. The nitrate and nitrite was from 40.75 ±1.06 to 80.65 ±4.25mg/L and 11.8 ±0.11 to 13.9 ±0.05mg/L respectively. Chloride content ranged from a minimum of 380.0 ±0.50 to a maximum of 1325.0 ±1.01mg/L and the fluoride content from 0.51 ±0.02 to 1.54 ±0.03mg/L. Potassium content in the water samples ranged from 38.0 ±3.51 to 88.0 ±4.72mg/L. The maximum calcium content in the water sample was 282.0 ±1.97mg/L while minimum ranged from 60.0 ±0.93 to 92.0 ±0.81mg/L. The magnesium values were also observed to be at a maximum of 150.0 ±0.16 and a minimum of 112.0 ±2.0mg/L. The silica content of the Buckingham canal water sample varied between 37.56 ±0.06 to 63.65 ±0.09mg/L. The phosphate content varied between 15.23 ±0.02 and 18.66 ±0.04mg/L. Sodium concentration was estimated to be between a minimum of 286.0 ±2.48 and a maximum of 453.0 ±8.15mg/L and sulphate content of the water samples ranged from 143.05 ±3.05 to 162.73 ±6.23mg/L.

4. Discussion

Nutrients stimulate growth of aquatic plants which in turn decay and consume oxygen and emanate hydrogen sulphate. This accumulation exerts high biological demand on the ecosystem. In addition, with accumulation of nutrients, the organic biomass increases leading to pollution. A study by Dhinamala *et al* [7]. reported on the seasonal variations of nutrients in Pulicat lake, Chennai from January 2011 to December 2012. In the present study, the quantity of nutrients present in the Buckingham canal water samples varied widely. The nitrogen pool of limonitic environment comprises of two components, organic and inorganic. The inorganic components of nitrogen are ammonia, nitrite and nitrate. Low level of ammonia recorded in Buckingham canal ranged from 1.24 ±0.02 to 1.81 ±0.53mg/L because of complete oxidation of liberated ammonia to nitrite and nitrate. During the present investigation, moderate values of nitrate and nitrite were recorded during monsoon. Similarly the low nitrate level recorded during some months in the canal was due to the

immediate oxidation of nitrate to nitrite by microbes. Welch [8] reported that rain contributed substantially towards nitrites. A positive correlation would have been recorded between nitrates and dissolved oxygen [9]. However, Singh [10] reported that the two parameters behaved independently. The present study was also found to be in conformity with the reports of Singh [10], Munawar [11] as well as Sultana *et al* [12]. It may be emphasized here that the conversion of nitrogenous organic matter to nitrates and nitrites are brought about by anaerobic

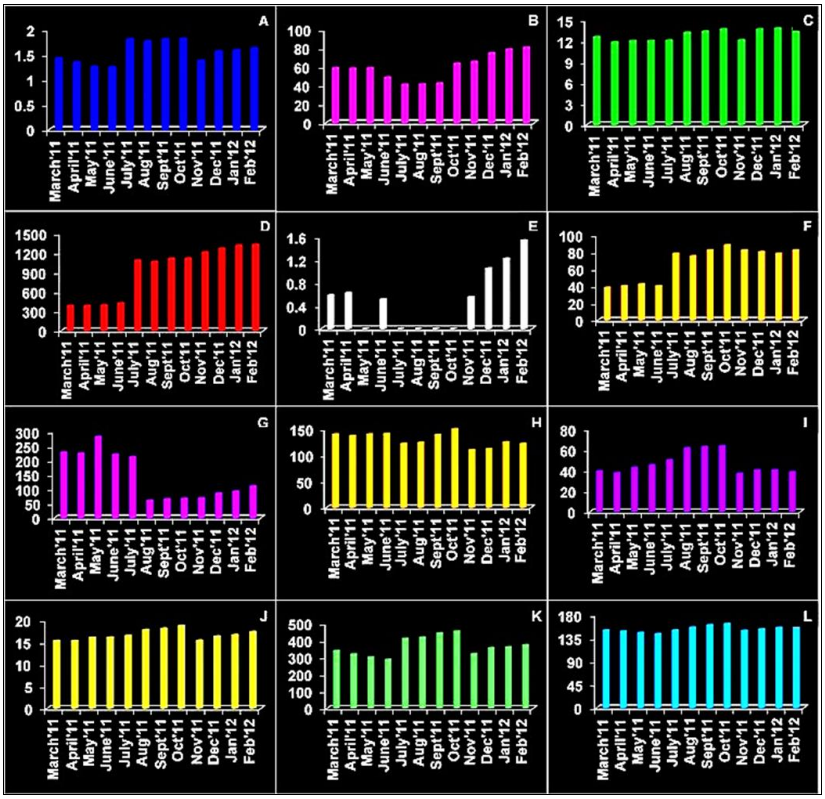

Fig 2: Nutrient parameters of Buckingham canal (all values in mg/L). A: free ammonia; B: nitrate; C: nitrite; D: chloride; E: fluoride; F: potassium; G: calcium; H: magnesium; I: silica; J: phosphate; K: sodium; and L: sulphate

Bacteria which are more active in waters having no oxygen.

Nitrate is a common pollutant in both surface waters and groundwater that causes health problems in infants, animals and also causes eutrophication of water bodies. The major reason for high nitrate in Buckingham canal may be due to the application of fertilizers for agriculture and also due to leaching of human wastes from septic tanks. Fertilizer use, domestic effluents, sewage sludge disposal to land, industrial discharges, leachates from the refuse dumps and changes in the land use all contribute to increase in the nitrate levels of the Buckingham canal [13]. High nitrates would indicate high pollution. Intrusion of sewage into the natural water increases levels of nitrate. Nitrate level in the present investigation was found to be 80.65 ±4.25mg/L which was above the permissible limits [14] making them unsuitable for humans and livestock consumptions [15]. The increased nitrite content of the Buckingham canal was noted as 11.8 ±0.11 to 13.9 ±0.05mg/L which indicates that it received rich organic matter, which was evidenced by the direct discharge of Chennai city sewage into the canal.

Chloride plays a key role in water quality determination. If the chloride content is more than 250mg/L it is considered as salt water. The chloride content ranged from 380.0 ±2.50 to 1325.0 ±6.0 mg/L, and higher chloride content is considered as an index of water pollution [12]. The high chloride content of the Buckingham canal water was due to increase in temperature and evaporation of water from the water bodies. Similar observations were made by Reddy *et al*. [16] and Khare *et al*. [17]. Levels of chloride are important in detecting the contamination of water by sewage and waste water and also due to industrial effluents, which is true with regard to Buckingham canal. Human as well as animal defecation may be the main cause for high chloride content present in Buckingham canal. The fluoride content varied from 0.51 ±0.02 to 1.54 ±0.02mg/L. Fluoride ions have high significance in water quality monitoring. The higher concentration of fluoride causes dental fluorosis. At the same time, concentration less than 0.5mg/L causes dental carries and dental molting [16]. Various workers have carried out extensive studies on the problem of fluoride in water [18,19]. Hence, it is essential to maintain the fluoride concentration in the range of 0.6 to 1.5mg/L. However, in the present study the fluoride content of the Buckingham canal water was found to be below the required level of the BIS standard.

Potassium level varied with a maximum of 88.0 ±4.72 and a minimum of 38.0 ±3.51mg/L. Potassium ions occur in natural waters in far less concentration than Ca^{+}, Mg^{+} and Na^{+}. It impart softness and makes water salty. Though, found in small amounts, it plays a vital role in metabolism of fish, aquatic environments and is an important macronutrient [20]. The

calcium and magnesium ranged from 60 ±0.93 to 282 ±1.97 and 112.0 ±2.0 to 150 ±0.16mg/L respectively. Low levels of calcium and magnesium were observed in monsoon seasons and a similar trend was seen in the Arakkonam lake [21]. The untreated domestic sewage and industrial wastes are considered to be important source of calcium and magnesium [22] and is responsible for hardness of water. Calcium forms the most abundant cation in freshwater. It contributes hardness to waters. It has been a basic parameter for detecting pollution of water by sewage plant before development of bacteriological procedure. The present investigation in Buckingham canal water samples observed that the level of calcium was above the permissible limit of WHO [14]. Similarly, the sulphate ion was also, one of the important anions in natural water and when present in higher quantity, it produces a cathartic effect in human beings, nevertheless it was found to be well within the permissible limit of WHO [14] in the water samples of Buckingham canal. The silica content of the Buckingham canal was found to be high in monsoon (63.65 ±0.09mg/L) and post monsoon (40.36 ±0.06mg/L) which may be due to the result of sediment content from the shallow bottom of the canal to the surface water due to influx of rain water [23].

Phosphate is an essential metabolic element since it normally occurs in low concentration in natural aquatic ecosystem. Phosphates are the major nutrients that are considered to trigger eutrophication [24, 25]. Phosphate concentrations varied greatly as a result of canal water contamination resulting from domestic wastage and agricultural sources from the surrounding agricultural areas were frequent use of the phosphate and nitrogen fertilizers are common. The phosphate content of the present study are in conformity with those of the study on Manchar lake in Pakistan which contains high contents of phosphate and nitrogen due to anthropogenic activities, *viz*., fertilizer usage, organic pollutants releases and discharge of water from domestic sources [26]. The monsoon season show highest phosphate contents. This is because of inflow of rain water mixed with fertilizers from nearby agricultural fields. The sodium content in Buckingham canal was ranged between 286 ±2.48 and 453 ±8.15mg/L. Sodium is another important factor to study sodium hazard. The use of high per cent sodium water for irrigation stunts plant growth. The most suitable for irrigation is having per cent sodium values less than 20%. Excess sodium in water used for irrigation changes soil properties and reduces soil permeability. Hence, the assessment of sodium concentration is necessary while considering the suitability of water. High sodium chloride in the samples indicates pollution from human and animal waste, which enters the canal through open defecation practices in the vicinity of a water body. The sulphate content of the Buckingham canal ranged between 143.05 ±3.05 and 162.73 ±6.23mg/L and the phosphates fluctuated between 15.23 ±0.02 and 18.66 ±0.04mg/L. Sulphate content in the study period was found to fall within the permissible limit of BIS standard considered amongst primary limiting nutrients in ponds and lakes [27]. Open refuse dumping is adversely affecting the Buckingham canal water in this area, which is a serious of concern and immediate action should be initiated to prevent further deterioration of the Canal.

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