International Journal of Ecology and Environmental Sciences 49: 381-386, 2023
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2023.2713

Survey of Lead Concentration in Tiger Prawn (*Penaeus monodon*) in the Seafood Market of Mumbai and Palghar Districts of Maharashtra

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ABSTRACT
Lead (Pb) is one of the major heavy metal pollutants found in water bodies. Lead gets accumulated in various floral and faunal species present in the water bodies, which further enters the human food chain through the consumption of aquatic species from such water bodies. This may lead to lead (Pb) toxicity. Seafood from polluted water bodies is especially a matter of great concern. World Health Organisation (WHO) has given standard limits of metal concentration in the marine fauna and human body which act as guidelines for metal analysis. In this study, we investigated the concentration of Lead in Tiger Prawns (*Penaeus monodon*) collected from Mumbai and Palghar districts of Maharashtra, India, and compared the results with safe limits given by the WHO. The analysis was done using Inductively Coupled Plasma–Optically Emission Spectrophotometer (ICP-OES) technique. According to the results, Lead (Pb) concentrations in the samples from Madh and Palghar area significantly exceed the permissible limit for both humans and aquatic life.

Key words: Lead, Toxicity, Seafood, Prawns, ICP-OES.

INTRODUCTION

Excessive industrialization has laid heavy metal pollutants into the environment, especially into marine bodies causing pollution which is a threat to all marine life and indirectly to humans consuming seafood. Lead accumulates in organisms such as plankton and gets transferred to marine fauna (fish, crustaceans, cephalopods, mussels, etc) and then enters the human food chain through consumption of seafood, leading to a very negative impact on health. Health effects depend upon the type of heavy metals, route of exposure, duration, dosage, and age. Gills, flesh, intestine, and skin are the site of the accumulation of heavy metals in fish. Heavy metals entering the water body are one of the hazardous pollutants for marine life as there is no natural process to get rid of metal contaminants.

Industrial waste and sewage are mostly released into the coastal aquifers without any treatment. Lead accumulates in the tissues of the marine fauna instead of getting excreted which leads to bioaccumulation. Due to this bioaccumulation, there are higher chances of exposure of lead to the people consuming seafood. The aquatic animals like prawns, shrimp, fishes, crabs, etc. might become immune to the accumulation and might not be affected due to the presence of this lead in their bodies. But when lead-contaminated seafood is consumed by people, it might cause lead toxicity. The World Health Organization (WHO) has given the permissible limit as 300 ppb for lead concentration in fishes and a permissible level of 10 ppb for lead in humans.

Numerous studies have been reported on the estimation of heavy metals, especially lead in marine fauna that forms part of seafood. Falco et al. (2006) undertook a study on intake of arsenic, cadmium, mercury, and lead by consumption of edible marine species from six cities of Catalonia through Inductively Coupled Plasma Mass Spectroscopy. Cirillo et al. (2010) undertook a survey of lead, cadmium, mercury, and arsenic in seafood marketed in Campania, Italy. Gueguen et al. (2011) reported a study on the identification of residual chemical hazards in shellfish collected from the marine environment and market in France. Pastorelli et al. (2012) undertook an evaluation study on human exposure to lead, cadmium, and mercury through fish and seafood products like blue mussel, carpet shell clam, European squid, veined squid, deep-water rose shrimp, red mullet, European seabass, bluefin tuna, and swordfish. Hosomi et al. (2012) examined the significance of seafood in the human diet.

Rantetempang and Mallongi (2013) estimated lead contamination in aquatic habitat potential risks of seafood consumption from Sentani Lake, Papua (Indonesia). He et al. (2016) reported a study on species characteristics of lead in seafood collected from coastal water of Fujian and Southeastern China. The study detected the presence of Pb^+ and trimethyl lead (TML) in seafood and concluded that the presence of TML or Pb^+ was dependent on the aquatic species rather than the sampling area. Winiarska et al. (2018) examined the presence of Cadmium and Lead in content in commercial fishery products consumed in Poland and found the fishery products in Poland were safe for consumption with lead and cadmium content within permissible limits. Ariano et al. (2019) reported the presence of cadmium, mercury, and lead in the muscle and digestive gland of Common Octopus (*Octopus vulgaris*). A higher concentration of lead was found in the digestive gland as compared to muscle. Djedjibegovic et al. (2020) reported a study on the presence of cadmium, lead, and mercury in seafood products consumed by the adult population of Bosnia and Herzegovina. Tamele and Loureiro (2020) assessed the incidence of lead, mercury, and cadmium in seafood of African countries on the Indian ocean and the Red Sea coasts. Di Bella et al. (2021) carried out a risk assessment of cadmium, lead, and mercury intake from farmed Sea Bass in Sicily. The study was carried out through ICP-MS and Atomic Absorption Spectroscopy (AAS) and estimated weekly intake were compared with provisional tolerable weekly intake. Moxness et al. (2021) determined to lead, arsenic, cadmium, and mercury in 24 marine fishes from the Bay of Bengal commonly consumed in Sri Lanka and Bangladesh.

In the Indian context, Zodape (2011) collected prawn and shrimp from Vile Parle and Bandra in Mumbai from the month of June to December and analyzed by using AAS. Velusamy et al. (2014) collected commercially important fishes from the Mumbai Harbour and evaluated them using Atomic Absorption Spectroscopy and ICP-OES. Khodake et al. (2015) collected fish species from Latipada dam, Dhule between the period January 2012 to June 2012 and were analyzed for heavy metals by using AAS. Khillare et al. (2015) collected a sample of *Tilapia mossambica* from Aurangabad district from January 2015 to April 2015 to study analysis of heavy tissues. Chaitanya *et al*. (2016) collected Seer, Indian Mackerel, and Silver Pomfret from Vishakapatnam and Bheemili regions to analyze heavy metals using Flame AAS. Patil et al. (2016) collected Prawn samples from Arnala beach, Naigaon creek, and Vasai creek, and Bombay duck from Rangoon beach and analyzed them for heavy metals using ICP-AES. Shingadia (2016) collected marine water fishes from Versova and studied the concentration of heavy metals. The analysis was carried out using Flame AAS. Oza and Muralidharan (2018) collected *Harpodon nehereus* in different seasons from Sassoon dock to estimate lead in the liver, gill, muscle, and brain tissue using ICP-AES. Recently Aggarwal and Bhatla (2022) monitored presence of heavy metals (Cu, Cr, Pb and Zn) in dietary vegetables collected from local market of Delhi. Keeping in view the health risk of consuming seafood from polluted water bodies, the current study was undertaken to assess the amount of lead in Giant Tiger Shrimp (*Penaeus monodon*) which are commonly consumed seafood. The samples were collected from Mumbai and Palghar districts of Maharashtra, India, and determined lead concentrations were compared with the permissible limits given by the WHO.

MATERIALS AND METHODS

A total of three hundred (300) prawn samples were collected from Gorai, Sasson, Naigaon, Palghar, Madh, and Versova fish markets. CEM Mars6 instrument was used for the microwave digestion by using the standard procedure for digestion of prawn sample by using concentrated Nitric Acid and Hydrogen Peroxide in the ratio 1:10:3 (Prawn sample: Nitric Acid: Hydrogen Peroxide). All the samples including were prepared and kept overnight for pre-digestion purposes. The microwave digestion was done at 160 degrees for 1 hour. The samples were then diluted to 100 mL with Milli-Q water and were analyzed. Prodigy7 ICP-OES instrument was used to determine the lead concentration in the sample. Calibration was done before analysis. Data were analyzed with PAST (Paleontological Statistics Software Package) version 3.02 (2001).

RESULTS AND DISCUSSION

The maximum permissible limit for lead in the human body is 10 ppb and in shrimp is 300 ppb. The statistical observations for these samples are given in Table 1. Figure 1 shows the Pb concentration at sampled sites as a box plot. It is apparent the samples from Madh (Mean value1878.642±56.7ppb) and Palghar (Mean value 622.6815±5.99ppb) area has a very high concentration of lead. Especially, the tiger prawn samples from Madh have a very high concentration with a maximum value reaching 2708.039 ppb. The results obtained were compared to the permissible limit given by WHO for both marine organisms and humans. It is apparent that the samples from Madh and Palghar have a very high concentration of lead and is much higher than the permissible limit given by the World Health Organisation. However, the samples from Gorai, Naigaon, Sasson, and Versova have a lead concentration within the permissible limits and Sasson having the minimal concentration of lead (Mean value 27.20±1.37ppb).

When compared with the previous studies the results support the previous findings of high lead concentration in seafood from Mumbai region. Studies across the globe indicated certain cases where lead concentrations were higher than the permissible limits of WHO. Lead concentration of 0.10mg/kg (100ppb) was reported in salmon from Catalonia, Spain by Falco et al. (2006). Cirillo et al. (2010) estimated lead concentration of 689 ng/g (689 ppb) in marine fish from Campania, Italy, which was higher than the permissible limit of WHO. Rantetampang and Mallongi (2013) determined the concentration in bivalve, pelagic and benthic fish as 0.43 to 2.76 mg/Kg (430 to 2760ppb), 0.27 to 2.78 mg/Kg (270 to 2780ppb) and 1.39 to 3.55 mg/Kg (1390 to 3550 ppb) respectively. The upper limits here were on the higher side of the permissible limits. He *et al.* (2016) estimated the quantity of lead in shrimp and clam (*Paphia undulate*) as 0.19 ng/g (0.19ppb) and 0.41 (0.41 ppb) respectively. Winiarska et al. (2018) determined the concentration of lead in marinated fish as 58.8 µg/Kg (58.8 ppb). The concentration of lead in digestive gland of Octopus was estimated as 0.763 µg/g (763ppb) which was on the higher side of permissible limit (Ariano et al. 2019). Djedjibegovic et al. (2020) found lead concentration range of 0.092 to 0.278mg/Kg (92 to 278ppb) and 0.004-0.024mg/kg (4-24ppb) blue mussel and Indian white prawn. Di Bella et al. (2021) reported concentration of 0.11µg/g (110ppb) in farmed sea food of Italy. Lead concentration for small and large fish from Bay of Bengal was reported as 0.019 mg/Kg (19ppb) and 0.005 mg/Kg (5ppb) by Moxness et al. (2021).

Focussing on the Indian scenario, especially that of Mumbai region, in the previous study from the Vile Parle and Bandra region of Mumbai, the lead concentration of Giant Tiger Shrimp (*Penaeus monodon*) was reported as 1.132 ppm (1132 ppb) and 3.135 ppm (3135 ppb) by Zodape et al. (2011). The lead concentrations were clearly more than the permissbile limits of WHO and the current study supports the pervious finding of high lead concentration in certain areas. Velusamy (2014) reported lead concentration of 0.26 µg/g (260ppb) for *Arius maculatus* from Mumbai harbour. The value although within the permissible limits, but is not very less than the permissible limit. Shingadia (2016) had reported high lead concentrations of 0.68 ppm (680 ppb) and 1.04 ppm (1040ppb) in two fin fish species (*Lepturacanthus savala* and *Rastrelliger kanagurta*) from Versova, Mumbai. Oza and Murlidharan (2018) had reported very high concentration of lead (1.25mg/Kg to 6.4 mg/Kg; 1250 to 6400 ppb) in fish muscle from Sassoon dock Mumbai. However the current study indicates that the concentration is much lower (mean 23.2 ppb) and in safe limits. In silver pomfret (*Pampus argenteus*) from Vishakhapatnam (Andra Pradesh) the lead concentration was estimated as 0.09 mg/Kg (90 ppb) in meat, 4.14 mg/Kg (4140 ppb) in liver and 3.16 mg/Kg (3160ppb) gills (Chaitanya et al. 2016). It is apparent that the lead concentration in liver and gills is quite high. In case of vegetables (Cauliflower and Spinach) lead concentration of 0.125mg/Kg (125ppb) and 0.114 mg/Kg (114ppb) was observed in unwashed condition by Aggarwal and Bhatla (2022). However after washing the lead concentration was below detectable limits.

CONCLUSIONS

The results indicate that lead concentration in the prawns' sample from Madh and Palghar area is 1878.642±56.7 ppb and 622.6815±5.99 ppb,

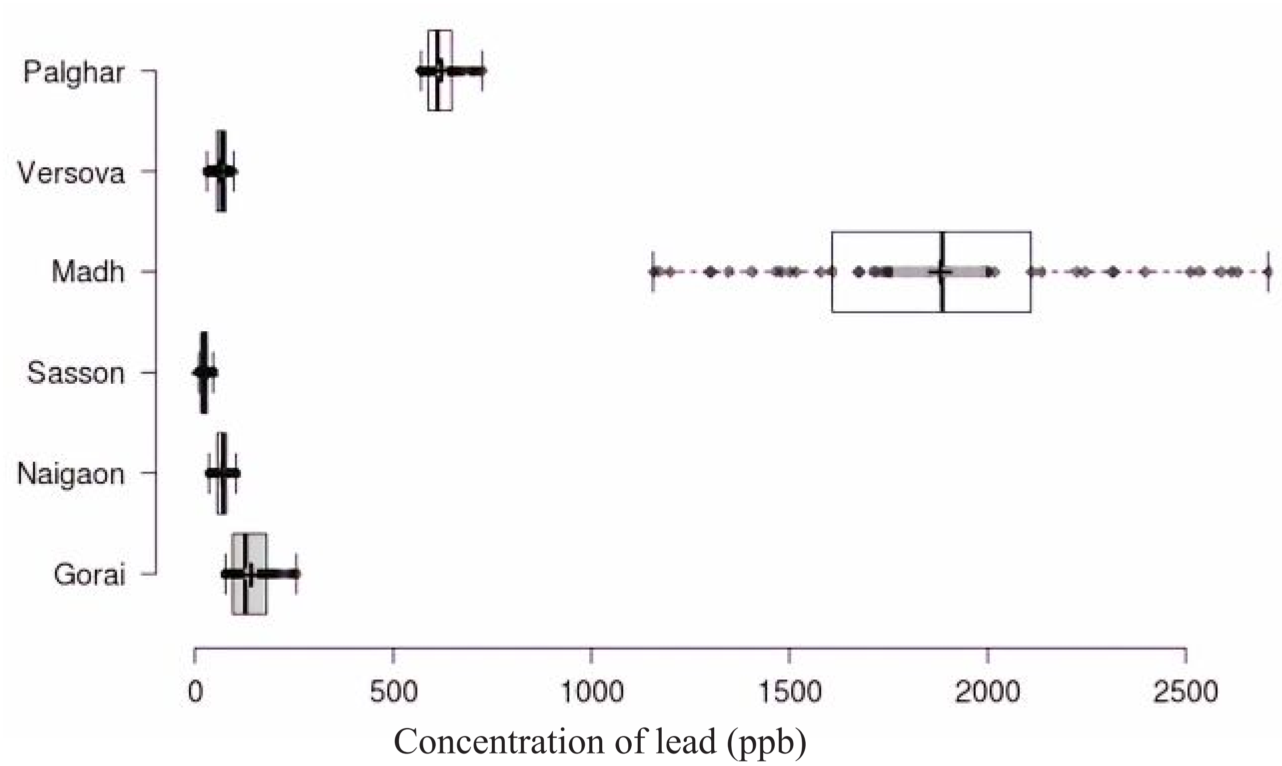

Figure 1. Lead Concentration in various samples analysed from the selected sites.

Table 1. Statistical analysis results for the various parameters for samples from selected sites.

	Gorai	Naigaon	Sasson	Madh	Versova	Palghar
N	50	50	50	50	50	50
Min	76.2305	36.1372	10.5765	1156.123	30.96	568.9973
Max	256	104.2603	46.4552	2708.039	96.7642	724.4596
Sum	7033.948	3469.493	1160.079	93932.1	3281.475	31134.07
Mean	140.679	69.38987	23.20158	1878.642	65.62949	622.6815
Std. error	7.272782	2.614654	1.373747	56.70397	2.275399	5.997979
Variance	2644.668	341.8207	94.35905	160767	258.872	1798.788
Stand. dev	51.42633	18.48839	9.713859	400.9576	16.0895	42.41212
Median	127.163	71.47855	21.07675	1886.011	68.6005	611.0095
25 prcntil	94.48125	54.16105	16.17645	1600.732	54.33253	587.4398
75 prcntil	182.6128	79.38235	30.39185	2115.443	77.45933	648.3183
Skewness	0.66453	-0.08998	0.836753	0.235371	-0.38081	0.794993
Kurtosis	-0.6031	-0.77238	-0.0709	-0.45356	-0.58316	-0.28493
Geom. mean	132.0621	66.78137	21.36976	1836.21	63.43991	621.3087
Coeff. var	36.55581	26.64423	41.86723	21.34295	24.51565	6.811206

respectively which is higher than the permissible limits for marine organisms as well as for humans. The samples from other locations have lead concentrations below the permissible limit for marine organisms but more than that for humans. The reason for the increased concentration might be due to the release of industrial effluent or sewage into the water bodies which are exposed to aquatic life. Thus, there is a need to take precautionary steps towards the proper treatment of effluents and sewage before releasing them into the water body to avoid lead toxicity. Further, it is of utmost necessity that seafood is screened for presence and concentrations of lead, prior to allowing it into the market. In addition there is further need to take up a detailed study on the sources that are causing this high concentration of lead in marine fauna and suggest possible mitigatory measures.

ACKNOWLEDGEMENTS

We would like to express our gratitude to the Director, Institute of Forensic Science, Mumbai for the support and encouragement throughout our work. We would like to express our thanks and gratitude to LabIndia Analytical Instruments Private Limited, Navi Mumbai for their coordination during the instrumental analysis.

Authors' contributions: DB and VS conceived and designed the experiments. AM and MS did sample collection and performed all the wet lab experiments. DB and VS analyzed the data and wrote the manuscript. All the authors participated in the discussion and provided inputs to improve the manuscript's content. All authors read and approved the final manuscript.

Conflict of interest: The authors declare that they have no competing interests.

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Received: 17th September 2022
Accepted: 27th November 2022