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Cadmium and Nickel Accumulation in Water, Sediment and Tissues of *Esox lucius* in Lake Büyük Akgöl, Turkey

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Abstract

The aim of this study was to establish cadmium and nickel levels accumulated in water and sediment of the lake and tissues (muscle, liver and gill) of *Esox lucius* Linnaeus, 1758 living in the lake Büyük Akgöl. The samples were collected from five seasonal stations during August 2009 and April 2010.The water had0.045 mg/L of Cd and 0.052 mg/L of Ni whereas sediment had12.2 mg/kg of Cd and 41.5 mg/kg of Ni. The fish muscle tissue had 12.03 mg/kg of Cd and 22.2 mg/kg of Ni, which were above the limit values determined by the Food and Agriculture Organization. Data obtained as a result of these measurements demonstrate that the Büyük Akgöl faces with pollution and the fish hunted in the lake being eaten poses a danger for public health.

Keywords: Lake Büyük Akgöl, cadmium, nickel, *Esox lucius*.

INTRODUCTION

Heavy metals are released into the environment as a result of industrial activities such as mining, energy and fuel consumption, and the use of pesticide and fertilizers [1, 2, 3]. Having a more closed system compared to sea and streams, lakes are exposed to such pollution on a high level. Metals released into lakes are accumulated in lake water, sediment and biotic elements and they cause an ecological deterioration of aquatic environment. Fish samples are considered to be one of the most indicative factors in freshwater systems for the estimation of trace metals pollution [4]. Heavy metals are taken up through different organs of the fish [5]. These metals cause tissue and spinal disorder in fish, respiratory alteration and death even in the water low concentrations [6].

Metal pollution in fish need to be analyzed from two different perspectives. Firstly becoming the metals may damage the fish metabolism, reduce the reproduction activities and ultimately cause mortality. Secondly the metal taken up by the fish will gain entry into the humans through food and have prove health hazardous [7].

E. lucius is one of the most important predator fish in the lake ecosystem and hence presence of any contaminant in the system will ultimately affect fish directly and the human population indirectly through food.

The purpose of this study was to determine the concentration of cadmium and nickel in water and sediment of tissues *E. lucius*.

MATERIALS AND METHODS

The study area

Büyük Akgöl (Adapazarı) is located in 41°01' N, 30°33' E in the middle of Ferizli and Karasu Districts of Sakarya Province in Marmara Region that is densely occupied by the industrial plants of Turkey and 4-5 km inwards from the Black Sea coast [8]. It is known that there is a recreational area and a restaurant around the lake and those 236 industrial plants are found within the borders of Sakarya Province. While water from the lake was in use as drinking and municipal water by Gölkent Municipality that was populated by some 2000 people in 1997, today the lake is faced with the dangers of pollution and destruction and it is not being used for human consumption purposes [9].

Water, sediment and fish samples were collected from 5 stations (Fig.1) during August and Novemberof 2009 and February and April of 2010.

The water and sediment samples were collected according to standard methods [10]. Water samples of 1 L in volume were taken at each sampling point in plastic bottle and were adjusted to pH 2 by adding HNO_3. Before sampling, sample bottles were cleaned by washing them with detergent and then soaking them in 50% HCl for 24 h. Finally, the bottles were washed with distilled water. Bottles were kept in 1% nitric acid before their use.

Sediment was collected at all stations by using an Ekman-dredge taking with a polyethylene spoon to avoid contamination by metallic parts of the dredge. Sediment samples were dried in oven at 105°C for 3 hand then approximately 0,5g samples digested with concentrated HNO_3 in a microwave. All samples filtered through nitrocellulose membrane and were rounded out to 100 ml with deionized water.

Fish were caught with gillnets in the lake and transferred to the laboratory with ice box. The fish were washed with distilled water, dried in filter paper and then frozen at -25°C until dissection. Samples were dried at 105°C for 24 h and then approximately 0.5-1 g of fish tissues were digested with nitric acid at 200°C for 30 min in CEM brand microwave oven [11]. Samples were filtered; volume was completed to 100 ml with ultra-distilled water.24 fish were meauserd.

All metal concentrations of water, sediment and fish tissues were analyzed with ICP-OES Varian 720 ES by triplicate measurements [12].

In the ICP-OES analysis, the following wavelength lines were used; Ni 231.604 nm, Cd 238.8 nm, the analytical process quality was also controlled by certified reference material of NCS DC73350 (leaves of poplar) and RTC-CRM033-050 (soil metals). The analysis of these standard reference materials showed good accuracy, with the recovery rates of the metals, between 90 % and 100 %.

Mean values and standard deviations were calculated for metal concentrations of sediment, water and fish tissues. The concentrations of Cd differences between of seasonal and tissues of fish were analyzed by ANOVA and that is F value of muscle 865,608 (<0.0001). Statistical analysis of data was carried out using SPSS 19.0 statistical package programs for Windows.

RESULTS AND DISCUSSION

The mean and min-max values, standard deviations of metal concentrations in water and sediment are given in the Table 1.

According to Turkish Water Pollution Control Regulations the water samples seasonally collected from lake, the Cd concentrations of summer, winter, spring and with an annual average of 0.025 mg/L were the 4th Grade Quality. These values were significantly above the limit values of EPA. The Cd concentrations values of this study are higher than the values obtain (2,54 µg/L¹) in Abant lake on the contrary the annual Ni concentrations values (0,025 mg/L) of our study are lower than the values obtain (51,37 µg/L¹) from Abant lake [13]. The Ni concentration was highest in winter, at the 3rd Grade, at the 2nd Grade according to annual average and below the EPA limit value.

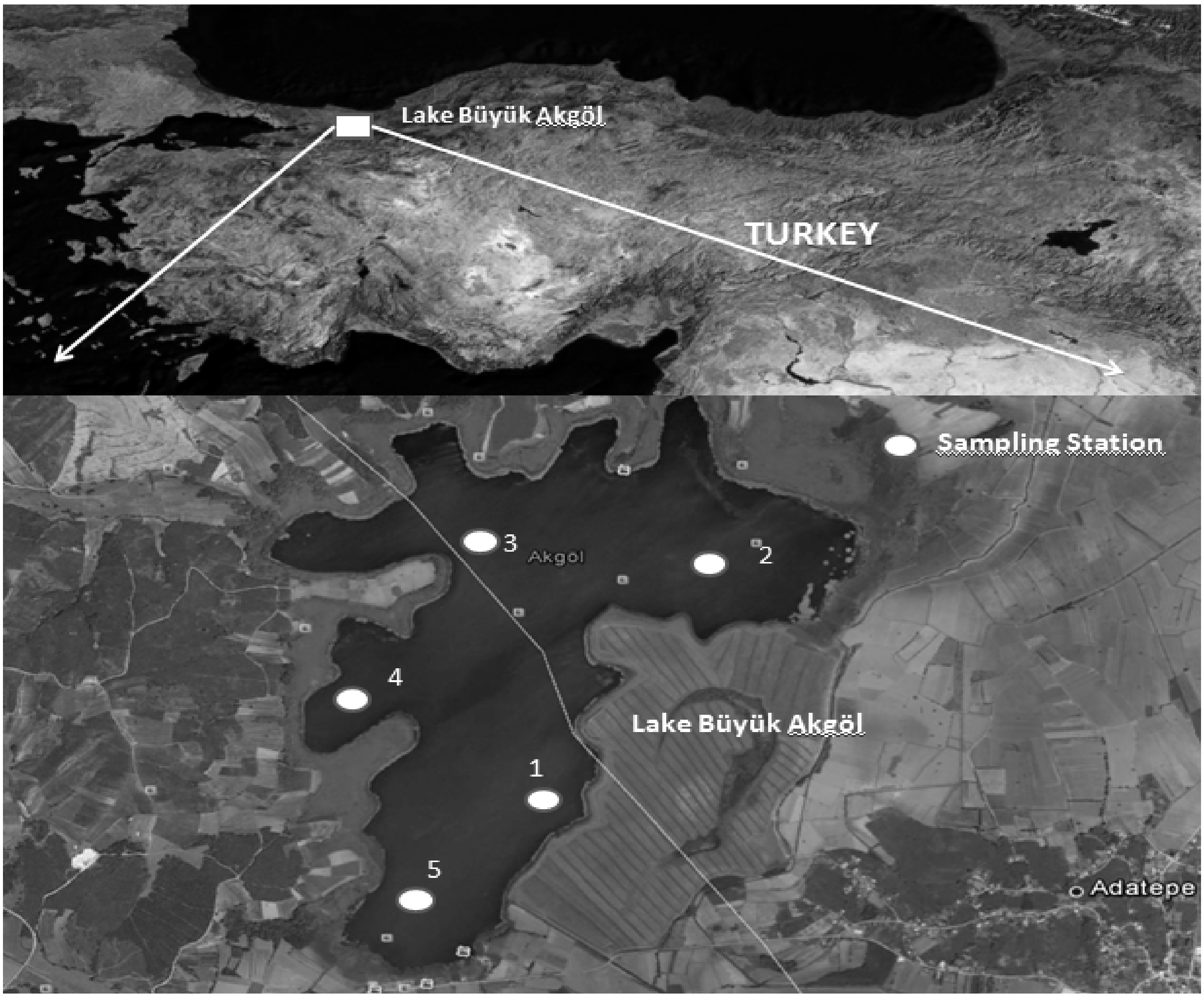

Fig. 1 Stations from which the samples were collected at BüyükAkgöl (41°01' N, 30°33' E).

Table 1. Seasonal variation in level of cadmium and nickel (mg/L; min.-max., **mean** ± Sd) in the water and sediment of Lake Büyük Akgöl, Sakarya, Turkey

		Summer Min.-Max. **Mean** ± Sd	Autumn Min.-Max. **Mean** ± Sd	Winter Min.-Max. **Mean** ± Sd	Spring Min.-Max. **Mean** ± Sd	Annual Min.-Max. **Mean** ± Sd
Water	Cd	0.026-0.026 **0.026** ± 0	0.007-0.008 **0.007** ± 0.0001	0.045-0.046 **0.045** ± 0.0003	0.023-0.023 **0.023** ± 0	0.007-0.046 **0.025** ± 0.01
	SKKY*	**IV**	**III**	**IV**	**IV**	**IV**
	Ni	0.004-0.006 **0.004** ± 0.0008	0.001-0.008 **0.004** ± 0.001	0.05-0.059 **0.052** ± 0.002	UDL	0.001-0.059 **0.025** ± 0.024
	SKKY	**I**	**I**	**III**	**I**	**II**
		SKKY limits (mg/L)				EPA limit (mg/L)
		I	II	III	IV	
	Cd	0.003	0.005	0.01	>0.01	0.004
	Ni	0.02	0.05	0.2	>0.2	0.47
Sediment	Cd	3.56-4.19 **3.87** ± 0.21	UDL	11.26-13.9 **12.2** ± 0.83	3.39-4.06 **3.6** ± -0.18	3.39-13.93 **7.14** ± 4.21
	Ni	27.4-57.8 **41.5** ± 11.2	23.4-46.1 **35.6** ± 7.35	19.4-105.5 **38.3** ± 27.8	20.18-42.16 **31.2** ± 8.19	19.42-105.5 **35.9** ± 15.8
MacDonald(2000) sediment criteria (mg/kg)						
		TEL		LEL		MET
	Cd	0.596		0.6		0.9
	Ni	18		16		35

*Turkish Water Pollution Control Regulations

UDL: Under the detection limit

Table 2. Concentration of cadmium and nickel (mg/kg; min.-max., **mean** ± Sd) in muscle, liver and gill tissues of *E. lucius* collected from Lake Büyük Akgöl, Sakarya, Turkey

		Summer Min-Max **Mean** ± Sd	Autumn Min-Max **Mean** ± Sd	Winter Min-Max **Mean** ± Sd	Spring Min-Max **Mean** ± Sd	Annual Min-Max **Mean** ± Sd	TFC (mg/kg)	FAO (mg/kg)
Muscle	Cd	4.52-5.81 **4.88** ± 0.39	UDL	11.2-15.3 **12.03** ± 1.09	2.66-3.19 **2.8** ± 0.15	2.6-15.3 **8.1** ± 4.3	0.05	0.1
	Ni	1.62-4.84 **3.05** ± 1.21	UDL	15.8-53.8 **22.2** ± 8.1	UDL	1.62-53.58 **19.9** ± 9.9	-	0.4
Liver	Cd	4.71-5.2 **5.1** ± 0.15	UDL	8.64-16.52 **11.7** ± 2.76	2.72-5.78 **3.3** ± 1.14	2.72-16.52 **7.01** ± 4.32	-	-
	Ni	UDL	UDL	15.21-36.5 **22.2** ± 7.48	UDL	15.21-36.5 **22.2** ± 7.48	-	-
Gill	Cd	4.67-5.29 **4.9**±0.22	UDL	11.76-34.7 **23.5**±6.37	2.70-3.96 **3.4**±0.58	2.70-34.7 **13.2**±10.64	-	-
	Ni	5.33-5.33 **5.3**±0	UDL	20.6-147.5 **72.3**±39.04	UDL	5.33-147.5 **68.7**±40.93	-	-

TFC (2002): Turkısh Food Codex

FAO (1983): Food and Agriculture Organization

Cd concentration of sediment was quite high in all seasons. In winter, threshold effect value (TEL) has while is 20 times that reported MacDonald [14]. Ni level was found to be twice the amount of TEL provided by MacDonald in all seasons. The Cd concentrations values of this study are higher than the values (2,15 mg/kg) in Seyhan dam lake [15], (0,76 mg/kg) in Avşar dam lake [16], (0,21 mg/kg) in Beyler dam lake [17].

Max-min values and meaning, standard deviations of metal concentrations in tissues of fish in the Table 2. Cd and Ni concentrations of *E. lucius* were found to be quite high. Mean Cd concentration in all seasons especially in winter was determined 240 times higher than the Turkish Food Codex (TFC) limits [18] and 120 times higher than FAO limits [19]. Ni concentration in summer was found to be 7 times and in winter was 55 times higher than FAO limits.

Ni concentrations of fish ranged from high to low as Gill>Liver>Muscle according to annual averages. Permeation of nickel into the body in excessive doses can be dangerous for living creatures while in fact its intake in small amounts is actually necessary for the body. Excessive nickel intake causes congestion in lungs, respiratory failure, asthma and chronic bronchitis, cardiac diseases, fatigue and dizziness in addition to pulmonary, nasal, prostate, and throat cancers [20]. TFC did not establish a limit value for Ni, but FAO specified 0.4mg/kg as a limit value for Ni in edible fish tissue. Mean Ni concentration of *E. lucius* was above the than FAO limits.

Cd concentrations of *E. lucius* ranged from high to low as Gill>Muscle>Liver according to annual values. Cd is a element widely used in industry. It can demonstrate toxic effect even in small amounts and is also quite a harmful metal for human and environmental health. Cd in water effects body surface and gills of fish and then spreads to other tissues and then it causes spinal disorder, respiratory alteration, anemic reaction, significant decreases in hematocrit, hemoglobin, erythrocyte levels and death in fish [21, 22, 23, 24]. Another significant effect of cadmium on fish is the disturbance of ion balance due to its ionic size being close to calcium and causing hypocalcaemia by competing against calcium [25].

These data demonstrate that the ecological life and *E. lucius* individuals in Büyük Akgöl were densely exposed to Cd and that their future is endangered. According to De Conto et al. [26], Cd accumulation in liver of carp *(Cyprinus carpio)* reaches high levels in the shortest period, but the accumulation in muscle reaches longer period. Cd concentration in muscle higher than in liver shows that *E. lucius* was exposed to Cd for along period. Linear regression was observed that Cd adsorption were statistically significant between liver and muscle tissues on a significance level of 0.05 (0.017<0.05). When checked the standardized coefficients, it is observed that a single unit Cd increase in liver tissue would cause 0.114 unit increase in muscle tissue.

Cd concentration of edible fish tissues in this study is quite above the TFC and FAO limits. Our values are higher than the values gather (0,0024 mg/kg) in Poland [27], (0,5 µg/g) in three locations of Norway and Russia [28], (16,57 µg/kg) in Tizsa River [29] and (2,17-4,00 mg/kg) in Beyşehir Lake [30].

Human activities (such as industrial wastes, settlement wastes etc.) as well as geological structure constitute the main source of metals in aquatic ecosystems [31, 32, 33]. It is a known fact that Cd content has increased in soil around the world. The most significant reason for such an increase in Cd content is reported to be dense use of phosphate fertilizers and waste treatment mud [34].

Köleli and Kantar [35] reported a high Cd content of composed fertilizers used for the purpose of increasing the efficiency of agricultural lands in Turkey. This study established that 87% of fertilizers produced in Turkey had approximately 8mg/kg Cd which is the limit value for fertilizers, and that the said value for other fertilizers was 2 to 5 times above the former. This is an indication of the pollution of agricultural lands where fertilizer consumption in Turkey is dense.

CONCLUDING COMMENTS

Büyük Akgöl is surrounded by approximately 15 hectares of irrigable agricultural land. Drainage water reaches the lake through irrigation canals dug by the Turkish General Directorate of Hydraulic Works. Therefore, toxic metals found in fertilizers used for fields are carried to the lake.

These data demonstrate that the ecological life and *E.lucius* individuals in Büyük Akgöl were densely exposed to Cd and that their future is endangered. Additionally the (Marmara) region covers lots of industrialized companies or factories and that situation may have been caused the heavy metal pollution that we put forward in this study. Finally, Büyük Akgöl faces with metal pollution and could be danger for public health.

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