Caspian J. Env. Sci. 2013, Vol. 11 No.2, pp. 247~253

CJES
Caspian Journal of Environmental Sciences

[Short Communication]

Comparison of Copper Concentrations in Liver and Muscle of *Squalius cephalus* and *Capoeta capoeta gracilis* (Pisces: Teleostei) in Tajan River, Iran

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(Received: Apr. 7.2012, Accepted: Aug.18.2012)

ABSTRACT

The aim of this study was to determine and compare the concentration of copper (Cu) in liver and muscle of two fish species *Squalius cephalus* and *Capoeta capoeta gracilis*. The fish were caught in four sampling sites along Tajan River, Mazandaran Province, northern Iran. The concentration of Cu was determined using flame atomic absorption spectrometry. There were significant differences ($P<0.05$) between the sampling sites with regard to Cu concentration in both muscle and liver of fish species. Significant differences were also found ($P<0.05$) between *S. cephalus* and *C. c. gracilis* regarding Cu content in liver and muscle tissues. The content of Cu in the liver was greater ($P<0.05$) than that in the muscle in both species. Also, Cu content of liver in both species was higher than the standard limits declared by WHO. This study reports high loads of Cu in Tajan River and a high content of Cu in the muscle and liver of *S. cephalus* and *C. c. gracilis*.

Keywords: *Heavy metal, Liver, Muscle, Capoeta capoeta gracilis, Squalius cephalus.*

INTRODUCTION

Rapid population growth and the extension of agricultural and industrial areas impose large quantities of effluents with hazardous chemical materials on aquatic ecosystems (Wicker & Gantt 1994; Eslami et al., 2010). These hazardous chemicals can be accumulated in the body of aquatic organisms and transferred to the human diet. There is an increasing attention on how human will be affected by heavy metals in aquatic organisms (Eslami et al., 2010). Impanpour Namin et al. (2011) stated that one potential risk of dietary fish intake is its content of heavy metals. The absorption and accumulation rates of heavy metals in the body of aquatic organisms is a function of biological and physical-chemical conditions of the aquatic environment, type of metal and organism, and the physiological conditions of organisms (Plaskett & Potter 1979; Wicker & Gantt 1994; Jaffar et al., 1998). Furthermore, seafood consumption is continuously increasing in line with population growth. Jafari (2002) reported that seafood consumption has been increased from 14 kg per capita in 1994 to 16 kg in 1997 on a global scale and also from 1 kg in 1979 to 5 kg in 1997 in Iran.

Numerous studies reported the concentration of heavy metals in various tissues of fish and other aquatic organisms throughout the world (e.g., So et al., 1999; Allen-Gi 1997; Zare & Ebadi 2005; Imanpour Namin et al., 2011). For example, Vinikour et al. (1980) found that the concentration of Zinc (Zn) in liver and muscle of Black crappie (*Pomoxis nigromaculatus*), Bluegill (*Lepomis macrochirus*), Yellow perch (*Perca flavescens*) were 103, 208, 106 and 101, 109, 100 mg/kg, respectively, in rivers adjacent to industrial areas of the United States. Impanpour Namin et al. (2011) observed that the concentration of Cu was significantly higher in liver than in muscle of *Esox lucius*.

Chub, *Squalius cephalus*, is the most abundant fish in small streams and large rivers of the Caspian Sea basin and is mainly important for sport fishing and minor commercial purposes. While juveniles feed on zooplanktons, adults prey on various aquatic animals. Large individuals prey predominantly on young fishes. The Siah Mahi, *Capoeta capoeta gracilis*, is a widely distributed taxon in rivers, lagoons, bays and water reservoirs in the Caspian Sea basins of northern Iran. Also, *C. c. gracilis* is an important taxon for sport fishing, inland water fishing, aquaculture and from the zoogeographical point of view (Samaee et al., 2006).

Industrial development accompanied by human population growth and land use change are the biggest threats for aquatic environments such as rivers, wetlands and the sea in northern Iran (Mehrdadi et al., 2006; Charkhabi et al., 2008). Because of numerous pollution sources along Tajan River due to high anthropogenic activities, there are probably high loads of heavy metals in the River (Zare & Ebadi 2005). However, no study reported the accumulation of such metals in the tissues of the mentioned fish species. The objective of this study was to determine and compare the concentration of Cu in liver and muscle of *S. cephalus* and *C. c. gracilis*.

MATERIALS AND METHODS

Study area

Tajan River with about 180 km length is one of the longest rivers in Mazandaran Province, northern Iran. It flows from its source in the Alborz Mountain range and northern parts of Semnan province and drains into the Caspian Sea. Tajan River basin with a total area of 4015 km² has humid temperate climate with a mean annual rainfall, temperature and discharge of 693 mm, 17.5 °C and 20 m³/s, respectively (Mehrdadi et al., 2003). Tajan River is amongst the most important rivers of the Caspian Sea basin (Eslami et al., 2010).

Sampling procedure

Four sampling sites were determined along the river in accordance with the location of the main sources of pollution and the presence of target fish species. Forty fish were caught in four selected sampling sites at Tajan River in 2011. Liver and muscle of fishes were placed in an air-forced oven at 60 °C for 72 hours, then were weighed using a measuring balance sensitive to 0.10 g. Dried samples were ground and sieved to obtain soft powder. Sample preparation was completed with a series of chemical reactions. Microwave digestion was used for chemical analysis. Five mL of HNO_3 was added to 0.2 g liver and muscle of each species separately and mixed using a rotating horizontal agitator at a frequency of 180 rpm for 2 minutes. Then samples were placed under a vented fume hood for 1 hour before digestion (Tabatabaee & Dast goshadeh 2002).

Chemical analysis

The concentration of Cu was measured using Perkin Elmer Atomic Absorption Spectrometer. The device was calibrated with standard solutions (Tel well 1967). The accuracy of measurements was checked with 3 control samples (Wicher & Gantt 1994).

Statistical analysis

Assumptions of normality and homogeneity of variance were checked and found to be valid. Data were tested for normality using Kolmogorov-Smirnov statistic and for homogeneity of variance with Leven's test. One-way analysis of variance (one-way ANOVA) procedure was used to test difference between groups. Duncan test was used for comparison between means. All tests were run with SPSS statistical software. The study used a $P \leq 0.05$ level for testing significance.

RESULTS

Table 1 shows the mean value of Cu concentration in the sampling sites. The content of Cu in specimens of site 2 was higher than that in other sites. In addition, the accumulation of Cu in liver was higher than that in muscle of both species in all sampling sites. The maximum and minimum values of Cu concentrations in the muscle of *S. cephalus* and *C. c. gracilis* were recorded in the sampling stations 2 and 1, respectively. Furthermore, the specimens from the stations 2 and 1 showed the highest and the lowest values of Cu concentrations in the liver of both fish species, respectively (Figure 1). The concentration of Cu in liver was greater than that in muscle tissues in both species (Figure 1).

There was a significant difference (P<0.05) between the sampling sites with regard to the concentration of Cu in the muscle of both *S. cephalus* and *C. c. gracilis* (Table 2). In addition, significant differences (P<0.05) were found between the sampling sites in relation to the content of Cu in the liver of both fish species (Table 2).

Table 1. Mean values of Cu concentrations (mg L^{-1}) in the tissues of *S. cephalus* and *C. c. gracilis* in Tajan River, northern Iran.

Tissue	Fish species	Sampling site	Max	Mean	Min
Muscle	*S. cephalus*	1	0.03	0.02	00
		2	0.17	0.15	0.13
		3	0.17	0.14	0.12
		4	0.09	0.09	0.08
	C. c. gracilis	1	0.07	0.06	0.05
		2	0.15	0.14	0.14
		3	0.16	0.13	0.12
		4	0.12	0.07	0.04
Liver	*S. cephalus*	1	0.49	0.46	0.45
		2	0.78	0.76	0.75
		3	0.61	0.58	0.56
		4	1.12	1.12	1.10
	C. c. gracilis	1	03.4	0.42	0.41
		2	0.72	0.69	0.68
		3	0.98	0.96	0.10
		4	0.74	0.54	0.17

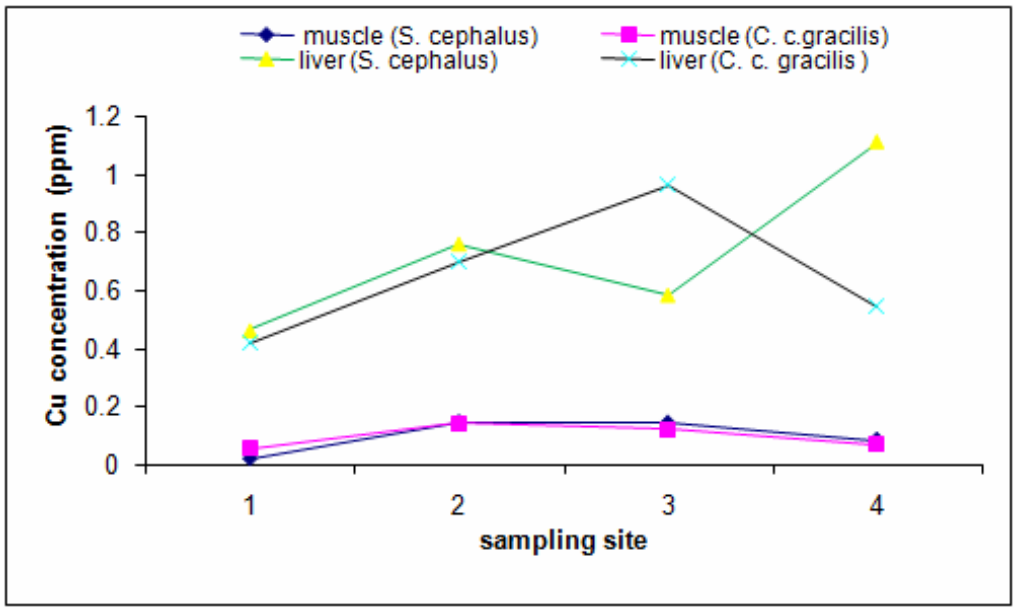

Fig. 1. Variation of Cu in the liver and muscle of *S. cephalus* and *C. c. gracilis* in Tajan River, northern Iran

Table 2. Comparison of Cu accumulation (mg kg^{-1}) in the tissues of *S. cephalus* and *C. c. gracilis* in Tajan River, northern Iran.

Tissue	Species	Sampling site	Mean	*F*	*P*
Muscle	*S. cephalus*	1	0.02[a]	38.61	00
		2	0.15[c]		
		3	0.14[c]		
		4	0.09[b]		
	C. c. Gracilis	1	0.06[a]	9.36	0.005
		2	0.14[b]		
		3	0.13[b]		
		4	0.07[a]		
Liver	*S. cephalus*	1	0.46[a]	62.61	00
		2	0.76[c]		
		3	0.58[b]		
		4	1.11[d]		
	C. c. Gracilis	1	0.42[a]	6.26	0.02
		2	0.69[ab]		
		3	0.96[b]		
		4	0.54[a]		

Within each sampling site groups, means followed by unlike small letter are significantly different ($P \leq 0.05$)

DISCUSSION

Liver and muscle of fish are usually used as the target tissues for the analysis of metal concentrations because muscle is main edible part and liver plays a role in the bioaccumulation process (Eslami et al., 2010). Differences in the concentrations of Cu in the sampling sites indicate various levels of pollution along Tajan River. Sampling site 2 showed the highest level of heavy metals which can be mainly attributed to the effluents of surrounding sources of pollutants such as Mazandaran Wood and Paper Industry, Mazandaran Steel Industries, municipal wastes, domestic sewage, road and dam construction (Zare & Ebadi 2005). The level of pollutants and their accumulation in aquatic organisms were declined with distance from anthropogenic and industrial points. Zare and Ebadi (2005) reported that the concentration of Cu in Mahi sefid (*Rutilus kutum*) and mullet (*Liza auratus*) correlated with the location of industrial plants along Tajan River. Allen-Gi et al. (1997) and Fuhrer et al. (1996) stated that the accumulation of metals in the body of an organism is a function of organism characteristics such as species, age, weight, sex, tissue, diet, ecological conditions of aquatic environment, and physical-chemical properties of the water body including hardness, pH, temperature and nutrients.

According to the results, the accumulation of Cu in the liver of both fish species was higher than that in the muscle. This is in consistent with the findings of So et al. (1999) and Allen-Gi et al. (1997). Impanpour Namin et al. (2011) found that the concentration of Cu was significantly higher in liver than in muscle of *Esox lucius* in Anzali Wetland, northern Iran. This high amount of Cu in liver can be explained by the function of liver in the body. Heavy metals accumulate mainly in the liver where metals are stored for detoxification through metallothioneins (Eslami et al., 2010). Elements are mainly accumulated in the liver of aquatic organisms and muscle consequently contains low levels of these elements.

The concentration of Cu in the liver of both fish species was higher than the WHO standard limits for this metal. This indicates high loads of Cu in Tajan River. However, Cu content of muscle was lower than the mentioned guidelines. Esalmi et al. (2010) also found that the concentration of Cu in the edible parts of *Rutilus kutum*

was lower than WHO/FAO standards in Tajan River. Tajan River is the main source of irrigation water in the region. Pollutants including heavy metals from agricultural land can be transferred to human diet through bioavailability (uptake by organisms) and chemical availability (leaching and mobility) (Pourang 1993). Consequently, Bio-monitoring of this river and its pollutants is important to assess ecosystem health over time (Eslami et al., 2010).

CONCLUSION

It can be concluded that the concentration of Cu in the liver of both *S. cephalus* and *C. c. gracilis* was more than that in their muscles. Furthermore, Cu content of liver in both species was higher than WHO standard limits. Consequently, this study reports a high level of Cu content in the muscle and liver of both *S. cephalus* and *C. c. gracilis* in the Tajan River, northern Iran.

ACKNOWLEDGMENTS

This project was supported by funding from the Islamic Azad University, Bojnord branch, Iran. The authors thank the anonymous reviewers for their valuable suggestions.

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مقایسه میزان غلظت مس در بافت عضله و کبد دو گونه ماهی سفید رودخانه ای *Squalius cephalus* و سیاه ماهی *Capoeta capoeta gracilis* در رودخانه تجن، استان مازندران

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(تاریخ دریافت: 91/1/19 - تاریخ پذیرش: 91/5/28)

چکیده

هدف از این مطالعه تعیین و مقایسه مقدار مس (Cu) در بافت عضله و کبد دو گونه ماهی سفید رودخانه‌ای (*Squalius cephalus*) و سیاه ماهی (*Capoeta capoeta gracilis*) بود. نمونه‌های ماهی در چهار سایت نمونه برداری در طول رودخانه تجن، استان مازندران، صید شدند. میزان غلظت فلز مس با استفاده از دستگاه جذب اتمی با شعله تعیین گردید. میزان غلظت مس در بافت کبد و عضله هر دو گونه ماهی در نقاط مختلف نمونه‌برداری تفاوت معنی‌داری داشت ($P<0/05$). بین ماهی سفید رودخانه ای و سیاه ماهی تفاوت معنی‌داری از نظر میزان مس در کبد و عضله وجود داشت ($P<0/05$). در هر دو گونه ماهی، میزان مس در کبد بیش از عضله بود ($P<0/05$). هم‌چنین، میزان غلظت مس در کبد هر دو گونه ماهی بالاتر از حد استاندارد WHO بود. این مطالعه نتیجه‌گیری می‌کند که میزان غلظت فلز سنگین مس در بافت‌های کبد و عضله دو گونه ماهی سفید رودخانه‌ای (*Squalius cephalus*) و سیاه ماهی (*Capoeta capoeta gracilis*) در رودخانه تجن، استان مازندران بیش از مقدار مجاز می‌باشد.

*مولف مسئول