

## Chromium accumulation in gills and muscles of shellfish species from Pulicat lake, Tamil Nadu, India

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### Abstract

Heavy metals are harmful to most organisms at some levels of exposure and absorption. Many marine organisms have the potential to bio-concentrate high levels of metals from their environment and can accumulate the biologically available forms of pollutants that are always present in the environment thus enabling the continuous monitoring of pollutants. In the present study, six species of shellfish, *Fenneropenaeus indicus*, *Fenneropenaeus monodon*, *Fenneropenaeus semisulcatus*, *Scylla serrata*, *Meretrix casta* and *Clibanarius longitarsus* in Pulicat lake, Tamil Nadu, India were analysed for the presence of chromium in its gills and muscles from January 2011 to December 2012. A seasonal variation in the uptake of chromium was observed. The results indicated that *Scylla serrata* during premonsoon accumulated the highest amount of chromium in its muscles in 2011 and 2012 and the values were 5.79 and 5.86 µg/g respectively. In conclusion, though the level of chromium in the tissues of all the six species of shellfish studied at Pulicat lake was within the accepted levels, it is emphasized that for the better management of the estuary and as an example to similar estuaries around the world, detailed metal speciation studies should always be considered alongside biomonitoring programmes, in order to correctly assess the potential risk of metal pollution in aquatic ecosystems.

**Keywords:** heavy metals, chromium, pollution, pulicat lake

### 1. Introduction

Trace metals, as the name signifies, are those present in extremely small quantities in a given environment. Their distinct property of being toxic above a specific threshold of bioavailable level is significant in determining the overall health of the ecosystem [1, 2]. Little attention has been directed towards the trace metal contamination of aquatic environments, viz., streams and estuaries [3]. The wide diversity of human activities introduce pollutants into the environment, as well as their magnitudes which make the assessment of environmental impact a subject of utmost interest [4]. The presence of metals in aquatic ecosystems originates from the natural interactions between water, sediments and atmosphere [5, 6]. Various activities by man in recent years have increased the quantity and distribution of heavy metals in the atmosphere, land and water bodies. The extent of this wide spread but diffused contamination has raised concern about their hazards to plants, animals and humans [7]. The fates of heavy metals introduced by human activities into aquatic ecosystems have recently become the subject of widespread concern, since beyond the tolerable limits they become toxic [8, 9]. All heavy metals are potentially harmful to most organisms at some levels of exposure and absorption [7]. Metals like Fe, Cu, Zn and Mn are essential since they play important roles in biological systems; whereas Hg, Pb and Cd are toxic even in trace amounts [10].

Many marine organisms have the potential to bio-concentrate high levels of metals from their environment [11]. Fish, crab and prawn form an important link as possible transfer media to human beings [12]. Assessing the toxicity of contaminants on

aquatic life has been a longstanding practice [13]. Information on the level of heavy metal pollution in coastal environment is important as they cause serious environmental health hazards [14-16]. These organisms can only accumulate the biologically available forms of pollutants that are always present in the environment thus enabling the continuous monitoring of pollutants [17-20]. The United States Environmental Protection Agency (USEPA) recommends the use of bioassays, biological and habitat data in addition to chemical data for water quality assessments [21]. Determination of harmful and toxic substances in water sediments and biota, gives direct information on the significance of pollution in the aquatic environment [22]. Therefore, metal bioaccumulation by marine organisms has been the subject of considerable interest in recent years because of serious concern that high levels of metals may have detrimental effects on the marine organisms and may create problems in relation to their suitability as food for humans [23].

### 2. Materials and methods

#### 2.1 Study area

Pulicat lake (13°24'–13°47' N, 80°03'–80°18' E) is the second largest brackish water body of India with an area of 18,440 hectares and is located 40km north of Chennai. The length of this lake is about 60km and varies in breadth (0.2 to 17.5km). Pulicat lake is drained by four rivers, the Swarnamukhi, the Kalangi, the Araniar and the Royyala Kalava apart from many minor inflows. Industrial and domestic waste are brought into this lake by the Buckingham canal and finally to the Bay of Bengal [24]. Local climate, riverine inflow and the neritic

waters from the Bay of Bengal influence the hydrological characters of Pulicat lake. Many euryhaline species are present in this lake which acts as breeding grounds for many organisms and certain fishes [25]. Untreated effluents from industries and urban areas are considered to be point sources of pollution [24, 26, 27].

## 2.2 Collection of specimens

Six shellfish species viz., *Fenneropenaeus indicus*, *Fenneropenaeus monodon*, *Fenneropenaeus semisulcatus*, *Scylla serrata*, *Meretrix casta* and *Clibanarius longitarsus* were collected from Pulicat lake, Tamil Nadu, India on a monthly basis for a period of two years from January 2011 to December 2012. The collected organisms were brought to the laboratory in an ice box and were stored at 4°C until analyses. The organisms were thoroughly washed with running tap water to eliminate mud and other debris and were subsequently rinsed with double-distilled water. Rust free stainless steel kit was used to dissect the animal. Care was taken to avoid external contamination of the samples.

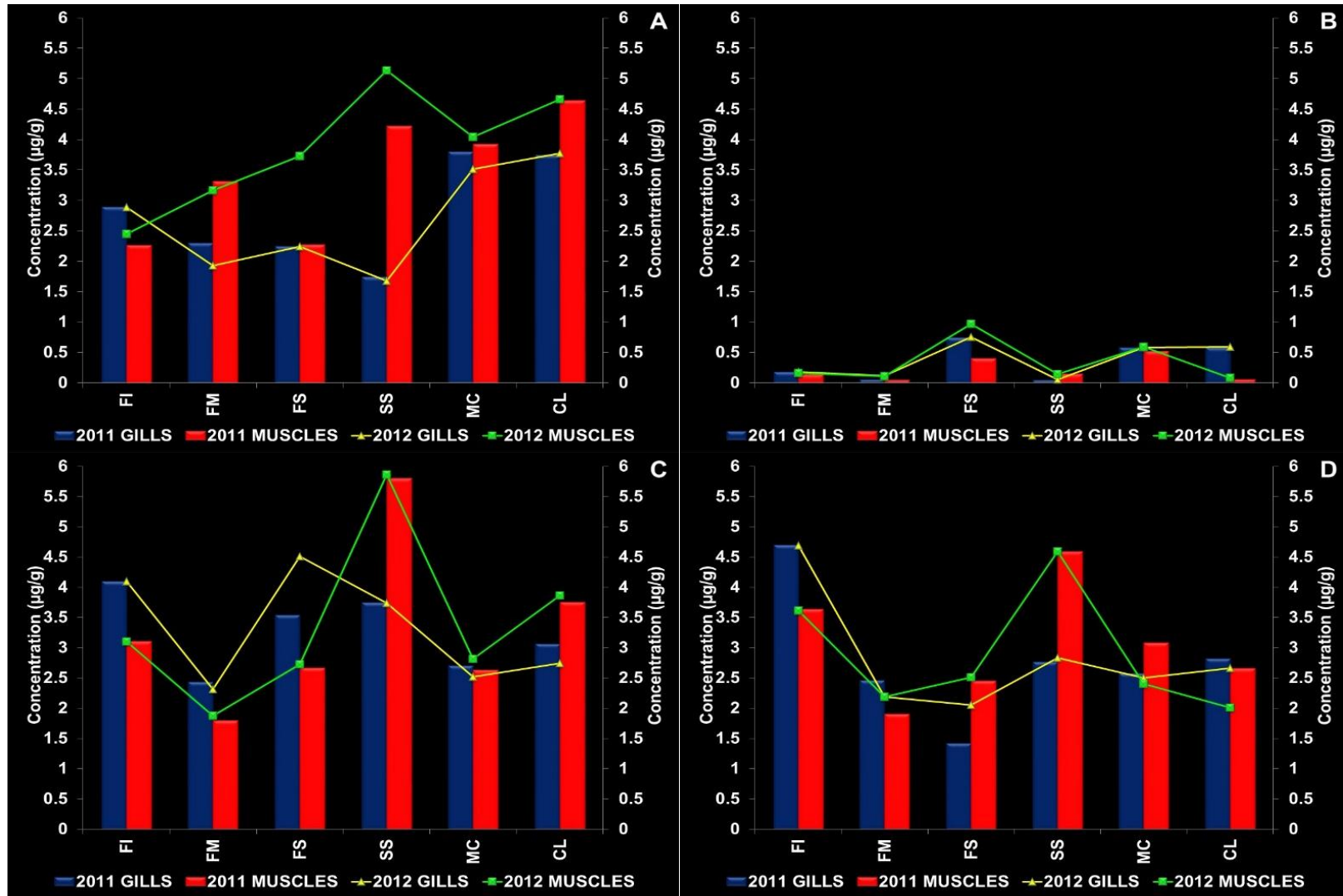
## 2.3 Determination of metals in animals

The gills and muscles of the shellfish species were used to estimate the chromium content. The analysis was carried out using the method suggested by Watling and Emmerson [28]. Analytical grade reagents were used. For analysing chromium, the samples were oven dried at 60°C for 24 hours. The dried sample (0.5g) was taken and ground with a mortar and pestle. Using nitric and perchloric acid (3:1), the ground samples were digested. After adding the acids, the samples were kept in a hot plate at 120°C until white residues were formed. Finally, the residue was dissolved in 10mL of distilled water and then filtered. The filtered sample was aspirated into the

atomic absorption spectrophotometer and the reading was recorded. The solution was then diluted and filtered through a 0.45µm nitrocellulose membrane filter. Determination of chromium in samples was carried out by inductively coupled plasma atomic emission spectroscopy (Optima 2100 DV, Perkin-Elmer, USA).

## 3. Results

During post monsoon, among all the six shellfish species, *Meretrix casta* had the highest accumulation of chromium in their gills in 2011 and in 2012 it was *Clibanarius longitarsus* and the values were 3.79 and 3.77µg/g respectively. Whereas, *Clibanarius longitarsus* accumulated the highest amount of chromium in its muscles in 2011 and it was *Scylla serrata* in 2012 and the values were 4.63 and 5.14µg/g respectively (Figure 1A). In summer, *Fenneropenaeus semisulcatus* had the highest accumulation of chromium in their gills in 2011 and 2012 with 0.73 and 0.75µg/g respectively. Whereas, *Meretrix casta* accumulated the highest amount of chromium in its muscles in 2011 and it was *Fenneropenaeus semisulcatus* in 2012 and the values were 0.51 and 0.97µg/g respectively (Figure 1B). For premonsoon, *Fenneropenaeus indicus* accumulated the highest amount of chromium in their gills in 2011 and 2012. The values were 4.09 and 4.10µg/g respectively. Whereas, *Scylla serrata* accumulated the highest amount of chromium in its muscles in 2011 and 2012 and the values were 5.79 and 5.86µg/g respectively (Figure 1C). In monsoon, *Fenneropenaeus indicus* accumulated the highest amount of chromium (4.69µg/g) in their gills in 2011 and 2012. Whereas, *Scylla serrata* accumulated the highest amount of chromium in its muscles in 2011 and 2012 and the values were 4.58 and 4.59µg/g respectively (Figure 1D).



**Fig 1:** Accumulation of chromium in the gills and muscles of shellfish species from Pulicat lake  
**A:** POSTMONSOON; **B:** SUMMER; **C:** PREMONSOON; **D:** MONSOON  
**FI:** *Fenneropenaeus indicus*; **FM:** *Fenneropenaeus monodon*; **FS:** *Fenneropenaeus semisulcatus*  
**SS:** *Scylla serrata*; **MC:** *Meretrix casta*; **CL:** *Clibanarius longitarsus*

#### 4. Discussion

There are thirty five metals that are of concern because of occupational or residential exposure; twenty three of these are the heavy elements or "heavy metals" viz., antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium and zinc [29]. Small amounts of these elements are common in our environment and diet and are necessary for good health, but large amounts of any of these above mentioned heavy metals may cause acute or chronic toxicity. Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, damage to blood composition, lungs, kidneys, liver and other vital organs. Long-term exposure may result in slowly progressing physical, muscular and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy and multiple sclerosis. Allergies are not uncommon and repeated long-term contact with some metals or their compounds may cause cancer.

Biological availability of trace metals is highly dependent on the seasonal meteorological factors which affect their concentration as well as physical and chemical forms of the sea water [30]. Of the processes affecting metal dynamics in marine organisms, variability in physicochemical conditions of water and sediment, related to changes in the concentrations of biologically available metals and temporal variability in the physiological state of organisms are considered important [31]. The extent of occurrence or accumulation of heavy metals by organisms in different tissues is dependent on the route of entry: either from surrounding medium or in the form of food or chemical form of material available in the media [32]. Kilgour [33], in his study showed that the concentration of metal in sediment can raise their percentage in water. Marine organisms are also able to take up metals that are adsorbed onto inorganic particles and organic matter as well from solution [34]. Seasonal fluctuations of tissue metal concentrations in species may be driven by various environmental and biological factors [35]. Saleh *et al.* [36] observed high chromium levels in the water and sediment from the Abo Kir shellfish habitat which arose from industrial sources, such as the textile, ceramic, dye and fertilizer companies that dominate the Abo Kir bay, as well as from sewage sludge, which contains chromium levels as high as 900mg/Kg. Further, he also concluded that chromium levels decreased considerably in other places devoid of any industries. Heavy metals may be accumulated by organisms either through food or water [37]. Saleh *et al.* [36], have recorded that oysters from Abo Kir exhibited higher chromium concentrations which then decreased in non-polluted areas. This finding suggests a more extensive contamination of the shellfish growing at the Abo Kir coast which was highly polluted with industries. Ujević *et al.* [30], concluded that seasonal variations of trace metal concentrations in shellfish soft tissues take the form of a sinusoid curve with the metal concentrations generally being the highest in the coldest part of the year (late winter and early spring), and the lowest during the summer and early fall [38].

In crustaceans, high metal concentrations were observed mainly during summer [39-41]. These results along with the

results of Ujević *et al.* [30] indicated seasonal changes in metal contents in the whole soft tissue of *Mytilus*, in moderate climates of the northern hemisphere. Abeshi *et al.* [42] showed that benthic animals and predators which live and eat in the bottom of the sea had the highest concentrations of metals in their tissues and organs. The authors, Storelli *et al.* [43], Juresa and Blanusa [44], Cogun *et al.* [45] and Karadede-Akin and Unlu [46] in their studies have concluded that in benthic organisms, the accumulation of heavy metals was higher than in pelagic forms. Benthic species due to close contact with sediment particles may accumulate heavy metals. Firat *et al.* [35] have determined that the order of metal concentrations found in muscle tissue of *Penaeus semisulcatus* as Cr>Cu>Zn>Fe>Cd indicating that chromium tends to accumulate much higher than the other metals. Gills present higher levels of metals than muscles and it is well known that crabs and shrimps concentrate the heavy metals in their tissues [40, 47-51].

Physiologically, chromium is considered as a trace element and is required for the optimum function of insulin in mammalian tissues and maintenance of normal metabolism of glucose, cholesterol and fat. The normal level of blood chromium concentration in human beings is 20-30µg/L. It was found, that the intake of chromium about 50-200µg/day are regarded to be safe and adequate. Hexavalent chromium is an extremely toxic metal, which exist as an anion (CrO<sub>4</sub><sup>2-</sup>) and are most readily absorbed by the gastrointestinal tract, skin and lungs. Most reports describe the toxicity of hexavalent chromium in the form of chromate or dichromate which can cause chronic ulceration of skin surface, denaturation of tissue proteins, asthma, kidney failure, discolouration of teeth and inflammation of skin. Further, acute poisoning results in symptoms which include, dizziness, intense thirst, abdominal pain, vomiting, shock and sometimes death due to the presence of urea in blood [52].

Chromium and cadmium are the two key elements of the series of heavy metals in the highest quantities that cause a significant damage to aquatic fauna [53]. Chromium is a hard brittle grey transition metal with atomic number 24 and relative atomic mass 51.99. The form of various alloys and compounds from chromium has been in widespread commercial use for over one hundred years. In recent decades, chromium has also been widely used in chromium alloys and chrome plating. The major uses of chromium are for transportation, construction products, machinery equipment, home appliances and equipment, plating of metals, pigment and paints [54]. Due to their carcinogenicity of hexavalent chromium to humans and other mammals and the prevalence of its use in the leather and textile industries, there is a significant justification to continue the monitoring of shellfish for this metal. Chromium is currently banned in seafood in developed countries; however, the results presented by Saleh *et al.* [36] do not suggest that chromium is currently a threat to public health since the values are below the FAO/WHO limit (13.0mg/Kg tissues) [55]. This observation is in concordance with the findings of the present study at Pulicat lake. In conclusion, even though the level of chromium in the tissues of all the six species of shellfish studied in Pulicat lake was within the accepted levels, it is emphasized that for the better management of the estuary and as an example to similar estuaries around the world, detailed metal speciation studies

should always be considered alongside biomonitoring programmes, in order to correctly assess the potential risk of metal pollution in aquatic ecosystems <sup>[56]</sup>.

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