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Original Research

Water quality of temporarily open/closed Muttukadu backwater, Tamilnadu, India

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ABSTRACT:

The mouth dynamics of non-permanent open/shut estuaries (TOCEs) assume a key part in their general functioning. In this examination, the impact of the inlet state (closed versus open) on spatial fluctuation of water quality was surveyed in a briefly open/closed Muttukadu Backwater . Samplings were carried out in two periods during closed (May to August) and open phases (January to December and October to December). The water samples were collected from 9 stations during open and total closure conditions and analyzed for the physico-chemical characteristics. After the closure of mouth, it is found that increase in salinity and dissolved oxygen decreases in the backwater which in turn lead to fish kill. Nutrients in the estuarine system demonstrate high values amid closure condition and get diluted when the mouth is opened. The present outcomes recommend that the high nutrient supply from the upper ranges to the estuary is because of the Industrial outlet, Crab farming and tourism prompting Eutrophication when the sand bar is shut . Since the system is shallow, it is clear that there is a build up of pollutants in stations 4, 5 and 6 . It is observed that after the closure, the fishing activity is greatly affected due to the change in water quality.

Keywords:

Backwater, Muttukadu, Sandbar formation, Tamil Nadu, Water quality.

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INTRODUCTION

An estuary is where inland waters, which are regularly new, blend with saline oceanic water (Hunter 1970). The estuary demonstrates interactions from various main forces that decide the unique function of its environment. The volume of fresh, low density water entering the estuary, passage of seawater because of the tidal impacts, turbulent blending at the interface between the two water bodies and the distinction in their dendities are essential main forces that control the estuarine procedures (Hodgkin, 1978). The blend of these powers makes a dynamic and various eco system in estuaries, where the water quality can shift generally on various time scales.

The behaviour of estuaries that are detached from the sea for variable timeframes is subject to beach behaviour and rainfall, as when the sand bar is available, it limits tidal flushing and can make flooding, keeping run-off from the catchment (Baldock *et al*., 2004). Human and ecological utilization of in-stream water requires to be considered for both the amount and the nature of water (Chang, 2008; Masamba and Mazvimavi, 2008). Contaminations entering a river typically result from many transport pathways including storm water spillover, release from trench and rivers, vadose zone leaching, groundwater leakage and atmospheric deposition (Ouyang *et al*. 2006; Nouri *et al*. 2011; Jha *et al*. 2010). These pathways are likewise seasonal-dependent. Thusly, seasonal changes in surface water quality must be considered while building up a water quality management program (Ouyang *et al*. 2006). Eutrophication happens when nutrient loads enhance past the assimilative limit of the estuary and support abundant growth of microalgae (Carpenter *et al*., 1998). The information on water quality and pollution sources are important for implementation of sustainable water -use management strategies (Sarkar *et al.,* 2007; Zhou *et al.,* 2007; Nouri *et al.,* 2008a; Bu *et al.,* 2009; 2010; Soner Kara and Onut, 2010).The water quality of the estuary is linked to this distinctive pattern of opening and closing of the sand bar at the mouth. In wave dominated systems, the natural opening (and closing) of the estuary/ backwater is a major management issue considering the changes in water salinity, temperature, dissolved oxygen, nutrients levels and sediment accumulation pattern and species composition.

Estuaries and their adjacent environments are continually subjected to stress by human perturbations (Hodgkin, 1984). These regions receive large anthropogenic inputs of nutrients from terrestrial effluent to which estuaries are particularly vulnerable due to the limited water exchange with large bodies of water (Qu *et al*., 2003). Moreover, coastal developments and fishing demands can change dominant coastal processes, placing additional stress on estuarine ecosystem. The health status and the biological diversity of the Indian estuarine eco system are breaking down every day through human activities, transfer of huge amounts of sewage into the estuary has radically diminished the population of the fishes. It has likewise caused significant biological imbalance and brought about vast scale vanishing of their flora and fauna. Moreover, entrance of untreated municipal wastewater and industrial effluents into these water bodies prompts high water contamination including overwhelming metal contamination, which gets biomagnified and reaches man through food-chain implications. Opening of estuaries are frequently supported due to its effect on social and financial resources, for example, property and recreational amenity.

MATERIAL AND METHODS

Muttukadu (Kovalam) backwater (latitude 12° 46'N and longitude 80° 18'E) is located at 36 km south of the Chennai, Southeast coast of India. Muttukadu backwater form a complex system of shallow estuarine network spread over an area of 0.87sq.km. intended for fishing and boating activities. The backwater extends to

Table 1. Correlation between physico-chemical parameters of Muttukadu backwaters

a. During open condition

S. No	Parameters	Temp	Salinity	pH	DO	TN	Silicate	TP	Chl a
1	Temp	1.00							
2	Salinity	0.82	1.00						
3	pH	0.05	0.22	1.00					
4	DO	0.59	0.48	0.25	1.00				
5	TN	-0.30	0.00	0.28	-0.56	1.00			
6	Silicate	-0.61	-0.40	0.13	-0.32	0.60	1.00		
7	TP	-0.46	-0.53	-0.05	-0.63	0.42	0.39	1.00	
8	Chl a	0.07	-0.08	-0.67	-0.32	-0.18	-0.15	0.31	1.00

b. During closed condition

S. No	Closed	Temp	Salinity	pH	DO	TN	Silicate	TP	Chl a
1	Temp	1.00							
2	Salinity	0.58	1.00						
3	pH	-0.06	0.03	1.00					
4	DO	-0.18	-0.15	0.20	1.00				
5	TN	-0.33	-0.56	0.02	-0.21	1.00			
6	Silicate	-0.08	-0.42	0.18	0.15	0.36	1.00		
7	TP	0.06	0.19	0.33	0.01	-0.18	0.17	1.00	
8	Chl a	0.12	0.03	0.06	-0.33	0.50	-0.01	-0.16	1.00

about 15 km in N-S direction with width ranges from 800m to 1050m and opens into the Bay of Bengal at its eastern end by a narrow opening varying from few meters to 200m width (Figure 1). The estuary is shallow, the maximum depth being 2 m in the middle of the estuary, while in most of the areas; it is 1m or less. The estuary is normally cut off from the sea between March and September, when a sand bar is formed. In October-December because of immersion by the water from the upper reaches, sand bar gets disintegrated and the association with the ocean is reestablished.

It has been recognized three possible pollutants – sewage from the BC, oil spillages from the TTDC boat house and industries along the banks of the estuary. Dumping of oil and grease from cleaning of the engines and leakage of kerosene from the boats into the estuary cause the fish having the smell of kerosene. Small-scale artisanal fishing in this backwater is an important source of livelihood for a large section of economically backward population of the fishing village. Fishing activities are plentiful and the area is surrounded by many aquaculture farms. Fishermen mostly use the traditional catamaran for fishing and wait for hours together to catch fish. There are several aquafarms in this region growing prawns which are exported due to their taste. These farms not only draw waters from the Muttukadu, but also, let off their farm discharges back into the estuary and cause nutrient enrichment in the waters.

In order to determine the water quality with respect to the sand bar formation sampling stations were selected. Based on the various environmetal stress and sandbar formation near the mouth, nine sampling stations as follows were identified (Figure 1).

Station 1 - 1.5km from the mouth near TTDC Boat house

Station 2 - 2 km distance from the mouth

Station 3 - 3km from the mouth near seasonal crab culture

Station 4 - 4km from the mouth

Station 5 - 6km from the mouth near Industrial outlet

Station 6 and 7 - located in Buckingham Canal

Station 8 - 0.5km away from the mouth

Station 9 - Near sea

From all the stations, 1L surface water samples were collected in polyethylene bottles during closed and opened conditions respectively and brought to the laboratory immediately for analysis. Physico-chemical characteristics of water viz., Temperature, pH, Salinity, Dissolved Oxygen (DO), Total Nitrogen (TN), Total Phosphorus (TP), Silicate (Si) and Chlorophyll-a (Chl-a) were studied to determine the role of sand bar on the water quality. Variables such as DO, water temperature, salinity and pH were measured *in situ* with WTW probes (multi-line field kit). Subsamples were separated in duplicate through Whatman filter paper to determine chlorophyll-a concentration using Parson *et al.* (1984) and nutrients were resolved after Grasshoff *et al*. (1993). Correlation between the water quality parameters during opening and closing conditions were computed.

RESULTS AND DISCUSSION

Physical observations in the field

The sand bar was closed during summer periods of low riverine flow. The water level in the estuary fluctuated with the dynamics of the bar. Estuary stage height increased when the bar was closed and dropped significantly and quickly when the bar opened. Generally, the bar was closed during summer and was open during northeast monsoon and post monsoon. When the inlet is fully opened, Muttukadu backwater is clear and the colour changes to green after the closure of the sand bar. The length of the sandbar is around 5m during its full formation. During closure, death of fish and prawn within the estuary close to the sand bar is noticed. Fishermen complained that fishery potential is very much reduced within the backwaters and fish catch

Figure 1. Study area with sampling stations

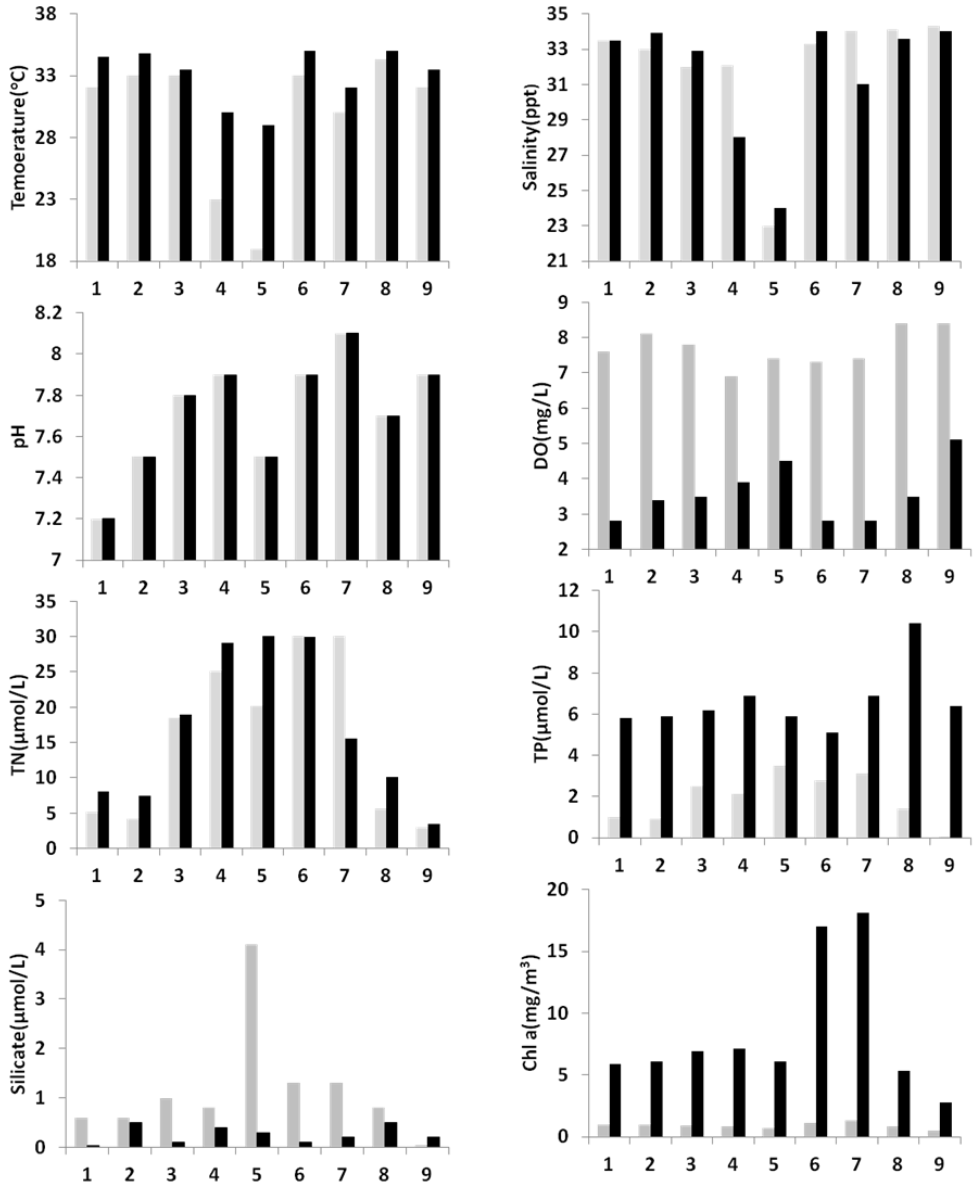

Figure 2. Variations in water quality in Muttukadu backwater

time increases when the sand bar is closed for longer period. Algal growth observed in stations 6 and 7 after the closure indicating eutrophication; may be due to the direct consequence of nutrient addition to backwater due to tourism, aquaculture and indirect consequences such as sewage disposal, changes in the abundance and diversity of higher trophic levels (benthic and planktonic fauna), abundant of toxic algae, and loss of dissolved oxygen in the water which get locked up due to the lack of flushing activity making it a cess pool.

Physico-chemical parameters

Water quality variations during opening and closing conditions are shown in Figure 2. Temperature varies from 18 to 35°C (Figure 2). Surface water temperature shows an increase upto 5°C when it is closed may be owing to the intensity of solar radiation and evaporation. The observed low value of 18°C at station 5 is due to strong land sea breeze and precipitation. (Das *et al*., 1997; Karuppasamy and Perumal, 2000; Govindasamy *et al*., 2000; Senthilkumar *et al*., 2002; Santhanam and Perumal, 2003).

Temperature and salinity shows a positive correlation irrespective of the sand bar formation. pH of the estuary ranged from 7.2 to 8.1 when the sand bar is open and closed (Figure 2). All nine stations are tidally influenced based on a combination of observed salinity values and qualitative field observations. The lowest salinity (28 and 24ppt) was recorded in stations 4 and 5 which is located in the upstream of the estuary where the tidal action is minimal. Statistical analysis revealed highly significant positive correlation (Table 1) of salinity with temperature throughout the year. High atmospheric temperature particularly during March - May leads to increase the rate of evaporation, which in turn increase the salinity values in Backwater when the sand bar is closed. Heavy clouds reduce the solar radiation decreasing the temperature and rate of evaporation during monsoon.

Dissolved oxygen is an important water quality parameter. The minimum value of 2.8mg/L was observed when sand bar is closed to station1,6 and 7 is due to heavy pollution resulting from boating and sewage disposal. The observed low dissolved oxygen concentrations when sandbar is closed, may be due to the combined effect of primary production and oxidation of organic matter as seen by strong negative correlation with chlorophyll a. It is also seen that after the closure of the mouth, there is marked increase in fish death due to the reduction in DO. On the other hand, when the sandbar is open, comparatively higher DO of 8.1mg/L concentration is observed by the reduction in pollution load caused by flushing of sea. In the present investigation, higher values of dissolved oxygen were recorded during monsoon season and positive correlation of DO with temperature and salinity when the sandbar is open (Table 1) which might be due to the cumulative effect of higher wind velocity coupled with heavy rainfall and the resultant freshwater mixing (Govindasamy *et al*., 2000; Rajasegar, 2003; Saravanakumar *et al*., 2008).

Total concentration of soluble inorganic nitrogen which is the sum of concentrations of nitrate, nitrite and ammonia. Total nitrogen value vary from 3 to 30.1µmol/L. Total nitrogen is high when the mouth is closed compared to open conditions (Figure 2). The highest TN concentration is noticed at station 4,5 and 6 is due to the discharge of sewage and industrial effluent having nitrates. Total nitrogen shows a negative correlation with total phosphate when the sandbar is closed (Table1). Total nitrogen shows a positive correlation with total phosphate when the sand bar is open. Total nitrogen shows a negative correlation with total phosphate when the sandbar is closed. Overall the chlorophyll-a shows a positive correlation with total nitrogen throughout the year indicating that it is marine environment and the backwater is influenced by the tidal activity.

In summer when sandbar is closed high phosphate concentration ranging from 5.1 to 10.4µmol/L is seen in all stations except for station 9. The consistently of high concentrations at station 6 ad 7 confirms the poor water quality due to the discharge of domestic and/or urban wastewater. High concentration in station 5 is due episodic occurrence of industrial discharge. Phosphate shows a positive correlation with nitrate when sand bar is open or closed. Phosphate shows a positive correlation with chlorophyll-a when sand bar is closed. When Total Phosphate concentration increases, dissolved oxygen levels significantly decrease in all the stations. Total Phosphate exhibits negative correlation with salinity and DO when sandbar is open. During closure, high total phosphate (10.4µmol/L) concentration is observed close to the mouth (station 8) compared to the inner stations may be of desorption of phosphate taking place from the sediments.

Silicate concentration is low when sand bar is closed than its open state (Figure 2). The recorded low values when sand bar is closed could also be attributed to uptake of silicate by phytoplankton for their biological activity (Sujatha Mishra *et al*., 1993; Ramakrishnan *et*

al., 1999). The silicate concentration was high during the monsoon in all stations due to heavy inflow of freshwater derived from land drainage carrying silicate leached out from rocks. Chlorophyll-a is the pigment that allows plants, including algae, to convert sunlight into organic compounds through photosynthesis. When the bar is open at the mouth of the estuary, chlorophyll a concentrations are generally low at the surface ranging from 0.5 to 1.8mg/m^3. When the bar is closed, the surface chlorophyll a concentrations are predominantly high in all stations especially in station 6 and 7 on the Buckingham canal. Relatively higher chl-*a* values observed during June could be due to the phytoplankton productivity in summer. When the sandbar is closed chlorophyll-a shows a significant positive correlation with phosphate and inorganic nitrogenous nutrient compounds which is necessary for phytoplankton to grow. The higher values of chlorophyll 'a' during summers indicates high primary production giving rise to phytoplankton bloom, more evidently noted in the month of June.

CONCLUSION

Nutrients in the estuarine system show high values during closure condition and get diluted when the mouth is opened. The present results suggest that the high nutrient supply is from the upper reaches to the estuary is due to the industrial outlet, crab culture and tourism leading to eutrophication when the sand bar is closed. Since the system is shallow, it is clear that there is build up of pollutants in stations 4, 5 and 6. Chlorophyll-a concentration also increases when the sand bar is closed due the availability of nutrients. When the estuary is flushed, nutrients and pollutants are removed from the estuarine environment. It is evident that the sand bar dynamics affect water quality by the pattern of opening and closing. When the bar isolates the estuary from the ocean, the flushing mechanism deteriorates, affecting the water quality of the estuary. The sand bar traps water in the estuary or allows interaction with the ocean. The sand bar physically regulates the estuarine water level and mixing within the water column. The present study has throw light on the role of sand bar and its impact on the water quality of Muttukadu Estuary. This will help to protect the environment and ecology of the estuary and its effective management.

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