Journal of Environmental Biology **July 2006,** 27(3) 475-478 (2006)

Concentration of heavy metals in the food web of Lake Egirdir, Turkey

Sibel Yigit and Ahmet Altindag
Ankara University, Faculty of Science, Department of Biology, 06100-Ankara, Turkey

(Received: 19 November, 2004 ; Accepted: 7 May, 2005)

Abstract: *The concentration of heavy metals (Cr, Cd, Hg and Pb,) was determined by atomic absorption spectrophotometry in sediment, water, plankton and fish samples from Lake Egirdir in South - Western Turkey. Lake Egirdir is an important bird nesting and visiting areas, and it is also used as irrigation and drinking water source. The heavy metal concentrations were in the order Cd > Pb > Cr > Hg in water, Cr > Pb > Cd > Hg in sediment, Pb > Cd > Cr > Hg in plankton, Cd > Cr > Pb > Hg in the muscle and Cd > Pb > Cr > Hg in the gills of Ctenopharyngodon idella. The significant differences of concentrations occurred in water, sediment, plankton and fish tissues (Chi square test, p < 0.05). The concentrations of the heavy metals in water and fish tissues of three years old, were above the maximum permissible level for human consumption.*

Key words: *Fish, Heavy metals, Food web, Lake.*

Introduction

Heavy metals are regarded as serious pollutants in the aquatic environment because of their environmental persistence and tendency to concentrate in aquatic organisms (Harte *et al*., 1991; Schüürmann and Markert, 1998). High concentrations of heavy metals in water, sediments, and organisms may result in serious ecological consequences. Most heavy metals released into the environment enter the aquatic phase as a result of direct input, atmospheric deposition and erosion due to rain (Veena *et al*., 1997). Therefore, aquatic animals are often exposed to elevated levels of heavy metals (Kalay and Canlı, 2000; Farkas *et al*., 2000; Farkas *et al*., 2001).

Contamination of aquatic ecosystems by heavy metals has been observed in water, sediment and organisms (Förstner and Wittmann, 1983). Heavy metals may be directly absorbed by organisms but are also transferred from lower to higher trophic levels of the food chain. The high accumulation of heavy metals in these components can result in serious ecological changes. One of the most serious results of their persistence is the biological amplification of metal in the food chain (Ünlü and Gümgüm, 1993). Metals transferred through aquatic food chains and webs to fish, humans and other animals are of more environmental concern to human health (Farkas *et al*., 2001; Chen *et al*., 2000a). In Lake Egirdir water is mainly used for irrigation, recreation and also for commercial fishing. Although more than 15 fish species have been known to live in the Lake and most of them have became extinct due to introduction of a carnivorous perch (*Lucioperca lucioperca*). Grass carp was introduced into the lake to reduce the aquatic vegetation, and is now commonly used for fishing purpose. The present study evaluates the pollution level of the aquatic ecosystem of Lake Egirdir by determining the concentration of metal Pb, Cd, Cr and Hg that are present in the water, sediment, plankton and fish samples, so that one can have the potential human risk of consumptions of water and fish.

Materials and Methods

Study area: The Lake Egirdir is located on the eastern side of the city, Isparta (37° 50′ 4″ - 38° 16′ 55″ North and 30° 57′ 43″ - 30° 44′ 39″). The city is 918 m above the sea level and covers an area of 442 km^2 extent (Fig. 1). The water of the lake is mainly used for irrigation, commercial fishing and recreation. Dominant fish species in the Lake Egirdir is grass carp (*Ctenopharyngodon idella*). Water, sediment, plankton and fish samples were collected from three different stations in the lake during the spring of 2001 (Fig. 1).

Sampling procedure: Water samples were obtained by means of a Nansen sampler 0.5 m below the water surface in one litre bottles, precleaned with polyethylene and acidified by adding 0.5% concentrated nitric acid. Plankton samples were collected with a Hydrobios Kiel plankton net, of 25 cm diameter with 55μm mesh size by horizontal and vertical hauls at each sampling station. The sediments of upper 10 cm were collected with an Ekman dredge, dried at 40 ºC, homogenized by grinding, and sieving through a 2 mm siever. The fish samples (n = 36) (*Ctenopharyngodon idella*) were collected using a standard skimmer at selected stations and placed in plastic bags and brought to the laboratory. The age determinations of fish were estimated by checking scales (Lagler, 1966).

Analysis of heavy metals: All tissue samples were frozen at 18°C (Bernhard, 1976), and analysed by a Hitachi Z 8200 polarized Zeeman atomic absorption spectrophotometer at the Ankara University Research Centre, by following the procedure give by Eaton *et al*., 1995.

Physicochemical parameters: Physicochemical parameters of the lake viz, dissolved oxygen and temperature were determined by a YSI 51 B type oxygen-meter, pH by a WTW 340-A/SET-1 model pH-meter, electrical conductivity by a WTW LF 92 type conductometer and water transparency by a secchi disk of 20 cm in diameter.

Statistical analysis: Statistical evaluations were done using Student's t-tests (Microsoft Excel t-test: two–sample

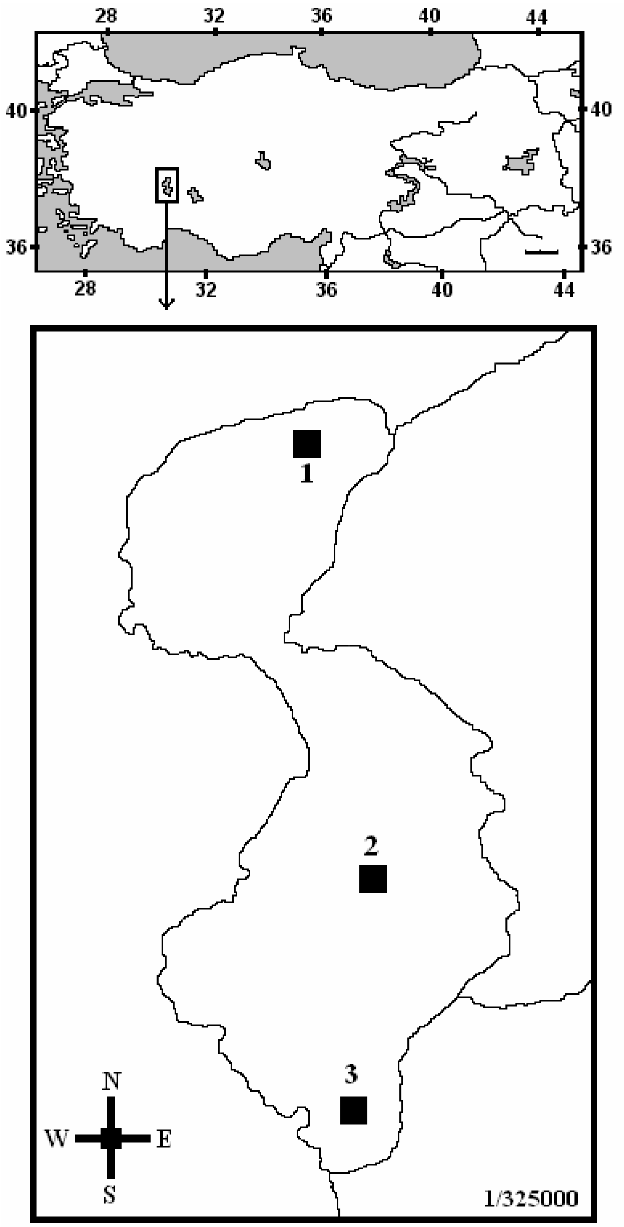

Fig. 1: Map of Lake Egirdir and sampling stations (■).

assuming unequal variance) and Chi square test for the above determination (Ricker, 1975).

Results

The physicochemical parameters determined in lake are given in Table 1. The temperature was between 19 and 24.5 ºC; the pH between 7.06 – 8.3; the EC between 203 – 365 µs/ cm; the dissolved oxygen DO between 7.4 – 11.5 mg/l and secchi depth between 2.85 – 4.50 m in the spring of 2001 in Lake Egirdir. According to these parameters, the lake, is of oligotrophic character with phosphorus (P) concentration of 6.9 µ/l, but the water is fed by several adjoining streams, many with erratic water flow contaminated with sewage.

Table – 1: Some physicochemical parameters of the Lake Egirdir.

Parameters	Mean
Temperature (ºC)	22.8
pH	7.8
EC (µs / cm)	272.6
DO (mg / l)	8.8
Secchi depth (m)	3.62

Table – 2: Mean heavy metal concentrations in water, plankton, sediment and fish (*C. idella*) in the Lake Egirdir.

	Cd Mean	Cr Mean	Hg Mean	Pb Mean
Water (mg / l)	0.113	0.028	0.0032	0.054
Sediment (µg / g)	8.95	23.30	0.16	10.25
Plankton (µg / l)	42.11	30.54	1.362	50.67
Fish (Muscle) (µg / g)	0.604	0.317	0.017	0.280
Fish (Gill) (µg / g)	0.601	0.343	0.018	0.556

The concentrations of heavy metals estimated in water, sediment, plankton and fish samples collected from Lake Egirdir are given in Table 2. The water samples in Lake Egirdir analysed have the average concentrations of Cd, Pb, Hg and Cr 0.113, 0.054, 0.0032, 0.028 mg/l respectively (Table 2). In addition, the concentration of heavy metals are in the order of Cd > Pb > Cr > Hg, and the concentrations of Pb and Hg in water samples were statistically significant (Chi square test, $p < 0.05$) and are in higher concentrations than those permissible levels of drinking and for irrigation.

In sediment samples, the highest concentration was recorded Cr and the lowest for Hg (Table 2). The concentrations of Pb, Cd and Hg in Lake Egirdir were 10.25, 8.95 and 0.16 µg /g respectively. Whereas the heavy metals were in the order Cr > Pb > Cd > Hg.

In plankton samples of the lake, the highest concentration 50.67 µg /g was recorded for Pb whereas the lowest 1.4 µg /g is for Hg. Cd and Cr concentrations were 42.1 and 30.5 µg /g respectively (Table 2). The above determined data confirmed that planktonic organisms, which are having critical roles of the food chains in aquatic ecosystems, were affected, owing to its lethality. The difference accumulations were also statistically significant. (Chi square test, $p < 0.05$) (Ricker, 1975).

The heavy metal concentrations in the tissues of *C. idella* were also determined for a period of three years in aged fish, which have reached a length of having as commercial value. The highest concentration of Cd (0.604 µg /g) and the lowest of Hg (0.017 µg /g) occurred in the muscle tissue of fish (Table 2). Whereas Cr and Pb concentrations are 0.317 and 0.280 µg /g, respectively, in *C. idella*, the concentration order of heavy metals in muscle and gill tissues respectively are Cd > Cr > Pb > Hg and Cd > Pb > Cr > Hg, (Table 2). Concentrations showed statistical importance (Chi square test, $p < 0.05$), and it can be said that the highest concentration of Cd, Cr and Pb in the tissues, accumulated from the water and sediment, whereas Pb concentrations in muscle and gill are statistically different (t-test, $p< 0.05$), as per the result of the Table 2. However, there are no statistical differences, among the concentrations of Cd, Cr and Hg between the muscle and gill tissues (t-test, $p > 0.05$). The concentrations of these metals, except for Hg, are higher to the permissible levels.

Discussion

Heavy metal, concentrations varied in water, sediment, plankton and fish samples in Lake Egirdir. Cd is highest and Hg is lowest. The concentration of former is in agreement with the earlier reports of high in water may be attributed to the low rate of accumulation in sediment (Kerrison *et al*., 1998). Ayaş and Kolonkaya (1996) and Barlas (1999) also reported Cd in the highest concentration in the Göksu delta and the Sakarya river basin, respectively. The report is unlike of Perez *et al*. (1999) who reported the concentration order of heavy metals to be Hg > Cr > Pb in the water of a Mexican reservoir and gave two reasons for high concentrations of Hg and Cr in the water and sediment: Natural; concentrations of Hg and Cr in sediment and soil that bear minerals such as cinnabar and mercuferous soils for Hg and chromite and silicates for Cr and due to anthropogenic activities.

Perez *et al*. (1999) stated that the concentration of heavy metals in the sediment of a Mexican reservoir is in order of Cr > Pb > Cd. This is consistent with the result of the present work. Ayaş and Kolonkaya (1996) reported 0.478 µg /g Pb in the sediment of Göksu delta (Turkey), and Barlas (1999) found in the range of 0.418 – 2.834 µg /g Pb in the sediment of the Sakarya river basin (Turkey). The Pb concentrations reported by both researchers are lower than those determined in the sediment of Egirdir Lake.

The concentration of heavy metals in plankton depends on, the physicochemical properties of the water, quantitative and qualitative species composition of zoo- and phytoplanktons, the productivity of the water body capability of heavy metal absorbance of biota in the different seasons (Kerrison *et al*., 1998, Marshall and Mellinger 1980). Ayaş and Kolonkaya (1996) have reported significant concentrations of Hg in plankton samples in the Göksu delta whereas Cd, Pb and Cr were not determined. In contrast to the above findings, it was found significant concentrations of Cd, Pb and Cr in planktonic organisms in the lake. Chen and Folt (2000b) stated that differences in metal bioaccumulation in zooplankton could result from several mechanisms, such as changes in food composition that alter ingestion, exposure and assimilation of metal in the taxonomic composition of the zooplankton community to species with relatively greater or lesser metal burdens or in aqueous concentrations that directly affect zooplankton burdens. Due to this assumption, high concentrations of Cd, Pb and Cr in plankton samples might be resulted from increased concentrations of heavy metals in water of the Lake Egirdir. In the Lake Egirdir, grass carp is commercially an important fish, and the concentrations of heavy metals that are found are higher than the permissible levels. The Pb was found higher concentration in gill than in muscle and this will be especially significant. In controversy to this, Hilmy *et al*. (1985) and Kargın (1996) found higher accumulations of Cd in the gills than in the muscle tissue of *Mugil cephalus* and *Tilapia zilli*, respectively. Radwan *et al.* (1990) found higher accumulations of Pb than of Cd in the tench fish and higher accumulations of Cd than of Pb in the pike fish. According to Deb and Fükushima (1999), metals may be in high concentrations in the gills, intestine and digestive glands, and all these organs have relatively high potential for metal accumulation. Apart from this, Geldiay and Balık (2000) suggested that different accumulation rates of heavy metals in fish might be due to different feeding behaviours of each species. The chub, carp and tench are omnivorous species and have a similar feeding behaviour; however, pike is a carnivorous species and its feeding behaviour is entirely different. According to Chen and Folt (2000b), even within particular trophic groups (among the zooplankton or the fish), animals with different foraging behaviours are expected to have different burdens. Ramelow *et al*. (1989) noticed that differences in heavy metal accumulations, i.e. Pb, in the muscle tissue of pike might be due to the different feeding habits. The different concentrations of Pb and Cd in the tench and pike (Radwan *et al*., 1990) may be originated from different food habits of fish species. Farkas *et al*. (2000) also stated that concentration of heavy metals in fish showed significant differences in seasons, and accumulation of the concentrations of Cd, Cu, Pb and Zn higher in eel and bream than in pike perch, while high Hg concentration was found in a predator fish. Ünlü and Gümgüm (1993) reported that the high concentrations of heavy metals in the sediment and fish were possibly due to direct contamination of the water by metals or the geochemical structure of the region. In Lake Egirdir, the major source of heavy metal contaminations originated from sewage contamination and some streams adjoining the lake. Chen *et al*. (2000a) stated that Hg and Zn concentrations in fish were both biomagnified, whereas As and Pb were biodiminished due to the food chain. However, Cd appeared to biomagnify from micro to macrozooplankton but diminish from them to fish. In this present study, Cd concentration was also found to diminish from plankton samples to fish. According to Farkas *et al.* (2001), the fish is the indicator organism for heavy metal pollution and their possible risk for human consumption. Storelli *et al.* (2001) reported that holothurians could serve as bioindicator for Hg and Cu, in South Adriatic Sea. In Lake Egirdir, a bioindicator species such as *Ctenopharyngodon idella* is necessary to monitor the levels of heavy metal contaminations. Therefore it would be possible to take necessary steps against to harmful affect of heavy metals to this aquatic ecosystem, by assessing the pollution indicator.

References

Ayaş, Z. and D. Kolonkaya: Accumulation of some heavy metals in various environments and organisms at Göksu delta, Türkiye, 1991-1993. *Bull. Environ. Contam. Toxicol.*, **(56)**, 65 – 72 (1996).

Barlas, N.: A pilot study of heavy metal concentration in various environments and fishes in the upper Sakarya river basin, Turkey. *Environ. Toxicol.*, **14 (3)**, 367 – 373 (1999).

Bernhard, M.: Manual of methods in aquatic environment research, FAO, Fisheries Technical Paper, Rome, pp. 58 (1976).

Chen, C. Y., R. S. Stemberger, B. Klaue, J.D. Blum, C. Pickhardt and C. L. Folt: Accumulation of heavy metals in food web components across a gradient of lakes. *Limnol. Oceanogr.*, **45 (7)**, 1525 – 1536 (2000a).

Chen, C. Y. and C. L. Folt: Bioaccumulation and diminution of arsenic and lead in a freshwater food web. *Environ. Sci. Technol.*, **(34**), 3878-3884 (2000b).

Deb, S. C. and T. Fükushima: Metal in aquatic ecosystems: mechanisms of uptake, accumulation and release. *Intl. J. Environ. Studies*, **56 (3),** 385 – 433 (1999).

Eaton, D. A., L. S. Clesceri and A. E. Greenberg: Standard methods, 19 th edition for the examination of water and wastewater, American Public Health Association, Fifteenth street, NW Washington, DC, pp. 1015 (1995).

Farkas, A., J. Salanki and I. Varanka: Heavy metal concentrations in fish of lake Balaton. *Lakes and Reservoirs: Res. Manage.*, **5**, 271-279 (2000).

Farkas, A., J. Salanki, A. Specziar and I. Varanka: Metal pollution as health indicator of lake ecosystems. *Intl. J.Occupational Medi. Environ. Hlth.*, **14 (2)**, 163-170 (2001).

Förstner, U. and G. T. Wittmann: Metal pollution in aquatic environment, Springer-Verlag, Berlin, Heidelberg, New York, Tokyo, pp. 486 (1983).

Geldiay, R. and S. Balık: Türkiye Tatlısu Balıkları (In Turkish). Ege Üniversitesi Fen Fakültesi Kitaplar serisi, İzmir, pp. 519 (2000).

Harte, J., C. Holdren, R. Schneider and C. Shirley: Toxics A to Z, A guide to everyday pollution hazards, University of California Press, Oxford, England, pp. 478, (1991).

Hilmy, A. M., M. B. Shabana and A. Y. Daabees: Effects of cadmium toxicity upon the in vivo and in vitro activity of proteins and five enzymes in blood serum and tissue homogenates of *Mugil cephalus. Compared. Biochem. Physiol.*, **81(1)**, 145 – 153 (1985).

Kalay, M. and M. Canlı: Elimination of essential (Cu and Zn) and non-essential (Cd and Pb) metals from tissue of a freshwater fish, *Tilapia zilli*. *Tr .J. Zool.,* **24**, 429 – 436 (2000).

Kargın, F.: Effects of EDTA on accumulation of cadmium in *Tilapia zilli. Tr. J. Zool.*, **(20)**, 419 – 421 (1996).

Kerrison, P. H., D. Annonsi, S. Zerini and O. Ravera and B. Moss: Effects of low concentrations of heavy metals on plankton community dynamics in a small, shallow, fertile lake. *J. Plank. Res.*, **10,** 779-812 (1998).

Lagler, K. F: Freshwater fishery biology. W. M. C. Brown Company Publishers, Dubuque, Iowa, pp. 421 (1966).

Marshall, J. S. and D. L. Mellinger: Dynamics of cadmium-stressed plankton communities. *Can. J. Fish. Aquatic Sci.*, **37**, 403 – 414 (1980).

Pérez, A., M. Balcázar, G. Zarazúa - Ortega, I. Barceló - Quintal and C. Díaz, Delgado: Heavy metal concentrations in water and bottom sediments of a Mexican reservoir. *Sci. Tot. Environ.*, **234 (1-3)**, 185 – 196 (1999).

Radwan, S., W. Kowalik and R. Kornijow: Accumulation of heavy metals in a lake ecosystem. *Sci. Tot. Environ.***, 96 (1-2)**, 121– 129 (1990).

Ramelow, G. J., C. L. Webre, C. S. Mueller, J. N. Beck, J. C. Young and M. P. Langley: Variations of heavy metals and arsenic in fish and other organisms from the Calcasieu River and lake, Louisiana. *Bull. Environ. Contam. Toxicol.*, **18**, 804 – 818 (1989).

Ricker, W. E.: Handbook of Computations for Biological Statistic of Fish Populations. Fisheries research board of Canada, pp 300 (1975).

Schüürmann, G. and B. Markert: Ecotoxicology, ecological fundamentals, chemical exposure, and biological effects, John Wiley & Sons, Inc. and Spektrum Akademischer Verlag, pp. 900 (1998).

Storelli, M. M., A. Storelli and G. O. Marcotrigiano: Heavy metals in the aquatic environment of the Southern Adriatic Sea, Italy macroalgae, sediments and benthic species. *Environ. Intl.,* **26**, 505-509 (2001).

Ünlü, E. and B. Gümgüm: Concentrations of copper and zinc in fish and sediments from the Tigris river in Turkey. *Chemosphere*, **26 (11)**, 2055 – 206 (1993).

Veena, B., C. K. Radhakrishnan and J. Chacko: Heavy metal induced biochemical effects in an estuarine teleost. *Indian J. Marine Sci.,* **26**, 74 – 78 (1997).

Correspondence to:
Dr. Sibel Yigit
Ankara University, Faculty of Science
Department of Biology
Besevler-Ankara/Turkey
E-mail: yigit@science.ankara.edu.tr
Tel.: +90-312-2126720 / 1134
Fax: +90-312-223 23 95