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Presence of Cd, Co, Mg, Ni and Hg in Commercially Important Shrimp 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 Mg was found well below the permissible levels for human consumption whereas no Hg was detected in all the shrimp as well as in water samples because its concentration is less than 0.0001ppm). However the concentrations of Cd and Co and Ni were observed somewhat greater than some of the recommended levels as prescribed by FAO/ WHO and cited literature.

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 tendency of heavy metals to get accumulated in marine animals is of scientific interest in heavy metal chemistry. The bioavailability of trace metals is the key factor determining tissue metal levels in the marine biota. 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 caused 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 Cd, Co, Mg, Ni and Hg, 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, 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. Experimental 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 g 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

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cool for half an hour and dissolved in 30 mL of deionized 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 HNO_3 per liter sample and capped tightly until they were ready for analysis as proposed [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. HNO_3 diluted to 50 mL solution. The working standards of these metal ion solutions were prepared by appropriate dilutions in deionized 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.

3. Results and Discussion

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

S.No.	Name of the Shrimp Species	Cd N= ppm	Co N= ppm	Mn N= ppm	Ni N=ppm	Hg N= ppm
1	***Parapenaeopsis sculptilis***					
	Carapace	1.66	1.44	1.01	1.26	ND
	Gills	1.66	1.45	0.93	1.27	ND
	Remaining body	1.67	1.45	4.99	1.27	ND
	Whole body	1.67	1.44	0.45	1.27	ND
2	***Parapenaeopsis hardwickii***					
	Carapace	1.66	1.44	0.17	1.26	ND
	Gills	1.67	1.44	0.60	1.27	ND
	Remaining body	1.66	1.44	0.39	1.28	ND
	Whole body	1.67	1.45	0.17	1.27	ND
3	***Solenocera crassicornisthe***					
	Carapace	1.72	1.54	0.98	1.27	ND
	Gills	1.66	1.45	0.95	1.27	ND
	Remaining body	1.67	1.44	0.58	1.27	ND
	Whole body	1.67	1.46	0.66	1.29	ND
4	***Metapenaeopsis stridulans***					
	Carapace	1.67	1.42	38.64	1.23	ND
	Gills	1.66	1.45	0.05	1.27	ND
	Remaining body	1.67	1.44	1.36	1.28	ND
	Whole body	1.67	1.45	0.89	1.27	ND
5	***Acetes indicus***					
	Carapace	1.66	1.44	0.25	1.27	ND
	Gills	1.66	1.44	0.30	1.28	ND
	Remaining body	1.66	1.44	0.86	1.28	ND
	Whole body	1.66	1.44	0.98	1.32	ND
6	**Water sample**					
	Surface Water Sample	1.66	1.44	0.15	1.26	ND
	Bottom water sediments	1.66	1.43	0.48	1.26	ND

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

3.1 Cadmium

Cadmium a highly toxic metal, is present throughout the environment and accumulates in liver and kidney of mammals through the food chain [9]. Cadmium may enter into the aquatic bodies through sewage sludge and with the run off from agricultural lands as it is one of the major components of phosphate fertilizers. Also, the major sources of contamination include electroplating, paper, PVC plastic, pigments and ceramic industries, battery, mining and smoldering units and many other modern industries [10].

The kidney is the critical organ of intoxication after long-term exposure to cadmium. One of the initial signs of renal dysfunction is an increased urinary excretion of proteins. Cadmium-induced proteinuria is generally considered to be characterized by the excretion of low molecular weight proteins. This form of proteinuria, caused by an impaired re-absorption function of the proximal tubules, is not specific for the metal and may be found in hereditary forms of tubular dysfunction [11]. It is now known that the ltai-itai sickness in Japan (with bone damage) is a result of the regular consumption of rice, highly contaminated with cadmium [12, 13].

The result obtained from our present analysis, in shrimp *Parapenaeopsis sculptillis* the mean minimum and maximum concentration of Cd was observed in carapace and gills was (1.66 ppm) and in remaining body and whole body (1.67 ppm). In shrimp *Parapenaeopsis hardwicki* the mean minimum concentration of Cd was observed in carapace and remaining body (1.66 ppm) and maximum concentration was observed in gills and whole body (1.67 ppm). In shrimp *Solenocera crassicornisthe* mean minimum and maximum concentration of Cd was observed in gills (1.66 ppm) and in carapace (1.72 ppm). In shrimp *Metapenaeopsis stridulans* the mean minimum and maximum concentration of Cd was observed in gills (1.66 ppm) and in carapace, remaining body and whole body (1.67 ppm). In *Acetes indicus* the mean minimum and maximum concentration of Cd was observed same in all the parts of the body (1.66 ppm). Amongst all the species of shrimps the mean minimum concentration of Cd was observed in the carapace and gills of *Parapenaeopsis sculptillis,* carapace and remaining body of *Parapenaeopsis hardwicki, gills of Solenocera crassicornisthe* and *Metapenaeopsis stridulans* and was observed same in all the parts of the body in *Acetes indicus* (1.66 ppm) whereas the maximum concentration of Cd was observed in the carapace of *Solenocera crassicornisthe* (1.72 ppm). Amongst the water samples the mean minimum concentration of Cd was observed same in surface water and in bottom water sediments (1.66 ppm). The result obtained from our present analysis, the mean minimum and maximum concentration of cadmium detected in the shrimps and water samples were found above the specified Maximum acceptable concentration as prescribed by WHO (1984).

3.2 Cobalt

Cobalt is not often freely available in the environment, but when cobalt particles are not bound to soil or sediment particles the uptake by plants and animals is higher and accumulation in plants and animals may occur. Cobalt is used in many alloys (superalloys for parts in gas turbine aircraft engines, corrosion resistant alloys, high-speed steels, cemented carbides), in magnets and magnetic recording media, as catalysts for the petroleum and chemical industries, as drying agents for paints and inks. The radioactive isotopes, cobalt-60, is used in medical treatment and also to irradiate food, in order to preserve the food and protect the consumer. Cobalt is beneficial for humans because it is a part of vitamin B12, which is essential for human health. Cobalt is used to treat anemia with pregnant women, because it stimulates the production of red blood cells. However, too high concentrations of cobalt may damage human health, mainly with people that work with cobalt. Health effects may also be caused by radiation of radioactive cobalt isotopes. This can cause sterility, hair loss, vomiting, bleeding, diarrhea, coma and even death. Cobalt dust may cause an asthma-like disease with symptoms ranging from cough, shortness of breath and dyspnea to decreased pulmonary function, nodular fibrosis, permanent disability, and death.

The result obtained from our present analysis, in shrimp *Parapenaeopsis sculptillis* the mean minimum and maximum concentration of Co was observed in carapace and whole body was (1.44 ppm) and in gills and remaining body (1.45 ppm). In shrimp *Parapenaeopsis hardwicki* the mean minimum concentration of Co was observed in carapace, gills and remaining body (1.44 ppm) and maximum concentration was observed in whole body (1.45 ppm). In shrimp *Solenocera crassicornisthe* mean minimum and maximum concentration of Co was observed in gills (1.45 ppm) and in carapace (1.54 ppm). In shrimp *Metapenaeopsis stridulans* the mean minimum and maximum concentration of Co was observed in carapace (1.42 ppm) and in gills and whole body (1.45 ppm). In *Acetes indicus* the mean minimum and maximum concentration of Co was observed same in all the parts of the body (1.44 ppm). Amongst all the species of shrimps the mean minimum concentration of Co was observed in the carapace of *Metapenaeopsis stridulans* (1.42 ppm) whereas the maximum concentration of Co was observed in the carapace of *Solenocera crassicornisthe* (1.54 ppm). Amongst the water samples the mean minimum concentration of Co was observed in surface water (1.44 ppm) whereas the mean concentration of Co was found maximum in bottom water sediments (1.43 ppm). Arun Kumar and Hema Achyuthan 2007 have evaluated the concentration of heavy metal chromium accumulation in certain marine animals along the East Coast of Chennai, Tamil Nadu, India and they found the concentration of cobalt was (0.0001 ppm). The study carried by Jin et al [14] have been measured the concentration of cobalt in edible tissues of the brown shrimp *Crangon crangon* [15] collected from Samsun coasts in the Black

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Sea coast of Turkey in 2010. The heavy metal concentration in *C. crangon* was 0.24 ppm to 0.61 ppm. The result obtained from our present analysis, the mean minimum and maximum concentration of cobalt detected in the shrimps and water samples were found above the specified Maximum acceptable concentration as sited in the literature.

3.3 Manganese

Manganese is a mineral that is required in small amounts in the human body, in normal conditions, contains about 10 mg to 20 mg of manganese, and it is present in enzymes like oxidoreductases, transferases, hydrolases, lyases, isomerases, and ligases [16, 17] which are necessary for several biological functions. High levels of manganese in human body can cause dermatitis, problems in the glucose metabolism and of proteins, mitochondria abnormalities, infertilities, bad formation of the bones, decrease of the serum cholesterol, and other diseases [18]. Excess of manganese can be a toxicant and the nervous system seems to be the most vulnerable to it [19].

The result obtained from our present analysis, in shrimp *Parapenaeopsis sculptillis* the mean minimum and maximum concentration of Mn was observed in whole body was (0.45 ppm) and in remaining body (4.99 ppm). In shrimp *Parapenaeopsis hardwicki* the mean minimum concentration of Mn was observed in carapace and whole body (0.17 ppm) and maximum concentration was observed in gills (0.60 ppm). In shrimp *Solenocera crassicornisthe* mean minimum and maximum concentration of Mn was observed in remaining body (0.58 ppm) and in carapace (0.98 ppm). In shrimp *Metapenaeopsis stridulans* the mean minimum and maximum concentration of Mn was observed in gills (0.05 ppm) and in carapace (38.64ppm). In *Acetes indicus* the mean minimum and maximum concentration of Mn was observed in carapace (0.25 ppm) and in whole body (0.98 ppm). Amongst all the species of shrimps the mean minimum concentration of Mn was observed in the gills of *Metapenaeopsis stridulans* (0.05 ppm) whereas the maximum concentration of Mg was observed in the carapace of *Metapenaeopsis stridulans* (38.64 ppm). Amongst the water samples the mean minimum concentration of Mg was observed in surface water (0.15 ppm) whereas the mean concentration of Mn was found maximum in bottom water sediments (0.48 ppm). The result obtained from our present analysis, the mean minimum and maximum concentration of Manganese detected in the shrimps were found above the specified Maximum acceptable concentration as proposed by WHO (1 ppm) only in *Metapenaeopsis stridulans* where as in remaining shrimps and water samples it was found below the specified maximum acceptable concentration as prescribed by WHO (1 ppm).

3.4 Nickel

Nickel is called the depression and suicide metal as it is associated with these feelings and symptoms. It is a particularly deadly toxic metal [20]. Like many environmental agents, the toxic effect of nickel is related to the way it gets into an organism. Nickel can enter body *via* inhalation, ingestion and dermal absorption, but the route by which nickel enters cells is determined by its chemical form. Human exposure to highly nickel-polluted environments causes a variety of pathologic effects such as nickel allergy in the form of contact dermatitis, lung fibrosis, cardiovascular and kidney diseases and cancer of the respiratory tract [21-23]. Acute health effects generally result from short-term exposure to high concentrations of pollutants and they manifest as a variety of clinical symptoms (nausea, vomiting, abdominal discomfort, diarrhea, visual disturbance, headache, giddiness, and cough). The most common type of reaction to nickel exposure is a skin rash at the site of contact. Skin contact with metallic or soluble nickel compounds can produce allergic dermatitis. Women have greater risk for dermatitis, possibly due to a more frequent contact with nickel-containing items: jewelry, buttons, watches, zippers, coins, certain shampoos and detergents, pigments etc. [24, 25]. Cocoa is one of the foodstuffs with higher than average natural nickel content. Small amount of nickel is needed by the body to produce red blood cells. However, excess amount can become toxic [26].

The result obtained from our present analysis, in shrimp *Parapenaeopsis sculptillis* the mean minimum and maximum concentration of Ni was observed in carapace was (1.26 ppm) and in gills, remaining body and whole body (1.27). In shrimp *Parapenaeopsis hardwicki* the mean minimum concentration of Ni was observed in carapace (1.26 ppm) and maximum concentration was observed in remaining body (1.28 ppm). In shrimp *Solenocera crassicornisthe* mean minimum and maximum concentration of Ni was observed in carapace, gills and remaining body (1.27 ppm) and in whole body (1.29 ppm). In shrimp *Metapenaeopsis stridulans* the mean minimum and maximum concentration of Ni was observed in carapace (1.23 ppm) and in remaining body (1.28 ppm). In *Acetes indicus* the mean minimum and maximum concentration of Ni was observed in carapace (1.27 ppm) and in whole body (1.32 ppm). Amongst all the species of shrimps the mean minimum concentration of Ni was observed in the carapace of *Metapenaeopsis stridulans* (1.23 ppm) whereas the maximum concentration of Ni was observed in the whole body of *Acetes indicus* (1.32 ppm). Amongst the water samples the mean minimum maximum concentration of Ni was observed same in surface water and bottom water sediments (1.26 ppm). The result obtained from our present analysis, the mean minimum and maximum concentration of nickel detected in the shrimps and water samples were found above the specified Maximum acceptable concentration as prescribed (0.5 ppm to 1.0 ppm) by WHO (1989).

3.5 Mercury

This is extremely harmful, even a concentration of 0.03 ppm in drinking water is not permissible. Mercury enters natural water through industrial discharge where by bacterial action it is converted into very stable and water soluble methyl mercury ion. Mercury which is taken up by fish and through food chain enters higher animals and man. Most of the fish today have a mercury concentration of 0.02-0.2ppm which is now considered 'normal'. In polluted water its concentration may be even 1ppm. Consumption of such fish is hazardous, which was indeed the cause of death of over one thousand persons in the Minamata Island of Japan, due to what goes by name 'Minamata Disease'. Mercury deactivates sulphur containing enzymes with active –SH groups, affects brain cells and central nervous system. Symptoms of mercury poisoning are physical and emotional disturbances, self-consciousness, timidity, embarrassment with insufficient reasoning, anxiety, indecision, lack of concentration, depression or despondency, resentment of criticism, irritability or excitability, a complete change of personality as of the Mad Hatter, a character depicted in the well-known " Alice in Wonderland" story [27]. Methyl mercury causes irreversible damage of the central nervous system. [28-33] that methylmercury is responsible for kidney impairments.

In the present work, the values of the mean minimum and maximum concentrations of mercury in the shrimp samples and surface water and bottom water sediments were not detected as these concentrations were either less than 0.001ppm or absent in all the species of shrimps and surface water and bottom water sediments as prescribed by WHO (1989) 0.02-0.2 ppm for prawn.

4. Conclusion

The toxic metals such as Cd, Co, Mg, Ni and Hg, 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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