



STUDIES ON THE LEVEL OF HEAVY METALS IN THE ANTARCTIC FISH

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The level concentration of metallic elements (Hg, Cd, and Fe, Mn, Zn, Cu, Pb, and Ni) in muscles and liver tissue, which have a tendency to accumulate different metals, of marine fish (*Pagothenia borchgrevinki*) in the Antarctic ocean is investigated. With the view that it may lead to a further investigation of the quality of the Antarctic ocean environment.

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Introduction

Heavy metals and other trace elements in aquatic environment are generally natural constituents.¹ They occur in these media as result of the weathering of soils and rocks, from volcanic eruptions, and from a variety of human activities such as the mining, processing, or use of metals or substances that contains metal contaminants² and from the atmospheric input of many substances into the oceans.³

Metals in the ocean have a specific biological response⁴ and a tendency to attach themselves to the marine organisms and undergo bioaccumulation.⁵ Although some metals such as Mn, Fe, Cu and Zn are essentials micronutrients necessary to promote the growth of marine organisms. However, an accumulation of these metals and Hg, Cd and Pb even in small amounts become hazardous to marine lives. Because fishes accumulate trace metals from their environment, they are excellent organisms for the study of long term changes in trace elements in the environment.⁶ Therefore, the concentrations of heavy metals in various tissues and organs of marine fish, *Pagothenia borchgrevinki* from the Antarctic ocean were investigated.⁸ The analysis of the concentrations of trace elements in individual organisms of fish showed that the metallic elements are concentrated in particular organs.⁷ The level composition of metal ions in tissues of marine fish (*Seriola grandis*) from New Zealand (North Island) followed the order : Zn>Fe>Cu>Mn>Pb>Ni>Cd.⁸ The liver tissue of arctic cod (*Boreogadus saida*) from Strathcona sound, northern Baffin Island were found to have a level of metal concentration in the order: Zn>Fe>Cu>Cd. Previously it was shown that concentration of Mn, Fe and Zn decreased with size⁹ as do concentration of Cu and Zn in whole striped bass fingerlings (*Morone saxatilis*) for wet weights less than 15 gram.¹⁰ For striped bass ranging from 15 to 60 gram, concentration of Cu and Zn were constant with weight.

Muscle tissue of fish is one of the means for investigating the amount of heavy metals entering the human body by consumption of the fish as food chain, and has therefore been investigated more than other organs. On the basis of the varying affinities of the metals for the in individual

organs, the fish muscle tissue proves not to be suitable for determining the extent of the heavy metal contamination of the entire organism. The absolute increase of heavy metals in muscle tissue of contaminated fish is often much lower than other organs.¹¹ In addition, the ability of organisms to concentrate trace elements is one of very great complexity and little information's is known concerning physiological processes that regulate the concentrations of trace metals in marine organisms. There are no reports about the relation between the bioaccumulation of metallic elements in individual tissue and size of antarctic marine fish.

Materials and Methods

Materials

Twenty two Antarctic fish (*Pagothenia borchgrevinki*) were caught during 22nd Japanese Antarctic Research Expedition (JARE). The fish were collected around syowa station (69°00 S, 39°35'E) Antarctica.

All specimens appeared to be in good healthy conditions, with no macroscopic pathological symptoms. All of them were kept frozen at about 20 °C until analysis. Body organs were dissected and excised. Samples of skin, muscle, liver, testis, ovary and other organs were separated and wrapped in plastic pocket and weighed and then frozen until next analysis.

Determination of Heavy Metals

For analysis of the heavy metals, homogenized samples of tissue and organ (0.2-5 g in wet weight) were digested in a nitric, perchloric and sulfuric acid mixture, and other organs (bone and muscle mixture) samples in nitric, and perchloric acid mixture. The resultant solutions were then diluted to a known volume with deionizer water, and the concentrations of Fe, Zn and Mn were directly measured by atomic absorption spectrophotometry (AAS). The concentrations of Hg was determined by Flameless AAS after adding SnCl₂.H₂SO₄ solution. The Cu, Pb, Ni and Cd, were extracted with methyl isobutylketon (MIBUK) and determined after chelation with sodium diethyl-dithiocarbamate (DDTC) using ASS.¹²

Results and Discussions

Levels of Heavy Metal Concentrations

The concentration of Fe, Mn, Zn, Cu, Pb, Ni, Cd and Hg distributed in individual tissues and organs of fish (*Pagothenia borchgrevinski*) are shown in Fig.1, which showed that affinities of metals for the individual tissue and organ of fish is different.

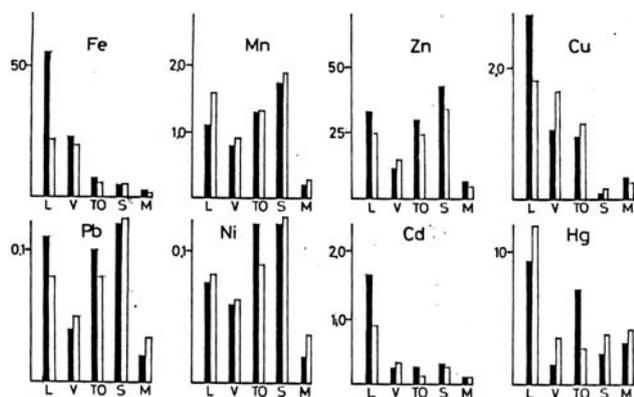


Figure 1. Comparison of heavy metal concentrations ($\mu\text{g g}^{-1}$, wet weight) in liver, other viscera, gonads, skin and muscle tissue of *Pagothenia borchgrevinski*. L-liver; V-viscera except for liver; T-testis; O-ovary; S-skin; M-muscle: ■ male □ female

The highest concentration ratios of (Mn, Zn, Pb and Ni) (Hg) : (Fe, Cu, Cd, and Hg) : (Cu, Pb, and Cd) : (Fe, Cu and Cd), and (Ni) are found in the skin, muscle, liver, ovary or testis, other organs, and bone and muscle mixture respectively. Among the tissues and organs of fish only in the lowest area except the mercury (Hg). It is also to be noted that the highest percentage of Fe, Mn, Zn, Cu, Pb and Ni, about 49-70% is present in bone and muscle; cadmium is present in liver tissue in about 42 %, whereas mercury is present in muscle tissue in about 44 % (Fig.2).

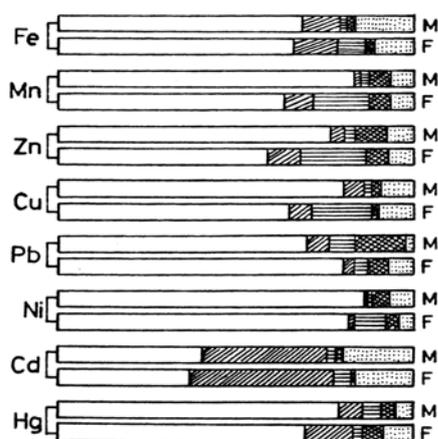


Figure 2. Percentage of tissue burden to body burden of heavy metals in *Pagothenia borchgrevinski*,

□: muscle+bone; ▨: liver; ▩: testis (ovary); ▤: skin ◻: other viscera; M-Male, F-Female

This fact is evident from the tendency of metals to accumulate in different tissues and organs, and that the accumulation is different for different metals. The differences in the distribution of heavy metals in body organs are probably due to the differences of constituent composition in the tissue and organ of fish, such as protein lipids, blood content etc.

Distribution of Heavy Metals in Tissues and organs

The results of the variations of the concentration of Fe, Mn, Zn, Cu, Cd, Pb, Ni and Hg in muscle, liver tissue and whole body of fish (*Pagothenia borchgrevinski*) from Antarctic ocean are discussed here. As seen in table 2 fish (*Pagothenia borchgrevinski*) caught in the Antarctic ocean averaged lower concentration of Fe, Mn, Zn, Cu, Cd, Pb, Ni and Hg in the muscle than in the liver tissue. These results are same as observations for seven species of (*Chondrichtyes*) and that the concentration of Cu, Cd and Zn metals was higher in liver than in muscle tissue.^{13,14} The mean concentration of cadmium and iron from seven individual arctic cod (*Boreogadussaida*) was also found higher in liver than in the muscle.¹⁵ The highest values of Zn, Cu, Cd, Pb, and Hg metals were found to have a greater variation coefficient in the liver than in the muscle in 42 black marlin (*Macaïra indica*) from unpolluted water of Northeast Australia.¹¹ In order to confirm further this tendency, determination of the ratio of metal concentration levels in liver to muscle tissue were carried out; it was found for Fe 15.22 : 1, Mn 5.42 : 1, Zn 4.97 : 1, Cu 5.74 : 1, Pb 2.42 : 1 Ni 2.38 : 1 Cd 47.22 : 1 and for Hg 2.0 : 1. These findings appeared to indicate that liver has great ability to accumulate these eight metals when compared with muscle tissue. The similar ratio for Cu 1600 : 1 and Zn 47 : 1 were found in (*Epinephelus striatus*) by Taylor and Bright.¹⁶

It is further necessary to know the level of chemical composition of metallic elements present in muscle and liver tissue of fish (*Pagothenia borchgrevinski*) because both muscle and liver tissue are mostly edible parts, which are possibly unfit for human consumption from a toxicological point of view¹⁷⁻²² considered using the fish tissue as indicator organisms for the heavy metals pollution. As shown in the Table 1, the chemical composition of mean concentration level of each metal combined in muscle and liver tissue of fish (*Pagothenia borchgrevinski*) are such as summarized as follows :

Muscle Zn > Hg > Fe > Cu > Mn > Pb > Ni > Cd

Liver Fe > Zn > Hg > Cu > Mn > Cd > Pb > Ni

The next case indicated that in muscle tissue, range coefficient variation are 0.155 for Zn and 0.652 for Cu, while in liver tissue it was found 0.123 for Zn and 0.875 for Ni. These results are in agreement with the range of 0.1 – 1.0 which is of the same range of coefficient of variation of various components in organisms as pointed out by Eberhardt.²³

The results mentioned above are explained on the basis that the concentration of metals differ greatly between different parts of fish organs in particular in muscle and liver tissue of the same fish.

Table 1. Metal concentrations ($\mu\text{g g}^{-1}$ wet weight) in muscle, liver, and whole body of *Pagothenia borchgrevinki*

Metal	Muscle			Liver			Whole Body		
	n*	Mean	Range	n*	Mean	Range	n*	Mean	Range
Fe	(22)	2.07±0.98	(1.04-4.34)	(18)	31.5 ± 19.6	(7.30–83.3)	(22)	4.99 ± 1.65	(2.52–10.65)
Cv		0.474			0.621			0.332	
Mn	(22)	0.24 ± 0.07	(0.10–0.46)	(18)	1.30 ± 0.60	(0.42–2.94)	(22)	0.65 ± 0.16	(0.33–1.03)
Cv		0.307			0.463			0.251	
Zn	(22)	5.65 ± 0.88	(4.27–8.15)	(18)	28.1 ± 3.46	(22.4–34.2)	(22)	11.21 ± 1.72	(8.73–14.92)
Cv		0.155			0.123			0.154	
Cu	(22)	0.43 ± 0.28	(0.17–1.39)	(18)	2.47 ± 1.58	(0.92–5.88)	(22)	0.75 ± 0.33	(0.38–1.73)
Cv		0.652			0.64			0.448	
Pb	(22)	0.12 ± 0.06	(0.02–0.28)	(18)	0.29 ± 0.24	(0.04–0.96)	(22)	0.13 ± 0.05	(0.02–0.29)
Cv		0.558			0.833			0.423	
Ni	(22)	0.08 ± 0.04	(0.02–0.23)	(18)	0.19 ± 0.17	(0.04–0.66)	(22)	0.08 ± 0.02	(0.05–0.17)
Cv		0.55			0.875			0.278	
Cd	(22)	0.02 ± 0.01	(0.01–0.04)	(18)	0.85 ± 0.52	(0.30–2.46)	(22)	0.07 ± 0.03	(0.02–0.12)
Cv		0.451			0.606			0.494	
Hg**	(22)	5.2 ± 1.9	(2.3–8.7)	(18)	10.4±5.52	(5.0–26.3)	(22)	2.69 ± 0.85	(0.9–4.7)
Cv		0.356			0.533			0.317	

* Number of samples analyzed; ** Ng/g, wet weight Cv = Coefficient variation

These concentrations difference in the tendency of metals to bind to the various molecular groups is found within the cells of each fish, as well as to the degree of the exposure to the metal as influenced by its metabolic characteristic.²

Conclusions

The experimental fish (*Pagothenia borchgrevinki*) was collected from the 22nd Japanese Antarctic Research Expedition (JARE). The concentrations of Fe, Mn, Zn, Cu, Ni, Pb, Cd, and Hg were determined by atomic absorption spectrophotometry. It was found that the tendency of metal to accumulate in the individual tissue and organs of the fish is different for each metal. Mean concentration of these metals in twenty two of fish are found higher in the liver than muscle tissue. The concentration ratios of these metals in liver to muscle tissue are found for Fe 15.22 : 1, Mn 5.42 : 1, Zn 4.97 : 1, Cu : 5.74 : 1 Pb, 2.42 : 1, Ni 2.38 : 1, Cd 47.22 : 1 and Hg 2.0 : 1.

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