HEAVY METALS (CU, PB, CD, ZN) MONITORING IN WATERS OF THE SHAHID BEHESHTI STURGEON HATCHERY, RASHT, IRAN

ARSHAD, U.*[1]. SADEGHI, M.[2] ALIAKBAR, A.[3], CHUBIAN, F.[4]
*[1, 2,, 4]*International Sturgeon Research Institute, P.O. Box 41635-3464, Rasht, Iran*
[3]*College of Basic Sciences, Gilan University, Namjou Street, P.O. Box 41335-1914, Rasht, umenon_94@yahoo.com*

MONITORING TEŠKIH METALA (CU, PB, CD, ZN) U VODAMA SHAHID BEHESHTI MRESTILIŠTA JESETRI, RASHT, IRAN

Abstract

The presence of heavy metals; copper (Cu), lead (Pb), cadmium (Cd) and zinc (Zn) in water was monitored during different stages of breeding and rearing of *Acipenser persicus* at the Shahid Beheshti Sturgeon Hatchery. Water samples were collected (3 samples from each point) from the main pond, Kurenski pond, incubators, vniro tanks, earthen ponds and at the river estuary where fingerlings are released into the sea. Water parameters such as pH and water and air temperature were measured and recorded at the time of sampling. Heavy metal concentrations in water samples were determined using Atomic Absorption Spectrophotometer FAAS-Varian AA-220.

In the present study the distribution pattern for heavy metal concentrations in different stages of breeding and rearing was as follows: Zn>Cu>Pb>Cd. Highest concentrations of heavy metals belonged to the element Zn (36.0±3.6 ppb) which was determined in the water sample collected from the inlet of master pond. Lowest concentration for Zn recorded was 0.98±0.26 ppb. Highest concentration for Cu was 10.5±1.18 ppb and the lowest concentration for this element was 0.65±0.26 ppb. The highest and lowest concentrations recorded for lead were 9.33±1.19 and 0.15 ±0.01 ppb, respectively, while those for cadmium were 0.116±0.019 and 0.016±0.003 ppb, respectively. The results obtained indicate the presence heavy metals studied in the water samples although they were lower than the maximum permissible concentration for these pollutants for the breeding and rearing of *Acipenser persicus* in sturgeon hatcheries.

Key words: *Sturgeon fingerlings, heavy metals, incubation, vniro tanks, rearing ponds*

INTRODUCTION

In addition to the type and level of contaminant and its behavior in the environment (air, water, sediment and their interfaces), the response of the organisms will also depend on its developmental stage and the interaction between it and its environment. For example, the consequences of any impact of genotoxic compounds is likely to be far more severe if the impact is on germ cells than if it is on adult somatic cells. The organism's health, age, reproductive state and nutritional state will all affect its response to pollution load (Lawrence & Hemingway, 2003).

In an extensive study, Nriagu (1979) studied the concentrations of heavy metals in water, sediments and organisms in ponds and lakes and reported various effects of these heavy metals such as decline in growth, changes in behavior, genetic changes and mortality in aquatics. These changes may also imperil aquatic life completely. Similar studies on the effects of heavy metals in rivers are available (Mortazavi, 1994; Barak and Mason, 1989; Dixit and Witcomb, 1983; Mason, 1981).

Sturgeons are among the aquatic organisms that are affected by pollutants entering the Caspian Sea. They are the most valuable commercial species of the Caspian Sea and are being protected in different ways. Although the concentrations of heavy metals in Caspian Sea sturgeons are low, similar to that of freshwater fish, they are higher than the levels reported for marine species. It was recently reported that muscle atrophy and abnormality of gonad development in sturgeons was caused by increasing pollution levels in the Caspian Sea (Khodorevskaya et al., 1997).

The I. R. Iran contributes 5% of the freshwater flowing into the Caspian Sea. About 128 large and small rivers flow into the Caspian from Iran. About 36 rivers are considered as major rivers of the basin. The total average flow of these main rivers exceeds 16839×10^6 m^3. More than 90% of pollution is brought by rivers. Hence, continuous monitoring of rivers can provide us with information on their hydrological cycles as well as on the pollutant load entering the Caspian Sea through these rivers (Sadeghi, 2005).

Study of rivers of the coastal regions of the Caspian Sea is very important in that rivers are the main source of water flowing into the Caspian Sea. Hence any decrease or increase in the volume of water entering the sea will have direct effects on the amount of nutrients transferred and on the productivity of the sea. Secondly most fish are anadromous in nature, and rivers serve as the spawning ground for them. In the recent decades, rivers have been confined and their flow has been deviated and their water is used for agricultural and industrial purposes, causing the deterioration of many spawning grounds and decreasing natural reproduction in fish (including commercially important sturgeon species). The worldwide drastic decline in sturgeon stocks, particularly in the Caspian Sea necessitates the development of aquaculture of these species (Jenkins, 2001).

Development of artificial breeding operations and rearing of native species to produce fingerlings tolerant to culture conditions and the supply of suitable diets during larval and fingerling stages and ultimately releasing fingerlings into the sea at higher weight are among the objectives of conservation programs. Nowadays experts are of the opinion that the current stocks are dependant on artificial breeding and rearing programs of these species under suitable and controlled conditions. Hence a suitable culture environment is the main factor to enhance resistance and survival of larvae and fingerlings in artificial breeding programs.

The Shahid Beheshti Sturgeon Hatchery water is obtained from the Sepidrud River, which is exposed to heavy metal pollution from agricultural wastes and drainage. The aim of this study was to determine the concentrations of heavy metals such as Zn, Cu, Cd and Pb in water used in different stages of sturgeon breeding and rearing.

MATERIALS AND MATHODS

Water samples were collected from different sections of the Shahid Beheshti Hatchery including the master pond (2 samples collected one at the inlet and the other at the outlet), incubators, vniro tanks, earthen rearing ponds and the point of release of sturgeon fingerlings into the Sepidrud River.

Water parameters such as pH and water and air temperature were measured and recorded at the time of sampling. About 50 liters of water was collected in plastic containers from each sampling point and transferred to the laboratory.

To prepare water samples for the determination of heavy metals, about 3 liters of each sample was taken and heated gently for about 15 h until about 10 ml of sample remained. Heavy metal concentrations in the water samples were determined following standard analytical procedures using a FAAS-Varian Atomic Absorption Spectrophotometer (detection limit of Pb was 0.3-25 ppm, 0.1-15 ppm for Cu, and 0.3-3 ppm for Cd). Standards for each element were used to establish the stability and for calibration of the apparatus. Using the calibration curve the concentration of heavy metal in each sample was calculated (ASTM, 1996).

Data obtained were analyzed using computer based statistical software SPSS and Excel**.**

RESULTS

Mean concentrations of heavy metals in water in different stages of breeding and rearing in the Shahid Beheshti Hatchery are presented in Table 1.

Table 1. Mean concentrations (n=3) of heavy metals in water used at the Shahid Beheshti sturgeon hatchery

Sample	Pb (ppb)	Cd (ppb)	Zn (ppb)	Cu (ppb)
Master pond (inlet)	9.33±0.019	0.116±0.019	36.0±3.6	10.5±1.18
Master pond (outlet)	4.66±0.098	0.083±0.098	18.83±2.84	6.5±0.95
Kurenski Pond	0.016±0.003	0.016±0.003	11.16±2.48	8.33±1.46
	0.11±0.035	0.11±0.035	0.98±0.26	1.01±0.17
Incubator	0.15±0.014	0.15±0.014	10.66±1.31	3.66±0.4
	0.16±0.007	0.16±0.007	22.33±5.64	2.9±0.36
Vniro	0.007±0.1	0.007±0.1	2.0±0.32	1±0.45
	0.15±0.021	0.15±0.021	11.66±2.89	2.83±0.17
Earthen Ponds	0.15±0.028	0.15±0.028	19.15±3.92	0.65±0.26
Point of Release	0.20±0.035	0.2±0.035	5.15±1.8	1.66±0.036

Highest concentrations recorded belonged to Zn while the lowest concentrations were recorded for Cd. Highest concentrations for Zn (36 ppb) belonged to water sample collected from the inlet of the master pond, while Zn concentrations (18.83 ppb) at the outlet of the master pond were much lower. Lowest Zn concentrations (0.98 ppb) were recorded water samples collected from the Kurenski ponds.

Highest concentrations for Cu (10.5 ppb) belonged to the water sample collected from the inlet of the master pond, and the lowest Cu concentrations (0.65 ppb) belonged to the water sample from the earthen rearing pond. Negative correlation (-87) was detected among the samples studied. No significant differences were observed for Cu concentrations among the various samples (t=0.061, sig. lev=0.95) and their replicates (t=2.2, sig. lev=0.040).

Highest Pb concentrations (9.33 ppb) belonged to the water sample collected from the inlet of the master pond, while water samples from the vniro tanks showed the lowest Pb levels (0.15 ppb). Negative correlation (-24) was detected among the different samples studied. No significant differences were observed among the samples (t=5.14, sig. lev=20.101) and replicates (t=1.9, sig. lev=0.08).

Similar trends were observed for Cd concentrations in the different samples studied. Highest Cd concentrations (0.116 ppb) were found at the inlet of the master pond, and lowest concentrations of Cd (0.016 ppb) were recorded in the Kurenski pond. Positive correlation (0.63) was found for Cd concentrations among the samples. Significant differences were detected for Cd among the various samples (t=683, sig. lev=0.0001) and among the replicates studied (t=7.66, sig lev=0.001).

DISCUSSION

Considering that the Shahid Beheshti Sturgeon Hatchery water is obtained from the Sepidrud River, the contamination of this water with various chemicals including pesticides and heavy metals is inevitable.

In the present study the distribution pattern for heavy metal concentrations in different stages of breeding and rearing was as follows: Zn>Cu>Pb>Cd. Zn showed the highest concentration (36 ppb), and Cd showed the lowest concentration (0.016 ppb) determined. Pb, Ni, Cr and Cd concentrations in water monitored in seven sampling points located between the Sepidrud estuary and behind the Manjil Dam during the spring, summer and autumn of 1993 demonstrate significant variations in the concentrations of these elements in the Sepidrud River in the different seasons studied. These variations are mainly due to the volume of wastes entering this river and the sources which produce these wastes. Nickel showed the highest concentrations (51-200 ppm) in all the stations studied. Highest concentrations were recorded in autumn which is associated with the activity of factories in that region. The lowest and highest concentrations for Cd and Pb in this study were 0.9±0.05 ppb, 7.4±0.557 ppb, 12.7±0.35 ppb and 260±94 ppb, respectively (Mortazavi, 1994).

In the present study, the lowest and highest concentrations for Cd were 0.016±0.003 ppb and 0.116±0.019 ppb, respectively, while those for Pb were 0.15±0.01 and10.33±0.13 ppb, respectively which were lower than the estimated concentrations in previous studies (Mortazavi, 1994). This could be due to the lower concentrations of these heavy metals from the source. The estimated highest maximum allowable concentration (MAC) for Pb, Zn, Cu and Cd for *A. persicus* fingerlings are 12.84, 0.97, 0.0025 and 0.41 mg/l, respectively and those for *A. stellatus* are 12.061, 0.865, 0.0018 and 0.51 mg/l, respectively. The LC50 96h for Pb, Zn, Cu and Cd for *A. persicus* fingerlings were 128.4, 9.7, 0.025 and 4.1 mg/l, respectively while that for *A. stellatus* fingerlings were 120.61, 8.65, 0.018 and 5.1 mg/l, respectively (Mirzaie, 2004). Except for copper, the estimated concentrations for heavy metals in the present study were lower than the MAC for aquatic organisms (Table 2) and water quality (WHO, 1993). The effects of heavy metals on aquatic ecosystems is a matter of serious concern and Nriagu (1979) conducted a comprehensive study on the sediments and organisms of ponds and lakes. Similar studies have been carried out on heavy metals in rivers. The main factors influencing the concentrations of heavy metals in living organisms in freshwater systems have been documented by Mason (1981), Hellawell (1986), Connel & Mill (1984) and Kelly (1988).

Table 2. Comparison of maximum levels of heavy metals in the present study with standard MAC values

Reference	Zn	Pb	Fe	Cu	Cr	Cd
Present study	36	10.33	-	10.5	-	0.116
MAC for aquatic life (Gardiner and Mance, 1984)	40	25	-	5	15	5
Water quality standards (WHO, 1993)	3000	10	-	-	50	5
Protection of life in seawater (Anon, 1998)	2.5 (sea) 5 (estuary)	15	5	1000	25	40

The bioaccumulation of heavy metals in organisms maybe the result of direct absorption from the external environment through the cell membrane or food and/or a combination of both. It is not clearly known which of the two routes is more important because the toxicity of heavy metals may spread and affect the internal organs. In terrestrial environments food is the main route of absorption (Ireland, 1983), whereas in aquatic systems heavy metals are mainly absorbed from the body surface (Oze et al. 2006) because heavy metals are always suspended in the water and a large volume of this water enters the body of organisms during respiration and exchange of gases and thus provide the route for the entry of heavy metals. Most invertebrates and vertebrates (fishes and aquatic mammals) are not able to absorb heavy metals directly from water.

In another study, Russian sturgeon fingerlings were exposed to different concentrations of heavy metals, pesticides and petrochemical compounds for two months. Being in their early stages of exogenous feeding, muscle tissue in Russian sturgeon fingerlings showed severe degradation after exposure to these pollutants (Adeli, 1999).

Comparison of heavy metal concentrations determined in this study with those reported by Mirzaie, 2004) revealed that they were below the lethal concentrations for sturgeon fingerlings. However further studies are needed to demonstrate if these levels can cause pathological and histological effects on these fingerling**s.** Therefore careful monitoring of pollutants and their effects in the environment is suggested for successful rearing of sturgeons.

ACKNOWLEDGEMENTS

This study was funded by the Iranian Fisheries Research Organization. The authors would like to thank all those who have helped us with the study at the International Sturgeon Research Institute. Our special thanks are also due to Mr. Jamalzad for his assistance. We are also very grateful to the Manager and staff of the Shahid Beheshti Sturgeon Hatchery for allowing us to collect the samples required for this study.

REFERENCES

Adeli, Y. (1999): Effects of various toxic substances on histogenesis of muscle tissue in *Acipenser gueldenstaedtii* fingerlings. Gilan Fisheries Research Center. Translated from Russian text by Yevgeneva, S.P. and Kucherboshkina(1994). Moscow.

Annual Book of ASTM Standards (1996). Water and Environmental Technology. Volume 11.01, Water (1). Publication code number (PCN). 01-110196-16, pp.824.

Anon. (1998). Caspian Sea Environment National report of I. R. Iran. Department of the Environment.

Barak, N.A.E. & Mason, C.F. (1989) Heavy metals in water, sediment and invertebrates from rivers in eastern England. Chemosphere **19**, 1709-1714.

Connell, D.W. & Miller, G.J. (1984). The Chemistry and Ecotoxicology of Pollution. John Wiley Sons, New York.

Dixit, S.S. & Witcomb, D. (1983) Heavy metal burden in water, substrate and macroinvertebrate body tissue of a polluted river Irwell (England). *Environ. Pollut*. 6, 161-172.

Gardiner, J. and Mance, G. (1984) Water quality standards arising from European community directives. Water Research Center, No.204.

Hellawell, J.M. (1986) Biological Indicators of Fresh-water Pollution and Environmental Management. Elsevier Applied Science Publishers, London.

Ireland, M.P. (1983) Heavy metal uptake and tissue distribution in earthworms. In: *Earthworm Ecology* (d. J.E. Satchell), pp. 247-265. Chapman & Hall, London.

Jenkins, R.G. (2001). Sustainable sturgeon fisheries In the Caspian Sea. Will a trade ban contribute To achieving this objective? IWMC – World Conservation Trust.

Kelly, M. (1988). Mining and the Freshwater Environment. Elsevier Applied Science Publishers, London.

Khodorevskaya, R.P., Dovgopol, G.F., Zhuravleva, O.L., Vlasenko, A.D. (1997). Present status of commercial stocks of sturgeons in the Caspian Sea basin. Environ. Biol. Fishes 48, 209-219.

Lawrence, A.J., and Hemingway, K.C. (2003). Effects of Pollution on Fish. Blackwell Publishing. 342 pp.

Mason, C.F. (1981) Biology of Freshwater Pollution. Longman, London.

Mirzaie, H. (2004): Acute toxicity of heavy metals Pb, Zn, Cu, Cd, in two sturgeon species (*A. persicus* and *A. stellatus*) of the Caspian Sea. M.Sc. thesis. Islamic Azad University, Lahijan.

Mortazavi, M.S. (1994): Study of heavy metals in the Sepidrud River. M.Sc. thesis. Islamic Azad University, North Tehran Branch.

Niagru, J.O. (1979). Copper in the Environment, Parts 1 and 2. Wiley Interscience, Chichester.

Oze, G., Oze, R., Anunuso, C., Ogukwe, C., Nwanjo, H. and Okorie, K. (2006). Heavy Metal Pollution Of Fish Of Qua-Iboe River Estuary: Possible Implications For Neurotoxicity. *The Internet Journal of Toxicology.* 3(1).

Rainbow, P.S. (1989) Copper, cadmium and zinc concentrations in oceanic amphipod and eupausiid crustaccans, as a source of heavy metals to pelagic seabirds. *Mar. Biol*. 103, 513-518.

Sadeghi Rad, M. (2005): Caspian Sea, Sturgeons, Pollution. International Sturgeon Research Institute Publication (in Persian).

Sadeghi Rad, M., Amini Ranjbar, A., Arshad, U., Jooshedeh, H. (2002): Heavy metal determination in muscle tissue and caviar in *A. persicus* and *A. stellatus*. Final Report of research project. Iranian Fisheries Publication.

World Health Organization (WHO) (1993). Revision of WHO Guidelines for Water Quality. WHO. Geneva.