Marine Geology 371 (2016) 44–56

Contents lists available at ScienceDirect

Marine Geology

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

Evaluation of the influence of monsoon climatology on dispersal and sequestration of continental flux over the southeastern Arabian Sea

Onkar S. Chauhan *, A.S. Shukla

CSIR-National Institute of Oceanography, Dona Paula, Goa 403 004, India

ARTICLE INFO

Article history:
Received 18 February 2015
Received in revised form 21 October 2015
Accepted 31 October 2015
Available online 2 November 2015

Keywords:
Clay minerals
Detrital suspended matter
Southeastern Arabian Sea
Hydrography
Wind regime
Fluvial influx

ABSTRACT

Associated with the coupled land–ocean heating–cooling, seasonal reversal of monsoon winds regulates hydrography, precipitation, upwelling, fluvial influx and a host of biogeochemical processes. We evaluate the role of the monsoon winds, fluvial discharge and currents on continental flux dynamics from advection magnitude of clays over an anomalous high precipitation regime of the southeastern Arabian Sea. Coupled with the intense rains and a high fluvial discharge, we archived an elevated content of detrital clays (>41 mg l^{-1}) during the southwest monsoon over the <40 m water depth. The deeper waters (>40 m), however, had much reduced detrital clays (<6 mg l^{-1}) year round. Therefore, two distinct environments (high and low detrital clays) prevailed over the shelf. Derived from the variations in the clays in the local riverine discharge and in the seawater loads, we found a dominant role of the southwest monsoon winds and that of the winter and the southwest monsoon (summer) coastal currents over the dispersal and sequestration processes. Over the inner shelf, an alongshore (equatorward) advection and merging of several, small, fluvial plumes by the southwest monsoon winds had sequestered most of the local fluvial discharge over the shallow region only. The outer-shelf received detritus mostly as a result of (a) the high salinity Arabian Sea Water during the southwest monsoon, (b) through the Bay of Bengal Water and (c) by way of aeolian supply from the Arabia and the Somalia.

1. Introduction

Regulated by the coupled ocean–land heating–cooling, there is a seasonal reversal in the winds over the northern Indian Ocean that is termed as monsoon (Prell and Kutzbach, 1992). Being a regulator of the magnitude of weathering, fluvial supply, ocean circulation and winds, the monsoon plays a vital role upon yield, supply, dispersal and sequestration of continental fluxes (Chauhan et al., 2006; Naqvi et al., 2009; Rixen et al., 2009). Conventionally, the Arabian Sea has been considered to have a strong evaporation over precipitation regime (E ≫ P), and it is therefore deemed that it receives a low amount of fluvial discharge (Vörösmarty et al., 1996; Yu and McCreary, 2004). The River Indus is the only large river that debouches into the northern region of the Arabian Sea (Fig. 1). However, because of the orographic influence by an elevated regional topographic high (the "Western Ghats"), a narrow belt of the entire southwestern continental margin of India has been found to receive incessant seasonal rains (2700–4800 mm) during the southwest monsoon (SWM; Chauhan et al., 2010, 2011). Aided by such a high precipitation and the existence of hilly terrain all along the coast (average elevation ~2000 m), this rainfall is expected to sustain a large fluvial discharge that carries anthropogenic load of untreated sewage, fertilizers and insecticides from the littoral states by way of fluvial route into the sea. Studies found elevated marine productivity in the coastal region during the prevalence of the fluvial supply (Chauhan et al., 2011; Raghavan and Chauhan, 2012). The study of Lückge et al. (2012) also found that marine productivity and carbon sequestration were linked with the magnitude of detritus supply into the Arabian Sea. There are, however, several climate regulated processes that may supply detritus and nutrients into the Arabian Sea.

During the SWM, strong onshore winds are known to induce upwelling over the shelf and it sustains high marine productivity (Naqvi et al., 2009). The winter cooling is known also to supply a large amount of nutrients (Madhupratap et al., 1996; Kumar et al., 2001). Aided by the SWM climate, there is an intrusion of high salinity from the Arabian Sea Water (ASW) into the Bay of Bengal by way of the West India Coastal Current (equatorward summer coastal current; Kumar et al., 2004). Upon the termination of the SWM, there is a reversal of winds and current regime, and that leads to an advection of nutrient rich, low salinity Bay of Bengal Water (BBW) into the southeastern Arabian sea by way of a poleward coastal current (known also as the East India Coastal Current; Kumar et al., 2004). The winter coastal currents were found to be carriers of nitrate and phosphate, and these have enhanced marine productivity along the southeastern Arabian Sea (Kumar et al., 2004). The southwestern continental margin of India is known to have anoxia (Naqvi et al., 2000, 2009; Chauhan et al., 2011 and references therein). There is a widespread use of fertilizers and insecticides in the hinterland, and that may enhance their import into the sea by way of the

* Corresponding author.
E-mail address: onkar@nio.org (O.S. Chauhan).

http://dx.doi.org/10.1016/j.margeo.2015.10.018
0025-3227/

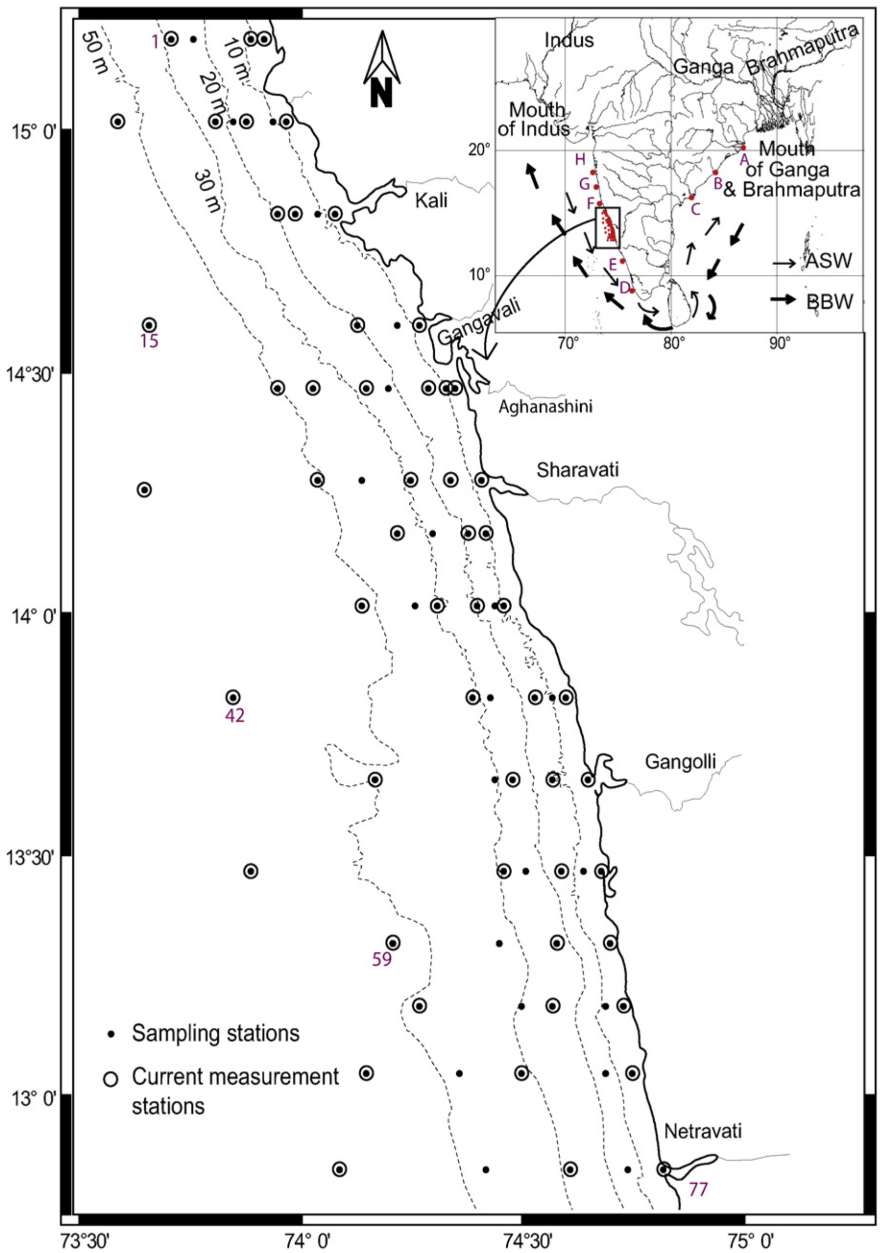

Fig. 1. Study area with sample location of the Bay of Bengal and the Arabian Sea. The mouths of the River Indus and the River Ganga–Brahmaputra are shown. BBW in the inset figure denotes the low salinity Bay of Bengal Water (winter hydrographic coastal current), and ASW denotes the high salinity Arabian Sea Water (summer hydrographic coastal current). A color version is available on the web.

fluvial route. Any further augmentation in nutrient input from a distal or a local source may therefore be a further cause of anoxia, and that may lead to environmental degradation or fish mortality along the southeastern Arabian Sea. It remains pertinent, therefore, to determine detritus contribution from each of the aforesaid sources to get an insight into the processes that regulate marine biogeochemical cycle in the Arabian Sea.

Source and dispersal pathways of continental fluxes over the Arabian Sea have been investigated rather inadequately. The time series trap data were the only archive that had estimated the role of climate on detrital flux dynamics over the Arabian Sea (Nair et al., 1989; Haake et al., 1993; Rixen et al., 2009). These studies speculated that because of high fluvial fluxes of the River Indus (aided by the seasonal rains in the hinterland) and seasonal upwelling, the magnitude of terrigenous flux into the deeper regions of the Arabian Sea (>2000 m water depth) enhanced many fold during the SWM. However, being point observations (three traps), it is not known if the inferences drawn in these studies remain valid for the shallow region of the continental shelf. Nor had these studies elucidated the specific source, dispersal and sequestration mechanism of the detritus. Unlike the deeper regions of the Arabian Sea, however, the continental shelf has: (a) several, closely-spaced, fluvial discharge points, each with variable intensity; and (b) seasonal currents, upwelling, down-welling, etc. (Kumar et al., 2004 and reference therein; Raghavan and Chauhan, 2012). Winds are known also to transport aerosol dust into the Arabian Sea (Sirocko et al., 1991; Chauhan, 1996). No insight, however, has been acquired over the comprehensive role of the monsoon specific morphodynamic agents such as rainfall, fluvial influx, winds, and seasonal currents over dispersal or sequestration pathway of detritus that may carry micronutrients such as iron and zinc into the shelf of the southeastern Arabian Sea.

The spatiotemporal variations in suspended particulate matter (SPM) have been used as a proxy to estimate dispersal and sink pathways of fluvial fluxes in the northern Indian Ocean (Chauhan et al., 2005, 2006, 2010, 2011; Raghavan and Chauhan, 2012). However, the