A Study on the Bioaccumulation of Lead and Zinc in Tissues of some Fresh Water Fish Species in Greater Zab River-Iraq

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Abstract

Current study was conducted to determine heavy metal lead (Pb) and zinc (Zn) concentrations in three fish species (***Acanthobrama marmid, Capoeta damascina*** and ***Chondrostoma regium***) and water samples from Greater Zab River, Kurdistan Region-Iraq, during spring 2009. Six organs from each fish species were included which were testis, ovaries, kidneys, liver, gills and muscles. Generally, there were no significant accumulations of Pb in different fish organs ($P<0.05$) and there were no significant differences between the organs of the three fish species and water samples. In ***A. marmid***, kidneys have showed significant Zn accumulation in comparison with water samples, and in ***C. damascina*** and ***C. regium***, testis was the only organ showed significant Zn accumulation. Multiple comparison showed no significant differences between the three studied fish species. The orders of Pb accumulations were: muscles > testis > ovary > kidney > liver > gills; testis > ovary > liver > kidney > muscles > gills; and ovary > kidney > liver > gills > testis > muscles for the three fish species ***A. marmid***, ***C. damascina*** and ***C. regium*** respectively. While, the orders of Zn accumulations were: kidney > testis > ovary ≥ gills > liver > muscles; testis > liver > gills > ovary > kidney > muscles; and testis > kidney > liver > gills > ovary > muscles for the three fish species respectively. Generally, lead showed greater bioconcentration factor (BCF) than zinc in different fish species. For both Pb and Zn, ***C. damascina*** showed the highest BCF which were 6.546 and 5.996 respectively.

Keywords: Bioaccumulation, Lead, Zinc, Bioconcentration factor (BCF), Fish Tissues.

Introduction

The pollution of the ecosystem by heavy metals is a real threat to the environment because metals cannot be naturally degraded like organic pollutants and persist in the ecosystem having accumulated in different parts of the food chain and are considered as major environmental pollutants causing cytotoxic, mutagenic and carcinogenic effects in animals (Rauf *et al.,* 2008 and Ashraf and Ali, 2007). The natural aquatic waters may extensively be contaminated with heavy metals released from domestic, industrial and other man-maid activities (Khopkar, 2004). Essential heavy metals are absolutely required by an organism to grow and complete its life cycle, become toxic when its concentration levels exceed those required for correct nutritional response by factors varying between 40 and 200 folds (Venugopal *et al.,* 1975). Meanwhile, some other metals Such as Pb, Hg and Cd are toxic at quite low concentrations (Ogino and Yang, 1980). Aquatic organisms have the ability to accumulate heavy metals from various sources including sediments, soil erosion and runoff, air depositions of dust and aerosol, and discharges of waste water (Labonne *et al.,* 2001). The metal accumulation in tissues of aquatic animals depends upon exposure concentration and the rate of uptake and storage as well as some other factors such as salinity, temperature and metabolic activity of tissues. The main target organs of heavy metal accumulation are liver, kidneys and muscles (Kalay *et al*., 1999). Among animal species, fishes are the inhabitants that cannot escape from the detrimental effects of these pollutants. Fish are often at the top of aquatic food chain and may concentrate large amounts of some metals from the water (Mansour and Sidky, 2002). Fish are considered as a good source of protein, poly unsaturated fatty acids (particularly Omega-3), calcium, zinc and iron (Viessman and Hammer, 2005). However fish are widely used to evaluate the health of aquatic ecosystems because pollutants build up in the food chain and are responsible for adverse effects and death in the aquatic systems (Ahmed and Hussein, 2004). The gills are directly in contact with water. Therefore, the concentration of metals in gills reflects their concentration in water where the fish lives, whereas the concentrations in liver represent storage of metals in the water (Romeo *et al*., 1999). The present study was found an importance to investigate heavy metals including lead and zinc accumulation in various organs of ***Acanthobrama marmid***, ***Capoeta damascina*** and ***Chondrostoma regium*** fishes in the Greater Zab River, Erbil-Iraq.

Materials and methods

1. Description of the study area

Greater Zab River locates about 35 kilometers southwest of Erbil city. It originates from Turkey and passes Iraq frontier at Pish Khabour village which receives many branches. Greater Zab River considered as one of the main tributaries of Tigris River (Shekha, 2008). During its flow it provides water supply for drinking, irrigation and fishery. For meeting the requirements of this study, water and fish samples were collected from this river at coordinates of location 35°99′05″ (North) and 43°34′41″ (East) (Figure 1).

2. Sampling

Samples of water and of three fresh water fish species namely (***Acanthobrama marmid***, ***Capoeta damascina*** and ***Chondrostoma regium***) which belonging to the family: Cyprinidae, were collected from Greater Zab River, during spring 2009. Water samples were collected using pre-washed polyethylene bottles. 5-liter clean polyethylene containers were rinsed with the water samples and filled, stoppered and labeled. Fish specimens were collected by local fishermen by using gill netting (2 x 100m mesh sizes 1.5x1.5, 3x3, 4x4 and 6x6cm) and cast netting (2 x 50m mesh sizes 2 x 2cm). All samples of water and fish were stored in pre-washed polyethylene containers in ice and brought as soon as possible to the laboratory on the same day of capture.

3. Water analysis

Each water sample was put in screw-capped bottles and boiled till complete dryness. Then concentrated nitric acid was added to the samples and boiled close to dryness, then diluted with distilled deionized water. The solution was filtered through Whatmann no. 1 and stored in refrigerator till analysis (APHA, 1999).

4. Fish analysis

From each species, fifteen fishes were taken and dissected. From each fish sample the organs: testes, ovaries, kidney, liver, gills and muscles were taken, using clean and sterilized dissecting equipments and put separately in prewashed and labeled petri dishes and transferred into oven to dry at 105°C. After 24 hours, the dried tissues were placed in Muffle Furnace at 480 °C for 4-5 hours, then the dry-ashed samples were cooled at room temperature then digested in 2N HCl and the volume completed with distilled de-ionized water and the solutions were filtered (Dalaly and Al-Hakim, 1987). The resulting solutions of digested water and fish organ suspensions were analyzed by Flame Atomic Absorption Spectrophotometer (PYE UNICAm SP9-Philips) for detection of lead and zinc concentrations according to (APHA, 1999). Results expressed in ($\mu g.gm^{-1}$ dry weight).

5. Determining of bioconcentration factor

The degree of bioconcentration is expressed as bioconcentration factor (BCF), which is represented as the concentration of a chemical in an organism divided by the concentration of the same chemical in the environment (Pandey *et al*., 2005).

$$BCF = \frac{\text{Concentration of a chemical in tissue of organisms}}{\text{Concentration of the same chemical in water}}$$

6. Statistical analysis and quality control

Statistical analysis for the obtained data was performed by SPSS version 11.5 and Microsoft excel 2010, using descriptive statistics and one way analysis of variance ANOVA accompanied with Duncan's test to find out statistical differences among various organs and water samples at the level of significant of 0.05 according to the recommendations of (Townend, 2002). In order to ensure quality control in the course of the analyses, all plastics and glassware used in manipulation of samples were completely acid-washed and reagents of analytical grade were utilized for the blanks and calibration curves (Bartram and Balance, 1996). Analyses were done in triplicate to ensure precision of the analytical procedure and the instruments used.

Results

The obtained results by the present investigation expressed in mean ± S.E. with regard to the measured concentrations of lead and zinc in various organs of ***Acanthobrama marmid***, ***Capoeta damascina*** and ***Chondrostoma regium*** as well as for water samples of Greater Zab River are presented in Table 1 and Figures 2-7. For ***A. marmid***, the maximum lead concentration was 0.732±0.003 μg.gm^{-1} dry wt. in the muscles, while the lowest Pb concentration was 0.680±0.052 μg.gm^{-1} dry wt. in the gills (Figure 2). While, for ***C. damascina*** the range of Pb concentrations was between 0.729±0.054 and 0.688±0.069 μg.gm^{-1} dry wt. in both testis and gills respectively (Figure 3). Moreover, ***C. regium*** showed a range of 0.707±0.057 and 0.687±0.004 μg.gm^{-1} dry wt. in ovaries and muscles respectively (Figure 4). Highest zinc value was 0.360±0.038 μg.gm^{-1} dry wt. in kidneys of ***A. marmid*** and the lowest value was 0.100±0.006 μg. gm^{-1} dry wt. in muscles (Figure 5). On the other hand, testis of ***C. damascina*** showed highest Zn value of 0.430±0.035 μg. gm^{-1} dry wt. and lowest value of 0.155±0.030 μg. gm^{-1} dry wt. in muscles (Figure 6). Furthermore, the maximum value of zinc was 0.305±0.005 μg. gm^{-1} dry wt. in testis of ***C. regium***, while the minimum level was evaluated by 1.263 μg. gm^{-1} dry wt. in muscles (Figure 7). Generally, statistical analysis results showed that there were no significant accumulations of lead in different fish organs (P<0.05) and there were no significant differences between the organs of the three fish species and water samples. While, zinc concentrations showed different results in the three studied fish species. For ***A. marmid***, kidneys have showed significant Zn accumulation in comparison with water samples, while the other organs have not show bioaccumulation of Zn. For ***C. damascina***, testis showed significant Zn accumulation and the remaining organs have no accumulation. In ***C. regium***, testis was the only organ showed significant Zn accumulation (Table 1). Moreover, multiple comparison between the three studied fish species for lead and zinc showed no significant differences between the studied fish species (Table 2). The orders of Pb accumulations were: muscles > testis > ovary > kidney > liver > gills; testis > ovary > liver > kidney > muscles > gills; and ovary > kidney > liver > gills > testis > muscles for the three fish species ***A. marmid***, ***C. damascina*** and ***C. regium*** respectively. While, the orders of Zn accumulations were: kidney > testis > ovary ≥ gills > liver > muscles; testis > liver > gills > ovary > kidney > muscles; and testis > kidney > liver > gills > ovary > muscles for the three fish species ***A. marmid***, ***C. damascina*** and ***C. regium*** respectively. Generally, lead showed greater bioconcentration factor (BCF) than zinc in different fish species. For both Pb and Zn, ***C. damascina*** showed the highest BCF which were 6.546 and 5.996 respectively (Table 3).

Discussion

Freshwater contamination with heavy metals nowadays has been taken in consideration (Khopkar, 2004). Despite the fact that some heavy metals are essential elements, but they have toxic adverse effects on human and ecosystem health even in small doses due to their non-degradability and accumulation in the food chains (Ayres and Ayres, 2002). Accumulation of heavy metals in aquatic organisms particularly fish may have a long lasting effect on biogeochemical cycles in the ecosphere (Kalay *et al*., 1999). Therefore, tissue concentrations of heavy metals can be a reasonable measurement for public health standards and for animals' health point of view. Since fish are often the last link in aquatic food chains, the metal concentrations of many fish species have been analyzed in relation to metal contents of aquatic environments, and this were the reports of many authors in different countries (Kargin, 1998; Ayas *et al*., 2007; Vinodhini and Narayanan, 2008). In Iraq, many studies have been done on the distribution of some of heavy metals in the water of some aquatic systems and their fishes (Khalaf *et al*., 1986; Abaychi and Al-Saad, 1988; Abdullah and Abdul-Hassan, 1994; Abdullah and Barak, 1995; Khdhir *et al*., 2011; Al-Alem *et al*., 2013). In Kurdistan, some studies were carried out such as Rasheed (2008) and Rasheed (2012). However, the concentration of heavy metals are varying considerably among different studies possibly because metal accumulation by aquatic organisms is influenced by a number of intrinsic factors such as size, age, sex, feeding behavior and growth rate and extrinsic factors such as metal concentrations in surrounding waters, salinity, hardness and temperature (Viessman and Hammer, 2005 and Timbrell, 2000). In the present study, although the concentrations of lead were high in various organs of the fish species comparing with their concentrations in water of Greater Zab River, but the statistical analysis showed no significant differences between the organs; in other word, there was no accumulation of Pb in various fish organs, the observations of Khdhir *et al*. (2011) seem to confirm this finding who observed that there were no differences in the levels of lead, cadmium, copper and zinc in two fish species (***Barbus luteus*** and ***Cyprinion macrostomum***) collected from Greater Zab River-Erbil. The orders of Pb accumulations were: muscles > testis > ovary > kidney > liver > gills; testis > ovary > liver > kidney > muscles > gills; and ovary > kidney > liver > gills > testis > muscles for the three fish species ***A. marmid***, ***C. damascina*** and ***C. regium*** respectively. It is revealed that testis and ovaries showed highest concentrations of lead in comparing with the other organs. In this regard Williams *et al*. (2000) and Gad (2007) the previous experimental findings suggest that lead, mercury, and cadmium are capable of damaging oocytes and producing atrophy of the oviduct or uterus which can clearly prevent the transport of the germ cells and embryo. Cadmium affect directly on the vasculature surrounding the testis and epididymis, the adjacent tubular organ in which sperm are stored and mature, and destroy the spermatogenic cells. Also, lead and cadmium cause general metabolic inhibition of the cells in the reproductive tract, leading to cell death and declining organ weight. Moreover, the concentrations Pb were recorded minimum in gills of ***A. marmid*** and ***C. damascina***. In this regard, the conclusions of Vinodhini and Narayanan (2008) related to the lowest level of Pb in gills seem to be coincided with the present results. In fact, the gills are directly in contact with water, therefore, the concentration of metals in gills reflect their concentration in water whereas the fish liver and kidney represent storage of metals in water (Pandey *et al*., 2005). On the other hand, results regarding to Zn accumulation showed that ***A. marmid*** kidneys have significant Zn accumulation in comparison with water samples and the order of Zn accumulations was: kidney > testis > ovary ≥ gills > liver > muscles. The observation of Vinodhini and Narayanan (2008) who found that in kidney tissues considerable amounts of heavy metals were accumulated, possibly because kidney is the gateway for heavy metal detoxification in the body. In the three fish species, muscles showed the lowest Zn accumulation because muscle is one of the ultimate parts for heavy metal accumulation and similar finding was given by Allen-Gil (1997) and Vinodhini and Narayanan (2008). The heavy metals were uniformly spread over the body muscles. Hence, the observed values were relatively lower than the other potential organs. The presence of higher amounts of heavy metals in any parts of the body will definitely induce changes in biochemical metabolisms and other induced stresses (Vinodhini and Narayanan, 2008). As shown in Table (2), the multiple comparisons showed no significant differences between fish species regarding to the accumulation of lead and zinc. This finding seem to be similar with those of Al-Alem *et al*. (2013) who found that there are no differences in the concentration of cadmium and copper in three fish species (***A. marmid***, ***C. damascina*** and ***C. regium***) collected from the Greater Zab River, Erbil-Iraq; moreover, the finding of Al-Weher (2008) who noted that there are no differences in the concentration of cadmium, copper and zinc in three fish species (***Cyprinus carpio***, ***Oreochromis aureus*** and ***Clarias lazera***) collected from the Northern Jordan Valley, Jordan, seem to be the same as obtained by this study. However, Javed (2005) found that ***Catla catla*** showed significantly higher tendency to accumulate iron, zinc, lead, nickel and manganese and this may refer to the type of food of fish species because heavy metals when discharged into the river enter the food chain and accumulate in fish body. Bioconcentration factor (BCF) refers to accumulation of xenobiotics in certain tissues of the organisms at concentrations above those of the immediate environment. The degree of bioconcentration is expressed as bioconcentration factor (BCF). It is mostly used to predict the degree of accumulation by fishes for pollutants in water.

Conclusion

By the present investigation we obtained that there were no significant accumulation of lead by the three studied fish species, whereas Zn was significantly accumulated in kidneys of ***A. marmid*** and testis of both ***C. damascina*** and ***C. regium***. Although there was no significant Pb accumulation in the studied fishes, but sex organs including testis and ovaries contained higher concentrations of lead and zinc in comparison with Greater Zab River water, while fish gills and muscles generally contained lowest concentrations of lead and zinc. Generally, lead showed greater bioconcentration factor (BCF) than zinc in different fish species. For both Pb and Zn, ***C. damascina*** showed the highest BCF.

References

Abaychi, H. K. and Al-Saad, H. T. (1988). Trace elements in fish from the Arabian Gulf and the Shatt Al-Arab River, Iraq. Bull. Environ. Contam. Toxical. 40: 226-232.

Abdullah, A. A. and Abdul-Hassan, J. K. (1994). Distribution of zinc and copper in the tissues of some marine fishes around the coast of Fao, south Iraq. J. Basrah Res. 10(1): 17-28.

Abdullah, A. M. and Barak, N. A. (1995). Concentrations of zinc and copper in some freshwater fish and crustaces from Basrah, Iraq. Basrah J. Agric. Sci. 8(2): 65-73.

Ahmed, A.M. and Hussein, M.M. (2004). Residual levels of some heavy metals in fish flesh and water from El-Manzala Lake, Egypt. J. King Saud Univ. 16(2): 187-196.

Al-Alem, L. S.; Khdhir, N. S. and Abdullah, S. M. A. (2013). Detection of copper and cadmium concentrations in some local fishes from Greater Zab River, Iraq. J. Koya Univ. 26: 75-84.

Allen-Gil, S. M.; Gubala, C. P.; Landers, D. H.; Lasorsa, B. K.; Crecelius, E. A. and Curtis, L. R. (1997). Heavy metal accumulation in sediment and freshwater fish in U.S. arctic lakes. Environ. Toxicol. Chem. 16(4): 733-741.

Al-Weher, S. M. (2008). Levels of heavy metal Cd, Cu and Zn in three fish species collected from the Northern Jordan Valley, Jordan. Jordan J. Biol. Sci. 1(1): 41-46.

APHA. Standard Methods for the Examination of Water and Wastewater (1999). Twentieth edition. American Public Health Association, American Water work Association (AWWA) and Water Pollution Control Federation (WPCF). Washington.

Ashraf, R. and Ali, T. A. (2007). Effect of heavy metals on soil microbial community and mung beans seed germination. PAK. J. Bot., 39(2): 629-636.

Ayas, Z.; Ekmekci. G.; Yerli, S. and Ozmen, M. (2007). Heavy metal accumulation in water, sediments and fishes of Nallihan Bird Paradise, Turkey. J. Environ Biol. (Online). 28(3):545-549.

Ayres, R.U. and Ayres, L.W. (2002). A Handbook of Industrial Ecology. Edward Elgar Publishing Ltd, UK.

Bartram, J. and Balance, R. (1996). Water Quality Monitoring (a Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes). United Nations Environmental Programme-UNEP- and WHO. E & FN Spon, an imprint of Chapman & Hall. London, U.K.

Dalaly, B.K. and Al-Hakim, S.H. (1987). Food Analysis. The book house for press and publication. Univ. Mosul. Iraq.

Gad, S.C. (2007). Animal Models in Toxicology. Second edition. Taylor & Francis Group, CRC Press. New York.

Javed, M. (2005). Heavy metal contamination of fresh water fish and bed sediments in the River Ravi Stretch and related tributaries. Pakistan J. of Biolo. Sci. 8(10): 1337-1341.

Kalay, M.; Ay, Ö. and Canli, M. (1999). Heavy metal concentrations in fish tissues from the northeast Mediterranean Sea. Bull. Environ. Contam. Toxicol. (Online). 63(5): 673-681.

Kargin, F. (1998). Metal concentrations in tissues of the freshwater fish *Capoeta barroisi* from the Seyhan River (Turkey). Bull. Environ. Contam. Toxicol. (Online). 60(5): 822-828.

Khalaf, A. N.; Al- Huggins, R. J.; Al- Yas, S. S. and Warda, M. A. (1986). Bio-accumulation of some heavy metals in some tissues of Barbus belayewi from Deyala River. J. Biol. Res. 17(1): 27-46.

Khdhir, N. S.; Al-Alem, L. S. and Abdullah, S. M. A. (2011). Bioaccumulation of some heavy metals in the tissues of two fish species (*Barbus luteus* and *Cyprinion macrostomum*) in Greater Zab River- Iraq. J. Dohuk Univ. 14(1): 71-77.

Khopkar, S. M. (2004). Environmental Pollution "monitoring and control". New International (P) Ltd. New Delhi, India.

Labonne, M.; Othman, D. B. and Luck, J. M. (2001). Lead isotopes in muscels as tracers of metal sources and water movements in a Lagoon (Thau Basin, S. France). Chem. Geology. 181: 181-191.

Mansour, S. A. and Sidky, M. M. (2002). Ecotoxicological studies. 3: Heavy metals contaminating water and fish from Fayoum Governorate, Egypt. Food Chem. 78: 15-22.

Ogino, O. and Yang, G. Y. (1980). Requirements of carp and rainbou trout for dietary manganese and copper. Bull. Japan. Soc. Fish. 46: 455-458.

Pandey, K; J.P. Shukla and S.P. Trivedi. (2005). Fundamentals of Toxicology. New Central Book Agency (P) Ltd. India.

Rasheed, O. R. (2008). Evaluation of heavy metals and polyaromatic hydrocarbons in water, fish and sediments within Derbendikhan Reservoir, PhD thesis, Univ. of Sulaimani, Iraq.

Rasheed, O. R. (2012). Assessment of some heavy metals in muscle tissues of Silurustriostegus from Derbendikhan Reservoir, Kurdistan Region - Iraq. Raf. J. Sci., 32(1): 11-18.

Rauf, A.; Javed, M. and Ubaidullah, M. (2008). Heavy metal levels in three major carps (*Catla Catla*, *Labeo Rohita* and *Cirrhina Mrigala*) from the River Ravi, Pakistan. Pakistan J. Vet. 29(1): 1-3.

Romeo, M.; Siau, Y.; Sidoumou, Z. and Gnassia-Barelli, M. (1999). Heavy metal distribution in different fish species from the Mauritania coast. Sci. Total Environ. 232: 169-175.

Shekha, Y.A. (2008). The effect of Erbil city wastewater discharge on water quality of Greater Zab River, and the risks of irrigation. Ph.D. Thesis, Univ. of Baghdad, Iraq.

Timbrell, J. (2000). Principles of Biochemical Toxicology. Third edition. Taylor & Francis Ltd. London.

Townend, J. (2002). Practical Statistics for Environmental and Biological Science. John Wiley & Sons, Ltd. England.

Venugopal, B.; Luckey, T. D. and Hutcheson, D. H. (1975). Heavy Metal Toxicology, Safety and Hormology. Thieme, Stuttgart.

Viessman, W. and Hammer, M.J. (2005). Water Supply and Pollution Control. 7th edition. Pearson Education, Inc. USA.

Vinodhini, R. and Narayanan, M. (2008). Bioaccumulation of heavy metals in organs of fresh water fish *Cyprinus carpio* (Common carp). Int. J. Environ. Sci. Tech. 5(2): 179-182.

Williams, P.L; James, R.C and Roberts, S.M. (2000). Principles of Toxicology: Environmental and Industrial Applications. Second edition. John Wiley & Sons, Inc.

Table 1: Mean values (µg.gm^{-1} dry weight ± SE) of lead (Pb) and zinc (Zn) in various body organs of three fishes collected in Greater Zab River water during spring 2009.

Parameters		**Lead**	**Zinc**
Acanthobrama marmid	Testis	0.726±0.030^{a}	0.240±0.040^{b}
	Ovary	0.715±0.003^{a}	0.205±0.005^{b}
	Kidney	0.713±0.006^{a}	0.360±0.038^{a}
	Liver	0.696±0.004^{a}	0.150±0.040^{bc}
	Gills	0.680±0.052^{a}	0.205±0.023^{b}
	Muscles	0.732±0.003^{a}	0.100±0.006^{c}
	Water	0.653±0.046^{a}	0.230±0.026^{b}
Capoeta damascina	Testis	0.729±0.054^{a}	0.430±0.035^{a}
	Ovary	0.722±0.051^{a}	0.190±0.023^{b}
	Kidney	0.713±0.052^{a}	0.170±0.023^{b}
	Liver	0.719±0.065^{a}	0.230±0.035^{b}
	Gills	0.688±0.069^{a}	0.204±0.020^{b}
	Muscles	0.702±0.058^{a}	0.155±0.030^{b}
	Water	0.653±0.046^{a}	0.230±0.026^{b}
Chondrostoma regium	Testis	0.692±0.068^{a}	0.305±0.005^{a}
	Ovary	0.707±0.057^{a}	0.180±0.016^{de}
	Kidney	0.704±0.058^{a}	0.270±0.029^{ab}
	Liver	0.702±0.059^{a}	0.255±0.005^{ab}
	Gills	0.701±0.003^{a}	0.198±0.006^{cd}
	Muscles	0.687±0.004^{a}	0.142±0.003^{e}
	Water	0.653±0.046^{a}	0.230±0.026^{bc}

Mean values with different letters in each column indicate significant differences ($P<0.05$).

Table 2: Multiple comparison between the three studied fish species for lead (Pb) and zinc (Zn) concentrations.

Parameters	Lead	Zinc
Acanthobrama marmid	0.710±0.008[a]	0.210±0.036[a]
Capoeta damascina	0.712±0.006[a]	0.230±0.041[a]
Chondrostoma regium	0.699±0.003[a]	0.225±0.025[a]

Mean values with the same letters in each column indicate no significant differences (P<0.05).

Table 3: Bioconcentration factor (BCF) for lead (Pb) and zinc (Zn) in different fish species.

Fish species	Lead	Zinc
Acanthobrama marmid	6.528	5.478
Capoeta damascina	6.546	5.996
Chondrostoma regium	6.422	5.870

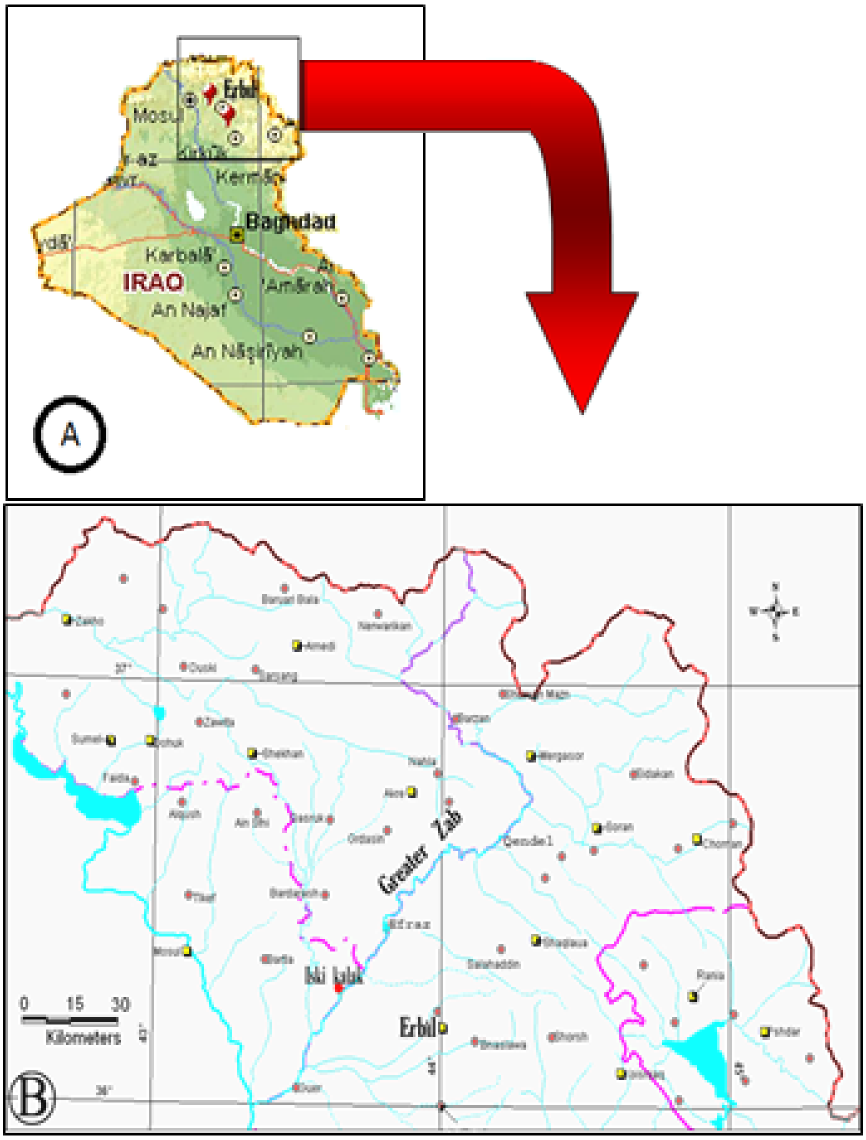


Figure 1: A- Map of Iraq showing Kurdistan region (Map Info. V.9),
B- Map of Kurdistan region showing Greater Zab river.

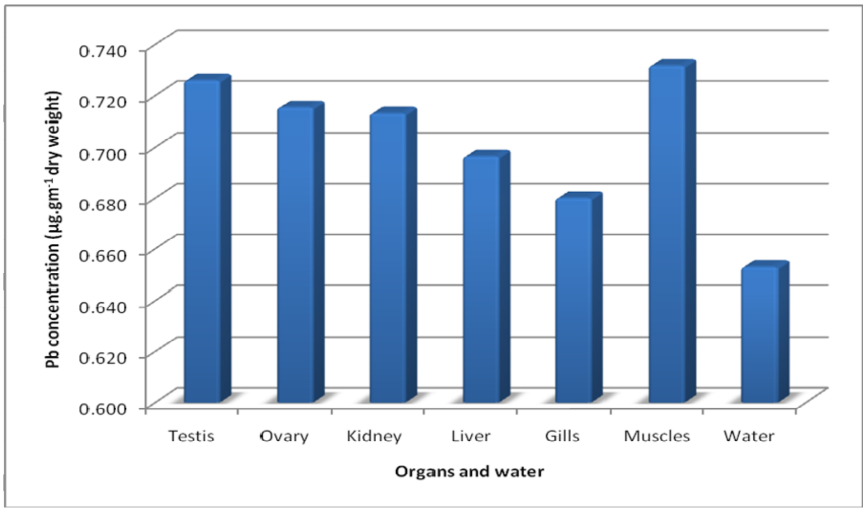
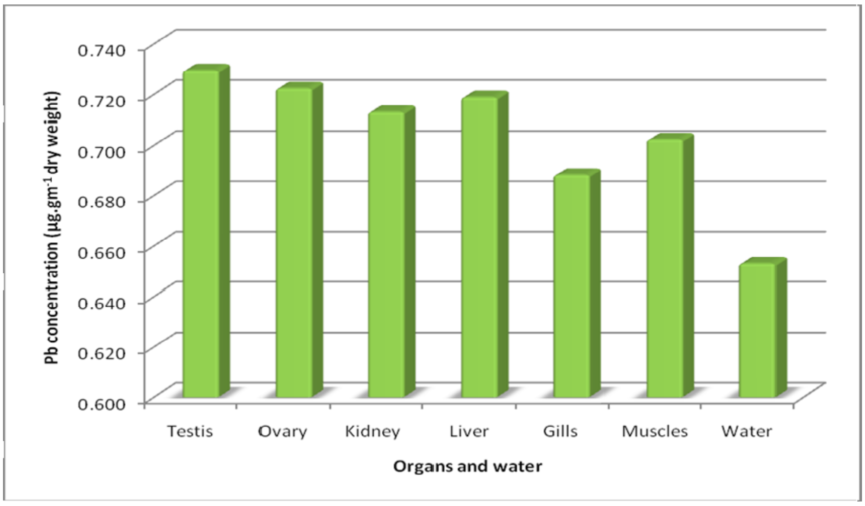


Figure 2: Lead concentrations (µg.gm^{-1} dry weight) in different fish organs of



Acanthobrama marmid and water samples.

Figure 3: Lead concentrations (µg.gm^{-1} dry weight) in different fish organs of ***Capoeta damascina*** and water samples.

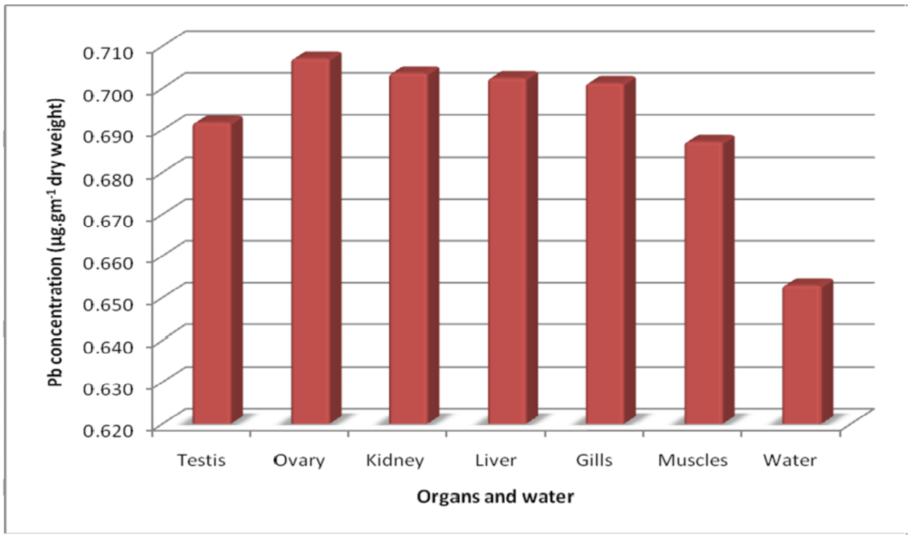


Figure 4: Lead concentrations (µg.gm^{-1} dry weight) in different fish organs of ***Chondrostoma regium*** and water samples.

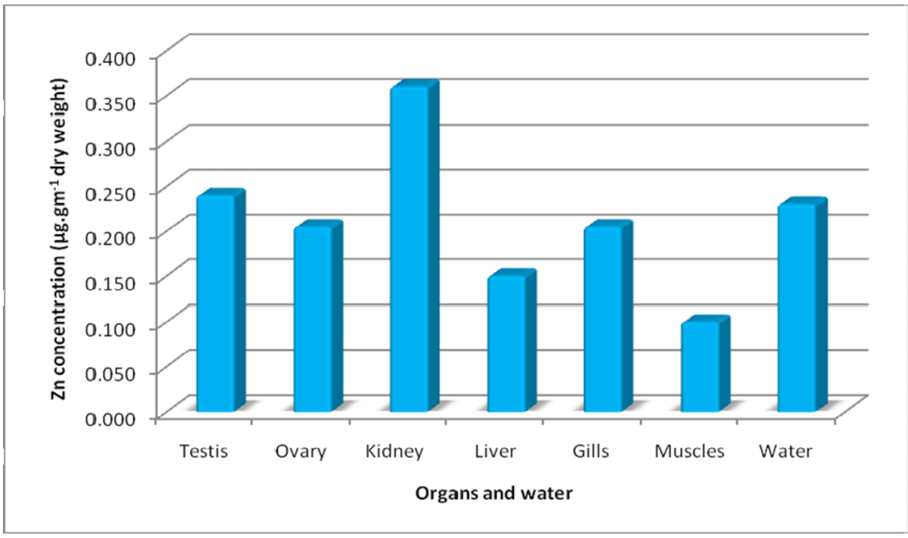
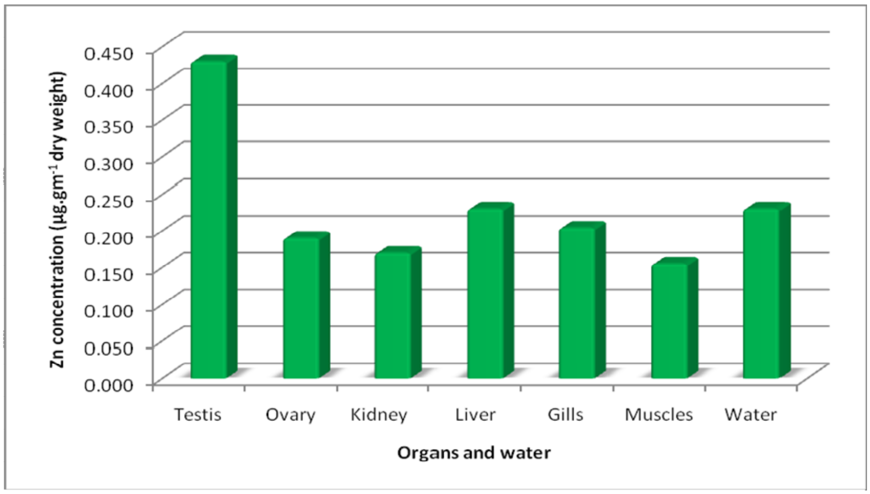


Figure 5: Zinc concentrations (µg.gm^{-1} dry weight) in different fish organs of



Acanthobrama marmid and water samples.

Figure 6: Zinc concentrations (µg.gm^{-1} dry weight) in different fish organs of ***Capoeta damascina*** and water samples.

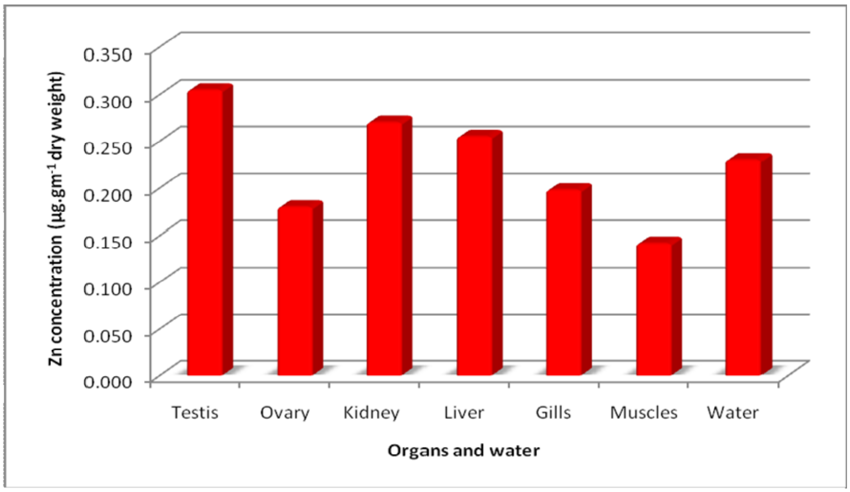


Figure 7: Zinc concentrations (µg.gm^{-1} dry weight) in different fish organs of ***Chondrostoma regium*** and water samples.

پوختە

توێژینەوەیەك لەسەر زیندەكەڵەكەبووی قورقوشم وزینك لە شانەكانی هەندێك جۆری ماسی لە ئاوی روباری زابی گەورە – عیراق

ئەم توێژینەوەیە بۆ پێوانە كردنی خەستی توخمە قورسەكانی قورقوشم وزینك لە سێ جۆر ماسی (*Acanthobrama marmid* و *Capoeta damascina* و *Chondrostoma regium*) لە ئاوی ڕوباری زابی گەورە لە هەرێمی كوردستانی عیراق لە بەهاری 2009 دا ئەنجام درا. شەش ئەندام بۆ هەر جۆرە ماسیەك وەرگیرا كە بریتی بوون لە گونەكان وهێلكەدان وگورچیلە وجگەر وگوێچكەكان وماسولكەكان. بە شێوەیەكی گشتی زیندەكەڵەكەبوونی قورقوشم لەناو شانەی ماسیەكان بەدی نەكرا وجیاوازی واتایی (P<0.05) لە خەستی قورقوشم لە نێوان شانەی ماسیەكان وئاوی زاب بەدی نەكرا. لە *A. marmid* گورچیلەكان زیندەكەڵەكەبوونێكی واتاییان بۆ زینك نیشان دا بە بەراورد لەگەڵ نموونەی ئاوی زاب، ولە ماسی *C. damascina* و*C. Regium* گونەكان تاكە ئەندام بوون كە زیندەكەڵەكەبوونی واتاییان بۆ زینك نیشان دا. هیچ جیاوازیەكی واتایی لە نێوان هەرسێ جۆرە ماسی بەدی نەكرا. ڕیزبەندی كەڵەكەبوونی قورقوشم بەم شێوەیە بوو: ماسولّەكان > گونەكان > هێلكەدان > گورچیلە > جگەر > گوێچكەكان بۆ A. marmid، گونەكان > هێلكەدان > جگەر > گورچیلە > ماسولكەكان > گوێچكەكان بۆ C. damascina، و هێلكەدان > گورچیلە > جگەر > گوێچكەكان > گونەكان > ماسولكەكان بۆ C. regium . لە كاتێكدا ڕیزبەندی كەڵەكەبوونی زینك بەم شێوەیە بوو: گورچیلە > گونەكان > هێلكەدان ≤ گوێچكەكان > جگەر > ماسولكەكان بۆ A. marmid، گونەكان > جگەر > گوێچكەكان > هێلكەدان > گورچیلە > ماسولكەكان بۆ C. damascina، و گونەكان > گورچیلە > جگەر > گوێچكەكان > هێلكەدان > ماسولّەكان بۆ C. regium . بە شێوەیەكی گشتی قورقوشم كۆڵكەی زیندەكەڵەكەبوونی لە زینك بەرزتر بوو لە سێ جۆرە جیاوازەكەی ماسی. ماسی C. damascina بەرزترین كۆڵكەی زیندەكەڵەكەبوونی نیشان دا بۆ هەردوو توخمی قورقوشم وزینك كە 6.546 و 5.996 بوو.

الخلاصة

دراسة عن التراكم الحيوي للرصاص والخارصين في أنسجة بعض أنواع الأسماك في نهر الزاب الأعلى– العراق

أجريت هذه الدراسة لتحديد تراكيز العناصر الثقيلة الرصاص والنحاس في ثلاثة أنواع من الأسماك المياه العذبة (*Acanthobrama marmid* و *Capoeta damascina* و *Chondrostoma regium*) في نهر الزاب الأعلى، أقليم كوردستان– العراق، خلال ربيع 2009. تم أخذ ستة أعضاء لكل نوع من الأسماك الثلاثة والتي هي: الخصى، المبايض، الكلى، الكبد، الخياشيم والعضلات. بشكل عام، لم يتواجد تراكم حيوي للرصاص في أنسجة الأسماك ولم يكن هناك اختلافات معنوية (P<0.05) في تراكيز الرصاص في أنسجة الأسماك ونماذج الماء. ففي *A. marmid*، وجِدَ تراكم حيوي للخارصين مقارنة بنماذج الماء، اما في *C. damascina* و*C. regium* كان الخصى هو العضو الوحيد الذي شَهَد التراكم الحيوي للخارصين. ولم يكن هناك فروقات معنوية بين أنسجة الأسماك الثلاثة. وكان الترتيب التراكمي للرصاص بالشكل الآتي: العضلات > الخصى > المبايض > الكلى > الكبد > الخياشيم، الخصى > المبايض > الكبد > الكلى > العضلات > الخياشيم، والمبايض > الكلى > الكبد > الخياشيم > الخصى > العضلات للأنواع الثلاثة من الأسماك A. marmid وC. damascina وC. regium على التوالي. بينما كان الترتيب التراكمي للخارصين بالشكل الآتي: الكلى > الخصى > المبايض ≤ الخياشيم > الكبد > العضلات، الخصى > الكبد > الخياشيم > المبايض > الكلى > العضلات، و الخصى > الكلى > الكبد > الخياشيم > المبايض > العضلات للأنواع الثلاثة من الأسماك A. marmid و C. damascina وC. regium على التوالي. بشكل عام كان عامل التراكم الحيوي للرصاص أكبر مما هو فيه للخارصين. كان أكبر عامل تراكم حيوي للعنصرين الرصاص والخارصين في السمكة C. damascina وكان 6.546 و 5.996 على التوالي.