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Assessment of Water Quality Parameters in Ennore Estuary, Chennai, Tamil Nadu, India

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Abstract: This study has been conducted to assess the physico-chemical parameters of Ennore estuary to know the current status of the estuarine water. It has already been reported that, Ennore estuary often constitutes a major effluent receiving environment directly or indirectly, of substances contaminated by pollutants, untreated urban and industrial wastewater discharges and oil spills. The present study concludes with the fact the that oil spill offs have not adversely altered the water parameters and reaffirms the fluctuations in most of the water quality parameters as accepted under brackish water or estuarine environmental conditions.

Keywords: Ecology, Environment, Ammonia, Ecosystem, Pollution, Alkalinity, Physico-chemical parameters

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Introduction

Water is one of the most valuable natural resources on earth, essential for every living organism. Human history is tied directly or indirectly to fresh water source such as lakes, rivers and estuaries. Human beings as well as other terrestrial and aquatic life forms are sensitive to changes in the quality of the fresh water supply (Aloysius *et al*., 2022). An estuary is a body of water or an area where a river or stream meets the ocean (Kanga, 2020; Mohan *et al*., 2023). There is mixing of freshwater, saline water, and sediments from land and sea in an estuary (Mitra, 2018). Estuarine habitats are one of the most biologically productive ecosystems and have great economic value for a wide range of ecosystem services (Thrush *et al*., 2013; Daborn and Reddden, 2018). The population living around estuaries depends on it for their food and livelihood (Hanazaki *et al*., 2013). Yet, these unique ecosystems are subjected to varied anthropogenic interventions, thereby changing the dynamics of water quality (Wang *et al*., 2022).

Thus, most estuaries face a range of stresses so much that estuarine degradation is a common problem in developing countries (Kennish, 2002; Zambrano and Ruano, 2021). Almost on a global scale, estuarine ecosystems are degrading and human action is the main cause (Lotze *et al*., 2006; De Juan *et al*., 2014). In fact, estuaries often constitute a receiving environment, direct or indirect, of substances contaminated by pollutants, of untreated urban or industrial wastewater discharges, and of leaching water from the river basin supplying the estuary (Borrego *et al*., 2013). Another type of degradation that disrupts the physico-chemical quality of the estuary environment is poorly studied development or the dredging of sand from the estuary (Hughes *et al*., 2014). Moreover, among the consequences of anthropogenic interventions on estuaries is the gradual loss of ecological balance which often begins with a change in the physio-chemical conditions of the water in the estuary resulting in a subsequent biological modification of the water in the hydro system. Thus, to develop any preventive control strategy against degradation of an estuary, it is necessary to estimate the physico-chemical characteristics of the biotope (Samiha *et al*., 2022).

Estuaries, the main contributors of fisheries in India, suffer from severe damage which receive large amount of contaminants due to increased industrialization and urbanization along the coastal areas by continuous discharge of domestic sewage and industrial effluents (Mathu Mitha *et al*., 2022). Overloading of the estuaries with contaminants for a longer period of time has resulted in the significant build-up of pollutants with a resulting impact on water properties (Padmini *et al*., 2004). Ennore is located on the northeast coast of Chennai, India. 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 into the Bay of Bengal (Kannan *et al*., 2007). Ennore estuary was once encompassed with rich biodiversity for the paradise of mangroves, however, reptiles, molluscs and rare fishes have been wiped out by the existing industrial complex by pumping their effluents into the Ennore estuary environment (Mukuntha *et al*., 2012; Mohan *et al*., 2013a).

Oil and grease are present in wastewater (Tchobanoglous, 2002), with a concentration range between 10 to 100 mg/l (MDEQ, 2019). An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially the marine ecosystem, due to human activity, and is a form of pollution. The term is usually given to marine oil spills, where oil is released into the ocean or coastal waters. Several incidents have occurred in Chennai, India in the recent past. The coastline now faces a serious ecological threat since 2017 and also the Ennore estuary particularly in 2023. Hence it was deemed appropriate to investigate the level of oil spill off pollutants in the Ennore estuary water. The objective of the present study was to obtain information on physio- chemical characteristics of water quality which is imminent in order to envisage effective pollution control and water resource management strategies of Ennore estuary.

Materials and Methods

The present study was carried out at Ennore estuary located in Chennai, Tamil Nadu, India. Sampling was done during morning hour, water samples were collected in the polyethylene bottles, closed bottle was dipped in estuary at the depth of 0.5 to 0.7 m, and then the bottle was opened inside and was closed again to bring it out at the surface. The samples were collected from five different points and were mixed together to prepare an integrated sample. The water temperature and pH were analysed immediately on the spot after collection, whereas the analyses of salinity, dissolved oxygen, total hardness, total alkalinity, nitrate, inorganic phosphate, ammonia and silicate were done in triplicate in the laboratory as per the standard methods. The mean value of the data and standard deviation was

calculated.

Results and Discussion

The appearance of Ennore estuary water was clear, colourless and odourless. The temperature of Ennore estuary water was 28˚C (Table 1). Generally, water temperature corresponds with air temperature indicating that the samples collected from shallow zones has a direct relevance with air temperature, shallow water reacts quickly with changes in atmospheric temperature (Rajkumar *et al*., 2011). In the present study turbidity was found to be 8.80 NTU, similar findings were seen in Pulicat estuary ranged from 4.6 to 6.1 NTU (Dhinamala *et al*., 2015). High turbidity may be due to input of sediments brought by fresh water inflow and tidal movements. Turbidity was affected by salinity; salts settle sediments and hence the presence of salt in estuaries had the effect of reducing turbidity. Increased turbidity decreases light penetration, plant growth and oxygen production in the water. Therefore, breeding and survival of fish and other aquatic animals were reduced (Dhinamala *et al*., 2015).

Hydrogen ion concentration (pH) in Ennore estuary was 7.71. Similar findings were recorded by Jankiraman *et al.* (2012) in Adyar estuary (7.06 to 7.86). Likewise, in Uppanar estuary the pH value ranged from 7.6 to 7.72 ppm (Velsamy *et al*., 2013). The pH of the coastal seawater normally falls between 7.8 and 8.3 and is controlled by the buffering action of bicarbonate (Martin, 2007). The factors like photosynthesis, respiratory activity, temperature exposure to air, disposal of industrial waste, bring out changes in the pH (Jankiraman *et al*., 2012). High pH of water can be fatal to fish as the pH of water is the main driving force in controlling the relative proportion of the different forms of chemicals present. A pH rise above 10 can be lethal to fish (Wright *et al*., 1986).

Salinity is one of the important factors that influences the functional physiology and reproductive activity of the organisms. In the present study, salinity in the Ennore estuary was 24‰. The observed salinity variations in estuaries are due to the influx of freshwater. Generally, salinity acts as a limiting factor in the distribution of living organisms and its variation coursed by dilution and evaporation is most likely to influence the faunal distribution (Kamalkanth *et al*., 2012). The electrical conductivity of water, commonly referred to as conductivity in water quality analysis, is a measure of the conductance of water, in other words the ability of water to transmit electrical charge (Allan *et al*., 2021). In the present study electrical conductivity recorded in Ennore estuary was 31000 µS/cm. Conductivity is extremely low in pure water and increases with the concentrations of ions and thus with salinity and TDS (Vineis *et al*., 2011; Rusydi, 2018; Allan *et al*., 2021).

Total Dissolved Solids (TDS) is one of the physical parameters of water quality. TDS affects river morphology due to sediment and erosion, resulting in bed sediment washout, sandbar moves, mudflat, or silting-up. Other influences are changes in light attenuation and primary production, oxygen saturation, and modification of nutrient pathways (Gernez *et al*., 2015). TDS in the present study recorded was 19220 mg/l. Similar findings were observed in Pulicat lake (22428 mg/l) (Dhinamala *et al*., 2015). Variations in TDS may be due to the inflow of industrial, animal and agriculture wastes and also by evaporation and less rainfall. Verma *et al*. (2015) stated that large number of dissolved solids may result in high osmotic pressure. Alkalinity of water is a measure of weak acid present in it and the cations balanced against them. Total alkalinity is the total concentration of bases in water usually bicarbonates and carbonates. Total alkalinity depends on the concentration of the substance which would raise the pH of the water. In the present study alkalinity recorded was 184 mg/l (Table 1). High levels of alkalinity indicate the presence of strongly alkaline industrial waste water and sewage in the estuary. The degradation of plants, living organisms and organic waste in the estuary might also be one of the reasons for increase in carbonate and bicarbonate levels,

Table 1: Water Quality Parameters of Ennore Estuary

S. No.	Parameters	Unit	Test Method	Result Mean±SD
1	Temperature			28℃
2	Turbidity	NTU	IS 3025 Part 10 1984	8.80
3	pH value at 25℃		IS 3025 Part 11: 2022	7.71
4	Salinity	ppt		24
5	Electrical Conductivity	µS/cm	IS 3025 Part 14: 2013	31000
6	Total Dissolved solids	mg/l	IS 3025 Part 16 :2023	19220
7	Total Alkalinity as $CaCO_3$	mg/l	IS 3025 Part 23 :1986	184
8	Chloride as Cl-	mg/l	IS 3025 Part 32 :1988	7504
9	Sulphate as SO_4^{2-}	mg/l	APHA 24th Edn. 2023-4500 SO4 2-: E	1374
10	Total Hardness as $CaCO_3$	mg/l	IS 3025 Part 21: 2009	8360
11	Calcium as Ca	mg/l	IS 3025 Part 40 :1991	293
12	Magnesium as Mg	mg/l	IS 3025 Part 46: 1994	1855
13	Nitrate as NO_3	mg/l	APHA 24th Edn. 2023-4500 NO3 -: B	10.4
14	Silica as SiO_2	mg/l	IS 3025 Part 35 :1988	1.55
15	Calcium Hardness as $CaCO_3$	mg/l	IS 3025 Part 40 :1991	732
16	Magnesium Hardness as $CaCO_3$	mg/l	IS 3025 Part 46: 1994	7629
17	Phosphate	mg/l	IS 3025 Part 31 :1988	0.96
18	Ammonia	mg/l	IS 3025 Part 34 :1988	1.61
19	Oil & Grease	mg/l	IS 3025 Part 39 :2021	BLQ (LOQ:4.0)

BLQ: Below Limit of Quantification; LOQ: Limit of Quantification

thereby showing an increase in alkalinity (Wang *et al*., 2006).

The chloride concentration found in the Ennore estuary was 7504 mg/l. The possible reason for lower concentration of chloride may be due to the lesser input from the industrial activity while, higher concentration of it may be due to seawater intrusion coupled with huge influx of sewage and industrial wastewater. The high chloride concentration in water indicates the presence of large amount of organic matter. The higher concentration of chloride in water is an index of pollution of animal origin and there is a direct correlation between chloride concentration and pollution levels. Excess chloride in the form of human excreta and industrial wastes would reduce the DO content of water, which turns harmful for aquatic organisms (Naik and Purohit, 1997).

Total hardness is used to describe the effect of dissolved minerals (mostly calcium and magnesium) determining suitability of water for domestic, industrial and drinking purpose attributed to presence of bicarbonates, sulphates, chloride and nitrate of calcium and magnesium. 8360 mg/l of hardness was recorded in the present study. Likewise, 4703 mg/l was recorded in the Pullicat lake (Dhinamala *et al*., 2015). High values of hardness are probably due to regular addition of large quantities of detergents used by the nearby residential localities which drains into estuaries (Cuihong *et al*., 2011). In the present study the nitrate value was 10.04 mg/l (Table 1) in Ennore estuary, which is rather less when compared to 58 mg/l recorded at Piracicaba River in Brazil (Luiza *et al*., 1999). 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 depletion of dissolved oxygen and production of toxic algae. As a result of oxygen

depletion and sickness death of marine organisms will take place (Palanisamy *et al*., 2006).

Phosphate value in Ennore estuary was 0.96 mg/l, likewise 1.16 mg/l was recorded in Muttukadu estuary (Mohan *et al*., 2013b), similarly 0.719 to 1.920 mg/l phosphate were reported by Kalaiarasi *et al*. (2012) at the coastal waters of Palk Straight, India. Nutrients like nitrate and phosphate influenced the productivity of the marine environment, which are always higher during the monsoon season due to river run off and rapid oxidation of plankton detritus and decomposing matter (Nedumaran *et al*., 2001). The variation may also be due to the processes like adsorption and desorption of phosphate and buffering action of sediment under varying environmental conditions (Govindasamy and Kannan, 2000)

Ammonia is toxic to aquatic life, and toxicity is affected by pond pH. Ammonia toxicity increases as pH increases; presence of ammonia is an evidence of sewage inflow to water body. In Ennore estuary ammonia recorded was 1.61 mg/l, similar trend was recorded by Mohan *et al.* (2013b) in the Muttukadu estuary (1.45 mg/l). Slight increase in ammonia may be due to the death and subsequent decomposition of phytoplankton and excretion of ammonia by planktonic organisms. The concentration of oil and grease in the present study is below limit of quantification in Ennore estuary. It is necessary to assess the contamination level and oil distribution pattern in these estuarine waters regularly. Besides, the study of Oil and Grease level in estuarine, seawater and sediment are still limited in these regions.

Conclusion

The healthy estuarine eco systems are determined by the water regimes and hydrography of the own eco systems. This study has been conducted to assess the physico-chemical parameters of Ennore estuary (Chennai, Tamil Nadu, India) to know the current status of the estuarine water. The present study shows the significant role on the estuarine eco systems and their proportional correlation between the parameters and also with ecosystems services. Regular monitoring of water quality in estuarine ecosystem is very important to safeguard the estuarine habitats.

Ethical Statement

No animal or microbes have been used or sacrificed for this study, hence Ethical Approval not required.

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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