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Presence of Metals Cu, Zn, Fe, Na and Pb, in Commercially Important Shrimp's and Water Sediments Collected from Gorai Creak of Mumbai Suburb of West Coast, India

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Abstract: The research paper is focused on distribution of toxic metal in various tissues of different shrimp species, and in surface and bottom water sediments. The possible roles of these trace elements in this regard are emphasized. Moreover, patterns of toxic metal bioaccumulation and their order of occurrence have been evaluated. Another part of this paper deals with comparison of the related data from different aquatic environments as well as existing guidelines and limits for human consumption. Comparison between the mean concentrations of the toxic metal in Carapace, gills, remaining body tissues and whole body tissues and in water samples are compared with existing guidelines indicate that the concentrations of Zn, Fe, and Na are well below the permissible levels for human consumption. However the concentrations of Cu and Pb were observed somewhat greater than some of the recommended levels as prescribed by FAO/WHO and cited literature.

Key words: Toxic metals, Creak, Shrimps, sediments, contamination

1. Introduction

Coastal belts are highly populated and urbanized with industries. Marine food such as fish, prawn, crab and mussel are delicacies and form an important staple part of daily food. The bioavailability of trace metals is the key factor determining tissue metal levels in the marine biota. The tendency of heavy metals to get accumulated in marine animals is of scientific interest in heavy metal chemistry. Trace metal uptake occurs directly from surrounding marine water across the permeable body surface and from food along with the seawater to the gut [1]. Fish, crab and prawn form an important link as possible transfer media to human beings. Information on the level of heavy metal pollution in coastal environment is important as they cause serious environmental health hazards [2-4]. Pollution of aquatic environments with heavy metals has seriously increased worldwide attention and under certain environmental conditions, fish, Prawns and shrimps may concentrate large amounts of some metals from the water in their tissues. Heavy metals such as Cu, Zn, Fe, Na and Pb are potentially harmful to most organisms even in very low concentrations and have been reported as hazardous environmental pollutants able to accumulate along the aquatic food chain with severe risk for animal and human health [5]. Toxic heavy metal can cause dermatological diseases, skin cancer and internal cancers (liver, kidney, lung and bladder), cardiovascular disease, diabetes, and anaemia,

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as well as reproductive, developmental, immunological and neurological effects in the human body [6, 7].

Hence it is necessary to monitor the concentration of these contaminants in prawns and shrimps so that a warning signals can be given to the society in case the concentration levels cross the threshold limits. The available literature reveals that the inshore water of the above creeks around Mumbai possesses elevated levels of contaminants and their consistent inputs have resulted their high build up a marine organism particularly fishes, prawns and shrimps. Hence it is expected that the sea food available around Mumbai may have elevated levels of pollutants. These contaminants if determined can lead to identify causes of disease or toxic effects which would be prevented in the population.

At present the population of Mumbai is severally suffering from lots of disorders particularly respiratory and digestive due to air and drinking waters. Most of these causes have been identified and remedial measures have been taken up. However, toxic effect due to metal contamination of fish, Prawns and shrimps, which is a main diet of majority of the population of Mumbai is not primarily addressed and completely neglected. In fact the relevant toxic effect may be already prevalent in the society and most probably they may become severe in due course of time. Hence, the stage has already reached to address the problem in detailed and to dig the thought under the problem.

It is therefore necessary to determine the extent of contaminants in prawns and shrimps as one of the major source of food so that the warning signals can be given to the society in case the threshold limits have reached. Even otherwise it becomes necessary to educate the society of the social evils of pollution. The study can also provide the information on possible causes of pollution. So that mitigation measures to minimize the pollution can be taken in time.

2. Materials and Methods

2.1 Sample Collection

The Shrimps and water samples were collected from 200 meters away from the Gorai creak of Mumbai from April, 2014 to December 2014. The Shrimp samples, packed in propylene bags, were stored at 20°C in deep freeze in the Department of Zoology, S.S & L.S. Patkar College, Goregaon (West) Mumbai for further analysis.

2.2 Sample Digestion

The samples were identified as per the FAO guidelines manual and were brought to the laboratory in the Department of Zoology S.S & L.S. Patkar College Goeregaon (West) Mumbai, and washed in sea water. Five replicates of the above samples containing shrimps in a Petri dish were oven dried at 80°C for 2 days to get the dry weight (DW). The dried samples were crushed into a fine powder by mortar and pestle and pass through a 2 mm sieve and stored in amber colored bottles in vacuum desiccators. For digestion, 1 mL of concentrated nitric acid 70% was added to the 1 gm of dry weight samples and wait for 24 h, the samples were digested in Kjeldal flask. This mixture was digested by heating the flask in a heating mantel, at 100°C for 2 h, and 30% hydrogen peroxide was added to it intermittently till a pale yellow-colored solution was obtained. The digestion flask was further heated gently until frothing subsided and the sample was then heated to dryness. The residue so obtained was left to cool for half an hour and dissolved in 30 ml of deionised water and the solution was filtered using Whatman filter paper No. 42. The digested sample was quantitatively transferred into 50 ml flask, and then diluted with distilled water up to the mark and stored in a polypropylene bottle. The water samples were well mixed with 2 mL concentrated HNO3 per liter sample and capped tightly until they were ready for analysis as proposed by Ref. [8]. The above procedure was repeated for all the other samples. All above chemicals used were of analytical grade.

2.3 Preparation of Standard Metal Ion Solutions

The instrument was calibrated by using standard solution of metal with different concentration 1, 2, 3, 10, 20 ppm (Merck, Sigma Aldrich). The graph is plotted as area Vs concentration and from this graph unknown concentration of metal was determined. The standard metal ion samples were prepared by dissolving 1.00 g of appropriate standard metal ion in 5 mL Conc. HNO3 diluted to 50 mL solution. The working standards of these metal ion solutions were prepared by appropriate dilutions in deionised distilled water to get the final 10 ppm concentration.

2.4 Instrumentation

The Elemental concentration was determined by Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES, Model Spectro Arcos, FHS-12) at the Catalysis & Inorganic Chemistry Division, National Chemical Laboratory, Dr. Homi Bhabha Road Pune 411008, India.

Table 1 Range of toxic metals in shrimps and water samples collected from Gorai creak of suburban of Mumbai west coast of India.

S. No.	Name of the Shrimp Species	Cu	Zn	Fe	Na	Pb
1	***Parapenaeopsis sculptilis***					
	Carapace	10.8	11.4	12.9	478.0	3.5
	Gills	10.4	09.3	12.2	452.1	3.3
	Remaining body	09.3	06.9	08.2	409.4	4.0
	Whole body	10.6	10.1	13.0	421.7	3.7
2	***Parapenaeopsis hardwickii***					
	Carapace	10.3	08.3	13.0	388.5	3.3
	Gills	09.5	10.5	10.4	410.6	2.8
	Remaining body	10.6	10.2	12.3	389.1	3.5
	Whole body	10.6	10.9	10.6	371.4	3.1
3	***Solenocera crassicornisthe***					
	Carapace	10.3	10.2	31.2	364.8	4.1
	Gills	10.6	09.5	12.1	425.5	3.4
	Remaining body	10.2	10.3	11.2	275.2	3.9
	Whole body	10.9	10.0	12.3	429.9	3.5
4	**Metapenaeopsis stridulans**					
	Carapace	08.5	05.2	00.2	373.7	3.3
	Gills	10.6	09.9	07.9	424.5	3.3
	Remaining body	10.5	07.7	10.2	206.3	3.1
	Whole body	10.6	11.2	11.3	360.2	2.9
5	***Acetes indicus***					
	Carapace	10.9	11.2	12.2	391.2	3.4
	Gills	10.8	03.7	12.5	370.4	3.9
	Remaining body	10.9	10.9	12.6	412.3	3.3
	Whole body	11.1	14.2	13.1	513.4	4.2
6	**Water sample**					
	Surface Water Sample	09.9	11.1	12.7	102.1	3.9
	Bottom water sediments	10.2	10.9	12.5	232.7	3.6

N = 5 (Average of Five determents) ND = Not detected or less than 0.0001 ppm)

3. Results and Discussion

Copper is an essential trace metal for all living organisms and also required by crustacean species as an essential part of their oxygen-carrying pigment haemocyanin [9]. The possible contamination of copper can occur from animal feed, higher copper content in water and also from copper bearing and copper alloys used in equipment [10]. Contamination of copper from brass containers has been cited as the major environmental factor in the etiology of Indian childhood cirrhosis [11, 12]. Excess accumulation of copper in hepatic cells causes liver diseases [13]. Abnormal accumulation of copper in the tissues and blood is a point of similarity with genetic disease of man called Wilson's disease [14, 15]. Most absorbed copper is stored in liver and bone marrow where it is bound to metallothionein [16] and acute exposure to copper results in nausea, vomiting, bloody diarrhea, hypertension, uremia and cardiovascular collapse [17].

The result obtained from our present analysis, in shrimp *Parapenaeopsis sculptillis* the mean minimum and maximum concentration of Cu was observed in remaining body was (09.3 ppm) and in carapace (10.8 ppm). In shrimp *Parapenaeopsis hardwicki* the mean minimum concentration of Cu was observed in gills (09.5 ppm) and maximum concentration was observed in Remaining body whole body (10.6 ppm). In shrimp *Solenocera crasscornisthe* mean minimum and maximum concentration of Cu was observed in remaining body (10.2 ppm) and in whole body (10.9 ppm). In shrimp *Metapenaeopsis stridulans* the mean minimum and maximum concentration of Cu was observed in carapace (08.5 ppm) and in gills and whole body (10.6 ppm). In Acetes indicus the mean minimum and maximum concentration of Cu was observed in gills (10.8 ppm) and in whole body (11.1 ppm). Amongst all the species of shrimps the mean minimum concentration of Cu was observed in the carapace of *Metapenaeopsis stridulans* (08.5 ppm) whereas the maximum concentration of Cu was observed in the whole body of *Acetes indicus* (11.1 ppm). Amongst the water samples the mean minimum concentration of Cu was observed in surface water (09.9 ppm) whereas the mean concentration of Cu was found maximum in bottom water sediments (10.2 ppm). The result obtained from our present analysis, the mean minimum and maximum concentration of copper detected in the shrimps and water samples were found above the specified Maximum acceptable concentration as prescribed by FAO (10 ppm) but was found below the (30 ppm) WHO (1989).

3.1 Zn

Zinc is called an "essential trace element" because very small amounts of zinc are necessary for human health [18]. Zinc is used for treatment and prevention of zinc deficiency and its consequences, including stunted growth and acute diarrhea in children, and slow wound healing [19]. Chronic ingestion of excess supplemental zinc (Zn) can produce anemia and leucopenia consequent to induced copper deficiency [19]. It is also used for asthma; diabetes; high blood pressure; acquired immunodeficiency syndrome (AIDS); Alzheimer's disease, Down syndrome, Hansen's disease, ulcerative colitis, peptic ulcers and promoting weight gain in people with eating disorders such as anorexia nervosa [20].

Both acute and chronic toxicity syndromes occur with large overdoses of zinc and the principal features are epigastric pain, diarrhea, nausea and vomiting. In addition to the gastrointestinal effects, the central nervous system may be affected, showing symptoms such as irritability, headache and lethargy [21]. Prolonged intake of a relatively modest excess of zinc may depress serum high density lipoprotein cholesterol levels [22]. Zinc toxicity in humans from excessive dietary ingestion is uncommon, but gastrointestinal distress and diarrhea have been reported [23-25].

The result obtained from our present analysis, in shrimp *Parapenaeopsis sculptillis* the mean minimum and maximum concentration of Zn was observed in remaining body was (06.9 ppm) and in carapace (11.4 ppm). In shrimp *Parapenaeopsis hardwicki* the mean minimum concentration of Zn was observed in carapace (08.3 ppm) and maximum concentration was observed in whole body (10.9 ppm). In shrimp *Solenocera crassicornisthe* mean minimum and maximum concentration of Zn was observed in gills (09.5 ppm) and in remaining body (10.3 ppm). In shrimp *Metapenaeopsis stridulans* the mean minimum and maximum concentration of Zn was observed in carapace (05.2 ppm) and in whole body (11.2 ppm). In *Acetes indicus* the mean minimum and maximum concentration of Zn was observed in gills (03.7 ppm) and in whole body (14.2 ppm). Amongst all the species of shrimps the mean minimum concentration of Zn was observed in the gills of *Acetes indicus* (03.7 ppm) whereas the maximum concentration of Zn was observed in the whole body of *Acetes indicus* (14.2 ppm). Amongst the water samples the mean minimum concentration of Zn was observed in bottom water sediments (10.9 ppm) whereas the mean concentration of Zn was found maximum in surface water (11.1 ppm). The result obtained from our present analysis, the mean minimum and maximum concentration of Zn detected in the samples of shrimps and water samples were found below the specified maximum acceptable concentration as prescribed by WHO (1992) limits (1000 ppm).

3.2 Fe

The ingestion of large quantities of iron results in haemochromatosis a condition in which normal regulatory mechanisms do not operate effectively, leading to tissue damage as a result of the accumulation of iron. This condition rarely develops from simple dietary overloading [26, 27]. Tissue damage has occurred, however, in association with excessive intake of iron from alcoholic beverages in some cases of alcoholism. Tissue damage has also resulted from prolonged consumption of acidic foodstuffs cooked in iron kitchenware [27].

Poisoning of small children has occurred following ingestion of large quantities of iron tablets [28]. As adult iron tablets can contain considerably more elemental iron than children's tablets, children who accidentally ingest iron supplements destined for adults risk being poisoned [29]. National Academy of Sciences [30] Suggest that 3 g of Fe (II) sulphate is regarded as the lethal dose for two-year-olds and was found lethal between 14 and 17.5 g for an adult male. Iron supplements are commonly used (14% of pre-menopausal Canadian women in one study) without reported toxic effects, except for gastrointestinal upset [31].

There is no evidence of dietary iron toxicity in the general population. Because absorption is regulated, body tissues are generally not exposed to high iron concentrations. Pharmaceutical sources and disease states, such as idiopathic haemochromatosis [32] and thalassaemia major (which requires many blood transfusions), will result in elevated iron concentrations. Those individuals who do develop an iron overload are reported to be at greater risk of developing neoplasms [33]. Liver, kidney and the cardiovascular systems are the target organs for iron toxicity. Iron can cause problems in dairy technology because of its catalytic effect on oxidation of lipids with development of unpleasant smell, bounding preferably proteins and membrane lipoproteins of milk fatty globule [34].

The result obtained from our present analysis, in shrimp *Parapenaeopsis sculptillis* the mean minimum and maximum concentration of Fe was observed in remaining body was (08.2 ppm) and in whole body (13.0 ppm). In shrimp *Parapenaeopsis hardwicki* the mean minimum concentration of Fe was observed in gills (10.4 ppm) and maximum concentration was observed in carapace (13.0 ppm). In shrimp *Solenocera crassicornisthe* mean minimum and maximum concentration of Fe was observed in remaining body (11.2 ppm) and in carapace (31.2 ppm). In shrimp *Metapenaeopsis stridulans* the mean minimum and maximum concentration of Fe was observed in carapace (00.2 ppm) and in whole body (11.3 ppm). In *Acetes indicus* the mean minimum and maximum concentration of Fe was observed in carapace (12.2 ppm) and in whole body (13.1 ppm). Amongst all the species of shrimps the mean minimum concentration of Fe was observed in the carapace of *Metapenaeopsis stridulans* (00.2 ppm) whereas the maximum concentration of Fe was observed in the carapace of *Solenocera crassicornisthe* (31.2 ppm). Amongst the water samples the mean minimum concentration of Fe was observed in bottom water sediments (12.5 ppm) whereas the mean concentration of Fe was found maximum in surface water (12.7 ppm). The result obtained from our present analysis, the mean minimum and maximum concentration of Fe detected in the shrimps and water samples were found below the specified Maximum acceptable concentration as prescribed by WHO (1989) (100 ppm) limits for prawn.

3.3 Na

Sodium is the principal cation in extracellular fluid in the body, and is an essential nutrient necessary for maintenance of plasma volume, acid-base balance, transmission of nerve impulses and normal cell function. In healthy individuals, nearly 100% of ingested sodium is absorbed during digestion, and urinary excretion is the primary mechanism for maintaining sodium balance [35]. Sodium and chloride are the chemical components of common table salt; however, sodium can be found in other forms, and the primary contributors to dietary sodium consumption depend on the cultural context and dietary habits of a population [36]. Sodium is found naturally in a variety of foods, such as milk, meat and shellfish. It is often found in high amounts in processed foods such as breads, crackers, processed meats and snack foods [37-40]. High amounts of sodium are also found in many condiments (e.g., soy and fish sauces) [41]. Thus, a diet high in processed foods and low in fresh fruits and vegetables is often high in sodium [40, 41]. Although the minimum intake level necessary for proper bodily function is not well defined, it is estimated to be as little as 200-500 mg/day [42, 43]. Data from around the world suggest that the population average sodium consumption is well above the minimal physiological needs, and in many countries is above the value recommended by the 2002 Joint World Health Organization/Food and Agriculture Organization of the United Nations (WHO/FAO) Expert Consultation (WHO, 2003) of 2 g sodium/day (equivalent to 5 g salt/day) [44]. Increased sodium consumption is associated with increased blood pressure, whereas lower sodium consumption appears to decrease blood pressure in adults [45-48]. A number of recent high-quality systematic reviews of randomized controlled trials (RCTs) have concluded that decreased sodium intake relative to usual or higher intake results in lowered blood pressure in adults with or without hypertension [49-52].

The result obtained from our present analysis, in shrimp *Parapenaeopsis sculptillis* the mean minimum and maximum concentration of Na was observed in remaining body was (409.4 ppm) and in carapace (478.0 ppm). In shrimp *Parapenaeopsis hardwicki* the mean minimum concentration of Na was observed in whole body (371.4 ppm) and maximum concentration was observed in gills (410.6 ppm). In shrimp *Solenocera crassicornisthe* mean minimum and maximum concentration of Na was observed in remaining body (275.2 ppm) and in whole body (429.9 ppm). In shrimp *Metapenaeopsis stridulans* the mean minimum and maximum concentration of Na was observed in remaining body (206.3 ppm) and in gills (424.5 ppm). In *Acetes indicus* the mean minimum and maximum concentration of Na was observed in gills (370.4 ppm) and in whole body (513.4 ppm). Amongst all the species of shrimps the mean minimum concentration of Na was observed in the remaining body of *Metapenaeopsis stridulans* (206.3 ppm) whereas the maximum concentration of Na was observed in the whole body of *Acetes indicus* (513.4 ppm). Amongst the water samples the mean minimum concentration of Na was observed in surface water (102.1 ppm) whereas the mean concentration of Na was found maximum in bottom water sediments (232.7 ppm). The result obtained from our present analysis, the mean minimum and maximum concentration of Na detected in the shrimps and water samples were found above the specified Maximum acceptable concentration as prescribed by (WHO/ FAO) Expert Consultation (WHO, 2003) of 2 g sodium/day (equivalent to 5 g salt/day).

3.4 Pb

It is known as deadly and accumulative poison even when consumed in small quantities and is capable of dealing nerve receptor in man [52]. The main sources of lead pollution in the environment include effluents & emissions from industries, emissions from vehicles running on leaded petrol, the smoke and dust emissions of coal and gas-fired power stations, use of lead sheets by roofers as well as the use of paints and anti-rust agents. Contamination by lead of foodstuffs is caused by the soldered seams of cans and the soldered closures of condensed milk cans, the metal caps of wine bottles and, also by lead pipes used in drinking water systems [53].

From the public health point of view, lead toxicity reportedly causes renal tubular dysfunction indicated by proteinuria, aminoaciduria, glucosuria, hyperphosphaturia and impairment of sodium transport [54, 55]. Lead toxicity also has multiple hematological effects causing shortening life-span of circulating erythrocytes and inhibits hemoglobin synthesis and cause fragile red blood cells which results in anemia [56]. Clinically, lead toxicity has been associated with sterility causing gametotoxicity effects in both male and female [57, 58], reduction in sperm counts, abnormal sperm motility and morphology. CNS is the target of lead toxicity in children while in the adults the peripheral system is affected [59]. In addition, gastrointestinal problems are associated to lead exposure [60] and cardiovascular collapse leading to death is also reported [61]. Permissible limit of lead as prescribed by FAO/WHO is (0.5 ppm).

The result obtained from our present analysis, in shrimp *Parapenaeopsis sculptillis* the mean minimum and maximum concentration of Pb was observed in gills (3.3 ppm) and in remaining body (4.0 ppm). In shrimp *Parapenaeopsis hardwicki* the mean minimum concentration of Pb was observed in gills (2.8 ppm) and maximum concentration was observed in remaining body (3.5 ppm). In shrimp *Solenocera crassicornisthe* mean minimum and maximum concentration of Pb was observed in gills (3.4 ppm) and in carapace (4.1 ppm). In shrimp *Metapenaeopsis stridulans* the mean minimum and maximum concentration of Pb was observed in whole body (2.9 ppm) and in gills and carapace (3.3 ppm). In *Acetes indicus* the mean minimum and maximum concentration of Pb was observed in remaining body (3.3 ppm) and in whole body (4.2 ppm). Amongst all the species of shrimps the mean minimum concentration of Pb was observed in the gills of *Parapenaeopsis hardwicki* (2.8 ppm) whereas the maximum concentration of Pb was observed in the whole body of *Acetes indicus* (4.2 ppm). Amongst the water samples the mean minimum concentration of Pb was observed in bottom water sediments (3.6 ppm) whereas the mean concentration of Pb was found maximum in surface water (3.9 ppm). The result obtained from our present analysis, the mean minimum and maximum concentration of Pb detected in the shrimps and water samples were found above the specified Maximum acceptable concentration as prescribed by by WHO (1989) (2 ppm for Pb) for prawn.

4. Conclusion

The toxic metals such as Cu, Zn, Fe, Na and Pb, are potentially harmful and caused toxic effects to most organisms even in very low concentrations. From the above results it is expected that the sea food available in and around Mumbai may have elevated levels of pollutants. These toxic metals may cause dermatological diseases, skin cancer and internal cancers (liver, kidney, lung and bladder), cardiovascular disease, diabetes, and anemia, as well as reproductive, developmental, immunological and neurological effects in the human body. These toxic metals transferred to man through the consumption of Prawn and shrimp, pose health hazards because of their cumulative effect in the body. Therefore, it was concluded that the shrimps are not heavily burdened with toxic metals, but a danger must be considered depending on the agricultural and industrial developments in this region. The Prawn and shrimp from Arabian Sea should be monitored periodically to avoid excessive intake of trace metals and toxic elements by human, and monitor the pollution of aquatic environment. In view of these findings strict method of waste disposal control should be adopted to ensure the safety of the environment and safeguard our aquatic life.

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