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Impact of maintenance dredging on macrobenthic community structure of a tropical estuary

T.V. Rehitha*, N. Ullas, G. Vineetha, P.Y. Benny, N.V. Madhu, C. Revichandran

CSIR-National Institute of Oceanography, Regional Centre, Cochin, 682 018, India

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ABSTRACT

This paper demonstrates the impact of maintenance dredging activities on the macrobenthic community structure of a tropical monsoonal estuary (Cochin estuary), located in the southwest coast of India for three consecutive years. The results of the study indicates apparent differences in benthic fauna and sediment characteristics between dredging and non-dredging sites, while most of the hydrographical parameters (temperature, pH, DO and BOD) exhibited inconspicuous variations. The dredging sites were characterized by significantly lower faunal density, biomass, and diversity and sustained distinct benthic faunal communities. The tubificid Oligochaeta, an opportunistic benthic taxon, was highly abundant in the dredging sites along with less density of Mollusca and Amphipoda. Prominent distinctions were evident in the feeding guilds of macrobenthic fauna between the dredging and non-dredging sites. The Benthic Opportunistic Annelida Amphipods Index (BO2A index), an index of benthic habitat quality showed relatively higher values (>0.24), which indicates the prevalence of poor environmental conditions in the dredging locations. The present study reveals the extent of impacts associated with maintenance dredging activities in a tropical estuary, which can be used to formulate effective management strategies for the protection of ecologically and economically significant benthic communities of estuarine ecosystems.

1. Introduction

Estuaries, the transitional ecosystem between the marine and limnetic environments, are characterized by a highly dynamic and often unpredictable environmental scenario (Day, 1989). As they are endowed with rich bio resources, estuarine regions often form one of the most over exploited natural habitats on the Earth (Qasim, 2003). Being an ecologically significant region, a proper evaluation of the human associated changes in estuaries is of utmost importance for the healthy sustenance, and for the proper management of the bioresources they harbor. In order to abate the effects of siltation and to maintain navigable depth, regular dredging activities are carried out in the channels connecting estuaries to the sea. These recurrent dredging activities often have serious repercussions on the estuarine environment as they alter the bottom topography, sediment resuspension and composition, modifies the depth and current strength and also leads in the removal of a stable substratum (Jones et al., 2015; Newell et al., 1998, 2004).

Cochin estuary (CE), a tropical micro-tidal estuary, located in the southwest coast of India, running parallel to the Arabian Sea (AS), is remarkable for its rich biodiversity and productivity (Qasim, 2003). It is connected to the AS through two permanent inlets; one at Cochin (width 450 m) and the other at Azhikode (width 250 m). The estuary comes under the influence of the Indian Summer Monsoon (ISM), receiving heavy rainfall and associated runoff much larger than its volume during the wet monsoon season and hence is often categorized as a 'monsoonal estuary' (Vijith et al., 2009). Being shallow (2.5–15 m depth) the CE is often partially or completely mixed during the dry pre-monsoon season (Shivaprasad et al., 2013). The close proximity of the estuarine region to the bordering land and also the increased developmental activities along its coasts have adversely affected the estuarine ecology to a great extent (Gupta et al., 2009; Madhu et al., 2010a). Among the two inlets of the CE, the wider Cochin inlet forms the main navigational channel to the AS. Adjacent to the Cochin inlet, three channels (Fig. 1) are maintained for navigational purposes, i.e. the approach channel oriented along an east-west direction (~10 km length; 500 m width) and two inner channels (Balchand and Rasheed, 2000) located on either side of Willington Island,

* Corresponding author.
E-mail address: rehitarajan@gmail.com (T.V. Rehitha).

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known as Ernakulum channel (~5 km length; 250–500 m width), and Mattancherry channel (~3 km length; 170–250 m width). The approach channel was constructed in 1928 by cutting a sand bar, situated 1.6 km west of the coast. As siltation often leads to a reduction in the depth of the channel, the materials silted up after the construction was removed by dredging (Gopinathan and Qasim, 1971). Since then, with the process of siltation, a synchronized siltation removal strategy through continuous dredging activity is being employed in these channels to ensure the depth for easy navigation.

Macrobenthos (>0.5 mm), ecologically significant faunal components of estuarine ecosystems, play a crucial role in the nutrient recycling, secondary production and pollutant metabolism, dispersion and burial (Snelgrove, 1998). Macrobenthic fauna inhabiting different substrata exhibits varied behavior and feeding modes to cope with their different functional needs (Forbes et al., 1994; Gutperlet et al., 2015; Kroncke, 2006), hence they are used as efficient indicators of physical disturbance such as dredging, which affects the sediment structure and composition (Taupp and Wetzel, 2013; Whomersly et al., 2008). As comprehensive knowledge on macrobenthic community structure gives a better insight on their responses to anthropogenic disturbances, it often becomes a prerequisite for evaluating the benthic community dynamics of a region (Berlow and Navarrete, 1997; Gutperlet et al., 2015). Recurring dredging activities often lead to substantial reduction in benthic standing crop and species diversity (Desprez, 2000; Guerra Garcia et al., 2003; Van Dalfsen et al., 2000). Although, studies on the impact of dredging activities on the benthic fauna is widely researched worldwide (Kaplan et al., 1975; Newell et al., 2004; Van Dolah et al., 1984), extensive studies providing detailed information on this aspect from tropical estuaries are scanty (Bemvenuti et al., 2005; Brown and Kumar, 1990; Ogbeibu et al., 2010). In CE, earlier studies on macrobenthic fauna mostly focused on their distribution and diversity (Devi et al., 1991; Martin et al., 2011; Pillai, 1977; Kumar, 2002), but the impact of dredging on macrobenthic fauna have not been addressed comprehensively till date. In this context, the present study in the CE was designed to evaluate in detail whether the dredging activities carried out here (1) have any adverse impact on the water quality, sediment properties and community structure of macrobenthos (2) have any implications on the functional traits of the benthic community.

2. Material and methods

2.1. Study area

The CE is a semidiurnal micro-tidal estuary covering an area of ~25,600 ha along the south-west coast of India (Qasim, 2003). The estuary receives an annual freshwater influx of 22,000 $\times$ 10^6 m^3 from two rivers via its northern limb and from five rivers via its southern limb (Revichandran et al., 2012; Srinivas et al., 2003). Annual precipitation in and around CE is about 320 cm and of which nearly 60–70% occurs during the south-west monsoon season (Qasim, 2003). Regular intrusion of sea water from the AS occurs through tidal intrusion (tidal range avg. 1 m), which gradually diminishes towards the head of the estuary (Martin et al., 2012). In the pretext of the construction of the Cochin port in 1936, an artificial island, (known as Willingdon Island), was created around a small pre-existing islet, using the dredged soil. After the construction of the port regular dredging activity is being carried out in and around the navigation channels to prevent shallowing of the estuary due to the increased siltation process. In the earlier years (during 1990s), intermittent dredging was carried out throughout the year (except monsoon) with a dredged volume ranging from 3.58 to 3.89 million cubic meters (Rasheed, 1997). At present, continuous dredging activities are being carried out in these channels throughout the year including the monsoon and an average of 13.38 million cubic meters of dredged materials are

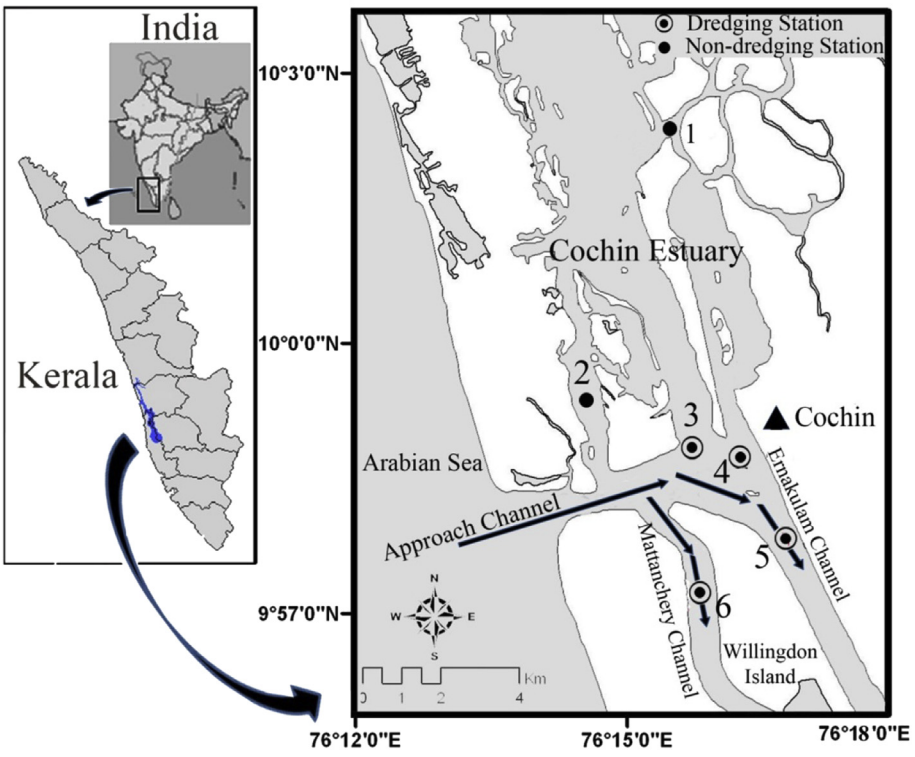

Fig. 1. Map of the Cochin estuary showing sampling locations.