Austin Environmental Sciences

Open Access

Austin Publishing Group

Special Article - Environmental Pollution

Bioaccumulation of Heavy Elements in *Laccobius* spp. (Coleoptera: Hydrophilidae) and their Abiotic Environment from Polluted and Unpolluted Areas of Erzurum Wetlands, Turkey

Aydogan Z*, İncekara U and Gürol A
Department of Biology, Atatürk University, Turkey

***Corresponding author:** Zeynep Aydoğan, Narman Vocational School, Atatürk University, Narman, Erzurum, 25530, Turkey

Received: April 06, 2018; **Accepted:** May 09, 2018; **Published:** May 16, 2018

Abstract

During 2014 (May-September), the genus *Laccobius* spp. (Coleoptera: Hydrophilidae), water and sediment samples from the same location were collected and heavy element content of these samples were evaluated at six sampling sites of Erzurum (Turkey).Heavy element concentrations were measured by Energy Dispersive X-Ray Fluorescence (EDXRF) spectroscopy. Fourteen elements were detected at measurable levels in all the samples. *Laccobius* spp. was evaluated for the first time as a biomonitor of heavy metal pollution. The results indicated that *Laccobius* spp. were contaminated by water and sediment from their habitat, and accumulated higher concentration of elements than water and sediment, revealed their role as bioindicators of heavy element pollution. Heavy element concentration levels of the water samples were compared with national water quality guidelines. Some heavy elements' concentration was found at high level than the acceptable limits. The mean concentration of studied elements in the study region increased in the following order: in sediment samples was Zn<Co<Mn<As<Cu<Se<Ni<V<Ti<Sr<Pb<Cr<Fe; in water samples was Se<Zn<As<Br<Cu<Ni<Pb<Sr<Co<Fe<Mn<Cr<V<Ti.

Keywords: Biomonitor; EDXRF; Heavy element; *Laccobius* spp; Turkey

Introduction

Heavy element pollution is a byproduct of industrialization, urbanization and intensive usage of different chemicals in human routine activity results in damage to the food chain [1,2]. Therefore, an early detection of heavy element concentrations in ecosystem is vital for nature conservation. Heavy element residues at the poles was widespread during recent years [3].

The use of biota for monitoring quality of environment originated mainly in Europe early in this century and it has been widely used [4,5]. Bioaccumulation of elements from air, soil, water and sediment is currently evaluated with reference to some biological communities such as plankton [6], periphyton [7], fish [8], lichens, mosses [9], algae [10], plant [11], insects [12,13]. To assess and monitor the environment, bioindicators are more useful, because chemical and physical measurements provide information only on conditions when the samples were taken, whereas biologic surveillance reflects long time period conditions [14]. Bioaccumulation process defined as when chemical pollutant enters into the body of an organism, it accumulates in the organism's tissues due to non-degradable feature of chemicals [15]. Many researchers reported that benthic invertebrates are most useful in monitoring aquatic ecosystems [4,12,13]. Aquatic insects have been widely used as biomonitor systems, because they can accumulate these contaminants in measurable amounts. Even though for a long time passed over, they can reflect element concentrations [15].

Hydrophilidae also called water scavenger beetles are large family and distributed worldwide. These species can live in a wide variety of habitats and are commonly found in temporary or permanent puddles, ditches, margin of shallow lakes and ponds. Many aquatic species of Hydrophilidae, both adults and larvae are abundant in some certain habitats. The larvae are predatory or carnivorous and not scavenging, generally feeding on dipteran larvae, small crustaceans and other hydrophilid larvae. Whereas, adults are scavengers and vegetarians, usually inhabit in richly vegetated water bodies, and generally feed on dead or decaying plants also living plants, especially on algae. They are important in aquatic food chain, since fish, aquatic and birds depend on these insects [16,17]. In this study heavy element content of water, sediment, *Laccobius* spp. and distribution of *Laccobius* Erichson 1837 (Coleoptera: Hydrophilidae) was studied. *Laccobius* Erichson 1837 is one of the most diverse genus of Hydrophilidae and 257 species are known worldwide [18]. *Laccobius* spp. were evaluated previously by [19] and last status (abundance or absence) of this genus were evaluated with this study. This genus has greater swimming ability and occurs in swiftly flowing streams. They can be easily distinguished from remaining hydrophilid genera by the combination of abdomen with 6 ventrites, curved posterior tibiae, and short maxillary palpi [20]. These insects are actively moving on the water surface and are tolerant to pollution [21]. Many researchers have reported that, sediment serves as an archive to environmental pollution, because they are open access to the disposal of industrial, agricultural and domestic wastewater [22,23]. Sediment function as a reservoir for industrial contaminants and its quality is a good

Citation: Aydogan Z, İncekara U and Gürol A. Bioaccumulation of Heavy Elements in *Laccobius* spp. (Coleoptera: Hydrophilidae) and their Abiotic Environment from Polluted and Unpolluted Areas of Erzurum Wetlands, Turkey. Austin Environ Sci. 2018; 3(1): 1030.

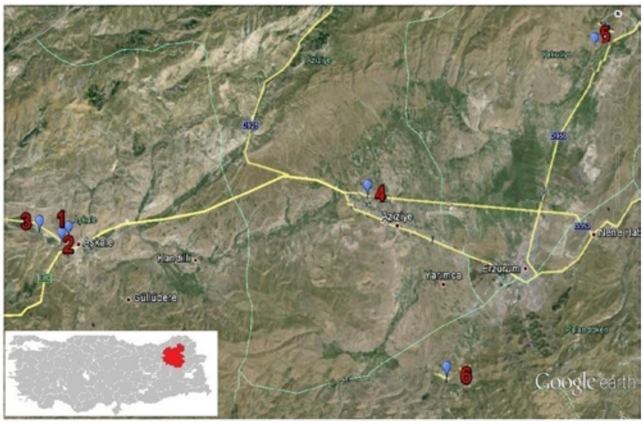

Figure 1: The six sampling points in Erzurum province.

indicator of environmental pollution. For this purpose sediment, water samples and insects were collected from selected localities of Erzurum. Because of the Aras, Çoruh and Euphrates basins originate in Erzurum province, monitoring these aquatic environments based on abiotic and biotic samples is important for conservation of Erzurum's wetlands. The study was aimed to assess the effect of pollution on water, sediment of fresh water bodies and to prove *Laccobius* spp. as a potential bioindicator of heavy element pollution.

Materials and Methods

Erzurum is a city in eastern Anatolia of Turkey and very rich in terms of water resources. In this study, six different sampling sites were selected. Information about these stations was given below (Figure 1).

Station 1: This station is located between 39°55'19 North 40°40'01 East coordinates and west of the cement plant. Altitude is 1636m. Sampling was done on the edge of Karasu River. Contamination sources are Erzurum-Trabzon highway traffic pollution and cement plantash emissions.

Station 2: It is located between 39°55'39 North 40°40'41 East coordinates east of the cement plant. Altitude is1669m. Source of pollution is less intense traffic and ash emissions from cement plant. Aquatic habitat was small brook.

Station 3: This station is located Aşkale-Trabzon road, between 39°55'41North 40°38'44 East coordinates. Altitude is 1636m. Stream source of pollution is traffic.

Station 4: This station is located Erzurum-Ilıca road, between 39°59'11 North 41°09'21 East coordinates. Altitude is 1753m. Stream source of pollution is effluents from sugar factory and traffic.

Station 5: This station is located between 40°05'34 North 41°22'37 East coordinates, 28 km away to Erzurum center. Altitude is 1819m. Due to extensive farming and livestock management the effluent to water bodies is livestock, agricultural and domestic wastes.

Station 6: This station is located Erzurum-Çat road, between 39°48'49 North 41°09'45 East coordinates. Teke Stream altitude is 1981m. There is no traffic and also settlements around it. Therefore it is intended as clean sampling point.

Table 1: The error sources in the experimental results.

Nature of Uncertainty	Uncertainty (%)
Counting Statistics	~1.00
Systematic errors	~2.00
Peak evaluation procedure	~3.00
Fundamental parameter methods	~3.00

Sample collections were done from six different locations in Erzurum, between May-September 2014. As described in [24] insects were collected via1 mm mesh aperture sieve and mouth aspirator then stored in 70% alcohol and station information labeled in the field. In the laboratory, before identification, insects humidified 1-2 hours in petri dishthen grass and sand on the insects were cleaned via paint brush. Male genitalia were dissected under stereo microscope for identification. Identification was made by first author and certificated by second author with the aid of Hansen [20]. Five species belonging to genus *Laccobius* Erichson 1837 (Hydrophilidae: Coleoptera) were determined. The following species were recorded: *Laccobius* (Dimorpho *laccobius*) syriacus Guillebeau 1896, *Laccobius* (D.) *simulatrix* D'orchymont 1932, *Laccobius* (D.) *bipunctatus* (Fabricius 1775), *Laccobius* (D.) *sculptus* D'orchymont 1935, and *Laccobius* (D.) *sulcatulus* Reitter 1909.Insect samples were collected only in summer months due to marginal ice condition of other months. Benthic zone sediment was taken via plastic shovel, put into a glass bottle in 30 cm depth. Water glass bottles washed 4-5 times with the study area water then filled with water. Then, the samples were kept in the refrigerator until analysis.

The data were subjected to the Mean ± SD variances using SPSS statistical package programs version 10.0 to perform the analysis. Elemental analyses were made by using EDXRF. Insect and sediment samples were dried in an oven at 80°C during 36 hour. Dried insects were pulverized in mortar and cellulose was added. Cellulose helps to form a shape. Proportion of cellulose changes according to the insect size. Insect size and proportion of cellulose do not affect the measurement of EDXRF. Pulverized insect poured into a DIE set, which has 13 mm diameter, then put in a press machine and then applied five tons pressure. For emit photons, an Al sample holder with Mylar films on both sides were used for water and sediment samples. Samples were irradiated by 59.5 keV photons, emitted by 1 Ci241Am radioactive source. X-ray spectra were collected with HPGe detector which use Genie-2000 software (Canberra) program. HPGe detector resolution is ~180 eV. The irradiation time was 14.400 s for water and sediment, 43.200 s for insect samples. Source/Sample distance was 35.5 mm.To eliminate elements on air, all measurements were carried out under vacuum. The spectral data were stored on disks, and the concentration of elements in each samples were determined by Win AXIL software (Canberra) and WinFund software package (Canberra), which use the Fundamental Parameters Method (FPM) for quantitative analysis. Possible error sources for some uncertainties due to EDXRF (maximum ~5%) are listed in (Table 1).

Results

Hydrophilidae are distributed throughout Turkey. Different kind of aquatic habitat such as streams, pools, dams and drains have a population of one or more species. Among 25 spp. of *Laccobius* in Turkey, 11 were recorded previously in Erzurum [19]. In this study,

Table 2: Heavy element content (Mean ± SD) in water, sediment and insect samples (ppm).

Station	Samples	Heavy Element (Mean ± SD)													
		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Se	Br	Sr	Pb
1	Water	436 ±6.55	82.6 ±4.50	22 ±2.64	6.20 ±0.26	2.96 ±0.15	1 ±1	0.3 ±0.2	0.36±0.15	0 ±0	0.2 ±0.1	0 ±0	0.34±0.14	0 ±0	1.76 ±0.2
	Sediment	1.76 ±0.25	0.32 ±0.11	849±6.02	0 ±0	0.13 ±0.06	0 ±0	20 ±2	9.2±0.25	4.90 ±0.65	9.56 ±0.4	10 ±0.51	5.03 ±0.45	9.6 ±0.36	10.8 ±1.04
	Laccobius syriacus	130.4±0.52	22.7 ±0.25	19.7 ±0.3	6.6 ±0.45	2.7 ±0.25	1.26 ±0.2	0.57 ±0.09	0.3 ±0.04	0.16 ±0.05	0 ±0	0.4 ±0.01	0.18 ±0.07	317.3 ±3.05	612.6 ±2.94
	Laccobius simulatrix	125 ±2.5	22.7 ±0.65	25 ±0.26	8.9 ±0.36	3.8 ±0.2	5.03 ±0.3	0.69 ±0.18	0.33 ±0.1	0.19 ±0.09	0 ±0	0.34 ±0.2	0.25 ±0.13	415.6 ±3.51	0.16 ±0.05
2	Water	322 ±20	63.8±2.75	14.6±2.51	4.9±0.65	2.23±0.25	0.03±0.02	0.5±0.1	0.13±0.05	0.2±0.1	0.23±0.15	0±0	0.25±0.13	0±0	1.96±0.2
	Sediment	1.26±0.25	0±0	663.6±13.4	231.3±12.5	244±4.58	8.86±0.41	15±3	7.53±0.45	3.73±0.37	7.36±0.77	8.26±0.30	3.63±0.55	9.5±0.5	2.53±0.5
	Laccobius bipunctatus	98.4±1.27	0±0	4.26±0.25	1.3±0.26	0.73±0.2	0±0	0.1±0	0±0	0±0	0±0	0±0	0.1±0.001	0.003±0.002	1.43±0.2
	Laccobius sculptus	17.5±0.5	0±0	0.5±0.2	0.16±0.05	0.1±0	0±0	0±0	0±0	0±0	0.02±0.009	0±0	0.01±0.004	0±0	0.26±0.1
	Laccobius sulcatulus	5.49±0.19	0±0	0.14±0.08	807.6±3.51	717.6±2.51	122±1	51±1.6	26.4±0.5	38.6±0.45	22.8±0.75	27.6±0.35	161.6±1.52	3.96±0.45	369.6±1.5
	Laccobius syriacus	0.11±0.01	0±0	50.5±0.81	0±0	42.3±1.52	0±0	1±0.1	0.51±0.08	0.43±0.11	0.43±0.30	0.4±0.2	1.2±0.25	0.11±0.02	9.6±0.5
	Laccobius simulatrix	2.7±0.25	0±0	0.12±0.02	372±2	728.6±4.16	0±0	27±3	12.2±0.25	17.5±0.45	11.6±0.52	12.1±0.41	23.4±1.5	1.8±0.15	192±2
3	Water	796.8±5	140.5±8	10.2±0.25	10.1±0.76	4.8±0.4	1.8±0.28	0.7±0.26	0.26±0.15	0.2±0.1	0.23±0.15	0±0	0.23±0.05	0±0	3.23±0.2
	Sediment	0.29±0.11	745.3±82.3	0±0	42±19	325±27.8	0±0	5.53±1.56	0±0	0.93±0.2	2.03±0.15	2.03±0.5	1.03±0.25	1.93±0.47	0.5±0.3
	Laccobius bipunctatus	2.08±0.08	0±0	917.6±2.51	0±0	309±8.5	0±0	19.23±0.25	9.5±0.51	13.16±2.84	8.73±0.25	10.3±0.26	77.6±2.51	0.63±0.15	195.6±4.9
4	Water	402.3±3.21	80.6±0.57	17.5±1.32	5.8±0.28	2.2±0.26	0.6±0.26	0.43±0.11	0.13±0.05	0±0	0.12±0.03	0±0	0.12±0.03	0±0	1.93±0.1
	Sediment	0.3±0.05	0±0	0±0	0±0	657±2.57	0±0	4.93±0.6	2.2±0.26	1±0.05	1.96±0.2	2.2±0.26	1.2±0.26	1.6±0.52	0.56±0.2
	Laccobius sulcatulus	4.93±0.40	0.71±0.21	0.13±0.05	0±0	909.3±3.05	0±0	37.8±1.89	20±1	10.5±0.5	16.5±1.5	20.6±0.79	31.3±1.5	2.4±0.35	192.6±2.5
	Laccobius syriacus	954±4.58	178.6±3.05	37.16±1.75	0±0	26.6±1.52	0±0	0.63±0.15	0.4±0.1	0.25±0.09	0.33±0.20	0.3±0.1	1.03±0.15	0.02±0.02	6.26±0.2
5	Water	573.6±3.51	0±0	25.6±0.76	6.96±2	3.9±0.26	1.23±0.25	0.66±0.2	0.2±0.1	0±0	0.2±0.1	0±0	0.27±0.06	0.23±0.05	2.9±0.36
	Sediment	0.43±0.2	0.1±0.1	0±0	69.6±1.5	949±6.55	0±0	5.73±1.1	0±0	1.43±0.2	3.26±0.25	3.56±0.51	2.96±0.55	5.33±0.15	1.03±0.05
	Laccobius simulatrix	0.17±0.06	429.8±1.75	91.3±1.89	26.9±1.78	15.8±0.26	0±0	1.93±0.3	0.7±0.2	0.73±0.37	0.6±0.1	0.93±0.11	5.13±0.61	0.1±0	8±0.2
	Laccobius bipunctatus	600±6.5	112.3±2.08	22±2	0±0	10.5±0.6	0±0	0.36±0.15	0.16±0.05	0.21±0.12	0.2±0	0.13±0.05	0.36±0.19	0.02±0.01	4.03±0.15
	Laccobius syriacus	1.99±0.55	0±0	888.3±5.68	285±5.56	315.6±4.04	42±3.60	16.3±1.89	10.2±1.66	6.93±0.4	8.23±0.25	9.36±0.85	21±1.04	1.06±0.4	114.6±2.5
6	Water	95±3	15.5±2.5	22.6±5.85	8.63±1.06	3.8±0.26	0±0	0.71±0.22	0.43±0.11	0.22±0.04	0±0	0.36±0.05	0±0	310±3	656±5.29
	Sediment	67.3±2.51	11.16±0.76	13.3±1.99	5.41±0.36	0±0	0±0	12.03±1.37	0.27±0.06	0.52±0.14	0±0	0±0	0±0	213.3±3.05	511.5±3.77
	Laccobius bipunctatus	24.9±2.73	0±0	2.38±0.34	0.67±0.16	0.93±0.11	0.18±0.10	889±10.1	334±4	181.6±5.13	695±5	0±0	200±3.51	26±3.6	915.1±5.83

only five species belonging to genus *Laccobius* were determined. In total, 236 specimens from six stations in Erzurum were collected and analyzed for contaminants. The concentrations of these elements were found to vary in all samples. The results showed that element concentration in the *Laccobius* spp. showed differences in accordance to the sediment and water contamination of the each station. Concentrations of Ti, Ni and Pb were measured in all stations' water, sediment and insects samples. The most abundant specie was *Laccobius simulatrix*, followed by *Laccobius syriacus* 48.3% and 26.6% respectively. On the other hand *Laccobius sculptus*hadless population (0.84%). Ti, Cr, Fe, Br and Pb were measured in all insects. Heavy element concentration in water samples indicated that in water of stations 3 had the highest level of Ti, and in water of Station 6 had the highest level of Pb, Sr. In all other studied water samples had Cr, Mn, Fe, Ni, Cu concentration. The rest of the heavy elements in water samples, that is V, Co, Zn, As, Se and Br had lowest concentration. Except insects, Station 3 sediment heavy element contents indicated that V had the highest concentration among the fourteen elements; in Station 1 and 2 sediments, Cr had the highest level; in Stations 2, 3 and 5 sediments, Mn had the highest level; in Station 2, 3, 4 and 5 sediments, Fe had the highest level; in sediment of Station 6 Sr level was the highest. Co measured only in Station 2sediment.Zn and Br had the nearly same level in all sediments. The rest of the heavy elements had the lowest level. According to the results in insects, L. *bipunctatus* is the best accumulator for some certain elements, L. *sulcatulus* followed it.Cr, Ni, Cu, Zn, As, Br and Pb were measured in L. *bipunctatus* in highest level. Also L. *sulcatulus* is the best accumulator in regard to Mn, Fe, Co and Se. The highest level of V and Sr were measured inL. *simulatrix* and L. syriacus. The highest level of Ti was measured inL. syriacus. Ti, Cr, Mn, Fe, As, Br and Pb were only measured in L. *sculptus*, but the levels of these elements were not considerable. As it seen in Table 2, Ti, Cr, Fe, Ni, Cu, Zn, Se, Br, Sr and Pb were the most abundant elements in the *Laccobius* spp. In the station 1, L. syriacus and L. *simulatrix* have high contamination of titanium, vanadium, chromium, and the same happens in water. In the station 2 was the most diverse, have the five insect species collected, among the stations; L. syriacus, L. *simulatrix* and L. *sulcatulus* have less metal contamination of titanium, vanadium, strontium, although except Sr the water were high; others like L. *simulatrix* and L. sulcatus have high contamination of iron and manganese, the same happens in sediment.

Table 3: Results of elements tested in water were compared with national regulation (TWPCR) (ppm).

Heavy Elements	1. Station	2. Station	3. Station	4. Station	5. Station	6. Station	TWPCR (µg/L)			
							I	II	III	IV
Pb	1.76 ±0.2	1.96±0.2	3.23±0.2	1.93±0.1	2.9±0.36	656±5.29	10	20	50	>50
As	0.2 ±0.1	0.23±0.15	0.23±0.15	0.12±0.03	0.2±0.1	0±0	20	50	100	>100
Cu	0.36 ±0.15	0.13±0.05	0.26±0.15	0.13±0.05	0.2±0.1	0.43±0.11	20	50	200	>200
Cr	22 ±2.64	14.6±2.51	10.2±0.25	17.5±1.32	25.6±0.76	22.6±5.85	20	50	200	>200
Co	1 ±1	0.03±0.02	1.8±0.28	0.6±0.26	1.23±0.25	0±0	10	20	200	>200
Ni	0.3 ±0.2	0.5±0.1	0.7±0.26	0.43±0.11	0.66±0.2	0.71±0.22	20	50	200	>200
Zn	0 ±0	0.2±0.1	0.2±0.1	0±0	0±0	0.22±0.04	200	500	2000	>2000
Fe	2.96 ±0.15	2.23±0.25	4.8±0.4	2.2±0.26	3.9±0.26	3.8±0.26	300	1000	5000	>5000
Mn	6.20±0.26	4.9±0.65	10.1±0.76	5.83±0.28	6.96±2	8.63±1.06	100	500	3000	>3000
Se	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0.36±0.05	10	10	20	>20
Ba	0.0071	0.0053	0.0114	0.000182	0.0093	3.3	1000	2000	2000	>2000

stations 3 and 6 have the same insect species (L.bipunctatus), and both have high contamination of lead, the same happens in water and sediment; station 4 L. syriacus have high contamination of titanium and vanadium, the same happens with water, and L. *sulcatulus* have high contamination ofiron, the same happens in the sediment; station 5 L. *bipunctatus* has high contamination of titanium, the same happens in water; L. syriacus has high contamination of iron and manganese, and the same happens in sediment and water.The element concentration showed a general trend of Se<Zn<As<Br<Cu <Ni<Pb<Sr<Co<Fe<Mn<Cr<V<Ti in water and Zn<Co<Mn<As<C u<Se<Ni<V<Ti<Sr<Pb<Mn<Cr<Fein sediment samples.

In Station 6 where the human activity is limited, Pb, As, Cu, Cr, Co, Ni, Mn and Se residues determinates the extent of the element spread in Erzurum. When the results were compared to Turkish Water Pollution and Control Regulation [25], these results signify that the water bodies are highly polluted (IV). But the waters are high quality water (I) in regard to Zn and weakly polluted water (II) in regard to Fe. As it seen in (Table 3) there are four quality classes: high quality water (I), weakly polluted water (II), polluted water (III) and highly polluted water (IV) [25]. According to (Table 3), all stations' waters have highly polluted (IV) with regard to Pb, As, Cr; highly polluted water quality (IV) and polluted water quality (III) in regard to Cu, Co; highly polluted water quality (IV) in regard to Ni but except to this 4th Station which has pollution free (I) in regard to Zn and Ba but except to this 6th Station which has high polluted water quality (IV). Se concentration measured only 6th station and has highly polluted water quality (IV). 1th and 2nd stations have III and IV water quality level in regard to Pb, As, Cr, Cu, Co, Ni and Mn, this can due to cement factory and also highway traffic. 3th Station has IV water quality level in regard to Pb, As, Cu, Cr, Co, Ni and Mn, Aşkale-Trabzon highway may lead to this. 4th Station has IV water quality level in regard to Pb and Cr this can be due to sugar factory wastes and also traffic due to Erzurum-Ilıca road. 5th Station has IV water quality level in regard to Pb, As, Cu, Cr, Co, Ni and Mn, this can be due to traffic and domestic pollution. 6th station, where there is no industry around it and human activity is limited, has IV water quality level in regard to Pb, Cu, Cr, Co, Ni, Mn, Se and Ba. Ba measured only the water of 6th stations and its water quality level is IV. In all samples, Ce, Mo, Sn, In, Ba, Nb, Pm and Pd elements and their concentrations (ppm) were measured but their concentrations were below EDXRF detection limit.

Discussions

In this study, concentration of heavy element in the water, the sediment and aquatic insect due to anthropogenic activity were measured. Also, potential use of some *Laccobius* spp. as biomonitor for heavy element pollution was evaluated. *Laccobius* spp. was evaluated for the first time as a biomonitor of heavy metal pollution. The study shows that the heavy element concentrations in sediments varied significantly. The sediments of station 1, 2 and 3 are enriched with these elements and byproduct of human activities (industrial, traffic and agricultural). Besides to sediment quality, water quality played a key role in space richness of *Laccobius* spp. because the contaminant residues in biologic materials reflect quality of environment [26]. *Laccobius* is a suitable species as bioindicator. Because it is; cosmopolitan; easily identifiable; represented in high abundance and wide spread in all over the monitoring area; have numerical abundance. Our study is in agreement with the earlier reports [12,13] and *Laccobius* spp. embodies all these criteria. Also as it is seen (Table 2) that aquatic beetles accumulate some elements in higher levels than their environments, hence these beetles can be useful tool for environmental monitoring studies. Most literature supports the fact that some aquatic insects are quite sensitive whereas others tolerant to pollution. Resulted degradation of aquatic environment and element concentrations in aquatic environments lead to a reduction of these insects' richness and abundance. [27] reported that industrial and mining activities alter water beetle populations, [28] noted that the insects impacted by sugar cane cultivation, [29] in their studies showed that pollutants in the environment, resulted in obvious changes in biochemical processes and cytogenetic parameters and this will affect growth competence of insects, thus decrease in both richness and diversity of insects. Decreasing species level in *Laccobius* spp. as compared to [19] can be explained the current pollution statius of Erzurum province. Thus, our results are in accordance with the same studies.

Conclusion

When all of the findings are summarized, results confirm that

Laccobius spp. accumulate more elements than their environments and can play important role to transport the elements from the sediments up into food web. These insects take up elements in excess of their need or they do not need such as Pb, As and accumulate these elements at higher concentration than their surrounding environments. As a food source of fishes, birds these insects represent a dangerous link for the transference of elements to upper trophic levels and finally to human. Analysis of the heavy element status of the sediment and water complemented the study. The accumulations of elements in the sediments reduce environmental quality and leads to bioaccumulation of elements by aquatic organisms. Despite being widely disturbed in Turkey, there is no *Laccobius* spp. based study to assess ecological quality. [19] recorded 11 spp. of *Laccobius* from Erzurum region. In this study were collected only 5 species. This decrease can be due to wide spread pollution in Erzurum. This pollution may cause in a near future severe damage to Erzurum wetlands and also other aquatic communities. Many of the measured heavy elements may have detrimental effects to the environment include human health. Thus, understanding the status and level of heavy element pollution is the basic idea for remediating the pollution from the environment. If pollution prevention does not occur, environmental pollution damage, decreasing of tourism activities, public health risk will rise in the future.

Acknowledgments

This work was supported by Atatürk University Scientific Research Project (SRP) under grant (162/2012), and is a part of first author's Ph. D. Thesis. The authors express their sincere gratitude to Dr. Buğrahan EMSEN in department of Biology at the University of Karamanoğlu Mehmet Bey, for statistical analysis of samples.

References

1. Waseem A, Arshad J, Iqbal F, Sajjad A, Mehmood Z, Murtaza G. Pollution status of Pakistan: a retrospective review on heavy metal contamination of water, soil, and vegetables. BioMed research international. 2014.
2. Islam MS, Ahmed MK, Habibullah-Al-Mamun M. Determination of heavy metals in fish and vegetables in Bangladesh and health implications. Human and Ecological Risk Assessment: An International Journal. 2015; 21: 986-1006.
3. Dietz R, Riget F, Born EW. Geographical differences of zinc, cadmium, mercury, and selenium in polar bears (Ursus maritimus) from Greenland. Sci Total Environ. 2000; 245: 25-47.
4. Cairns JJ, Pratt JR. A history of biological monitoring using benthic macroinvertebrates. Freshwater Biomonitoring and Benthic Macroinvertebrates.1993.
5. Metcalfe-Smith JL. Biological water-quality assessment of rivers: use of macroinvertebrate communities. Calow Pand Petts GE, editors. In: Hydrological and Ecological Principles. Blackwell Science Ltd, Oxford. 1994.
6. Luoma SN, Johns C, FisherNS, Steinberg NA, Oremland RS, Reinfelder JR. Determination of selenium bioavailability to a benthic bivalve from particulate and solute pathways. Environ Sci Technol. 1992; 26: 485-491.
7. Patrick R, Palms J, Kreeger D, Harris C. Twenty-five-year study of radionuclides in the Susquehanna River *via* periphyton biomonitors. Health physics. 2007; 92: 1-9.
8. Uysal K, Köse E, Bülbül M, Dönmez M, Erdoğan Y, Koyun M, et al. The comparison of heavy metal accumulation ratios of some fish species in Enne Dame Lake (Kütahya/Turkey). Environ Monit Assess. 2009; 157: 355-362.
9. Loppi S, Bonini I. Lichens and mosses as biomonitors of trace elements in areas with termal springs and fumarole activity, Mt. Amiata, central Italy. Chemosphere. 2000; 41: 1333-1336.
10. Ali AY, Idris AM, Ebrahim AM, Eltayeb MA. Brown algae (Phaeophyta) for monitoring heavy metals at the Sudanese Red Sea coast. Applied Water Science. 2017; 1-8.
11. Bonanno G, Borg JA, Martino VD.(). Levels of heavy metals in wetland and marine vascular plants and their biomonitoring potential: A comperative assessment.Science of The Total Environment. 2017; 576: 796-806.
12. Nehring BR. Aquatic insects as biological monitors of heavy metal pollution. Bulletin of Environmental Contamination & Toxicology. 1976; 15: 147-154.
13. Bonada N, Prat N, Resh VH, Statzner B. Developments in aquatic insect biomonitoring: A comparative analysis of recent approaches.Annual Review of Entomology. 2006; 51: 495-523.
14. Rosenberg DM, Resh VH. Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York. 1993.
15. Markert B, Wappelhorst O, Weckert V, Herpin U, Siewers U, FrieseK, et al. The use of bioindicators for monitoring the heavy metal status of the environment.Journal of Radioanalytical and Nuclear Chemistry. 1999; 240: 425-429.
16. Anderson JME. Aquatic Hydrophilidae (Coleoptera).The biology of some Australian species with descriptions of immature stages reared in the laboratory. Australian Journal of Entomology.1976; 15: 219-228.
17. Smetana A. Review of the family Hydrophilidae ofCanada and Alaska (Coleoptera). Memories of the Entomological Society of Canada.1988; 120: 3-316.
18. Bilton DT, GentiliE. *Laccobius leopardus sp*. nov. from the Western Cape of South Africa (Coleoptera: Hydrophilidae). Zootaxa. 2014; 3835: 397-400.
19. Darılmaz MC, İncekara Ü. Checklist of Hydrophiloidea of Turkey (Coleoptera: Polyphaga). Journal of Natural History. 2011; 45: 685-735.
20. Fikáček M, Gentili E, Short AEZ. Order Coleoptera, family Hydrophilidae. Arthropod fauna of the UAE. 2010; 3: 135-165.
21. Hansen M. The Hydrophiloid beetles phylogeny, classification and a revision of the genera (Coleoptera, Hydrophiloidea). Biol Skr, Copenhagen.1991.
22. Yu RL, YuanX, ZhaoYH, HuGR, TuXL. Heavy metal pollution in intertidal sediments from Quanzhou Bay, China. Journal of Environmental Science. 2008; 20: 664-669.
23. ZhangWG, FengH, ChangJN, QuJG, XieHX, YuLZ. Heavy metal contamination in surface sediments of Yangtze River intertidal zone: An assessment from different indexes. Environmental Pollution. 2009; 157: 1533-1543.
24. Aydoğan Z, Gürol A, İncekara Ü. The investigation of heavy element accumulation in some Hydrophilidae (Coleoptera) species. Environ Monit Assess. 2016; 188-204.
25. TWPCR. Turkish water pollution control regulations-25684 (in Turkish). Ministry of environment and urbanization. 2004.
26. Wang X, ZhangL, Zhao Z, Cai Y. Heavy metal contamination in surface sediments of representative reservoirs in the hilly area of southern China. Environmental Science and Pollution Research. 2017; 24: 26574-26585.
27. Eyre MD, Carr R, Mcblane RP, Foster GN. The effects of varying site-water duration on the distribution of water beetle assemblages, adult and larvae (Coleoptera: Haliplidae, Dytiscidae, Hydrophilidae). Arch Hydrobiol. 1992; 124: 281-291.
28. Corbi JJ, Froehlich CG, Strixino ST, Santos A. Bioaccumulation of metals in aquatic insects of streams Located in areas with sugar cane cultivation. Quim Nova São Paulo. 2010; 33: 644-648.
29. El-Moaty Z, Kheirallah D, Elgendy D. Impact of Cement Dust on Some Biological Parameters of Trachyderma hispida (Coleoptera: Tenebrionidae) Inhabiting the Vicinity of a Cement Factory, Mariout Region, Alexandria, Egypt.Journal of Entomology and Zoology Studies. 2016; 4: 797-805.