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Analysis of Wastewater Treatment Plant Dimensions and Phosphate Content in the Euphrates River: A Chemical and Biological Study

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Abstract: In this study was performed to ascertain the effect of wastewater discharge on the level of phosphate in the water of station on the Euphrates river and the engineering design of the wastewater treatment plants to reduce the level of phosphate. Samples were collected near the station during the winter and spring seasons in 2024. Our study involves three aspects, the first aspect detects phosphate concentration. The second aspect concerned with measuring some engineering aspects of wastewater treatment plant, while the third aspect is measuring the biological properties, which is the excessive growth of the algae Chlorella vulgaris. The results of phosphate were compared with the Iraqi limits and the World Health Organization, and it was found that the concentration of phosphate (0.32 mg/1) exceeded the permissible limitaonly in spring 2024, within Iraqi specifications. The algae growth was thriving (0.9)and there was a record deviation from control (50%) indicating the inefficiency of treatment in Spring .

Keywords: Phosphate Content, Euphrates River, Sewage discharge station, Biological indicator, Engineering methods.

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Introduction

The basic pillar of life is water. The beginning of life was with water, and without this basic element, life would not continue. In ancient centuries, humans have understood the importance of rivers and lakes, as they wanted to obtain water for their various uses [1].

The percentage of water on the Earth's surface is 71%, while its percentage of the total human body is 65%, and for this reason it is considered necessary for life on Earth. Of these percentages, it is considered an important and essential element for all organisms and their activities, especially humans, in various agricultural, industrial, health, and other aspects, as the percentage used by humans is estimated at 0.01% of the 3% fresh water present on the surface of the Earth [2].

Quantities of nutrients and organic materials continue to be released as a result of the discharge of untreated wastewater into water bodies, and this causes many effects on environmental components, including physical change in the water.

Large quantities of detergents present in wastewater cause the formation of a floating foam layer. This layer prevents gases from dissolving in the water and increases the phosphate content in the water. [4]. In view of the changes that occur in the water referred to above, and in order to reduce the harmful effects that result from discharging sewage directly into rivers, some countries have established stations whose purpose is to treat water and reduce pollution in a better way to reach the permissible limit of pollutants that do not harm the quality of water and living organisms. The processes used to treat water to improve Basic specifications of this water and reduce harmful effects on the environment are chemical, biological and physical processes. Given the aforementioned effects, and in order to reduce pollution from wastewater discharge into rivers, it has become necessary to establish treatment plants. These plants aim to treat wastewater and prevent pollutant concentrations from exceeding permissible limits, thus protecting the environment, water quality, and aquatic life. This treatment involves a series of chemical, biological, and physical processes designed to improve the properties of the water and minimize harmful environmental impacts [5]. The stages that the wastewater purification process goes through [6] are primary treatment: floating materials, solids, various fatty materials and sand are removed. This is done physically using flotation, sedimentation, filters (sections), etc.

Biological or secondary treatment: During which organic matter is destroyed using microorganisms and various techniques such as trickling filters, aeration tanks, and lagoons.

Advanced treatment: According to this stage, the quality of the water that was treated in the above-mentioned stages is improved by removing some nutrients such as phosphates and nitrates and pollutants such as heavy metals, viruses and bacteria using multiple techniques, including physical and chemical factors and biological processes.

The intersection of structural engineering and phosphate pollution of river water includes different aspects. Structural solutions can significantly impact the state of rivers from an environmental standpoint. From a design and construction standpoint, structural engineers design and build the infrastructure for wastewater treatment plants (WWTPs), including tanks. Treatment, filtration systems, and support structures, in addition to advanced treatment processes incorporating technologies such as membrane bioreactors, chemical sedimentation, designing basins that capture rainwater and release it slowly, allowing sediments and phosphates to settle before the water reaches natural water bodies, and constructing retaining walls, slopes, and other structures to stabilize river banks and reduce sediments, combined sewer overflow mitigation, and implementation of Sustainable Urban Drainage Systems to manage urban run off to filter phosphate [6,7].

The aim of this study is to evaluate the phosphate content in the Euphrates River near wastewater treatment plants using three aspects and to find the relationship between them, to suggest some engineering thoughts treatment plants in chemical stage.

Materials and Methods

Water samples of the Euphrates River were taken from the site near the dumping of sewage from the sewage treatment plant in the city of Al-Nasiriyah during the winter-spring period of 2024. Polyethylene bottles were used to collect samples, which were washed with dilute nitric acid (0.1 N) and then with distilled water.

Phosphate concentration and biological indicators were measured by calculating the excessive growth of algae and the percentage deviation coefficient of the growth rate of *Chlorella vulgaris* and clarifying the engineering solutions of the station.

Water samples were collected to measure phosphate concentration in bottles after Iit was homogenized with river water before collecting the samples. They were completely filled, they were tightly closed to prevent air entry, and then stored at 4°C.

For the purpose of measuring the phosphate ion: the ferrous chloride method according to [8].

The bioassay was performed according to the [9].

The structural engineer calculates the effect of structural design on reducing water pollution of rivers with phosphates since this design can have a negative or positive effect in terms of reducing or increasing the effect of phosphate pollution on the river, the following are the steps for calculating the size of the sedimentation basins in order to avoid the effect of phosphate pollution on the river water [10]:

$$SA_{min} = (1.2 \, x \, Q) \div V \quad (1)$$

$$L_{min} = (L: W_e \, x \, SA_{min}) \quad (2)$$

$$W_e = SA_{min} \div L_{min} \quad (3)$$

$$Vol_{min} = Depth \, x \, SA_{min} \quad (4)$$

Where:

SA_{min} – minimum surface area (square feet);

Q – maximum discharge from the system in cubic foot per second;

V – Terminal velocity of a particle in water ≈ 0.00065 feet per second;

L_{min} – Minimum flow path length within the sediment basin (feet);

$L_{min} : W_e$ – Length to Width ratio of the sediment basin (values range from 0 to 10); We – Effective width of the sediment basin (feet);

Vol_{min} – Minimum containment volume of the sediment basin ≥ 3,600 cubic feet per acre draining to the structure;

Depth = Average pond depth ≥ 3.0 feet and at least 2.5 feet deep at the outlet structure.

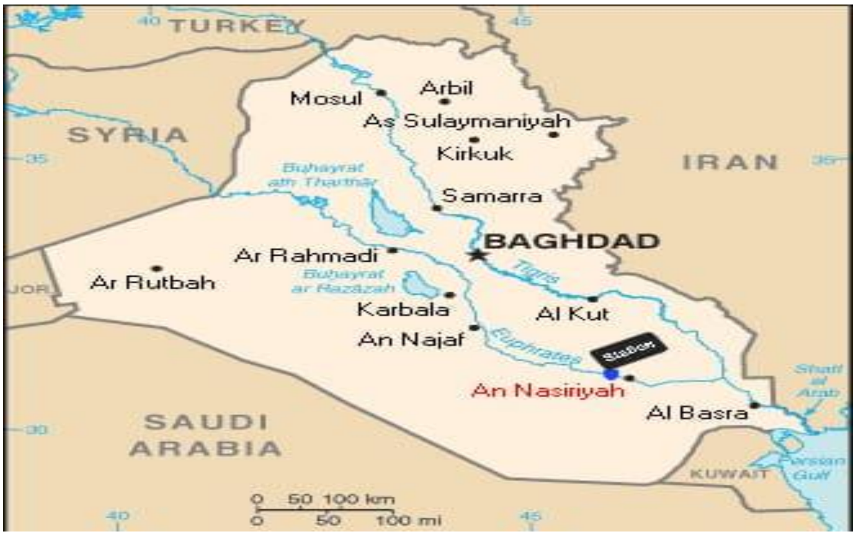

Figure 1. The study station were collected within the city of Al-Nasiriyah.

Results and Discussion

Table 1 shows the concentration of the phosphate in the studied sample in winter and spring 2024. Phosphate concentration values did not exceed the permissible limits for irrigation purposes when compared with Iraqi standards in winter, but it exceed the permissible limits in spring; the impact of phosphate on water quality was evident in the spring season and its effect on the blooming of Chlorella algae, as its concentration level increases in the spring. This requires an engineering intervention at the wastewater treatment plant due to the insufficient efficiency of the current filtration system. Inorganic forms of phosphorus, such as phosphate, are mainly found in detergents, domestic wastewater, fertilizers, and industrial wastewater [11]. Phosphate is not inherently toxic to humans or animals unless it is present at a very high level, so it is necessary to test its effect on water quality.

Table1. Mean monthly concentration of phosphate.

Seasons	Phosphate concentration(mg/l)
Winter 2024	**0.08**
Spring 2024	**0.32**

According to the results of the current study, different growth rates of the algae *Chlorella vulgaris* were obtained for river water samples in studied station, where the highest growth rate of the algae *Chlorella vulgaris* in spring was (0.9) after 24 hours simultaneously with an increase in phosphate concentration (Tab. 1 and 2) , while lowest growth rate was in winter (0.16) after 72 hours (Tab. 1 and 3) .

This may be attributed to the presence of phosphate and another nutrients that helped the algae to grow in the environment. This may be attributed to pollution from inefficiency of wastewater treatment plants.

Table 2: Growth rates of *Chlorella vulgaris* algae in the studied station in winter 2024

Time	Control	Growth rate in station
24 hrs.	0.62	0.66
48 hrs.	0.51	0.32
72 hrs.	0.32	0.16

Table 3: Growth rates of *Chlorella vulgaris* algae in the studied station in spring 2024.

Time	Control	Growth rate in station
24 hrs.	0.66	0.9
48 hrs.	0.57	0.8
72 hrs.	0.48	0.72

The percentage of growth deviation coeffeiciant of the alga *Chlorella vulgaris* out of control was recorded in winter (-50%) (subacute toxicity with an inhibition effect) and spring (50%) after 72 hours (subacute toxicity with a stimulating effect). As for the lowest values of the deviation coefficient for the growth rate, it was recorded in winter, with an inhibitory effect, as phosphate concentration was low in winter compared with spring. Toxicity with an inhibitory effect on cell growth was recorded and may belong to various chimecal pollutions[12].

The high deviation in growth rates (stimulating effect for bloom algae) indicates the presence of a high content of phosphate in water.

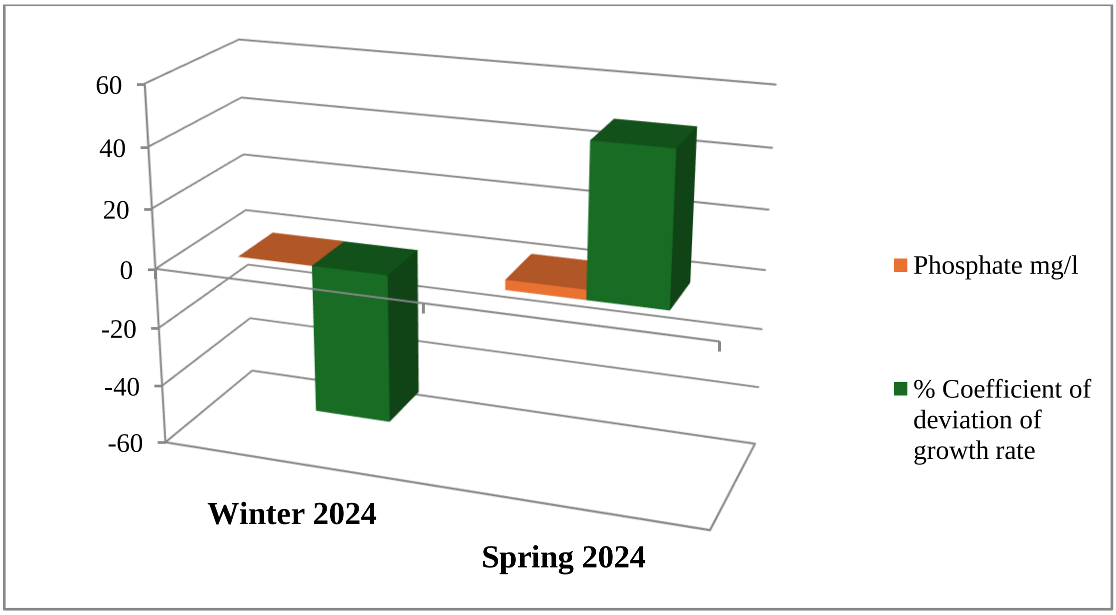

Figure 2: The relationship between phosphate concentration and Percentage coefficient of deviation of the growth rate (GR) of *Chlorella vulgaris* after 72 hrs.

Conclusion

The study was conducted in conjunction with biological and chemical indicators with engineering calculations for the dimensions of the wastewater discharge station for treating phosphate in wastewater.

The results showed that phosphate exceeded the permissible limit in the spring, and therefore the impact value was calculated in water was rated as toxic in stimulating effect for growth rate of algae. However, in case of using some engineering measures in the design of a wastewater treatment plant, the phosphates level will changed in water river.

Finally, the difference in toxic effects and growth rate may be attributed to the with and without phosphate. The most commonly encountered pesticide preparations in water bodies were used as pollutants: organophosphates [13]. Moreover, inhibition effect of toxicity belongs to another chemical pollutants . Despite this, this study and its results are a basis that decision makers can benefit from structural engineering methods in designing and constructing sedimentation basins, as effective design contributes to reducing the effect of phosphate pollution of river water, which helps in maintaining the environmental balance.

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