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Assessment of Heavy Metal Concentrations in Tunas Caught from Lakshweep Islands, India

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Abstract**—**The toxic metal contamination and their biomagnification in marine fishes is a serious public health concern specially, in the coastal areas and the small islands. In the present study, concentration of toxic heavy metals like zinc (Zn), cadmium (Cd), lead (Pb), nickel (Ni), cobalt (Co), chromium (Cr) and mercury (Hg) were determined in the tissues of tunas (*T. albacores*) caught from the area near to Lakshdweep Islands. The heavy metals are one of the indicators for the marine water pollution. Geochemical weathering, industrialization, agriculture run off, fishing, shipping and oil spills are the major pollutants. The presence of heavy toxic metals in the near coastal water fishes at both western coast and eastern coast of India has been well established. The present study was conducted assuming that the distant island will not have the metals presence in a way it is at the near main land coast. However, our study shows that there is a significant amount of the toxic metals present in the tissues of tuna samples. The gill, lever and flash samples were collected in waters around Lakshdweep Islands. They were analyzed using ICP–AES for the toxic metals after microwave digestion. The concentrations of the toxic metals were found in all fish samples and the general trend of presence was in decreasing order as Zn > Al > Cd > Pb > Cr > Ni > Hg. The amount of metals was found to higher in fish having more weight.

Keywords**—**Biomagnifications, marine environment, toxic heavy metals, Tuna fish.

I. Introduction

THE main diet of majority of the population of coastal cities is primarily sea food. Specially, island populations have limited sources of other foods and vegetables. Contaminated marine fish contributes toxic effect on coastal and island human population. It is, therefore, imperative to pay the attention and give serious thought to the problem. There is a potential risk involved in fish eating in large quantities, as some species which have high content of heavy metals may affect the health [1]. Recently, studies suggest that high mercury content in diet may cause cardio problem and damage developing fetuses [2], [3]. Poisoning by mercury in the adult brain shows several effects like neuronal loss in the cerebellum granule layer, damage of discrete visual cortex areas etc. [4]. Cadmium, arsenic and lead have serious health effects, among the other dietary food consumption of fish with high content of these metals as reported by several authors [5]-[7]. Typical health effects of cadmium in human are reported as effect on the respiratory system, hepatic toxicity, bone disease etc. Cd is seen to accumulate in the kidney over a relatively longer period of time from 20 to 30 years [8]. At high doses, other health effects of Cd are hepatic slow function, poor reproductive capacity, hyper tension and tumors [9]. Seafood gets contaminated due to the presence of toxic heavy metals in sea waters as a result of environmental pollution, weathering of the earth's crust, geological weathering and other human activities. Consumption of such food leads to the transfer of these metals to human beings causing serious effects on human health around the world. In the case of Arabian Sea, industrial activities have been causing of death/extinction of few marine species and fish [10].

The biological half-life of methyl mercury in human body is approximately 65 days [11]. Bioaccumulation level of toxic heavy metals in fish tissues is mainly due to biotic and abiotic factors. These factors are fish habitat, chemical form of heavy metals in the water, dissolved oxygen level, pH value, water temperature, fish age, and other environmental conditions [12]. Metal distribution between the different tissues within an organism depends on the mode of exposure and can serve as a pollution indicator [13].

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II. Tuna Fisheries

Tuna and tuna-like species are commercially very important and at the same time, these are a significant source of food. They include approximately forty species occurring in the Atlantic, Indian and Pacific Oceans and in the Mediterranean Sea. Their global production has tended to increase continuously from less than 0.6 million tons in 1950 to above 6 million tones today [14].

The yellow fin tuna fish is commercially second most important species of tunas worldwide. Its catches were on increasing path till the early 1990s. Since then, the catches were relatively stable at around 1 million tons, in 2002 the catch reached about 1.3 million tons. Generally, most yellowfin tuna are used for canning. Subsequently, more and more of the catches are being sold in fresh fish markets and also some as frozen fish. Catches in the Atlantic in last two decades are fluctuating between 129 000 tons and 156 000 tons in 1995 to 2002 [14].

From the Indian Ocean, the catches of yellow fin tuna increased to the maximum of over 300000 tons in 1993, fluctuating between 245000 tons and 300000 tons in 1995 to 2002. Catches of yellow fin tuna from the Pacific region increased consistently and it has reached to 906000 tons in 2002 [14].

When we see the scenario of consumption of marine products and fish, around three billion world's population consume 20% of their meat protein intake as fish product. For around 4.2 billion world's population, it is about 15% fish protein. In 2009, global per capita consumption of fish was estimated at 18.4 kg. For global population, it is estimated that the 16.5% of their meat protein are the fish products. It is also stated that the fish products contribute around 6.4 percent of all protein consumed by world's population. Preliminary estimates for 2012 indicate a further growth in fish consumption at about 19 kg per capita human population. During 2012, the production of aquaculture has reached to 47% and consumption of fish products by world's population has reached to 136 million tons. The recent report shows that the fish accounts almost 17% of the protein intake of world population. In certain coastal and island populations, this figure goes up to 70% [15].

The concentration of mercury in different studies is shown in Table I. The maximum concentration of 0.431 μg/g was in canned long fin tuna of N Jersey followed by that of NW Mexico as shown.

TABLE I
COMPARISON OF HG CONCENTRATIONS IN CANNED TUNA

Species	Site	Hg (μg/g)	Reference
Tuna fish	N Jersey USA	0.431	[6]
Tuna fish	N Jersey USA	0.419	[6]
skipjack tuna	N Jersey USA	0.096	[6]
skipjack tuna	N Jersey USA	0.149	[6]
Longfin Tuna	US Pecific coast	0.210	[16]
Tuna fish	Italy	0.610	[17]
Tuna fish	Istanbul Turkey	0.140	[18]
Longfin Tuna	NW Mexico	0.362	[18]
Longfin Tuna	NW Mexico	0.258	[18]

III. STUDY AREA

The Lakshadweep Islands spreading from 08°16'-13°58' N to 71°44°-74°24' E are coral islands, they have lagoons of 4,200 km^2. It has coastal line of about 132 km long, territorial waters of 20,000 km^2 and exclusive economic zone of 0.4 million km. These groups of islands are rich in fishery resources and tuna fishery is more dominant in Lakshadweep waters. As per the estimation of fish production in Lakshadweep waters made in 1977, it was around 50,000 tons [19] and in 1987, it was 90,000 tons [20]. However, the average production for the last ten years is about 6000 tones. Out of 27 islands, fishing activity is more on 11 islands and reef areas of Perumul Par, Valiyapani and Cheriyapani islands [20].

The Pole and Line fishing is a unique fishing method for the exploitation of tuna, which is practiced in Lakshadweep Islands for the centuries. About 80% of the total landing of Lakshadweep contributes skip jack tuna and 60% of the total landing is converted to dried products and about 40% goes for local consumption [20]. There are about 900 motorized fishing boats in Lakshdweep. The Lakshadweep Marine Fishing Regulation, 2000 and Marine Fishing Rules came in force in 2001. There are some strategies and efforts made to develop and manage tuna fishery in these islands so as to increase the production [21]. The potential tuna resources in these islands are estimated at around 0.1 million tons [20].

IV. MATERIALS AND METHODS

A. Collection of Real Time Fish Samples

For collecting the large fishes for sample from the deep sea area, we needed to have a large size fishing vessel capable of fishing in distant areas, far away from the coast. For the present study, services of the fisheries resources survey research vessel shown in Fig. 1, belonging to the Fishery Survey of India, Mumbai, Ministry of Agriculture and Farmers welfare were used. It took its course for the survey bycatching fish using long lining fishing methods.

The tuna species were caught as shown in Fig. 2. The weight and length of all samples were recorded and finally gill, liver and flash samples, as it shown in Fig, 3, were taken for further analysis.

Fig. 1 Fishery survey tuna long liner

Fig. 2 Yellow fin tuna

Fig. 3 Gill and liver of yellow fin tuna

B. Processing and Analysis of Samples

The sample of 0.5 g was digested in Microwave Digester (model MARK, CEM) in Teflon vessels/block tubes to which 5 ml of concentrated HNO_3 and 2 ml of 30% H_2O_2 were added. The ramp time was 20 minutes, hold time 15 minutes, the maximum temperature kept 180 ^{0}C and the power 1200 watts. The digested samples were diluted at different Dilution Factor (DF) such as 5, 10, 20, 50 and were run through the Inductively Coupled Plasma (ICP) Spectroscopy (model 7500ce, Agilent) for Zn, Pb, Al, Cr, Ni, Cd and Hg. They were separated metal wise in the excel sheet. For further refinement of data, the intensity was entered in computer. After the processing, the quantity of toxic metal was obtained in microgram per gram of sample.

V. Results and Discussion

There were a total of 17 samples of yellow fin tunas which were weighing in the range from 35 kg to 55 kg. The minimum and maximum concentrations of various metals were found for each metal in gill, liver and flash as it is shown in Table II.

TABLE II
METAL CONCENTRATION (μG/G) IN TUNAS (MINIMUM-MAXIMUM)

Metals	Gill	Liver	Flash
Zn	13.48-24.42	60.61-121.22	6.02 - 22.38
Pb	1.68-2.32	1.12-1.82	1.24 - 1.68
Al	1.16-9.76	2.38-11.84	1.24 - 5.68
Cr	0.60-0.92	0.46-0.79	0.43 - 0.64
Ni	0.24-0.39	0.28-0.42	0.22 - 0.36
Cd	0.03-0.65	2.32-10.74	0.02 - 0.03
Hg	0.50-0.98	0.80-2.40	0.30 - 0.980

Zn is an essential element in animal and plant kingdom. It acts as enzyme activator and less toxic then the other toxic heavy metals. However, it may be harmful, if it is consumed more than the specified limit. Zn concentration in tuna fishes especially in the liver was in the range of 60.61 μg/g to 121.22 μg/g and in the flash, it was found in the range of 6.02 to 22.38 μg/g as it is shown in Table II.

The levels of Pb in gill samples were in the range from 1.68 μg/g to 2.32 μg/g whereas in the flash, it was in the range of 1.23 μg/g to 1.68 μg/g. For human, Pb is considered to be harmful as it affects the thinking process, cognitive development in infant and in children. In adults, it is known for increasing the blood pressure and causing harmful effect on cardiovascular blood vessels. Further, it causes serious effect on other small blood vessels and brain blood vessels. The provisional tolerable weekly intake of lead recommended as 25 μg/kg body weight, accordingly 1,500 μg/g lead per week for a 60 kg person by WHO 1990 [24]. Pb can cause serious health issues; abdominal pain, adrenal insufficiency, anemia, arthritis, attention deficit, back problems, blindness, cancer, constipation, convulsions, deafness, depression, diabetes, dyslexia, epilepsy, fatigue, gout, impaired glycogen storage, hallucinations, hyperactivity, impotency, infertility, inflammation, kidney dysfunction, learning disabilities, diminished libido, arteriosclerosis, migraine headaches, multiple sclerosis, psychosis, hyperactivity, thyroid imbalances, tooth decay and serious effect on growth rate of children [22].

Aluminum is not considered as an essential element for human body, exposure to aluminum leads to several diseases like dental caries, alzheimer disease, amyotrophic lateral sclerosis, colic, fatigue, dementiadialactica, hypoparathyroidism, kidney and liver dysfunctions, neuromuscular disorders, osteomalacia. It is also seen as potential cause for Parkinson disease in elder population and causing other serious blood related disorders. The concentration of Al was found in the range of 2.38 μg/g to 11.84 μg/g in the liver and in the flash, it was in the range of 1.24 μg/g to 1.68 μg/g. The limit for Al has been specified for a person 60 mg per day [23].

Cr concentration in very small quantity may be required for human as it is related to carbohydrate, lipid, and protein metabolism. The maximum level specified is 50 μg/gas per [21]. In the present study, the maximum quantity of Cr was found 0.92 μg/g in the gills whereas 0.64 μg/g was found in the flash.

Ni concentration is generally low in the aquatic environment. Nickel concentrations in the liver tissue ranged from 0.28 to 0.42 μg/g. It was more as compared to gill and flash as it has been shown in Table II. For Ni, it is specified as 100 to 300 μg for daily intake [23]. Nickel can cause cancer (oral and intestinal), depression, heart attacks, hemorrhages, kidney dysfunction, low blood pressure, malaise, muscle tremors and paralysis, nausea, skin problems, tetany and vomiting.

Cadmium is not considered as essential metal for human body as well as for other marine species. High concentrations are often a threat to marine biota. This may get accumulated in marine fishes through the food chain, in turn it may enter to the human population and cause many serious damages to body vital argons like kidney dysfunction, skeletal damage, reproductive deficiencies, hypertension, arthritis, diabetes, anemia, arteriosclerosis, impaired bone healing, cancer, cardiovascular disease, cirrhosis, hypoglycemia, headaches, osteoporosis, schizophrenia and kidney diseases. [24]. Cadmium concentration in the present study was maximum in the liver (2.32 μg/g to 10.74 μg/g) whereas in the gill and flash, 0.03 μg/g to 0.06 μg/g and 0.02 μg/g to 0.03 μg/g respectively.

Specifically, in the case of Hg, concentration levels were in the range of 0.08 μg/g to 2.40 μg/g in the liver. However, in the flash, it was in the range of 0.9 μg/g to 1.07 μg/g. This is slightly on the higher side than the specified limits. As per the WHO, 1994 the Permissible Tolerable Weekly Intake of Hg has been decided as 5 μg/kg body weight. For a person having 60 kg weight, 300 μg Hg/week can be the limit [24]. Hg is considered to be a latent neurotoxin than the other heavy metals, hence even a small dose may also be a cause of concern. It may lead to human health issues like adrenal gland dysfunction, alopecia, anorexia, ataxia, bipolar disorder, birth defects, blushing, depression, dermatitis, discouragement, dizziness, fatigue, headaches, hearing loss, hyperactivity, immune system dysfunction, insomnia, kidney damage, loss of self-control, memory loss, mood swings, nervousness, numbness and tingling, pain in limbs, rashes, excessive salivation, schizophrenia, thyroid dysfunction, timidity, tremors, peripheral vision loss and muscle weakness.

VI. Conclusions

As indicated above, each heavy toxic metal has adverse effect on different organs of human body. The toxicity of each metal has been indicated by different agencies and the provisional tolerable weekly intake (PTWI) is decided by WHO, CEC, FAO, ASFS, CAFS and also by other Agencies. The results showed that larger the species, higher the concentration. It can be suggested that large species of yellow fin tuna in large quantity in daily intake food may not be encouraged for human consumption.

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