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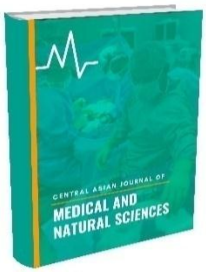

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The Impact of Population and Industrial Waste on the Waters of the Shatt Al-Arab, Basra, Southern Iraq

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Abstract: The current study included measuring the concentrations of total petroleum hydrocarbon compounds and the concentrations of polycyclic aromatic compounds in the water and sediments of four stations of the Shatt al-Arab, It is Al-Maqil, Al-Ashar, Shatt al-Arab and Abu al-Khasib, seasonal from summer 2021 to spring 2021, as well as measuring a set of important environmental factors, which are (water temperature, electrical conductivity, salinity, total dissolved solids (TDS), pH, and dissolved oxygen). In addition to measuring some heavy metals its Arsenic, Vanadium and Cadmium. The water temperature values ranged between(23-12.5°C), Electrical conductivity between (1.404 −4.58 mS/cm), Salinity between (1.2−2.6 ppt), Total dissolved solids (TDS) between (2932-1042mg/l), and pH between (7.51−8.58). And dissolved oxygen between (2.11−10.40mg/l). The values of the concentrations of heavy elements in the waters of Shatt Al-Arab stations were given, where Arsenic recorded the highest value of 1.99 μg/l in the Abu al-Khasib station during the Autumn season, and the lowest value of 0.11 μg/l in the Al-Ashar station during the summer, while the highest value of vanadium was 9.1 μg/l at Al-Maqil station during the summer, and the lowest value was 4.49 μg/l at Shatt Al-Arab station during the spring. As for cadmium concentrations, it reached its highest value of 0.336 μg/l at Shatt Al-Arab station, and the lowest value of 0.018 μg/l during the winter at Abu station. fertile.

Key words: Shatt al-Arab - Petroleum hydrocarbons - Heavy elements - Industrial and population waste.

The concentrations of the compounds were estimated Total petroleum hydrocarbons in water and sediment, the highest concentration of total petroleum hydrocarbon compounds in the water reached 33.027 μg/l in Al-Maqil station during the winter season, and the lowest value was 2.995 μg/l in Abu Al-Khasib station during the summer season, while the sediment reached its highest value of 55.882

μg/l weight. dry weight at Al-Maqil station during the winter season and the lowest value was 5.692 μg/l dry weight at Abu Al-Khasib station during the summer season, As for polycyclic aromatic compounds in water and sediments, they reached the highest value of 30.255 ng / l during the winter season at Al-Maqil station and the lowest value of 5.085 ng / l in the summer of Abu Al-Khasib. While the highest value in the sediments was 69.966 ng/l dry weight in Al- Maqil station. During the winter, the lowest value was 7.841 ng/l dry weight in Abu Al-Khasib station during the summer.

Introduction

Large cities are considered large sources of untreated waste, which is one of the most important sources of pollution of internal waters, especially rivers and streams, as a result of their runoff into cities (Ismail and Hassan, 2007). The Shatt al-Arab is the main source of fresh water in Basra Governorate. As it depends on it in most of the daily vital activities, as it is considered one of the most important sources of fresh water that flows into the Arabian Gulf, as it consists of the confluence of the Tigris and Euphrates rivers at the Karmat Ali area, at a distance of 116 km. 195 km and the width of the Shatt al-Arab stream ranges between (400 m - more than 2 km), while the depths of the Shatt al-Arab vary according to locations and tidal conditions, as they range between (8-15m). Shatt al-Arab is affected by the tidal movement in the Arabian Gulf, It suffers from pollution resulting from multiple sources, such as industrial and residential waste, in addition to oil pollutants. Pollution of the water environment can be defined as including all variables that affect the physical, chemical and biological properties of water resulting from direct or indirect human intervention by introducing unwanted substances into the water environment. Which leads to disturbance in the ecosystem and negatively affects the living creatures and their existence, extending its impact to humans (Salim, 2013), Among the most important sources of pollution of the aquatic environment is the flow of sewage effluents and industrial discharges as a result of the global increase in preparation and manufacturing (El-Amier *et al*., 2015). Environmental pollution resulting from oil is a major concern due to the fact that petroleum hydrocarbons are harmful to most forms of life (Abha and Singh, 2012) .The damage may be invisible or come after a long period of time (Al-Saad *et al*., 2017). Inorganic chemicals, including heavy elements, are among the most prominent pollutants, as most researchers agree on their seriousness and toxicity (Al-Hajjaj, 1997), along with petroleum hydrocarbons. Which is the most widespread pollutant or impact on the aquatic environment (Guerra-Gracia *et al*., 2003) and oil pollution, along with urban, industrial and agricultural pollution, are among the most important causes of the destruction of the aquatic ecosystem and the valuable resources of the aquatic animals present in it (Pourang *et al*., 2005). Rivers in all countries of the world suffer from continuous deterioration due to human misuse of them by throwing waste of various kinds (Al-baydani, 2014). Therefore, the level of water pollution must be assessed and the impact of major pollutants on water quality over time due to human activities (Tabari *et al*., 2011), and the pollution is of three degrees, the first is acceptable pollution, which is the degree at which the balance of the environmental system, especially the biological system, is not affected, and the second is called dangerous pollution, which is the degree at which the quality and quantity of pollutants exceed the critical limit and negative environmental effects appear, and the third is destructive pollution at which it is disturbed The balance of the ecosystem depends on the ability to produce (Watut, 2018).

Materials and methods

Study area

The current study was conducted on Shatt Al-Arab in Basra Governorate, and four selected stations were identified, which are Al-Maqil, Al-Ashar, Shatt Al-Arab and Abu al-Khasib districts, which are as shown in Figure (1).

Table (1) Coordinates of the current study stations

NO.	Station	Coordinates
1	**Maqil**	**47.789380E-30.563346N**
2	**Al-Ashar**	**47.842862E-30.521135N**
3	**Shatt al-Arab**	**47.900357E-30.474831N**
4	**Abu al-Khasib**	**48.028640E-30.457568N**

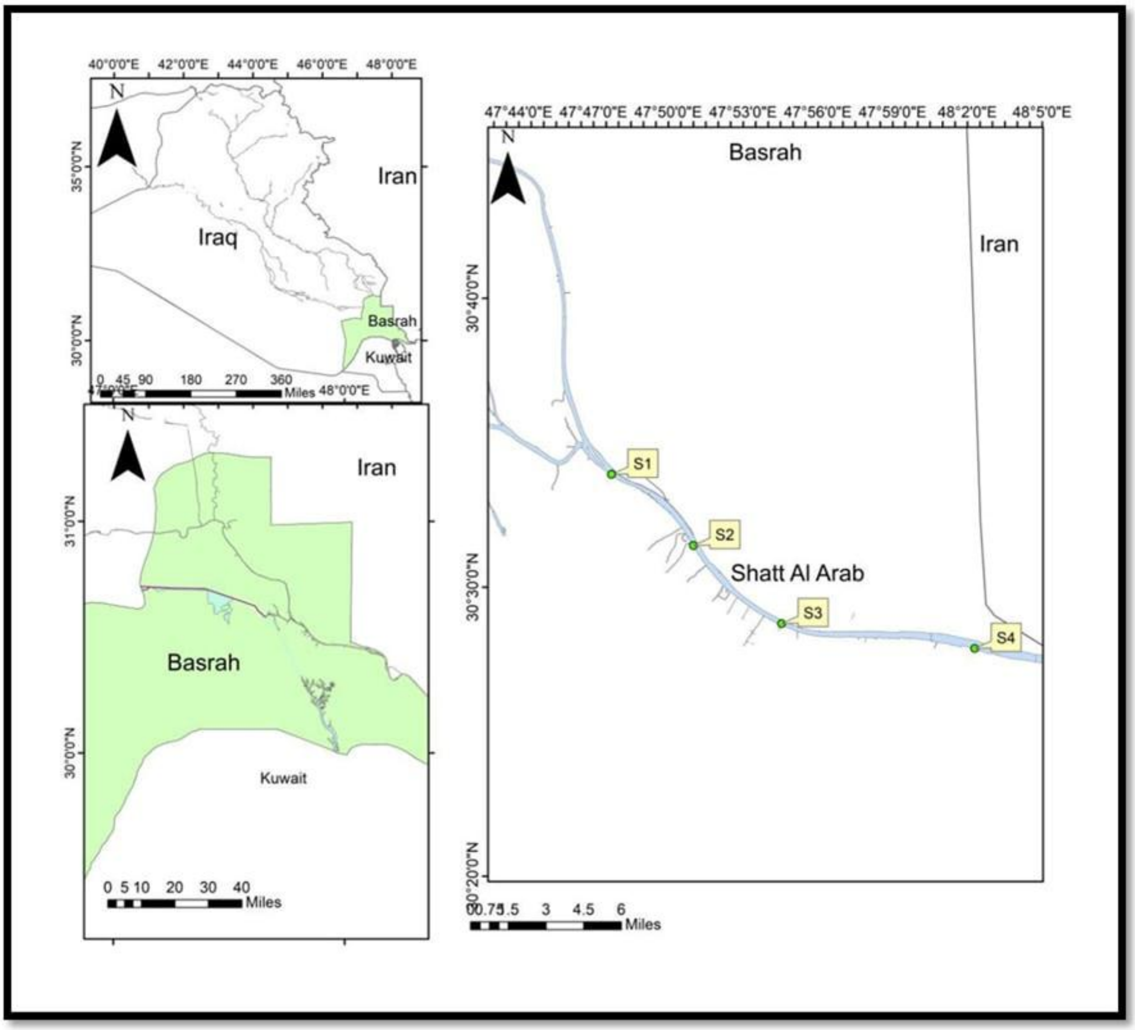

Figure (1):study area

Sample collection

Water samples were collected seasonal, starting from summer 2021 to spring 2022, from four stations on the Shatt al-Arab, namely (Al-Maqil, Al-Ashar, Shatt al-Arab and Abu al-Khasib) at a depth ranging between 15-25 cm at the middle of the river during the tidal period. 5 liters were collected from each site and kept in bottles, dark glass for hydrocarbon analysis, and the sample was fixed by adding 25 ml of ccl4 compound, and about 4 liters were collected using a water sampling tool, and placed in polyethylene bottles to conduct other analyzes.

Field analyses

Field devices were used to measure water temperature, electrical conductivity, salinity, pH and dissolved oxygen (mercury thermometer - conductivity measuring device - salinity measuring device -

pH device - dissolved oxygen device) respectively for the purpose of obtaining the best and most accurate results.

Laboratory analyzes

A set of measurements were made on the water samples. The method described by(UNEP ,1989) was used to extract hydrocarbons from the water sample. The samples were measured with a SpectroFluorometer and a GC device. As for the measurement of heavy elements in the water, the samples were digested according to the method (APHA, 1995) and measured with an atomic absorption spectrometer. flame retardant and the amount of total dissolved solids and TDS was measured according to the method described in (APHA, 2005).

Statistical analysis

The Minitab ver.17 program was used in the ANOVA test to analyze the results statistically under the probability level of 0.05 and the relative least significant difference (RLSD) test was used.

Results and discussion

water temperature

Temperature has an important role in regulating the chemical processes in the ecosystem. The water temperature in the current study ranged from 12.5 °C in the Maqil station during the winter to 23 °C in the Al-Ashar and Abu al-Khasib station during the summer. The statistical analysis showed There are significant differences between the seasons at the level of probability ($P<0.05$, RLSD =0.886), while there is no significant difference between the stations at the level of probability $P>0.05$ this variation results from the nature of Iraq's climate in general, as it is characterized by thermal extremes, so it is hot and dry in the summer and cold and rainy in the winter (Al-Atbee, 2018), as well as due to solar radiation and the length of the day, especially in the summer (Salim, 2013). Significant differences between sites indicate that water is a substance that gains heat and loses it slowly compared to air, and the samples were collected at close times during the day.

Table (2) Water temperature for study stations in Shatt Al-Arab water.

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abu al-Khasib	Mean	
summer	22	23	22.5	23	22.6	0.479
autumn	20	21	21	21	20.7	O.503
winter	12.5	13	13	13.5	13	0.408
spring	17	17	17	17	17	0
Mean	17.8	18.5	18.3	18.6		

Electrical conductivity

The highest value of electrical conductivity in the study was 4.58 ms/cm at the Shatt al-Arab station during the summer season and the lowest value was 1.404ms/cm at the Maqil station in the autumn season, Table (3) Statistical analysis showed that there are significant differences between the seasons at the probability level $P<0.05$ electricity during the summer season may be caused by an increase in evaporation rates and a decrease in water discharges (Al-Hajjaj, 2019). In addition to the disposal of untreated sewage water containing a high amount of salts, the Shatt al-Arab water is characterized by high electrical conductivity values, due to several factors, including the lack of water coming from the Tigris River as a result of building dams and reservoirs in Turkey and Syria (Hussein and Graabe, 2009) and electrical conductivity exceeded the limits The allowable value according to the World Health Organization (WHO, 2018) is 2.5 mS/cm. The reason for the decrease in electrical conductivity values during the fall season is due to the relative increase in water discharge and the low evaporation rates (Al-mansoori and Al-mahmoud 2009).

Table (3) Electrical conductivity mS/cm for the study stations in the Shatt Al-Arab waters.

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
summer	3.01	4.23	4.58	4.44	4.06	0.717
autumn	1.404	1.703	4.07	1.699	2.219	1.241
winter	2.68	2.86	3.03	2.89	2.865	0.143
spring	2.86	2.92	2.76	2.21	2.687	0.516
Mean	2.488	2.930	3.61	2.809		

Salinity

The highest concentration of salinity in the current study was 2.6 ppt in the summer at Abu al-Khasib station and the lowest concentration was 1.2 ppt at Maqil and Al-Ashar stations during the winter. Table (4) The statistical analysis showed that there are significant differences between the seasons at the probability level $P<0.05$. While no significant differences were observed between the stations at $p>0.05$, the reason for the high salinity rates during the summer season is due to the decrease in water levels and the increase in evaporation rates as a result of the high temperature (Al-Kenzawi, 2007) as a positive linear relationship was found between salinity values and water temperature. As well as the decrease in the discharge of the Shatt al-Arab from the Tigris and Euphrates rivers, which was indicated by (Al-Maliky, 2012) and the reason for the decrease in salinity concentrations during the winter season is the rain and the increase in water levels (Al-baydani,2014; Mansouri and Mahmoud, 2009).

Table (4)Salinity ppt of the study stations in Shatt Al-Arab waters.

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
summer	2.2	2.4	2.4	2.6	2.4	0.163
autumn	1.4	1.5	1.42	1.54	1.465	0.065
winter	1.2	1.2	1.25	1.52	1.292	0.153
spring	1.61	1.71	1.62	1.64	1.645	0.045
Mean	1.602	1.702	1.672	1.825		

Total dissolved solids

The results showed a clear increase in the concentrations of total dissolved solids (TDS) in the study stations during the summer season, while it decreased in the autumn season at the Ashar station, table (5) and the statistical analysis showed that there were significant differences between the seasons at the level of probability $P<0.05$, while no significant differences were observed between the stations at $p>0.05$, the reason for its high concentrations in the summer is high temperatures and evaporation, in addition to sewage water that adds solids, which increases its value in the river (Al-Hejuje,2014), and the results were higher than permissible. According to the World Health Organization (WHO, 2018) it is mg/L 1000. Total dissolved solids are clearly associated with electrical conductivity, and this was observed in the current study, where a positive correlation was found between them. This is consistent with both (Al-Hejuje, 2019; Al-Hajaaj, 2014).

Table (5) Total dissolved solids(TDS) mg/l for study stations in Shatt Al-Arab water.

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
summer	1825	2765	2835	2932	2589	514
autumn	1060	1042	1100	2616	1454.5	774
winter	1780	1838	1840	1930	1847	61.9
spring	1838	1880	1398	1768	1721	220
Mean	1625	1881	1793	2311.5		

Potential Of Hydrogen ion(PH)

In the current study, the pH recorded the lowest value of 7.51 at Maqil station during the autumn season, while the highest was 8.58 at Abual-Khasib station during the summer season. Table (6) The results showed that there were no significant differences between the stations at the level of probability $P<0.05$, while significant differences appeared between the chapters at the level of probability $P>0.05$. The reason for the decrease in pH is due to the decomposition of aquatic plants, phytoplankton and organic matter, and the production of dissolved CO_2 gas, which leads to lower values (Al-Moussawi, 2019). While the high pH may be due to the large flowering of plants and phytoplankton, which consume dissolved carbon dioxide gas (Rubio-Arias *et al*., 2013) and the Iraqi waters are characterized by a tendency towards the alkaline direction due to the nature of the earth's composition and the presence of carbonate and bicarbonate ions (Hussein *et al*, 1991). The results of the current study of the pH at the Abual-Khasib station during the summer were higher than the permissible limits according to the World Health Organization (WHO, 2018), which is .5-8.56.

Table (6) The pH of the study stations in Shatt Al-Arab water.

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
summer	7.70	8.30	8.49	8.58	8.22	0.4
autumn	7.51	7.69	7.79	7.80	7.74	0.4
winter	7.90	7.89	7.89	7.99	7.91	0.12
spring	8.31	8.21	8.11	8.20	8.20	0.08
Mean	7.85	8.02	8.07	8.14		

Dissolved oxygen(DO)

In the current study, dissolved oxygen values decreased during the summer and autumn seasons for all stations, while it increased during the winter season for all study stations, table (7) the highest value of 10.40 mg/l was recorded at Maqil station in the winter and the lowest value was 2.11 mg/l at Shatt al-Arab station during the summer. The statistical analysis showed that there were significant differences between the chapters at the level of probability $P<0.05$, while no significant differences were observed between the stations at the level of probability $p>0.05$ The reason for the decrease in dissolved oxygen values during the summer and autumn may be due to the rise in water temperature, which leads to increased oxidation of the organic matter that causes the consumption of dissolved oxygen (Valdes and Real, 2004), or due to the decomposition of organic matter in wastewater by bacteria that consume dissolved oxygen (Al-Awady *et al* .,2015) It is noted that the concentrations of dissolved oxygen rise during the winter due to the low temperature, It causes an increase in the solubility of gases, as well as winds and rains that increase the movement of water, and thus an increase in dissolved oxygen (Al-Atbee, 2018) and the decrease in dissolved oxygen values, especially in the Shatt al-Arab station during the summer, due to the increase in the release of untreated sewage water. An inverse relationship was found between temperature and dissolved oxygen. Most of the results of the current study of dissolved oxygen were higher than the permissible limits according to the World Health Organization (WHO). WHO, 2018) which is 6 mg/l .

Table (7) dissolved oxygen (DO) mg/l for study stations in Shatt Al-Arab water.

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
summer	7.4	7.29	2.11	4.88	5.42	2.53
autumn	7.10	6.61	6.1	4.90	6.17	0.94
winter	10.40	9.16	8.84	9.69	9.52	0.68
spring	8.91	7.85	9.44	9.18	8.84	0.69
Mean	8.45	7.72	6,62	7.16		

Heavy elements

The entry of heavy elements into the water environment changes over time, and the main factor affecting this change is the amount of untreated waste received by the water. There are many biochemical processes that control the transfer and readiness of these elements in the aquatic environment, Including adsorption processes on the surfaces of sediments and plants, dissolution processes, the formation of complexes with organic compounds, and bioabsorption processes (Abdulnabi, 2016). The industrial progress in recent years and the emergence of populated cities has exposed the water environment to many pollutants, the most important of which are trace element pollutants that may be have been thrown with untreated polluted sewage waste,whether it is from industrial or residential cities that disturb the equilibrium process in the system is watery (Al-Saad *et al.*, 1996).The human resources related to human activities, such as various industrial activities, excessive use of agricultural pesticides, and wastes of the oil refining process, are among the most important sources that increase pollutants with trace elements to the water environment (Song *et al*, 2010).

Arsenic

In the current study, the results of arsenic concentrations in the study water showed significant differences at the probability level of $P<0.05$between the four stations, the highest concentration was 1.99 µg/l in autumn at Abual-Khasib station and the lowest concentration was 0.11 µg/l at Al-Ashar station during summer, table (8) The element arsenic is found naturally in the earth's crust, where this substance is widely distributed throughout the environment, including air, water, and soil. The increased accumulation rates of arsenic constitute a threat to public health for humans and can cause cancerous diseases, heart diseases, and infant deaths (Quansah *et al.*, 2015). The higher concentration of arsenic at the Abual-Khasib station, 1.99 µg/l, may be due to the presence of agricultural lands adjacent to this station that use pesticides and fertilized fertilizers that seep with the drainage water into the river basin (Agbozu *et al.*, 2007)) and that the values of arsenic levels in the current study are safe in comparison With WHO standards of 10 µg/l for drinking water (WHO, 2011).

Table (8) the values of arsenic µg/l As for the study stations in Shatt al-Arab waters.

Seasons	Stations					SD±
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
Summer	1.98	0.11	0.52	0.22	0.70	0.8
Autumn	ND	ND	ND	1.99	0.49	0.8
Winter	1.39	0.32	0.61	ND	0.58	0.4
Spring	ND	ND	ND	0.41	0.10	0.1
Mean	0.84	0.08	1.03	0.15		

Vanadium

Vanadium is found in places that contain petrochemical activities, and in general, the presence of vanadium in nature increases with the increase in its uses in industrial processes, as low concentrations of vanadium are often recorded in areas far from industrial waste, and high concentrations of it have been recorded in areas close to industrial waste.(Zaki *et al*., 2010),in the current study, the element vanadium had its highest value in the summer, 9.1 µg/l, at Maqil station, and the lowest value was at Shatt al-Arab station during the spring, amounting to 4.49 µg/l. Table (9), while the values were imperceptible in winter and autumn, and the reason may be the tendency of vanadium to accumulate in sediments, algae and aquatic plants (De diaz *et al.*, 2001). The reason for the high values in the summer and spring may be due to the high temperatures and the high current of the water, which leads to the breaking of the adsorption bonds and the release of the elements (F ernandes *et al.*, 2008), or this may be due to the exposure of the region to oil pollution that enters the aquatic environment from multiple sources, where vanadium is one of the most generated elements of oil pollution, as it was widely used as an indicator of oil pollution (Mortazavi *et al*., 2005), and the results agreed with what was reached by (Amer, 2020) and the element vanadium exceeded the internationally permissible limits according to (Commentuijn *et al.*, 1997).

Table (9) Vanadium V values for the study stations in the Shatt Al-Arab waters.

Seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
Summer	9.1	7.93	6.96	6.11	7.52	1.2
Autumn	ND	ND	ND	ND	-	-
Winter	ND	ND	ND	ND	-	-
Spring	4.87	4.53	4.49	4.66	4.63	0.1
Mean	3.49	3.36	2.86	2.69		

Cadmium

The element cadmium in the current study recorded the highest concentration in the summer and reached 0.336 µg/l at Shatt al-Arab station, and the lowest concentration in the winter when it reached 0.018 µg/l at Abual-Khasib station. Table (10), and there were significant differences between the seasons at the probability level of $P<0.05$, the reason for the high concentration of cadmium during the summer season may be the decrease in the dilution factor due to the low water levels as a result of the lack of rain and the high temperature that increases the evaporation rates as well as the increased decomposition of materials. Organic by microorganisms (Abd and Musa, 2009), while the winter season witnessed the lowest concentrations, and this may be attributed to the dilution factor (Olu, 2019) or because of the removal process that occurs by living organisms, and to the ability of these elements to accumulate inside the bodies of living organisms or to be absorbed by suspended materials, which leads to sedimentation (Al-Hayali 2001). The main factor in heavy metal concentrations is the untreated agricultural, industrial and domestic waste received by the water (Taghizadeh *et al*., 2018).

Table (10) Cadmium Cd values for study stations in Shatt Al-Arab water.

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
summer	0.177	0.286	0.336	0.251	0.26	0.06
autumn	0.112	0.174	0.162	0.045	0.11	0.05
winter	0.031	0.092	0.03	0.018	0.04	0.02
spring	0.024	0.021	0.043	0.044	0.03	0.01
Mean	0.08	0.19	0.14	0.08		

Total petroleum hydrocarbons

The origin of petroleum hydrocarbons is oil and its derivatives, which come either naturally from a crude oil spill (Klenkin *et al.*, 2010) or unnaturally as a result of human activities (Al-Saad *et al.*, 2017). The hydrocarbons reach the water environment from various sources, including In that biosynthesis or its entry from neighboring lands and the atmosphere (Al-Baydani, 2014). The concentrations of total petroleum hydrocarbons in the water ranged between 2.995 µg/l at the Abual-Khasib station during the summer and 33.027 µg/l at the Maqil station during the winter. Table (11) the statistical analysis showed that there were significant differences between seasons at the level of probability $P<0.05$, while no significant difference was observed between stations at the level of probability $p>0.05$, the high levels of TPHs in the water during the winter may be attributed to the lack of evaporation and oxidation of hydrocarbon compounds in the water as well as the increase in combustion processes and the use of fuel and the increase in the summer of these compounds with rain from the air (Al-Saad, 1995). Removing most of the petroleum hydrocarbon compounds from the water, as the high temperature leads to increased evaporation, and in this process carbon compounds with low molecular weights evaporate, as well as cracking carbon compounds that have high molecular weights (Law, 1981). These results agreed with both from Hajjaj (2019); Al-Atbee (2018).

Table (11) Concentrations of total petroleum hydrocarbons TPHs µg/l in the water of study stations in Shatt Al-Arab

Seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
Summer	7.001	6.012	5.998	2.995	5.49	1.7
Autumn	14.449	11.102	7.988	4.896	9.60	4.1
Winter	33.027	18.022	15.979	14.112	20.28	8.6
Spring	16.011	14.277	14.736	11.991	14.25	1.6
Mean	17.62	12.35	11.17	8.49		

Total petroleum hydrocarbons in sediments

The concentrations of total petroleum hydrocarbon compounds in the sediment ranged between 55.882 µg/g dry weight at Maqil station in the winter season and 5.692 µg/g dry weight at Abual-Khasib station during the summer season, Table (12) statistical analysis showed that there were significant differences between seasons at the level of probability $P<0.05$, while there were no differences between stations at the level of probability $p>0.05$. Total petroleum hydrocarbons in the sediments recorded higher concentrations than those found in the water. Hydrocarbons that reach the aquatic environment in urban areas in the form of domestic waste or industrial waste remain part of it in the river load, while the largest part is deposited from the water column to the sediment (Adeniji *et al.*, 2017) These results agreed with Al-Hajaj (2019).

Table (12) Concentrations of total petroleum hydrocarbons in sediments (TPHs µg/g) dry weight of study stations in Shatt Al-Arab waters

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
summer	12.750	8.939	8.812	5.692	9.04	2.8
autumn	17.995	9.022	10.999	8.332	11.58	4.4
winter	55.882	25.455	24.610	22.987	32.23	15.7
spring	22.123	16.010	18.898	15.799	18.20	2.9
Mean	27.18	14.85	15.82	13.20		

Polycyclic aromatic compounds in water

The total concentrations of polycyclic aromatic compounds in the water ranged between 5.086 ng/l during the summer at Abual-Khasib station and 30.255 ng/l at the Maqil station during the winter. Table (13) statistical analysis found significant differences between seasons at a probability level of $P<0.05$and found that there was an inverse correlation between water temperature and PAHs concentrations ($r = 0.5$). The low concentrations during the summer season are attributed to the high temperatures that lead to the evaporation of some PAHs in the water. High temperatures also stimulate microorganisms to break down these compounds by the process of Biodegradation, especially with low molecular weights (Al-Dosari, 2008). Photooxidation also increases more due to the length of the day and the intensity of solar radiation. As for the increase in concentrations of PAHs during the winter season due to the decrease in evaporation processes of PAHs, the effectiveness of microorganisms in analyzing these compounds at low temperatures decreased (Al-Tamari *et al.*, 2003). These results agreed with (Al-Atbee**,2018)** The results of the current study of polycyclic aromatic compounds in water were within the permissible limits of the World Health Organization (WHO, 2018) which is 100 ng/l.

Table (13) Concentrations of polycyclic aromatic compounds in water (TPHs ng/l) for study stations in Shatt Al-Arab water

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
summer	13.102	11.012	6.519	5.086	8.929	3.7
autumn	21.144	19.011	8.033	6.01	13.549	7.6
winter	30.255	25.912	19.901	11.979	22.011	7.9
spring	26.059	25.001	17.107	10.03	19.549	7.6
Mean	22.64	20.234	12.89	8.276		

Polycyclic aromatic compounds in sediments

The highest concentration of polycyclic aromatic compounds in the sediments was 69.966 ng/g dry weight at Maqil station during the winter season, and the lowest concentration was 7.841 ng/g dry weight at Abual-Khasib station during the summer Table (14) and the statistical analysis showed that there were significant differences between the seasons and the stations at the probability level of $P<0.05$. The study of sediment has an important role in the study of environmental pollution, as it provides a good guide to the state of water pollution. Polycyclic aromatic compounds are lipophilic compounds with very low solubility in water and tend to adsorb on particles that quickly settle to the bottom (Kafilzadeh *et al.*, 2011). The concentration of polycyclic aromatic compounds in the sediment is higher than that in the water as a result of photo-oxidation and precipitation of PAHs from the water column to the bottom as well as the decomposition of PAHs with low molecular weight in the water column (Jazza, 2015), the results of the current study for polycyclic aromatic compounds were within the permissible limits according to(CCME,2010) which is ng / g dry weight 16770.

Table (14) Concentrations of polycyclic aromatic compounds (TPHs ng/g) dry weight in the sediments of the study stations in the Shatt Al-Arab waters.

seasons	Stations					±SD
	Maqil	Al-Ashar	Shatt al-Arab	Abual-Khasib	Mean	
summer	22.998	17.955	16.049	7.841	16.210	6.3
autumn	33.898	28.897	17.941	8.151	22.221	6.6
winter	69.966	59.886	37.620	20.076	46.887	18.2
spring	40.958	31.799	30.935	19.212	30.726	8.9
Mean	41.95	34.,63	17.90	13.81		

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