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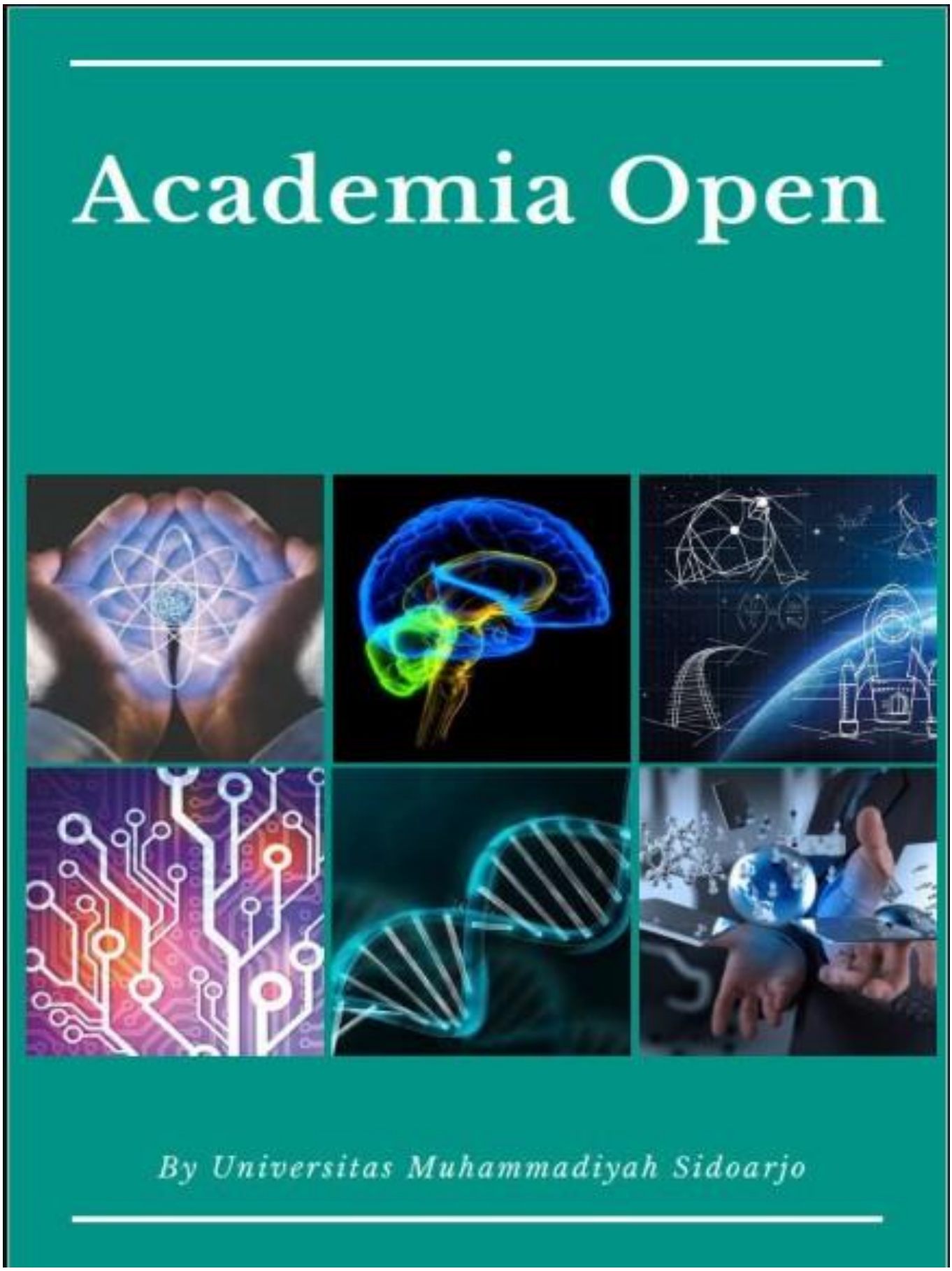

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Sources of Euphrates River Water Pollution in Nasiriyah City

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Abstract

General Background Anthropogenic pressures on freshwater ecosystems threaten sustainable urban development. **Specific Background** In Nasiriyah City, the Euphrates River experiences severe degradation from expanding urban practices. **Knowledge Gap** However, localized seasonal dynamics and precise municipal, industrial, and biological pollution contributions remain insufficiently quantified. **Aims** This study evaluates seasonal water quality and specific source pathways driving this decline. **Results** Hydrochemical analysis reveals parameter concentrations exceeding national regulatory thresholds during both seasons. Total dissolved solids reached 2948.83 mg/L in winter and 3266.33 mg/L in summer (limit: 1500 mg/L), while sulfates peaked at 976.66 mg/L (limit: 200 mg/L). High sodium, chloride, and hardness levels confirm intense contamination from untreated sewage, industrial power plant effluents discharging 20,000 m^3/h, agricultural runoff, plastic waste, and invasive water hyacinths. **Novelty** This research empirically maps multi-sectoral pollution dynamics to extreme seasonal fluctuations. **Implications** The findings underscore an urgent need to rehabilitate treatment plants and implement eco-friendly filtration technologies.

Keywords: Aquatic Ecosystem Management, Environmental Hydrochemistry, Industrial Effluent, Seasonal Water Quality, Wastewater Treatment

Key Findings Highlights

Total dissolved solids and sulfates drastically exceed national limits across both winter and summer seasons.

Thermal power plants release massive volumes of untreated liquid waste directly into the river channel.

Microclimatic changes, solid plastic waste, and invasive aquatic weeds accelerate long-term ecosystem degradation.

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First: Introduction

Water is a fundamental pillar of life and a direct cause of development; even the rise of ancient civilizations occurred near water sources. In the city of Nasiriyah, the Euphrates River is a major water source. Despite its importance, in recent years the problem of pollution of the Euphrates River in Nasiriyah has worsened. The issue is not limited to the city alone; studies on the river in different areas of Iraq have shown that it suffers from pollution, meaning that the pollution problem is general and not confined to the study area. This pollution results from the disposal of various wastes, both liquid and solid, into the river directly or indirectly, which has affected the quality of the river water, impacting the aquatic organisms and negatively affecting the water quality leaving the city towards the southern cities and marshlands south of Nasiriyah. This escalation in pollution is due to population increase in Nasiriyah and the rise and diversity of various activities within the city, as well as the lack of treatments commensurate with the scale of the problem. This, in turn, poses a direct threat to the lives of city residents, potentially contributing to the spread of many diseases and epidemics. It also affects the fish stocks in the river and damages crops in areas near the city, thereby impacting economic life.

Second: Study Problem

The problem is summarized by raising a set of questions about the sources of pollution of the Euphrates River water in Nasiriyah, which can be highlighted as follows:

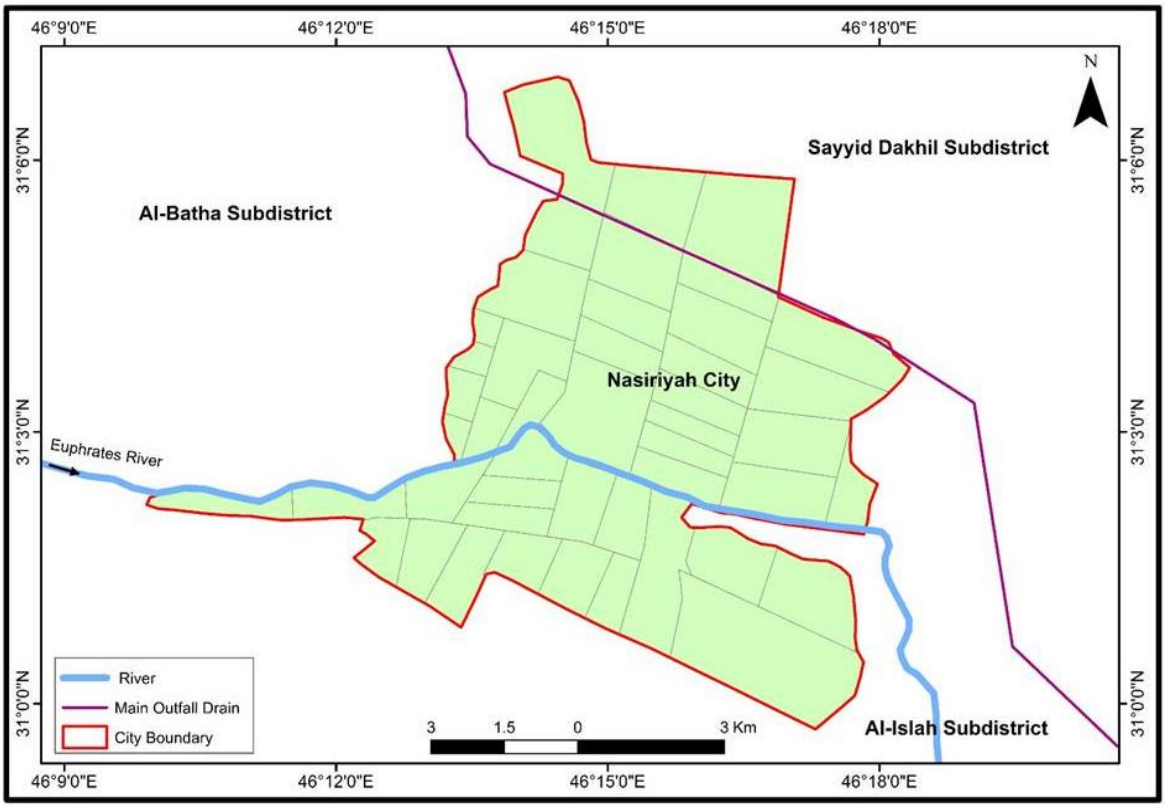
Is the amount of pollutants in the Euphrates River water in Nasiriyah within the health and environmental limits of local and international standards? What are the main sources of pollution of the Euphrates River in Nasiriyah? Are there treatments for the polluted water discharged into the river within the city? Are there treatment methods that can be adopted for treating polluted water?

Third: Hypothesis

The Euphrates River is experiencing physical and chemical pollution in its waters, resulting from natural and human factors, most notably the human aspect related to daily activities practiced by residents in the city and the cities it passes through before entering Nasiriyah, and the inefficiency of services provided by responsible authorities by directing sewage drains towards the river water, which negatively affected water quality and increased the amount of pollution, exacerbated by low water inflows and low rainfall over the past five years, except for the wave of rain and floods that Iraq witnessed last April, which contributed to a slight increase in water volume in the riverbed. The decrease in water inflows and high pollution levels have caused the water to exceed local and international standards. The sources of river water pollution in Nasiriyah vary due to the diversity of sources and activities within the city, most notably (sewage water, industrial water, agricultural water, aquatic plants, and solid waste). There are no treatments for the water discharged into the Euphrates River in Nasiriyah, although multiple methods and models used in other countries are available and can be applied. Some methods that can be applied to treat polluted water in Nasiriyah will be presented to reduce its risk and create a safe environment, as water is an essential part of the activities in any city.

Fourth: Study Area

Astronomically, the city of Nasiriyah lies between latitudes (30° 0' 0") and (30° 6' 0") and longitudes (46° 14' 0") and (46° 20' 0") east. Geographically, it is located in southern Iraq, in the southern part of Dhi Qar Governorate. It is bordered by Al-Batha'a district to the west, Ur to the south and east, and from the northeast by Sayyid Dakhil district and Al-Islah district, as shown in It contains (51) residential neighborhoods. (Tuma, 2024, p. 503). Map (1).



Map (1) Study Area Location

Source: From the researcher's work using Arc Map GIS and based on the Survey Authority, administrative map of Dhi Qar Governorate, scale 1:500,000, year 2025.

Fifth: Water Pollution

Pollution is defined as the disposal of waste that spoils the beauty and cleanliness of nature. Environmental pollution is a problem that emerged with the rise of industry and has received great attention because it has affected humans and their property and disrupted many prevailing ecosystems. It is described as the heir that replaced famines and epidemics. (Al-Muzaffar, 2002, p. 146).

Water pollution refers to any change in the natural (physical), chemical, and biological properties that render water unfit for drinking or domestic and industrial use. This is due to thermal changes resulting from water pollution. (Abu Al-Khail and Qawwas, 2005, p. 241).

It refers to water containing toxic chemicals or pathogenic microorganisms that transmit infection, which may be visible on the water, while

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the sample is free of odor and taste. It is also defined as causing damage or spoilage to water quality directly or indirectly, resulting from changes that affect the physical, chemical, and biological properties, leading to an imbalance in the ecosystem, thereby reducing its performance of its natural role, making it less suitable or unsuitable for multiple uses, thus becoming harmful to living organisms of all kinds or losing its economic value in agriculture or fisheries.

Forms of Water Pollution

- Depletion of large amounts of dissolved oxygen in river waters, resulting in a decrease in aquatic organisms.
- There is a direct relationship between chemicals in water and the toxicity of living organisms; the higher their proportion, the higher the toxic substances in aquatic organisms.
- Decrease in the value of water as a source for drinking or irrigating agricultural crops due to the increase and rise of parasites, bacterial growth, as well as microorganisms in the water. (Al-Zarqa, 2010, pp. 51-52).

Sixth: Field Study of the Water Quality of the Euphrates River in the City of Nasiriyah:

Water quality assessment is essential for water resource management. In this research, the researcher focuses on the Euphrates River in the city of Nasiriyah, identifying and estimating the amount of pollution in the river water to determine its suitability for various human activities (Hussien & Al- Dabbas, 2023, p.3963).

To determine the water quality of the Euphrates River, a set of characteristics serving as indicators was examined and studied, including Total Dissolved Solids (T.D.S), pH, total hardness, and the concentration of major ions (Ca^{2+}, Mg^{2+}, Na^{+}, Cl^{-}, SO_4^{2-}, HCO_3^{-}), in addition to nitrogen and phosphorus compounds such as nitrate (NO_3^{-}) and phosphate (PO_4^{3-}). These are key indicators for assessing water quality, monitoring its degradation, and understanding the relationship with hydrological and environmental factors.

Table (1) Iraqi Standards for Water Use

No.	Parameter	(mg/L) Iraqi Standards
1	Total Dissolved Solids (T.D.S)	1500
2	pH (Hydrogen Ion Concentration)	9 – 6,5
3	)Ca (Calcium	200
4	Sodium (Na)	350
5	Sulfates (SO4)	200
6	Nitrate (NO3)	50
7	Hydrogencarbonate HCO3	170
8	Chlorides (Cl-)	200
9	Total hardness	480-160

Source: Prepared by the researcher based on

1- Republic of Iraq, Ministry of Health, Environmental Legislation, Center for Environmental Protection and Improvement, 1998.

2- Republic of Iraq, Law No. (2) of 2001 amending the Environmental Determinants Law for the System of Maintaining Rivers and Public Waters from Pollution No. (25) of 1967, Iraqi Official Gazette, Issue No. (3890) on 8/6/2001, Iraq, 2001.

3- Republic of Iraq, Ministry of Oil, Iraqi Environmental Laws and Instructions, System for the Preservation of Water Resources No. (2) of 2001 as amended, Iraq.

1- Total Dissolved Solids (TDS)

It means the organic and inorganic dissolved salts present in a water sample or samples, where inorganic substances or salts are a primary source of total dissolved solids and include calcium, sodium, sulfates, and also bicarbonates. These dissolved substances lead to the growth of algae in water. The field study showed (from Figure 1) that the winter season reached (2948.83 mg/l), while the summer season reached (3266.33 mg/l); thus, the level of total dissolved solids (TDS) exceeded the specified limit according to the Iraqi determinant, which records (1500 mg/l).

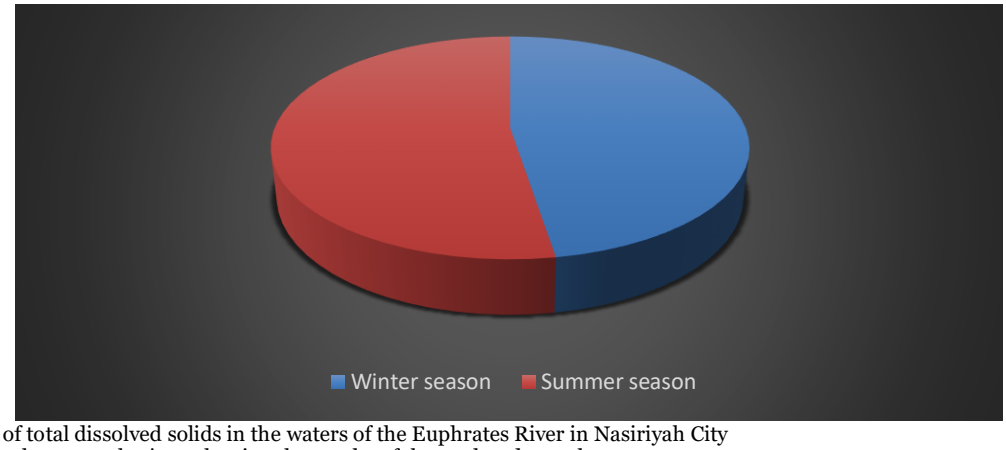

Figure (1) Value of total dissolved solids in the waters of the Euphrates River in Nasiriyah City

Source: Based on the researcher's work using the results of the analyzed samples.

2- pH

It means indicating the alkalinity and acidity level of water. Its value in water and acids ranges from (0-14). If it is acidic, its value ranges from (0-7), while if it exceeds (7), the water is alkaline, and in the case of neutrality, its value is (7). It was shown from Figure (2) that the pH value for both winter and summer seasons was (7,7), thus the water is alkaline.

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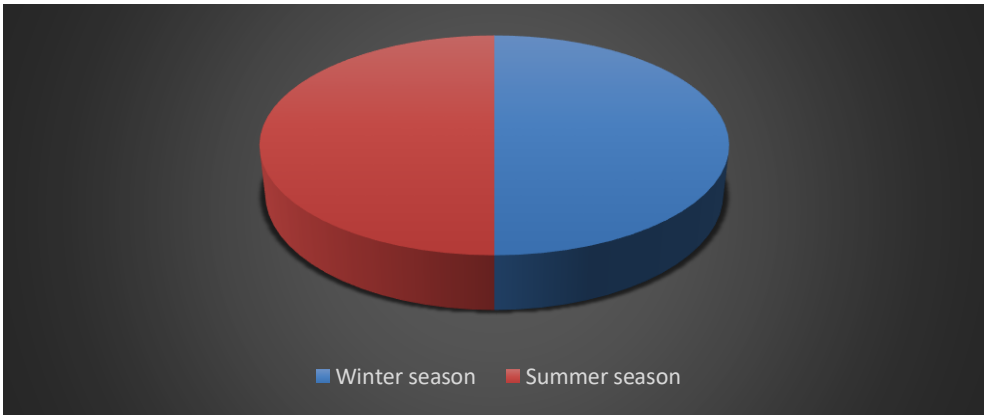

Figure (2) pH value in the waters of the Euphrates River in the city of Nasiriyah
Source: Based on the researcher's work using the results of the analyzed samples.

3- Calcium Ca

Calcium is one of the most important cations in water and one of the most abundant elements in the Earth's crust; therefore, it is found in surface waters at varying concentrations. It is a major contributor to water hardness. Its primary source comes from chemical weathering of carbonate rocks such as limestone and calcareous rocks, and it is of great importance to water quality and calcium concentration. It is also an important element for humans; a deficiency in this element causes osteoporosis in the elderly, rickets in children, and tooth decay, while an excess has many negative effects. (Abdul Jalil and Shabut, 2024, p. 242). Figure (3) shows that the winter season reached (172.5 mg/l), while the summer season recorded (174 mg/l); thus the summer season was higher than the winter season, and the results of both seasons did not exceed the local standard limit of (200 mg/l).

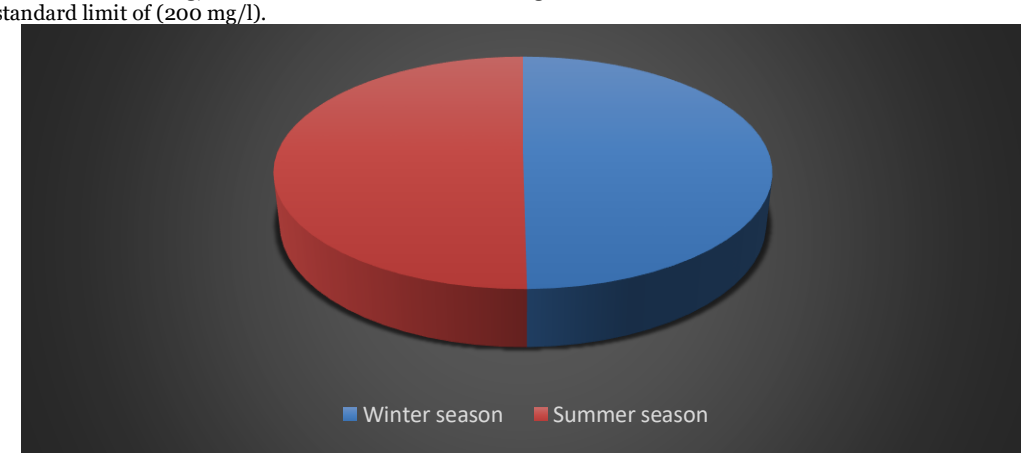

Figure (3) Calcium value in the waters of the Euphrates River in the city of Nasiriyah
Source: Based on the researcher's work using the results of the analyzed samples.

4- Sodium Na

Sodium is present in most natural waters and ranks sixth among the most abundant elements in the Earth's crust. It is one of the ions that contribute to water hardness. Sodium plays an important role in maintaining the normal distribution of water in body tissues, as well as regulating blood pressure and heart rhythm. Sodium is the most influential element in athletic activity as it contributes to the transmission of nerve impulses to muscles (Ali, 2021, p. 18). From Figure (4) it is clear that the winter season records (599,33 mg/L) exceeding the Iraqi standard of (350 mg/L), while the summer season records (598,16 mg/L) also exceeding the standard. Thus, both seasons exceed the specified value for sodium in the Euphrates River water in the city of Nasiriyah.shape (4) it becomes clear to us that the winter season records (599.33 mg/L) exceeding the Iraqi standard of (350 mg/L), while the summer season records (598.16 mg/L) exceeding the specified standard. Thus, both seasons exceed the specified value for sodium in the Euphrates River water in the city of Nasiriyah.

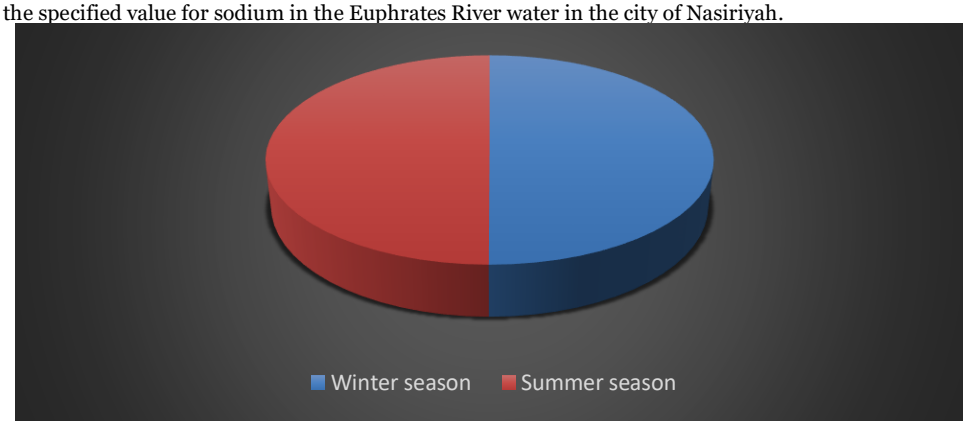

Figure (4) Sodium value in the waters of the Euphrates River in the city of Nasiriyah
Source: Based on the researcher's work using the results of the analyzed samples.

5- Sulfate SO4

The sources of sulfate in soil result from the oxidation of sulfide derived from natural rocks as well as from the breakdown of organic sulfide materials. Sulfates occur naturally and are found in many ores. It is evident from the field study of the amount of sulfate SO4 recorded in the Euphrates River water within the city of Nasiriyah that the analysis results show the winter season amount is (884,33 mg/L) Figure (5) and

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the summer season is (976.99 mg/L), exceeding the specified limit of (200 mg/L).

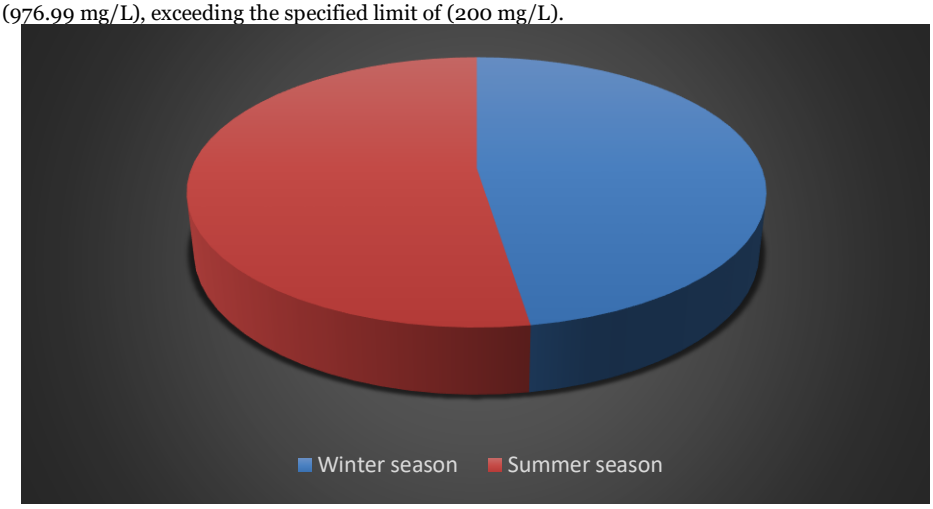

Figure (5) Sulfate content in the waters of the Euphrates River in the city of Nasiriyah
Source: Based on the researcher's work using the results of the analyzed samples.

6- Nitrate NO3

Nitrate ions are widespread in soil and water, with concentrations in unpolluted fresh surface waters typically at 5 mg/L or less, and in some cases reaching 50 mg/L due to surrounding influences such as random water use, untreated waste dumped into rivers, intensive use of nitrogen fertilizers, and untreated industrial wastewater. From Figure (6), it was found that the winter season recorded (9.35 mg/L) and the summer season recorded (10,13 mg/L), while the specified maximum standard in Iraq is (50 mg/L).

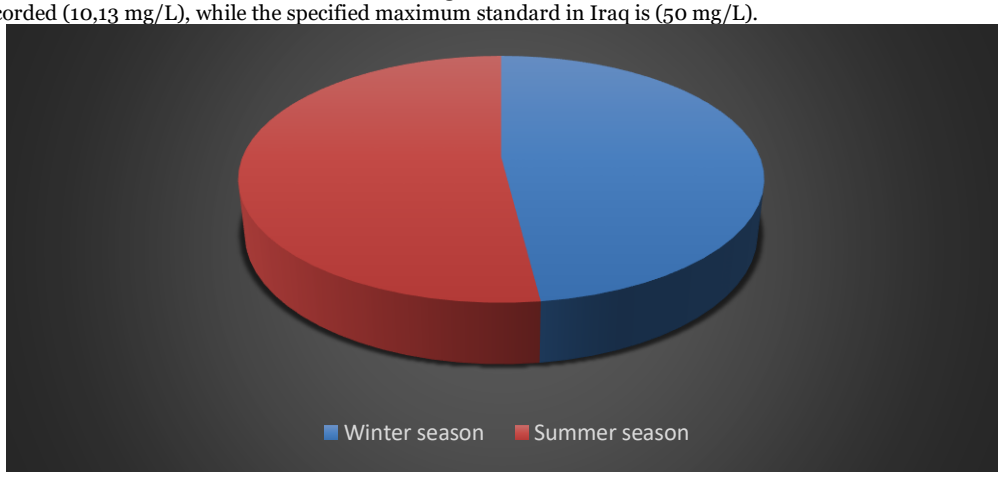

Figure (6) Nitrate value in the waters of the Euphrates River in the city of Nasiriyah
Source: Based on the researcher's work using the results of the analyzed samples.

7- Bicarbonate HCO3

It comes from limestone, lime stone, and dolomite. Dolomite and its concentration are usually less than (500 mg/L) in natural waters, and may exceed (1000 mg/L) in waters highly saturated with bicarbonates (Arjaih, 2022, p. 242). From the analysis results of samples taken from the Euphrates River water in Nasiriyah, it was found that the bicarbonate HCO3 (169,33) and (174,5) for the winter and summer seasons, respectively. The winter season was within the specified standard, while the summer season exceeded it by a difference of (4,5 mg/L) (Figure 7).

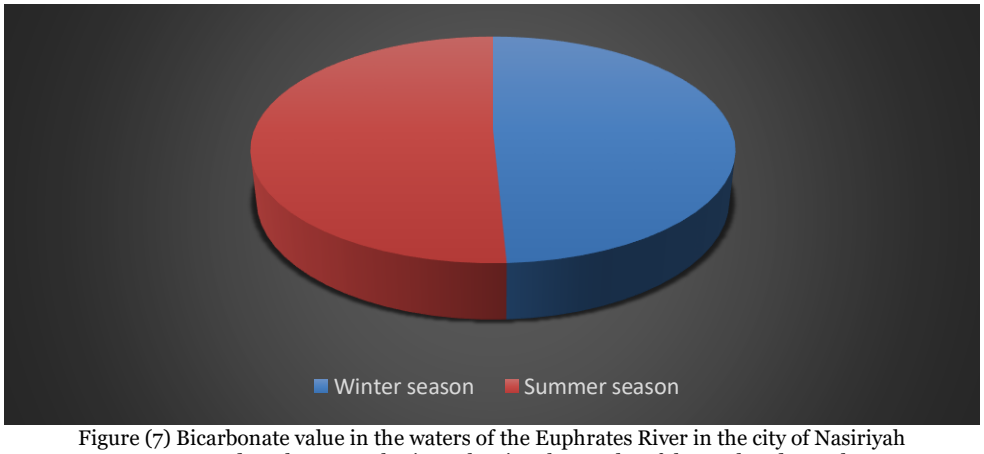

Figure (7) Bicarbonate value in the waters of the Euphrates River in the city of Nasiriyah
Source: Based on the researcher's work using the results of the analyzed samples.

8- Chlorine CL

It exists on the earth's surface as sodium, calcium, and potassium chloride, and its concentration in water varies. The presence of chlorides Cl in water is an indicator of pollutionresulting from direct pollutants in water or those that seep indirectly. Figure (8) shows that the winter season value is (821,16 mg/L) while the summer season recorded (839,33 mg/L), and the standard set the value at (170 mg/L).

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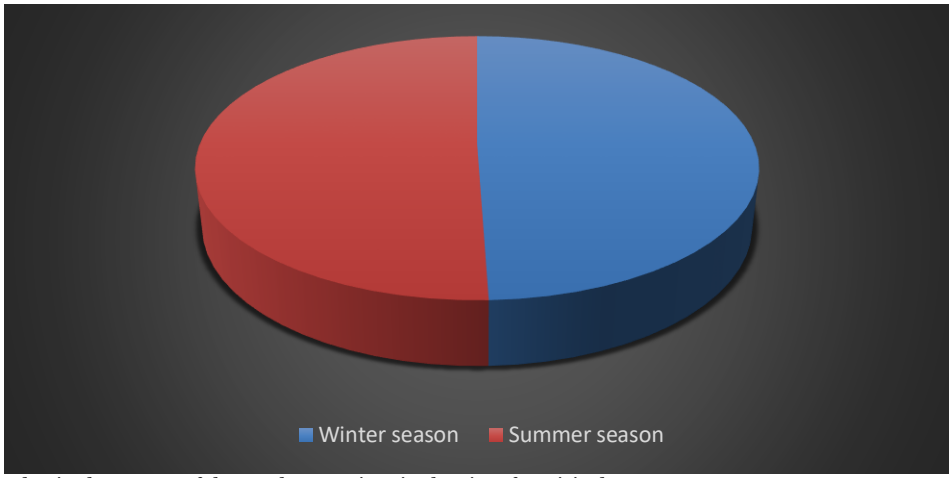

Figure (8) Chlorine value in the waters of the Euphrates River in the city of Nasiriyah
Source: Based on the researcher's work using the results of the analyzed samples.

9- Total Hardness TH

Total hardness measurement is an important factor that determines the suitability of water for various uses. It is a natural property of water and a measure of calcium and magnesium ions in water. Sometimes Iron, magnesium, and aluminum ions contribute to increasing it. Its high levels lead to water being unsuitable for human use in terms of taste (Numas and Hashim, 2017, p.137). The results of the field study show that the total hardness for the winter season is (1173,3 mg/L) and for the summer season (1251,66 mg/L). Thus, it exceeds the local standard specified at (160 – 480 mg/L) Figure (9).

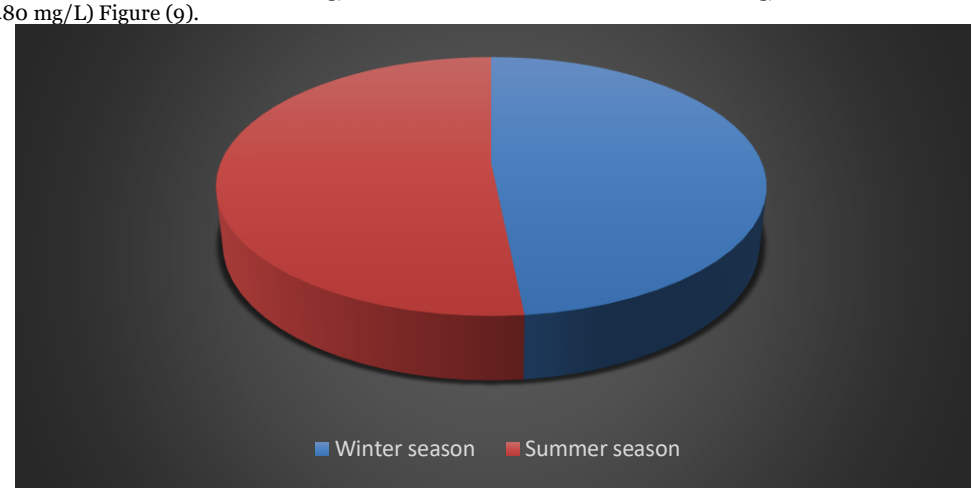

Figure (9) Total hardness value in the waters of the Euphrates River in the city of Nasiriyah
Source: Based on the researcher's work using the results of the analyzed samples.

The concentration of various pollutants increases in fresh and saline water bodies, despite them being the lifelines for living organisms, but they have become a cause of their destruction, including humans. A World Health Organization report on the Third World indicated that about (9,0 million people) die annually in developing countries due to water pollution diseases and malnutrition. The large amounts of bicarbonates the river receives affect water alkalinity, contributing to increased nitrate salts and algal growth, which can deplete large amounts of vital oxygen, making the water turbid, hindering light penetration, and leading to algal death and decomposition (Musa, 2021, pp.23-24). From the above, it is clear that the water quality in the Euphrates River is polluted and mostly exceeds the local standards, resulting from the diversity and multiplicity of sources that contribute to its pollution, which will be presented and analyzed in the next section.

Seventh: Analysis of Pollution Sources of the Euphrates River Water in the City of Nasiriyah

1- Domestic Wastewater:

It refers to what is discharged through sewage networks within cities, resulting from diverse human activities carried out by residents in homes, markets, and various government institutions, as well as private and other activities and activities continuously performed by residents, which are collected through a unified network and treated and disposed of outside cities at treatment plants or disposal sites (Sidkhan, 2007, p.84). Wastewater consists of (99,9%) water and the remaining (0,1%) dissolved and suspended solids (Yassin and Abbas, 2018, p.98). The quantity of wastewater may vary from place to place in developed versus developing countries, rural versus urban areas, and high-income versus low-income urban areas. (Doorn & others, 2016, p.6.7).

Sources of wastewater

1-1- Polluted rainwater:

Pollution levels of rainwater vary according to the local environment, depending on the amount of pollutants in the air. In industrial areas, pollutants are more than in non-industrial areas. Consequently, this contributes to pollution of the environmental system according to the location. These waters fall on agricultural lands, homes, streets, and roads, eventually draining into the city's sewers and ultimately reaching the Euphrates River, affecting the quality of water in the river.

Figure (1)

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Figure10: Domestic Wastewater: The photos were taken by the researcher on 10/1/2026

1-2- Leachate and wash water:

Leachate water results from breaks in water pipes used to supply water to residents within the city from designated sources, or from water overuse in some city areas, in addition to street washing. This phenomenon is common in Iraqi city streets in general. These waters drain into the sewers in the street and are laden with amounts of sand, soil, and some solid waste, which are swept into the sewers. Eventually, these waters are discharged into the river through the sewers.

1-3- Household, governmental and non-governmental institutional water:

Wastewater resulting from human activities inside homes and government institutions, including schools and universities, as well as scientific laboratories, public and private hospitals, health centers, medical clinics, health laboratories, markets, shops, restaurants, hotels, barbershops, beauty centers, and others. Domestic water sources vary from bathrooms, kitchens, which are rich in organic materials, fats, detergents, and soap, and blackwater from toilets, which is rich in hazardous organic materials. The remaining activities produce organic waste, germs, viruses, toxic substances, chemicals, and complex compounds containing trace (heavy) elements.In public and private health institutions, treatment processes vary by efficiency; some government hospitals, despite having treatment plants, are inefficient and private hospitals, although they have treatment plants, are also inefficient despite regulatory bodies issuing warnings (Khadhir, personal interview, 25 March 2026). It is worth noting that there is only one water treatment plant in Nasiriyah (Al-Hindiya Plant), but it is inefficient, dilapidated, and non-operational, thus discharging water into the Euphrates River without any treatment.

2- Industrial wastewater

The Euphrates River in Nasiriyah faces a challenge regarding polluted industrial wastewater from various industrial activities. Water is used for processing raw materials, cleaning machines and equipment, and cooling operations. The quantity and quality of produced water vary, which in turn affects the amount of pollutants, as there is a direct relationship between the amount of water used and the amount of pollutants: the more water used, the more pollutants, especially if the industrial wastewater is discharged into the river. A prominent source is the power plant, which contributes to water pollution as it is built on the Euphrates River.

The power plant discharges large quantities of polluted water during production processes, especially since it uses different types of fuel (crude oil, gas oil, diesel, and fuel oil). Fuel is used to boil water, producing steam to rotate the turbine, converting mechanical power into electrical power. In all these cases, polluted water is produced and discharged into the Euphrates River. The amount of water discharged into the Euphrates River reached (20000 and 10 m3/h) at the Nasiriyah Thermal Power Plant and the Nasiriyah Steam Power Plant, respectively.

Table (2) Pollutants released by operating power plants into the Euphrates River and discharge volume

No.	station	Operating units	Drainage authority	Discharge volume m3/h
1	Nasiriyah Thermal Power Plant	4	Euphrates River	20000
2	Nasiriyah Combined Cycle Power Plant	4	Euphrates River	10

Source: Prepared by the researcher based on: Republic of Iraq, Ministry of Environment, Directorate of Urban Environment, Department of Monitoring and Evaluation of Industrial Activities, Energy Industry Division, unpublished data, 2024.

The table shows that the amount of water discharged into the Euphrates River is large, and these quantities correspond to the demand for electrical energy, which increases with rising demand.

Steam power plants rely on large quantities of water for steam generation and cooling, requiring raw water to undergo a series of physical and chemical treatment processes before being introduced into the operational system. Water is typically drawn from surface or groundwater sources and often contains suspended solids, floating materials, and dissolved salts and minerals. Treatment begins with primary sedimentation and removal of large suspended solids, followed by coagulation and flocculation using chemicals (such as aluminum or iron salts) to improve the efficiency of removing fine particles and colloidal substances (American Public Health Association, 2017, p. 129). To achieve a high level of purity consistent with the requirements of steam boiler operation, dissolved salt removal techniques are used, foremost among them the reverse osmosis system (Reverse Osmosis - RO), which relies on semi-permeable membranes to remove a large proportion of dissolved salts, minerals, and micropollutants. In some plants, treatment is supplemented by deionization units (Hassoun, 2025, p. 153) to obtain ultrapure water, as dissolved salts can lead to scale formation, deposits, or corrosion inside boilers and steam lines, reducing thermal efficiency and increasing maintenance costs.

These treatment processes generate liquid waste containing high concentrations of dissolved solids and chemicals used in coagulation and periodic membrane cleaning. If not managed properly, this waste may be discharged into water bodies, negatively affecting water quality and associated ecosystems (U.S. Environmental Protection Agency Office of Water, 2014, p. 4-32).

As for cooling water, it is the largest contributor to total water consumption in thermal plants. Cooling systems use either once-through cooling or closed-loop systems with cooling towers. In once-through systems, water is returned to the source at a higher temperature, causing thermal pollution, which affects dissolved oxygen concentration and alters the ecological structure of aquatic life, Evaporation in closed-loop cooling systems increases the concentration of dissolved salts in the remaining water (blowdown water), requiring a portion to be discharged to maintain proper chemical balance, which may add pollutant load to the aquatic environment (World Bank Group, General Environmental,

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Health, and Safety Guidelines, World Bank, 2019, pp. 24-36).

Among the prominent industries in the city of Nasiriyah is the Ur General Company, which is one of the formations of the Ministry of Industry and Minerals. It contains factories for the production of cables (aluminum) from large suspended and buried sizes to small sizes used in the manufacture of electric motors, in addition to many aluminum industries and various shapes and molds. There is also a new factory under construction, specializing in small molds for doors and windows, and types of colored and plain molds. There is also a woodworking workshop, which is a secondary workshop that supports other factories with wooden bobbins. Despite the importance of the company and the products it manufactures, there is no special treatment plant for treating industrial wastewater resulting from the industrial activities within the company itself. Instead, it is discharged and treated in cooperation with the neighboring Spinning and Weaving Company by the Ur General Company. Note that the treatment plant is currently not operational and needs maintenance or construction of a new plant to treat the industrial wastewater discharged from the company and the Spinning and Weaving Factory (personal interview, 2026).

3- Agricultural Sources and Aquatic Plants:

Agricultural wastewater is produced from agricultural activities and surplus irrigation water through drainage networks, which mixes with salts in the soil and residues of fertilizers and pesticides. When this water reaches the river, it leads to an increase in total dissolved solids, as well as higher concentrations of nitrates and phosphates. These pollutants can increase, especially during low-water periods, affecting water quality and its suitability for human uses within the city, thus exacerbating the number of problems resulting from polluted water in the city.

As for aquatic plants, they in turn constitute a source of pollution of the Euphrates River water in the city of Nasiriyah. Some of these plants are associated with the Iraqi environment, including plants (reeds, papyrus, tamarisk, sesban, and willow), while others are alien (invasive plants). Reeds and papyrus plants are distributed on both sides of the river in the study area, varying from one place to another. The presence of plants affects the flow velocity of water in the stream, contributing to the accumulation of plants and waste, which can become suitable places for the accumulation of viruses and the endemicity and easy spread of diseases. Moreover, the accumulation of these plants can form river islands in the middle of the river stream within the city (Salman and Hassan, 2020, p. 154). As for invasive plants, the most important of which is the water hyacinth, their presence contributes to increased turbidity, water hardness, and salinity, which will cause an imbalance in the ecological balance, as the hyacinth consumes nutrients at the expense of other organisms, resulting in an increased deficiency of dissolved oxygen (Al-Wahid, 2017, pp. 101-105). Among the other indirect effects, it increases the concentration of carbon dioxide in the water and helps reduce water transparency. The decomposition of dead leaves and root residues increases its biological and chemical oxygen demand, in addition to the spread of unpleasant odors in the water and the presence of suspended colored materials resulting from the vegetation cover of the water hyacinth (Salem, 2020, p. 23). And the remains of dead plants spread on both sides of the river.

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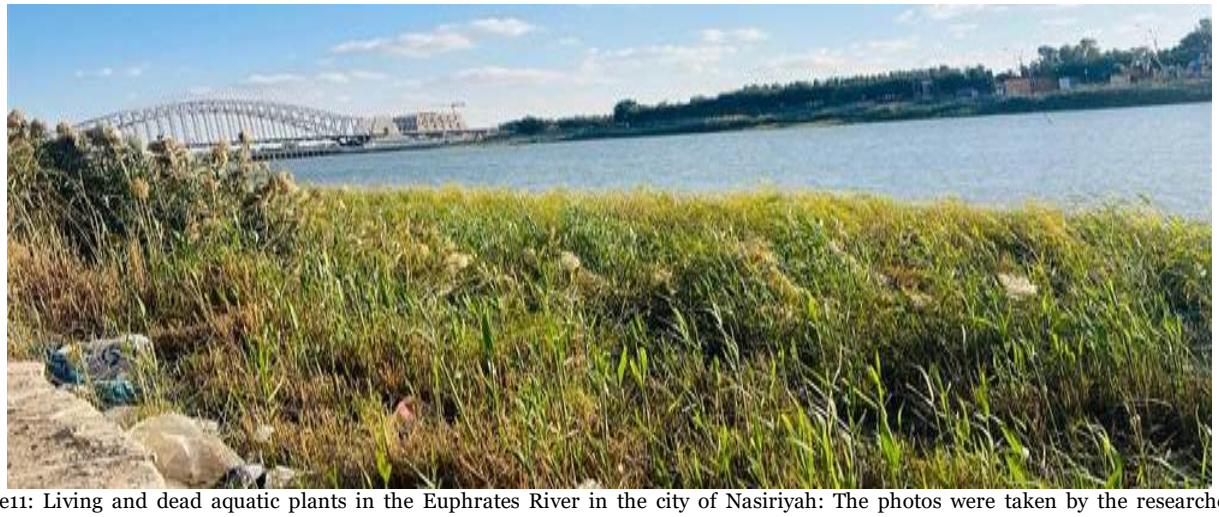

Figure11: Living and dead aquatic plants in the Euphrates River in the city of Nasiriyah: The photos were taken by the researcher on 10/1/2026

4- Solid Waste

It refers to the residues generated from production or conversion processes as well as from use, and thus it includes all materials or objects that are useless to their user and which the user attempts to dispose of in one way or another and remove them for the purpose of preserving the environment in which they live and out of concern to reduce their impact on their health (Al-Fahdawi and Al-Ameri, 2020, p. 150).

Disposing of solid waste in the aquatic environment leads to its pollution, posing a direct and indirect risk to all forms of life. Massive quantities of solid waste are produced globally, with diverse components including organic and inorganic materials, some biodegradable while many are non-biodegradable, and toxic metals. The sources of solid waste in the waters of the Euphrates River within the city of Nasiriyah vary, most notably plastic waste. Plastic waste constitutes 75% of the total amount of solid waste reaching the waters of oceans, seas, and rivers, estimated at (6.4 million tons/year). The plastic products industry relies on mixing polymers with other materials to improve their properties, facilitate manufacturing, reduce production costs, save energy, and protect the environment. The amount of additives ranges from zero polymer for materials used in food packaging to more than 50% in other products. These materials consist of (antioxidants, antistatic agents, lubricants, blowing agents, heat stabilizers, as well as color additives and others (Al-Oud et al., 2015, p. 48).

The field study revealed the presence of large quantities of solid waste scattered in the riverbed within the city of Nasiriyah. These materials varied, including plastics represented by (water, juice, and soft drink bottles of various sizes and bags). Single-use containers and their accessories were also found in the water, as well as food containers (styrofoam containers). Boxes used for transporting fruits and vegetables were also present in large numbers. In the field study, a large number of candidate photos were observed in the water, which had been used near the Euphrates River, whether hung on bridges or in nearby areas, and were carried by the wind. Some of these photos were large in size and attached to special iron structures for this purpose; it appears that those structures were taken and the photos or posters were thrown near the river, noting that this scene was near Al-Nasr Bridge in the city center.

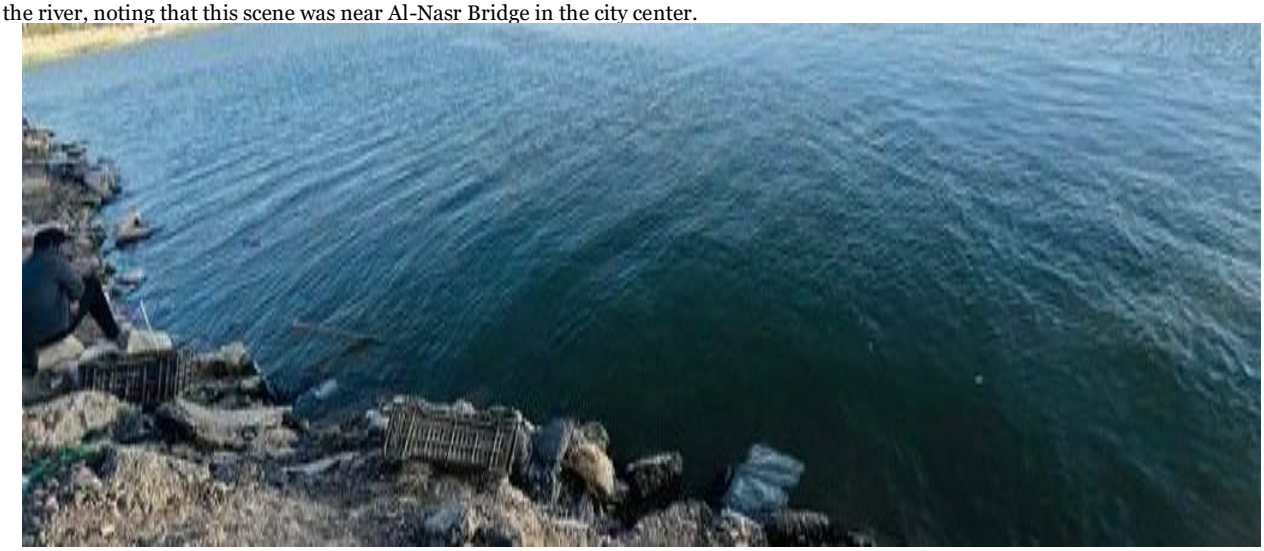

Figure12: plastic boxes in the Euphrates River in the city of Nasiriyah: The photos were taken by the researcher on 10/1/2026

The danger of car tires lies in their non-biodegradability. Experts compare rubber tires to a large reservoir of carbon pollutant that affects organisms and the ozone layer, and takes up to 400 years to decompose naturally. This explains their persistence in nature without being affected even by climate, due to the presence of natural rubber, which constitutes 30-40% of car tires. Moreover, tires can become easy vectors and safe breeding sites for mosquitoes that transmit viruses and diseases, linked to their circular shape and impermeability, which retains water and some aquatic plant leaves or debris near rivers or within water bodies, turning them into ideal places for larval and mosquito growth and spread (Bu Buraima, 2021, pp. 356-357), even with safety measures in place. It was found that tires in the river water of Nasiriyah, in areas frequented by many locals on the corniche, pose a risk to their public health.

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Figure13: car tires in the Euphrates River in the city of Nasiriyah: The photos were taken by the researcher on 10/1/2026

Forms of solid waste pollution within the riverbed in Nasiriyah include construction debris, concrete pieces used in building the corniche along the river, scattered glass bottles, food scraps, mattresses, and even clothing remnants.

Figure14: plastic water bottles in the Euphrates River in the city of Nasiriyah: The photos were taken by the researcher on 10/1/2026

There is a close link between plastic waste and pollution of aquatic environments. Poor management of solid waste leads to the transfer of plastics into rivers, lakes, and coastal waters, where they undergo physical and photolytic degradation, turning into microplastic particles. These particles are a dual pollution source: they are physical pollutants suspended in the water column or settling in sediments depending on polymer density, and chemical pollutants releasing industrial additives such as plasticizers and flame retardants, besides their ability to absorb and transport heavy metals and persistent organic pollutants within aquatic systems.

Eighth: Treatment of Pollution Sources of the Euphrates River Water in Nasiriyah

The type of treatment varies according to the water pollution source. Treatment of domestic wastewater differs from that of healthcare facilities' wastewater and industrial water, necessitating treatments appropriate to the source.

Wastewater Treatment

Water treatment aims to provide safe water for the city for various activities, chemically and microbiologically safe for domestic consumption. Therefore, it must be free from turbidity, color, odor, and unacceptable taste (Hammer & Hammer, 2011, p. 465).

The methods used for wastewater treatment vary, most notably:

- **Activated Sludge Treatment**

Since the water arriving at the plant is polluted, it contains various pollutants such as oils, greases, dust, and solids like stones and plastics. Therefore, the filtration stages vary. This is one of the most commonly used methods, requiring organic matter, microorganisms, and continuous aeration.

- **Lagoon Treatment**

An aerobic biological treatment process equipped with an artificial aeration system that ensures oxidation of wastewater, where the latter is mechanically brought in by a surface aerator or air blower. The flow-through lagoon principle relies primarily on the degradation of organic matter in wastewater through a food chain of microorganisms.

- **Phytoremediation**

One of the methods used for wastewater treatment, also known as the garden system, is an artificial wetland that relies on the same conditions as natural wetlands through the activity of plants and microorganisms in breaking down pollutants and organic matter. The preferred retention time of water in the basin is (4-5 days), and it is advisable for the garden basin to be large to allow water to stay the required duration to obtain high-quality treatment (Ben Hamza and Ben Salem, 2022, pp. 14-19).

- **Treatment by biological membrane technology**

Among the techniques used in wastewater treatment and recycling, its advantage lies in not requiring large areas and its appropriate cost. It is a new technology as an alternative to traditional biological treatment methods that rely on activated sludge and extended aeration.

- **Treatment using clay**

Clay is a natural resource, easy to extract and low in cost for use in wastewater treatment, which can be utilized for irrigating agricultural

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crops and preserving the environment. To achieve positive and good results in removing pollutants, it is necessary to have a set of optimal conditions for treatment, including (temperature 30°C, stirring speed 526-700, contact time 90-150 minutes, while pH is around 8 at a concentration of 3,33 mg/L). (Arar and Lakhle, 2020, p. 80).

There are many methods that can be used in wastewater treatment depending on the type of pollutant source. However, they rely on various techniques, some of which are advanced. The systems that can be used to treat polluted water in the Euphrates River in the city of Nasiriyah require large sums of money as well as large areas for their construction. A set of methods that are used in some Arab countries were selected, and these experiences and models can be utilized and applied in Iraq in general and in the study area in particular, due to the availability of raw materials on one hand and the low financial cost that can be used on the other. Additionally, existing stations within the city can be benefited from and brought back into operation after being shut down, or attempts can be made to benefit from projects of stations currently under construction with some modifications to bring them into operation.

Ninth: Proposals

1-Rehabilitation and maintenance of the wastewater treatment plant in the city of Nasiriyah, known as Al-Hindiya Station, as it does not carry out any treatment of the incoming water, and striving to complete the treatment plant projects under construction.

2-The Ministry of Agriculture and Water Resources providing financial support to the competent authorities for conducting river cleaning campaigns, including the removal of harmful aquatic plants such as (water hyacinth).

3-Directing industrial activities to treat the waste they produce, especially liquid waste, and not discharging it into the river without treatment as it affects the water quality in the river.

4-Monitoring health hospitals (governmental and private) to treat water before discharging it into the city's sewers, as it leaves a harmful effect on water and consequently affects all living organisms without exception, since that water contains harmful elements.

5-Seek to submit a proposal to include private clinics and private laboratories in water treatment before discharge, as the resulting water contains hazardous pollutants.

6-Compel municipal authorities to monitor various activities within the city on the banks of the Euphrates River to avoid dumping waste near or into the river.

7-Provide support and backing to the Environment Directorate in the governorate as it is a regulatory body that records and monitors violations that harm the environment within the city.

8-Activate the Law for the Protection and Improvement of the Environment regarding the formation of committees and accountability of violators, while striving to remove all pollutants and forms that contribute to pollution of the Euphrates River waters, especially since the council includes representatives from government departments and institutions in the governorate.

9-Conduct continuous field studies to monitor and evaluate water quality in the river by selecting specialized researchers from universities in the city of Nasiriyah or Dhi Qar Governorate alike.

10-Cooperate with civil society organizations in the field of awareness and education about the harms of dumping or discharging waste into the river.

Appendix (1) Results of sample analysis during the winter and summer seasons

Season	T.D.S	PH	Ca	Na	SO4	NO3	HCO3	CL	TH
Winter	2948.83	7.7	172.5	599.33	884.33	9.35	169.33	821.16	1173.5
Summer	3266.33	7.7	174	598.16	976.66	10.13	174.5	839.33	1251.66

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