E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(6): 332-335

www.fisheriesjournal.com
Received: 04-09-2018
Accepted: 08-10-2018

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Trace metal accumulation in marine molluscs (*Perna indica* & *Bursa* sp) along the southern coast of Kerala, India

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Abstract
The study explores the bioaccumulation of trace metals in *Perna indica* and *Bursa sp* in relation to the prevailing coastal pollution along the coast of Neendakara, one of the largest fish landing centres of South India, polluted by trace metal and oil. The tissues were analysed for heavy metal (Cd, Fe, Pb & Hg) by ICP-AES. The results revealed significant levels of heavy metals except Pb. Morphometry has statistically significant linear relationship with Pb in *P. indica* and Cd and Pb in *Bursa* sp. The high loads of heavy metal detected in Neendakara can impact the life processes of man through the food chain. The present findings highlight the risk based on the exposure of man to trace metal concentration in the surrounding marine environment and also the associated risk that emerges from the consumption of food from the sea that is likely to be contaminated by the ambient metal concentrations.

Keywords: bioaccumulation, *Bursa* sp, Heavy metals, *Perna indica*, PAHs, pollution

1. Introduction
Increasing globalization has resulted in an increase in pollution resulting environmental degradation. The distinct amount of pollution by direct and indirect discharges of sewerage into the marine setting of Kerala coast is troubling. Heavy Metals are the foremost predominant form of aquatic waste due to their toxicity, long persistence, and accumulation by trophic structure. Studies on the pollution status of Kollam coast have reported by several scientists through increasing microbial contamination [1] and PAHs [2]. Neendakara is found to be a lot of contaminated than alternative coastal areas of Kollam [3, 4, 5]. This dismaying load of sewage, solid and industrial waste has created utmost extremely destructive to the flora and fauna [6].
Molluscs area common, highly visible, ecologically, and commercially important on a global scale as food and as non-food resources. In marine biota, gastropods are often used as potential bio monitors for serious metal pollution [6, 7, 8, 9]. Bivalves are widely used as bioindicators of heavy metal pollution in coastal areas since they are notable to concentrate these parts, providing a time integrated indication of environmental contamination. As compared to fish and crustaceans, bivalves have awfully low level of activity in their accelerator systems capable of metabolizing persistent organic pollutants, like aromatic hydrocarbons and polychlorinated biphenyls. Therefore, contaminant concentrations within the tissues of bivalves a lot of accurately mirror the magnitude of environmental contamination [10, 11, 12, 13].
In the present work, an attempt has been made to assess the presence of serious metals in gastropods along the coast of Neendakara, Kollam, Kerala, south west coast of India. The study conjointly provides an insight into the rising pollution standing along the coast of Neendakara.

2. Materials and Methods
2.1 Study Area
The coast of Neendakara (80 56' N Latitude and 760 32' E longitude) in Kerala, India is characterized by inorganic pollution of heavy metals and oil pollution since it is a fishing harbor and port, with large scale motor boat/trawler traffic. Five stations were selected viz., S_1: Inner harbour area, S_2: Middle harbour area, S_3: Outside harbour area and S_4: opposite harbour area (Fig 1).

Fig 1: Neendakara Harbour

2.2 Field sampling
Samples were collected between 6.00 am -9.30 am morning during the low tide, 1 km from the shoreline using a VanVeen grab ($0.1m^2$). Brown mussel specimens (*Perna indica* and *Bursa* sp) of different sizes were collected from four stations along the study area. The samples after collection were placed in separate polyethylene bags packed with ice and transported for further laboratory analysis. Duration of the study was one seasonal sampling (Premonsoon) during February 2017.

2.3 Laboratory Analysis
The samples were cleaned with deionized water to remove sand, shell, and all other particles. After measuring their size and weight, all samples were photo documented (Fig 2& 3). Samples of soft tissues (1.2g) in different sizes were inserted into a vaporizer cup for preparing tissue extracts for heavy metal analysis using ICP-AES [13].

Fig 2: *Perna indica* of different size

Fig 3: *Bursa* sp of different size

2.4 Statistical Analysis
The analysis was done using SPSS (V.24). Correlation was used to determine the relation between heavy metal concentration and morphometric characters.

3. Results and Discussion
The brown mussel belongs to the family Mytilidae of the phylum Mollusca (*P. indica*). The heavy metal concentrations of collected sample tissues were analysed and the results were found to be in the decreasing order of Station 1 (*Inner harbour area*) Fe>Pb>Hg>Cd, Station 2 (*Middle harbour area*) Fe>Pb>Cd>Hg, Station 3 (*Outer harbour area*) Fe>Pb>Cd and Station 4 (*Opposite harbour area*) Fe>Pb>Cd (Tables 1&2, Figs 4&5).

Table 1: Length and weight of *P. indica*

Stations	Length(cm)	Weight(gm)
1	4	5
2	4.5	8
3	5.3	13
4	6.2	18

Table 2: Level of Heavy Metals in tissues of *P. indica (ppm)*

Station	Cd	Fe	Pb	Hg
1	0.01	12.93	0.72	0.01
2	0.02	5.85	0.60	0.01
3	0.01	7.65	0.76	BDL
4	0.01	7.03	0.87	BDL
DL	0.03	0.01	0.02	0.01

DL: Detection Limit; BDL: Below Detection Level

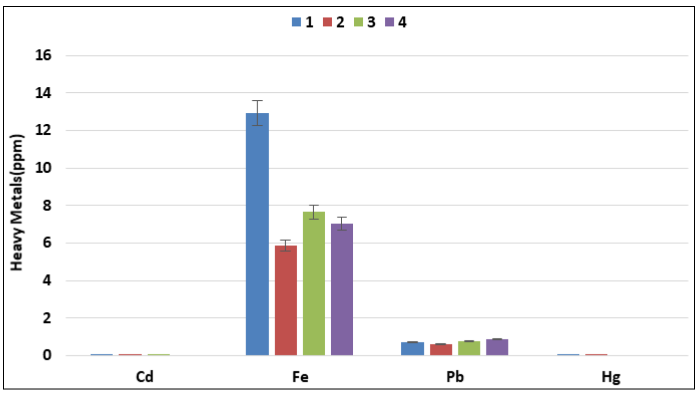

Fig 4: Heavy Metals in Tissues of *P. indica*

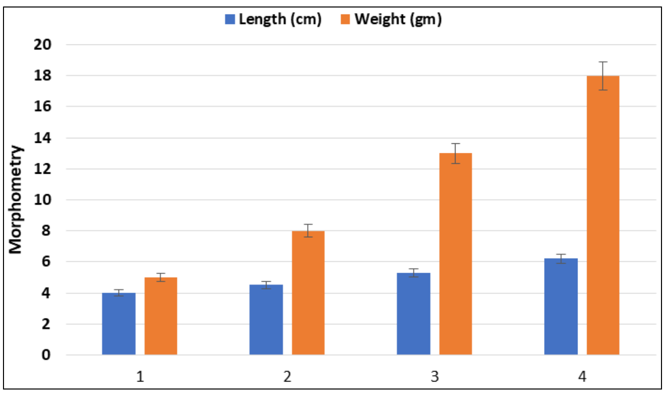

Fig 5: Length and weight of *P. indica*

Heavy metal concentrations in sample tissues of *Bursa* sp were also analysed and the results were found in the decreasing order: Station 1 (*Inner harbour area*) Fe>Pb>Cd, at Station 2 (*Middle harbour area*) Fe>Pb>Cd, Station 3 (*Outer harbour area*) Fe>Pb>Cd and Station 4 (*Opposite harbour area*) Fe>Pb>Cd (Tables 3&4, Figs 6&7)

Table 3: Length and weight of *Bursa* sp

Stations	Length(cm)	Weight(gm)
1	5	10
2	5.6	14
3	6.1	20
4	6.5	24

Table 4: Level of Heavy Metals in Tissues of *Bursa sp (ppm)*

Stations	Cd	Fe	Pb	Hg
1	0.01	5.11	0.73	BDL
2	0.01	4.38	0.61	BDL
3	0.03	4.50	1.38	BDL
4	0.05	3.78	0.42	BDL
DL	0.03	0.01	0.02	0.01

DL: Detection Limit; BDL: Below Detection Level

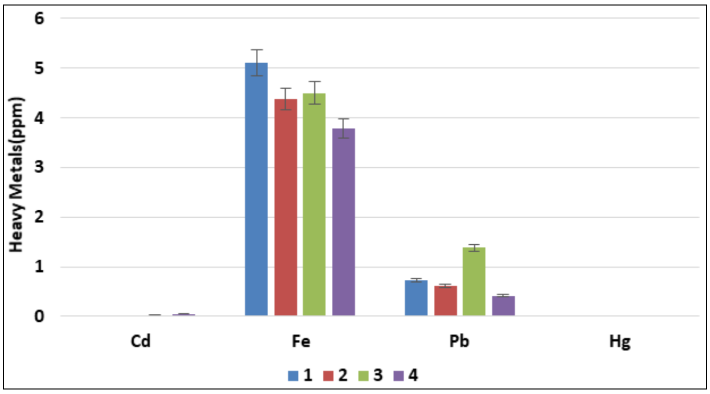

Fig 6: Heavy Metals in Tissues of *Bursa* sp

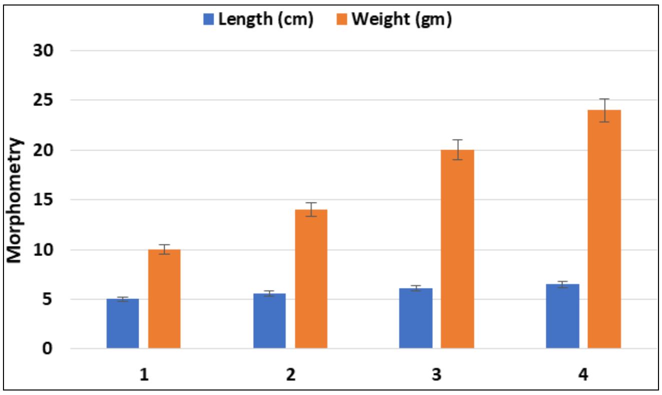

Fig 7: Length and weight of *Bursa* sp

Correlation between heavy metal concentrations in the tissues with morphometric characters were seen in the case of *P. indica*, in which Pb showed a significant strong positive correlation with height and weight of the specimens. Cadmium and Fe shows approximately medium correlation (0.3 <r <0.5) with length and weight and least correlation (0.1 < r < 0.3) with Pb and Hg. Cadmium, Fe, and Hg decreased with increase in length and weight (p >0.01). Pb showed a positive correlation, with increase in length and weight (Table 5). 7.

Table 5: Correlation between length, weight and heavy metals in *P. indica*

Variables	Length	Weight	Cd	Fe	Pb	Hg
Length	1	1.000**	-0.346	-0.566	0.783	-0.9
Weight	1.000**	1	-0.35	-0.57	0.78	-0.909
Cd	-0.346	-0.35	1	-0.535	-0.822	0.577
Fe	-0.566	-0.57	-0.535	1	0.07	0.378
Pb	0.783	0.78	-0.822	0.07	1	-0.803
Hg	-0.9	-0.909	0.577	0.378	-0.803	1

**. Correlation is significant at the 0.01 level (2-tailed).

Pb and Cd also showed a significant strong positive correlation in *Bursa* sp, while Fe showed a negative correlation. The strength and association of Pb and Cd with length and weight showed strong positive correlation (0.5 < r) with increase in length and weight (Table 6). Fe showed weak negative correlation (0.1<r<0.3) with morphometric pattern of decrease with increase in length and weight (p > 0.01). Morphometry has statistically significant linear relationship with Pb, in *P. indica* and Cd and Pb in *Bursa* sp.

Table 6: Correlation between length, weight, and heavy metals in *Bursa* sp.

Variables	length	Weight	Cd	Fe	Pb
Length	1	.993**	0.913	-0.913	0.002
Weight	.993**	1	.952*	-0.88	0.018
Cd	0.913	.952*	1	-0.809	-0.113
Fe	-0.913	-0.88	-0.809	1	0.367
Pb	0.002	0.018	-0.113	0.367	1

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

In the present study, molluscs were used for the bioaccumulation studies (*P. indica* and *Bursa* sp). Results revealed that Fe and Pb were the most abundant metals found in tissues compared to other metals. Fe was found to be higher in tissues of *P. indica* than that of *Bursa sp.*

During the study, the essential metal (Fe) was found to be higher than the non-essential metals (Cd, Pb and Hg). In all the samples, high levels of Fe than Cd, Hg, and Pb was detected when compared to the permissible levels of FAO 2003 guidelines [14]. All metals were found in significant levels, except Pb in *P. indica* at station 1(*Inner harbour area*), similar to *Bursa* sp found in station 4 (*Opposite harbour area*). This may be due to the impact of fuel waste from motor boats (station 1) and industrial runoff of effluents in the water column (station 4). High accumulation levels of Fe in soft bodied gastropods are attributed to their metabolic requirement, since these metals act as a co-factor in metabolic process. Similar correlations between trace element accumulations and metabolic activities have been reported in bivalves [15, 16].

Bivalves were selected for the present study as they are bioindicators, being abundant, easily collected and eaten widely. Their potential for significant metal accumulation, rate of uptake and elimination and influence of environmental factors are the criteria for using them as bioindicators. The study area is anthropogenic ally impacted. The coastal sediment was also found moderately polluted with Fe & Pb [17]. The high load of Fe is found to be a matter of concern due to its carcinogenicity.

4. Conclusion
The present findings highlight the risk based on the exposure of man to trace metal concentration in the surrounding marine environment and also the associated risk that emerges from the consumption of food from the sea that is likely to be contaminated by the ambient metal concentrations. Stringent bio monitoring should be enforced to protect our coastal ecosystems.

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