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Research Article

Analysis of Toxic Metal-Induced Ecological Risk in Kepez Stream, Çanakkale

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Abstract

Ecological risk in the mouth of Kepez Stream has recently increased notably due to waste from the Kepez settlement, agricultural activity in the Kepez delta, maritime traffic in the Çanakkale Strait, and summer houses in the coastal area. This study analyzed the ecological risk of 10 sediment samples along the bed in the mouth of Kepez Stream to shed light on anthropogenically induced pollution. The pollution proxies such as chlorophyll degradation products, heavy metal concentrations and organic carbon of the sediment samples were determined. Enrichment Factor (EF), Contamination Factor (CF), Geoaccumulation Index (Igeo) and Potential Ecological Risk Index (PER) were calculated from the results obtained. Spearman's correlation analysis and factor analysis were also performed. The obtained data show that there is moderate enrichment of Zn, As and Co, a significant level of Pb, and very high level of Cr in the sediments of Kepez Stream. Ni enrichment was determined to be excessive and poses a high potential ecological risk. Cleaning and rehabilitation need to be carried out urgently in the mouth of Kepez Stream. It should be determined whether metals are being transmitted to aquatic organisms, and measures should be taken to reduce the sources of pollution.

Keywords: Sediment, Ecological risk, Kepez Stream, Çanakkale

Introduction

Estuaries and coastal ecosystems are productive, rich and hydrologically variable areas that support 75% of the world's population (; Gönenç and Wolflin 2004; Paerl 2006; Rodrigues-Filho et al., 2023). The chemical, physical and biological interactions between seawater and freshwater are very important in terms of the properties of the suspended particles in the water column carrying the elements (Zhai et al., 2021).

Metal accumulations caused by the rapid social development associated with human activity have become a topic of worldwide interest in the last decade (Yang et al., 2021).While one source of metals deposited in soil, sediment, and water is the weathering of rocks and natural processes, such as volcanic eruptions, another source is anthropogenic activities. After the Industrial Revolution, human intervention caused significant degradation by disrupting the water and sediment quality of rivers, which are fragile living spaces. Today, common sources of pollution are industrial wastes (Yuan et al., 2019; Khan et al., 2019), excessive use of fertilizers in agriculture, and pesticides used for pest control (Tepe and Aydın, 2017), domestic and/or urban wastes, and fossil fuels in thermal power plants. The metals released from the consumption of these metals reach the coasts via rivers and accumulate in shallow waters, especially in the sediments of gulfs and harbors (Palas, 2020; Özkan et al., 2022) or coastal lakes and lagoons (Kükrer et al., 2020; Öztura, 2023; Kumaş and Akyüz, 2023).

The sediments, which are enriched with metals but provide a source of nutrients for benthic organisms due to the micronutrient trace elements they contain, also form a natural reservoir for many fish species living and feeding in the bottom waters (Ustaoğlu et al., 2017). Metals are major pollutants of sediment and are characterized by their long residence time, toxicity, resistance to microbial degradation, and insidiousness (Wang et al., 2021). Metals enriched in sediments accumulate especially in surface sediments, and when they reach high concentrations, they exhibit toxic effects because they do not dissolve in water (Engin et al., 2020; Fural et al., 2021). Thus, since metals cannot be metabolized easily in living organisms, they accumulate in soft tissues over time and can cause serious health problems by being carried into the food chain (Saha et al., 2017). Therefore, the concentrations of elements such as Cd, Pb, Zn are frequently studied and monitored to avoid their adverse effects on ecosystem and public health (Shahabi-Ghahfarokhi et al., 2021)

As all over the world, there are ecological risks arising from the accumulation of heavy metals due to human influence in the rivers and ports that are exposed to the sediment load of the rivers in Türkiye (Aksu, 1998; Bakan and Özkoç, 2007; Karadede-Akın and Ünlü, 2007; Doğan-Sağlamtimur et al., Subaşı, 2018; Varol, 2011; Ustaoğlu and Tepe, 2018, 2019; Eker, 2020; Ustaoğlu et al., 2020a, 2020b; Akarsu et al., 2022; Kükrer et al., 2022; Ustaoğlu and Islam, 2020; Ustaoğlu, 2021). These ecological risks form part of a wide variety of anthropogenic processes throughout the country during the Anthropocene (Cürebal et al., 2015). As is well-known, the Marmara Region is one of the most polluted regions in Türkiye due to agricultural, industrial and urban wastes.

In this study, the potential caused by urban and industrial wastes, secondary residences, pollutants from agricultural activities (chemical fertilizers, pesticides, etc.) and ensuing toxic elements was investigated. According to the results of the geochemical analysis, we assessed the pollution and ecological risk for the amount of heavy metals determined at the sampling stations.

Study Area

Kepez Stream is located in the South Marmara section of the Marmara Region in Türkiye and flows into the Çanakkale Strait (Fig. 1a-b). It has a much smaller drainage area (95.56 km²) compared to the basins of River Sarıçay to the north and Karamenderes Stream to the south (Erginal et al., 2002). The stream, which forms an alluvial filled plain that is followed up to 11 km inland from the shoreline, ends in a delta intruding 1.5 km into the Çanakkale Strait. According to the 92-year data of Çanakkale Meteorology Station covering the years 1929-2021 (URL1), the annual average temperature is 15.2°C. The average highest temperatures are experienced in July and August (30.7°C), and the lowest temperatures are experienced in January (3.2°C). The annual average rainfall is 625.5 mm. December has the highest precipitation average (105.6 mm), while August has the lowest (9.2 mm) average.

Materials and Methods

For the ecological risk analysis, bottom sediment samples were collected using a Van Veen grab from 10 stations in the source direction, starting from the mouth of Kepez Stream where it empties into the Çanakkale Strait (Fig. 1c). Chlorophyll degradation products (CDP) were measured from wet samples of all the sediment samples collected, on average 200 grams. Organic carbon was measured from powder samples that were dried in an oven at 85°C and pounded in a porcelain mortar using the Walkley-Black titration method (Gaudette et al. 1974). Metal measurements were performed with Inductive Conjugated Plasma Optical Emission Specrometry (ICP-OES) at the laboratories of Bureau Veritas in Ankara.

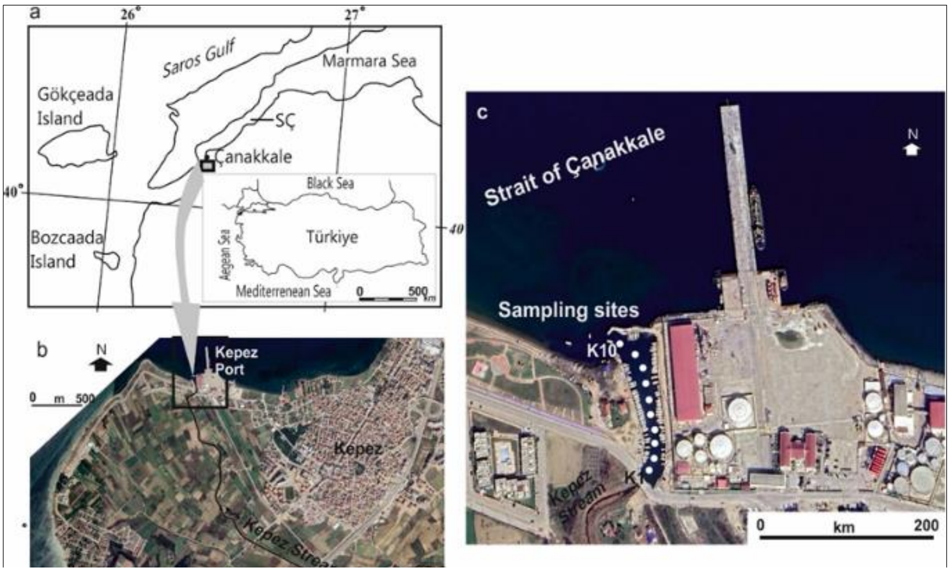

Fig. 1. Location of study area (a) and sampling sites on Google Earth Images (b-c). SÇ: Strait of Çanakkale. Last access to Google Earth Images.

Ecological Risk Indexes

The enrichment factor (EF), contamination factor (CF) modified contamination factor (mCd), potential ecological risk index (PER) and geo-accumulation index (Igeo) were calculated from the obtained ICP-OES data. Detailed information about these analyses is presented below.

Enrichment Factor (EF)

In the EF calculation, Fe, Ti or Al, which are the main components of the earth's crust, are used as conservative elements in order to minimize the error due to grain size in the sediment (Zhang et al., 2007). EF is calculated by the formula:

$$EF = (C_1 / C_{ref})\ sample / (B_1 / B_{ref})\ background \quad \text{(Eq. 1)}$$

Here, Ci is the element concentration, Cref is the concentration of the reference element used for normalization, Bi is the regional background value of the element, and Bref is the background value of the reference element selected for normalization. EF findings were evaluated considering the following ranges (Sutherland, 2000);

EF < 2 deficiency to minimal enrichment, EF = 2 – 5 moderate enrichment, EF = 5 – 20 significant enrichment, EF = 20 – 40 very high enrichment, EF ≥ 40 extremely high enrichment.

Contamination Factor (CF) and Modified Contamination Degree (mCd)

CF is another method used to determine the possible human effect on the environment and to classify environmental pollution (Hakanson, 1980). It is obtained by dividing the current metal concentration by the background metal concentration. According to Hakanson (1980), CF; low contamination (CF<1), moderate contamination (1≤CF<3), high contamination (3≤CF<6) and very high contamination (CF>6). CF is calculated as:

$$CF = C_i / C_{ni} \qquad \text{(Eq. 2)}$$

In the formula, Ci is the element concentration, and Cni is the background value of the element. Geochemical normalization is not performed in the CF calculation. For this reason, CF has some disadvantages in eliminating the errors from the grain size. mCd has been developed to eliminate this disadvantage (Abrahim and Parker, 2008). mCd is calculated as:

$$mCd = \left(\Sigma_{i=1}^{i=n}\right) CF / n \qquad \text{(Eq. 3)}$$

In the formula, CF is the contamination factor; and n is the number of elements used in the analysis. mCd findings are evaluated as follows; mCd<1.5 very low, 1.5 <mCd<2 low, 2 <mCd<4 medium, 4 <mCd<8 high, 8 <mCd<16 very high, 16 <mCd<32 extremely high, and mCd> 32 ultra-high (Abrahim and Parker, 2008).

Potential Ecological Risk Index (PER)

The potential ecological risk index (PER) developed by Hakanson (1980) was used to make predictions about the potential toxic effects of metals accumulated in the sediment to the ecosystem. The modified risk factor (Eri) calculated separately for each metal and the potential ecological risk factor (PER), which expresses the integrated risk of all metals, are evaluated as follows (Hakanson, 1980):

$$mEri = E \times T \qquad \text{(Eq. 4)}$$

The 'mEri' used in the formula is the risk factor calculated for each metal, 'E' is the enrichment factor, and "T is the toxicity coefficient for each metal separately. According to Hakanson (1980); low potential ecological risk (mEri < 40), medium potential ecological risk (40 mEri < 80), significant potential ecological risk (80 mEri < 160), high potential ecological risk (160 ≤ mEri < 320), and very high potential ecological risk (mEri 320) are interpreted as:

$$PER = \Sigma E \qquad \text{(Eq. 5)}$$

Potential ecological risk (PER) values according to Hakanson (1980) are interpreted as low ecological risk (PER <150), moderate ecological risk (PER 150 <300), significant ecological risk (PER 300 <600), and very high ecological risk (PER 2600).

Toxic Risk Index (TRI)

To determine the toxicity risk caused by each metal, the toxic risk index (TRI_i) was used. It is formulated as follows (Zhang et al., 2016):

$$TRI_i \sqrt{\frac{\{(C_i / TEL)^2 + (C_i / PEL)^2\}}{2}} \qquad \text{(Eq. 6)}$$

where Ci is the metal concentration; TEL is the threshold effect level; and PEL is the probable effect level i (Macdonald et al., 1997). The total of the individual TRI_i values for the metals gives the integrated TRI thus:

$$TRI = \sum_{i=1}^{n} TRI_i \qquad \text{(Eq. 7)}$$

The TRI values are interpreted based on following scales: TRI ≤ 5: no toxic risk; 5 < TRI ≤ 10: a low toxic risk; 10 < TRI ≤ 15: a moderate toxic risk; 15 < TRI ≤ 20: a considerable toxic risk; and TRI > 20: a very high toxic risk.

Geoaccumulation Index (Igeo)

The geoaccumulation index (Igeo) is another method used to determine the anthropogenic effect on the metal concentration in the sediment. Igeo provides advantages in detecting, identifying and classifying the contamination present in samples. The Igeo value is calculated as (Muller, 1969):

$$I_{geo} = log_2 \{(C_m / (B_m \times 1.5)\} \qquad \text{(Eq. 8)}$$

C used in the formula represents the metal concentration, and B denotes the background metal concentration. The 'C' used in the formula represents the metal concentration, and 'B' the background metal concentration. Igeo values are according to Muller (1969); Igeo ≤ 0) unpolluted, (0 < Igeo < 1) unpolluted to moderately polluted, (1 < Igeo < 2) moderately polluted, (2 < Igeo < 3) moderately to strongly polluted, (3 < Igeo < 4) strongly polluted, (4 < Igeo < 5) strongly to very strongly polluted, and (5 ≤ Igeo) very strongly polluted.

Results and Discussion

Chlorophyll Degradation Products (CDP) and Organic Carbon (OC)

As is known, CDP values represent the primary production of water masses and give an idea about the role of plant biomass in transporting metals from water to sediment (Fig. 2). CDP concentration in Kepez Stream sediments varies between 25.50 µg/g and 86.70 µg/g. The average of all samples is 52,779 µg/g. Considering the basin size of the Kepez Stream, it can be stated that the CDP level is very high. The value range of OC, which plays an important role in the transport of metals, was measured between 0.918 and 1.89 µg/g. The presence of OC in the sediment content positively affects the metal transport to the environment. Its coexistence and the strong correlation with CDP is suggestive of the contribution of phytoplankton (Kükrer et al., 2020).

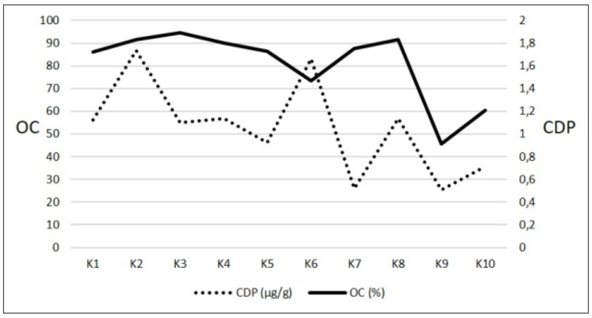

Fig. 2. CDP and OC distribution.

Enrichment Factor (EF)

EF data evaluated to determine whether the metal content comes from natural or anthropogenic sources indicate a deficiency to minimal enrichment in Cu, Fe and Mn metals according to the Sutherland (2000) classification. Transported from natural sources, the average values of these metals are 0.61, 1.2 and 1.69, respectively (Table 1). Zn, As and Co, which have EF averages of 4.07, 2.41 and 3.16, respectively, showed moderate enrichment. Pb, which shows an average EF value of 5.92, has values between 3.78 and 9.46 in the studied samples. This is indicative of a significant enrichment of Pb in the sediments. The metals that indicate an advanced stage of enrichment are Cr and Ni. Cr values vary between 18.48 and 59.02 and the EF value is 38.67. This is a sign of very high enrichment in terms of Cr. In the metal Ni, enrichment varying between 29.59 and 102.86 was determined, and the average EF value was found to be as 64.42. This explains the extremely high enrichment for Ni. These findings support the current data on metal enrichment in streams flowing into the Çanakkale Strait. Akarsu et al. (2022) determined a very high enrichment in terms of Cd, significant enrichment in terms of Cr, Ni, and Pb, and a moderate enrichment in terms of As and Mn in the sediments of Sarıçay Stream, 5 m north of Kepez Stream. This shows that metal enrichment in the sediment of these rivers, which are very close to each other, has reached a significant level.

Considering the possible sources of the enriched metals, Pb is commonly transported into the environment by precipitation from the atmosphere (Dang et al., 2021), associated with fossil fuels from vehicular traffic and used for heating purposes (Dousova et al., 2020). Similar studies reveal that Pb is an important source of pollution in port areas (Chen et al., 2020; Jeong et al., 2020). Comparable to Pb, the As moderately enriched in Kepez Port sediments may also be involved in the ecosystem through common sources such as traffic, as elsewhere (Bai et al., 2011; Dousova et al., 2020). Zn, another moderately enriched metal, could be related to domestic wastes and/or port activities (Di Beneditto et al., 2019; Merhaby et al., 2018).

Showing very high and extremely high enrichment, Ni and Cr are also of anthropogenic origin. Ni accumulation is referred to the use of coal, diesel, fuel oil and the burning of wastes (Cempel and Nikel, 2006). The source of Cr, on the other hand, is wastewater, atmospheric deposition and agricultural fertilizers (Quinton and Catt, 2007). The fact that the mouth of Kepez Stream is surrounded by agricultural lands, along with wastes from the densely populated Kepez settlement to the north, sewage from summer houses to the south, maritime traffic in the Çanakkale Strait and wastes possibly dumped into the waters from ships arriving at the port are likely to be among the common sources of the metals that we identified.

Table 1. Enrichment Factor values.

Sampling site	Cu	Pb	Zn	Ni	Fe	As	Co	Cr	Mn
K1	0.75	5.68	5.45	58.79	0.00011	2.12	2.71	40.86	1.49
K2	0.72	5.99	5.40	60.60	0.00011	2.63	2.98	38.63	1.78
K3	0.71	5.96	5.18	56.53	0.00011	1.84	2.89	34.43	1.43
K4	0.59	5.83	4.26	52.65	0.00010	2.24	2.71	32.28	1.48
K5	0.44	4.12	2.48	102.86	0.00011	1.90	3.73	55.25	1.44
K6	0.69	5.65	3.94	48.69	0.00010	1.51	2.46	30.41	1.28
K7	0.28	3.78	1.77	29.59	0.00009	2.56	1.91	18.48	1.65
K8	0.49	4.95	3.19	42.04	0.00010	2.08	2.35	26.23	1.38
K9	0.66	7.77	3.70	91.49	0.00015	3.31	4.69	51.15	2.29
K10	0.77	9.46	5.30	100.90	0.00	3.84	5.18	59.02	2.63
Average	**0.61**	**5.92**	**4.07**	**64.42**	**0.00012**	**2.41**	**3.16**	**38.67**	**1.69**

Geoaccumulation Index (Igeo)

Geoaccumulation averages of the studied samples based on Muller's (1969) classification are in good agreement with the EF results (Table 2; Fig. 3). Kepez Stream sediments are unpolluted in terms of Cu, Al and Mn, since the values are below 0. The average Igeo values of As (0.34) and Co (0.72) point to unpolluted to moderate pollution for these metals. On the other hand, the Pb and Zn values are 1.64 and 1.07, respectively, indicating that the sediments are moderately polluted. The highest values determined in metals were in Ni (5.03) and Cr (4.32). This means that the sediments are strongly to very strongly polluted in terms of these metals. These data are similar to the Sarıçay sediments which have high values for Pb and

Ni (Akarsu et al., 2022). Possible sources of enriched elements are as given in section 3.2.

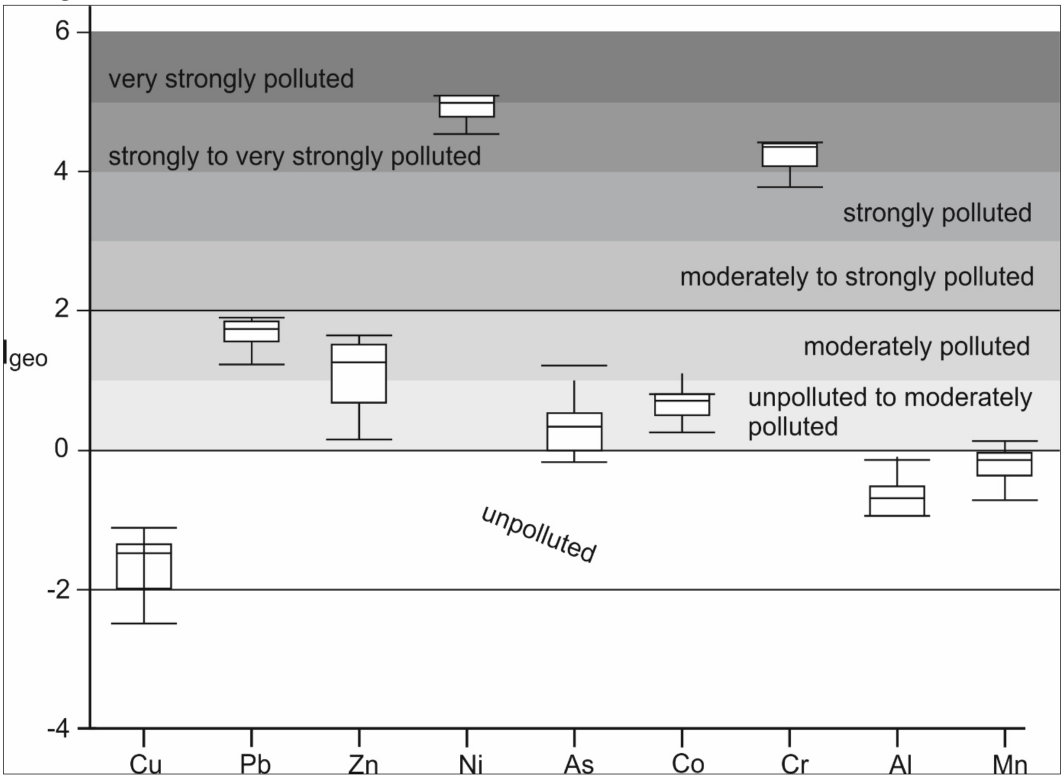

Fig. 3. Geoaccumulation index box whisker diagram.

Modified Contamination Degree (mCd)

The modified contamination degree (mCd) is an integrated version of the separately calculated CF values for each element and allows for a contamination assessment by looking at a single value for a region. The mCd values in the studied samples were calculated in the range of 8.09-24.44 (Table 3). The average mCd value is 12.27. The mCd value (24.44) representing an extremely high range was determined in only one of the sampling stations. In all of the other samples, the values ranged between 8 and 12.29, representing a very high mCd.

Among the stations, the highest mCd value was determined at K5, indicating a high contamination class. Values at all other stations are in the very high contamination class. According to these results, the port is under intense anthropogenic pressure and K5 is the point where pollutants accumulate most heavily. The largest contribution to the mCd values comes from Ni and Cr, respectively. With these two elements under control, normalization of values can be expected.

Modified risk (RI) and Potential Ecological Risk (PER) Indexes

The individual risk levels for each metal were calculated using the RI. The metal with the highest mean RI is Ni, which has a high level of risk (Table 4). This is followed by Cr, with moderate risk. The risk levels of other elements are low. The point distributions of Ni are in the high-very high range, and of Cr in the medium-important range. Among the elements with a low level of risk, Pb reached the intermediate level pointwise at sampling point 10. This indicates that this element has the potential to reach dangerous levels in the future. Cr is an element with mutagenic and carcinogenic effects. The high level of ecological risk in the study area is a situation that should be taken into account (Bazrafshan et al., 2016). The important health effects of Ni with high risk levels can be listed as follows: cardiovascular and kidney system poisoning, lung fibrosis, and skin allergies (Denkhaus and Salnikow, 2002).

According to the integrated potential ecological risk (PER) values of the elements, the average risk level in the port is significant. The point distribution of risks is between medium and very high. The section with the highest risk is K10 and K9, respectively.

Toxic Risk Index (TRI)

The determined TRI values range from 8.34 to 23.49 and vary from low to very high (Table 5). The mean value indicates a moderate toxic risk. The station with the highest toxic risk is station 5, and stations 9 and 10 are the stations with the least toxic risk. The contributions of the elements to TRI are listed as follows: Ni (53%), Cr (17%), As (13%), Cu (7%), Zn (6%) and Pb (4%).

Factor Analysis

According to the factor analysis performed to determine possible sources of metal concentrations obtained from surface sediment samples, the studied metals as well as CDP and OC are grouped under three factors (Table 6). Accordingly, TOC, Mn, Fe, As and Al constitute Factor 1. These components must have common lithogenic sources and the metals were attached to the organic carbon and precipitated in the sediment. Thus, the plant biome is efficient in transport. In the second factor, there are CDP, TOC, Cu, Pb and Zn. The algal community makes an important contribution to the transport of these metals. In other words, they must have been taken into the cell and carried by the algae that settled on the bottom after they died. On the other hand, plant biomass has an effect on the transport of these metals. Ni, Co and Cr make up the third factor load.

Table 2. Geoaccumulation index values.

Sampling site	Cu	Pb	Zn	Ni	Fe	As	Co	Cr	Al	Mn
K1	-1.3507	1.5654	1.5075	4.9378	-14.0791	0.1472	0.4972	4.4129	-0.9398	-0.3613
K2	-1.3507	1.7097	1.5619	5.0492	-14.0020	0.5257	0.7037	4.3995	-0.8721	-0.0382
K3	-1.2206	1.8410	1.6399	5.0877	-13.8865	0.1472	0.7968	4.3723	-0.7334	-0.2132
K4	-1.4062	1.9024	1.4509	5.0781	-13.8658	0.5257	0.7968	4.3723	-0.6402	-0.0789
K5	-1.5867	1.6394	0.9086	6.2827	-13.5316	0.5257	1.4972	5.3859	-0.4018	0.1257
K6	-1.1244	1.9024	1.3819	5.0097	-13.8455	-0.0048	0.7037	4.3304	-0.5959	-0.2385
K7	-1.9911	1.7769	0.6815	4.7466	-13.6154	1.2176	0.7968	4.0674	-0.1404	0.5819
K8	-1.5550	1.7769	1.1409	4.8621	-13.7925	0.5257	0.7037	4.1816	-0.5317	-0.0697
K9	-2.3237	1.2243	0.1528	4.7822	-14.4270	-0.0048	0.4972	3.9434	-1.7334	-0.5389
K10	-2.4936	1.1248	0.2881	4.5402	-14.6096	-0.1747	0.2562	3.7665	-2.1167	-0.7199
Average	**-1.6403**	**1.6463**	**1.0714**	**5.0376**	**-13.9655**	**0.3431**	**0.7249**	**4.3232**	**-0.8705**	**-0.1551**

Table 3. Modified contamination degree values.

Sampling site	Cu	Pb	Zn	Ni	As	Co	Cr	Mn	mCd
K1	0.5882	4.4393	4.2646	45.9732	1.661	2.117	31.9527	1.1677	11.52
K2	0.5882	4.9065	4.4286	49.6644	2.159	2.443	31.6568	1.4608	12.16
K3	0.6437	5.3738	4.6747	51.0067	1.661	2.606	31.0651	1.2940	12.29
K4	0.5660	5.6075	4.1006	50.6711	2.159	2.606	31.0651	1.4202	12.27
K5	0.4994	4.6729	2.8157	116.7785	2.159	4.235	62.7219	1.6366	24.44
K6	0.6881	5.6075	3.9092	48.3221	1.495	2.443	30.1775	1.2714	11.74
K7	0.3774	5.1402	2.4057	40.2685	3.488	2.606	25.1479	2.2453	10.21
K8	0.5105	5.1402	3.3078	43.6242	2.159	2.443	27.2189	1.4292	10.73
K9	0.2997	3.5047	1.6676	41.2752	1.495	2.117	23.0769	1.0325	9.309
K10	0.2664	3.2710	1.8316	34.8993	1.329	1.792	20.4142	0.9107	8.089
Average	0.5028	4.7664	3.3406	52.2483	1.977	2.541	31.4497	1.3868	12.28

Table 4. Modified risk (RI) and potential ecological risk (PER) values.

Sampling site	Cu	Pb	Zn	Ni	Fe	As	Co	Cr	Mn	PER
K1	3.67	27.74	5.33	287.33	-	10.83	10.38	5.29	39.94	390.53
K2	3.50	29.25	5.28	296.16	-	10.90	12.87	5.82	37.75	401.57
K3	3.48	29.10	5.06	276.28	-	10.73	8.99	5.64	33.65	372.97
K4	2.87	28.47	4.16	257.31	-	10.20	10.96	5.29	31.55	350.84
K5	2.14	20.11	2.42	502.68	-	10.90	9.29	7.29	53.99	608.86
K6	3.38	27.61	3.85	237.95	-	10.03	7.36	4.81	29.72	324.73
K7	1.35	18.45	1.72	144.61	-	8.58	12.52	3.74	18.06	209.06
K8	2.40	24.21	3.11	205.47	-	9.95	10.17	4.60	25.64	285.58
K9	3.24	37.96	3.61	447.14	-	14.75	16.19	9.17	50	582.09
K10	3.76	46.22	5.17	493.14	-	16.95	18.77	10.12	57.69	651.85
Average	2.98	28.91	3.97	314.81	-	11.38	11.75	6.18	37.80	417.81

Table 5. Toxic risk index values.

Sampling site	Cu	Pb	Zn	Ni	As	Cd	Cr	Hg	TRI
K1	1.06	0.41	0.96	6.01	1.45	-	2.21	-	12.12
K2	1.06	0.45	0.99	6.50	1.88	-	2.19	-	13.10
K3	1.16	0.49	1.05	6.67	1.45	-	2.15	-	13.00
K4	1.02	0.51	0.92	6.63	1.88	-	2.15	-	13.14
K5	0.90	0.43	0.63	15.28	1.88	-	4.35	-	23.49
K6	1.24	0.51	0.88	6.32	1.30	-	2.09	-	12.37
K7	0.68	0.47	0.54	5.27	3.04	-	1.74	-	11.76
K8	0.92	0.47	0.74	5.70	1.88	-	1.88	-	11.63
K9	0.54	0.32	0.37	5.40	1.30	-	1.60	-	9.55
K10	0.48	0.30	0.41	4.56	1.16	-	1.41	-	8.34
Average	**0.91**	**0.44**	**0.75**	**6.83**	**7.72**	**-**	**2.18**	**-**	**12.85**

Table 6. Factor analysis results.

	Factor 1	Factor 2	Factor 3
CDP	-0.146829	**0.893923**	0.03541
TOC	**0.583621**	**0.659154**	0.187034
Cu	0.07143	**0.965299**	0.171342
Pb	0.578028	**0.749992**	0.0727766
Zn	0.0561943	**0.96454**	0.00341234
Ni	0.0829342	0.0235862	**0.995051**
Co	0.354501	0.0568508	**0.926417**
Mn	**0.970089**	-0.0328343	0.166793
Fe	**0.774666**	0.287769	0.536747
As	**0.965888**	-0.140882	0.00696358
Cr	0.109027	0.145941	**0.976479**
Al	**0.884022**	0.303019	0.300662

Conclusion

The antropogenically induced pollution in the mouth of Kepez Stream has reached a significant level where urban waste, agricultural activities, maritime traffic and vacation homes put great pressure on the stream ecosystem. The data obtained reveal an ecological risk that has reached an alarming level in the mouth of Kepez Stream, which flows from the edge of Kepez Port. Therefore, it is not in doubt that there is an ecological risk in the sediment, especially in terms of Pb, Cr and Ni. Therefore, monitoring anthropogenic activities around the river and disconnecting it from the river can have a significant impact on preventing metal accumulations. This study lis the base for future studies. This study can be carried forward with the determination of metal fractions and more information about the bioavailability of metals can be obtained.

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