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Water quality Parameters and it influences in the Ennore estuary and near Coastal Environment with respect to Industrial and Domestic sewage

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Abstract

The present investigation was aimed to study the effect of industrial and domestic sewage on the water quality parameters of Ennore estuary and coastal water of Ennore. The concentrations of the water quality parameters like temperature, pH, salinity, total hardness, nitrite, nitrate, ammonia, phosphate etc., were above the coastal water level due to the continuous discharge of domestic sewage and industrial effluent. Higher nutrient levels estimated from the Ennore estuary may be attributed due to the domestic sewage and industrial effluent discharged from the nearby human settlements and industrial establishments.

Keywords: Ennore estuary**, w**ater quality, industrial effluent, domestic sewage.

Introduction

The increasing population, urbanization and industrial sources are given rise to environmental stress and pollution all over the world. In fact, most of the developed countries have already realized that human existence on the earth may be endangered if suitable steps are not taken for the abatement; the pollution to the water bodies causes a serious threat to the mankind[1]. Estuaries are complex and dynamic environmental components which receive large amounts of contaminants from urban and industrial sites[2]. Industrialization and urbanization of the coastal region often lead to decrease in coastal resource and destruction of natural defense structures[3]. Discharge of agricultural wastes, industrial effluents and urban activities is considered to be the primary sources for increasing nutrient load in nearby aquatic water bodies[4]. Eutrophication is of great environmental distress, leading to complicity in the aquatic environment, causing problems such as formation of algal blooms which results reduction in oxygen levels, leads to mortality of aquatic fauna and flora and eventually loss of biodiversity[5]. India is bestowed with long coastline of 8,129 km and of this 6,000 km is rich in estuaries, creeks, brackish water, lagoons and lakes. The southeast coast of India is an important stretch of coastline, where many major rivers drain into the Bay of Bengal and they are also richer in marine fauna and flora. Ennore is located on the northeast coast of Chennai[6] and Ennore coast consists of alluvial tracts, beach dunes, tidal flats and creek in the eastern part. Ennore comprises of lagoons, with salt marshes and backwaters, which are submerged under water during high tide and form an arm of the sea opening in to the Bay of Bengal[7]. Estuaries constitute a major interface between land and the ocean and have been regarded as one of the most important aquatic system. The progressing of large industries in nearby areas has become a threat to the health of estuarine and coastal water environment[8].

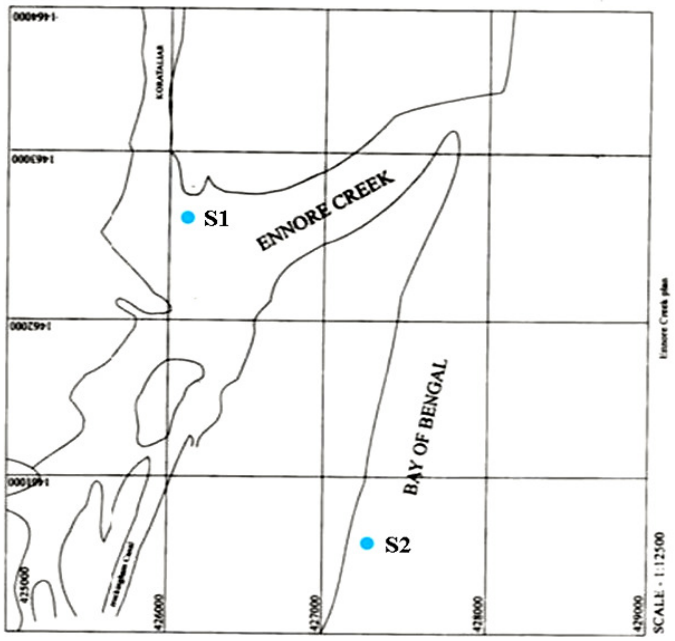
Ennore coast receives major amount of untreated domestic sewage from Royapuram area, untreated or treated industrial effluents from Manali Industrial Belt, which houses many refineries and chemical industries. The dredging activities in Ennore area result in changes in the landscape, sediment transport and dust pollution to the coast by quarrying process taking place[9]. Southern arm of the creek is well developed with industries, utilities, suburban residential areas and fishing hamlets. Northern section of the creek is connected to the Pulicat lagoon and has two major developments North Chennai Thermal power Core (NCTPS) and Ennore satellite port has chocked the mouth of the Ennore creek. Raw municipal sewage, industrial trade effluents industrial cooling waters all of them make it through Buckingham canal, enters into Ennore estuary and eventually drains into the Bay of Bengal of Chennai coast[10]. So long as the assimilating capacity of the water body is not exceeded, the ecosystem is able to recover from additional stresses without permanent damage[11].

Estuaries, the important contributors of fisheries in India, suffer from severe loss of fish production due to increased industrialization and urbanization along the coastal zone by continuous discharge of industrial effluents[12]. Ennore creek was once encompassed with rich biodiversity for the paradise of mangroves, reptiles, turtles and rare fishes has been totally wiped out by the petrochemical complex by pumping their effluents into the Ennore Creek, consequently the natural wealth is eroded to mere sewage channel and biological productivity of the coast has come down[13]. Overloading of the estuaries with contaminants for a longer period of time has resulted in the significant buildup of pollutants with a resulting impact on water properties. The present study was therefore undertaken with a view to provide much needed information on the water quality parameters in the Ennore estuary and the coastal water of Ennore, Chennai.

Material and Methods

Study area description: Ennore creek (13°13'54.48" N, 80°19' 26.60" E) is located in the northeast coast of metropolitan Chennai city, India. The total area of the creek is 2.25 sq km and is nearly 400 m wide. Its channels connect it in to the Pulicat Lake to the north and to the Kortalaiyar River in the south[7]. Araniar and Kortalaiyar are the two seasonal rivers which transverse Ennore creek.

Sample collection: The present study was carried out for Ennore estuary (S1 - Station 1) and the coastal water (S2 - Station 2) of Ennore located in Chennai city (figure- 1). Sampling was done during morning hours, water samples were collected in polyethylene bottles, closed bottle was dipped in the estuary at a depth of 0.5 to 0.7 m, and then the bottle was opened inside and closed again to bring it out at the surface. The samples were collected at five different points mixed together to prepare an integrated sample. Same procedure was followed for the coastal water sample also. The water temperature and pH were noted immediately on the spot after collection, whereas the remaining parameters were analyzed triplicate in the laboratory. Mean value of the data and standard deviation was calculated.



Figure–1
Study area map S1 Station 1 Ennore estuary sample collection, S2 Station 2 Coastal water sample collection

Water quality analysis: Temperature and pH: Temperature (°C) was measured using mercury filled Celsius thermometer with an accuracy of 1ºC. pH was measured using digital pH meter with glass calomel electrode, pH 0.01 accuracy.

Salinity and Dissolved oxygen: Salinity (PSU) was determined by Mohr-Knudsen argentometric titration method, using standard solution of silver nitrate (Merck) to precipitate halide ions in seawater using potassium chromate (Merck) as an indicator to form silver halides, presence of excess silver ions lead to the formation of red silver chromate (the endpoint of titration). Dissolved oxygen (mg/l) was estimated by Winkler's method in seawater, dissolved oxygen in water reacted with manganese hydroxide in strongly alkaline medium forming manganese (trivalent) hydroxide. When acidified to a pH less than 2.5, the manganese hydroxide dissolved to liberate manganese, which was titrated against a standard thiosulphate (Sodium thiosulphate- Merck) solution using starch as indicator[14].

Total hardness and Total alkalinity: Total alkalinity (mg/l) was determined by the amount of sulphuric acid (H_2SO_4) (Merck) neutralized together with a phenolphthalein (Merck) and methyl orange, (Merck) which gave pink colour in the presence of hydroxide and carbonate. Mixed indicator consisting of methyl orange and bromo cresol green (Merck) in which the colour changed from blue green to orange when bicarbonates was titrated with acid. Phenolphthalein gave a pink colour only with hydroxides and carbonates. End point was pink to colourless, at a pH of 8.3. The mixed indicator indicated the bicarbonate titration at a pH of 4.3. Total hardness (mg/l) was determined by complex metric titration using Ethylenediamine Tetra Acetic Acid (EDTA) (Merck). Small amount of Erichrome Black 'T' was added to an aqueous solution containing calcium (Ca^{+2}) and magnesium (Mg^{+2}) ions at a pH of 10 and the solution turning wine red when titrated against EDTA. All Mg^{+2} and Ca^{+2} formed complexes with the addition of EDTA, the solution turned from wine red to blue which indicated the end point of the titration[14].

Nitrite and Nitrate: Nitrite (mg/l) in seawater was determined by the reaction of aromatic amine, sulfanilamide (Merck) combined with n-(1-naphthyl)-ethylene diamine dihydrochloride, (Merck) forming an azo dye. Absorbance of the dye was measured spectrophotometrically (Plate 1.6) at 540 nm. Nitrate (mg/l) was reduced to nitrite through cadmium granules (Merck-Cadmium coarse powder, GR of size 0.3-1.6 mm) reduction column. Nitrate was quantitatively reduced to nitrite at the flow rate of 8 ml per minute. The column was washed with ammonia buffer (prepared with 10g of ammonia chloride per litre of distilled water with the addition of ammonia solution till the pH 8.5 is adjusted) after running of every sample. It was then analyzed by the aromatic amine, sulfanilamide combined with n-(1-naphthyl)-ethylene diamine dihydrochloride reaction forming an azo dye was then measured spectrophotometrically at 540 nm. This concentration was subtracted with the nitrite concentration earlier to acquire the nitrate concentration in seawater[14].

Inorganic phosphate and Ammonia: Inorganic phosphate (mg/l) in seawater was determined by reaction with acid-ammonium molybdate, forming a phosphomolybdate complex, which was reduced into ascorbic acid in the presence of antimonyl ions to a blue coloured complex. The extinction of the blue colour was measured spectrophotometrically at 880 nm

using 5cm cell. To avoid interference by silicate, the pH was kept below one[14]. Ammonia (mg/l) was determined based on the blue colour of indophenol formed by phenol and hyperchlorite in presence of nitroprusside (sodium nitroprusside- Merck). This blue colour of indophenol was measured spectrophotometrically at 630 nm. To prevent precipitation of calcium and magnesium hydroxides and carbonates present at a pH higher than 9.6, citrate buffer was added[14].

Silicate: Silicate (mg/l) in seawater was allowed to react with acid ammonium molybdate forming a yellow silicomolybdic acid, which was reduced by ascorbic acid in presence of oxalic acid (to prevent interference from phosphate) to develop blue coloured complex. The extinction of the blue colour was measured spectrophotometrically at 810 nm using 1 cm cells. All standards were prepared and standardized following Grasshoff method[14].

Results and Discussion

Water quality parameters in Ennore estuary and the coastal water of Ennore are given in (table 1). The appearance of both Ennore and coastal water was clear, colorless and odorless. Temperature is an important limiting factor, which regulates the biogeochemical activities in the aquatic environment. Temperature of both Ennore estuary and the coastal water remains same 29˚C and there is no change or difference is found. Generally variation in water temperature may be due to different timing of collection and also the influence of season during that particular period of time. Temperature controls behavioral characteristics of organisms, solubility of gases and salts in water[15].

Table-1
The variation of mean, standard deviation (SD) values of environmental variables in the Ennore estuary and the coastal water of Ennore, Chennai

Parameters	Ennore Estuary Mean±SD	Ennore Coastal water Mean±SD
Appearance	Clear, colorless, odorless	Clear, colorless, odorless
Temperature (˚C)	29±0.05	29±0.04
pH	7.58±0.15	8.12±0.11
Salinity (‰)	27.56±1.22	33.70±1.75
Dissolved Oxygen (ppm)	5.3±0.65	6.7±0.91
Total Hardness (ppm)	5860±1.22	4640±1.34
Total Alkalinity (ppm)	157±1.46	76±1.11
Nitrite (mg/l)	0.82±0.28	0.21±0.41
Nitrate (mg/l)	9.37±1.15	4.47±0.89
Phosphate (mg/l)	1.02±0.11	0.57±0.06
Ammonia (mg/l)	1.68±0.60	0.53±0.79
Silicate (ppm)	2.41±0.26	1.01±0.35

pH of water is an important environmental factor, the fluctuation of pH is linked with chemical changes, species composition and life processes. It is generally considered as an index for suitability of the environment[16]. In Ennore estuary the pH recorded is 7.58 ppm and in the coastal water it is 8.12 ppm. Similar findings were recorded in Adyar estuary ranged from (7.06 to 7.86 ppm)[17]. From the present study the pH result indicating slight alkaline nature which could be due to solutes, shows buffering action, i.e. H^+ ions are compensated with OH^- ions. It has been mentioned that the increasing pH appear to be associated with increasing use of alkaline detergents in residential areas and alkaline material from wastewater in industrial areas[18]. Salinity acts as a limiting factor in the distribution of living organisms, its variation caused by dilution and evaporation which influence the characteristic change of fauna in the intertidal zone[19-20]. In the present investigation, salinity was 27.56 ‰ and in the coastal water it was 33.70%. Generally, salinity changes in brackish-water habitats such as estuaries are due to the influx of freshwater from land run off caused by monsoon or by tidal variations[21].

The value of dissolved oxygen is remarkable in determining the water quality criteria of an aquatic ecosystem. The Dissolved oxygen is regulator of metabolic activities of organisms and thus governs metabolisms of the biological community as a whole and also acts as an indicator of trophic status of the water body[22]. Dissolved oxygen, of the Ennore estuary shows 5.3 ppm whereas in the coastal water it is 6.7 ppm. The lower mean dissolved oxygen values when compared to coastal water could be due to the turbidity nature of water, inflows from run-offs and decomposition of organic matter in the water[23]. Similarly, average dissolved oxygen level of Gomti River in Pipraghat region was 5.4 ppm, due to the flow of urban drains into the river[24]. Dissolved oxygen is the most important indicator of the health of a water body and its capacity to support a balanced aquatic ecosystem of plants and animals. Waste water containing organic pollutants depletes the dissolved oxygen and may lead to impact benthic communities by producing acute changes in their distribution, abundance, and diversity of species[25]. The lower dissolved oxygen also implies that the estuaries were more polluted downstream.

Total hardness is the parameter of water quality used to describe the effect of dissolved minerals (mostly Ca and Mg), determining suitability of water for domestic, industrial and drinking purpose attributed to presence of bicarbonates, sulphates, chloride and nitrates of calcium and magnesium[26]. Total hardness showed 5860 ppm in Ennore estuary, while in coastal water it was 4640 ppm. High values of hardness are probably due to regular addition of large quantities of detergents used by the nearby residential localities into lakes which drains into estuaries. The alkalinity of water is its capacity to neutralize acids. Alkalinity of water is a measure of weak acid present in it and of the cations balanced against them[27]. Total alkalinity is the total concentration of bases in water usually bicarbonates and carbonates[28]. The amount of total alkalinity recorded in Ennore estuary is 157 ppm and in the coastal water is was 76 ppm. Total alkalinity depends on the concentration of the

substance which would raise the pH of the water. High levels of alkalinity indicate the presence of strongly alkaline industrial waste water and sewage in the estuary[29]. The degradation of plants, living organism and organic waste in the estuary might also be one of the reasons for increase in carbonate and bicarbonate levels, shows an increase in alkalinity value[30].

Nitrite is the major component in the form of dissolved inorganic nitrogen followed by ammonia and nitrate in the process of nitrification. When the nitrification is taking place in the water, which leads to an increase in nitrite level and a reduction in ammonia is a regular phenomenon. To support algal growth Inorganic nitrogen above 0.03mgl^{-1} is required, high level of nitrite in water may not be suitable for growth of aquatic organisms[30]. In Ennore estuary nitrite estimated was 0.82 mg/l, whereas in coastal water it was 0.21 mg/l indicating high level eutropic nature with inorganic nitrogen present in the water. Studies show that increased utilization of fertilizer in agricultural industry due to that effluent discharge result in the increase of nitrogen and phosphorous in the estuary[31]. In the present study the nitrate value was 9.37 mg/l in Ennore estuary and 4.47 mg/l in the coastal water, which is rather less when compared to 58 mg/l recorded at Piracicaba River in Brazil[32]. The main sources of nitrate in water are human and animal waste, industrial effluent, use of fertilizers and chemicals, silage through drainage system. The increased concentrations of nitrate and nitrite will lead to excessive aquatic plant production, which may negatively impact estuary water environments causing deplete dissolved oxygen and production of toxic algae. As a result of oxygen depletion and sickness death of marine organisms will take place[9]. Major source of phosphate in water may be from domestic sewage, agricultural effluents and industrial waste waters. Phosphate value in Ennore estuary was 1.02 mg/l while the coastal water was 0.57 mg/l. High levels of both nitrates and phosphates can lead to eutrophication ultimately reducing dissolved oxygen levels in water[33-34]. The high concentration of phosphate is indication of pollution.

Ammonia is present in terrestrial and aquatic environments. Plants and animals excrete ammonia; it is produced by the decomposition of organisms and by the activity of micro organisms[35]. High concentrations of ammonia present in water may be toxic to aquatic organisms. In Ennore estuary ammonia recorded was 1.68 mg/l, whereas in the coastal water it was 0.53 mg/l. similar findings were recorded in Adyar estuary where it was 1.80 mg/l[19]. Results showed that higher level of ammonia was observed in estuary, when compared to coastal water, may be due to the discharge of domestic and industrial effluents in the water and also due to the excretion and decomposition of aquatic organisms in the ecosystem. In the present study silica concentration in the Ennore estuary was 2.41ppm, whereas in the coastal water it was 1.01ppm. Silicate is associated with land-based resources with concentration higher in rainy season than in dry season[36]. Thus it is evident from the observations recorded in this work as well as other documented literature that water quality of aquatic reservoirs play significant role in the conservation of biodiversity.

Conclusion

The study reveals water quality parameters of Ennore estuary showed that concentrations of nutrients were above the coastal water level due to continuous discharge of domestic sewage and industrial effluents and the estuary is severely polluted. Water quality forms the basic intuition for the life sustaining medicine for propagation of aquatic organisms especially to juveniles. The continues discharge of effluents to the estuarine ecosystem is vulnerable to all compartments of the food web. Awareness has been created if not immediate, definitely block or alert the input from industrial area. Estuaries are extremely exploited ecosystems, due to their proximity to major civilization throughout the globe. There is an urgent need to control or restore the discharge of domestic sewage and other industrial effluents to restore breeding ground of finfish and shell fish, secondary and tertiary productivity in the estuarine water body for the benefit of Chennai coast.

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