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Total Petroleum Hydrocarbons (TPHs) Their Sources and Distributions in Sediment of Khor Al-Zubair, Southern Iraq

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Abstract
In this study, the concentration of Total petroleum hydrocarbons (TPHs), grain size distribution, and total organic carbon (TOC%) were determined in sediment samples from five stations along Khor Al-Zubair region, in Basrah southern Iraq. The highest TPHs concentration 12.1586 mg/g was observed at station 5, while the lowest concentration 0.7656 mg/g was recorded at station 3. Regarding grain size, the dominant was mainly clay. As for TOC% The highest concentration was 0.193% found in fifth station, whereas the lowest concentration was recorded 0.076% in the third station. There is a positive correlation between TPHs and TOC (r=0.7507). To the best of our knowledge, this is the first study of its kind in the Khor Al-Zubair area, thus providing a foundational reference for future research.
Key Words: Basrah, Khor Al-Zubair, TOC, TPHs, Grain size, Total petroleum hydrocarbons.

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1. Introduction

The environmental pollution caused by petroleum hydrocarbons is a complex and multidisciplinary problem. (Al-Halfy et al., 2021). The total petroleum hydrocarbons refer to the total extractable petroleum hydrocarbons. They can be defined as a mixture of hundreds of hydrocarbons that vary in both structure - such as alkanes, alkenes, cycloalkanes, and aromatics - and size, ranging from 6 to more than 35 carbon atoms per molecule (Kuppusamy et al., 2020).

Total petroleum hydrocarbons (TPH), as defined by laboratory analytical methods, typically encompass gasoline-range organics (GRO) (C6-C10), diesel-range organics (DRO) (C10-C28), and oil-range organics (ORO) (C28-C55+). These compounds may arise from accidental spills, continual leaks, or intentional discharges of both refined and unrefined hydrocarbons, which include diesel, gasoline, heating oil, lubricating oil, grease, machine oil, aviation fuel, fuel additives, carbon tetrachloride, and other products derived from petroleum (Garabedian, 2023). Additionally, TPH may be present in trace amounts within vegetation and wildlife that have been exposed to petroleum hydrocarbons. TPH mainly consists of hydrocarbons made up of carbon (C) and hydrogen (H) and are hydrophobic, meaning they tend to resist dissolving in water (Resen et al.2024). TPH represents a wide range of co-solvent type compounds derived from crude oil or produced synthetically, including waste oils, lubricating oils, gasoline, diesel fuel, kerosene, plastics, and related products (Salem et al.2022). The presence of

TPH can negatively affect aquatic ecosystems by diminishing water quality, disrupting ecological balance, hindering the natural degradation of contaminants, and posing risks to drinking water sources (Hassaan et al., 2024).

The properties of petroleum are influenced by the geological and geographical conditions of the crude oil's origin, in addition to the specific cracking techniques employed during the refining process (Karem et al., 2023).

Total petroleum hydrocarbons (TPH) consist of hydrocarbon compounds originating from crude oil, encompassing all aliphatic and aromatic hydrocarbons, primarily composed of carbon and hydrogen. The occurrence of petroleum spills poses significant risks to marine species, resulting in both physiological alterations and changes in foraging behavior, which can lead to mortality or abnormal physiological states (Alinnor et al., 2014). The toxic effects associated with TPH contamination vary greatly across different locations, influenced by the extent of the contamination. TPH encompasses harmful organic trace substances found in crude oil and related products, such as benzene, toluene, methylene chloride, and chloroform, which are highly soluble in water and capable of penetrating human skin (Garabedian, 2023). Consequently, chronic exposure, even at low concentrations, is likely to impact human health and well-being (Resen et al.2024). Additionally, many TPH compounds exhibit toxicity to aquatic species, some being directly harmful, while others pose carcinogenic risks to fish and benthic organisms. Environments that are adversely affected by TPH contamination typically become unsuitable for human activities, including water sports, swimming, and navigation through polluted areas (Salem et al.2022). Therefore, it is essential to continuously implement measures to reduce such contamination through monitoring, recovery actions, or the application of safe technologies. The involvement of international organizations focused on managing and mitigating oil spills should be prioritized. Given the significant repercussions on aquatic and marine ecosystems, it is crucial to monitor and evaluate TPH levels in contaminated areas resulting from petroleum byproducts. Advanced analytical instruments are now available, enabling chemists to identify and quantify a wide range of contaminants, including those present at very low concentrations (Al-Imarah and Al-Saad, 2021). TPH pollution is recognized as a major global environmental issue due to its serious health implications for both the natural environment and human populations. Environmental preservation is an urgent priority worldwide, and it remains a primary goal for numerous scientific organizations dedicated to fostering ecological well-being (Hassaan et al., 2024).

One significant issue are the distribution and sources of petroleum hydrocarbons in sediments, soils, and surface and groundwater, particularly in areas such as Basra in Iraq, which has significant petrochemical resources. Petroleum hydrocarbons continue to be released into the environment in large quantities through both natural and anthropogenic processes (Al-Saad et al., 2015).

Sediments are a major sink for hydrophobic organic compounds (HOC) in the environment. In an aquatic ecosystem, sediments have the function of trapping and storing hydrophobic chemicals. Total Petroleum Hydrocarbons (TPH) are categorized as the most difficult hydrocarbons to be degraded by bacteria. Khor Al-Zubair is an area where oil products, such as crude oil and its derivatives are accumulated in the sediment. TPH was initially found in the Kuwait desert soil in 1991 following the Gulf War oil field fires. TPH consist of aliphatic and aromatic hydrocarbon mixtures produced by the incomplete combustion and raw oil. Sediment is an important environmental phase that controls the availability and pathway of organic contaminants in the environment. Sediment can sequester hydrophobic organic compounds (Lu, 2003). Several environment variables, such as pH, salinity, and the presence of organic matter, impact TPH interaction with the sediment. Adsorption is the major mechanism of TPH retention by sediment. The polarity of the TPH decreases and agglomerates. These processes slow desorption rate that is controlled by the desorption of remnant amount of polyaromatic hydrocarbons (PAH) and volatile oils from dust particulates. Sediments are characterized by its texture, mineral composition, and organic carbon content that can influence the distribution of TPH within sediment. The availability of TPH in the sediment can come from two sources: the recently deposited TPH and the previously deposited TPH, which mobilized by disturbance of the sediment. The presence of TPH in the sediment can affect the biota by reducing the population, as well as change the physiological performance of the organisms. The potential release of TPH in the Khor Al-Zubair sediment can be triggered by changes in salinity, pH, and the presence of nutrients.

The release of significant amounts of petroleum hydrocarbons into rivers and coastal ecosystems during oil production and transportation poses substantial threats to both environmental quality and human health (Ihunwo et al., 2021). This contamination impacts water systems, influencing their dissolved particles, aquatic organisms, and sediment phases (Raja et al., 2022).

Hydrocarbons have emerged as a significant global concern in both developed and developing countries due to their widespread availability, persistence in the environment, toxicity (classified as hazardous substances), adverse effects on aquatic ecosystems and human health, as well as their prolonged atmospheric transport (Ukalaska & Smreczak, 2020).

Total Petroleum Hydrocarbon (TPH) is a term used to describe a large family of several hundreds of hydrocarbons, ranging from light, volatile and biodegradable substances to those that are extremely heavy and less prone to degradation (versatile hydrocarbons). Total Petroleum Hydrocarbon can have a number of impacts on the environment and biota. When TPH release into the environment, the lighter fractions may rapidly volatilize, whilst the heavier fractions slowly migrate and accumulate in soil and sediment. Past studies showed numerous impacts on aquatic life including both marine and freshwater biota, which are of high economic importance in many regions. These impacted in regions where mangroves, estuaries, or delta areas provide optimal habitats for both aquatic species such as fish, crab, and molluscs, and a variety of pelagic and benthic species (Kuppusamy et al.,2020).

The major contributors to petroleum hydrocarbon pollution, particularly in port areas like Basrah Governorate, include activities related to the petrochemical industry, pollution originating from refineries, flaring and leakage of natural gas, oil and gas production operations, as well as spills and leaks of crude oil (Garabedian, 2023).

These substances exist in various states in the environment, ranging from the natural components of crude oil to a variety of degradation products resulting from physical, chemical, and biological weathering processes.

The objective of this study is to examine the current levels of total petroleum hydrocarbons (TPH) in the sediments of Khor Al-Zubair. This search will contribute to improved management of sediment contamination in a heavily industrialized oil and petroleum context, Additionally it will include the determination of the Total organic carbon (TOC) concentration, alongside the analysis of grain size.

2.Material and Methods

2.1 Study area

The Khor Al-Zubair is part of the Iraqi marine waters located in the northwest of the Arabian Gulf, and it plays an important role in the country's economy, industries, fisheries, and oil transportation. (Lafta et al. 2019).

The area also works as a crucial drainage outlet for a network of rivers, including the Tigris and Euphrates. The Shatt Al-Basrah flows into Al-Zubair Creek, which acts as a significant outlet for saline water and connects to the Shatt al-Arab estuary. This river faces Umm Qasr port, the main port leading to the Arabian Gulf, and is strategically located at the mouth of the network. Due to its easy access to the open sea, the area has become a vital aquatic habitat that supports marine life, relying on the exchange of freshwater from the land and saline water during both seasons.(Hazza and Jassim, 2024). (Fig. 1).

Khor Al-Zubair is an extensive urban area that stretches to 645 km2; it is part of the Basrah backswamp. The creek is affected by pollution from oil spills and refining activity, sewage germs, floating rubbish, and low water reserves, because it is not cleaned by fresh water except for a few spills. The Khor Al-Zubair is a section of the old Shatt Al-Arab River southeast of Basrah city; it is the southernmost part of the Shatt Al-Arab. The Khor mouth is 9 km east of the Baramahal port at the Shatt Al-Arab. The creek extends southwest for about 84 km long to end at Al-Faw district. The Khor width ranges from 80 to 480 m. It merges with the Al-Musharah channel at 19 km, and to its south-east it merges with the Garraf River. Oil spills often occur and would remain a problem in many parts of the underdeveloped countries, where lack of effective emergency response measures allows long periods of time for the interaction of spilled oil with the environment (Monazami Tehrani et al., 2014).

The climate of the region is characterized by an arid desert climate with two distinct seasons: summer which is long and hot, lasting about 230 days, and winter which is cold and rainy. There are two types of prevailing winds in study area. (lafta et al.2019)

The geological composition of the area mainly comprises of Quaternary deposits, including sand, silt, and clay, which are associated with diverse geological formations. In the northern Arabian Gulf region, Khor Al-Zubair is considered the largest and most significant lake. (Hazaa and Jassim, 2024).

The study area covered by water with an average approximately 60 Km2. The depth of the navigation channel in the area ranged from 10 to 20 m. the northern part of Khor Al-Zubair consists of several irregular shallow lagoons with a complex geometry. (Lafta et al. 2019).

Human activity can have a negative impact on the aquatic ecosystem in the form of organic and metal contaminations. Many western and developing countries as well as industrialized cities are sources of industrial and other pollutants. Al-Zubair industrial city, which includes refineries, petrochemical units and metal industries and numerous other industries, is built around the creek. The industrial discharge affects the water quality by increasing hardness and salinity, and ammonia-N, chemical oxygen demand, and total petroleum hydrocarbons decrease the creek dissolved oxygen (Al-zuhairy et al., 2023). The country's remaining oil reserves are located in the south of Basrah, including the Khor Al-Zubair area. Oil pollution from the refineries could spread as a film on the creek surface and reach the water hyacinth, thus lowering the plant's productivity. Aquatic weeds reduce fish yield by occupying the space, snuffing out submerged and floating plants, and obstructing the water flow, causing it to stagnate in various places. Oil pollutants have detrimental effects on water bodies. This has been registered when oily birds were fished out from oil-contaminated water bodies in the Khor Al-Zubair of Basrah. Birds have been negatively affected by oil spills in the Khor Al-Zubair area, being the largest petro-chemical industrial city in Iraq, particularly during the 1991 Gulf War. Various activities such as maintenance of pipelines, excessive boat traffic, illegal dumping of petroleum fuel, and general apathy from the authorities would worsen the situation (Younus, 2021).

Samples were collected from five stations, each positioned approximately five kilometers apart within the study area. the samples were taken from the shallow part of about 0-20 cm. (Fig 2).

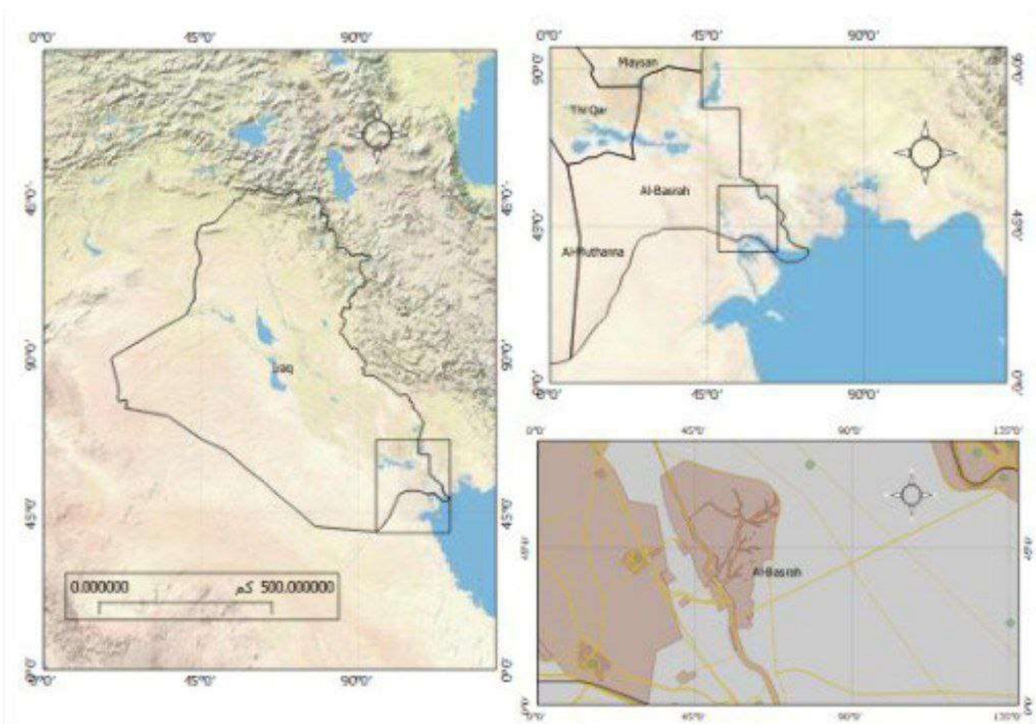

Figure 1: Study area

Figure 2: Sampling Stations (Google earth).

2.2.TPHs Analysis

The samples were taken from outspread five stations in Khor Al-Zubair region (Figure 2). Dry sediment samples were ground into fine powder using an electric grinder, then sieved through 63 µm metal seive. Then 50 g of sediment samples were taken and placed in conical. A mixture of 150 ml of methylene chloride and methanol in a 3:1 ratio was added to the sample, along with small amount of copper to desulfurize the extracts and prevent sulfur interferences during analysis.

The sample was then passed through a separation column containing glass wool at the bottom, followed by 5 g of silica gel, 1 g of alumina to remove residual fatty acids, and 1 g of anhydrous sodium sulfate to absorb any water present. Subsequently, 25 mL of n-hexane was used to separate the aliphatic components, and 25 mL of benzene was utilized to separate the aromatic components. Finally, the sample of aromatic fraction was completely dried and prepared for analysis.

Regular crude oil was used as the reference sample for preparing standard solutions. To create these solutions, 0.003 grams of crude oil was dissolved in a known volume of pure n-hexane (10 ml). To quantify the total petroleum hydrocarbons in the extracted soil samples, a Shimadzu RF 540 spectrofluorometer was employed. Measurements were taken at an emission intensity of 360 nm and an excitation wavelength of 310 nm, with monochromatic slits set to 10 nm (Goutx and Saliot, 1980; Al-Hejuje, 2014).

2.3. Total organic carbon (TOC) Analysis

The dried sediment samples were meticulously processed using a mechanical mortar for precise grinding, followed by sieving through a 63-micron to achieve uniform particle size distribution. Subsequently, the samples were prepared for Total Organic Carbon (TOC) analysis, employing the combustion method as described by Ball (1964). In this procedure, 1 grams of the sieved sediments were accurately weighed and placed into a pre-dried and pre-weighed crucible. The samples were then subjected to combustion in a furnace at 550°C for two hours. Upon completion of the combustion process, the crucible containing the sample was transferred to desiccators to cool and equilibrate with the surrounding environment. The crucible was weighed repeatedly until a constant weight was achieved. The Total Organic Carbon (TOC) content was determined by calculating the difference in the weight of the crucible with the sample before and after combustion. (Ball, 1964)

2.4. Grain size Analysis

The pipette technique described by Folk (1974) was utilized to determine the average grain size in samples. Initially, 20g of dried samples were placed in a beaker, and distilled water was added to facilitate the disintegration of sediment particles into sand, silt and clay components. The resulting solution was then sieved through a mesh sieve with a 63-micron diameter to separate the sand fraction from the finer particles (silt and clay). The separated sand was collected in a pre-weighed beaker and dried in an oven at 105°C for 24 hours. Meanwhile, the remaining silt and clay fractions were transferred to a 1000 mL cylinder and washed multiple times with distilled water to remove salts. Subsequently, 20 mL of 20% sodium hexametaphosphate solution was added to the cylinder and left to stand for 4 hours and 6 minutes to ensure thorough disaggregation of fine particles. Then a 20 mL sample of the suspension was extracted from a depth of 5 cm using a volumetric pipette and transferred into a pre-weighed beaker. This sample was dried in an oven at 105°C for 24 h and then weighed, representing the clay content in the soil samples. (Folk, 1974)

3. Result and Discussion

Petroleum hydrocarbons encompassing compounds like asphaltenes, aliphatics, and aromatics, naturally occur as integral components of surface sediments on Earth's. The interactions of these substances with their environment are essential in shaping their ultimate outcome. Developing a comprehensive understanding of petroleum hydrocarbons in natural sediment is essential for tackling issues related to environmental pollution and driving progress in fundamental energy research (Saleem,2022).

This study revealed that the fifth station exhibited the highest concentration of total petroleum hydrocarbons, reaching a value 12.1586, whereas the third station demonstrated the lowest concentration, which was approximately 0.7656 as shown in (Table 1)

The levels of total petroleum hydrocarbons (TPHs) in the environment can increase or decrease due to various factors such as industrial activities, oil extraction, accidental oil spills, and improper disposal of petroleum waste can lead to higher TPHs levels. While the natural processes like biodegradation by microorganisms, exposure to sunlight and oxygen, and effective environmental management practices help reduce TPHs levels (Garabedian,2023).

Table 1: Total petroleum hydrocarbon concentrations.

Stations	TPHs	Mean	Standard deviation
Station 1	**2.0456**		
	2.0556		
	2.0656	**2.0556**	**0.01**
Station 2	**1.6708**		
	1.7708		
	1.8708	**1.7708**	**0.1**
Station 3	**0.6656**		
	0.7656		
	0.8656	**0.7656**	**0.1**
Station 4	**5.5244**		
	5.6244		
	5.7244	**5.6244**	**0.1**
Station 5	**12.0586**		
	12.1586		
	12.2586	**12.1586**	**0.1**

Currently, there is a lack of published local and international data regarding total petroleum hydrocarbons (TPH) in Khor Al-Zubair. Additionally, information on the physical and chemical properties of the oil itself remains unavailable. This absence of data complicates the identification of potential sources of TPH pollution in the sediment of Khor Al-Zubair (Monazami Tehrani et al., 2014). The Arabian Gulf region is significant due to its vast proven oil reserves, necessitating ongoing efforts to comprehend the environmental effects of oil development on coastal marine environments (Al-Qurnawi et al.2024). A thorough understanding of both new and used oil mixtures is essential for effective oil spill management and the development of pollutant contingency plans. Given the complexities associated with oil pollution, effective strategies involve utilizing knowledge gained from oil spill events and conducting effluent oil analyses through various techniques (Younus, 2021). Oil spill analysis involves both sampling and fingerprinting contaminated sites to assess the level of pollution and the characteristics of both fresh and aged oil. Sediment plays a crucial role in the hydrocarbon cycle within aquatic ecosystems, tending to accumulate hydrocarbon pollutants from both air and water, ultimately returning them to their sources. Khor Al-Zubair is a semi-enclosed coastal area near Basra that has experienced rapid urban development since the 1980s, primarily focused on industrial, agricultural, and commercial activities, which is likely contributing to high levels of toxicity (Qasim & Ali, 2022, Kareem et al., 2023). The region hosts the majority of industrial activities, and the expansion of urban areas leads to increased instances of uncontrolled waste disposal. Moreover, the impacts of intensive shipping activities on the aquatic ecosystem and other anthropogenic effects in this densely populated area are well-documented (Salman et al.2024, Townsend, 2021).

Petroleum hydrocarbons are present in all environments as natural substances derived from both geogenic and biogenic sources (Haider et al.2021, Zahed et al., 2022). Both geogenic and biogenic sources play a crucial role in differentiating ambient hydrocarbon concentrations from anthropogenic impacts, particularly those resulting from the release of non-aqueous phase liquid hydrocarbons (Li et al., 2023). Geogenic sources primarily involve the natural seepage of hydrocarbons from underground oil deposits into the environment. Human-induced factors such as atmospheric deposition from accidents, re-mobilization of hydrocarbons from contaminated sediments, and tectonic disturbances also contribute to the release of hydrocarbons. On the other hand, biogenic hydrocarbons are produced through natural processes without human interference. This production occurs when organic matter undergoes thermogenic processes under specific geological conditions. Biogenic hydrocarbons can be seen as free hydrocarbons that are adsorbed onto mineral particles, which are typically assumed to be geogenically produced (Zaeri et al.2023). Geological factors, including the organic richness of the source rock, its maturation status, and tectonic uplift occurrences, significantly influence the formation of both geogenic and biogenic hydrocarbons. Identifying the contribution of these natural sources to total petroleum hydrocarbons (TPH) in the environment is complex, especially regarding specific TPH detection (Padhye et al.2023). The aim is to assess the influence of natural sources on TPH relative to sediment background levels through these natural mechanisms. It is essential to note that one major limitation of existing studies is the tendency to overlook low concentration levels, which may not be deemed significant, even though they could be meaningful (Beaubien et al.2023)(Al-shamri,2022).

There is a significant history of human activities that contribute to Total Petroleum Hydrocarbons (TPH) contamination in Khor Al-Zubair. The contamination in this region primarily stems from land-based sources and direct discharges resulting from anthropogenic actions (Garabedian, 2023). The southern region of Iraq, specifically south of the Al-Faw Peninsula and encompassing the eastern part of the Arabian Peninsula, is home to a major oil refinery. One of the discharge outlets for the petroleum refinery's effluents is the Al-Zubair discharge channel, which directs treated sewage from the refinery into the Arabian Gulf. Khor Al-Zubair, in southern Iraq, is heavily trafficked due to the movement of oil tankers and crew transfer operations, which transport oil from refineries to various oil fields and offshore exploration locations. Furthermore, industrial growth and urban expansion in the area have led to increased light pollution, negatively affecting the aquatic ecosystem and potentially contributing to sediment accumulation (Resen et al.2024). The region faces TPH contamination from local sources and pollution associated with maritime activities, which significantly influence the environmental conditions and raise concerns about their detrimental effects on benthic communities and food safety. The combined impact of various anthropogenic contaminant sources may lead to synergistic or antagonistic effects, affecting overall sediment quality and the health of the aquatic ecosystem (Salem et al.2022). The synergistic effects observed in this region are largely attributed to industrial operations and urban development. Additionally, several petrochemical, fertilizer, and cement industries situated near Khor Al-Zubair have been discharging effluents into the Khor and adjacent sea since the late 1960s. These ongoing discharges can stress aquatic benthic ecosystems, particularly when regulatory controls only address 'declared' substances. The influence of both natural and anthropogenic activities on what was once a pristine environment complicates the assessment of human activities and their toxic effects on the ecosystem (Hassaan et al., 2024). This assessment can be achieved by comparing current pollutant levels to natural background concentrations or historical data from before human interventions, where such data is available. The combined impact of food web bioaccumulation alongside toxicity from diverse compounds emphasizes the need for close monitoring and regulation of pollutant distribution, including TPH and PAHs, to assess potential combined effects. Recent measurements of TPH and n-alkanes in the study area indicate slightly elevated levels compared to prior concentrations, underscoring the urgency for a monitoring program to prevent further contamination (Saleh et al., 2021).

At high toxicity levels, the quick effect of TPH can be seen on mortality, impairment of growth rates and reproductive abilities, or acute changes in reproductive physiology. In contrast, lower levels of TPH can exert sublethal impacts, causing chronic biological alterations, providing the prelude to more severe effects. TPH can directly contaminate sediments and remains adsorbed on their components for long periods after the TPH sources have ceased. It has been suggested that sediments are both the main sink of TPH and the most important long-term source. The large surface areas and adsorptive capacities of sediments, coupled with the soft component matrix to form covalent or physical bonds, make them prime sites for the accumulation and storage of TPH. The leaching of adsorbed compounds from sediments is also possible, further exacerbating the contamination of the water column. Through atmospheric transport and the water cycle, TPH and associated contaminates can also be disseminated over large areas from their original sources (Kuppusamy et al., 2020). Depending on a series of circumstances, from the partition coefficient of the pollutants to the induced environmental currents or oscillations, these compounds may eventually fall out and be deposited over a receiving basin, which in turn may be hundreds of kilometers away. This poses concerns for the health of local inhabitants, as well as the local environment. Due to biomagnification, TPH and related compounds are often inflicted at all levels of the trophic chains, eventually reaching the highest trophic levels, which in many regions are also the species of higher economic value. In cases contaminated with TPH, regulatory and semi regulatory monitoring is vital in order to assess and mitigate the risks for human and environmental health. Yet, TPH contamination is a silent threat, perpetrated over years, often without immediate clearly visible effects or due to its natural ubiquity. Preventative actions such as environmental education of the local population or the implementation of large-scale strategies for the decontamination of the environment are often overlooked (Balachandar et al., 2021)

The total organic carbon (TOC) content in sediments reflects the dynamic processes occurring within depositional environments and serves as a robust tool for understanding both ancient and contemporary ecological systems. TOC analysis highlights a strong interconnection between biological, chemical, and physical processes within sediments, establishing it as an indispensable tool in geological and environmental studies. (Parameswaran et al.,2024).

The result of this study indicates that the total organic carbon (TOC) content in Khor Al-Zubair area ranged between 0.076% to 0.193% as shown in(Table 2 and Fig3). This variation reflects the diversity of environmental conditions and depositional characteristics within the region.

Higer TOC concentration (0.193%) may correspond to low energy depositional environment, such as muddy or tranquil setting, where organic matter is better preserved due to reduced oxygen levels and slower decomposition rates. Lower TOC value (0.076%) may result from oxidation of organic matter or higher decomposition rates associated with oxygen-rich environments (Lin et al., 2025).

Table 2: Total Organic carbon (TOC) concentrations

TOC %				
station 1	station 2	station 3	station 4	station 5
0.156	**0.149**	**0.076**	**0.166**	**0.193**

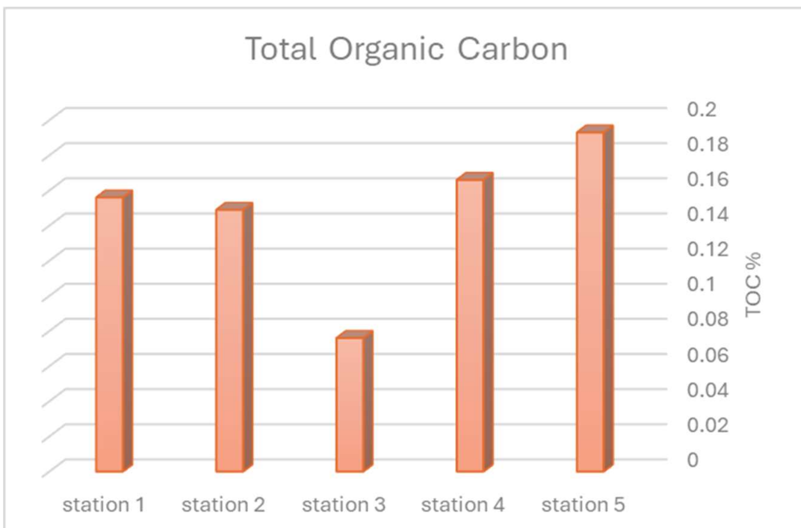

Figure 3: Total organic carbon concentrations in sediment samples.

The results demonstrate a statistically significant positive correlation between Total organic carbon (TOC) and Total petroleum hydrocarbons (TPHs), This relation is supported by the calculated correlation coefficient (r), which was found to be 0.7507, suggesting a statically significant and strong association.

Grain size is a fundamental physical property of particulate samples, sediments, and sedimentary rocks. The size of particles depends on environmental conditions, transporting agents, and depositional factors, making it a valuable ecological proxy (López, 2017).

Large-sized sand particles indicate high-energy environments, such as rapidly flowing rivers or coastal areas. On the other hand, fine clay signifies low-energy environments, such as lakes and lagoons.

The results of the grain size analysis for the study area indicate a dominance of clay particles, with limited presence for sand and silt. The highest sand percentage was recorded at the first station, reaching 73.74%, while the lowest percentage was observed at the fifth station, amounting to 2.76%. Regarding clay particles, the lowest percentage was documented at station 1 at about 23.64%, whereas the highest was found at station 2, reaching 71.71%. Silt percentage varied between 2.63 % at first station and 30.37 % at third station. (Table 3) (Figure 4).

Table 3: Grain size at sampling stations.

Stations	Grain Size			
	Sand	Silt	Clay	Texture
Station 1	**73.74**	**2.63**	**23.64**	**Sandy clay loam**
Station 2	**6.46**	**21.83**	**71.71**	**Clay**
Station 3	**23.08**	**30.37**	**46.56**	**Clay**
Station 4	**19.63**	**27.55**	**52.81**	**Clay**
Station 5	**2.76**	**29.59**	**67.64**	**Clay**

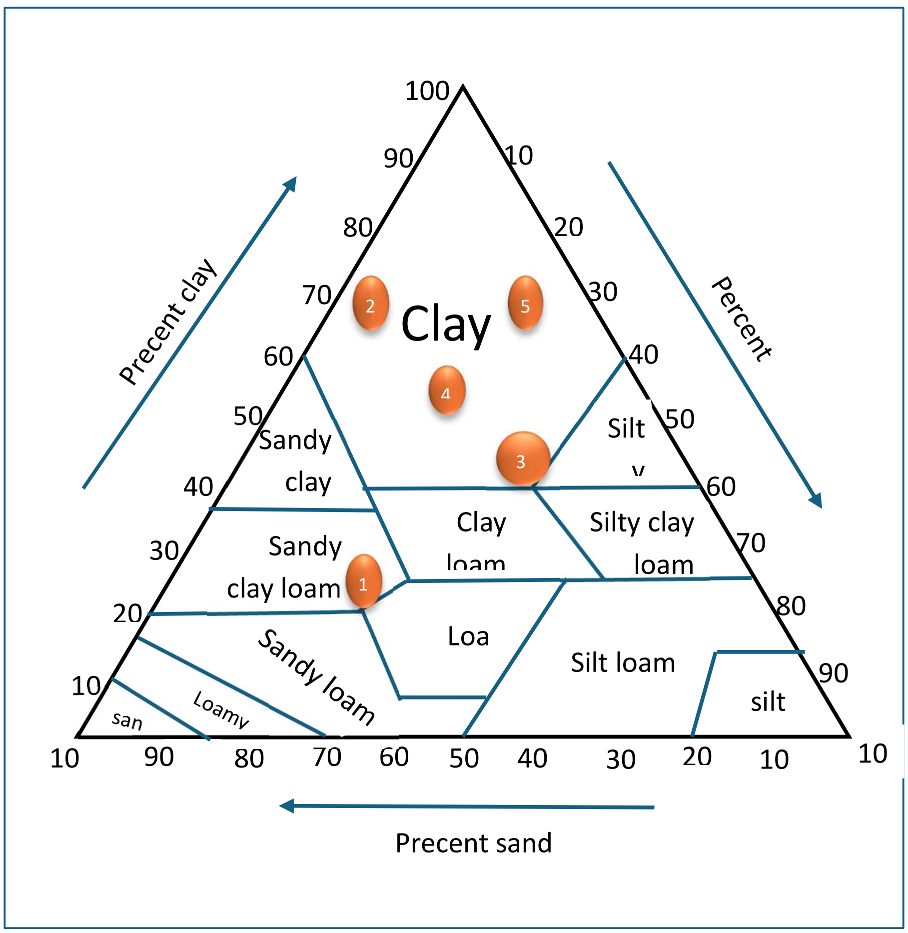

Figure 4: Grain size and soil texture for the selected stations, folk (1974)

If we compare our findings with those of other studies, it becomes evident that the results fall within the expected range, as shown in table 4.

Table 4: Compare of TPHs results of previous studies with current study.

Researcher name	Study area	TPHs concentration
Al-Hassen (2011)	**Basrah City**	**8.33-16.83**
Douabul et al. (2012)	**Basrah City**	**13-38.8**
Al-Ali et al. (2016)	**Basrah City**	**2.2-75.05**
Karem (2016)	**West Qurna-2 Oil Field**	**16.657-37.372**
Kadhim (2019)	**West Qurna-1 Oil Field**	**9.52-31.04**
Al-Halfy et al. (2021)	**Rumaila Oil Field**	**0.5-93.95**
Saleem (2022)	**Basrah City**	**4.95-685.19**
Resen et al. (2024)	**Selectid oil fields**	**8.22-389.70**
Current Study	**Khor Al-Zubair**	**0.076-12.1586**

4. conclusion

In this study, a comprehensive analysis was conducted to determine the Total petroleum hydrocarbons (TPHs), Total organic carbon (TOC), as well as the grain size distribution and soil texture in Khor Al-Zubair region, Basra governorate, southern Iraq. The diversity of sources and distribution of Total Petroleum Hydrocarbons (TPH) in sediment from semi-enclosed water bodies is still not well known. This study aims to determine the distribution, sources and composition of TPH in the sediment in Khor Al-Zubair, as well as understanding the relationship between sediment characteristics and TPH retention. The analytical process involves a comprehensive analysis of the sediment properties and uses advanced screening techniques. As a result of the complex mixing of pollutants from both natural sources and anthropogenic activities, sediment quality is classified as heavily polluted or seriously disturbed levels. Sorption capacity of sediment on TPH, this sediment act as a sink, and is affected by sediment properties, particularly content and clay fraction size. In addition to the sediment itself, biological risks are quite high, due to increased toxic effects and changes in local biodiversity. This research should be carried out in advance in order to understand the complexities of TPH contamination in the sediment, and how the dynamics are recorded in coastal ecosystems.

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الهيدروكربونات الكلية مصادرها و توزيعها في رواسب منطقة خور الزبير ,جنوب العراق

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الملخص

في هذه الدراسة تم تحليل نسب تراكيز وتواجد الهيدروكربونات الكلية (TPHs) وتوزيع الاحجام الحبيبية بالإضافة الى حساب نسبة المادة العضوية الكلية (TOC) في نماذج الرواسب المأخوذة من خمسة مناطق متفرقة في خور الزبير في البصرة. أظهرت النتائج ان اعلى نسبة للهيدروكربونات سجلت في المحطة الخامسة وبلغت 12.1586 mg/g ، في حين ان ادنى نسبة لوحظت في المحطة الثالثة حيث بلغت 0.7656 mg/g، اما بالنسبة الى الحجم الحبيبي فقد تم تحديد الاطيان كفئة سائدة في المنطقة. سجلت اعلى نسبة للمادة العضوية الكلية في المحطة الخامسة حوالي 0.193 %، في حين كانت ادنى نسبة في المحطة الثالثة حوالي 0.076 %. وقد تم إيجاد ارتباط موجب بين TPHs وTOC بالاعتماد على نسبة معامل الارتباط. (r=0.7507) وفقا لمعرفتنا, تعد هذه الدراسة الأولى من نوعها في منطقة خور الزبير مما يجعلها مرجع أساسي يمكن الاعتماد عليه في الدراسات المستقبلية.

كلمات مفتاحية: البصرة، خور الزبير، TPHs ، TOC، الاحجام الحبيبية