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Determining the Sediment Quality of Yağlıdere Stream (Giresun)

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A B S T R A C T

Sediments in aquatic systems are often contaminated by various pollutants originating from the sources such as industrial and agricultural discharges, municipal wastewater treatment plants, and storm water. These effects lead to the need to develop sediment quality objectives regarding the protection of aquatic ecosystems and human health. In this study, the sediment samples were collected from five sampling sites and then analyzed in order to identify the concentrations of certain metals (As, Se, Ag, Cd, Na, and K), the levels of pH, conductivity, water content (%) and organic matter (%) in the Yağlıdere Stream. Finally, Geo-accumulation index values calculated based on the estimations regarding the background trace element concentrations suggested the anthropogenic influences in most of the samples. In conclusion, it was observed that K, Na, As, and Se dominantly accumulated in the study area. These metals may have a negative impact on the research area and create an environmental risk.

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Yağlıdere Çayı (Giresun) Sediment Kalitesinin Belirlenmesi

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Ö Z E T

Sucul ekosistemlerde sediment endüstriyel ve tarımsal deşarjlar, evsel atıklar, atık su arıtma tesisleri ve yağmur gibi doğa olayları sonrasında çeşitli kirleticiler tarafından sıklıkla kirletilmektedir. Bu etkilerinden dolayı sucul ekosistem ve insan sağlığını korumak için sediment kalitelerinin geliştirilmeye ihtiyacı vardır. Bu çalışmada Yağlıdere Çayı'ndan 5 istasyondan toplanan sediment örneklerinde bazı metallerin (As, Se, Ag, Cd, Na, K) pH, elektriksel iletkenlik, (%) su içeriği ve (%) organik madde miktarı analiz edilmiştir. Elde edilen veriler ile yerkabuğundaki iz element miktarlarından faydalanılarak Jeoakümülasyon İndeks değeri tahmin edilmiş ve örneklerin çoğunda antropojenik etkinin varlığı belirlenmiştir. Sonuç olarak, çalışma alanında K, Na, As ve Se'nin baskın olarak biriktiği gözlemlenmiştir. Bu metaller Yağlıdere Çayı'nda olumsuz etkiye sahip ve çevresel risk yaratabilir.

Introduction

Rapid increase in the world's population in recent years, rapid and unplanned urbanization, tourism, failed land planning, and the domestic wastes, petrol, oils, detergents, radioactive wastes, pesticides, artificial and natural agricultural fertilizers, and heavy metals reach of the aquatic media as a result of intense industrial and technological development. The arrival of these pollutants to the water resources disturbs the balance of aquatic systems.

Hence, the aquatic environment, which is a component of ecosystem, has become the most polluted part of the ecosystem since it has been used as the receiver and the removal area for the used water and wastes, when compared to air and soil. Because of the release of untreated or inefficiently treated domestic and industrial wastes into river waters, many organisms living in these waters face with the threat of extinction. Under favor of developing environmental consciousness of today, as well as preventing the release of harmful wastes into the water, also the effects of the food chain and human are investigated (Griscom et al., 2000; Mutlu et al., 2014; Akcay et al., 2003; Kurnaz et al., 2016; Mutlu et al., 2013; Polat and Akkan, 2016; Mutlu and Aydın Uncumusaoglu, 2016).

The pollutants reach of the aquatic media through point and non-point discharges. Point discharges are the waste water discharges, and waste waters released from industrial sources, while the non-point discharges originate from the regions, where the dangerous wastes are disposed, and also the pollutants that are released accidentally.

Characterization of the point source types is generally easy. But, however, it is very difficult to accurately characterize the non-point discharges because they are the pesticides released from agricultural lands, and the leakages from the contaminated soils and aquatic sediments, atmospheric accumulation, and residential areas. Moreover, in many cases, the discharges originating from the non-point sources are the complex mixtures, and it is very difficult to estimate the timing and amount of the toxic matters and discharges. One of the most complicated issues with the non-point discharges is that variability of toxic characters because of the compounds (Çetinkaya, 2015).

The thickness and structure of sediment layer are closely related to the physical, chemical, geological, and biological phenomena emerging in aquatic systems, and these events are the main reason for the differences among the deep structures. By the origins, the sediments are divided into 3 groups; a) Lithogenic (terrestrial) Sediment consists of river, wind, anthropogenic factors, icecaps, and volcanic inputs, b) Hydrogenic Sediments, and c) Cosmogenic Sediments (Ergül, 2004).

As a result of the transportation of heavy metals, which are among the pollutant materials, into the aquatic media through rivers, erosion, rain, and floodwaters, the concentration in water and sediment layer also increases. Among the sediment pollutants, the pesticides, detergents, heavy metals, and poly-aromatic hydrocarbons (PAH) have the largest share (Atamanalp and Yanık, 2001; Ribeiro et al., 2005).

The accumulation of the metals in sediments at the surficial waters may vary depending on the particular structure, geochemical features, organic matter characteristics, grain size, and cation transfer capacity. Since the metals, which have significant importance for the biological cycle in aquatic ecosystems, have toxic effects above the certain concentrations, they are among the most important parameters paying attention in sediment quality studies.

The majority of metal pollution accumulates within the waters, and this accumulation may be in the form of dissolution, as well as it may be in the form of precipitation in sediment without dissolving. Metal pollution may be caused by industrial and agricultural wastes, but also any sort of metal released into the atmosphere may also cause this pollution. Metallic materials in atmosphere return to the earth as a result of the cycle, and then reach at the sediment through the streams. In metal pollution, no chemical or biological degradation occurs; a metal compound transforms into another metal compound, but the metallic ion doesn't disappear (Rainbow, 1995).

In this study, it was aimed to determine the concentrations of certain metals (As, Se, Ag, Cd, Na, and K) in Yağlıdere Stream and also the levels of pH, electrical conductivity, water content (%), and organic matter (%), and to reveal the level and sources of sediment pollution by calculating the Geo-Accumulation Index Value.

Materials and Methods

Collecting the Sediment Samples

The Yağlıdere stream is originated from Erimez Mountains and the length of its main branch is 70 km. After it is formed, Yağlıdere passes through the towns and sites and poured into the southeastern Black Sea in Espiye Town. Replicate sample for each location along the stream were collected monthly in November 2013 and October 2014 from 5 stations (Figure 1). Sediment samples were collected with Ekman type (15x15x15 cm) sediment buppies from 3 different points in each station. Sediment samples collected during the study were brought to the laboratory in ice-protected cups and stored at -21°C under laboratory conditions until analysis.

Figure 1 Map of study area with sampling point locations (adapted from Google earth).

Analysis of Sediment Sample

pH and Electrical Conductivity Analyses of sediment: the sediment samples weighed in wet form were treated with 1:2.5 pure water. Following the precipitation of well-stirred samples, the pH and electrical conductivity of supernatant liquid were measured (Landajo et al., 2004).

Amount of Organic Matter (%) in Sediment; sediment samples were dried at 60°C, pulverized into 2g powder, and then put into porcelain crucibles and kept in crematorium for 2 hours at 550°C. At the end of this duration, the samples were returned to the room temperature in a desiccator and, following the weighing, then the values were calculated (Egemen, 2000).

Water Content of Sediment (%); specimens were put into sample containers, dried at 105°C, and then cooled in desiccator. Using the differences between weights, the percentage of water was calculated (Anonymous, 1995).

Element Analysis of Sediment; for As, Se, Ag, and Cd analyses, the sediment specimens taken from 0-10cm layers of the deep sections of stations were sieved using 0.5 µm sieve. The sieved samples were left for drying at 102-105°C until reaching a constant weight. 1g samples were taken from the dried specimen and, after being added to 3mL HCl and 1mL HNO_3, they kept at room temperature for 24 hours. Then, the samples were taken to the heat table, and treated at 120°C unless they clarified. The prepared samples were diluted to 50 mL by adding deionized water, and prepared for scanning by filtering through blue band filter papers (Anonymous, 1984; Dural and Göksu, 2006). For Na and K analyses, the standard method steps in flame photometer were employed.

Statistical Analysis

The differences between the stations and seasons were analyzed using Variance analysis, One Way ANOVA test, and Tukey multiple comparison test. In order to determine the relationship between the sediment parameters, Pearson's correlation was used. All of the statistical calculations were performed using SPSS 17.0

Geo-accumulation Index Analysis (Igeo)

Proposed by Müller (1969, 1979), the Geo-Accumulation Index is now used for determining the level of pollution by comparing the actual metal content to the values obtained before the industrialization. The index was calculated using the formula below;

$$Igeo = \log_2(Cn/Bn)$$

Where *Cn* is the concentration of metals examined in sediment samples and *Bn* is the geochemical back ground concentration of the metal (n). The pollution classes are presented in Table 1 in harmony with the Geo-Accumulation Index (Vertacnik et al., 1995; Marvin et al., 2004).

Results and Discussion

As well as the metal accumulations in sediments through the natural processes cause pollution, the anthropogenic factors became non-ignorable. Besides determining the metals, it is also very important for determining the sediment quality to reveal the organic matter (%), pH, and water retaining capacity (Leong and Tanner, 1999; Aydın and Sunlu, 2004; Sunlu et al., 2005). In this study, no statistically significant difference was found between the mean values of stations (P>0.05).

The pH level in Yağlıdere Stream sediment ranged between 6.20 and 8.50. The lowest value was observed in 2nd station in the spring season, while the highest value was observed in 1st station in autumn season. Mean pH values were found to be 7.50 (±0.132) in summer, 7.78 (±0.088) in autumn, 7.86 (±0.072) in winter, and 7.25 (±0.117) in spring seasons. Statistically significant differences were observed between the seasonal mean pH levels (P<0.05) (Table 2). It is through that the geomorphological structure of the stream's bed may be the reason for high pH values. These findings are also consistent with the literature data (Akcay et al., 2003; Bakan and Şenel, 2000; Cappuyns and Swennen, 2005).

The mean electrical conductivity (EC) found to be 309 (±47.983) mS/cm in summer was determined to be 245 (±41.796) mS/cm in autumn, 198 (±30.898) mS/cm in winter, and 234 (±43.247) mS/cm in spring seasons. EC of the sediment of Yağlıdere Stream ranged between 60 and 710 mS/cm. The minimum value was observed in 1st station in winter season, while the highest level was observed in 4th station in summer season. It was also determined that the differences between the seasonal mean EC values were not statistically significant (P>0.05).

Sediment's water content (%) varied between 12.422 and 41.293; the highest value was observed in 2nd station in the autumn season, while the lowest value was determined in 1st station in autumn season. Seasonal mean values were found to be 20.046 (±1.451) for summer, 22.750 (±1.882) for autumn, 23.014 (±1.563) for winter, and 22.732 (±1.963) ppm for spring seasons. Besides these values, there was no statistically significant difference between the seasonal mean values (P>0.05).

The level of combustible organic matter (%) in sediment varied between 0.250 and 7.600, while the lowest and highest values were observed in the spring season in 1st and 5th stations, respectively. Mean seasonal values were found to be 1.951 (±0.124) for summer, 1.912 (±0.013) for autumn, 2.587 (±0.313) for the winter, and 3.160 (±0.529) for spring seasons. When compared to the literature data, the level of combustible organic matter is seen to be low (Bakan and Şenel, 2000). From the aspect of seasonal mean values of combustible organic matter concentration in sediment, the differences were found to be statistically significant (P<0.05) (Table 3).

Table 1 Geoaccumulation Index Classification

Class	Value	Categorization
Class 0	Igeo<0	Uncontaminated
Class 1	0<Igeo<1	Uncontaminated to moderately contaminated
Class 2	1<Igeo<2	contaminated
Class 3	2<Igeo<3	Moderately - strongly contaminated
Class 4	3<Igeo<4	Strongly contaminated
Class 5	4<Igeo<5	Strongly - extremely strongly contaminated
Class 6	Igeo>5	Extremely contaminated

Table 2 Seasonal Mean, Standard deviation (SD) and range (Minimum- maximum) of pH values in sediment

Stations	1	2	3	4	5	Mean
Summer	7.33±0.393 6.80-8.10	7.50±0.404 6.70-8.00	7.57±0.285 7.00-7.90	7.47±0.296 6.90-7.90	7.63±0.318 7.00-8.00	7.50±0.132[ab] 6.70-8.10
Autumn	8.17±0.167 8.00-8.50	7.53±0.120 7.30-7.70	7.70±0.200 7.30-7.90	7.80±0.153 7.50-8.00	7.70±0.231 7.30-8.10	7.78±0.088[b] 7.30-8.50
Winter	8.07±0.186 7,70-8,30	8.00±0.100 7.80-8.10	7.67±0.203 7.30-8.00	7.83±0.176 7.50-8.10	7.73±0.088 7.60-7.90	7.86±0.072[b] 7.30-8.30
Spring	7.23±0.384 6.50-7.80	6.83±0.376 6.20-7.50	7.57±0.067 7.50-7.70	7.37±0.120 7.20-7.60	7.27±0.176 7.00-7.60	7.25±0.117[a] 6.20-7.80

[a,b]The different letters in same column indicate significant differences (P<0.05)

Table 3 Seasonal Mean, Standard deviation (SD) and range (Minimum- maximum) of Organic matter (%) values in sediment

Stations	1	2	3	4	5	Mean
Summer	1.563±0.417 0.730-1.980	1.783±0.147 1.490-1.940	2.090±0.150 1.940-2.390	2.263±0.373 1.880-3.010	2.053±0.159 1.870-2.370	1.951 ±0.124[a] 0.730-3.010
Autumn	1.953±0.022 1.910-1.980	1.873±0.029 1.820-1.920	1.923±0.015 1.900-1.950	1.887±0.050 1.790-1.960	1.923±0.015 1.900-1.950	1.912±0.013[a] 1.790-1.980
Winter	2.587±0.632 1.950-3.850	2.253±0.298 1.950-2.850	2.027±0.087 1.930-2.200	3.123±1.188 1.930-5.500	2.943±1.054 1.850-5.050	2.587±0.313[ab] 1.850-5.500
Spring	1.033±0.434 0.250-1.750	1.950±0.506 1.100-2.850	3.167±0.689 1.800-4.000	4.717±1.120 3.450-6.950	4.933±1.353 3.200-7.600	3.160±0.529[b] 0.250-7.600

[a,b] The different letters in same column indicate significant differences (P<0.05)

Table 4 Seasonal Mean, Standard deviation (SD) and range (Minimum- maximum) of As values in sediment

Stations	1	2	3	4	5	Mean
Summer	3.691±0.638 2.867-4.946	2.395±0.080 2.242-2.514	3.232±0.302 2.799-3.813	3.188±0.972 2.095-5.127	3.305±1.403 1.502-6.068	3.162±0.332[a] 1.502-6.068
Autumn	4.768±0.266 4.242-5.102	3.855±0.798 2.872-5.435	3.820±0.244 3.356-4.182	6.929±1.643 3.676-8.961	4.976±0.132 4.824-5.238	4.870±0.437[b] 2.872-8.961
Winter	4.924±0.873 3,312-6.309	4.326±0.435 3.458-4.815	3.365±0.223 2.921-3.626	4.695±0.183 4.350-4.972	4.554±1.078 2.487-6.119	4.373±0.289[ab] 2.487-6.309
Spring	3.827±0.259 3.539-4.343	3.405±0.282 2.907-3.882	3.022±0.514 2.048-3.792	3.678±0.230 3.406-4.135	5.829±0.755 4.937-7.331	3.952±0.313[ab] 2.048-7.331

[a,b]The different letters in same column indicate significant differences (P<0.05)

The arsenic (As) concentration in sediment was found to range between 1.502 and 8.961 ppm. The lowest level was observed in 5th station in summer season, while the highest level was recorded at the 4th station in autumn. Seasonal mean As concentrations were calculated to be 3.162 (±0.332) ppm for summer, 4.870 (±0.437) ppm for autumn, 4.373 (±0.289) ppm for winter, and 3.952 (±0.313) ppm for spring season. Statistically significant differences were observed between the seasonal mean values (P<0.05) (Table 4).

The lowest concentration of Selenium (Se) was observed in the 3rd station in the spring season, while the highest level was recorded at the 4th station in autumn season. Se accumulation in sediment of Yağlıdere Stream was found to vary between 0.011 and 0.409 ppm. Seasonal mean values in ppm were found to be 0.101 (±0.015) for summer, 0.188 (±0.031) for autumn, 0.161 (±0.012) for spring, and 0.136 (±0,020) for winter seasons. There was statistically significant difference between the seasonal mean values (P<0.05) (Table 5).

The lowest concentration of silver (Ag) was observed at the 3rd station in summer season, while the highest level was recorded in the 2nd station in spring season. Ag accumulation in the sediment ranged between 0.070 and 0.844 ppm. Mean seasonal values expressed in ppm were found to be 0.100 (±0.007) summer, 0.170 (±0.024) for autumn, 0.100 (±0.006) for the winter, and 0.33 (±0.065) ppm for spring seasons. There was statistically significant difference between the mean seasonal values (P<0.05) (Table 6).

The lowest concentration of cadmium (Cd) in sediment of Yağlıdere Stream was found to be in the 3rd station in the spring season, while the highest level was observed in the 2nd station in the same season. Cd accumulation in sediment ranged between 0.009 and 0.473 ppm. The seasonal mean values expressed in ppm were calculated to be 0.132 (±0. 014) for summer, 0.155 (±0. 027) for autumn, 0.175 (±0. 020) for the winter, and 0.102 (±0. 028) for the spring season. All of the seasonal mean values were found to be higher than 0.0043 ppm that is the acceptable level of inland water sediments (Angelidis and Aloupi, 2000). The differences between the seasonal mean Cd concentrations in sediment were found to be statistically non-significant (P>0.05).

In this study, the sodium (Na) concentration in sediment ranged between 4.90 and 18.10 ppm. The lowest Na concentration was observed in 4th station in winter, while the highest level was recorded in the same station in autumn season. The seasonal mean values expressed in ppm were calculated to be 8.77 (±0. 567) for summer, 8.81 (±0. 717) for autumn, 7.17 (±0. 499) for the winter, and 8.31 (±0. 753) for spring seasons. The differences between the seasonal mean Na concentrations in sediment were found to be statistically non-significant (P>0.05).

Having the lowest value in 1st station in summer season, potassium (K) concentration peaked in 5th station in spring season. K concentration in sediment ranged between 0.30 and 7 ppm. The seasonal mean values were found to be 1.69 (±0.252) ppm in summer season, 1.69 (±0.179) ppm in autumn, 2.45 (±0.302) ppm in winter, and 2.20 (±0.465) ppm in spring. The differences between the seasonal mean K concentrations in sediment were found to be statistically non-significant (P>0.05).

When the relationship between parameters were analyzed, the Water Content (%) showed significant and positive correlation with OC, K and EC (r=0.532, r=0.688, r=0.648; P>0.01). The Se concentration showed significant and positive high correlation with as (r=0.894, P>0.01), while the EC showed significant and positive correlation with Na and K (r=0.638, r=0.653; P>0.01), which are responsible for the water mineralization. The K showed significant and positive correlation with OC (r=0. 582, P>0.01) (Singh et al., 2005; Thuong et al., 2013) (Table 7).

Table 5 Seasonal Mean, Standard deviation (SD) and range (Minimum- maximum) of Se values in sediment

Stations	1	2	3	4	5	Mean
Summer	0.146±0.038 0.098-0.222	0.071±0.005 0.065-0.082	0.083±0.029 0.053-0.141	0.098±0.047 0.051-0.191	0.106±0.046 0.050-0.196	0.101±0.015[a] 0.050-0.222
Autumn	0.170±0.039 0.103-0.237	0.189±0.105 0.049-0.395	0.105±0.016 0.074-0.126	0.317±0.091 0.135-0.409	0.160±0.020 0.122-0.192	0.188±0.031[b] 0.049-0.409
Winter	0.188±0.036 0.130-0.254	0.148±0.028 0.106-0.200	0.122±0.008 0.109-0.136	0.181±0.020 0.142-0.206	0.169±0.036 0.096-0.207	0.161±0.012[ab] 0.096-0.254
Spring	0.135±0.033 0.078-0.193	0.105±0.022 0.062-0.136	0.093±0.044 0.011-0.161	0.122±0.011 0.107-0.144	0.224±0.067 0.141-0.357	0.136±0.02[ab] 0.011-0.357

[a,b]The different letters in same column indicate significant differences (P<0.05)

Table 6 Seasonal Mean, Standard deviation (SD) and range (Minimum- maximum) of Ag values in sediment

Stations	1	2	3	4	5	Mean
Summer	0.114±0.022 0.092-0.157	0.088±0.001 0.085-0.089	0.095±0.012 0.070-0.110	0.099±0.019 0.078-0.138	0.103±0.021 0.076-0.145	0.100±0.007[a] 0.070-0.157
Autumn	0.147±0.034 0.112-0.214	0.124±0.032 0.084-0.187	0.148±0.060 0.081-0.268	0.304±0.060 0.184-0.368	0.127±0.005 0.119-0.137	0.170[a]±0.024[a] 0.081-0.368
Winter	0.110±0.019 0.091-0.148	0.093±0.012 0.080-0.117	0.089±0.005 0.082-0.098	0.104±0.009 0.087-0.115	0.103±0.018 0.079-0.138	0.100±0.006[a] 0.079-0.148
Spring	0.392±0.213 0.117-0.812	0.400±0.228 0.084-0.844	0.270±0.152 0.082-0.572	0.274±0.093 0.090-0.382	0.327±0.108 0.113-0.464	0.333±0.065[b] 0.082-0.844

[a,b]The different letters in same column indicate significant differences (P<0.05)

Table 7 Relations between parameters matrix (Pearson correlation)

P	Organic Matter	Water Content	As	Se	Ag	Cd	EC	Na	K	pH
OM	1									
WC	0.532**	1								
As	-0.053	0.061	1							
Se	-0.041	0.036	0.894**	1						
Ag	0.045	-0.025	0.147	0.089	1					
Cd	-0.126	-0.124	0,206	0.224	-0.313*	1				
EC	0.375**	0.648**	-0.039	-0.041	-0.033	-0.068	1			
Na	0.123	0.326*	0.163	0.133	-0.008	-0.122	0.638**	1		
K	0.582**	0.688**	0,114	0.089	0.063	-0.027	0.653**	0.388**	1	
pH	-0.122	-0.051	0.249	0.179	-0.455**	0.078	-0.175	-0.133	-0.075	1

P: Parameters, **P<0.01, * P<0.05

Since the streams have the character of continuous receiver media, they are the natural resources that are seriously open to the pollutants. The pollutions in any environment are not limited to those regions, but these pollutants are transported by the water streams. Especially the accumulation trend of toxic pollutants in an ecosystem poses a significant risk to the lives of organisms living in that system. Thus, determining the source of pollutants is very important for maintaining the balance of streams that are very sensitive. In order to verify that the metal accumulation in the sediment originates from the anthropogenic activities, certain quality indices such as Geo-Accumulation Index are employed. The Geo-Accumulation Index values calculated for 6 elements in 60 sediment specimens collected in our study are presented in Table 8.

The Igeo values calculated using the specimens taken from the sediment of Yağlıdere Stream are as follows; As: 1.17 (0-2.5), Se: 1.69 (0-5.2), Ag: -1.55 (-4.2 - -0.6), Cd: 0.79 (-1.2-4.5), Na: 9.65 (8.5-10.4), and K: 13.35 (11.3-15.9). It was determined that, except for Ag, there was an inclination towards the pollution for all of elements, and that Na and K parameters indicated severe pollution (Asa and Rath, 2014).

In other study that has been carried out in order to determine the heavy metal pollution at the points, where the some streams in Giresun coast are discharged to the sea, it has been reported that the mean seasonal cadmium (Cd) concentrations of Aksu, Batlama, Boğacık, Camiyalısı and Güre Streams were found to be 0.305, 0.433, 0.253, 0.129, 0.300 for winter season, 0.423, 0.875, 3.172, 5.113, 2.896 for spring season, 0.553, 0.552, 0.515, 0.790, 1.198 for autumn season, and 0.654, 0.589, 0.698, 0.800, 1.059 ppm for summer season (Türkmen and Akbulut, 2015). Cd element, which is also examined in our study, has been determined to be at its highest point in Camiyalısı Stream only in summer season. This parameter's values are lower in other seasons and stations.

In study of Bakan and Şenel (2000) on Mert River (Samsun), they have reported sediment pH to be 6.8-7.65 and the level of combustible organic matter to be 5.61% (Bakan and Şenel, 2000). In study of Ünal (2010) on sediment of Yeşilırmak River, the mean values were reported to be as follows (min., max.) in µg/g; Fe: 1097-3566, Zn: 26.5 - 45.5, Cu: 28.6 - 38.7, Pb: 5.2 - 17.3, Mn: 294- 446, Ni:70.3 - 7.2, Cd: lower than measurable limit -

0.55 (Ünal, 2010). In study of Gümüşler Stream, the mean values were reported to be Cd:4.4 ppm, As: 268.6 ppm, Ag:4.4 ppm, Na:2627.6 ppm, and K:15584 ppm (Yalçın et al., 2007). The concentrations of elements in sediment of Lot River (France) have been reported to be as follows; Cu: 97.7-26.9 ppm, Zn: 134-4430 ppm, Cd: 0.81-125 ppm, Pb:43.6-523 ppm (Audry et al., 2004).

As a result of sediment quality index analysis of Tiaozi River (China) according to Geo-Accumulation Index, the classes of 3 regions examined have been reported to vary between Class 0 and Class 1 (Dong et al., 2015). Igeo index result of Lich River (Vietnam) have indicated the quality to be Class 0 in terms of Mn, Fe, Ni and Cr, Class 1 in terms of Cu, Class 2 in terms of Pb and Zn, Class 3 in terms of As, and Class 4 in terms of Cd (Thuong et al., 2013). The Igeo vales determined in Kavak Delta were found to be positive for Cd, Li, Ni, Pb and Se and negative for Ba, Cr, Cu, Sr and Zn. In same study, it has also been reported that classes of Cd and Se were Class 2 and those of Li, Ni and Pb were Class 1 (Sungur and Özcan, 2014).

According to the results of Geo-Accumulation Index analyses implemented in this study, As was found to vary between Class 1 and 3, Se to be observed in all classes, Ag to be Class 0, Cd to be Class 0 and 5, and Na and K to be Class 6. Highest Igeo values were found to be in 5th station in June for As (2.50), in 3rd station in March for Se (5.20), in 3rd station in May for Cd 4.50, in 4th station in January for Na (10.4), and in 1st station in June for K (15.9).

Table 8 Elements of Geo-accumulation Index Analysis (Igeo)

	June					July					August				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
As	1.4	1.8	1.2	2.0	2.5	1.6	1.8	1.5	1.9	1.9	0.8	2.0	1.6	0.8	0.5
Se	2.0	2.3	1.5	3.0	3.0	1.7	2.6	2.8	3.0	2.5	0.9	2.6	2.9	1.1	1.0
Ag	-1.0	-0.9	-1.2	-0.8	-0.9	-1.0	-0.9	-0.6	-0.7	-0.7	-1.7	-0.9	-1.2	-1.6	-1.6
Cd	0.7	0.5	0.5	0.6	0.9	0.3	0.3	0.2	0.4	0.5	-0.4	2.0	1.2	0.9	2.5
Na	9.4	9.8	9.3	9.0	9.4	10.2	9.8	10.0	9.0	9.4	10.0	9.7	9.7	9.3	9.2
K	15.9	14.0	12.9	12.2	12.9	14.6	13.3	13.7	12.5	13.2	14.9	14.3	13.7	13.4	13.0
	September					October					November				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
As	0.8	1.6	1.1	0.0	0.8	0.8	0.7	1.1	0.1	0.8	1.0	1.4	1.4	1.2	0.7
Se	1.2	3.0	2.4	0.0	1.7	0.8	0.0	1.7	0.0	1.3	2.0	1.7	1.8	1.6	1.1
Ag	-1.3	-0.8	-0.8	-3.0	-1.6	-1.3	-1.1	-1.0	-2.0	-1.3	-2.2	-2.0	-2.5	-3.0	-1.4
Cd	-0.8	0.8	0.8	-0.2	0.9	0.3	-0.2	1.1	0.8	1.9	0.8	0.6	2.0	1.6	-1.0
Na	10.0	9.7	9.6	8.5	9.3	9.9	9.6	9.8	9.5	9.6	9.5	9.3	9.7	9.7	9.5
K	13.7	13.2	14.4	12.4	12.9	15.1	13.4	13.6	13.5	13.1	14.3	13.3	12.8	13.2	13.3
	December					January					February				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
As	0.5	0.8	1.3	1.0	0.5	0.8	0.9	1.3	0.9	0.8	1.4	1.3	1.6	0.8	1.8
Se	0.7	1.6	1.6	1.5	0.9	1.2	1.0	1.9	1.0	1.0	1.6	1.9	1.7	1.0	2.1
Ag	-1.7	-0.8	-0.9	-0.9	-1.6	-1.0	-1.3	-0.8	-1.3	-1.0	-1.0	-0.8	-1.1	-1.2	-0.8
Cd	1.0	0.1	0.6	0.4	-0.3	-0.4	0.7	0.6	0.8	-0.4	-0.9	0.3	0.7	0.4	0.9
Na	10.1	10.0	9.7	9.6	9.3	10.2	10.2	10.2	10.4	9.5	10.0	9.7	9.9	9.6	9.1
K	13.7	13.6	12.6	13.0	12.1	13.5	13.3	13.3	12.6	11.7	13.0	12.9	13.4	13.2	12.1
	March					April					May				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
As	1.3	1.6	2.1	1.1	0.2	1.0	1.2	1.4	1.3	0.7	1.3	1.3	1.2	1.3	0.8
Se	1.6	1,8	5.2	1.5	0.2	1.1	1.6	1.9	1.9	1.5	2.4	2.7	1.3	1.8	1.2
Ag	-2.4	-2.5	-1.7	-3.0	-3.3	-1.3	-0.8	-0.8	-1.0	-1.3	-4.1	-4.2	-3.6	-2.9	-3.1
Cd	2.0	1.5	3.5	1.9	1.5	0.5	-1,2	0.7	1.3	0.9	0.9	1.6	4.5	1.9	0.9
Na	8.6	9.9	9.6	9.2	10.0	10.1	9.9	9.7	9.7	9.1	10.1	10.3	9.6	9.5	9.5
K	13.4	14.3	14.9	12.5	13.3	13.4	14.1	14.4	12.8	12.5	14.1	14.6	12.9	11.8	11.3

Conclusion

It was determined that the accumulation in this streambed, where the industrial activities are not very intense, was at considerable level. Moreover, according to the index analysis results, it was also revealed that the streambed is very sensitive to the anthropogenic activities. Furthermore, it was concluded that the seasonal changes influenced some of the parameters in this streambed. Besides the fact that intense HPP (Hydroelectric Power Plan) activity alongside this stream draws attention, it was also observed that there were discharges of point wastes especially from the district center of Yağlıdere. Throughout the sampling period, significant decreases were observed in flowrate of stream, and it was also observed that the HPPs in the region were responsible for this variation. As another reason for the metal accumulation in stream sediment, because of the geomorphological characteristics of the region, natural landslides and those caused from anthropogenic factors were frequently seen in this region during the study. It was revealed that, except for Ag, pollution trend was observed for all of elements and Na and K posed the risk of severe pollution.

In conclusion, it was revealed that the streambed of Yağlıdere Stream is very sensitive to anthropogenic activities, as well as it was projected that the metal accumulation in sediment might threaten the aquatic life unless the discharge points of businesses alongside the stream towards Yağlıdere district center and Espiye district will be taken under regular control.

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