An assessment of temporal variations in physicochemical and microbiological properties of barmouths and lagoons in Chennai (Southeast coast of India)

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ABSTRACT

Two estuary and two coastal lagoon stations along Chennai, Southeast coast of India were monitored for 1 year to study both physicochemical and microbiological properties of the water. Influence of the marine environment over the systems was evident by elevated salinity levels. Considerable concentrations of total heterotrophic bacterial count and fecal bacteria such as total coliforms, fecal coliforms and fecal streptococci were observed throughout the study period which evinced a pattern of anthropogenic activities. Principle component analysis was employed for assessing the overall pattern of variation within the data sets. Climatic variation was highly correlated with changes in water quality, i.e. the Northeast monsoon and Summer had influenced considerably the microbial occurrence as well as the physicochemical parameters such as total suspended solids, chloride, sulphate and salinity. However, the effect of the Southwest monsoon was less prominent than the Northeast monsoon with its heavy rains. As both estuaries revealed elevated concentrations of polluted water, these stations can be used as indicators or alerts for the water quality along the coastal zone of Chennai.

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1. Introduction

Coastal lagoons are shallow water bodies separated from the ocean by a barrier, connected at least intermittently to the ocean by one or more restricted inlets, usually oriented parallel to the shore (Kjerfve, 1994). They comprise 13% of the earth's coastlines and are considered to be the most productive ecosystems in the biosphere with a very complex environment (Morris, 1986; Beltrame et al., 2009). Lagoons are reported to offer various services to mankind with an estimated economic value of >22,000 US dollars ha^{-1} yr^{-1} (Costanza et al., 1997). Since lagoons have limited water exchange capacity, they are more susceptible to anthropogenic pollution; but the changes in water quality seem to be irreversible at least for a certain period (Martínez-Alvarez et al., 2011). Furthermore, water quality fluctuates based on its salinity levels, commonly a function of its contact with either fresh or sea water (Coelho et al., 2007). As a result, lagoon waters are characterized by high fluctuation in physical and chemical parameters (Beltrame et al., 2009). This in addition to anthropogenic activities may be the reason why many countries have not yet defined the criteria of water quality for coastal lagoons (Coelho et al., 2007).

On the other hand, estuaries are complex ecosystems due to its highly dynamic environment (Morris, 1986). Estuaries are semi-closed systems with varying physical and chemical properties due to nutrient input from fresh and sea water (Jiang et al., 2011). The importance of estuarine environment management has been stressed for a long time, because marine systems are influenced by land based pollutants and their discharge into the sea (Lee et al., 2008). The estuarine process controls the sedimentation and transportation of suspended sediments into the sea (Anilkumar and Dineshkumar, 2002). Human based activities have led to the destruction of many of the natural water resources including estuaries (Aslan-Yilmaz et al., 2004). In addition, the level of indicator and enteric bacteria were greatly influenced by point source pollutants (Touron et al., 2007). (Since estuaries are considered to describe the entire area, but barmouth more specifically describes the point of sampling, we decided to refer to barmouth in the following manuscript.)

India has a coastline of about 8000 km which encloses a wide range of coastal ecosystems like estuaries, lagoons, backwaters, salt marshes, rocky coasts, and coral reefs (Venkataraman and Wafar, 2005). Chennai, the capital city of the state Tamil Nadu and one of the largest metropolitan cities in the country, is located adjacent to the Bay of Bengal. Its position along the Southeast coast of India, on the Northeastern corner of Tamil Nadu gave rise to the name "Gateway to South India". The growth of Chennai city with increased anthropogenic activities remains a great concern to the

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quality of nearby water bodies. The present work has been carried out as part of a study on coastal hazard preparedness programme conducted along Chennai coast. Among the various sampling stations involved in the programme, the barmouth water quality of Cooum and Adyar rivers in addition to the lagoons Muttukkadu and Pulicat behave differently, which made us to give special attention to these stations. For the study, twenty different physico-chemical and microbiological parameters were monitored in order to characterize the four sampling stations and to identify the mechanisms of change.

2. Materials and methods

2.1. Study area

The study area included two barmouths and two lagoons (Fig. 1) situated along Chennai, Southeast coast of India. The characteristic features of the stations are described below:

2.2. Pulicat lagoon

Pulicat lagoon (or Pulicat Lake or Pazhaverkadu in Tamil) is the 2nd largest brackish water lagoon in India, located ~60 km Northeast of Chennai city (Fig. 1). The lake is well-known for its biodiversity, aesthetic value and for hosting activities such as aquaculture, heritage and tourism. During Summer months it serves as a "negative estuary" from where the water from the hyper-saline state reverts to fresh water system during the Northeast monsoon (Shalini et al., 2006). The lagoon receives pollution threats from more than 25 industrial sites (Kannan and Krishnamoorthy, 2006) which greatly influence its ecological state. This pollution load reaches the Bay of Bengal affecting where it exerts a devastating effect on the coastal ecosystem.

2.3. Muttukkadu lagoon

The lagoon (12°49′N; 80°15′E) is located 35 km South of Chennai, near Kovalam in the district of Kancheepuram, Tamil Nadu. Muttukkadu is one location where the Buckingham canal empties into the sea. The Buckingham canal runs about 500 km parallel to the coast from Nellore district in the state of Andhra Pradesh to Marakkanam near Pondicherry. This backwater lagoon has been developed for tourism related activities by the Government of Tamil Nadu, India. The lagoon extends to a length of 3 km, with a breadth of 800–1050 km and a depth of 1–2 m. Further, several salt pans are located along the backwaters. The lagoon also serves as home for benthic fauna, fin fishes, birds and flora.

2.4. Cooum barmouth

Cooum river, a languid stream, is one of the three major waterways in Chennai originating approximately 48 km west of Chennai and confluences the Bay of Bengal passing through Chennai. While the water quality deteriorates by agricultural activities in its upper reach (Jayaprakash et al., 2008), at its middle and lower reaches, the river receives a substantial quantities of city sewage, liquid waste from various industries, hospitals and households wastes which has become a health hazard for nearby population for decades (Bunch and Dudycha, 2004). The river receives about 80×10^6 L and 0.4×10^6 L of sewage and domestic sewage water/day (Nammalwar and Pakshirajan, 1995). Both sludge and waste water host pathogens such as parasites and enteric bacteria while serving as a prime habitat for mosquitoes which spread diseases such as malaria and filariasis (Bunch and Dudycha, 2004). The deposition of the sandbar at the barmouth of the river results in water stagnation which further forms the deposition of sludge in the river bed (Ramesh et al., 2002).
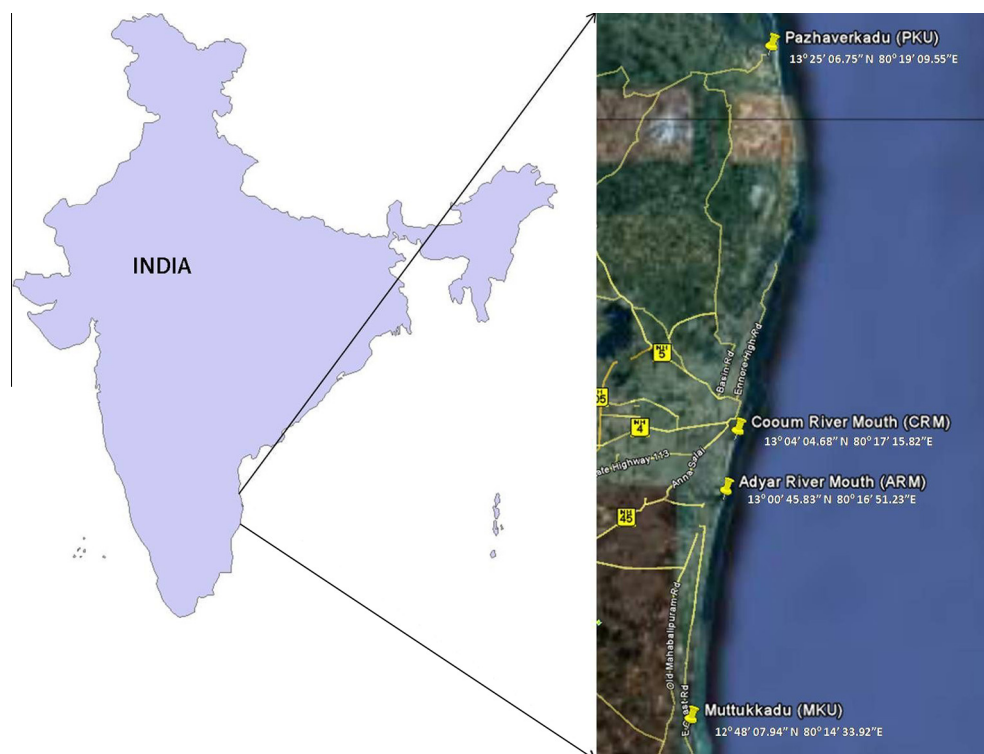

Fig. 1. Location of sampling stations.