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Baseline

Trace metals in water, sediment and bivalves of a tropical estuary, west coast of India

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ABSTRACT

Trace metal pollution was studied in water, sediment and three selected bivalves in Mandovi and Chapora estuaries of Goa. The trace metal in water and sediment of Mandovi was higher than in Chapora. The concentration in the tissues was in the range of 1205.2–2506.7 ppm for *Paphia malabarica*, 1906.2–2802.6 ppm for *Perna viridis* and 778.7–1607.5 ppm for *Saccostrea cucullata* in Mandovi estuary. Tha values for Chapora were 199.4–625.8 ppm for *P. malabarica*, 812.6–1220.2 for *P. viridis* and 392.5–418.6 ppm for *S. cucullata*. The anthropogenic input of metal in Mandovi estuary appears to be mainly responsible for the high accumulation of trace metals. These bivalves have potential to serve as indicator for metal contamination in seafood of Goa.

The major environmental problem of estuaries is the contaminants they receive from different sources. Goa has a long history of mining for iron ore, manganese ore and bauxite. The open cast mining in Goa creates waste to the order of three tons for each ton of ore produced (Nayak, 2002). These wastes are carried away from upstream by water current and deposited downward in the estuarine complex of Mandovi–Zuari and the associated mangroves of Goa (Parulekar et al., 1986; Alagarsamy, 2006). The trace metals are partitioned with the surrounding water and form a variety of complexes and/or associated with colloids and suspended particulate matter (Mitra and Chaudhury, 1993).

Goa has a good resource of edible bivalves. They form a regular fishery and are a source of income for the poor fishermen community. The problem of metal pollution and bio-accumulation in marine edible bivalves of Goa is a serious problem but sparsely addressed (Negi, 2008). Considering the demand of edible bivalves as seafood in Goa and potential bio-accumulator, it is important that level of metal concentration in these bivalves is monitored regularly for health and hygiene. This investigation was carried out to study the seasonal variation in the concentration and accumulation of iron and manganese in the water, sediment and tissue of some edible bivalves of Mandovi and Chapora estuaries, Goa.

Mandovi estuary (the effected site) and the Chapora estuary (reference site) of Goa were selected for the present (Fig. 1). The Mandovi is largely influenced by mining activities as compared to no mining along Chapora. Water and sediment samples (replicate) were collected from selected sites with the help of a Niskin sampler and a plastic core tube. Assorted samples of clams, oyster and mussels were also collected on each sampling date from the same area in December, 2010 (post-monsoon), April (pre-monsoon) and August (monsoon) of 2011.

In the laboratory the bivalves were cleaned with freshwater and whole tissue was removed with a plastic knife so as to avoid any metal contamination. The tissue and subsample of sediment was dried in an oven at 60 °C for 48 h.

It was then powdered and kept in glass tube for metal estimation. The analysis for iron and manganese was carried out according to the protocols of ultra-trace metal analysis (Bruland et al., 1979; Danielsson, 1980) using atomic absorption spectrophotometer (AAS, Perkin Elmer model 5000). A known quantity (0.5 g) of dried powder was digested in a Teflon vessel with a mixture of 5 ml hydrofluoric-nitric-perchloric acid. Reaction mixture was heated at 80 °C up to dryness. The residue was dissolved in 3 ml of dilute hydrochloric acid (Merck, supra pure). The digested clear solution was then filtered through Whatman No. 42 filter paper and diluted to 10 ml with 2% HCl used for metal determination by AAS. Estimation was done in triplicate and results were expressed in ppm on an average basis.

The two sites under consideration exhibited different characteristics in terms of trace metal distribution in water and sediment and accumulation in the tissue of the bivalves. The concentration of iron and manganese in the water of both Mandovi and

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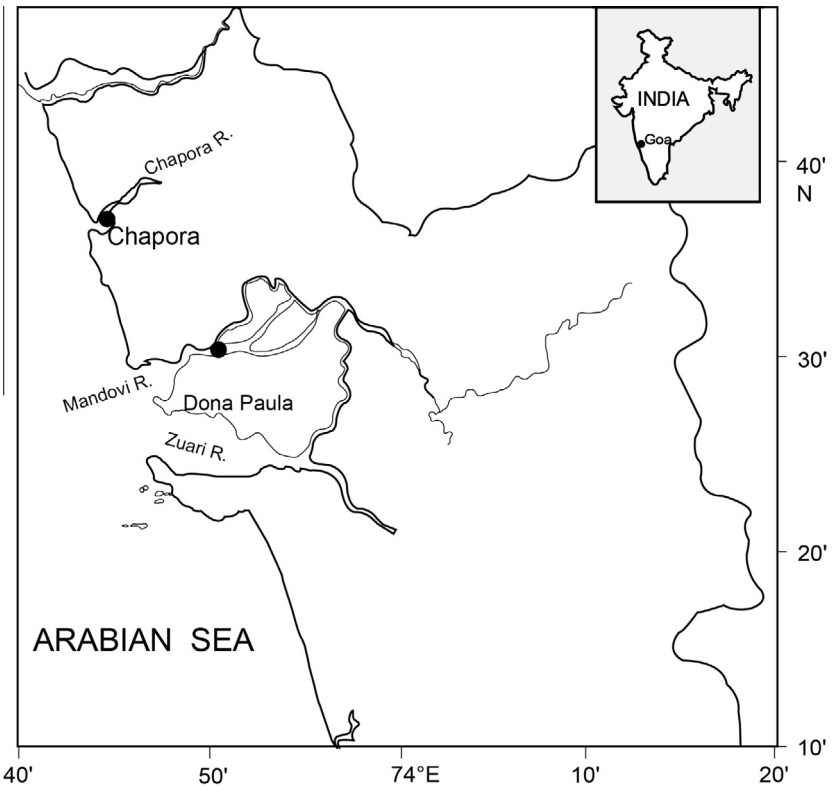

Fig. 1. Location of sampling site along the Chapora and Mondovi Rivers.

Chapora are presented in Table 1. The iron values were in the range of 20.7–118.9 ppm in Mandovi and 0.12–0.18 ppm in Chapora. Similarly the manganese values were in the range of 1.7–2.2 ppm in Mandovi and 0.01–0.05 ppm in Chapora. Thus a difference of an order of magnitude was observed with very high concentration of Fe in Mandovi and low concentration in Chapora. Site differences were highly significant (F 2,6 = 27.45, $P < 0.001$). Similarly the Mn concentration were higher in Mandovi as compared to Chapora and the differences were highly significant (F 2,6 = 51.72, $p < 0.001$).

The trace metal concentration in the sediment of the two areas is given in Table 2. The sediment of Mandovi was silty sand with high silt fraction while that of Chapora was dominantly sandy in nature. The concentration of Fe fluctuated from a minimum of 71.6 in monsoon to a maximum of 139.2 ppm in pre-monsoon in Mandovi and 14.2–17.8 ppm in Chapora respectively. Similarly the concentration of Mn was in the range of 0.8–75 ppm in Mandovi and 0.14–0.35 ppm in Chapora, respectively. The differences in concentration of Fe was highly significant (F 2,6 = 27.5, $p < 0.001$). Similarly the concentration of Mn in the sediment was found to be highly significant (F 2,6 = 54.79, $p < 0.001$).

The seasonal variation is presented in Fig. 2. The Fe content in the tissue of *Paphia malabarica* was in the range of 1205.2–2506.7 ppm, in *Perna viridis* 1906.2–2802.6 ppm and in *Saccostrea cucullata* 778.2–1607.5 ppm, respectively, of Mandovi. The Fe concentration in Chapora was in the range of 199.4–625.8 ppm for *P. malabarica*, 812.6–1220.2 ppm for *P. viridis* and 392.5–418.6 ppm in *S. cucullata*, respectively. The Mn values were found to be in the range of 110.3–115.8 ppm, 130.3–148.6 ppm and 17.5–27.9 ppm in *P. malabarica*, *P. viridis* and *S. cucullata*, respectively of Mandovi estuary. The Mn values in Chapora were 7.5–10.3 ppm, 92.5–104.2 ppm and 7.5–16.5 ppm, for *P. malabarica, P. viridis and S. cucullata*, respectively. The variation did not indicate any particular rhythm of variation. The average concentration (Table 2) showed higher values of Fe and Mn in Mandovi than Chapora. The variability was tested by 2 factor Anova and the concentration between sites showed significant differences (F 2,10 = 4.98, $P < 0.01$). Similarly the seasonal differences in the tissue concentration were highly significant (F 5,10 = 7.24, $P < 0.001$). The annual average distribution of trace metals in tissue was in the order of *P. viridis* > *P. malabarica* > *S. cucullata* (see Table 3).

The high metal concentration prevailed in the water and sediment of Mandovi is due to heavy pressure of mining discharge on benthic system. Alagarsamy (2006) while studying the metal in the sediment of Mandovi, has reported concentration of Fe in the range of 22–497 ppm with no seasonal pattern. In an other study Attri and Kerkar (2011) have reported Fe in the range of 81.0–298.5 ppm in mangrove sediment of Mandovi and 44.1–

Table 1
Seasonal variation in the concentration (ppm) of iron and manganese in water. Values are average of three observation.

Season	Mandovi		Chapora	
	Fe	Mn	Fe	Mn
Premonsoon	20.0 ± 2.6	1.7 ± 0.14	0.12 ± 0.05	0.06 ± 0.001
Monsoon	118.9 ± 15.3	2.2 ± 0.16	0.18 ± 0.009	0.02 ± 0.001
Postmonsoon	65.2 ± 4.85	1.8 ± 0.09	0.15 ± 0.004	0.01 ± 0.002

Table 2
Seasonal variation in concentration (ppm) of iron and manganese in sediment. Values are average of three observation.

Season	Mandovi		Chapora	
	Fe	Mn	Fe	Mn
Premonsoon	139.2 ± 18.7	1.7 ± 0.33	17.4 ± 3.50	0.35 ± 0.04
Monsoon	71.6 ± 10.2	0.8 ± 0.17	15.7 ± 2.1	0.14 ± 0.06
Postmonsoon	76.3 ± 11.4	1.4 ± 0.28	14.2 ± 2.7	0.19 ± 0.02