Marine Pollution Bulletin 99 (2015) 186–194

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Human-induced ecological changes in western part of Indian Sundarban megadelta: A threat to ecosystem stability

Dibyendu Rakshit [a], Santosh Kumar Sarkar [a,*], Bhaskar Deb Bhattacharya [a], M.P. Jonathan [b], Jayanta Kumar Biswas [c], Priyanka Mondal [a], Soumita Mitra [a]

[a] Department of Marine Science, University of Calcutta, 35, Ballygunge Circular Road, Calcutta 700019, India
[b] Centro Interdisciplinario de Investigaciones y Estudios sobre Medio Ambiente y Desarrollo (CIIEMAD), Instituto Politécnico Nacional (IPN), Calle 30 de Junio de 1520, Barrio la Laguna Ticomán, Del. Gustavo A. Madero, 07340 Mexico, DF, Mexico
[c] Department of Ecological Engineering & Environmental Management, International Centre for Ecological Engineering, University of Kalyani, Nadia, 741235, India

ARTICLE INFO

Article history:
Received 23 March 2015
Revised 29 June 2015
Accepted 10 July 2015
Available online 29 July 2015

Keywords:
Gangasagar festival
Hooghly estuary
Phytoplankton
Tintinnid
Water quality
Sundarban megadelta

ABSTRACT

The study first illustrates a comprehensive account of large-scale changes in water quality characteristics and plankton community structure due to occurrence of Annual Gangasagar Festival (AGF) at Sagar Island, western part of Indian Sundarban megadelta for 3-year duration (2012–2014; $n = 36$). About 1 million pilgrims across India converge to take their holy bath at the confluence of Hooghly estuary and Bay of Bengal during January each year. This mass scale bathing results negative impact on water quality due to high turbidity (14.02 ± 2.34 NTU) coupled with low chlorophyll *a* (1.02 ± 0.21 mg m^{-3}) and dissolved oxygen (3.94 ± 1.1 mg l^{-1}). A marked decrease in abundance (from 4140 to 2997 cells l^{-1}) and diversity ($H' = 2.72–1.33$) of phytoplankton and microzooplankton tintinnids (from 450 to 328 ind l^{-1}; $H' = 4.31–2.21$) was recorded. The festival acts as multiple stressors modifying natural functions of the delta. Sound and sustainable management strategies are to be adopted to maintain the protection-usage equilibrium.

1. Introduction

The Annual Gangasagar Festival (AGF) is the second largest annual congregation of pilgrims (>1 million) across India taking a holy bath in the farthest southern point of Sagar Island, west of the Indian Sundarban mangrove wetland. The landforms, shoreline configuration, ecology, and environmental conditions of this zone change continuously due to natural and anthropogenic activities (Gopinath, 2010). Unfortunately, laws for waste disposal have not been implemented, resulting in considerable human waste in the fluvial system, which is extremely hazardous to health. Consequently, waste in the AGF ground pollutes the adjacent streams, rivers, and coastal sea. Annual religious festivals such as AGF are as responsible as other sources of water pollution (Hajra et al., 2012). The waste from millions of pilgrims causes undesirable changes in the physical, chemical, and biological characteristics of the environment, posing a threat to the sustenance of mankind in the long run (Hajra et al., 2012). This study investigates in depth the negative impact of the AGF held at the southern point of Sagar Island, the largest delta of the Indian Sundarban mangrove wetland, on water quality and plankton community structure over 3 successive years (2012–2014) in three phases.

2. Materials and methods

2.1. Study sites

Sagar Island (21°37′21″ to 21°52′28″N and 88°2′17″ to 88°10′25″E) is a large low-lying archipelago on the continental shelf of the Bay of Bengal. It is the largest (272 km^2) and most vulnerable deltaic complex dominated by tide, situated the in western part of Indian Sundarban, formed by the deposition of sediment (Mondal, 2013). The island is prone to frequent natural hazards that lead to accretion, erosion, and change in topography. Due to the complex interplay between natural dynamics and human intervention, the sustainability of the island is under threat. The island's ecosystem is extremely vulnerable to anthropogenic stresses such as intensive boating and fishing activities, dredging, tourism and port activities, operation of mechanized boats, and excavation of sand from the riverbed. The ongoing degradation of beaches is caused by huge siltation, flooding, storm runoff,

* Corresponding author.
E-mail address: cusarkar@gmail.com (S.K. Sarkar).

http://dx.doi.org/10.1016/j.marpolbul.2015.07.027
0025-326X/

atmospheric deposition, and other human-induced and anthropogenic stresses that changes the water quality. For a general indication of the environmental degradation due to AGF, four sampling sites almost equidistant from each other (Sagar 1 to Sagar 4) were demarcated along the southern flank of the island covering a distance of ~8 km (Fig. 1).

2.2. Collection and preservation of samples

The Gangasagar festival is held in January of each year; a holistic sampling strategy was designed accordingly to characterize the changes in water quality and plankton community in three phases, namely during the festival (January) as well as before (December) and after (February) the event. Phytoplankton samples were collected by towing the net (20 μm) on the water surface for about 20 min, which were immediately preserved in 4% buffered formalin and taken to the laboratory for further analyses. 1 ml aliquot sample placed in a Sedgewick-Rafter counting cell was examined under a binocular microscope (Leica, China; Model 13395H2X) at 40× magnification for quantitative as well as qualitative analyses (Kellar et al., 1980). The phytoplankton was identified after performing the standard taxonomic monographs of Desikachary (1987) for diatoms, Subrahmanyan (1968) for dinoflagellates, and Fristch (1935) for green and blue-green algae (cyanobacteria).

For tintinnid analyses, 1000 ml of surface water samples were collected in pre-cleaned plastic bottles from each station, which were immediately preserved with Lugol's solution (2% final concentration, volume/volume) and refrigerated in the dark except during transport and settling (Dolan et al., 2002). In the laboratory, the water samples were concentrated to a volume of 25 ml in a 1000 ml measuring cylinder with two special outlets (Godhantaraman, 2002). The last 25 ml was added dropwise with a micropipette on a glass slide and observed under a phase contrast microscope at a magnification of 40× (NIKON Trinocular Microscope, Model E-200) for quantitative and qualitative analysis. Three aliquots of each sample were counted, and the mean value was considered. Tintinnids were identified based on their lorica morphology as described by Kofoid and Campbell (1929, 1939), Marshall (1969).

Simultaneously, environmental variables such as water temperature and salinity were recorded in situ with a Celsius thermometer (0–110 °C, mercury) and a refractometer, respectively. Winkler's titrimetric method (Strickland and Parsons, 1972) was used to estimate dissolved oxygen (DO) and biochemical oxygen demand (BOD_5: difference between DO of 100% saturated water on day 1 and after 5 days of incubation). The turbidity, pH, and inorganic nutrient content (nitrate, phosphate, and silicate) were measured using a Water Analyzer 371 (Systronics). To analyze

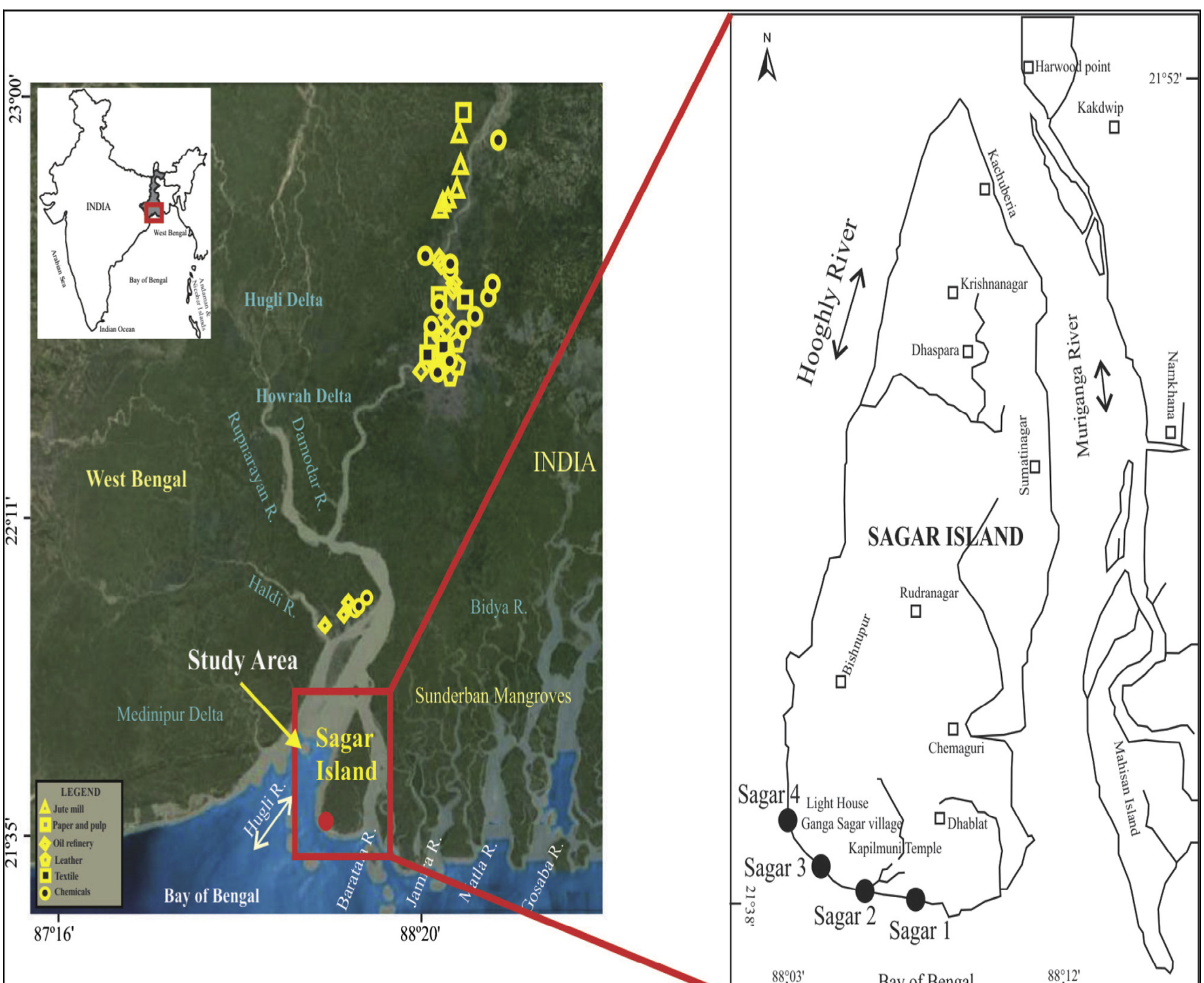

Fig. 1. Map showing the location of 4 sampling sites (Sagar 1 to Sagar 4) in the southern extreme of Sagar Island, the largest delta in Indian Sundarban wetland.