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Assessment of Boron in Water, Sediment and Fish Tissues of Porsuk Stream, Turkey

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Abstract.- In this study, boron concentrations has been estimated between 2010 and 2011 in water, sediment and some cyprinid species from thirteen stations (five of them were on the Porsuk Dam Lake) of Porsuk Stream, a tributary of Sakarya River. According to our data, in general boron accumulations in Porsuk Stream follows as sediment > fish tissues > water, respectively. The highest boron concentrations of abiotic components detected in Porsuk Stream were recorded as 2.37 mg L^{-1} in station 9 for water and as 71.8 mg kg^{-1} in station 3 for sediment in summer season. Also the highest boron concentrations of biotic components detected in Porsuk Stream was recorded as 24.8 mg kg^{-1} in gill tissues of *Carassius gibelio* collected from station 9.

Keywords: Boron, Porsuk Stream, Water, Sediment, Fish tissues.

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Boron occurs naturally in rocks, some soils and coal. The borate content of surface water can be significantly increased as a result of wastewater discharges, because borate compounds are ingredients of domestic washing agents. Boron is an essential element for organisms, but can be toxic for aquatic and terrestrial organisms especially when accumulated in high concentrations. More than 60% of boron resources at the earth are found in Turkey (WHO, 1998; Özen *et al*., 2009).

Fishes are widely used as bioindicator organisms in aquatic environment. Much of the element variability in fish tissues have been attributed to variability of age, life cycle and feeding habits of species (Canbek *et al*., 2007; Özan and Kir, 2008; Uysal *et al*., 2008).

Porsuk Stream that is one of the most important tributaries of Sakarya River, is an economically important area of the northwestern of the Central Anatolia and Porsuk Dam Lake is known as a highly polluted freshwater reservoir in Kütahya/Turkey due to industrialization and urbanization. The surroundings of this lake are also very rich in boron minerals and thermal springs. The aim of this paper was to determine the boron concentrations in water, sediment and fish tissues of Porsuk Stream (including Porsuk Dam Lake).

Materials and methods

Study area and sampling methods

The selected stations on the Porsuk Stream are shown on the map (Fig. 1). Sediment and water samples were collected seasonally from 13 stations by using Ekman grab and suitable containers. Five of them were on the Porsuk Dam Lake (4.1, 4.2, 4.3, 4.4, 4.5 stations). Significant differences of boron accumulations could not be detected from selected stations on the Porsuk Dam Lake so the average values of five stations were only given in the present study. Fish samples were collected seasonally (2010-2011) from four stations by using power of 220 V Honda generator and from Porsuk Dam Lake by fishing net (*Cyprinus carpio* Linnaeus, 1758; *Squalius pursakensis* Hankó, 1925; *Capoeta baliki* Turan, Kottelat, Ekmekçi ve Imamoglu 2006; *Capoeta sieboldii* Steindachner 1864; *Carassius gibelio* Bloch 1782*; Rutilus rutilus* Linnaeus 1758, *Barbus tauricus* Kessler, 1877).

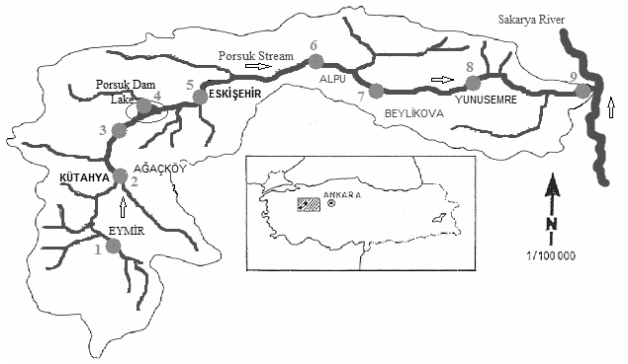


Fig. 1. Porsuk Stream Basin and selected

stations.

Chemical analysis

Water samples (1 liter) were taken at each sampling point and their pH adjusted at 2 with 2 ml of HNO_3. Sediment and fish samples were dried for 3 h at 105°C. Each sample (0.25 g) was placed in Pyrex reactors of a CEM Mars Xpress 5 microwave digestion unit. $HClO_4$:HNO_3 acids of 1:3 proportions were added in the reactor. Samples were mineralized at 200°C for 30 min. Afterwards, the samples were filtered and the volumes made up to 100 ml with ultra-pure distilled water. 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 analysis was done by using the Minitab 15 program and significant differences were determined by using SPSS 17.

Results and discussion

Boron values of water and sediment samples of Porsuk Stream are given in Table I. The highest B concentrations in water was found at station 9 in summer season (2.37 mg L^{-1}), the lowest B concentration were found at station 2 in winter season (0.024 mg L^{-1}). Boron concentration was not detected in summer season for station 7. The highest B concentration of sediment was determined in station 3 in summer season (73.2 mg kg^{-1}). The lowest B concentration of sediment was determined at station 6 in autumn season (2.9 mg kg^{-1}).

Table I.- Boron concentrations in water (Mg L^{-1}) and sediment of Porsuk stream, a tributary of Sakarya River.

Stations	Seasons			
	Spring	Summer	Autumn	Winter
Water				
1	0.09±0.00	0.0±0.002	0.04±0.004	0.04±0.00
2	0.08±0.00	0.10±0.005	0.03±0.002	0.02±0.00
3	0.15±0.00	0.26±0.003	0.23±0.04	0.06±0.005
4	0.15±0.00	0.20±0.0007	0.10±0.004	0.07±0.003
5	0.21±0.00	0.16±0.002	0.07±0.008	0.07±0.001
6	0.21±0.00	0.27±0.004	0.07±0.001	0.07±0.008
7	0.21±0.00	0.23±0.001	0.07±0.003	0.07±0.001
8	0.22±0.0	0.23±0.003	0.13±0.02	0.08±0.007
9	0.57±0.00	2.37±0.009	0.91±0.005	0.46±0.010
Sediment				
1	12.1±2.3	48±9.6	28±10.2	24.4±4.8
2	54.8±0.6	11.4±4.1	21.1±10.0	19.3±6.4
3	21.8±0.5	73.2±1.1	71.8±8.5	65.3±4.0
4	15.7±6.4	12.7±5.7	19.9±4.6	18.5±4.0
5	9.40±0.17	10.7±4.8	28.5±5.3	18.6±3.2
6	21.66±0.5	3.0±1.3	15.1±5.4	20.6±4.4
7	23.13±1.5	Nd	2.9±0.6	24.6±5.3
8	13.86±0.7	7.2±3.3	12.8±5.7	10.6±3.6
9	31.13±0.1	4.9±2.2	29.8±1.0	27.33±4.9

Mean ± Standard Error; nd: not detected.

Based on boron concentration of water (Fig. 2A), Porsuk Stream was categorized class I (< 1 mg L^{-1}) according to Turkish Environmental Legislation for all stations except for station 9. In summer season water of station 9 was of class IV category (SKKY, 2004).

Cluster analysis was used to detect similar groups (Fig. 2) according to boron contents of water and sediment. According to water, three clusters were determined. Cluster 1 contained the stations 1 and 2, cluster 2 comprised the stations 3, 4, 5, 6, 7 and 8, cluster 3 contained the station of 9. The

Table II.- Mean boron values of fish tissues (mg kg^{-1}).

Fish	Tissue	Stations				
		1	2	4	5	9
S. pursacensis	Muscle	15.1 ± 6.0	6.7±0.2	-	6.3 ± 1.1	14.7 ± 2.3
	Gill	4.5 ± 1.5	7.52±5.3	-	5.8 ± 1.3	19.9 ± 6.5
	Liver	19.4 ± 1.0	12.3.±9.8	-	1.0 ± 0.0	3.6 ± 0.8
C. sieboldii	Muscle	12.0 ± 7.1	16.7±3.4	-	-	23.9 ± 0.7
	Gill	16.8 ± 4.8	24.2±5.6	-	-	23.3 ± 0.4
	Liver	11.1 ± 2.8	12.4±5.1	-	-	-
C. baliki	Muscle	3.1 ± 1.6	-	-	-	-

	Gill	15.7 ± 6.2	-	-	-	-
	Liver	nd	-	-	-	-
B. tauricus	Muscle	0.2 ± 0.1	nd	-	-	-
	Gill	1.8 ± 0.6	3.4±1.7	-	-	-
	Liver	0.4 ± 0.2	nd	-	-	-
C. gibelio	Muscle	-	-	15.3 ± 3.6	-	14.7 ± 2.8
	Gill	-	-	15.7 ± 6.4	-	24.8 ± 3.5
	Liver	-	-	16.2 ± 4.3	-	16.1 ± 4.3
C. carpio	Muscle	-	-	23.3 ± 3.3	-	23.6 ± 1.5
	Gill	-	-	17.6 ± 4.7	-	22.1 ± 0.6
	Liver	-	-	18.7 ± 2.9	-	-
R. .rutilus	Muscle	-	-	3.1 ± 0.5	-	-
	Gill	-	-	2.4 ± 0.4	-	-

-: enough sample could not be obtained

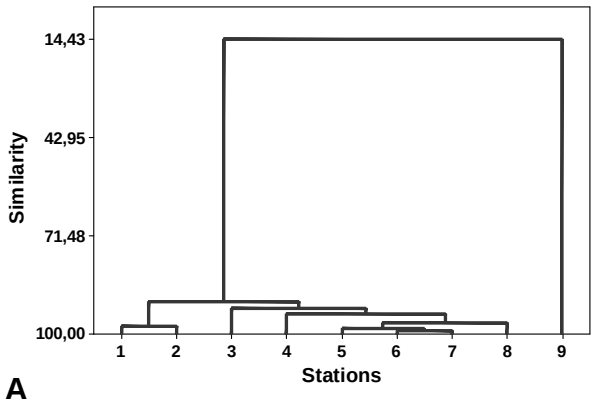
station 9 was located in the flows of Sakarya River and reflects all the discharges of Porsuk Stream. Canbek *et al*. (2007) reported that heavy metals were gradually increasing in Porsuk Stream.

Three clusters were determined according to boron contents of sediment. Cluster 1 contained the stations 4, 5, 6, 7, 8 and 9, cluster 2 comprised the stations 1 and 2, cluster 3 comprised station 3. The station 3 was located in exit of Kütahya and the agricultural, domestic and industrial wastes of Kütahya were discharged to the region.

Mean concentrations ($mg.kg^{-1}$) of B in different tissues (muscle, gill and liver) of fishes are given in Table II. Uysal (2011) reported that the levels of B in different cyprinid species in Porsuk Dam Lake and B accumulations in all tissues of species were below the detection limits of ICP-OES. In this study B accumulation in fish of Porsuk Dam Lake were found significantly higher than in other studies.

The highest B concentration was found in gill of *C. gibelio* collected from station 9 (24.8 mg kg^{-1}). The lowest B concentration was found in muscle of *B. tauricus* (0.2 mg kg^{-1}) collected from station 1. In general, gill tissues of fishes accumulate boron higher than other tissues. Gills are the first target organs to be exposed to resuspended with sediment, so gills can be significant sites of interaction with metal ions. On the other hands, the liver has a significant role in basic metabolism (Ural *et al*., 2011; Fernandes *et al*., 2007).

Results of this study could not have been compared with the levels of Turkish Food Codex Standard (TGK, 2002), because there is no information about maximum permissible boron limits in fish tissues in the Turkish Standards. Fishes, living in the polluted waters may accumulate trace metals via their food chains. The accumulation of trace elements are strongly related to the feeding habitat and life style of species (Emiroğlu *et al*., 2010; Ural *et al*., 2011). Emiroğlu *et al.* (2010) reported higher boron concentration of water, sediment and different organisms in Seydisuyu compared to our data. Seydisuyu is also one of important tributaries of Sakarya River and is significantly affected by Kırka-Boron Works.



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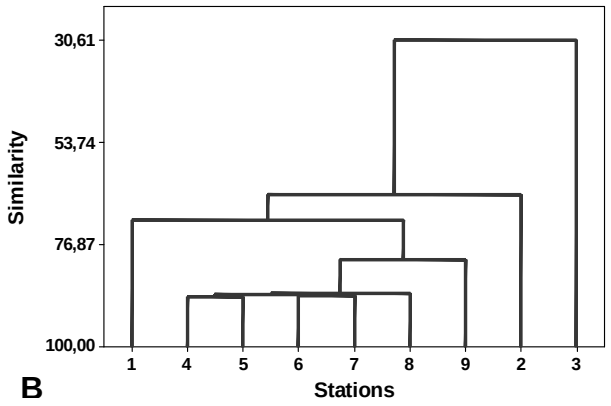

Fig. 2. Dendogram showing clustering of stations according to surface water (A) and sediment (B) of Porsuk stream

Conclusions

The results of our study indicate that the boron discharges of system affects the biotic components more than abiotics and cause significant bioaccumulation in fishes. Therefore, if this bioaccumulation continues unchecked, the biotic components of ecosystem including human around the basin are likely to be severally affected in a short time.

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