Journal of Research in Ecology

An International Scientific Research Journal

Original Research

Toxic element bioaccumulations in exotic fishes of Upstream of Sakarya River Basin (Turkey): Nile Tilapia (*Oreochromis niloticus)* and African Catfish (*Clarias gariepinus*)

Authors:
Arzu Cicek[1], Cem Tokatli[2*], Ozgur Emiroglu[3] and Esengul Kose[4].

Institution:
1.Applied Environmental Research Centre, Anadolu University, Eskişehir, Turkey

2.Department of Laboratory Technology, Ipsala Vocational School, Trakya University, İpsala / Edirne, Turkey

4.Department of Biology, Faculty of Science, Eskişehir Osmangazi University, Eskişehir, Turkey

3. Department of Environmental Protection and Control, Eskişehir Vocational School, Eskişehir Osmangazi University, Eskişehir, Turkey

ABSTRACT:

The Sakarya River that was known as Phrygia in ancient times is the third longest river in Turkey and was exposed to intensive agricultural, domestic and industrial pollution. In the present study, some toxic element concentrations (zinc, copper, manganese, cadmium and lead) were investigated in muscle, gill and liver tissues of *Clarias gariepinus* (Burchell, 1822) and *Oreochromis niloticus* (Linnaeus, 1758) caught from the Upstream of Sakarya River Basin. Cluster similarity and distance analysis and matrix plot distribution diagrams were applied to the results to evaluate the data properly by using the past package program. According to the data observed, cadmium, copper and lead levels recorded in liver tissues and manganese levels recorded in gill tissues of two exotic fish species were significantly higher than the other tissues. Lead concentrations detected in the muscle tissues of fishes were significantly higher than the limit value specified by the Turkish Food Codex.

Keywords:
Sakarya River Basin, Heavy metals, *Clarias gariepinus*, *Oreochromis niloticus*

Corresponding author:
Cem Tokatli.

Email Id:
tokatlicem@gmail.com

Web Address:
http://eologyresearch.info/documents/EC0015.pdf.

Article Citation:
Arzu Cicek, Cem Tokatli, Ozgur Emiroglu and Esengul Kose.
Toxic element bioaccumulations in exotic fishes of Upstream of Sakarya River Basin (Turkey): Nile Tilapia (*Oreochromis niloticus)* and African Catfish (*Clarias gariepinus*)
Journal of Research in Ecology (2013) 2(1): 083-090

Dates:
Received: 24 July 2013 **Accepted:** 05 Aug 2013 **Published:** 10 Aug 2013

INTRODUCTION

Environmental pollution has become a major problem in all developed and developing countries in especially recent years. Pollutants in aquatic environments may dramatically reduce the water quality and adversely affect the aquatic organisms. Heavy metals which remain for a long time in the contaminated areas, give rise to toxic effects in aquatic organisms and accumulate in the food chain are of great importance because of their threat to human health. Concentrations of certain heavy metals in aquatic environments are in equilibrium for normal conditions. But waste discharges from industrial, urban and agricultural activities containing heavy metals may cause extreme increasing of toxic element accumulations in the aquatic habitats (Wildi *et al.,* 2004; Tokatlı *et al.,* 2012a).

Clarias gariepinus (Burchell, 1822) that is still dispersed to all over the Africa was introduced to some regions in Europe. Although the natural spread areas of *C. gariepinus* is Niger and Nile River, it is widely introduced to other parts of Africa, Europe, Asia and also Turkey. It was moved from a small area in the south of Turkey to Sakarya River for the scientific purposes. But nowadays, it began to threaten the ecology in Sakarya river basin by demonstrating a high level of adaptation to its new habitat (Elvira, 2001; Emiroğlu, 2011).*Oreochromis niloticus* (Linnaeus, 1758) known as tilapias is not naturally found in Turkish waters; it is the most widely cultivated fish in Africa. According to the literature knowledge, first of all D.S.İ. (Public Water Works in Turkey) and then Faculty of Agriculture in Çukurova University brought tilapias from Israel and England and they have been tried to adapt the tilapias to the Turkish waters in the late 1970s (Tekelioğlu, 1991; Graaf and Janssen, 1996).

Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) are very common in the upstream of Sakarya River and they are being consumed by human in significant rate in the region. The aim of the present study is determine to heavy metal (zinc, copper, manganese, cadmium and lead) bioaccumulations in muscle, gill and liver tissues of two exotic fish species (*C. gariepinus* and *O. niloticus*) caught from the upstream of Sakarya river basin.

MATERIALS AND METHODS

Study Area and Collection of Samples

The study area selected on the upstream of Sakarya river basin is given in Figure 1. Fish samples were collected in the summer season of 2011 by using a modified Honda generator (EM1000F) from the most suitable and best appropriate areas with the structure of bottom stream, flow rate and method of electro shocker.

Sufficient amounts of all fish species for the element analysis (0.25 g dry weigh for each tissue) were collected and all collected fishes were transported to iceboxes in the laboratory for chemical analysis. Some characteristics of all fishes (three fishes for each species) used for toxic element bioaccumulation analysis are given in Table 1.

Chemical Analysis

Muscle, gill and liver tissues of fishes were dried for 24 h at 105°C and 0.25 gr of each tissue sample was

Table 1. Metric characteristics of fishes

Species	SampleNo	Sex	Weight (gr)	Standard Length(mm)	Total Length (mm)	Gonad Weight (gr)
O. niloticus	1	♂	270	190	239	5
O. niloticus	2	♀	414	230	282	4
O. niloticus	3	♀	276	186	234	5
C. gariepinus	1	♂	605	380	440	2
C. gariepinus	2	♀	545	350	411	40
C. gariepinus	3	♀	396	338	480	22

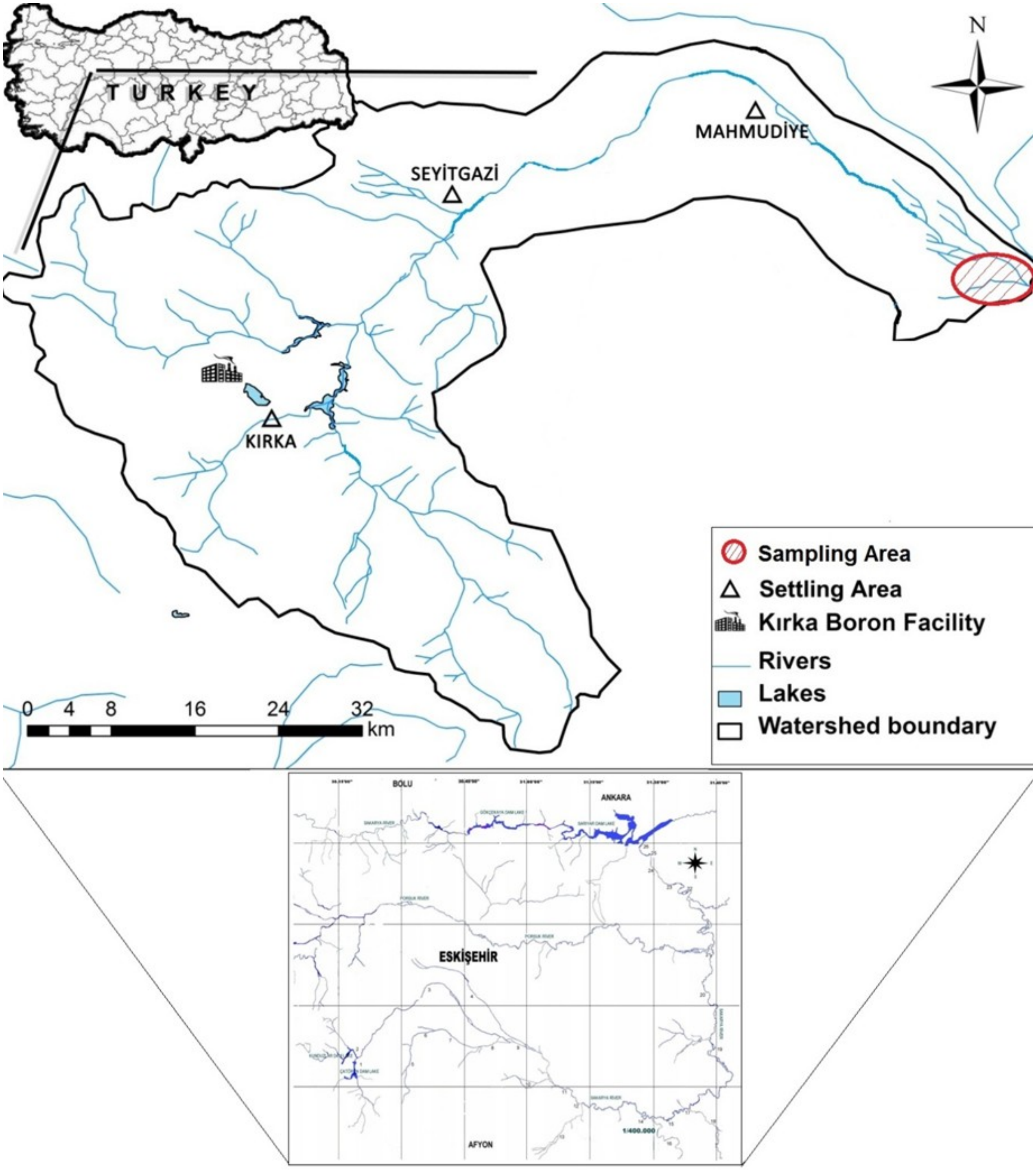

Figure 1. Study area and Sakarya river basin

placed in Pyrex reactors of a CEM Mars Xpress 5 microwave digestion unit. Perchloric and nitric acids of 1:3 proportions were inserted in the reactors respectively. Samples were mineralized for thirty minutes at 200°C. Subsequently, the tissue samples were filtered in such a way as to make their volumes to 100 ml with ultra – pure distilled water.

Zinc, cadmium, copper, lead and manganese bioaccumulations in tissues of fishes were investigated by ICP-OES (Varian 720 ES). The element analyses were recorded as means of triplicate measurements (ASTM, 1985; EPA, 1998).

Statistical Analysis

Cluster Analysis according to Bray Curtis and Matrix plot distribution diagrams were applied to the results by using the "Past" package program.

RESULTS AND DISCUSSION

Zinc, cadmium, copper, manganese and lead bioaccumulation levels in muscle, gill and liver tissues of *Oreochromis niloticus* (Linnaeus, 1758) and *Clarias gariepinus* (Burchell, 1822) are given in Table 2. Element bioaccumulation gradations in tissues and fishes according to fish species and tissues are given in Table 3. Matrix plot distribution diagrams that provide visual summaries of data and given in Figure 2 were used in the present study to compare the element distribution levels in different tissues of two fishes.

Cadmium, copper and lead bioaccumulations determined in liver tissues and manganese bioaccumulations determined in gill tissues of two exotic fish species were significantly higher than the other tissues. The highest Cd, Pb and Zn levels were recorded as 0.5 mg/kg, 9.9 mg/kg, 97.44 mg/kg respectively in liver tissues of *C. gariepinus*; the highest Cu level was recorded as 24.2 mg/kg in liver tissues of *O. niloticus*; and the highest Mn level was recorded as 44.44 mg/kg in gill tissues of *C. gariepinus*.

It is known that toxic metals in nonlethal levels accumulate in metabolically active tissues like liver and

Table 2. Element bioaccumulation levels in tissues of fishes

Elements (mg/kg)		Species					
		O.niloticus			***C.gariepinus***		
		Muscle	**Gill**	**Liver**	**Muscle**	**Gill**	**Liver**
Zn	mean	56.800	61.610	37.990	21.370	72.040	97.44
	SD	4.030	4.060	0.530	0.550	6.450	0.78
Cd	mean	0.008	0.012	0.039	0.024	0.027	0.50
	SD	0.001	0.007	0.007	0.005	0.008	0.03
Cu	mean	0.920	2.410	24.200	1.400	1.220	11.84
	SD	0.030	0.050	0.500	0.030	0.070	0.81
Mn	mean	4.480	15.270	0.870	0.940	44.440	3.90
	SD	0.930	1.270	0.008	0.110	3.110	0.47
Pb	mean	2.190	1.790	3.110	1.570	4.090	9.90
	SD	0.060	0.220	0.090	0.180	0.230	0.36

Table 3. Element bioaccumulation gradations in tissues and fishes

Elements	Fish Species	**Gradation for Tissues**(according to fishes)	Tissues	**Gradations for Fishes**(according to tissues)
Zn	*O. niloticus*	Gill > Muscle > Liver	Muscle	*O. niloticus* > *C. gariepinus*
	C. gariepinus	Liver > Gill > Muscle	Gill	*C. gariepinus* > *O. niloticus*
			Liver	*C. gariepinus* > *O. niloticus*
Cd	*O. niloticus*	Liver > Gill > Muscle	Muscle	*C. gariepinus* > *O. niloticus*
	C. gariepinus	Liver > Gill > Muscle	Gill	*C. gariepinus* > *O. niloticus*
			Liver	*C. gariepinus* > *O. niloticus*
Cu	*O. niloticus*	Liver > Gill > Muscle	Muscle	*C. gariepinus* > *O. niloticus*
	C. gariepinus	Liver > Muscle > Gill	Gill	*O. niloticus* > *C. gariepinus*
			Liver	*O. niloticus* > *C. gariepinus*
Mn	*O. niloticus*	Gill > Muscle > Liver	Muscle	*O. niloticus* > *C. gariepinus*
	C. gariepinus	Gill > Liver > Muscle	Gill	*C. gariepinus* > *O. niloticus*
			Liver	*C. gariepinus* >*O. niloticus*
Pb	*O. niloticus*	Liver > Muscle > Gill	Muscle	*O. niloticus* > *C. gariepinus*
	C. gariepinus	Liver > Gill > Muscle	Gill	*C. gariepinus* > *O. niloticus*
			Liver	*C. gariepinus* > *O. niloticus*

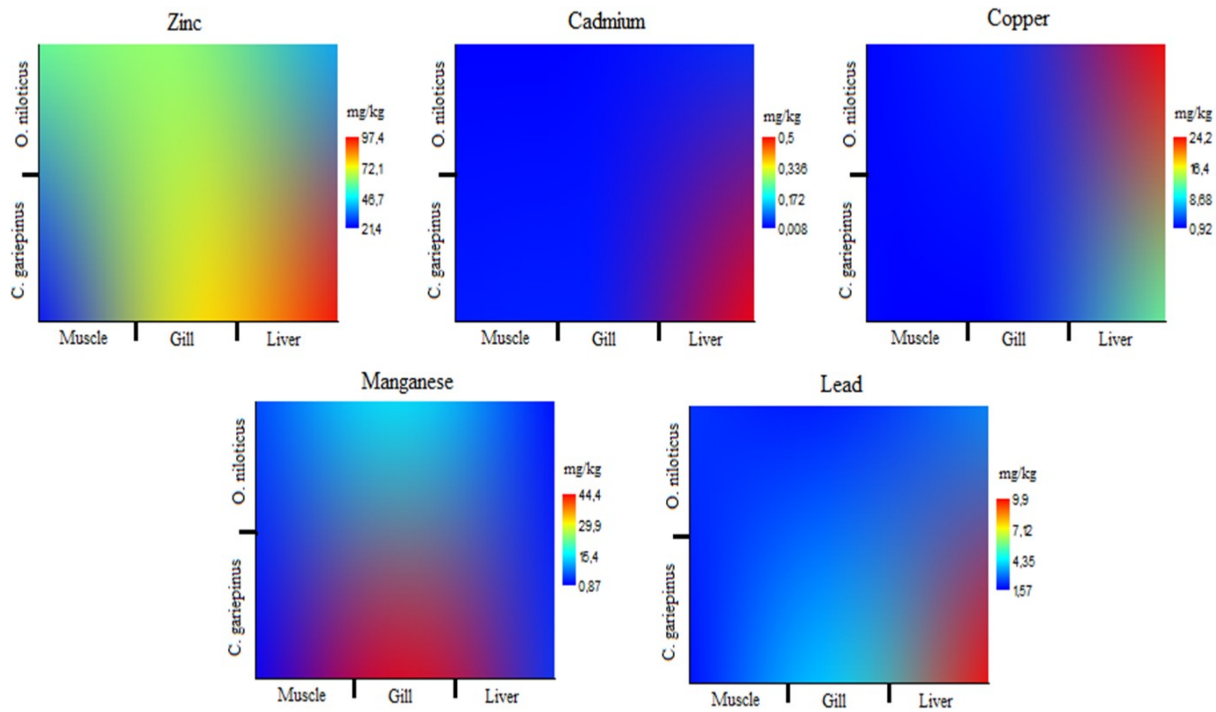

Figure 2. Distributions of elements in the tissues of *O. niloticus* and *C. gariepinus*

kidney, especially when the fishes exposed them for a long time (Kargın and Erdem, 1992; Vinodhini and Narayanan, 2008). But it is also known that the types of fishes, different physiological structures, and different exposure durations of heavy metals may be affective on bioaccumulations of metals in different levels and in different organs (Cid *et al.,* 2001; Mendil and Uluözlü, 2007; Al-Weher, 2008; Sen *et al.,* 2011; Tokatlı *et al.,* 2012b; Tokatlı *et al.,* 2013). In the present study, the highest bioaccumulations were recorded in liver tissues of two exotic fish species for cadmium and lead elements that have high toxicity. This situation may cause significant liver damage and primary impact on the health of fishes (Mayers and Hendricks, 1984; Ferguson, 1989).

Cluster Analyses (CA) was used to determine the similarity groups between the tissues of fishes. The diagram of CA calculated by using zinc, cadmium, copper, manganese and lead accumulations of tissues is given in Figure 3. The similarity coefficients are given in Table 4. According to the CA, three statistically significant clusters were formed: Cluster 1 corresponded to muscle – gill tissues of *O. niloticus*, and gill – liver tissues of *C. gariepinus*; liver tissue of *O. niloticus*; Cluster 3 corresponded to muscle tissue of *C. gariepinus*. The highest similarity was recorded between muscle and

Table 4. Similarity coefficients of fish tissues

Fishes		*O. niloticus*			*C. gariepinus*		
	Tissues	Muscle	Gill	Liver	Muscle	Gill	Liver
O. niloticus	Muscle	1					
	Gill	**0.87976**	1				
	Liver	0.64281	0.58482	1			
C. gariepinus	Muscle	0.55312	0.47543	0.55148	1		
	Gill	0.69165	0.78756	0.45969	0.34154	1	
	Liver	0.67899	0.6813	0.56746	**0.33992**	0.66241	1

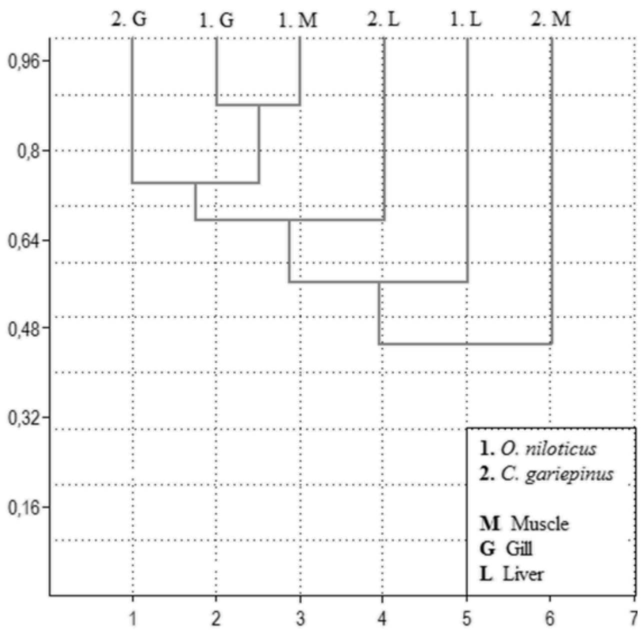

Figure 3.Diagram of CA

gill tissues of *O. Niloticus* (87.9%) and the lowest similarity was recorded between muscle and liver tissues of *C. gariepinus* (33.9%).

If we compare the same tissues of two fish species according to toxic element bioaccumulation levels, the highest similarity were recorded for the gill tissues (78.7%). Gills are the gas exchange tissues of the fishes and they are clearly in contact with water. Gill filaments are in contact with toxic elements more than the other tissues during the gas exchange process (Amundsen *et al.,* 1997; Canlı and Atlı, 2003; Altındağ and Yiğit, 2005). So detected similar heavy metal contents in gill tissues of different fish species were an expected situation. The results of the present study showed that using only gill tissues in order to determine the heavy metal effects on different fish species may not provide objective data in toxicological studies.

Phosphate rock as raw material of phosphatic fertilizers is imported from abroad to Turkey. Cd content of the raw material both imported and produced in Turkey is much more than it should be. As a result of using excessive amount of phosphate fertilizers in agricultural land unconsciously, compounds of phosphate rock accumulated on the upper surface of the soil are being transported into to the streams, lakes and reservoirs by the rain (Emiroğlu *et al.,*2013). Although significant agricultural activities are conducted around the upstream of Sakarya River, use of phosphate rocks is not common in the region, and the bioaccumulations of cadmium detected in tissues of *O. niloticus* and *C. gariepinus* were in quite low levels.

Lead is known as toxic metal even in low concentrations and has no known function in biochemical processes. Pesticides contain important amounts of lead, which sticks strongly to the soil particles and remains in the upper layer of soil for a long time (ATSDR, 2007). One of the important factors for accumulation of lead is hunting activities. It is known that each bullet contains 32 g lead (Akman *et al.,* 2004). Also burning leaded gasoline used in motor vehicle is a range source of Pb emissions (ATSDR, 2007).Lead concentrations detected in tissues of Nile tilapia and African catfish were in extremely high levels. Excessive use of pesticides for agricultural activities, intensive hunting activities carried around the upstream of Sakarya River and highways that are parallel to the river in many regions of the basin may cause this adverse situation. According to the Turkish Food Codex quality criteria (TGK, 2002), the muscle tissues of fish species caught from upstream of Sakarya River are extremely above the limit value. Lead levels of muscle tissues reached up to seven times of the limit value for *O. niloticus* and reached up to five times of the limit value for *C. gariepinus*. According to the results, consumption of these exotic fish species is very dangerous and may adversely affect the human health.

CONCLUSION

In the present study, some toxic element concentrations in muscle, gill and liver tissues of Nile tilapia and African catfish were investigated in the upstream of Sakarya river basin. The highest cadmium and lead levels that have high bio toxicity were detected in the liver tissues of two exotic fish species. It was also determined that the lead bioaccumulations in muscle tissues of *C. gariepinus* and *O. niloticus* are extremely above the limit value and the consumption of these fishes is very dangerous for human health.

The exported raw material without control, increased use of phosphate-based fertilizers obtained from the export raw materials and increased use of unconscious pesticides have become an ecological life-threatening factor in the upstream of Sakarya river basin. In order to solve this significant inorganic pollution problem in the basin, fertilization of agricultural lands have to be made after the soil analysis and the using natural methods against agricultural pests have to be more common in the agricultural activities.

ACKNOWLEDGEMENT

The authors would like to thank for the financial and technical supports supplied by Anadolu University, Turkey. This investigation has been supported by the project numbered as 1101F011 accepted by Anadolu University, Commission of Scientific Research Projects.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for Lead. Atlanta, GA: U.S. Department of Health and Human Services.

Akman Y, Ketenoğlu O, Kurt L, Düzenli S, Güney K and Kurt F. 2004. ÇevreKirliliği (ÇevreBiyolojisi). Palme Yayıncılık, Ankara.

Al-Weher SM. 2008. Levels of Heavy Metal Cd, Cu and Zn in Three Fish Species Collected from the Northern Jordan Valley, Jordan. Jordan Journal of Biological Sciences, 1(1):41 – 46.

Altindağ A, Yiğit S. 2005. Assessment of Heavy Metal Concentrations in the Food Web of Lake Beyşehir, Turkey. Chemosphere 60(4), 552–556.

Amundsen PA, Staldvik FJ, Lukin AA, Kashulin NA, PopovaOA, Reshetnikov YS. 1997. Heavy Metal Contamination in Freshwater Fish From the Border Region Between Norway and Russia. Science of The Total Environment, 201(3):211-224.

ASTM. 1985. Preparation of biological samples for inorganic chemical analysis 1, Annual Book of ASTM Standards, D-19, 740- 747.

Canli M, Atli G. 2003. The Relationships Between Heavy Metal (Cd, Cr, Cu, Fe, Pb, Zn) Levels and the size of Six Mediterranean Fish Species. Environmental Pollution, 121(1), 129–136.

Cid BP, Boia C, Pombo L, Rebelo E. 2001. Determination of Trace Metals in fish Species of the Ria de Aveiro (Portugal) by electrothermal atomic absorption spectrometry. Food Chem., 75(1), 93–100.

Elvira B. 2001. Identification of non-native freshwater fishes established in Europe and assessment of their potential threats to the biological diversity. Convention on the conservation of European wildlife and natural habitats. Council of Europe T-PVS İstanbul. 6: p. 35.

Emiroğlu Ö. 2011. Alien fish species in upper Sakarya River and their distribution. African Journal of Biotechnology 10 (73):16674-16681.

Emiroğlu Ö,Uyanoğlu M, Başkurt S, Sülün Ş, Köse E, Tokatli C, Uysal K, Arslan N, Çiçek A. 2013. Erythrocyte Deformations in Rutilusrutilus (Linnaeus, 1758) Provided From Porsuk Dam Lake. Biological Diversity and Conservation, 6 (1): 13-17.

Environmental Protection Agency (EPA) METHOD 3051. 1998. Microwave assisted acid digestion of sediments, sludges, soils and oils.

Ferguson HW. 1989. Systematic Pathology of Fish. Ames. IA: Iowa State University, Press.

Graaf G, Janssen H. 1996. Artifical reproduction and pond rearing of the African catfish *Clarias gariepinus* in sub-Saharan Africa-A handbook. FAO Fisheries Technical Paper. No.362. Rome, FAO. p. 73.

Kargin E, Erdem C. 1992. Bakır-Çinko Etkileşiminde Tilapia nilotica' nın Karaciğer, Kas ve Solungaç Dokularındaki Metal Birikimi. Doğa Tr. J. of Zoology. 16: 343-348.

Mayers TR, Hendricks JD. 1984. Histopathology. In GM Rand, S.R. Petrocelli, Eds. Fundamental of aquatic toxicology, Washington DC. Hemisphere.

Mendil D, Uluözlü ÖD. 2007. Determination of Trace Metal Levels in Sediment and Five Fish Species from Lakes in Tokat, Turkey. Food Chem., 101(2), 739–745.

Sen I, Shandil A, ShrivastavaVS. 2011. Study for Determination of Heavy Metals in Fish Species of the River Yamuna (Delhi) by Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES). Advances in Applied Science Research, 2 (2): 161-166.

Tekelioglu N. 1991. Course Notes for local water fish breeding. Ç.Ü. Water Products Academy Publications, No 2, S.243.

Türk Gıda Kodeksi (TGK). 2002. Türk Gıda Kodeksi Gıda Maddelerinde Belirli Bulaşanların Maksimum Seviyelerinin Belirlenmesi Hakkında Tebliğ. No:2002/63.

Tokatli C, Köse E, Çiçek A, Arslan N, Emiroğlu Ö. 2012a. Evaluations of water quality and the determination of trace elements on biotic and abiotıc components of Felent Stream (Kütahya, Sakarya River Basin/Turkey). Biological Diversity and Conservation, 5 (2): 73-80.

Tokatli C, Köse E, Çiçek A, Emiroğlu Ö, Arslan N, Dayioğlu H. 2012b. Lead Accumulations in Biotic and Abiotic Components of Emet Stream (Uluabat Lake Basin, Turkey). Pakistan Journal of Zoology, 44 (6): 1587-1592.

Tokatli C, Çiçek A, Köse E, Emiroğlu Ö. 2013. Uptake of Silver from Large Silver Deposits on Biotic and Abiotic Components of the Closest Lothic System: Felent Stream, Turkey. Pakistan Journal of Zoology, 45 (3): 701-707.

Vinodhini R, Narayanan M. 2008. Bioaccumulation of Heavy Metals in Organs of Fresh Water Fish *Cyprinuscarpio* (Common carp). Int. J. Environ. Sci. Tech., 5 (2), 179-182.

Wildi W, Dominik J, Loizeau JL, Thomas RL, Favarger P, Haller L, Perroud A and Peytremann C. 2004. River, reservoir and lake sediment contamination by heavy metals downstream from urban areas of Switzerland. Lakes and Reservoirs: Research and Management, 9(1): 75-87.