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Seasonal Variation of Heavy Metals in the Bivalves of a Major Fish Landing Centre in Mumbai

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Authors' contributions

This work was carried out in collaboration between both authors. Author PPS contributed in the overall design of the research study and did the statistical analysis work along with preparing the final draft of the manuscript. Author SMG did the final review of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

One of the most prevalent environmental contaminants found in aquatic ecosystems and its associated biota is considered to be heavy metals. The current study evaluated the heavy metal concentrations of Copper (Cu), Iron (Fe), Cadmium (Cd), Zinc (Zn), Manganese (Mn), Cobalt (Co), Chromium (Cr), Arsenic (As), Nickel (Ni), and Lead (Pd) in the soft tissues of *M.casta* and *Paphia malabarica* species seasonally for one year. The soft tissue of the two species were digested using a microwave digestion system (CEM-MARS-5) using nitric acid and perchloric acid. Evaluation of Cu, Ni, Cr, Mn, Co, Fe, and Zn was done using ICP-OES while for estimation of Pd, Cd and As, ICP-MS was used. During the study, Fe, Mn and Zn content dominated the whole soft tissues of both species. The findings demonstrated that the pre-monsoon season had higher amounts of the most examined heavy metals, whereas the monsoon season had the lowest quantities of these metals in the soft tissues of both species.

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Keywords: Heavy metals; marine pollution; bivalves; seafood; seasonal variation.

1. INTRODUCTION

Seafood provides humans with a great source of macro and micronutrients [1]. It is rich in proteins, minerals, vitamins, and essential omega-3 fatty acids [2]. Molluscs especially bivalves have been widely used for bioindication and biomonitoring purposes due to their sedentary, sessile habitat and filter-feeding habit [3]. Bivalves including clams, mussels, and oysters form a cheap source of proteins, especially to the coastal population [4]. However, bivalves have been known to accumulate high amounts of chemical contaminants like heavy metals [5].

The contamination of aquatic environments by heavy metals is a global concern [6]. They originate through both sources; natural as well as anthropogenic [7]. However, their level has increased in the last few decades due to different anthropogenic activities like mining, discharge of untreated effluents into the water, wastewater disposal, urbanization, and so on. When humans consume such metal-polluted seafood they are at risk of several toxic health effects [8]. Although heavy metals like Fe, Mn, Zn, and Cu are essential for organisms, heavy metals like Pb, Cd, Hg have no role at all in living organisms and become toxic when present at any concentration [8, 9,10-13]. Mumbai being a coastal city depends heavily on seafood like bivalves for nutrition which makes it essential to check the quality of the seafood being consumed on such a large scale by the people of this city.

2. MATERIALS AND METHODS

2.1 Sampling, Sample Preparation and Digestion

The samples were collected from the fish landing center – New Ferry Wharf for a period from 2020 to 2021. After collection, they were brought back to laboratory, washed, the soft tissues were oven dried, powdered and kept for further processing. 0.5 g of the samples were digested using microwave digestion system (CEM-MARS-5) [14], once digested the volume was raised to 25 ml using MilliQ water.

2.2 Heavy Metal Assessment

ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry; PerkinElmer Optima 7300 DV) was used for the estimation of Cu, Ni, Cr, Mn, Co, Fe, and Zn in the samples while for Pb, Cd and As, ICP-MS (Thermoscientific iCAP RQ) was used. For method validation Certified Reference materials were used (CRM TORT-2 and DOLT-4). The results of the study were expressed as µg/g dry weight.

2.3 Statistical Analysis

All samples were analyzed in replicates. Results are shown as mean ± standard deviations (SD). statistical analysis was done using One-way analysis of variance (ANOVA) with significance P = .05.

3. RESULTS AND DISCUSSION

3.1 Seasonal Concentrations of Trace Metals in *M.casta*

Table 1 demonstrates the mean heavy metal concentrations in *M.casta* during the three seasons; pre-monsoon, monsoon and post-monsoon. The results showed the majority of heavy metals had higher concentrations during the pre-monsoon season. A high accumulation of heavy metals like Fe, Mn, Co, and Ni (685.38, 46.09, 2.76, 13.856, and 6.69 µg. g^{-1}, respectively) was recorded in the pre-monsoon. The results in Fig. 1 show that the trace metal Fe was found to have much higher concentrations in all three seasons compared with the rest of the metals similar whereas Pb and Cd concentrations were lowest in all the three seasons.

3.2 In Mollusc Species

3.2.1 Seasonal concentrations of trace metals in *P. malabarica.*

Table 2 presents the mean heavy metals concentrations in *P. malabarica* during the three seasons. The majority of heavy metals showed high accumulation in the pre-monsoon season. A high accumulation of heavy metals like Cr, Fe, Mn, Co, Pb and Cd (4.38, 1850.66, 353.16, 2.35, 1.29, and 5,19 µg. g^{-1}, respectively) was also recorded in the pre-monsoon season. The results in Fig. 1 show that the trace metal Fe was found to have much higher concentrations in all three seasons on being compared with the rest of the metals whereas Pb and Cd concentrations were lowest in all the three seasons.

Table 1. Mean heavy metals concentrations in *M. casta* for the three seasons (µg. g^{-1} dry w.) Values with different superscripts (a, b, and c) are different significantly

Heavy Metals	Pre-monsoon	Monsoon	Post- monsoon	Overall Significance
Zn	39.9 ± 3.89^{a}	49.93 ± 13.83^{a}	43.62 ±8.63^{a}	Insignificant
Mn	46.09 ± 7.26^{a}	18.4 ± 5.57^{b}	42.53 ± 9.63^{a}	***
Fe	685.38 ± 25.86^{a}	233.61 ± 27.29^{b}	515.36 ± 23.97^{c}	***
Cu	23.85 ± 4.88^{a}	21.85 ± 4.67^{a}	22.57 ± 2.82^{a}	Insignificant
Co	2.76 ± 0.89^{a}	1.31 ± 0.8^{b}	1.5 ± 1.00^{b}	**
Cr	2.32± 1.22^{a}	2.04 ± 1.11^{a}	0.86 ± 0.7^{b}	**
Ni	6.69 ± 2.03^{a}	3.73 ± 3.41^{ab}	4.65 ± 1.47^{a}	*
As	12.61 ± 2.57^{a}	8.7 ± 3.22 ^{ab}	10.35 ± 1.46^{a}	**
Pb	0.73 ± 0.6^{a}	0.63 ± 0.32^{a}	0.4 ± 0.16 ^{a}	Insignificant
Cd	1.93 ± 0.68^{a}	0.6 ± 0.29 ^{b}	0.91 ± 0.99^{b}	***

**P ≤ .05, ** P ≤ .01 and *** P ≤ .001.*

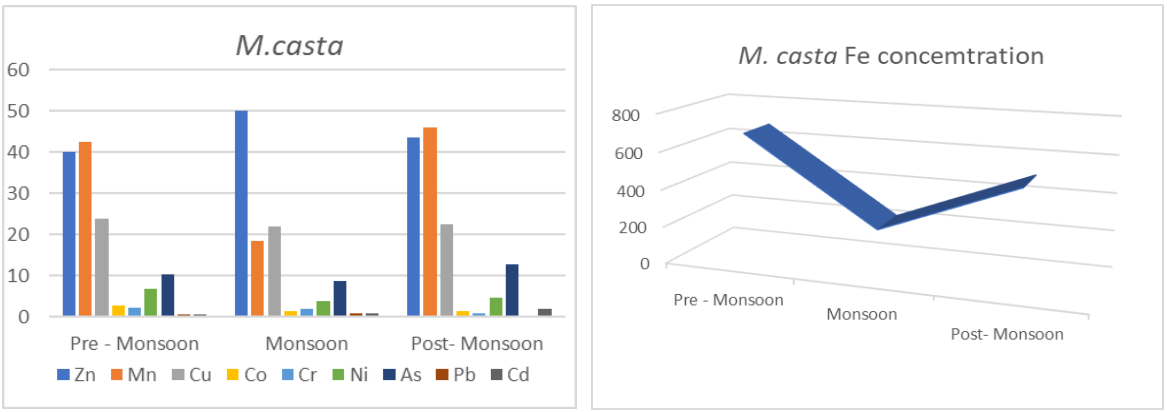

Fig. 1. Heavy metals accumulation in *M. casta.*

Table 2. Mean heavy metals concentrations in *P.malabarica* for the three seasons (µg. g^{-1} dry w.) Values with different superscripts (a, b, and c) are different significantly

Heavy Metals	Pre-monsoon	Monsoon	Post- monsoon	Overall Significance
Zn	52.98 ± 8.10^{a}	74.91 ± 13.24^{b}	57.45 ±10.14^{a}	***
Mn	353.16 ± 14.06^{a}	17.45 ± 6.26^{b}	71.41 ± 9.47 ^{c}	***
Fe	1850.66 ± 27.34^{a}	136.78 ± 13.95^{b}	900.53 ±29.06^{c}	***
Cu	33.95 ± 4.56^{a}	23.90 ± 3.83^{b}	19.4 ± 4.99^{b}	***
Co	2.35 ± 0.98^{a}	1.48 ± 0.18^{b}	1.3 ± 0.69^{b}	**
Cr	4.38 ± 1.67^{a}	1.22 ± 0.98^{ab}	2.67 ± 2.06^{b}	**
Ni	6.88± 3.17^{a}	6.28 ± 1.61^{a}	3.14 ± 1.71^{b}	**
As	8.21 ± 0.82^{a}	7.29 ± 2.31 ^{ab}	8.02 ± 3.30^{a}	Insignificant
Pb	1.29 ± 0.59^{a}	0.48 ± 0.35^{b}	0.61 ± 0.36 ^{b}	**
Cd	5.19 ± 0.93^{a}	0.35 ± 0.03 ^{b}	1.81 ± 0.95^{c}	***

**P ≤ .05, ** P ≤ .01 and *** P ≤ .001.*

Table 3 demonstrates the mean heavy metal concentrations in *M.casta* and *P. malabarica* during the three seasons; pre-monsoon, monsoon and post-monsoon.

The pre-monsoon (dry season) experiences weaker flushing from rivers and estuaries, which increases the settling rate of suspended particulate matter and significantly contaminates the bottom sediment [15]. Therefore, the higher levels of metals observed in the bivalve species in the present study during the pre-monsoon period could be attributed to a substantial increase in the precipitated metal forms in the water column, combined with enhanced filtration rates. Similar results were observed in studies conducted by Kibria et al. [16] and [17] in the mollusc species.

Table 3. Mean heavy metals concentrations in *M. casta* and *P. malabarica* for the three seasons (µg. g^{-1} dry w.)

Heavy Metals	Pre-monsoon		Monsoon		Post- monsoon	
	Meretrix casta	***Paphia malabarica***	***Meretrix casta***	***Paphia malabarica***	***Meretrix casta***	***Paphia malabarica***
Zn	39.9 ±3.89	52.98 ± 8.10	49.93 ± 13.83	74.91 ± 13.24	43.62 ±8.63	57.45 ±10.14
Mn	46.09 ±7.26	353.16±14.06	18.4 ± 5.57	17.45 ± 6.26	42.53± 9.63	71.41 ± 9.47
Fe	685.38±25.86	1850.66± 27.34	233.61± 27.29	136.78± 13.95	515.36 ± 23.97	900.53 ±29.06
Cu	23.85 ±4.88	33.95 ± 4.56	21.85 ± 4.67	23.90 ± 3.83	22.57 ± 2.82	19.4 ± 4.99
Co	2.76±0.89	2.35 ± 0.98	1.31 ± 0.8	1.48 ± 0.18	1.5 ± 1.00	1.3 ± 0.69
Cr	2.32±1.22	4.38 ± 1.67	2.04 ± 1.11	1.22 ± 0.98	0.86 ± 0.7	2.67 ± 2.06
Ni	6.69 ±2.03	6.88± 3.17	3.73 ± 3.41	6.28 ± 1.61	4.65 ± 1.47	3.14 ± 1.71
As	12.61 ±2.57	8.21 ± 0.82	8.7 ± 3.22	7.29 ± 2.31	10.35 ± 1.46	8.02 ± 3.30
Pb	0.73 ±0.6	1.29 ± 0.59	0.63 ± 0.32	0.48 ± 0.35	0.4 ± 0.16	0.61 ± 0.36
Cd	1.93 ± 0.68	5.19 ± 0.93	0.6 ± 0.29	0.35 ± 0.03	0.91 ± 0.99	1.81 ± 0.95

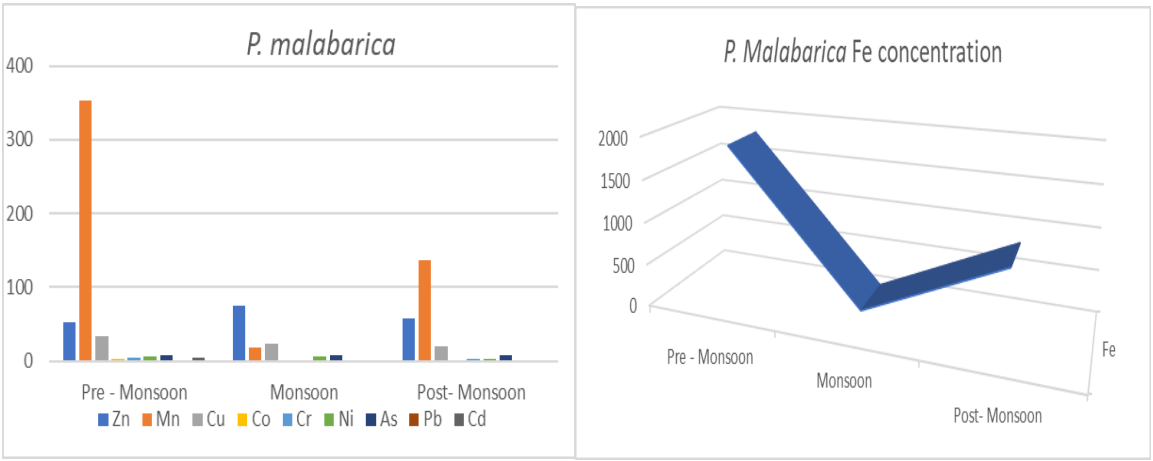

Fig. 2. Heavy metal accumulation in *P. malabarica.*

The high accumulation of Fe in the current study was similar to the studies conducted by George et al. [15] in *Cystoseira barbata***,** by Swaleh et al. [18] in S*accostrea, Mytilu and donax species,* by Krishnan et al. [19] in *Cerithidea obtuse* species and by [20] five molluscs *species from* Black Sea (Türkiye). Pb and Cd are non-essential elements that have no role in the organisms. The low mean level of Pb and Cadmium is similar to the mean values by Flores et al. [21] in *Anadara tuberculosa,* [22] in molluscs collected from southern coastal India. Their levels were however higher than the studies by Miedico et al. [23], Romero-Estévez et al., [24] while lower than in studies conducted by Bucșe et al. [25] in *M. Galloprovincialis* from Black Sea (Romania) [26,27].

4. CONCLUSIONS

Heavy metal pollutants are not only toxic to marine biota but also to humans via their consumption. Their toxicity is mostly the result of their persistent nature along with their bioaccumulation property in living organisms. Lead, cadmium, copper, arsenic, and zinc are the metals that pose the biggest risk to the environment because they are discharged into large quantities through wastewater discharges from industrial and agricultural processes. The results found in the current study provide information about the status of trace metal accumulated in the two commercially important bivalve species of an important fish landing center of Mumbai. It also reveals that both the species accumulated a high concentration of both heavy metals. Cu, Fe, Pb, Zn and Mn were higher in the pre-monsoon season in both species. Therefore, adequate action is required to protect our marine system, which may be accomplished by lowering the number of pollutants entering it.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

CONFERENCE DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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