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The effect of oil pollution on community structure of benthic macro invertebrates in the northwest of the Persian Gulf (Case study: Jafari creek)

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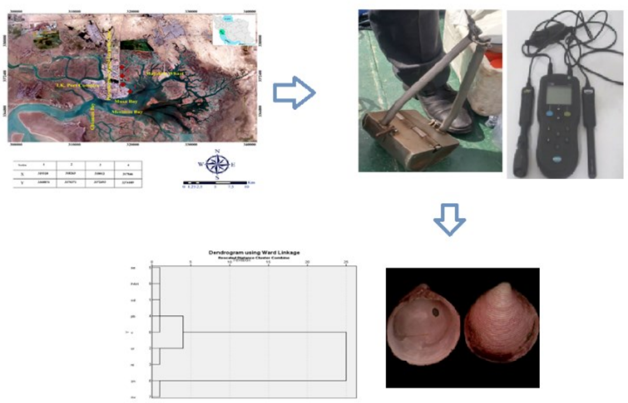
Graphical abstract



Abstract

This study evaluates the contamination levels of heavy metals and petroleum hydrocarbons in Jafari Creek sediments and the effect of these pollutions on Macrobenthos in 2017. Studies to understand the effect of heavy metal Cd, Cr, Ni, Pb, Se, Z, Cu, and V, and 16 hydrocarbon compounds, organic material, and soil texture on the population of Jafari Creek Macrobenthos in five stations along the estuary and analyzed using standard procedures. The 4 identified Macrobenthos included Bivalvia with 9 species, Gastropoda with 8 species, Crustacea with 7 species, and Polychaeta with 6 species totaling Macrobenthos 3645.14 per square meter. The dominant class was Polychaetes (53.9%), followed by Bivalvia (23.2%), Gastropoda (9.93%), and Crustaceans (15.8%), with slightly different ($P<0.05$), were in the second and third class. Among the studied metals, zinc, chromium, and nickel had the highest concentration. Among the hydrocarbons, Anthracene at station 1, Fluorene at station 2, Phenanthrene and Dibenzo [A, H] Anthracene at station 3, and Fluoranthene at station 4 with a concentration between <0.01 – 0.091 ppm had the highest value. The highest and lowest heavy metal concentrations were measured at station 4 (215.54 ± 14.58 ppm) and station 1 (102.39 ± 24.15 ppm), respectively. In return, stations 1 (0.339 ± 0.074 ppm) and 4 (0.196 ± 0.078 ppm) had the highest and lowest concentration of hydrocarbons, respectively. Regarding the number of identified Macrobenthos, stations 3 and 2, with 1738.64 and 333.28 n/m^2 had the highest and lowest numbers, respectively. The class of Crustacea had a positive correlation with zinc, copper, and lead metal and a negative correlation with Selenium. Polychaeta was positively correlated with cadmium and vanadium. Gastropoda had a negative correlation with vanadium and chromium, a positive correlation with lead and hydrocarbons, and Bivalvia correlated negatively with lead and zinc and had a correlation with vanadium. Considering that the areas around Jafari Creek are an industrial, petrochemical, and economic region considered one of the important catchments in the province of Khuzestan, the sediments, water, and animal tissues must be periodically the analysis of heavy metals and oil hydrocarbons should be considered.

Keywords: Heavy metals, Jafari Creek, Macrobenthos, Musa Estuary, Persia Gulf, Petroleum hydrocarbons.

1. Introduction

Contamination causes serious problems in the environment's structure by changing the animal ecosystem's population (Gonzalez *et al.* 2017). It is not enough to only study water and identify the pollution of water sources with the common methods of measuring the physicochemical parameters of water due to the variability of the hydrological conditions because it provides only instantaneous conditions and information at sampling time. This method is also time-consuming and expensive due to the need for repetition. Biological methods based on the study of water organisms, the most common of them are algae, fish, and benthic invertebrates. They can be used as other methods for measuring water pollution (Randolson *et al.* 1998). Biological monitoring of water resources provides information that cannot be measured by measuring physical and chemical factors. This information can include the ability of aquatic ecosystems to return to normal after pollution, long-term changes in water characteristics, and the rate of biological degradation. Physical-chemical measurements do not monitor phenomena such as the ability to self-cleaning water or bio-density of materials. Generally, biochemical and physic-chemical monitoring is also used to complement each other. Using biological monitoring, qualitative water classification can be applied (Ezekwu and Utong 2017). Change in the structure and composition of Macrobenthos populations affected by contamination is a sign of the impact of this infection on biochemical cycles and other biotic ecosystems and their performance. These creatures have a relatively long life cycle; they are very diverse, and their various species are found in a different range of contamination (from clean to severe contamination). The composition of Macrobenthos populations is closely related to environmental conditions, so physical and chemical disturbances can directly or indirectly affect the populations of these organisms through the distribution and presence of aquatic plants. High concentrations of pollutants can permanently deplete the population or replace resistant populations with native ones (Gilbert *et al.* 2015). Gholizadeh *et al.* (2021), Sudarso *et al.* (2022) and Kownacki *et al.* (2022) reported Macrobenthos as suitable indices for the measurement of biodistribution of heavy metals and oil hydrocarbons. In measuring aromatic hydrocarbons in the Euphrates River sediments in Iraq, in addition to Macrobenthos due to the storage capacity of metals by sediments, Al-Saad *et al.* (2016), reported a significant correlation between the input pollution and the levels of hydrocarbons in sediments and introduced sediment as an indicator of pollution levels.

It has a negative effect on the aquatic environment, the presence of pollutants in the water column, and these contaminations, in extreme concentrations, are considered a limitation in the supply chain and transmission of contamination (Nkwoji *et al.* 2020), in addition to affecting the biota population of the area (Hosseini *et al.* 2013). According to the source of contamination, pollutants, like heavy metals, are rapidly absorbed by suspended particles in the water column and stored hydro dynamically in water with fine particles of sediment (Al-Saad *et al.* 2016; Silva *et al.* 2017). Creeks are a specific shelter for the massive storage of contaminating materials (Vaalgamaa 2004).

Jafari Creek, in the northwest of the Persian Gulf, is one of the branches of Musa Creek. In addition to the importance of fisheries, environmental aspects of the Creek are also valuable. From the point of view of production, richness, and biodiversity, there are various aquatic species, including fish species and all kinds of benthic that are their foods. Establishing the Mahshahr Petrochemical Special Economic Zone in 1997 near the Creek, changes were made in this sensitive ecosystem. During this time, refined and untreated wastewater from polymer manufacturing plants, the production of aldehyde and acetic acid, PVC, and ... are entered from the surrounding area, and industries and structures of the pier and port. The explanations mentioned above highlight the importance of biological studies on water quality in Musa Creek and determine water quality. To understand the sustainability of an aquatic ecosystem, recognizing its aquatic organisms and the role of these organisms in assessing water quality is essential. Therefore, the purpose of this study was to use biological indicators and physicochemical parameters to determine the amount of contamination in Jafari Creek at Musa Creek, which is adjacent to the outlet of Imam Petrochemical wastewater.

2. Case studies

Musa Eestuary, located in the northwest of the Persian Gulf, consists of several large and small chains such as Creek Musa, Ghazalan Creek, Mermous Creek, and Jafari Creek. as well as several islands, including the Ghabr–e Nakhoda Island, the small and big Vasete Island and so on. 4 stations were considered total in Jafari Eestuary, considering the size of the area, access roads, drainage site, and the location of the pier and adjacent industries (Table 1, Figure 1).

Figure 1. The coordinates of the sampling points

Table 1. Coordinates of Jafari Creek sampling points

Satation	1	2	3	4
X	390319310	34239031826	390318012	390317846
Y	3968876	3370371	3372493	3374109

2.1. Sampling method

Sampling was carried out in 2017 from 4 stations in Jafari Creek and at a full reflow time of at least 1.5 meters of tidal water. In each station, three grab samples were taken for identifying benthic and indicator calculation, 1 grab for determining the concentration of metals in benthic samples, 1 grab for determination of metals in sediment, determination of the organic matter, and sediment aggregation. Samples were taken from a 5 cm sedimentation layer using a gravel van der Wien (with a cross-sectional area of 0.025 m2). Macrobenthos specimens were washed by a 500-micron sieve using seawater, and for fixing used 5% formalin. The sediment samples were also drained and labeled in polyethylene containers to measure heavy metals and petroleum hydrocarbons. Then, samples were transferred to the laboratory by icebox for subsequent steps.

2.2. Laboratory analysis

2.2.1. Preparation and digestion of benthic specimen

Benthos samples were collected from each station in petri dishes and identified by stereomicroscope (Loop), and the number of benthos was counted per group. Then, the samples were dried at an oven temperature of 105°C until tissue weight was established (Silvia *et al.* 2017). Dried specimens were completely powdered and passed through a 63-micron sieve, and a digital scale for digestion weighed 0.5 grams. With a mixture of nitric acid (69%) and chlorohydrin acid (60%), each powdered sample was placed on a hot Plate at a 4: 1 for 1 hour at 40°C and then for 4 hours at 140°C. After completely cooling the digested samples at the laboratory temperature, the digested solutions were transferred to 50 ml balloons and diluted with distilled water twice. The diluted specimens were filtered using Whatman's filter paper 42 and kept at a temperature of 4°C until they were determined for heavy metals (Yap *et al.* 2010).

2.2.2. Preparation and digestion of sediment samples

After drying the specimen in an oven at 70°C, 1 g of powdered sample was weighed. 6 mL HF was added to 1 cc HNO3 and HCL mixture with a ratio of 3: 1 and heated to 120 ºC for 150 minutes. After clearing and cooling the samples, 3.7 g of boric acid were dissolved in 20 mL of ion-free water and added to the cooled samples. The digested specimens were transferred to a 50 mL balloon and diluted twice with distilled water. The diluted specimens were filtered and filtered until heavy metals read them at 4°C (ROPME 1999).

The concentration of heavy metals in samples was analyzed using the ICP device and calculated by the following formula Eq (1) in grams per kilogram.

$$M = cv/w \quad (1)$$

M: Concentration of the metal in the sample at mg/kg
C: The amount of metal in the sample in ml/L read by the device.
V: Final sample size in ml

W: Dry weight of the sample prepared for digestion in grams

2.2.3. Grain size analysis of sediments

For grain size analysis, a part of the sediment was dried at 70°C for 24 h, then 25 g of dry sediment was added with 250 ml of water and 10 ml of hexametaphosphate solution. The sediments were stirred for 15 minutes and then settled down overnight. The next day the sediment was stirred again for 15 minutes and passed through a 63-micron sieve. The remaining material in the sieve was dried at 70°C, then carefully selected from a series of the sieve with 4, 2, 1, 0.5, 0.25, and 0.063 mm holes, and the number of residues deposited in each sieve was accurately weighed. Thus the weight of each type of aggregate was determined. Then, the percentages of each and the propagation frequency were calculated (Houte-Howes *et al.* 2004).

2.2.4. Data analysis

Data were analyzed using SPSS 18 software. The Kolmogorov-Smirnov test was used to check the normality of the data. LSD test, one-way ANOVA, and Duncan's complement test were used to compare and find a meaningful difference in the groups considered.

3. Results and discussion

3.1. Identification of Macrobenthos

Macrobenthos of Jafari Creek was placed in four categories: Bivalvia, Gastopoda, Polychaeta, and Crustacea. Bivalvia and Gastopoda classes had the highest percentages in Stations 1 and 2. Stations 3 and 4 were lacking Gastopoda. Station 3, with 1906.66 per square meter, is the most populated station, followed by Station 1, with 813.33 per square meter, station 4, with 760 per square meter, and Station 2, with 333.33 per square meter. The Polychaeta class had the highest frequency at Station 3, and the Crustacea class had the lowest percentage at Station 1 and the highest frequency at Station 4 (Table 2). At Stations 2, 3, and 4, the highest frequency was assigned to Polychaeta, and at Station 1, Bivalvia had the highest frequency.A comparison of the average of heavy metals in sediments of 4 Jafari Creek stations is shown in Table 3. The highest concentrations were for zinc metal in each of the four stations, and the lowest concentration was attributed to selenium metal. Of the 4 stations under study, station 4, with 215.5 ± 14.58 ppm, had the highest total concentration of metals, and station 1, with 102.39 ± 24.15 ppm, had the lowest concentration of heavy metals ($P < 0.05$).

3.2. Petroleum Hydrocarbons

The study of Petroleum hydrocarbons in Jafari Creek showed that Station 4 had a lower value than Stations 1, 2, and 3. Within the 16 examined Petroleum hydrocarbons, the phenanthrene hydrocarbons (stations 1 and 3), benzo-antrosan (station 3), floren (station 2), and fluorantene (station 4) showed the highest values. Regarding Anthracene number, in Station 1, with a 0.91 mg / l, the highest amount of hydrocarbon was in Jafari Creek (Table 4).

Table 2. List and frequency of *Macrobenthos* in the studied stations in Jafari Creek

Station / Macrobenthos	1	2	3	4	Total Percentage of Macrobenthos
			Bivalvia		
Paphia cor	-	8	-	1.20	2.32
Solen dactylus	3.27	-	-	-	0.82
Ostrea subucula	8.19	-	3.49	-	2.94
Paphia sp.	13.11	-	-	-	3.30
Anadara sp.	6.55	-	-	2.41	2.25
Tellina sp.	3.27	4	2.79	1.20	2.83

Ervillia scaliola	8.19	20	-	-	7.10
Dosinia sp.	4.91	-	-	-	1.23
Corbula sulculosa	1.63	-	-	-	0.41
			Gastopoda		
Natica sp.	1.63	-			0.41
Thais sp.	1.63	-			0.41
Mitrella misera	4.91	-			1.23
Atys cylidrica	3.27	-			0.82
Pseudonoba sp.	-	4			1.0
Cerithidea sp.	3.27				0.82
Calyptraea pellucida	1.63				0.41
Umbonium vestiarium	3.27	4			1.83
			Polychaeta		
Hydroides sp.	14.75	32.01	8.39	3.61	14.81
Nephtys sp.	-	-	9.79	-	2.46
Glycera sp.	-	-	-	3.61	0.91
Lumbrineris sp.	-	4	-	-	1
Unkonown Polychaeta sp.	3.27	4	-	3.61	2.74
Nereis sp.	8.19	4	66.44	48.20	31.98
			Crustacea		
Balanus amphitrite	1.63	-	2.09	-	0.93
Apseudes sp.	-	8	4.19	25.30	9.45
Amplisca sp.	-	4	-	-	1
Apanthura sandalensis	-	4	2.09	-	1.53
Penaeus sp.	-	-	0.69	-	0.17
Crab larva	-	-	-	4.82	1.21
Xenophthalmus sp.	-	-	-	6.02	1.51
Percentage	100	100	100	100	100

Table 3. Comparison of Average Heavy Metals in Jafari Creek Sediments (ppm) in Winter 2017

Station / Metal	Station 1	Station 2	Station 3	Station 4
Cd	0.77±0.01^{ab}	0.73±0.03^{a}	0.85±0.07^{b}	0.75±0.02^{a}
Cr	20.79±0.01^{a}	25.39±0.36^{c}	25.74±0.49^{c}	22.80±0.01^{b}
Ni	25.48±0.005^{a}	26.31±2.48^{a}	27.31±2.48^{a}	26.10±0.00^{a}
Pb	1.81±0.005^{a}	2.06±0.04^{a}	3.53±3.53^{b}	4.43±0.13^{c}
Se	0.20±0.00^{b}	<0.01^{a}	0.25±0.04^{c}	<0.01^{a}
Z	33.16±0.00^{a}	35.15±0.66^{a}	43.12±2.21^{b}	129.72±0.01^{c}
Cu	15±0.00^{a}	16.04±2.85^{a}	17.20±0.67^{a}	23.51±0.00^{b}
V	5.18±0.005^{a}	7.85±0.04^{b}	8.11±0.18^{c}	8.23±0.00^{c}
Total	102.39±24.15^{a}	113.53±21.92^{a}	125.11±39.64^{a}	215.54±14.58^{b}

The dissimilar letter indicates a significant difference (*P <0.05*)

Table 4. Comparison of the average of Petroleum hydrocarbon in Jafari Creek sediment (ppm)

Station / Hydrocarbons	1	2	3	4	Carcinogenicity based on USA EPA
Naphthalene	0.028±0.003^{c}	0.020±0.001^{b}	0.013± 0.001^{a}	0.013±0.005^{a}	+
Acenaphthene (Acn)	0.017±0.0005^{c}	0.017±0.001^{c}	0.014±0.005^{b}	<0.01	
Acenaphthylene (Acnp)	0.021±0.0005^{b}	0.011±0.002^{a}	0.011±0.001^{a}	<0.01	
Fluorene (Fl)	0.018±0.0005^{a}	0.052±0.067^{a}	0.011± 0.001^{a}	<0.01	
Phenanthrene (Pha)	0.032±0.12^{c}	0.026±0.001^{bc}	0.022± 0.001^{b}	0.013±0.005^{a}	-
Anthracene (An)	0.091±0.21^{a}	0.012± 0.004^{a}	<0.01	<0.01	±
Fluoranthene (Fla)	0.029±0.00^{b}	0.03±0.001^{a}	0.02±0.008^{a}	0.02± 0.005^{a}	-
Pyrene (Py)	0.020±0.005^{c}	0.016±0.002^{bc}	<0.01	0.013± 0.005^{ab}	-
Chrysene (Chr)	0.016±0.0^{c}	0.012± 0.012^{b}	0.010±0.010^{a}	0.01± 0.010^{a}	±
Dibenzo[A,H]Anthracene (Daha)	0.028± 0.00^{a}	0.029±0.001^{b}	0.022±0.001^{c}	0.014±0.005^{d}	+++
Benzo[G,H,I]Perylene (Bghip)	0.013±0.00^{b}	0.011±0.001^{a}	<0.01	<0.01	±

Benzo (A) Fluoronthene	0.013± 0.00[b]	0.011±0.001[a]	<0.01	<0.01	+
Indeno[1,2,3-Cd]Pyrene (IP)	0.013±0.005[a]	0.010±0.0005[a]	<0.01	0.013±0.005[a]	+
B(K) Fluoronthene	0.013± 0.005[a]	0.012±0.00[a]	0.011±0.0005[a]	0.013± 0.005[a]	+
B(B) Fluoronthene	0.026± 0.001[c]	0.025±0.001[c]	0.020± 0.001[b]	0.017±[a]	++
Benzo[G,H,I]Perylene (Bghip)	0.015± 0.0[a]	0.012±0.005[a]	0.01±0.0005[a]	0.01±0.005[a]	±
Total	0.393±0.074[c]	0.306±0.092[c]	0.213±0.059[b]	0.196± 0.078[a]	

The dissimilar letter indicates a significant difference (P <0.05).
++ and ++ it is sufficient information on the potency of the carcinogenicity of this hydrocarbon; • the information is not sufficiently available.

3.3. Grain size analysis and organic material

Based on the grain size analysis of sediment in each of the four stations of Jafari Creek, the percentage of clay particles in Jafari Creek sediments is higher than the percentage of the presence of silty and sandy particles (Table 5).

Table 5. Grain size analysis in sediments

Station \ Parameter	Sand%	Silt%	Clay%
1	0.40	1.54	94.88
2	0.17	0.84	97.44
3	0.62	2.74	89.72
4	0.35	3.04	91.24

3.4. Correlation between Macrobenthos and Environmental Parameters

Bivalvia and Gastopoda, in Jafari Creek had a negative correlation with pH at 0.01 and temperature at 0.05. Bivalvia was positively correlated with Clay at the level of 0.01%, and had a negative correlation with Silt at the level of 0.01% and Polychaeta (Clay) had a negative correlation with Clay at the level of 0.05% and positively correlated with Sand at 0/01% (Table 6). Polychaeta has a positive correlation with pH at 0.01%. Crustacea with DO and turbidity at 0.05 had a negative correlation and correlated with the temperature at 0.05.

Table 6. Correlation between *Macrobenthos* and Grain size analysis

Macrobenthos \ parameter	Sand%	Silt%	Clay%
Bivalvia	-0.469	-0.814**	0.796**
Gastopoda	-0.069	0.416	0.359
Polychaeta	0.710**	0.361	-0.634*
Crustacea	-0.625	0.621*	-0.273

**Correlation at the level of 0.05 ** Correlation at the level of 0.01*

3.5. Correlation between Macrobenthos, Heavy Metals, and Hydrocarbons

Bivalvia, Jafari Creek negatively correlated with 0.01% lead and Zn at 0.05. This Macrobenthos had a positive correlation with vanadium at 0.01% level. Gastopoda was negatively correlated with chromium and vanadium at 0.01% and positive at 0.05% with lead metal. Oil hydrocarbons had a positive correlation of 0.01% with Bivalvia and Gastropoda. Polychaeta positively correlated with cadmium and chromium at 0.05% and chromium at 0.01%. Crustacea had positively correlated with Lead, Zinc, and Copper at 0.01% level and Selenium at 0.05% level. Macrobenthos, except Crustacea, negatively correlated with Selenium at 0.05% level (Table 7).

Table 7. Correlation between *Macrobenthos*, Heavy Metals, and Particular Hydrocarbons

Parameter	Cd	Cr	Ni	Pb	Se	Z	Cu	V	PAHs
Bivalvia	-0.357	-0.501	-0.149	-0.919**	-0.068	-0.615*	-0.554	0.872**	0.186
Gastopoda	-0.084	-0.781**	-0.154	0.675*	0.239	0.437	-0.394	-0.980**	0.688**
Polychaeta	0.644*	0.776**	0.168	0.405	0.561	0.132	-0.207	0.603*	-0.387
Crustacea	-0.291	-0.019	0.076	0.779**	-0.650*	0.964**	0.964**	0.597*	-0.161

** Correlation at the level of 0.05** Correlation at the level of 0.01*

The main purpose of analyzing cluster diagrams is to achieve a criterion for classifying the variables as much as possible within the group and the greater the difference between the groups. According to Figure 2, the elements are located in 3 clusters. The first cluster includes copper and zinc; the second cluster includes nickel and chromium; the third cluster includes vanadium, lead, cadmium, petroleum hydrocarbons, and Selenium, which show the same origin of these metals.

In shallow waters such as Jafari Creek, with short tidal flow, surface fluxes, and atmospheric deposits are the most important source of transmission of contamination (Osuji *et al.* 2004). Jafari Creek had a concentration of 8 metals, including cadmium, chromium, nickel, lead, Selenium, zinc, copper, and vanadium, in the range of 0.01 to 25.74 ppm, which could be the origin of these metals by industrial activities. In particular, extraction activities, the existence of petrochemical complexes, the chemical industry, and urban and industrial wastewater pointed out that it has been proven in different parts of the world and different studies such as ElTokhi *et al.* (2008) on the coast of Gong *et al.* (2009) and Wang *et al.* (2010) on the shores of China and reported the origin of metals such as cadmium, nickel, copper, and lead, mainly crude. Among the metals studied, zinc, chromium, and nickel had the highest concentrations, which is justified in the case of zinc and chromium, given that these metals are part of the rock-forming elements. High concentrations of vanadium can also be attributed to oil pollution, water drainage from tankers, and soil erosion (Bastami 2014). A large part of the vanadium in the Persian

Gulf also relates to oil drainage and the water balance of ships (Pourang *et al.* 2005). In a study by Yan *et al.* (2018), the concentration of heavy metals in sediments in the Liaohe river bed was also associated with a high concentration of iron (154.95 mg/kg) and chromium (102.12 mg/kg) associated with high concentrations of these elements Cover the earth.

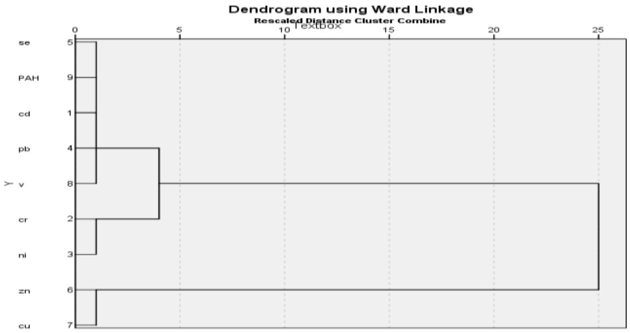


Figure 2. Cluster diagram of the studied elements in Jafari Creek

Lead and Selenium, among the metals, had the lowest concentration. Turer *et al.* (2001) considered atmospheric depositions as one of the main sources of lead in the soil or sediment. Therefore, the lead source in Jafari Creek can be considered petrochemical complex flairs. Bastami (2014) measured the concentrations of heavy metals cobalt, cadmium, nickel, and lead in Musa Creek (cadmium 2.43, nickel 32.87, lead 0.76 ppm), Ghanam (cadmium 0.13, nickel 30.76, lead 0.32 ppm) and Zangi (cadmium 1.05, nickel 34.7, lead 1.16 ppm) compared with Jafari Creek (cadmium 0.73-0.85, nickel 25.48-26.31, lead-1.81-4.43 ppm) that only nickel was less than the amount of Musa Creek, Ghanam and Zangi Creeks.

Among the Petroleum hydrocarbons, Anthracene at station 1, Fluorene at station 2, Phenanthrene and Dibenzo [A, H] Anthracene at station 3, and Fluoranthene at station 4 were the most abundant hydrocarbons and the concentration between <0.01-0.091 ppm. In 4 stations of Jafari Creek, the concentration of hydrocarbons in comparison with heavy metals showed a lower rate. Such a conclusion was made in the study of Mohammadi Gonghesh *et al.* (2018) comparing the concentrations of hydrocarbons and heavy metals in sediments of the Caspian Sea coast was obtained. The reason for this can be attributed to the study of hydrocarbons under the influence of various optical, physical, chemical, and biological processes, which makes the concentration of these pollutants in the environment less than the elements that part of their concentration from the decomposition of the same compounds enter the environment of the region. For example, vanadium metal as the methane (El-Moselhy, 2006) of oil pollution index (3) and (4) with higher hydrocarbon concentration had the highest concentration, and the dendrogram pattern also shows this relationship.

The highest concentration of heavy metals was at station 4 (215.5 ± 14.58 ppm), and the lowest was at station 1 (102.31 ± 24.15 ppm). Still, in the case of petroleum hydrocarbons, the result was a photographic finding. Heavy metals and Station 1 (0.393 ± 0.044 ppm) had the highest, and Station 4 (0.196±0.788 ppm) had the lowest concentration of hydrocarbons. However, regarding the number of identified Macrobenthos, Stations 3, 1, 4, and 2, with 1738.68, 813.25, 759.77 and 333.28 square meters, respectively, had the highest and lowest numbers, respectively. Still, the highest diversity was 8 Bivalvia species, 7 species of Gastropoda, 3 Polychaeta species, and 1 Crustacea species belonging to station 1. In total, in this study, on the shores of Jafari Creek, Bivalvia with 9 species, Gastropoda with 8 species, Polychaeta with 7 species, and Polychaeta with 6 species of Macrobenthos were identified. Tellin sp. from the category of Bivalvia and Nereis sp. of the Polychaeta category, there were two species in each of the four stations that *Tellina sp*. The highest frequency was observed at Stations 1 and 2 (highest level of pollution to heavy metals) and Nereis sp. at Stations 3 and 4 (highest pollution to oil hydrocarbons).

Gilbert *et al.* (2015) introduce the two categories of polychaetes and crustaceans as two dominant categories in the study of the sediments of the Gulf of Fos on the Mediterranean coast at an oil pollution site. In the present study, polychaetes were the dominant category. Bivalvia and crustaceans were slightly different in the second and third ranks, which is the same reaction to pollen in the environment.

Mineral contaminants such as heavy metals and organic pollutants such as cyclic hydrocarbons, which are part of oil pollution, also have the greatest impact through the toxication of sediment to Macrobenthos communities. Environmental stresses such as contamination and reduced diversity include species, taxonomic groups, and biological indices (Warwick *et al.* 1990; Clarke and Warwick 1994). For example, Gray *et al.* (1990) reported an increase in the presence of some species and oil pollution. Macrobenthos also absorb contamination through the skin and food, which is an effective absorption on their bones (Bryan 1971; Swartz *et al.* 1980). in this study concentration of lead in sediments and Macrobenthos of Bandar Abbas coasts, Ejlali *et al.* (2014), reported the trend of lead changes in the pond in the same way as the concentration in Jafari Creek, which confirms the trend of Macrobenthos demographic changes along with the change of Jafari Creek contamination. The highest number of Bivalvia and Gastropoda in parsley were found in Stations 1 and 2 with the highest pollution level. However, in two stations 3 and 4, with increasing levels of hydrocarbon pollution, two categories of Polychaeta and Crustacea increased significantly. They turned into a dominant population at these two stations, while the variation of the two classes of Bivalvia and Gastropoda was reduced. The ability of bivalves to absorb high amounts of heavy metals is highlighted (Fodrie *et al.* 2007), which justifies the high number of this class in the presence of high concentrations of heavy metals compared with other grades. At Crustacea station 4, in comparison with the rest of the stations, Bivalvia, Polychaeta, and Crustacea were the highest. In addition to the high level of hydrocarbons in Stations 3 and 4, which was a factor in reducing other grades, correlation analysis represented .that Crustacea showed a positive correlation with zinc, copper, and lead metal. Due to the high level of this metal at station 4 and the negative correlation of zinc metal with Bivalvia, Gasrtopoda, and Polychaeta Macrobenthos, the higher presence of Crustacea at station 4 could be justified.

Increasing the presence, especially the dominance of a species, has been proven through stress studies or contamination in a region in various studies (Pearson and Rosenberg 1978; Lenihan and Oliver 1995). In fact, some contaminants such as high zinc at Station 4 have caused the abundance of Crustacea. Morrisey *et al.* (1996) reported that increasing the concentration of copper in sediments caused a significant change in the soft substrate communities. In the case of Gastropoda, the results showed a positive and significant correlation (0.688**) with PAHs, and given that the highest presence of this species was observed at station 1 and also due to the absence of this category (with the exception of presence Two species at station 2) at other stations, can confirm the correlation between Gastropoda and PAHs. Bivalvia also showed a positive, but meaningless correlation with hydrocarbons, which highlighted the high number of this category at station 1.

In abnormal conditions, such as contamination, several classes provide a basis for survival by changing life and nutrition patterns (Buchanan 1964; Lopez and Levinton 1987; Lindsay and Woodin 1995; Fodrie et al. 2007; Riisgård and Larsen 2010). For example, the presence of oil at the surface of sediments leads to a decrease in the oxygen release to deeper layers of sediment that can be critical for some species. In these conditions, the classes such as Polychaetes such as Nereis caudate successfully migrate to a depth (Gilbert *et al.* 2015). Manouchehri *et al.* (2008) reported in the study of Macrobenthos Khangzangi (near Jafari Creek) declines and changes in the clammy population near the drainage site. However, there was a significant relationship between heavy metal concentrations and frequent changes in beds in different stations.

Various studies reported significant relationship between the number of heavy metal deposits with particle size (Clay and Silt) and these particles converted to a large sink, which has a large surface area and capacity for absorbing metals (Zhang *et al.* 2001; Shi *et al.* 2010). There is also a significant relationship between the size of the crustal deposits and the TPH level (Law and Kiungsqyr 2000). The granularity of Jafari Creek confirmed the superiority of Clay and Silt particles, which confirms this corn's ability to absorb heavy metals and hydrocarbons. In the study of Qua Iboe sediments in Nigeria, Benson and Essien (2009) introduced fine grains as an agent for the absorption of hydrocarbons.

In a study on the coast of India, Yahiya *et al.* (2016) suggested a positive correlation between Gastropoda and Clay and Silt particles and also a positive correlation between silt particles and a negative correlation of Clay particles with Bivalvia in several stations, which conflicts with the findings of this research.

Hydrocarbons and heavy metals stored in sediments can be absorbed by animals in this area or stored in the seabed to re-enter the food chain (Meador *et al.* 1995; Benson *et al.* 2008). Hence, the concentration of hydrocarbons is more than 0.001 mg/g in sediments as an amphibious mortality factor (Randolson *et al.* 1998) as well as the enzymatic oxidation (Vignier *et al.* 1992) and tissue normalization (McCain *et al.* 1978) have been reported that according to the values obtained in this study (Table 4), the sediments in the region are in a disturbing situation in terms of contamination. Due to the consumption of aquatic products in the area and similar areas by humans, there are unlikely any dangerous consequences for human health.

4. Conclusions

This study showed that nickel and zinc metals had the highest concentration of metals among the Anthracene, Fluorene, Phenanthrene, Dibenzo [A, H] Anthracene, and Fluoranthene hydrocarbons. The problem of contamination of heavy metals and petroleum hydrocarbons in Jafari Creek is similar to that of many of the world's waterways and rivers due to the continuous discharge of petroleum products, oil refining and refining products, water balances, and sewage of adjacent lands. Considering that the areas around Jafari Creek are an industrial, petrochemical, and economic region considered one of the important catchments in the province of Khuzestan, the sediments, water, and animal tissues must be periodically the analyzed of heavy metals and oil hydrocarbons should be considered.

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