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Heavy Metal Concentrations in Three Commercial Fish Species in Cuddalore Coast, Tamil Nadu, India

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Abstract

Three fish species samples were collected from Cuddalore along Tamil Nadu coast, Bay of Bengal, India were analyzed for the levels of heavy metals to elucidate the status of the contamination in fish meat for human consumption. Concentrations of Cu, Cr, Cd, Co, Ni and Zn were determined for the above species using Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES). The concentrations of heavy metal in the samples were below the maximum residual level recommended by various organizations. Therefore, the fish muscles of the samples analyzed were fit for human consumption in this region.

Key Words: Fish, Heavy metals, Bioaccumulation, Cuddalore coast

Introduction

Fish is a major and easily available source of food in nature for mankind. It provides a significant amount of animal protein intake in the diet of a large population of people. In recent years, the marine, estuarine and coastal water are facing the problem of contamination by pollutants. Pollution changes the seawater chemistry and upset the ecological balance in the ocean; eventually it can disrupt the productivity of the ocean[1]. The majority of pollutants that enters into the marine environment are chemical in nature and range from completely toxic substance such as agricultural pesticide, cyanide and salt of various heavy metals to nutrient such as phosphate, nitrate fertilizer and organic matter of domestic and industrial origin. Among the many pollutants, attention must be focused on heavy metals because of their environmental persistence, toxicity at low concentration and ability to incorporate into food chain of aquatic organism[2].

Industrial wastes, geochemical structure and mining of metals create a potential source of heavy metals pollution in the aquatic environment[3, 4]. Metals can be taken up by the fish from water, food, sediment and suspended particulate material. However, the presence of metals in high concentration in water or sediment does not involve the direct toxicological risk to fish, especially in the absence of significant bioaccumulation. It is known that bioaccumulation to a large extent mediated by abiotic and biotic factors that influence metal uptake[5]. Due to the deleterious effect of metals on aquatic ecosystem, it is necessary to monitor their accumulation in fishes, because this will give an indication of the temporal and spatial extent of processes as well as the assessment of the potential impact on organism health[6]. Metals bounded top the sediments might pose a threat to aquatic biota either to leaching into the aqua's phase or by direct contact with the organisms. The contamination of heavy metals is a serious threat because of their toxicity, long persistence, bioaccumulation and biomagnifications in the food chain[7]. The aim of this study is to provide the baseline information on heavy metal (Cu, Cr, Cd, Co, Ni and Zn) concentrations in three fish species off Cuddalore coast, Bay of Bengal, India, to determine whether these metals are within permissible limits for human consumption.

Materials and Methods

Cuddalore is a significant coastal city in Tamil Nadu State that hosts a number of large-scale industries. The Uppanar River runs parallel to the south coast of Cuddalore and a number of small streams of domestic, treated and untreated effluents from industries connect the coast via the river. The main industries along the western bank of Uppanar River include chemicals, beverage manufacturing, tanneries, oil, soap, paint production, paper and metal processing plants. Cuddalore harbour located in the estuarine region of Uppanar River is occupied by a fleet of mechanized fishing boats, which operates in the coastal zone.

Three fish species *Rastrilleger kanagurta*, *Kathala axillaris* and *Sardinella longiceps* were collected from Cuddalore coast, Tamil Nadu, India during September 2010 (Fig. 1). There are five fish samples from each kind of species were collected. After samples were identified using FAO sheet and field manuals, physical measurements were made for all the specimens. Samples were handled with cleaned stainless steel equipments. All samples were stored frozen until analysis. Only muscle tissues were taken for the determination of heavy metals levels. The collected samples were brought to the laboratory on the same day and were immediately dissected using stainless steel dissection instruments, cut into small pieces and dried in Microwave oven at 70 ºC for 15 minutes. After complete dry, the samples finely powdered using mortar and pistol and weighed to 1g using an electronic weighing balance. The weighed samples were digested in 100 ml glass beaker with concentrated nitric acid (20 ml) overnight. It is then mixed with 10 ml of concentrated nitric and perchloric acid (4:1) solution followed by hotplate method up to complete dryness.

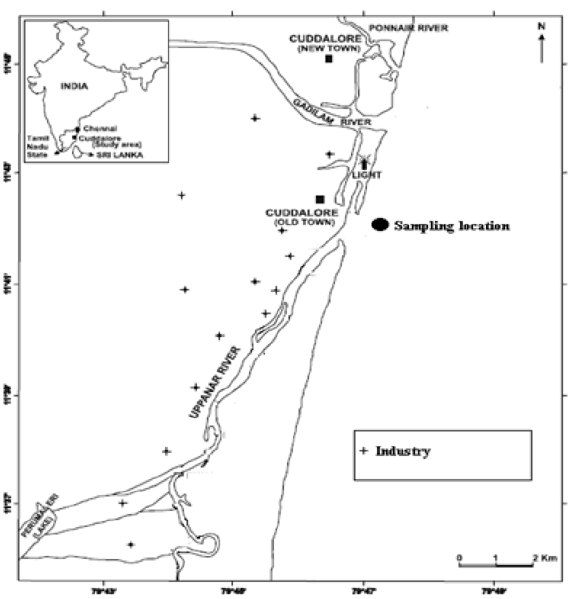

Figure 1. The study area showing sampling location

The ash is then made up to 20 ml solution by Milli-Q water with 20% conc. nitric acid after filtering through Whatman filter paper and then the metal concentrations were determined by using Inductively Coupled Plasma Optical Emission Spectrometer (Perkin Elmer, Optima 2100DV). All acids and chemicals were of analytical reagent grade. Metal concentrations were calculated in microgrammes per gramme dry weight (µg metal g^{-1} d. w.). The precision of the analytical procedure was checked by analyzing standard reference materials of commercially available standards (Merck KGCA, 64271 Damstadt, Germany, ICP-Multielement standard solution IV, 23 elements in nitric acid) in triplicate. Milli-Q water was obtained using a Millipore water system. Laboratory glass wares were kept overnight in a 10% nitric acid solution and rinsed with deionised water and air dried before use. The metals present in the fishes were statistically analysed by Pearson's Coefficient of Correlation and one way ANOVA.

Results and discussion

The present study revealed that concentration of both essential and non essential metals present in the fin fishes showed great variation in their edible part (Figure 2 & 3). Kalay et al. suggested that different fish species contained strikingly different metal level in their tissue[6]. This may be related to the difference in ecological needs behaviour and the metabolic activities among the finfish species. Among the three fish species, the Zn showed maximum accumulation and Co showed minimum accumulation (Table 1). Order of mean metal concentration of each metal in each fish species *R. kanagurta*, *K. axillaris* and *S. longiceps* is depicted in Table 2. The metal concentrations are positively correlated to each other and one way ANOVA analysis showed no significant difference for Cu, Cr, Cd, Co, Ni and Zn ($p>0.05$).

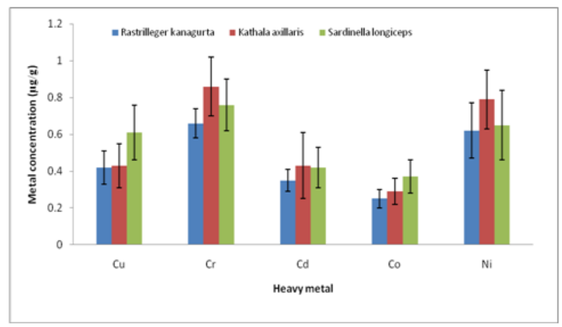

Figure 2. Metal concentrations in the fish species

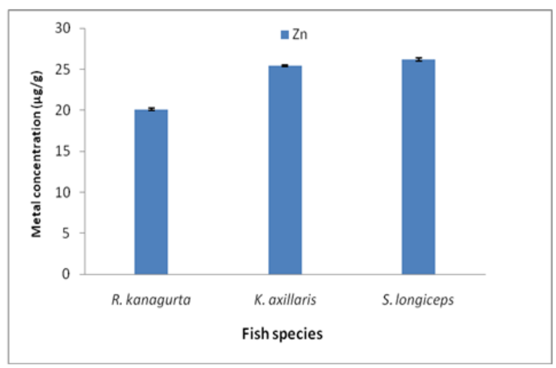

Figure 3. Zinc concentrations in the fish species

Table 1. Metal accumulation in the three marine edible fishes (Mean ±SD)

Fish species	Cu (µg/g)	Cr (µg/g)	Cd (µg/g)	Co (µg/g)	Ni (µg/g)	Zn (µg/g)
R. kanagurta	0.42±0.09	0.66±0.08	0.35±0.06	0.25±0.05	0.62±0.15	20.1±0.13
K. axillaris	0.43±0.12	0.86±0.16	0.43±0.18	0.29±0.07	0.79±0.16	25.4±0.09
S. longiceps	0.61±0.15	0.76±0.14	0.42±0.11	0.37±0.09	0.65±0.19	26.2±0.16

Table 2. Order of mean metal concentration in the commercial edible fishes of Cuddalore coast

Fish species	Metal concentration
R. kanagurta	Zn> Cr> Ni> Cu> Cd> Co
K. axillaris	Zn> Cr> Ni> Cd> Cu> Co
S. longiceps	Zn> Cr> Ni> Cu> Cd> Co

Table 3. Comparison of metal accumulation (µg/g) in various sampling areas

Sample area	Cu	Cr	Cd	Co	Ni	Zn	References
Mediterranean Sea	3.40–5.88	1.28–1.60	1.07–1.43	-	4.25–6.07	16.1–31.4	Kalay et al.[6]
Black Sea Coast	1.01–4.54	<0.06–0.84	<0.02–0.24	<0.05–0.40	<0.01–0.04	25.7–44.2	Topcuoglu et al.[9]
Mediterranean Sea	2.19–4.4	1.24–2.42	0.37–0.79	-	-	16.5–37.4	Canli and Atli[10]
Masan Bay, Korea	0.18–0.25	0.02–0.05	0.01	-	0.02	6.33–12.9	Kwon and Lee[11]
California Lagoons	1.9–7.5	1.9–24	0.1–0.3	1.6–1.7	0.61–12	36–150	Tamira et al.[12]
Middle Black Sea	1.28–2.93	-	0.09–0.48	-	-	9.5–22.9	Tuzen[13]
Kerguelen Islands	0.5–2.5	-	0.01–0.1	-	-	9.2–33.2	Bustamante et al.[14]
Iskenderun Bay	0.66–1.98	1.03–1.79	-	-	0.32–1.72	8.99-18	Yilmaz[15]
Cuddalore Coast	0.42-0.61	0.66-0.86	0.35-0.43	0.25-0.37	0.62-0.79	20.1-26.2	Present study

Metals such as iron, copper, zinc and manganese, are essential metals since they play an important role in biological systems, whereas mercury, lead and cadmium are non-essential metals, as they are toxic, even in traces. The essential metals can also produce toxic effects when the metal intake is excessively elevated. Heavy metal discharges to the marine environment are of great concern all over the world, and have a great ecological significance due to their toxicity and accumulative behavior. Thus, it can damage both marine species diversity and ecosystems[7]. Heavy metals in aquatic environment can remain in solution or in suspension and precipitate on the bottom or be taken up by organisms. The analysis of metal concentrations in biota samples at the same locations can indicate the transfer of metals through food chains[8]. Compared to the results of Kalay et al., [6] the levels of Cd, Co, Cr, Cu and Ni were lower in the present study, except Zn (Table 3). Canli and Atli[9] studied the heavy metals in different fish species from Iskenderun Bay and the Cr and Zn levels were higher than the present study but Cd, Co, Cu and Ni concentrations were well agreed with the present results. The concentrations of Cu and Ni in fish collected from the Black Sea coast were well agreed with the present results[8] (Table 3).

Among the different metals analyzed Cadmium, Chromium and Nickel are classified as chemical hazards and maximum residual levels have been prescribed for human. In this study, Cd, Cr and Ni level in the samples were much less than the permitted level. In the present study, all the metal concentrations are below the limit of European Commission report and FDA (US Food and Drug Administration). Data from the previous literatures showed that metal concentrations in fish muscles varied widely depending on the sampling area (Table 3). From the table, it is evident that, the present study area is not much polluted by heavy metals and there appears to be no immediate threat to the fisheries from heavy metal contamination.

Conclusion

Present study provides new information on the concentration of heavy metals in fish from Cuddalore coast. Based on the sample analyzed, metal concentrations found in the edible part of fish species are not heavily burdened with metals, and the concentrations are below both EC and FDA limit. The concentrations of heavy metals in muscle of the fish species studied were considerably lower than the maximum levels set by law and therefore, the samples analyzed were fit for human consumption in this region. There appears to be no immediate threat to these fisheries from heavy metal contamination. Even though, there are no high levels of heavy metals in fish, a possible hazardous may occur in the future depending on the agricultural and fishing development in this area.

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