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Analysis of heavy metals in fish samples along the east coastal region of Valinokkam, Ramanathapuram District, Tamilnadu

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ABSTRACT

Heavy metals are non-biodegradable which cause cytotoxic and carcinogenic effects in animals. Being at top of the aquatic food chain fish constitute a major source of heavy metal in food. The variation of Lead, Cadmium, Nickel, Copper and Cobalt concentrations in Muscle, Gill and Kidney of four fish species (Dussumieria acuta, Tenuaslosa ilisha, Sardinella longiceps and Caranx hippos) were collected along East Coast of Valinokkam. In this study we have used inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) technique for determination of heavy metals. The results revealed that the average concentration of the trace metals in selected organs of fish species were in the ranking order of Cu>Pb>Cd>Ni>Co indicating presence of Cu in higher concentration and Co in low concentration among the metals. Almost all heavy metal concentrations in the marine fishes are below the threshold levels associated with the toxicological effects and the regulatory limits. The bio-concentration factors revealed that the fishes have accumulated heavy metals along the food chain rather than from water column and sediment.

Key words: Heavy metals, Lead, Cadmium, *Dussumieria acuta, Tenuaslosa ilisha,* Food chain, Bio-concentration

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INTRODUCTION

Environmental pollution and its hazards are the most important problems of societies and living creatures. On the other hand, increased population with the development of technology and production can cause lack of attention to environmental safety [1]. Industrialization leads to the pollution of ecosystems. Therefore, recognition of pollutants and prevention of their environmental dispersion are one of the necessities in this field. Therefore, we must determine the pollution sources, their environmental effects and prevention methods; also, filtration of industrial waste water and education of instructions for environmental protection is vital works to control and protect against pollutants. In aquatic ecosystem metallic compounds occur in low concentration. Heavy metals may come from natural sources, leached from rocks and soils according to their geochemical mobility and also from anthropogenic source as the result of human land occupation and industrial pollution [2]. Depending on their solubility, these metals may be eventually associated with suspended particulate matter or accumulate in the bottom sediments. The increase of industrial activities has intensified environmental pollution problems and the deterioration of several aquatic ecosystems, with the accumulation of metals in the target organs. Trace elements are essential to life but at high concentration may become hazardous. Heavy metals are considered the most important form of pollution of the aquatic environment because of their toxicity an accumulation by marine organisms [3 and 4].

Under certain environmental conditions, heavy metals may be accumulated to a toxic concentration [5], and cause ecological damage [6]. Heavy metals were particular concern due to their toxicity and ability to be bio-accumulated in aquatic ecosystems [7], as well as persistence in the natural environment. Among the different metals analyzed, lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr) and arsenic (As) are classified as chemical hazards and maximum residual levels have been prescribed for humans[8]. Essential metals, such as copper (Cu) and zinc (Zn), have normal physiological regulatory functions [9], but bio-accumulate reach toxic levels [10]. Heavy metals pollution in aquatic environment has become a serious problem [11] and also an important factor in the decline of water sediments and fish quality. Fish are one of the most important and the largest groups of vertebrates in the aquatic system. Trace metals can be accumulated via both food chain and water in fish [12]. Patrick and Loutit [13] reported bio-magnification of Cr, Cu, manganese (Mn), iron (Fe), Pb and Zn from bacteria to tubificid worms in fish through the food chain. Fish have been considered good indicators for heavy metal contamination in aquatic systems because they occupy different trophic levels with different sizes and ages [14]. Meanwhile, fish are widely consumed in many parts of the world by humans, and polluted fish may endanger human health. In the present study, we selected fishes in Valinokkam Coastal region and tried to apply some basis for environmental variance and quality of fish.

MATERIALS AND METHODS

Valinokkam coastal area lies in the Gulf of Mannar region in Ramanathapuram. It is positioned at Latitude 9º09'32" N and Longitude 78º39'23" covers a coastal area of 12 km. This area also distributed with greatest coral reefs and Kilakarai forest department carries out the routine maintenance of this region. Dumping of industrial wastes like fly ash, etc, chemical discharges from industries because the study area located near Thoothukudi in particular, and illegal coral mining pose serious threat to the adjacent ecosystem. There are four fish samples such as *Dussumieria acuta, Tenuaslosa ilisha, Sardinella longiceps* and *Caranx hippos* were collected from Vallinokkam coastal area were caught by the local fisherman using gill net of various sizes. The fish communities of this study are economically important and they form a large part of the fish catch in the study. The size of the fish collected varied, depending on the species, between12 cm and 54 cm, and their age was from 6 months to 1years. Fish from each variety dissected to separate organs (muscle, gills and kidney) according to FAO method. The separated organs were put in petridishes to dry at 120°C until reaching a constant weight. The separated organs were placed into digestion flasks and ultrapure HNO_3 and H_2O_2 (1:1 v/v) was added. The digestion flasks were heated to 130°C until dissolution, diluted with water and analyzed for heavy metal concentration using atomic absorption Spectrometer.

RESULTS AND DISCUSSION

The fish community in these study area includes the native species. Heavy metals entering the fish have a possibility to get accumulated in different parts of the body and the residual amount can build up to a toxic level. Four fish species (*Dussumieria acuta*, *Tenuaslosa ilisha*, *Sardinella longiceps* and *Caranx hippos*) were collected from this coastal area and analysed for level of heavy metal contents recorded in muscle, gill and kidney (Table 1). The maximum concentration of heavy metal was found in Gill and Kidney, the order of heavy metal level in various argons Gill>Kidney>Muscle. The order of heavy metal concentration in Gills Cu>Pb>Cd>Ni>Co, in Kidney Cu>Cr>Cd>Ni>Co and in Muscle Cu>Pb>Cd>Ni>Co. The presence of heavy metals (Cu, Pb, Cd, Ni and Co) in selected organs of the fish species *Dussumieria acuta, Tenuaslosa ilisha*, *Sardinella longiceps* and *Caranx hippos* were graphically presented (Fig. 1 to 4). The presence of elevated levels of heavy metals Cu and Pb in almost organs is not a series matter of concern and the potential for human exposure to heavy metals from eating fish caught in this coastal area.

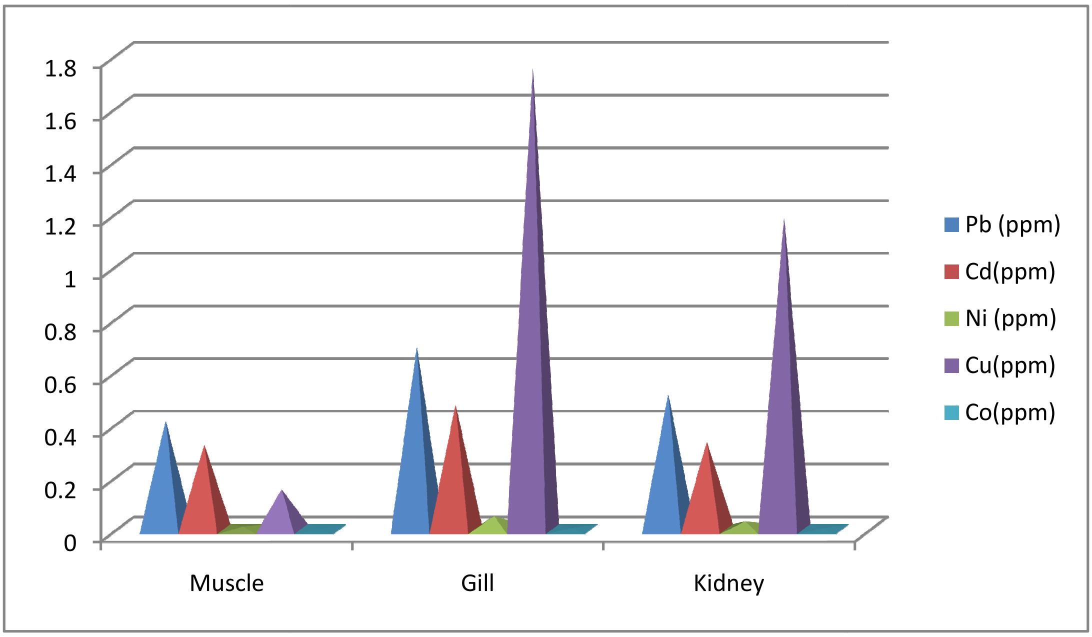
Cadmium

The level of Cadmium in selected fish organs ranged from 0.24 ppm to 0.47 ppm. The maximum concentration (0.47 ppm) was observed in Gills and minimum concentration (0.24 ppm) observed in the Muscle. Cadmium concentrations are lower than those reported earlier by Mendil *et al*. [15] in fish from Turkish Lakes. These values were found to be lower than the acceptable limit proposed by the EU [16] and TFC [17]. The European Community proposed threshold values of metal concentrations in fish muscle of only 0.05μg/g of Cd [18]. Cadmium can be accumulated with metallothioneins and uptake of 3–330mg/day is toxic and 1.5–9 mg/day is lethal to humans [19]. Cadmium injures kidneys and cause symptoms of chronic toxicity, including impairment of kidney function, poor reproductive capacity, hypertension, tumors and hepatic dysfunction [20].

Table 1: Detection of heavy metals in different organs of Fish samples collected from Valinokkam coastal area

Fish Samples	Pb(ppm)	Cd(ppm)	Ni(ppm)	Cu(ppm)	Co(ppm)
Fish 1					
Muscle	0.41	0.32	0.01	0.15	0.001
Gill	0.69	0.47	0.05	1.75	0.004
Kidney	0.51	0.33	0.03	1.18	0.003
Fish 2					
Muscle	0.29	0.30	0.01	1.08	0.002
Gill	0.52	0.34	0.03	1.21	0.004
Kidney	0.39	0.32	0.02	1.17	0.002
Fish 3					
Muscle	0.25	0.24	0.02	1.40	0.001
Gill	0.33	0.33	0.04	1.62	0.003
Kidney	0.32	0.30	0.03	0.30	0.002
Fish 4					
Muscle	0.26	0.28	0.03	0.36	0.001
Gill	0.31	0.30	0.05	1.82	0.005
Kidney	0.27	0.29	0.04	0.52	0.002

Fig.1. Distribution of heavy metals in fish, *Dussumieria acuta*



Copper
The concentration of Copper were found to be 0.15 ppm to 1.82 ppm in Gill, Kidney and Muscle Copper concentration range from 0.21ppm to 1.82 ppm in Gill, 0.30 ppm to 1.18 ppm in Kidney and 0.15 ppm to 1.40 ppm in Muscle. The higher Cu concentration (0.69 ppm) was detected in Gills and lowest concentration was detected in Muscle. Copper concentrations are lower than the values from earlier reports [21]. The copper contents in the samples were much less than the FAO-permitted level of 30μg/g [8] and Chinese food standards (10μg/g) [22]. Excessive intake of copper may lead to liver cirrhosis, dermatitis and neurological disorders [23].

Nickel
The Nickel concentration was 0.01 ppm to 0.05 ppm in Gill, Muscle and Kidney at selected fishes. The highest concentration (0.05 ppm) of Nickle was found to be Gill and the lowest concentration (0.01 ppm) was observed in Muscles of 2 fishes. Nickel concentration reported to be below than tolerance limits. In the study area, the presence of nickel concentration is due to lithogenic sources, industrial wastages and sometimes-anthropogenic activities. Spatial distribution map nickel in the study area is constructed and classified as low, medium and high. Nickel is a fairly toxic element, the volatile compound like nickel tetra carbonyl Ni (CO)4, which is used for the extraction of the element by the Mond process is poisonous. Nickel poisoning can lead to headache, vertigo, nausea, vomiting,

nephrotoxic effects, pneumonia, pulmonary fibrosis, rhinitis, sinusitis, bronchial asthuma, lung and nasal malignancies [24].

Fig. 2: Distribution of heavy metals in fish, *Tenuaslosa ilisha*

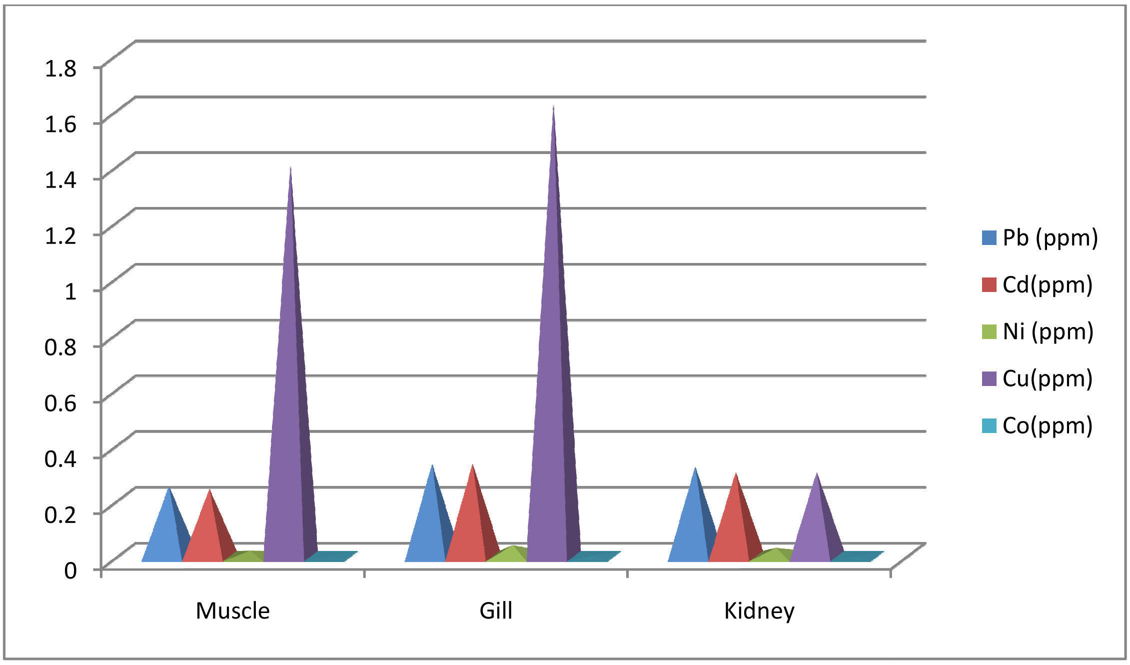


Fig. 3: Distribution of heavy metals in fish, *Sardinella longiceps*

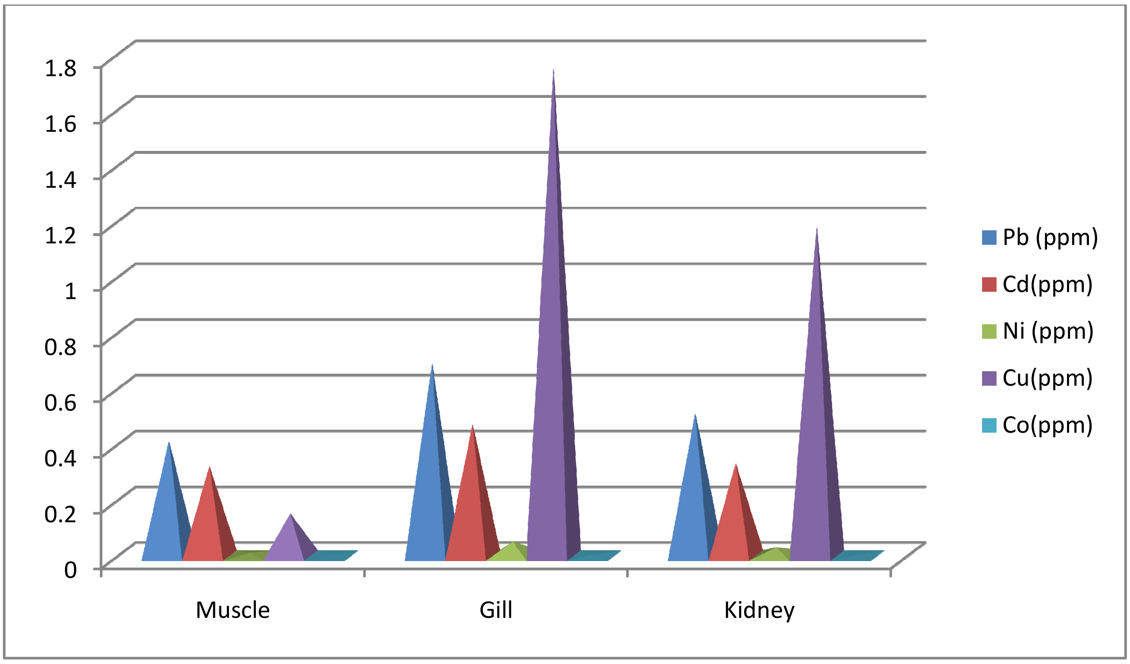
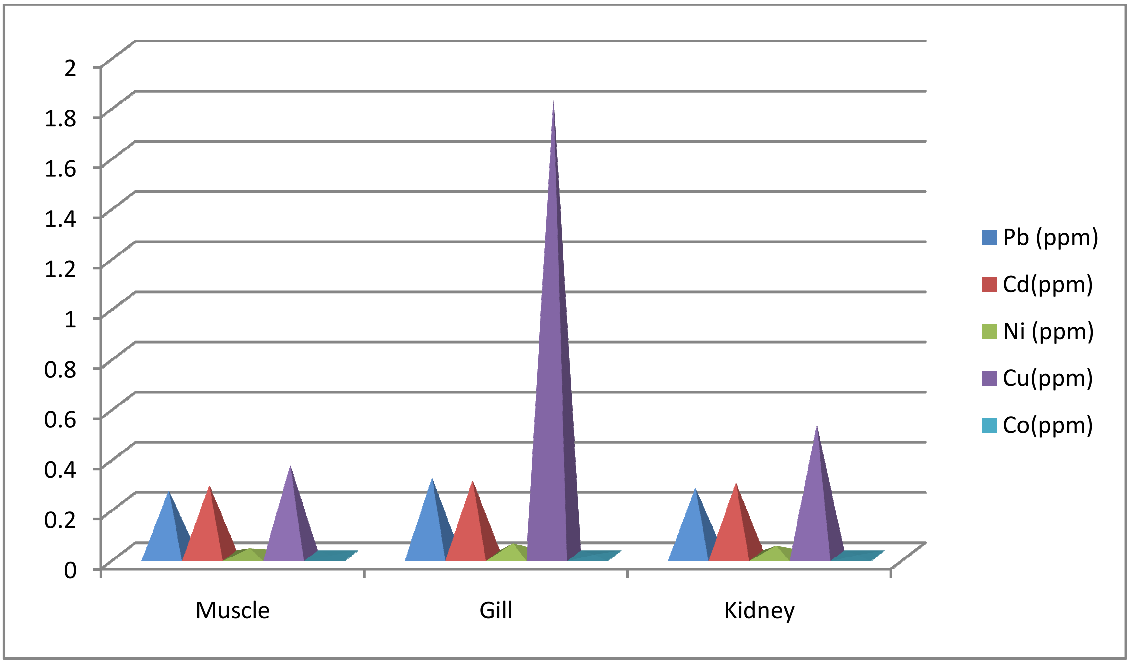


Fig. 4: Distribution of heavy metals in fish, *Caranx hippos*



Cobalt

Cobalt result obtained for different organs were found to be 0.001 ppm to 0.005 ppm. The highest values (0.005 ppm) observed in the Gill, while lowest values (0.001ppm) observed in the Muscle. Cobalt is an essential metal for human and it is part of the enzyme cyanocobalamin, Vitamin B12. Critical organs after Cobalt exposure include the skin, heart and the respiratory tract. Addition to cobalt chloride to beer has been used to improve the quality of the froth in Canada, the U.S. and Belgium, and the daily intake from food is about 5 to 45 µg/day. Cobalt is often regulated, detoxified and stored in an inert form, or may accumulate and cause toxic effects [25].

Lead

The lead results obtained for different organs are ranged from 0.25 ppm to 0.69 ppm in all organs. The higher concentration (0.69 ppm) was observed in Gill of all fishes and lowest concentration (0.25 ppm) was observed in Muscle. Exposure to Lead may cause demyelination, axonal degradation and presynaptic block. The peripheral nervous system damage causes paralysis and pain in the extremities. Lead inhibits the activity of the enzyme pyrimidine-5-nucleotidase in red cells. Heavy lead exposure is associated with reticulocytosis and occurrence of stippled erythrocytes in peripheral blood. Further the life span of circulating erythrocytes becomes shortened. Lead exposure may cause proximal tubular damage in the kidneys which is followed by aminoaciduria glucosuria and hyperphosphaturia. After heavy exposure, interstitial nephritis, interstitial fibrosis, tubular fibrosis, tubular atrophy, arteriosclerosis, decrease of renal plasma flow, followed by increase of blood urea nitrogen (BUN) resulting hyperuricemia. Alkyl lead poisoning is acute, causing irritability, headache, convulsion, delirium andcoma [26].

CONCLUSION

The present study revealed that the heavy metal contamination in different parts of the four fish species collected from Valinokkam coastal region. Based on the fish sample analysis the concentration of Cu recorded higher in different organs (muscle, gill and kidney) of all fish samples. The level of the heavy metal concentration in muscle, gill and kidney of the fish species is in the order as follows, Cu>Pb>Cd>Ni>Co. Besides, this study indicates the high concentration of toxic metals accumulated in gills and kidney, and least concentration was found in muscle tissue. Though the level of heavy metals did not exceed the acceptable levels for food samples, but keeping in view the persistence nature of heavy metals in the environment and in view of the importance of fish in the diet of human beings particularly of coastal regions, biological monitoring and assessment of heavy metals in fish meat for consumption should be carried out regularly to ensure the future food safety.

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