Cumhuriyet Science Journal

Cumhuriyet Sci. J., 44(3) (2023) 567-582
DOI: https://doi.org/10.17776/csj.1269391

| csj.cumhuriyet.edu.tr | Founded: 2002 ISSN: 2587-2680 e-ISSN: 2587-246X Publisher: Sivas Cumhuriyet University

Exploration of Seasonal Metal Pollution in Karacaören II Dam Lake Sediment Samples using X-ray Fluorescence Method

Gokhan Apaydin[1,a], Oguz Kagan Koksal[2,b*], Erhan Cengiz[3,c], Murat Sirin[4,d], Hasan Baltas[4,e], Engin Tirasoglu[1,f]

[1] Department of Physics, Faculty of Science, Karadeniz Technical University, 61080, Trabzon, Türkiye
[2] Department of Electrical Electronics Engineering, Faculty of Engineering, Adiyaman University, 02040, Adiyaman, Türkiye
[3] Department of Fundamental Science, Faculty of Rafet Kayis Engineering, Alanya Alaaddin Keykubat University, 07425, Antalya, Türkiye
[4] Faculty of Arts and Science, Department of Physics, Rize Recep Tayyip Erdoğan University, 53100, Rize, Türkiye
**Corresponding author*

Research Article

History
Received: 22/03/2023
Accepted: 07/07/2023

ABSTRACT

In this study, the seasonal metal pollution of sediment samples taken from twelve distinct notes of the Karacaören II Dam Lake was examined. The quantity of metal in soil samples was determined using energy dispersive X-ray fluorescence spectroscopy. The geoaccumulation index and enrichment factor expressions were created using the metal concentrations found in the sediments. Seasonal values at the local, state, and international levels were compared to the findings. The ratios of the elements copper, zinc, lead, arsenic, nickel, chromium, and mercury, measured in parts per million (ppm), were found to be 42-96, 53-78, 11-14, 4-7, 233-244, and 611-711, respectively. There is also discussion of the sediments' elemental composition and degree of pollution. In contrast, it was found that the Urbach energy increased from 0.246 eV to 0.630 eV with increasing levels of V2O5. These synthetic glasses' densities and molar volumes were also investigated and discussed.

Keywords: Karacaören II dam lake, Sediment, Heavy metal, Pollution, ED-XRF.

[a] *gapaydin@ktu.edu.tr* *https://orcid.org/0000-0002-4647-344X*
[b] *okoksal@adiyaman.edu.tr* *https://orcid.org/0000-0003-2671-6683*
[c] *erhan.cengiz@alanya.edu.tr* *https://orcid.org/0000-0002-4094-5784*
[d] *murat.sirin@erdogan.edu.tr* *https://orcid.org/0000-0001-6864-752X*
[e] *hasan.baltas@erdogan.edu.tr* *https://orcid.org/0000-0002-1939-8253*
[f] *engint@ktu.edu.tr* *https://orcid.org/0000-0001-7953-5638*

Introduction

Land use, chemical use, population growth, and distribution all have an impact on the environment. Sediments play a significant role in determining the level of contamination in aquatic systems [1]. They represent the history of pollution by acting as both toxin transporters and sinks, providing a record of watershed inputs into aquatic ecosystems [2, 3]. Metals are among the pollutants that have a substantial environmental impact. They accumulate in suspended particles and sediment instead of being eliminated from water by self-purification, which allows them to enter the food chain by being eaten by higher-level species [4, 5]. They are a constant in aquatic environments, moving only within different regions of them [6].

Using the energy dispersive X-ray fluorescence technique, sediment pollution in Lake Victoria has been linked to anthropogenic activity [7]. Additionally, to study heavy metal pollution, surface sediments from the Suez Gulf [5], Seyhan Dam [8], Egirdir Lake [9], and and Wadi Al Arab Dam [4] were statistically analyzed. Dam lakes are essential for irrigation and the supply of drinking water. Karacaören Dam Lake is one of Turkey's most important dam lakes. Numerous investigations have shown that heavy metal contamination, especially in aquatic environments, has been present on a global scale for more than ten years. What makes this dam notable is the lack of a scientific assessment of the level of pollution.

Marine habitat contamination is still a serious ecological issue on a global scale. The two primary sources of pollution are man-made and natural sources. The main causes of natural pollution are wave action, glacier erosion, ore-bearing rocks, metals released from sediments by chemical reactions, wind-blown dust, forest fires, chemical leaching of bedrock, water drainage basins, runoff from banks, and small amounts of vegetation. The primary sources of anthropogenic emissions include mining operations, industrial waste disposal, fossil fuel consumption in automobiles, and the smelting and refining of metals [10-14]. Anthropogenic sources, particularly those near coastal sediment, have a considerable impact on the metal's production [15]. As a result, sediments in marine environments can teach aquatic systems about heavy metal pollutants.

The pollution of heavy metals has a big impact on how contaminated aquatic systems are. It is generally known that sediments play a crucial role in the entry of heavy metals into the marine ecosystem [16, 17]. Sediment is therefore essential in determining the extent of heavy metal contamination in the marine environment [18, 19].

Using Karacaören-I Dam Lake as a case study, an investigation of a small-scale rainbow trout farm

(Oncorhynchus mykiss Walbaum, 1792) in Turkey's inland waters was done [20]. Trace metals in sediment and water, as well as their bioaccumulation, were studied in samples of carp (Cyprinus carpio L., 1758) obtained from the Karacaoren (I) Dam Lake in Turkey [21]. The fatty acid makeup of the muscle lipids of five fish species from Turkey's Işıklı and Karacaören Dam Lakes was examined [22]. Checking for the presence of heavy metals and metal levels in five distinct fish species from Işkl Dam Lake and Karacaören Dam Lake in Turkey [23]. For Turkey's Pikeperch (Sander lucioperca Linnaeus, 1758), changes in the population structure of Karacaoren-I Dam Lake were examined [24]. The mortality ratio and stock of the vimba (Vimba vimba tenella (Nordmann, 1840)) species in Karacaoren I Dam Lake were investigated (Burdur-Turkey) [25]. An analysis of the biological traits, chemical make-up, and meat yield of the Vimbra (Vimba vimba tenella (Nordmann, 1840)) population in the Karacaören I Dam Lake was conducted [26, 27]. The importance of the lake is increased by the desire to use it as a water source, but there is a lack of evidence that the lake is polluted, which has attracted attention. This investigation is important for revealing the pollution in sediments.

Recent years have seen a rise in the significance of technological research in preventing environmental contamination. Our concern for the environment has sparked the development of technologies like electric cars and renewable energy sources. Despite how important these developments are, there is still the problem of identifying and remediating environmental harm. This study is essential for determining the area's risk of environmental pollution and for providing information for further research.

Materials and Methods

Sample Locations

Despite the fact that the Karacaören II Dam Lake was initially built to meet the needs for irrigation and energy, it is thought to be used today for drinking water. When the area is geologically analyzed, it is known that it contains minerals like copper, lead, and zinc, according to statistics from the MTA agency. Along with these contaminants, cage fishing is reportedly practiced in a number of towns, parks, highways, and man-made structures. In order to evaluate the entire lake using the study's findings, twelve sampling stations were chosen. The road, the agricultural area, the residential area, etc. were all taken into account when choosing the points, as well as the fact that the intervals were almost equal. Coordinates are given based on the features. The coordinates and maps for these twelve locations are shown in the graphic below. Samples will be available for four seasons. The locations shown in Figure 1 were the sites where the sediment samples were collected in May, August, November, and February.

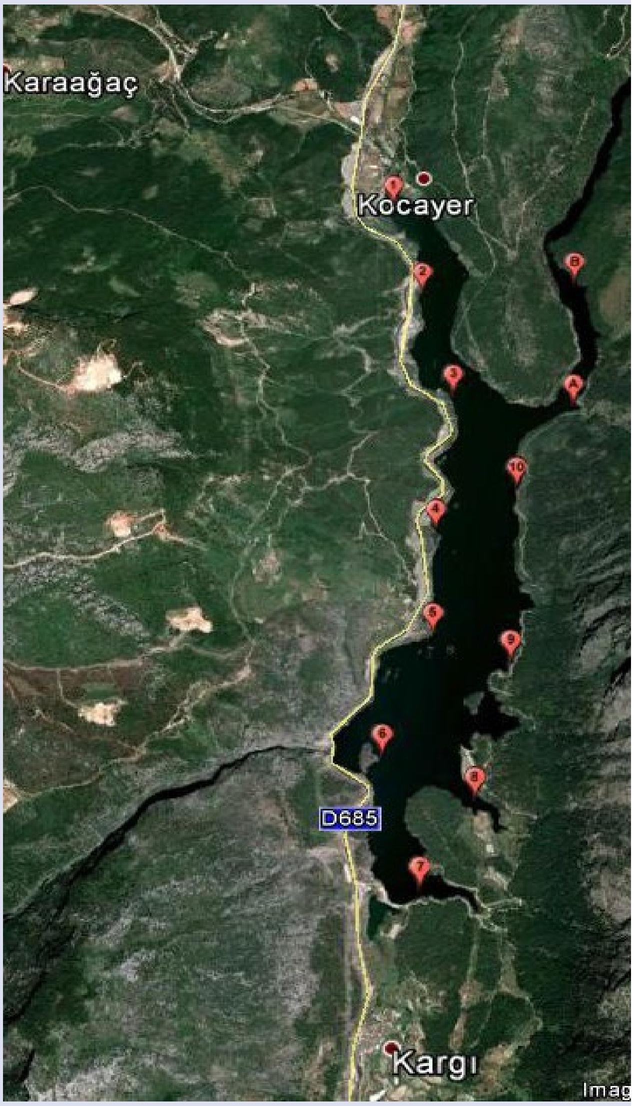


Figure 1. Sampling points of the study area by using google earth

Sediment Samples

At the locations shown in Table 1, sediment samples were taken from the fish farms in the lake in May, August, November, and February.

Table 1 Coordinates for the current sediment specimens

Sample Station	Latitude	Longitude
1	37°20'17.18"K	30°48'38.43"D
2	37°19'57.47"K	30°48'46.08"D
3	37°19'35.50"K	30°48'53.95"D
4	37°19'7.07"K	30°48'51.59"D
5	37°18'46.29"K	30°48'51.91"D
6	37°18'22.71"K	30°48'42.59"D
7	37°17'57.85"K	30°48'51.89"D
8	37°18'14.49"K	30°49'2.37"D
9	37°18'40.79"K	30°49'8.82"D
10	37°18'33.76"K	30°49'31.32"D
11	37°18'33.76"K	30°49'31.32"D
12	37°19'59.69"K	30°49'20.32"D

Samples will be collected during all four seasons. Using a "Van Ween grap," samples were taken from the lake's bottom. The lengthy sampling process was caused by the old settlements (trees, ruins of homes, etc.) in the reservoir. On occasion, samples were taken by approaching the edges. For elemental and radioactivity analyses, enough sediment samples were gathered, placed in clean bags, and delivered to the lab.

Sample Preparation for Sediment

The sediment samples were dried for 96 hours at 105 Celsius in the oven after being put in plastic containers and brought to the laboratory environment (4 seasons x 12 stations) [28]. To reduce the effect of particle size that could result in measurement errors, these dry materials were ground in the grinding mill, powdered in agate, and then passed through a 37-mm sieve. It can be seen that by doing this, the EDXRF readings' margin of error is decreased. Powdered sediment samples were placed in plastic bags with a code that indicated their approximate weight of 20 g for EDXRF studies. 200 g of samples were placed into plastic-lidded containers, whose mouths were then tightly sealed in order to measure radioactivity. After that, the samples were given some time to balance. Samples were kept in a cold environment in the lab prior to the measurement process.

Energy Dispersive X-ray Fluorescence Measurement System

An energy dispersive X-ray fluorescence spectrometer (EDXRF) is typically used to evaluate distinct X-rays and scattering photons produced by photon-matter interaction quantitatively and qualitatively. The elements themselves are calculated by calculating the energy of the X-rays that were collected from the sample that was being studied, and the amount of the elements is calculated by counting the incoming rays. As a result of its quickness and sensitivity, simplicity of use, and lack of material damage, it is essential in technological and scientific research. In order to calculate the concentrations of heavy metals (in the Na-U element range), this method analyzes samples in all forms, including solid (mineral, metal, polymer), liquid (water, oil, petroleum products), thin film, and pressed powder. It allows us to analyze it.

Calculations

Restrictions on detection based on the effectiveness of the device as measured by net measurement time;

$$DL = \frac{3C}{N_p}\sqrt{\frac{N_b}{t}} \tag{1}$$

The acronyms in the equation stand for detection limit (DL), concentration (C), net peak count (NPC), background count rate (BCR), and time (t) in that order [28].Based on measurement time, Table 2 shows detection limits.

Table 2 Limits on detection dependent on time

Element	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
Detection Limit (parts per million) (1500s)	2,36	1,10	0,93	0,39	0,43	0,47	0,52	0,20	0,34	0,98	1,37

The comparison with the sediment reference material (NRCMESS-3) used to assess the measurement accuracy of the EDXRF system is shown in Table 3.

Table 3 Results of a certified reference material sediment (NRCMESS-3) concentration

Element	NRCMESS-3 (parts per million)	Measured (parts per million)
Calcium	%1,47±0,06	%1,54
Chromium	105±4	108
Manganese	324±12	316
Iron	%4,34±0,11	%4,40
Nickel	46,9±2,2	45,1
Copper	33,9±1,6	35,4
Zinc	159±8	157
Arsenic	21,2±1,1	21,4
Strontium	129±11	130
Lead	21,1±0,7	19,2

Calculation of the geo-accumulation index (I Geo) of sediment samples

The geo-accumulation index (Igeo) will be used to assess the level of metal contamination in sediment samples. The formula for the geo-accumulation index is as follows:

$$I_{geo} = \log_2\left(\frac{C_n}{1.5 * B_n}\right) \tag{2}$$

The background matrix adjustment factor resulting from lithogenic effects is 1.5, where Cn = the concentration of n heavy metals in the residue, Bn = the mean geochemical background value of element n, and [29]. Table 4 presents the evaluation criteria in light of the collected data.

Table 4 Geo-accumulation Classification [30]

Geo-accumulation Index	Geo-accumulation classification	Description
≤0	0	No contamination.
0-1	1	No contamination to minimal contamination.
1-2	2	The contamination level is average.
2-3	3	There is a mild to severe level of contamination.
3-4	4	There is significant contamination.
4-5	5	There is moderately to extremely moderate contamination.
5<	6	There is too much contamination.

Enhancement factor

It is a method for evaluating metal pollution caused by pollutants in working environments as well as pollution caused by people. In particular, Al and Fe components are used in the normalizing operations. The enrichment factor can be calculated using the formula below [31];

$$\mathrm{EF} = \frac{\mathrm{X/Fe\ (Sediment)}}{\mathrm{X/Fe\ (Earth\ Crust)}} \tag{3}$$

The amount of metal in the sediment is represented by X. Fe (sediment) is the metal with the highest concentration in the investigated sediment. The earth's crust contains a lot of Fe [32]. The evaluation criteria are shown in Table 5 along with the EF results.

Table 5 Enhancement Factor [33]

Enhancement factor	Description
≤1	No enhancement.
3-5	Minimum enhancement.
5-10	Average enhancement.
10-25	From average to severe enhancement.
25-50	Severe enhancement.
>50	Very severe enhancement.

Statistical Calculation

The dry weight values were used to calculate the metal content of the sediment samples, and the results were given as parts per million. These grouped data were fed into the Statistical Package for the Social Sciences Environment. We examined the connections between the elements themselves as well as the connections between the position and the elements. All statistical analyses were performed in a computer environment using the Statistical Package for the Social Sciences application.

Results and Discussion

Metal Values in Sediment Samples

The results of the study showed that lead, aluminum, chromium, manganese, iron, nickel, copper, zinc, arsenic, and other elements were present in the sediment samples. The seasonal variations in the samples are shown in Tables 6–9.

Table 6: Metal concentrations (parts per million) of sediment samples for the period of May

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	156430	1845	1334,6	702,28	32890	213,88	46,58	72,94	6,84	2,86	14,08
2	153293	1788	817,92	685,21	27437	134,19	45,15	55,46	6,98	Not detected	11,03
3	179057	1398	507,89	569,36	34563	221,92	45,11	45,24	4,06	1,01	10,04
4	154954	2324	527,61	641,52	29667	166,16	43,98	56,41	8,89	1,26	11,73
5	130850	3250	547,32	713,68	24770	110,39	42,85	67,57	13,7	1,51	13,42
6	182377	Not detected	449,74	711,80	36633	244,03	39,99	100,7	3,89	1,78	11,81
7	186940	Not detected	566,71	742,15	39663	285,72	42,35	76,36	4,52	2,38	11,40
8	191503	Not detected	683,67	772,50	42693	327,40	44,72	52,00	5,15	2,98	10,98
9	195070	Not detected	648,71	786,48	42023	325,30	49,00	57,78	5,24	Not detected	13,54
10	188220	Not detected	630,40	867,24	40553	273,72	38,00	51,33	7,08	Not detected	11,53
11	125866	10160	164,21	981,90	13700	Not detected	26,78	39,29	2,99	Not detected	9,471
12	186203	1298	537,30	841,16	38937	269,22	41,86	53,29	3,67	Not detected	13,52
Minimum	125866	1298	164,21	569,36	13700	110,39	26,78	39,29	2,99	1,01	9,47
Maximum	195070	10160	1334,60	981,90	42693	327,40	49,00	100,70	13,70	2,98	14,08
Average	169230	3152	618,01	751,27	33627	233,81	42,20	60,70	6,08	1,97	11,88

Table 7: Metal concentrations (parts per million) of sediment samples for the period of August

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	152855	1906	593,91	620,36	32485	226,95	38,35	41,70	5,29	0,93	11,87
2	171600	ND	572,99	707,81	39360	292,94	95,56	55,62	3,73	Not detected	14,99
3	146415	1936	699,62	666,02	34175	247,61	45,41	44,62	6,37	0,85	12,02
4	128095	4385	598,37	981,81	33530	232,05	78,18	63,31	9,24	2,49	13,51
5	153950	5960	614,41	679,01	34750	228,54	48,51	60,30	3,17	Not detected	16,60
6	170960	4125	839,07	698,92	37360	268,74	47,86	56,29	3,62	Not detected	14,67
7	187970	2290	1063,7	718,82	39970	308,94	47,20	52,29	4,06	Not detected	12,75
8	167810	Not detected	672,94	680,98	34630	235,45	37,75	43,08	5,50	Not detected	12,02
9	145020	1683	969,87	836,21	33660	219,00	35,14	42,60	5,51	Not detected	11,60
10	153615	4960	808,65	681,40	32570	249,49	40,11	63,05	4,00	Not detected	13,83
11	141300	6895	1144,3	664,12	26530	162,70	32,33	52,66	5,19	Not detected	12,39
12	166590	5065	677,34	665,94	32250	244,19	45,67	64,70	3,94	Not detected	11,76
Minimum	128095	1683	572,99	620,36	26530	162,70	32,33	41,70	3,17	0,85	11,60
Maximum	187970	6895	1144,3	981,81	39970	308,94	95,56	64,70	9,24	2,49	16,60
Average	157182	3921	771,26	716,78	34273	243,05	49,34	53,35	4,97	1,42	13,17

Table 8: Metal concentrations (parts per million) of sediment samples for the period of November

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	172255	2960	639,01	880,63	40665	340,40	51,93	78,04	8,07	Not detected	12,87
2	180655	Not detected	599,82	744,48	41600	292,12	45,94	55,16	5,67	1,44	13,27
3	167545	1585	687,03	668,42	32900	211,07	38,75	40,62	5,73	0,51	12,18
4	175165	1562	966,14	790,36	39695	246,11	48,34	71,08	9,05	0,73	17,58
5	151355	2485	478,91	797,07	38215	214,87	59,62	58,70	10,9	3,18	15,21
6	162615	1899	480,19	740,17	36350	202,89	51,50	53,97	9,64	Not detected	12,45
7	179405	2595	615,94	707,72	34085	218,47	42,89	75,06	5,16	Not detected	10,45
8	193630	Not detected	535,56	697,48	38560	272,59	42,13	51,27	4,35	1,73	12,28
9	195085	1552	597,33	711,69	42450	305,28	57,45	64,63	5,52	Not detected	16,83
10	180155	Not detected	653,37	694,72	33185	233,08	35,74	44,22	4,71	Not detected	10,50
11	169960	Not detected	555,49	852,37	37970	234,71	36,94	43,96	7,16	0,91	11,79
12	187065	Not detected	650,47	790,29	44315	350,99	53,74	57,56	3,50	Not detected	14,14
Minimum	151335	1552	478,91	668,42	32900	202,89	35,74	40,62	3,50	0,51	10,45
Maximum	195085	2960	966,14	880,63	44315	350,99	59,62	78,04	10,9	3,18	17,58
Average	176241	2091	621,61	756,82	38333	260,22	47,08	57,86	6,62	1,42	13,3

Table 9: Metal concentrations (parts per million) of sediment samples for the period of February

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	192420	2830	528,89	587,37	35665	287,91	42,93	58,59	3,24	Not detected	13,19
2	196875	Not detected	539,73	636,98	39030	273,00	48,41	66,93	4,67	Not detected	12,28
3	215460	Not detected	480,33	635,14	39920	270,05	49,05	57,83	5,16	1,10	10,89
4	138420	Not detected	916,31	690,71	37265	234,86	49,75	55,25	5,95	Not detected	19,74
5	93690	4195	631,61	790,77	23495	164,27	44,67	36,76	10,1	Not detected	7,99
6	175375	Not detected	603,35	796,63	45165	308,35	46,67	55,03	11,3	1,62	14,54
7	192540	1649	542,87	724,94	39380	268,71	44,77	64,36	4,71	Not detected	11,13
8	197945	1072	463,07	650,38	41480	292,53	53,64	63,64	3,96	Not detected	11,45
9	188075	Not detected	510,90	684,50	40150	282,53	43,06	53,75	4,75	Not detected	12,02
10	170310	Not detected	769,30	710,55	33220	229,18	39,72	47,59	4,78	Not detected	10,69
11	194330	1566	869,26	1076,6	50230	337,19	72,41	81,30	5,94	Not detected	19,33
12	129720	1612	479,27	318,78	26840	105,6	25,57	43,78	4,33	Not detected	10,01
Minimum	93690	1072	463,07	318,78	23495	105,60	25,57	36,76	3,24	1,10	7,99
Maximum	215460	4195	916,31	1076,6	50230	337,19	72,41	57,06	11,3	1,62	19,74
Average	173763	2154	611,24	691,95	37653	254,52	46,72	77,90	5,74	1,36	12,77

The concentration of heavy metals in the sea and lake bottoms has risen over time as a result of the rocks going through processes like fragmentation, transit, sedimentation, and human activity. Metals in water-soluble forms precipitate and amass in the sediment, especially in wide areas where rivers meet lakes and seas. Heavy metal accumulation is more pronounced. The results of the study showed that lead, aluminum, chromium, manganese, iron, nickel, copper, zinc, arsenic, and other elements were present in the sediment samples. Based on the average values of the samples, the concentration changes of the element's chromium, nickel, copper, zinc, arsenic, and lead are depicted in figures 2–8. Chromium, nickel, copper, zinc, and other changes are depicted in figures 2 through 8. Based on the average values of the samples, the concentration changes of the element's chromium, nickel, copper, zinc, arsenic, and lead are depicted in figures 2–8. Based on the average values of the samples, Figures 2–8 depict changes in the concentrations of the element's chromium, nickel, copper, zinc, arsenic, and lead as well as changes in accordance with the global "freshwater sediment quality" standards (Table 10).

Table 10: Freshwater sediment quality criteria

		Concentration (parts per million)				
	Element	Rare effect level	Threshold effect level	Occasional effect level	Probable effect level	Frequent effect level
Metal	Arsenic	4,1	5,9	7,6	17	23
	Chrome	25	37	57	90	120
	Copper	22	36	63	200	700
	Lead	25	35	52	91	150
	Mercury	0,094	0,17	0,25	0,49	0,87
	Nickel	Not detected	Not detected	47	Not detected	Not detected
	Zinc	80	120	170	310	770

* Environment Canada and Ministère du Développement durable, de l'Environnement et des Parcs du Québec. 2007, "Criteria for the Asse ssment of Sediment Quality in Quebec and Application Frameworks: Prevention, Dredging and Remediation" 39 p

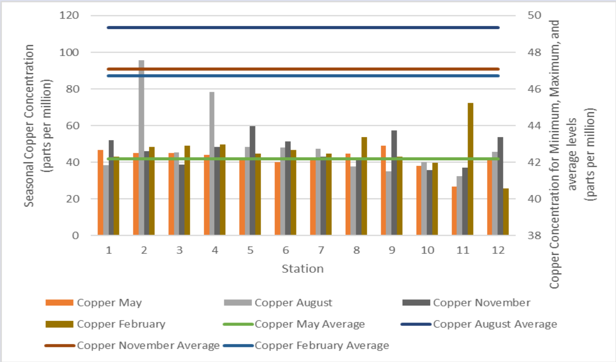


Figure 2. Seasonal variation of copper concentration versus sampling points of the study area

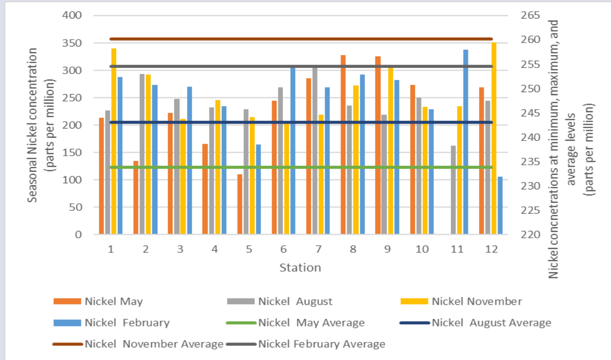


Figure 6. Seasonal variation of nickel concentration versus sampling points of the study area

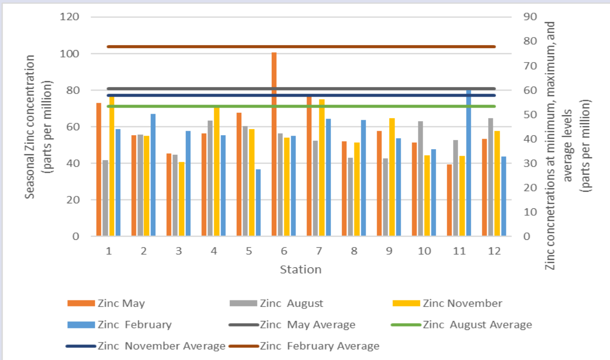


Figure 3. Seasonal variation of zinc concentration versus sampling points of the study area

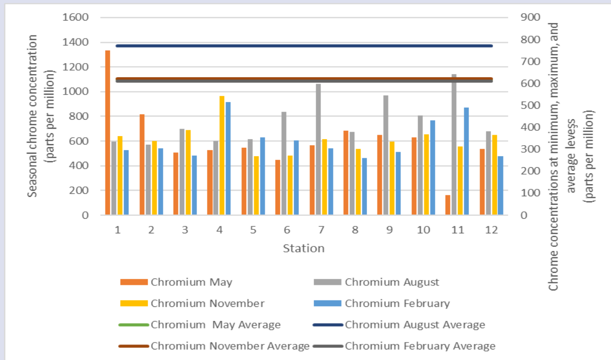


Figure 7. Seasonal variation of chrome concentration versus sampling points of the study area

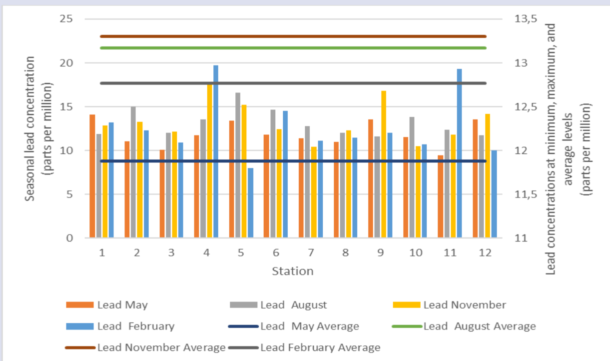


Figure 4. Seasonal variation of lead concentration versus sampling points of the study area

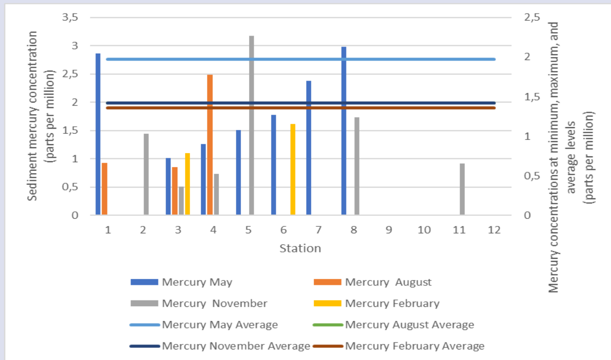


Figure 8. Seasonal variation of mercury concentration versus sampling points of the study area

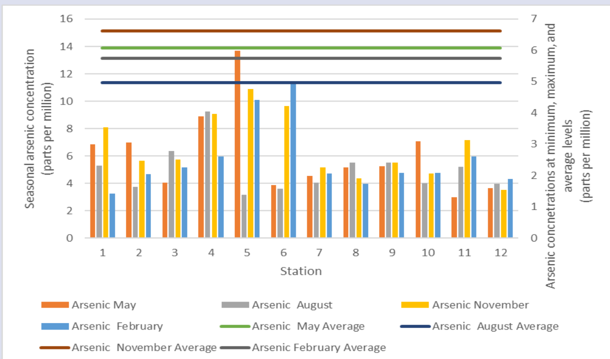


Figure 5. Seasonal variation of arsenic concentration versus sampling points of the study area

Aluminum: During the month of February, the aluminum value was measured at 93690-215460 parts per million (minimum-maximum). At each station, the aluminum value was calculated as follows: 125866-195070 (minimum-maximum) parts per million in May, 128095 (minimum-maximum) parts per million in August, and 151335-195085 (minimum-maximum) parts per million in November. The average values of the eras were found to be high (80000 parts per million) when compared to the average abundance value of Karuskopf [33] in the earth's crust.

Sulphur: Sulphur values were detected in May at stations 6, 7, 8, 9, and 10 because they were below the detection thresholds. The min-max range during this time was measured to be 1298-10160 parts per million.

In August, it was undetectable at stations 2 and 8. The change range is between 1683 and 6895 parts per million. In November, it was undetectable at stations 2,8,10,11, and 12. The min-max range for this time period was 1552-2960 parts per million. At stations 2,3,4,6,9, and 10 in February, it was undetectable. The fluctuation range is 107-4195 parts per million. 2400 parts per million is the average abundance value in the crust of the planet.

Chromium: The element chromium has been detected at all times and locations. The change occurred between 164.21 and 1334.60 parts per million (minimum-maximum) when all time periods were considered. It has been noted that when the international standards for freshwater sediment quality are taken into account, the chromium element's effect level is above the diffuse effect threshold [33] defined the sediment range as 41-125 parts per million.

Iron: Taking into account all four seasons, iron concentrations ranged from 13700 to 50230 parts per million. Iron concentrations were also found in other lakes, according to studies (Table 21). In most instances, the concentration values are comparable. Our values on average were less abundant than the average abundance in the earth's crust, which was estimated by [32] to be 47200 parts per million.

Nickel: The nickel element's change range in our investigation is between 105.6 and 350.99 parts per million. When the international standards for the quality of freshwater sediment are taken into account, it has been noted that the nickel element's effect level is higher than the transient effect level.

Copper: Copper was discovered throughout the sampling's locations and times. Between 25.57 and 95.56 parts per million, there can be a change. The effect level of the copper element was found to be above the temporary effect level at stations 2 and 4 in the period of November and at station no. 11 in the period of February, while other values were below this, according to the international standards for freshwater sediment quality.

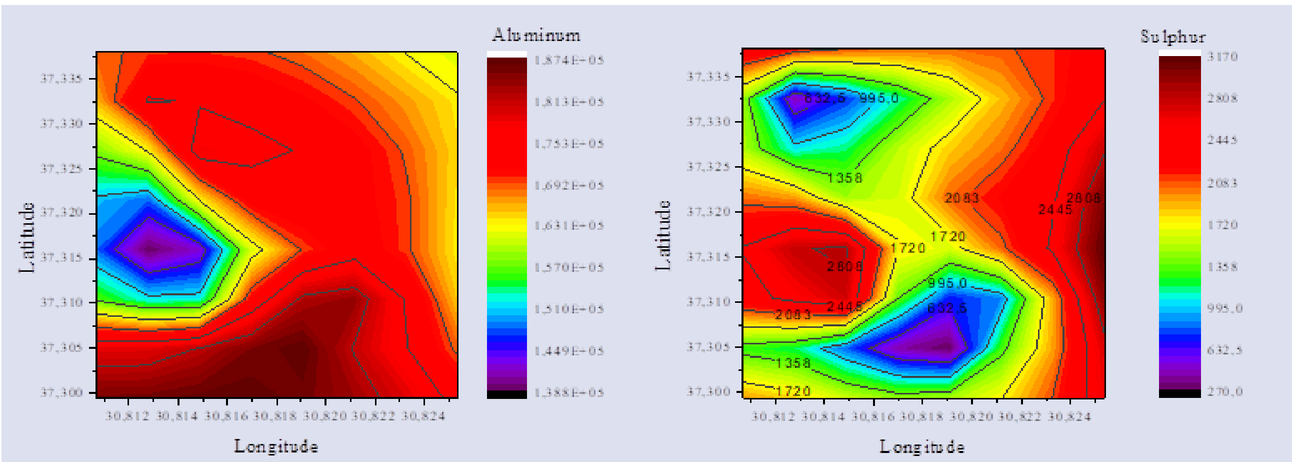
Zinc: The zinc element fluctuated between 36.76 and 100.70 parts per million at all times and locations. For the month of May, all concentrations' effect levels—with the exception of station 6—are below the level for uncommon effects.

Arsenic: The arsenic element in the investigation had a concentration range (minimum-maximum) of 2.99-13.70 parts per million. The influence level of the element Arsenic is transient while taking into account the periods of May, August, and November at station 4, May, November, and February periods at station 5, November, and February periods at station 6, and November at station 1. The other numbers, which are above the OEL, have been seen to be below this level.

Mercury: Mercury was discovered at stations 1, 3, 4, 8, 2, 3, and 5 in May, at stations 1, 3, 4, and 8 in August, and at stations 11 and 3.6 in November. The concentration range is 0.51 to 3.18 parts per million (minimum-maximum). For the month of November, all readings were found to be higher than the widespread effect level, with the exception of stations 3 and 4.

Lead: All epochs and points contained lead. The concentration range (min-max) in the study covered a range of 7.99 to 19.74 parts per million. The sediment range [34]'s investigation was determined to be 3 parts per million. The Pb element's rare-effect level has been found to be below the international standard for freshwater sediment quality.

Figure 9. illustrates the counter maps of the elements in the sediment samples according to latitude and longitude that were created by averaging the periods.



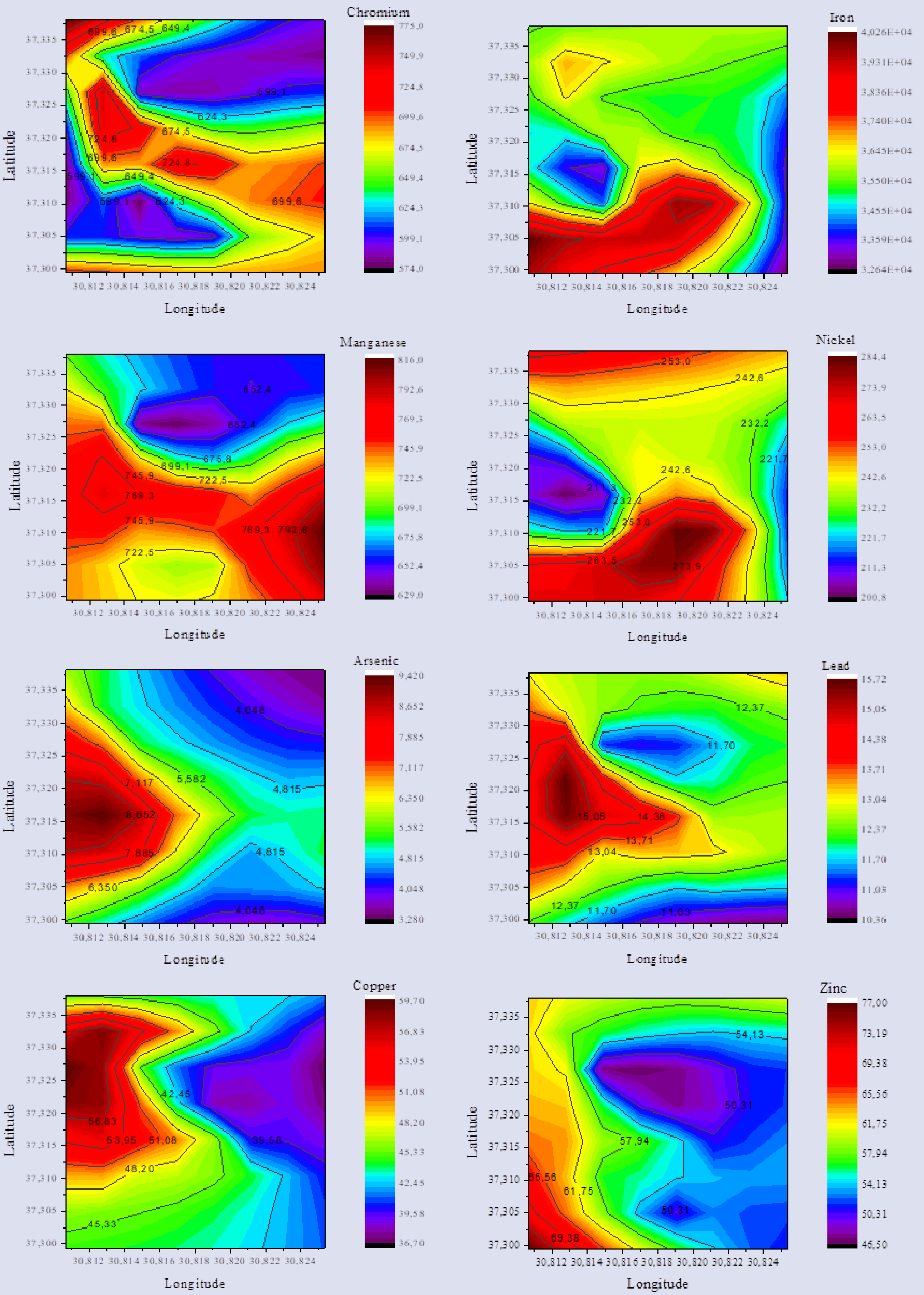


Figure 9. Spatial distribution of metal contents for sediment matrices

Table 11. lists studies that various researchers in our nation have conducted in dam lakes. When the papers are analyzed, it becomes clear that atomic absorption spectroscopy and inductively coupled plasma type spectroscopy procedures were used for the examinations. Regional geological variances have resulted in differences in elemental concentration. Sulphur, Nickel, Copper, Arsenic, and Mercury elements were also found in our analysis, which is also consistent with the findings of earlier sediment analyses in the study area. The elements were found to have varied concentrations as a consequence of the use of several spectroscopic techniques.

Table 11. Various studies on dam lakes in our country

	(Parts per million)										
	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
Atatürk Dam[a]	-	-	-	73,6-514,07	12587-19265	43,69-139,69	14,57-22,7	59,14-60,79	-	-	-
Seyhan Dam[b]	-	-	118,95	803,63	39350	-	19,80	39,09	-	-	-
Karacaören II Dam[c]	3,314-1068	-	41-125	305-558	7430-14680	-	-	19-330	-	-	3
Avşar Dam[d]	-		14,48	-	25268	29,99	29,98	-	-	-	2.44
Enne Dam[e]	-	-	59,08	626,40	34030	136,82	27,84	272,00	-	-	88,96
Porsuk Dam[e]	-	-	78,40	642,80	36550	159,12	26,08	656,40	-	-	90,00
Gökçekaya Dam[f]			421		16918	153	165	312,56	42,98	-	121.24
In current work (minimum-maximum)	93690-215460	1072-10160	164,21-1334,60	318,78-1076,6	13700-50230	105,60-350,99	25,57-95,56	36,76-100,70	2,99-13,70	0,51-3,18	7,99-19,74

[a] [34], [b] [35], [c] [36], [d] [37], [e] [38], [f] [39]

Values for the sediment geo-accumulation index (I_{geo})

Tables 12–15 display the calculated and given values of the geo-accumulation index for all time periods, which is used to evaluate metal contamination in sediment samples.

Table 12. Sediment geoaccumulation index values for the period of May

Station No	Aluminium	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	0,38	-0,96	3,31	-0,86	-1,11	1,07	-0,54	-0,97	-1,5	2,25	-1,09
2	0,35	-1,01	2,60	-0,90	-1,37	0,40	-0,58	-1,36	-1,48	-	-1,44
3	0,58	-1,36	1,91	-1,16	-1,03	1,12	-0,58	-1,66	-2,26	0,74	-1,58
4	0,37	-0,63	1,97	-0,99	-1,25	0,70	-0,62	-1,34	-1,13	1,07	-1,36
5	0,12	-0,15	2,02	-0,84	-1,52	0,11	-0,66	-1,08	-0,51	1,33	-1,16
6	0,60	-	1,74	-0,84	-0,95	1,26	-0,76	-0,50	-2,32	1,57	-1,34
7	0,64	-	2,07	-0,78	-0,84	1,49	-0,67	-0,90	-2,19	1,99	-1,40
8	0,67	-	2,34	-0,72	-0,73	1,68	-0,59	-1,45	-1,92	2,31	-1,45
9	0,70	-	2,26	-0,70	-0,75	1,67	-0,46	-1,30	-1,90	-	-1,15
10	0,65	-	2,22	-0,56	-0,80	1,42	-0,83	-1,47	-1,46	-	-1,38
11	0,07	1,50	0,28	-0,38	-2,37	-	-1,33	-1,86	-2,71	-	-1,66
12	0,63	-1,47	1,99	-0,60	-0,86	1,40	-0,69	-1,42	-2,41	-	-1,15

Table 13. Sediment geoaccumulation index values for the period of August

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	0,35	-0,92	2,14	-1,04	-1,12	1,15	-0,82	-1,77	-1,88	0,63	-1,34
2	0,52	-	2,09	-0,85	-0,85	1,52	0,50	-1,36	-2,38	-	-1,00
3	0,29	-0,89	2,38	-0,94	-1,0	1,28	-0,57	-1,68	-1,61	0,51	-1,35
4	0,09	0,28	2,15	-0,38	-1,08	1,19	0,21	0,01	-1,08	2,05	-1,15
5	0,36	0,73	2,19	-0,91	-1,03	1,16	-0,48	-1,24	-2,62	-	-0,85
6	0,51	0,20	2,64	-0,87	-0,92	1,40	-0,50	-1,34	-2,43	-	-1,03
7	0,65	-0,65	2,98	-0,83	-0,82	1,60	-0,52	-1,45	-2,26	-	-1,23
8	0,48	-	2,32	-0,90	-1,03	1,21	-0,84	-1,73	-1,82	-	-1,32
9	0,27	-1,10	2,84	-0,61	-1,07	1,10	-0,94	-1,74	-1,82	-	-1,37
10	0,36	0,46	2,58	-0,90	-1,12	1,29	-0,75	-1,18	-2,28	-	-1,12
11	0,24	0,94	3,08	-0,94	-1,42	0,67	-1,06	-1,44	-1,91	-	-1,28
12	0,47	0,49	2,33	-0,94	-1,13	1,26	-0,56	-1,14	-2,31	-	-1,35

Table 14. Sediment geoaccumulation index values for the period of November

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	0,52	-0,28	2,24	-0,53	-0,80	1,74	-0,38	-0,87	-1,27	-	-1,22
2	0,59	-	2,15	-0,78	-0,77	1,52	-0,56	-1,37	-1,78	1,26	-1,18
3	0,48	-1,18	2,35	-0,93	-1,11	1,05	-0,80	-1,81	-1,77	-0,23	-1,30
4	0,55	-1,20	2,84	-0,69	-0,83	1,27	-0,48	-1,00	-1,11	0,28	-0,77
5	0,33	-0,53	1,83	-0,68	-0,89	1,07	-0,18	-1,28	-0,84	2,41	-0,98
6	0,44	-0,92	1,83	-0,78	-0,96	0,99	-0,39	-1,40	-1,02	-	-1,27
7	0,58	-0,47	2,19	-0,85	-1,05	1,10	-0,65	-0,92	-1,92	-	-1,52
8	0,69	-	1,99	-0,87	-0,88	1,42	-0,68	-1,47	-2,16	1,53	-1,29
9	0,70	-1,21	2,15	-0,84	-0,74	1,58	-0,23	-1,14	-1,82	-	-0,83
10	0,59	-	2,27	-0,88	-1,09	1,19	-0,92	-1,69	-2,05	-	-1,51
11	0,50	-	2,04	-0,58	-0,90	1,20	-0,87	-1,70	-1,45	0,60	-1,35
12	0,64	-	2,27	-0,69	-0,68	1,78	-0,33	-1,31	-2,48	-	-1,09

Table 15. Sediment geoaccumulation index values for the period of February

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	0,68	-0,35	1,97	-1,12	-0,99	1,50	-0,65	-1,28	-2,59	-	-1,19
2	0,71	-	2,00	-1,00	-0,86	1,42	-0,48	-1,09	-2,06	-	-1,29
3	0,84	-	1,83	-1,01	-0,83	1,40	-0,46	-1,30	-1,92	0,87	-1,46
4	0,21	-	2,76	-0,88	-0,93	1,20	-0,44	-1,37	-1,71	-	-0,60
5	0,36	0,22	2,23	-0,69	-1,59	0,69	-0,60	-1,95	-0,95	-	-1,91
6	0,55	-	2,16	-0,68	-0,65	1,60	-0,53	-1,37	-0,79	1,43	-1,04
7	0,68	-1,13	2,01	-0,81	-0,85	1,40	-0,59	-1,15	-2,05	-	-1,43
8	0,72	-1,75	1,78	-0,97	-0,77	1,52	-0,33	-1,16	-2,30	-	-1,39
9	0,65	-	1,92	-0,90	-0,82	1,47	-0,65	-1,41	-2,04	-	-1,32
10	0,51	-	2,51	-0,84	-1,09	1,17	-0,77	-1,58	-2,03	-	-1,49
11	0,70	-1,20	2,69	-0,24	-0,50	1,72	0,10	1,22	-1,71	-	-0,63
12	0,11	-1,16	1,83	-2,00	-1,40	0,05	-1,40	-1,70	-2,17	-	-1,58

When the standards listed in Table 6 are applied to the sediment sample geo-accumulation indices computed (Tables 12–15), The coordinates number 11 for the month of May show average pollution for the elements aluminum and nickel, no contamination for the element chromium, moderate pollution for the element chromium, and severe pollution for the element mercury. As can be seen from the data for the August timeframe, aluminum and sulfur pollution are between no pollution and normal pollution, whereas chromium pollution is between average-severe pollution and severe pollution. Nickel pollution falls between no pollution and average pollution, whereas mercury pollution falls between no pollution and moderate-severe pollution. When the standards listed in Table 6 are applied to the sediment sample geo-accumulation indices computed (Tables 12–15), The coordinates number 11 for the month of May show average pollution for the element's aluminum and nickel, no contamination for the element chromium, moderate pollution for the element chromium, and severe pollution for the element mercury. As can be seen from the data for the August timeframe, aluminum and sulfur pollution are between no pollution and normal pollution, whereas chromium pollution is between average-severe pollution and severe pollution. Nickel pollution falls between no pollution and average pollution, whereas mercury pollution falls between no pollution and moderate-severe pollution.

Values for the sediment enrichment factor

The values for the enrichment factors that will be used in the evaluation of metal pollution caused by contaminants in the lake as well as pollution brought on by human activity are shown in the tables below (Tables 16–19).

Table 16. Enrichment factor values for sediment samples from May

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	2,78	0,42	3,45	0,38	0,36	1,75	0,45	0,23	0,21	1,22	0,31
2	2,57	-	2,97	0,39	0,39	2,01	0,99	0,27	0,13	-	0,35
3	2,53	0,44	4,25	0,43	0,40	1,99	0,55	0,26	0,27	1,17	0,33
4	2,25	1,14	4,15	0,72	0,44	2,13	1,09	0,94	0,44	3,89	0,42
5	2,61	1,29	3,55	0,42	0,38	1,75	0,56	0,33	0,13	-	0,43
6	2,70	0,80	4,36	0,38	0,37	1,85	0,50	0,28	0,13	-	0,34
7	2,77	0,41	5,03	0,36	0,36	1,93	0,45	0,23	0,13	-	0,27
8	2,86	-	3,56	0,38	0,35	1,65	0,40	0,22	0,20	-	0,29
9	2,54	0,39	5,94	0,54	0,39	1,78	0,43	0,25	0,23	-	0,32
10	2,78	1,08	4,68	0,42	0,36	1,91	0,46	0,35	0,16	-	0,36
11	3,14	1,63	7,20	0,44	0,32	1,35	0,41	0,31	0,23	-	0,35
12	3,05	1,01	3,61	0,38	0,33	1,72	0,49	0,33	0,15	-	0,28

Table 17. Enrichment factor values for sediment samples from November

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	2,81	0,39	7,58	0,42	0,36	1,61	0,53	0,39	0,27	3,66	0,36
2	3,30	0,39	4,74	0,42	0,30	1,03	0,52	0,30	0,28	-	0,29
3	3,06	0,26	2,52	0,30	0,33	1,46	0,45	0,21	0,14	1,12	0,22
4	3,08	0,50	3,03	0,39	0,32	1,26	0,50	0,31	0,35	1,62	0,30
5	3,12	0,83	3,72	0,51	0,32	0,99	0,58	0,43	0,65	2,30	0,41
6	2,94	-	2,19	0,37	0,34	1,57	0,39	0,47	0,13	1,96	0,26
7	2,78	-	2,69	0,37	0,36	1,80	0,40	0,34	0,15	2,55	0,24
8	2,65	-	3,17	0,38	0,38	2,01	0,42	0,23	0,17	3,12	0,23
9	2,74	-	2,96	0,38	0,37	1,96	0,45	0,25	0,16	-	0,28
10	2,74	-	2,98	0,43	0,37	1,71	0,36	0,23	0,23	-	0,25
11	5,42	2,69	1,16	0,73	0,18	-	0,38	0,26	0,15	-	0,30
12	2,82	0,23	2,56	0,43	0,35	1,70	0,40	0,24	0,12	-	0,29

Table 18. Enrichment factor values for sediment samples from August

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	3,18	0,49	2,44	0,29	0,31	1,76	0,40	0,26	0,10	-	0,27
2	2,98	-	2,44	0,30	0,34	1,63	0,44	0,29	0,15	-	0,25
3	3,18	-	1,98	0,28	0,31	1,47	0,40	0,23	0,15	1,02	0,20
4	2,19	-	5,88	0,47	0,46	2,00	0,64	0,34	0,26	-	0,57
5	2,35	1,49	5,99	0,79	0,43	2,06	0,85	0,33	0,66	-	0,34
6	2,29	-	3,06	0,43	0,44	2,07	0,47	0,26	0,40	1,85	0,33
7	2,88	0,29	2,51	0,35	0,35	1,64	0,41	0,28	0,15	-	0,23
8	2,82	0,18	2,08	0,31	0,36	1,74	0,48	0,27	0,12	-	0,23
9	2,76	-	2,41	0,34	0,36	1,77	0,41	0,24	0,16	-	0,26
10	3,02	-	4,02	0,39	0,33	1,58	0,41	0,24	0,17	-	0,25
11	2,28	0,27	3,98	0,52	0,44	2,04	0,66	1,44	0,19	-	0,40
12	2,85	0,41	3,28	0,23	0,35	0,96	0,35	0,28	0,21	-	0,31

Table 19: Enrichment factor values for sediment samples from February

Station No	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
1	2,50	0,57	3,30	0,48	0,40	2,32	0,54	0,38	0,29	-	0,30
2	2,56	-	2,95	0,39	0,39	1,90	0,45	0,26	0,19	1,59	0,29
3	3,00	0,32	3,64	0,38	0,33	1,48	0,41	0,20	0,21	0,61	0,29
4	2,60	0,30	4,90	0,42	0,38	1,65	0,49	0,34	0,32	0,83	0,40
5	2,34	0,55	2,81	0,50	0,43	1,67	0,70	0,33	0,44	4,20	0,40
6	2,64	0,39	2,62	0,43	0,38	1,47	0,56	0,28	0,36	-	0,31
7	3,11	0,48	3,05	0,37	0,32	1,43	0,43	0,35	0,18	-	0,23
8	2,96	-	2,46	0,34	0,34	1,66	0,39	0,22	0,14	1,79	0,25
9	2,71	0,27	2,72	0,34	0,37	1,84	0,52	0,28	0,17	-	0,35
10	3,20	-	3,22	0,36	0,31	1,52	0,35	0,21	0,16	-	0,23
11	2,64	-	2,91	0,47	0,38	1,62	0,39	0,22	0,26	1,07	0,28
12	2,49	-	3,09	0,40	0,40	2,21	0,51	0,26	0,12	-	0,30

The calculated enrichment factor for the sediment sample is shown in Tables 16 through 19. The enrichment factor index was assessed using the criteria shown in Table 7. When the enrichment factor values for the May period are examined, the elements sulfur, manganese, iron, copper, zinc, arsenic, and lead exhibit no signs of human enrichment (with the exception of coordinate number 11). However, there are only very slight to moderate enrichments in the aluminum and chromium elements. Elements sulfur and nickel only show minor enrichments for coordinate no. 11, whereas mercury elements show modest to medium enrichments. August saw no enrichment of manganese, iron, copper, zinc, arsenic, or lead elements. There were also small and average enrichments for nickel, no enrichment for the element mercury, small and average-severe enrichments for chromium, small and average-severe enrichments for chromium, small and average enrichments for aluminum, and no enrichment for sulfur. The enrichment factor values for the November timeframe show no enrichment in the elements sulfur, manganese, iron, copper, zinc, arsenic, and lead. The elements aluminum and chromium showed small and average enrichments, medium enrichments in the element nickel, no enrichment in the element mercury, and minor enrichments in the other elements. There were also small and average enrichments for nickel, no enrichment for the element mercury, small and average-severe enrichments for chromium, small and average-severe enrichments for chromium, small and average enrichments for aluminum, and no enrichment for sulfur. The enrichment factor values for the November timeframe show no enrichment in the elements sulfur, manganese, iron, copper, zinc, arsenic, and lead. The elements aluminum and chromium showed small and average enrichments, medium enrichments in the element nickel, no enrichment in the element mercury, and minor enrichments in the other elements.

Statistics for the Sediment Sample

Tables 20-23 show the seasonal correlation coefficients between the position and water sample components.

Table 20: May period correlation coefficients between sediment sample's location and elements

	Location	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
Location	1											
Aluminum	-,511	1										
Sulphur	,721	-,964*	1									
Chromium	-,859	-,002	-,264	1								
Manganese	,022	-,871	,709	,493	1							
Iron	-,772	,941	-,997**	,337	-,653	1						
Nickel	-,831	,903	-,985*	,429	-,575	,995**	1					
Copper	-,993**	,609	-,798	,792	-,141	,842	,891	1				
Zinc	-,236	-,715	,503	,701	,966*	-,436	-,344	,119	1			
Arsenic	,683	-,977*	,999**	-,212	,745	-,992**	-,974*	-,765	,548	1		
Mercury	-,733	-,211	-,057	,978*	,664	,133	,231	,647	,834	-,004	1	
Lead	-,205	-,737	,530	,678	,974*	-,464	-,373	,088	1,000**	,574	,816	1

Table 21. August period correlation coefficients between sediment samples location and elements

	Location	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
Location	1											
Aluminum	-,511	1										
Sulphur	,721	-,964*	1									
Chromium	-,859	-,002	-,264	1								
Manganese	,022	-,871	,709	,493	1							
Iron	-,772	,941	-,997**	,337	-,653	1						
Nickel	-,831	,903	-,985*	,429	-,575	,995**	1					
Copper	-,993**	,609	-,798	,792	-,141	,842	,891	1				
Zinc	-,236	-,715	,503	,701	,966*	-,436	-,344	,119	1			
Arsenic	,683	-,977*	,999**	-,212	,745	-,992**	-,974*	-,765	,548	1		
Mercury	-,733	-,211	-,057	,978*	,664	,133	,231	,647	,834	-,004	1	
Lead	-,205	-,737	,530	,678	,974*	-,464	-,373	,088	1,000**	,574	,816	1

Table 22: November period correlation coefficients between sediment sample's location and elements

	Location	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
Location	1											
Aluminum	-,666	1										
Sulphur	,855	-,956	1									
Chromium	-,426	,959	-,833	1								
Manganese	,888	-,249	,521	,038	1							
Iron	,744	,004	,289	,288	,968	1						
Nickel	,099	,677	-,432	,858	,545	,739	1					
Copper	,999*	-,700	,878	-,467	,866	,712	,052	1				
Zinc	,590	,210	,086	,479	,895	,979	,862	,552	1			
Arsenic	,987	-,536	,760	-,273	,951	,842	,259	,978	,713	1		
Mercury	,901	-,924	,995	-,776	,601	,380	-,343	,920	,181	,818	1	
Lead	,077	,693	-,451	,869	,527	,724	1,000**	,031	,850	,238	-,364	1

Table 23: February period correlation coefficients between sediment sample's location and elements

	Location	Aluminum	Sulphur	Chromium	Manganese	Iron	Nickel	Copper	Zinc	Arsenic	Mercury	Lead
Location	1											
Aluminum	-,160	1										
Sulphur	-,612	-,683	1									
Chromium	,149	-,276	,115	1								
Manganese	,073	,156	,094	,596*	1							
Iron	,034	,759**	-,647	,186	,581*	1						
Nickel	-,222	,786**	-,348	,120	,631*	,910**	1					
Copper	-,057	,404	-,191	,466	,850**	,744**	,749**	1				
Zinc	,350	,271	-,311	,493	,703*	,612*	,480	,793**	1			
Arsenic	-,053	-,472	,718	,235	,430	-,035	-,040	,114	-,022	1		
Mercury	-	-	-	-	-	-	-	-	-	-	-	
Lead	-,016	,179	-,425	,717**	,492	,647*	,510	,629*	,610*	,032	1,000**	1

To assist with seasonal reviews, tables were used. The Pearson correlation analysis for the month of May reveals a negative correlation between aluminum, chrome, iron, nickel, copper, zinc, mercury, and lead, but a positive correlation between sulfur, manganese, and arsenic. Only the correlation between the location and the copper element, however, is significant (p 0.05). When the relationships between the elements are examined, the element aluminum has a significant and adverse relationship with the elements sulfur and arsenic, while the element sulfur has an adverse relationship with the element's aluminum and iron and a significant and favorable relationship with the element arsenic. To assist with seasonal reviews, tables were used. The Pearson correlation analysis for the month of May reveals a negative correlation between aluminum, chrome, iron, nickel, copper, zinc, mercury, and lead, but a positive correlation between sulfur, manganese, and arsenic. Only the correlation between the location and the copper element, however, is significant (p 0.05). When the relationships between the elements are examined, the element aluminum has a significant and adverse relationship with the elements sulfur and arsenic, while the element sulfur has an adverse relationship with the element's aluminum and iron and a significant and favorable relationship with the element arsenic.

Looking at the correlation between position and elements in August, aluminum has a positive association with sulfur, chromium, and mercury, but a negative association with manganese, iron, nickel, copper, zinc, arsenic, and lead. However, only the chromium element exhibits a significant interaction (p 0.05). Significant positive correlations exist between aluminum and iron, nickel, and copper, while significant negative correlations exist with arsenic. The element sulfur only has a positive and significant association with mercury. No other element interacts with chromium in a significant way. The elements manganese and zinc have a positive and strong relationship. Nickel and aluminum both show a strong and positive association with iron. Looking at the correlation between position and elements in August, aluminum has a positive association with sulfur, chromium, and mercury, but a negative association with manganese, iron, nickel, copper, zinc, arsenic, and lead. However, only the chromium element exhibits a significant interaction (p 0.05). Significant positive correlations exist between aluminum and iron, nickel, and copper, while significant negative correlations exist with arsenic. The element sulfur only has a positive and significant association with mercury. No other element interacts with chromium in a significant way. The elements manganese and zinc have a positive and strong relationship. Nickel and aluminum both show a strong and positive association with iron.

Position and the Aluminum and Chromium elements exhibit a negative association when the data for the month of November are reviewed, whereas the other elements exhibit a positive relationship. Only the Copper element, though, has a discernible relationship with position. Only the elements Copper and lead displayed a positive and substantial connection when the relationships between the elements were studied.

According to the Pearson analysis for a year, there is a negative relationship between position and aluminum, sulfur, nickel, copper, arsenic, and lead, while a positive relationship exists between position and chromium, manganese, iron, zinc, and mercury. It only interacts with Mercury significantly. While the aluminum element has a positive and significant relationship with the elements iron and nickel, the sulfur element has no significant connections with any other elements. The elements manganese, mercury, and lead show a positive and strong association with the element chromium. There is a strong and positive correlation between mercury, iron, nickel, copper, zinc, and chromium. The elements iron and aluminum, manganese, nickel, copper, zinc, mercury, and lead all exhibit positive and significant correlations. While manganese, iron, copper, zinc, mercury, and lead are significantly and positively correlated with copper, aluminum, manganese, copper, and mercury are positively and significantly correlated with nickel. While the zinc element exhibits positive and significant correlations with manganese, iron, copper, mercury, and lead, while the arsenic element only shows a positive and significant correlation with mercury, mercury shows positive and significant correlations with all of the other elements and a negative correlation with aluminum. The association of lead with chromium, iron, copper, and mercury is positive and significant.

Conclusion

Element analysis was performed on sediment samples collected seasonally from Karacaören II Dam Lake. The sediment sample metal analysis revealed the presence of the element's aluminum, sulfur, chromium, manganese, iron, nickel, copper, zinc, arsenic, mercury, and lead when the data were evaluated. It has been compared to research done in our country in various lakes using different spectroscopic techniques. According to the international "sediment quality assessment" criteria, Chromium and Mercury were found to be above the common effect level, Lead and Zinc were found to be below the rare effect level, Arsenic and Copper were found to be close to the temporary effect level, and Nickel was found to be above the temporary effect level. The enrichment factor and the geo-accumulation index were calculated for pollution indicator metrics in the sediments. Despite the absence of significant human enrichment in these elements, it has been discovered that aluminum, chromium, mercury, nickel, and zinc elements have a minor enrichment. The chromium element has contamination that ranges from average to severe compared to other elements. It is thought that communities and agricultural lands are the primary sources of pollution, particularly at the sites where the concentration of arsenic in the sediment samples is high. The density of chromium and nickel levels in the area is thought to be a result of the geological structure of the area, particularly mining activity. Overall, it is believed that the study's findings offer preliminary insight into how water is used for drinking in the province of Antalya. Before using any water, it is important to carefully consider the circumstances of the activities occurring in and around the lake. It's critical to assess the Isparta Stream's pollution levels before they enter the lake. After deciding to use the water, efforts should be made to raise awareness among locals in the villages close by to persuade them to keep all household waste and potential pollutants, particularly agricultural runoff, away from the lake. The condition of the farms operating in the lake should also be evaluated by the accredited institutions. All spectroscopic studies on water that use chemicals will be thoroughly cleaned before use.

Acknowledgements

This work has been made possible thanks to TUBITAK Project No. 115Y768 from the Turkish Council for Scientific and Technological Research

Conflicts of Interest

There are no conflicts of interest in this work.

References

[1] Casas J., Rosas H., Solé M., Lao C., Heavy metals and metalloids in sediments from the Llobregat basin, Spain, *Environmental Geology,* 44 (2003) 325-332.

[2] Singh K.P., Mohan D., Singh V.K., Malik A., Studies on distribution and fractionation of heavy metals in Gomti river sediments—a tributary of the Ganges, India, *Journal of Hydrology,* 312 (2005) 14-27.

[3] Mwamburi J., Variations in trace elements in bottom sediments of major rivers in Lake Victoria's basin, Kenya, *Lakes & Reservoirs: Research & Management*, 8 (2003) 5-13.

[4] Ghrefat H., Yusuf N., Assessing Mn, Fe, Cu, Zn, and Cd pollution in bottom sediments of Wadi Al-Arab Dam, Jordan, *Chemosphere,* 65 (2006) 2114-2121.

[5] Khaled A., El Nemr A., El Sikaily A., An assessment of heavy-metal contamination in surface sediments of the Suez Gulf using geoaccumulation indexes and statistical analysis, *Chemistry and Ecology,* 22 (2006) 239-252.

[6] Linnik P.M., Zubenko I.B., Role of bottom sediments in the secondary pollution of aquatic environments by heavy-metal compounds, *Lakes & Reservoirs: Research & Management*, 5 (2000) 11-21.

[7] Makundi I.N., A study of heavy metal pollution in Lake Victoria sediments by energy dispersive X-ray fluorescence, *Journal of Environmental Science and Health, Part A*, 36 (2001) 909-921.

[8] Çevik F., Göksu M.Z.L., Derici O.B., Fındık Ö., An assessment of metal pollution in surface sediments of Seyhan dam by using enrichment factor, geoaccumulation index and statistical analyses, *Environmental monitoring and assessment,* 152 (2009) 309-317.

[9] Şener Ş., Elitok Ö., Şener E., Davraz A., An investigation of Mn contents in water and bottom sediments from Eğirdir Lake, Turkey, *Mühendislik Bilimleri ve Tasarım Dergisi,* 1 (2011) 145-149.

[10] Bat L., Yesim Ozkan E., Oztekin H. Can, The contamination status of trace metals in Sinop coast of the Black Sea, Turkey, (2015).

[11] Bryan G., Some aspects of heavy metal tolerance in aquatic organisms, *Effects of pollutants on aquatic organisms,* 2 (1976) 7- 34.

[12] Fernandez-Leborans G., Herrero Y.O., Toxicity and bioaccumulation of lead and cadmium in marine protozoan communities, *Ecotoxicology and environmental safety,* 47 (2000) 266-276.

[13] Järup L., Hazards of heavy metal contamination, *British medical bulletin,* 68 (2003) 167-182.

[14] Turekian K.K., Marine geochemistry, Eos, *Transactions American Geophysical Union*, 52 (1971) IUGG237-IUGG244.

[15] Alkan A., Alkan N., Yanar B., Investigation of pollution levels originated from anthropogenic gadolinium in Ankara Stream, *Environmental Science and Pollution Research,* 27 (2020) 23677-23685.

[16] Chatterjee M., Silva Filho E., Sarkar S., Sella S., Bhattacharya A., Satpathy K., Prasad M., Chakraborty S., Bhattacharya B., Distribution and possible source of trace elements in the sediment cores of a tropical macrotidal

estuary and their ecotoxicological significance, *Environment International*, 33 (2007) 346-356.

[17] Idris A.M., Combining multivariate analysis and geochemical approaches for assessing heavy metal level in sediments from Sudanese harbors along the Red Sea coast, *Microchemical Journal,* 90 (2008) 159-163.

[18] Ozkan E.Y., Buyukisik B., Geochemical and statistical approach for assessing heavy metal accumulation in the southern Black Sea sediments, *Ekoloji,* 21 (2012) 11-24.

[19] Wardas M., Budek L., Rybicka E.H., Variability of heavy metals content in bottom sediments of the Wilga River, a tributary of the Vistula River (Krakow area, Poland), *Applied Geochemistry,* 11 (1996) 197-202.

[20] Diken G., Köknaroğlu H., Can İ., Cultural energy use and energy use efficiency of a small-scale rainbow trout (Oncorhynchus mykiss Walbaum, 1792) cage farm in the inland waters of Turkey: A case study from Karacaören-I Dam Lake, *Aquaculture Studies,* 21 (2020) 31-39.

[21] Kir I., Erdogan M., Engin M.S., Cay S., Trace metals in sediment, water and their bioaccumalation in Carp (Cyprinus Carpio L., 1758) samples, captured from the Karacaoren (I) Dam Lake, Turkey, *Fresenius Environmental Bulletin,* 25 (2016) 3557-3562.

[22] Citil O.B., Kalyoncu L., Kahraman O., Fatty acid composition of the muscle lipids of five fish species in Işıklı and Karacaören Dam Lake, Turkey, *Veterinary Medicine International*, (2014) 2014.

[23] Kalyoncu L., Kalyoncu H., Arslan G., Determination of heavy metals and metals levels in five fish species from Işıklı Dam Lake and Karacaören Dam Lake (Turkey), *Environmental monitoring and assessment,* 184 (2012) 2231-2235.

[24] Ozvarol Z., Karabacak G., Changes in the population structure of pikeperch (Sander lucioperca Linnaeus, 1758) Karacaoren-I Dam Lake, Turkey, *Journal of Animal and Veterinary Advances,* 10 (2011) 224-228.

[25] Ozvarol Z.A.B., Ramazan I., Mortality ratio and stock analysis of Vimba (Vimba vimba tenella (Nordmann, 1840)) population ın Karacaoren I Dam Lake (Burdur-Turkey), *Journal of Applied Biological Sciences*, 3 (2009) 143-147.

[26] Becer Z., İkiz R., Investigation of some biological characters of the Vimba (Vimba vimba tenella (Nordmann, 1840)) population in Karacaören I Dam Lake, *Turkish Journal of Veterinary & Animal Sciences,* 25 (2001) 111-117.

[27] Diler, A., Becer Z., Chemical composition and meat yield of vimba (Vimba vimba tenella (Nordmann, 1840)) in Karacaören I Dam Lake, *Turkish Journal of Veterinary & Animal Sciences,* 25 (2001) 87-92.

[28] Mahommed N., Makundi I., Optimization of EDXRF for the study of heavy metal pollution of Lake Victoria, *Tanzania Journal of Science,* 28 (2002) 7-24.

[29] Al-Haidarey M., Hassan F., Al-Kubaisey A., Douabul A., The geoaccumulation index of some heavy metals in Al-Hawizeh Marsh, Iraq, *E-Journal of Chemistry,* 7 (2010) S157-S162.

[30] Loska K., Cebula J., Pelczar J., Wiechuła D., KwapulińskiJ., Use of enrichment, and contamination factors together with geoaccumulation indexes to evaluate the content of Cd, Cu, and Ni in the Rybnik water reservoir in Poland, *Water, Air, and Soil Pollution,* 93 (1997) 347-365.

[31] Hasan A.B., Kabir S., Reza A.S., Zaman M.N., Ahsan A., Rashid M., Enrichment factor and geo-accumulation index of trace metals in sediments of the ship breaking area of Sitakund Upazilla (Bhatiary–Kumira), Chittagong, Bangladesh, *Journal of Geochemical Exploration*, 125 (2013) 130-137.

[32] Krauskoph K., Bird D., *Introduction to geochemistry* McGraw-Hill Inc, New York, (1995) 647.

[33] Krauskopf K.B., Bird D.K., *Introduction to geochemistry*, McGraw-Hill New York, 1967.

[34] Karadede H., Ünlü E., Concentrations of some heavy metals in water, sediment and fish species from the Atatürk Dam Lake (Euphrates), Turkey, *Chemosphere*, 41 (2000) 1371-1376.

[35] Çevik F., Göksu M.Z.L., Derici O.B., Fındık Ö., An assessment of metal pollution in surface sediments of Seyhan dam by using enrichment factor, geoaccumulation index and statistical analyses, *Environmental monitoring and assessment*, 152 (2009) 309-317.

[36] Kır I., Tumantozlu H., Investigation of some heavy metal accumulation in water, sediment and carp (Cyprinus carpio) samples of Karacaoren-II Dam Lake, *Ekoloji*, 21 (2012) 65-70.

[37] Öztürk M., Özözen G., Minareci O., Minareci E., Determination of heavy metals in fish, water and sediments of Avsar Dam Lake in Turkey, *Journal of Environmental Health Science & Engineering*, 6 (2009) 73-80.

[38] Uysal K., Özden Y., Çiçek A., Esengül K., Bioaccumulation ratios of sediment-bound heavy metals of Porsuk and Enne Dam Lakes (Kütahya/Turkey) to different tissues of common carp (Cyprinus carpio), *Aquatic Sciences and Engineering*, 25 (2010) 1-10.

[39] Akin B.S., Kırmızıgül O., Heavy metal contamination in surface sediments of Gökçekaya Dam Lake, Eskişehir, Turkey, *Environmental Earth Sciences*, 76 (2017) 1-11.