Marine Pollution Bulletin 78 (2014) 15–25

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Review

Changes in metal contamination levels in estuarine sediments around India – An assessment

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A R T I C L E   I N F O

Keywords:
Metal pollution
Estuarine sediments
Pollution load index
Geoaccumulation index
Contamination factor

A B S T R A C T

This review is the first attempt to comprehend the changes in metal contamination levels in surface estuarine sediments with changing time around India. Contamination factor, geoaccumulation index, pollution load index, effects range low and effects range median analysis were used to evaluate the quality of the estuarine sediments (by using the available literature data). This study suggests that estuarine sediments from the east coast of India were comparatively less contaminated by metals than the west coast. Sediments from those estuaries were found to be more contaminated by metals on which major cities are located. An improvement in estuarine sediment quality (in terms of metal contamination) over time around India was noticed. This study provides managers and decision-makers of environmental protection agency with a better scientific understanding for decision-making in controlling metal pollution in estuarine sediments around India.

Contents

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0025-326X/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.marpolbul.2013.09.044

1. Introduction

With rapid industrialization and economic development, metals are continuing to be introduced to estuarine sediments via several pathways and may potentially result in associated environmental and health problems. Heavy/trace meals are one of the serious pollutants in our natural environment due to their toxicity, persistence and bioaccumulation problems (Chakraborty et al., 2010). Trace/heavy metals in natural waters and their corresponding sediments have become a significant topic of concern for scientists and engineers in various fields associated with water quality, as well as a concern of the general public. It has been reported that estuarine sediments are contaminated mostly with heavy/trace metals. They serve as filter for many pollutants between land and sea (Chapman and Wang, 2001). Estuarine sediments appear to be major repositories for metals. The environmental problems of estuarine sediment pollution by heavy/trace metals have received increasing attention in the last few decades in both developing and developed countries throughout the world (Zhang et al., 2007).

It has been widely recognized that heavy/ trace metals content in sediments can be useful in assessing the quality of the sediments (Burton and Scott, 1992; Caccia et al., 2003). However total metal concentrations in sediment are not a good indicator of predicting their bioavailability and toxicity. Knowledge of distribution and speciation of metals in sediments is necessary for providing a better understanding of their potential impacts at elevated concentrations in environments. Several studies have been carried out to understand the distribution of total metals content in sediments of the Indian estuaries over the last few decades (Tables 1 and 2); nevertheless, the information is quite limited for metal distributions and their speciation in the estuarine sediments of India. The rapid population growth along with the sharp increase of industrial and agricultural developments may lead to an irrevocable metal pollution of Indian rivers. An effort was made (in this review) to provide a better understanding of metals contamination and their changes with the progress of industrialization and urbanization in estuarine sediments around India.

The degree of quantification of metal pollution in sediments has been determined with respect to the metal concentrations in average shale (Förstner and Wittmann, 1983; Muller, 1979). Some authors (Baruah et al., 1998) have considered the background value of their area of study to be the geometric mean of concentration at the different sample sites, which is the antilog of the arithmetic average of log10 (log to the base 10) of the concentration values. The composition of upper continental crust (UCC) (Taylor and McLennan, 1985) was used as the background concentration (provided as supporting document, Table 1SD) to theoretically predict the contamination factors (CF), pollution load index (PLI), geoaccumulation index (I_{geo}) in estuarine sediments around India (by using the data available in the literature). The ERL (effects range low)/ERM (effects range median) analysis was also used to understand estuarine sediment quality. The objectives of this work were to (i) understand the distributions of metals in the estuarine sediments (from 8 major estuaries) (ii) understand the variation in the PLI, CF, and I_{geo} with respect to time and (iii) understand the contribution of human activities on metal loading in estuarine sediments around India. The summary of this review is expected to help: (1) Environmental managers to identify and fixing problems in estuaries (in terms of metal contamination); (2) concerned citizens who are interested to know about the estuarine sediments around India; and (3) researchers who wish to know what type of data (metal distribution) are available (in the literature) in the estuarine sediments around India.

Table 1
Trace metal concentrations (µg/g) in sediments from the major estuaries of the east coast of India.

Estuary	References	Cr	Ni	Cu	Zn	Pb	Cd	Hg	Mn	Fe	Co	As	No. of Samples	Year of sampling	Methods
Ganges	Subramanian et al. (1988)	67	32	26	71	29			553	31036	36		19	January 1980	EDXRF[a]
	Subramanian (1993)			26	71	29			550	31000			19	Winter season	AAS[a]
	Ramesh et al. (1999)	61.46	37.5		64.38	10.49	0.45				10.76	0.08	11		TIMS[a]
	Banerjee et al. (2012)	40.11	33.97	21.64	53.42	23.45	2.01		502.42	28600	18.23		17	June 2008	AAS[a]
Godavari	Ramesh et al. (1999)	50.88	23.55		27.28	10.15	0.18				6.04	0.05	6		TIMS[a]
	Ray et al. (2006)	1.73	20.7	40.2		46.7	9		429	4254	30.7		4	September 2001	AAS[a]
	Krupadam et al. (2007)		25.1	25.8	197.1	14.4					21.9		10	2004–2005	AAS[a]
	Chakraborty et al. (2012)	71.2	63.8	103.4	3876.7	424	24.8				25.5			2009	ICPMS[a]
Krishna	Subramanian et al. (1985)	68	30	49	31	9			1040	42280	29		19	October December 1980	EDXRF[a]
	Ramesh et al. (1989)	82	32	35	26				906	25100	32		14	Aug-84	XRF[a]
	Ramesh et al. (1999)	148.46	94.67		171.12	4.81	0.99				37.8	0.14	9		TIMS[a]
Cauvery	Srealathan (1987) and Seralathan and Seetaramaswamy	249.5	120.7	94.5	118.7	61			3100		14		6 and 15	1976–1977	Colorimetrically and AAS[a]
	Ramanathan et al. (1988)	68.3	79.4	21.7					607.2	35552	46.1		18	July 1986	AAS[a]
	Subramanian et al. (1989)	229	379	33	75	38	1.85	0.118	1310	33500			18	July 1986	AAS[a] and hydride system
	Ramanathan et al. (1993)	42.9		19.6	25.4	30.3	0.22		567.2	16285			16	June -1987 and April-1989	AAS[a]
	Ramesh et al. (1999)	73.39	34.16		49.36	15.12	0.73				9.49	0.35	22		TIMS[a]
	Dhanakumar et al. (2013)	49.5	13.5	29.5	30	8.5			160	5228.5			10	May-2008 and Nov-2009	AAS[a]

[a] AAS – atomic absorption spectrometry, TIMS – thermal ionization mass spectrometer, XRF (EDXRF) – energy dispersive X-ray fluorescence, ICPMS – inductively coupled plasma mass spectrometry.