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Lead Accumulations in Biotic and Abiotic Components of Emet Stream, Uluabat Lake Basin, Turkey

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Abstract.- Emet Stream is one of Turkey's most important river systems. It is used for purposes such as irrigation water, industrial water supply, receiving environment for domestic and industrial wastes and fishing activities around the regions that the stream passes. The aim of this study is to determine the lead levels both in biotic (fish tissues) and abiotic (water and sediment) components of Emet Stream. Water, sediment and fish samples (*Squalius cii*, (Richardson, 1857); *Capoeta tinca*, (Heckel, 1843); *Barbus oligolepis*, Battalgil, 1941) were collected from eight stations (one of them is on the Kınık Stream and one of them is on the Dursunbey Stream) on the Emet Stream seasonally between the dates of November 2010 – August 2011. According to data, the lowest Pb concentrations of water and sediment were determined in E1 station (0.00307 mg/L and 10.48 mg/kg); the highest Pb concentrations were determined in E4 station for water (0.02503 mg/L) and in E8 station for sediment (48.53 mg/kg). Pb accumulations in biotic and abiotic components of Emet Stream were determined as sediment > fish tissues > water; the Pb accumulations in tissues of *S. cii* and *B. oligolepis* follows as, liver > kidney > gill > muscle; in tissues of *C. tinca* follows as, kidney > liver > gill > muscle respectively and it was also determined that biotic components of system were highly affected by the lead.

Keywords: Emet Stream, Lead, *Squalius cii*, *Capoeta tinca*, *Barbus oligolepis*

INTRODUCTION

Water pollution originates from both natural and anthropogenic sources. Especially after the industrial revolution, almost all aquatic ecosystems were contaminated by human activities. Lead (Pb) is found in the earth's crust in small amounts, but over 90% of Pb in sediments and water is associated with human activities and lead sources in surface water and sediment are deposits of lead-containing dust from the atmosphere, waste water from industries, urban runoff and mining piles (ATSDR, 2007).

Emet Stream is the most important branch of Uluabat Lake Basin and also one of Turkey's most important river systems. Uluabat Lake, which has an important biological diversity and is located on the migration route for many bird species, is a Ramsar area and one of the most important wetlands not only for Turkey but also for Europe and the Middle East (Magnin and Yarar, 1997). In addition to geographic location and proximity of urban areas, the Emet Stream Basin is one of the most important mining areas of Turkey. So it is very clear that the investigation of lead levels of the system is very important for both ecosystem and human health.

The aim of our study is to determine Pb levels in biotic (muscle, gill, liver and kidney tissues of *Squalius cii*, (Richardson, 1857), *Capoeta tinca*, (Heckel, 1843) and *Barbus oligolepis*, Battalgil, 1941) and abiotic (water and sediment) components of Emet Stream.

MATERIALS AND METHODS

Study area and collection of samples

The stations selected on the Emet Stream for determination of the lead levels are shown on the map (Fig. 1). Field studies were made seasonally and completed in one year. The samples were collected in the dates of November 2010, February 2011, May 2011 and August 2011. Sediment and water samples were collected seasonally from all stations by using sediment dipper, Ekman grab and suitable containers. Fish samples were collected in winter season (February 2011) from E2, E4, E7 and E8 stations.

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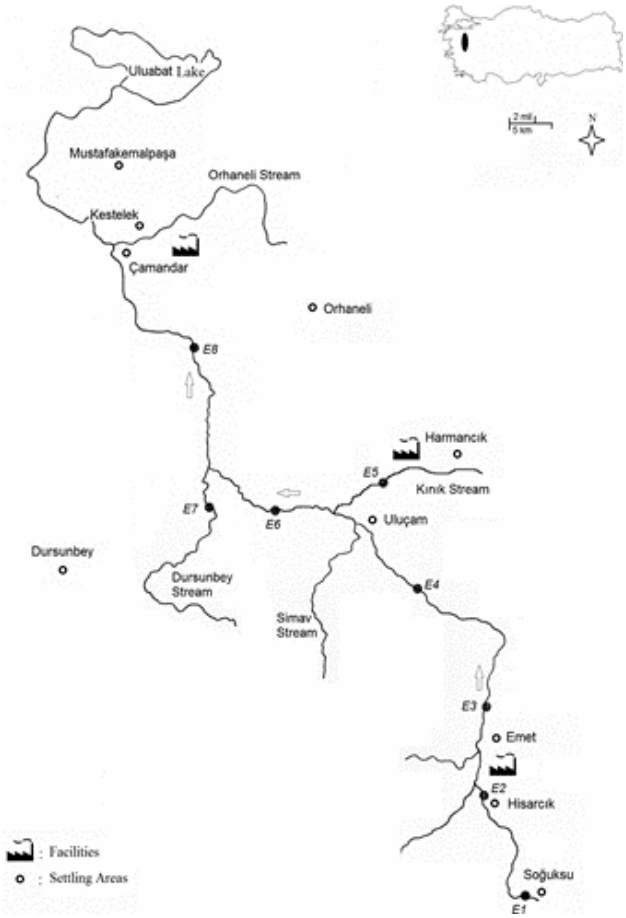


Fig. 1. Emet Stream, Uluabat Lake Basin, Turkey showing different station from where sampling was done.

Chemical analysis

Fish samples were dried for 24 h at 105°C. Sediment samples were dried for 3 h at 105°C. 0.25 g of each sample was placed in Pyrex reactors of a CEM Mars Xpress 5 microwave digestion unit. $HClO_4$:HNO_3 acids of 1:3 proportions were inserted in the reactors respectively. Samples were mineralized at 200°C for thirty minutes. Afterwards, the samples were filtered in such a way as to make their volumes to 100 ml with ultra-pure distilled water.

Water samples (1 liter) were taken at each sampling point and was adjusted to pH 2 with 2 ml of HNO_3. Element levels in samples were determined by ICP-OES (Varian 720 ES). The element analyses were recorded as means of triplicate measurements (ASTM, 1985; APHA, 1992; EPA, 1998, 2001).

Statistical analysis

Cluster similarity and distance analysis, Boxplot and Matrixplot diagrams was applied to the results by using the Past package program. The graphics of water, sediment and tissues of fishes were made by using the Microsoft office 2007 package program.

RESULTS AND DISCUSSION

Pb values determined in water and sediment of Emet Stream are given in Tables I and II. The average Pb values of fish tissues are given in Table III.

Table I.- Seasonal variations in levels of lead (mg/L; mean±SE) in water of Emet Stream, Uluabat Lake Basin, Turkey.

Stations	Autumn	Winter	Spring	Summer
E1	3.12±0.29	3.07±0.28	4.88±0.38	3.50±0.12
E2	5.08±0.27	5.19±0.25	15.81±0.39	2.80±0.11
E3	40.0±0.332	4.25±0.217	21.01±0.376	4.47±0.11
E4	3.99±0.27	4.14±0.39	25.03±0.34	8.56±0.13
E5	5.92±0.26	4.82±0.36	15.46±0.38	6.57±0.12
E6	5.05±0.31	5.10±0.31	19.81±0.37	7.62±0.13
E7	3.11±0.30	3.12±0.35	6.25±0.33	4.20±0.12
E8	12.74±0.30	12.83±0.34	16.77±0.33	18.29±0.36

Table II.- Seasonal variations in levels of lead (mg/kg; Mean±SE) in sediment of Emet Stream, Uluabat Lake Basin, Turkey.

Stations	Autumn	Winter	Spring	Summer
E1	13.83±0.22	18.33±0.34	10.48±0.35	12.37±0.26
E2	18.33±0.12	17.93±0.34	14.32±0.39	15.44±0.39
E3	19.93±0.16	21.73±0.35	31.50±0.44	29.14±0.34
E4	19.06±0.16	31.06±0.19	37.95±0.44	29.33±0.36
E5	26.13±0.19	30.66±0.24	26.73±0.30	28.12±0.20
E6	26.06±0.16	33.46±0.28	40.42±0.61	31.35±0.31
E7	12.26±0.13	17.6±0.23	18.78±0.38	14.66±0.25
E8	33.06±0.22	35.62±0.30	48.53±0.59	37.40±0.25

The highest Pb concentrations of water were determined in E4 station (0.02503 mg/L) in spring season and the lowest Pb concentrations of water were determined in E1 station (0.00307 mg/L) in winter season. The highest Pb concentrations of sediment were determined in E8 station (48.53

mg/kg) in spring season and the lowest Pb concentrations of sediment were determined in E1 station (10.48 mg/kg) in spring season.

Table III.- Concentration of lead (mg/kg; Mean±SE) in different tissues of *Squalius cii, Capoeta tinca* and *Barbus oligolepis* collected from different stations (E_2, E_4, E_7, E_8) of Emet Stream, Uluabat Lake Basin, Turkey.

Fish tissues	Stations			
	E2	E4	E7	E8
S. cii				
Muscle	0.68±0.12	0.89±0.13	1.13±0.14	1.21±0.13
Gill	2.59±0.34	2.29±0.29	2.17±0.22	2.72±0.32
Liver	4.49±0.31	4.73±0.24	4.18±0.24	5.36±0.30
Kidney	4.38±0.30	4.21±0.13	4.45±0.23	4.99±0.36
C. tinca				
Muscle	0.72±0.13	1.45±0.15	1.11±0.14	1.42±0.15
Gill	1.67±0.31	3.49±0.27	2.36±0.28	2.70±0.27
Liver	2.15±0.21	4.17±0.25	3.30±0.21	4.26±0.32
Kidney	2.57±0.15	4.14±0.23	3.44±0.29	4.39±0.34
B. oligolepis				
Muscle	0.26±0.09	0.68±0.08	0.76±0.16	1.01±0.14
Gill	0.62±0.17	1.89±0.27	1.90±0.15	1.95±0.18
Liver	3.09±0.26	4.03±0.35	3.95±0.31	4.07±0.26
Kidney	3.03±0.22	4.01±0.32	3.52±0.25	3.87±0.37

According to the Water Pollution Control Regulation in Turkey (SKKY, 2004), all stations except E8 have I. Class (< 0.01 mg/L) water quality in autumn, winter and summer seasons and E8 station has II. Class (0.01-0.02 mg/L) water quality in all seasons in terms of Pb levels. In spring season, E1 and E7 stations have I. Class, E2, E5, E6 and E8 stations have II. Class and E3 and E4 stations have III. Class (0.02-0.05 mg/L) water quality in terms of Pb levels.

According to the sediment quality criteria specified by MacDonald (McDonald *et al.*, 2000) the Pb levels of sediment in E1, E2, E5 and E7 stations in all seasons, E3 station except spring season, E4 station except winter and spring seasons, were under the limit values. The Pb levels of sediment in E8 station in all seasons and E6 station except autumn season were over the limit values. Especially in E8 station, the accumulation of Pb in sediment has reached critical levels. Furthermore, Pb levels of sediment in spring season have outrun the minimal effect threshold value (MET, 42 mg/kg) in E8 station.

If we describe the seasonal variations of Pb levels in water and sediment, the Pb accumulations show a significant increasing in spring season and decreasing in autumn season. Lead may enter rivers, lakes, and streams when soil particles are moved by rainwater and also lead is moved from the air by the rain to surface and groundwater (ATSDR, 1990, 2007). In spring season, more rainfall in Emet Stream Basin may explain the sudden rise of Pb levels in water.

There is no study about lead accumulations in Emet Stream but according to an investigation made in the Uluabat Lake, the determined Pb levels in water were about similar to the recent results (annual average was 0.025 mg/L), but the determined Pb levels in sediment were significantly lower than the recent results (annual average was 13 mg/kg) (Elmacı *et al.*, 2007). If we compare the result, it can be clearly understood that Emet Stream is a major source of lead for Uluabat Lake (Ramsar area).

Boxplots deviation diagrams show the range and mean concentrations of Pb levels in Emet Stream water and sediment in Figure 2. According to the boxplot diagram in water and sediment, the highest deviation of Pb levels were observed in spring season for water and sediment; the lowest deviation of Pb levels were observed in winter season for water and in autumn season for sediment.

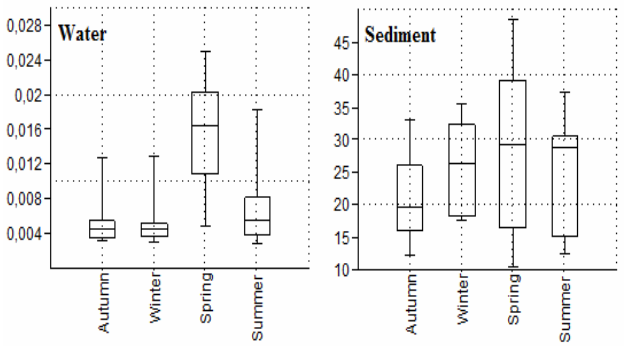
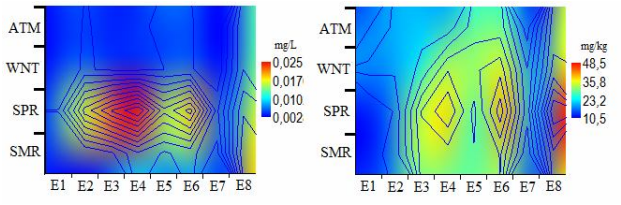


Fig. 2. Boxplots for water and sediment.

The matrixplot distribution diagrams with contour lines show the distribution of Pb concentrations in Emet Stream water and sediment for all stations and seasons (Fig. 3).



(ATM: Autumn; WNT: Winter; SPR; Spring; SMR: Summer)

Fig. 3. Matrixplots with contour lines for water (left) and sediment (right).

According to the Cluster similarity and distance analysis based on the Pb values of Emet Stream (in water and sediment), E4 and E6 stations show the highest similarity (94.4%) and E1 and E8 stations show the lowest similarity (52.4%). While the stations of E1, E2 and E7 with low Pb concentrations are forming a group with each other, the stations of E3, E4, E6 and E8 with high Pb concentrations are forming a group with each other (Fig. 4).

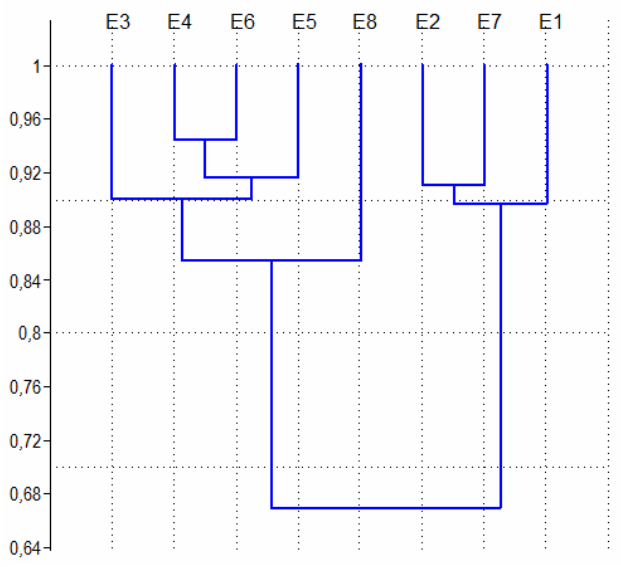


Fig. 4. Diagram of cluster analysis.

E1 and E2 stations were closed to the source of Emet Stream, so these stations were not exposed to Pb discharge as much as the other stations. E7 station was located on the Dursunbey Stream. Although E7 station was located on the down side of Dursunbey Stream, it has a low lead content. So we can say that, Dursunbey Stream is not exposed to Pb discharge and does not constitute any risk for Emet Stream Basin in term of lead.

E8 station is located in the down side of Emet Stream Basin and exposed to domestic, agricultural and industrial pollutions. These adverse effects are causing to high Pb accumulations in water, sediment and fish tissues.

Once lead falls onto soil, it sticks strongly to soil particles and remains in the upper layer of soil. That is why past and present uses of pesticides are so important in the amount of lead found in soil (ATSDR, 2007). Also, hunting activities are a significant factor for accumulation of Pb to the nature and it is known that each bullet contains 32 gr lead (Akman *et al.*, 2004). Intensive agricultural activities are carried out around the E3 and E4 stations. Excessive use of pesticides and hunting activities around the region can cause the high Pb accumulation in water, sediment and finally in biotic components of ecosystem.

Burning leaded gasoline is a large source of lead emissions and also contaminated air, soil and water (ATSDR, 2007). E6 station was located at the side of a highway. So this situation can explain the high Pb levels around this station.

E5 station was located on the Kınık Stream and far away from domestic and agricultural activities. But this stream is under pressure of Harmancık chromium mine and although it is not exposed to organic pollution, it is exposed to an important inorganic pollution.

In this study, three fish species were used as biotic components of Emet Stream to determine the bioaccumulation of Pb levels. The Pb accumulation in tissues of *S. cii* and *B. oligolepis* follows as, liver > kidney > gill > muscle; in tissues of *C. tinca* follows as, kidney > liver > gill > muscle, respectively. The highest Pb concentration of tissues were determined in E8 station (5.36 mg/kg) in liver of *S. cii* and the lowest Pb concentration of tissues were determined in E2 station (0.26 mg/kg) in muscle of *B. oligolepis*.

Pb levels that we determined in water and sediment of E7 station show that there is no significant Pb source around the region and abiotic components are not contaminated by the Pb. But the Pb levels of fish tissues in E7 station show that the bioaccumulation factor is very high for region.

The reason of high Pb levels in biotic components was the location of the station. As we say before, it was located on the Dursunbey Stream and very closed to E8 station. So fishes are affected from the Emet Stream which has a high content of lead close to E7 station.

According to the Turkish Food Codex quality criteria (TGK, 2002), the muscle tissues of all fish species caught from E2, E4, E7 and E8 stations (except *B. oligolepis* caught from E2 station) contains high levels of Pb and highly above the limit value (the limit value is 0.4 mg/kg). Pb content of muscle tissues in all fish species especially caught from E7 and E8 stations reach up to three times of the limit value. So consumption of these fish species is very dangerous for human health.

The matrixplot distribution diagram shows the distribution of average Pb concentrations in muscle, gill, liver and kidney tissues of three fish species according to the stations given in Figure 5.

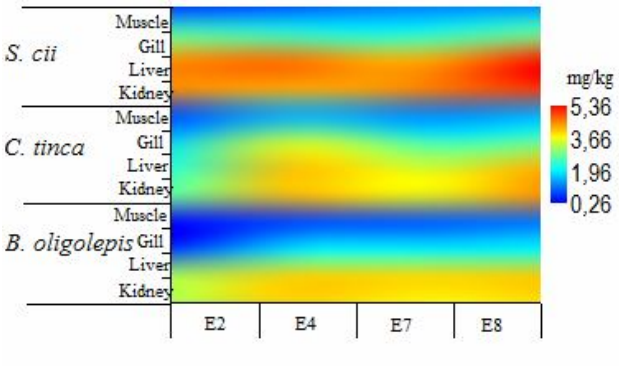


Fig. 5. Matrixplot for tissues of fish species.

Generally, the higher metal accumulation in fish tissues is seen in liver tissues and the lover accumulation is seen in muscle tissues. The metals (non-lethal concentrations) are accumulating in metabolically active tissues (Kargın and Erdem, 1992). As many researchers have identified, generally muscle tissues of fishes accumulate lead lower than metabolically active tissues (Kamaruzzaman *et al.*, 2008; Shirvani and Jamili, 2009; Kamaruzzaman *et al.*, 2011). Similar to all these literature information in this study, the lowest Pb levels were determined in muscle tissues of all fish species and the highest Pb levels were determined in liver tissues of *S. cii* and *B. oligolepis*, in kidney tissues of *C. tinca*.

CONCLUSIONS

As a result, the study clearly indicates that, the Pb accumulations of water and sediment in the entire river are rising in parallel of rainfall and although the abiotic components of system are not highly affected by the lead (except spring season), biotic components of system are highly affected. This adverse situation poses an important risk factor not only for the aquatic system but also for public health around the region.

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