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Study of the Water Pollution in the Euphrates River near the Wastewater Treatment Station in the City of Nasiriyah, Iraq

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ABSTRACT
Water pollution is considered one of the most significant challenges and problems facing humanity today. This is due to the transfer of pollutants in water to soil and field crops, particularly heavy metals, due to its cumulative effect and persistance. After the wastewater treatment plant in Nasiriyah was destroyed in 2023, these fields became irrigated with non-treated water. The aim of this research was to study the extent of pollution of the Euphrates River by sewage containing heavy metals such as chromium (Cr), lead (Pb), cadmium (Cd), and nickel (Ni) as well as the chemical and microbial contaminations. Water samples were collected from 10 sites along the Euphrates River, starting from the treatment plant in northern Nasiriyah to the southern end of Nasiriyah City, during both the summer and winter seasons of 2023. Heavy metals analysis results showed that Cr concentrations ranged between 0.02- 0.07ppm in summer and 0.02- 0.08ppm in winter. Pb concentrations fluctuated between 0.2- 0.6ppm in summer and 0.05- 0.13ppm in winter. Cd concentrations ranged between 0.01-0.06 ppm in summer and 0.09- 0.10ppm in winter. Ni concentrations varied between 0.03- 0.02ppm in summer and 0.02- 0.03ppm in winter. Concentrations of all the studied elements were within the permissible limits stated by the WHO, FAO with the exception of Cd. The data of chemical analyses showed that the chemical oxygen demand values in winter ranged between 19 and121mg/ L, while in summer they fluctuated between 101 and 941mg/ L. For the biochemical oxygen demand values, ranges between 111and176mg/ L were deteted in the summer and between 7 and 25mg/ L in the winter, and these values outperformed the permissible limits of the WHO. The *E. Coli* population outstipped the allowed ranges during the summer (2500–300,000 *Bacillus*) and winter (8500–39000 *Bacillus*).

INTRODUCTION

Water is an essential element for all living organisms on the surface of the Earth, as it represents a basic factor on which human life and social and economic activities are based. The quality of water in rivers, specially the surface water, requires continuous monitoring. In aquatic ecosystems, the quality of water depends on the chemical, physical and biological characteristics of the aquatic ecosystems of rivers and the surrounding environment. The great progress that man has achieved in the fields of urbanization and technical progress has led to a change in the environmental components. Sustainable man activities should be adopted to balance between preserving environmental services and civilization. The cost of pollution is significant and nonavoidable, comprising the emergence of air pollution, water, and soil depletion that accompanies the industrial and civilized progress of man **(Elhaddad *et al.*, 2022)**. The presence of heavy metals is considered one of the most significant health problems in drinking water sources, especially when they exceed the permissible limits according to international water specifications. Heavy metals in water cause various diseases for humans, including cancer, as they are considered a potential and effective factor in the occurrence of these diseases when they accumulate in the body **(Salaah *et al.*, 2022)**. The elevation in heavy metals' concentration is five times the density of water, i.e. more than 4- 5mg/ cm^3 **(Jia *et al.*, 2021; Ateshan & Misnan, 2025a)**. These elements have a potential risk effects on the health of humans and aquatic animals **(Ahmed *et al.*, 2022)**. These metals have physical properties that they share, and their chemical reactions are different. This also applies to their environmental effects, as they differ from one element to another. Some elements, such as cadmium (Cd), lead (Pb), and mercury (Mg), pose a risk to public health, while the presence of other metals, such as copper (Cu), iron (Fe), and chromium (Cr), affects human health only in workplaces where people are exposed to these elements for long periods **(Salaah & El-Gaar, 2020)**. Therefore, some metals are considered less dangerous than others, such as Pb, which is widely spread in the air, water, and food **(Scutarașu & Trincă, 2023)**. Although many heavy metals are considered important for life, at high concentrations, they are considered toxic and dangerous to human and animal, affecting the vital systems and cell differentiation.

Cadmium (Cd) is one of the most dangerous toxic heavy metals, while Cd is the element that causes toxicity associated with the consumption of plants irrigated with wastewater effluents **(Nawaz *et al.*, 2021)**. Cd is produced by various industries such as the manufacture of phosphate fertilizers, detergents, galvanic plating processes, and paints. Its total concentration in soil ranges between 0.001 and 2mg/ kg, and its concentration in irrigation water used in the long term is 0.01mg/ L, and 0.05mg/ L in water used in the short term **(Abd-Elwahed, 2018)**. Further, its concentration in plant tissues is considered normal if it ranges between 0.02 and 1.2mg/ kg, but if it exceeds 5mg/ kg, it is considered toxic **(Wang *et al.*, 2019)**. Another dominant heavy metal that accumulate in crops as a result of irrigation with wastewater is chromium. Cr is resulted from many industrial transformation activities such as glass, spinning, weaving, dyes, pharmaceuticals, tanning waste, and leather manufacturing industries **(Nur-E-Alam *et al.*, 2020)**. The concentration of Cr is 0.1mg/ L in treated wastewater used for irrigation in the long term, and 1.0mg/ L in treated wastewater used for irrigation in the short term **(Aydin *et al.*, 2015)**. In plant tissues, the natural concentration of Cr ranges between 0.5 and 2mg/ kg, and is considered toxic if it exceeds 5mg/ kg. In soil, the total Cr content ranges between 10 and 150mg/ kg **(Ertani *et al.*, 2017; Haider, 2025)**. One of the most common heavy metals encountered in both urban and rural agricultural environments is Pb; large quantities are associated with the manufacture of fertilizers, detergents, paints, galvanic coatings, cables and plastics, in addition to car washing and lubrication stations and gas stations. The total content of Pb in the long range irrigation-treated water used for irrigation was estimated at around 5mg/ L, while Pb concentration in treated irrigation water used in the short range was recorded with a value about 10mg/ L, and between 3 and 20mg/ kg in plant tissue **(Urbano *et al.*, 2017; Ateshan *et al.*, 2019; Khawla *et al.*, 2019)**. Eminently, Ni is known as one of the important heavy elements found in nature in large quantities. It is used in the battery industry, and the petroleum industries, in addition to the hydrogenation of oils. The allowed levels of total Ni concentrations in irrigation water ranges in the long term is 0.02mg/ L, and 0.2mg/ L in the short range **(Taghipour *et al.*, 2012; Nawaz *et al.*, 2021)**.

Abdullah, *et al.* (2013) and **Issa and Alshatteri (2021)** evaluated the pollution of heavy metals for both sides of the Diyala River water, soil, and plants nearby the agricultural lands. They reported high concentration of Cd in the river water with an average concentration of 0.0215mg/ L, which exceeds the permissible limit for irrigation water determined by the **WHO (2010)**.

Moreover, **Khlaif and Al-Hassany (2023)** and **Khlaif and AL-Hassany (2024**) addressed some heavy metals in the Bani Hassan stream, a branch of the Euphrates River in Karbala City, revealing that the levels of Cd, Pb and Cr at different sites were assessed to be within the permissible limits of the **WHO (2010)**.

Therefore, with the objectives of determining the total content of some elements in the Eufrates River water and investigating the bacterial and chemical pollution of water, the present study was organized.

MATERIALS AND METHODS

Research site

Water samples were taken from the Euphrates River in the areas below the sewage treatment station in the city of Nasiriyah, Iraq, as shown in the attached map (Fig. 1).

Sample collection

One-liter polyethylene containers were sterilized prior to being used for collecting water samples form the area under study. Water samples were filtered to remove any suspended contaminants. This step was done in two stages, where a water sample was taken from 10 sites over a long period of summer and winter, 2023. The samples were stored in 5 milliliters of concentrated HNO_3 with a 55 percent concentration per liter. This process is meant to prevent the samples from absorbing minerals contained in the containers. The samples were then taken to the lab, and maintained at 4 degrees Celsius until the tests were performed. The following analyses were conducted for each sample in the laboratory of the College of Science at Thi Qar University: (EC) using electrical conductivity device; (pH) using a pH meter; (TDS) utilyzing electrical conductivity meter; -Cations (potassium - sodium) using ion chromatography; ammonium using spectrophotometer, and phosphorus using spectrophotometer **(Ateshan *et al.*, 2020; Miswan *et al.*, 2023)**. Analysis of some heavy elements in water (Cd, Pb, Cr, Ni) was conducted using atomic absorption spectrophotometer (**Guru PK, 2000**). The following analyses were also conducted in the university laboratory: biochemical oxygen demand oxygen (BOD) and chemical oxygen demand (COD) using special kits. Bacterial tests (Total bacterial count in water - Salmonella – *E.coli.*) were applied according to the method used in **Gilcreas (1966)**.

Samples prepared and preserved by Atomic Absorption Spectrometry (AAS) from Spectra are examined according to the method followed in **Khan *et al.* (2018)**. The various sets of data collected from the stations in Nasiriyah City were compared with two-way ANOVA test (SPSS) v.26 software.

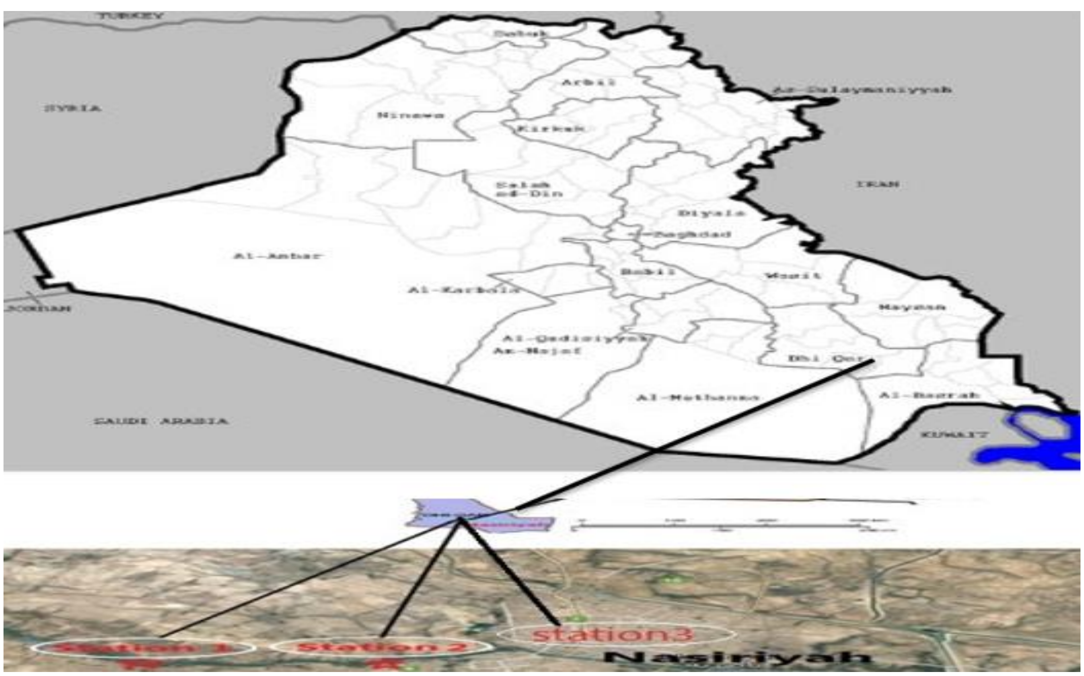


Fig. 1. Map of Iraq showing the study area in Nasiriyah City

RESULTS AND DISCUSSION

1- Electrical conductivity, pH and total dissolved salts

The results of water analysis with values of the water pH in summer and winter are depicted in Fig. (2). Data postulate that most of the values ranged between 7.4 & 8. This degree is considered moderately alkaline, and is within the permissible limits (6-9) of the Iraqi standard specifications for irrigation purposes. Upon addressing the results of the TDS analysis in terms of the seasons under study, it was found that the values in summer and winter ranged between 150 & 500mg/ L (Fig. 3), and are within the permissible limits (1500mg/ L) according to the Iraqi standard specifications for irrigation purposes in 2010.

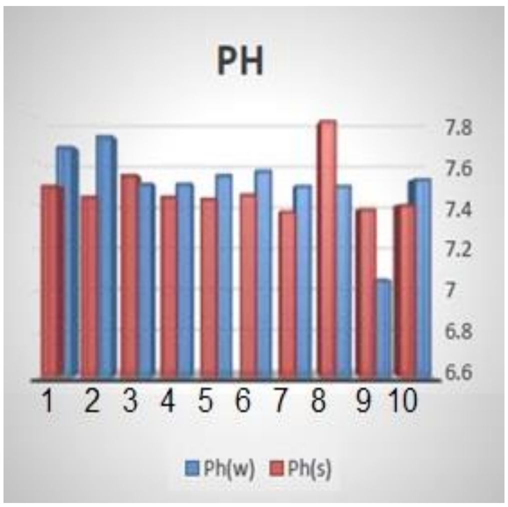


Fig. 2. pH values during summer and winter

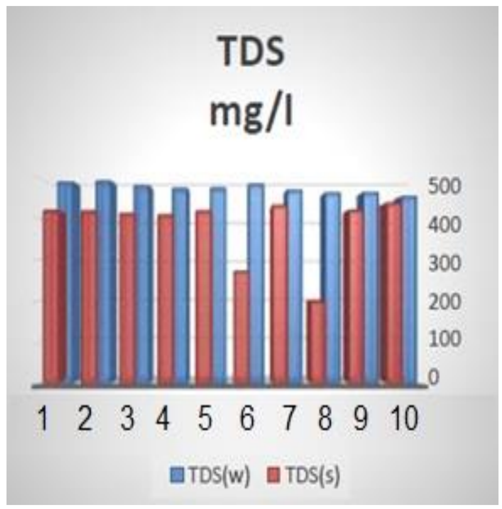


Fig. 3. Values of TDS mg/L during summer and winter

2. Results of analysis of some heavy metals

Figs. (4 -7) show the concentrations of Pb, Cr, Ni, and Cd in the stream water for the ten collected samples, respectively. The concentrations of these metals evaluated in summer and winter were subjected to a comparison, with results displayed in the following outcomes: The concentration of Pb element was recorded with ranges between 0.2- 0.7ppm in summer and 0.05- 0.13ppm in winter according to the Iraqi standard specifications for irrigation purposes in 2010.

For the Cr, the concentration ranged in summer from 0.02- 0.07ppm, and in winter it fluctuated from 0.02- 0.08ppm, which is within the permissible limits of 1ppm according to the Iraqi standard specifications for irrigation purposes 2010.

Ni concentrations ranged in summer between 0.03-0.04ppm, while in winter they varied between 0.02-0.03ppm, which is also within the permissible limits of 1ppm according to the Iraqi standard specifications for irrigation purposes 2010.

As for the cadmium metals, the concentration ranged in the summer between 0.02-0.07ppm and in the winter between 0.09 & 0.10ppm, which is higher than the permissible limits (0.05ppm) according to the Iraqi standard (2010) specifications for irrigation purposes, consistent with the reference studies of **Al-Shubaili *et al.* (2024)** and **Ateshan and Misnan (2025b)**.

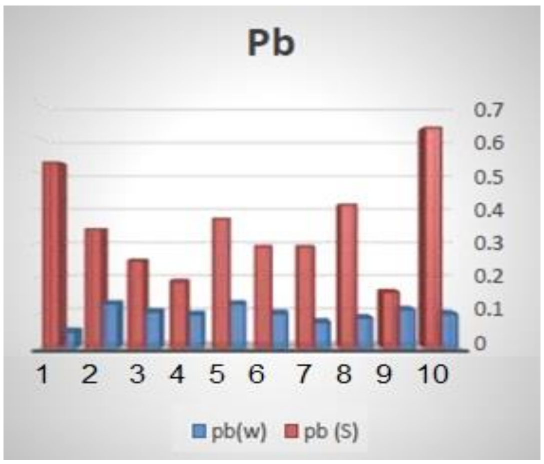


Fig. 4 Lead concentration during winter(w) and summer (s)

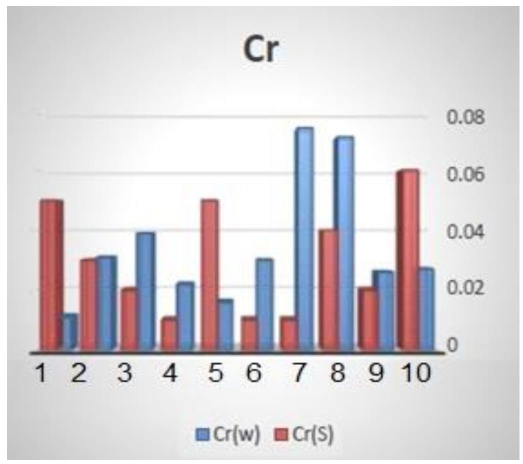


Fig. 5. Chromium concentration during winter (w)and summer (s)

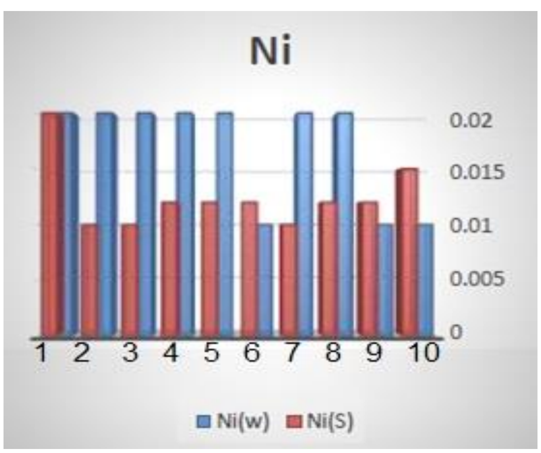


Fig. 6. Nickel concentration during Winter (w) and summer (s)

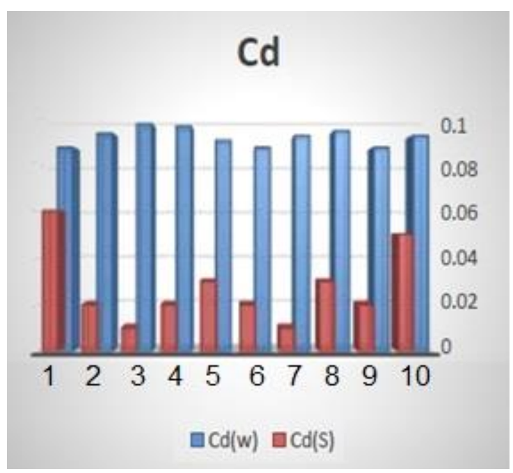
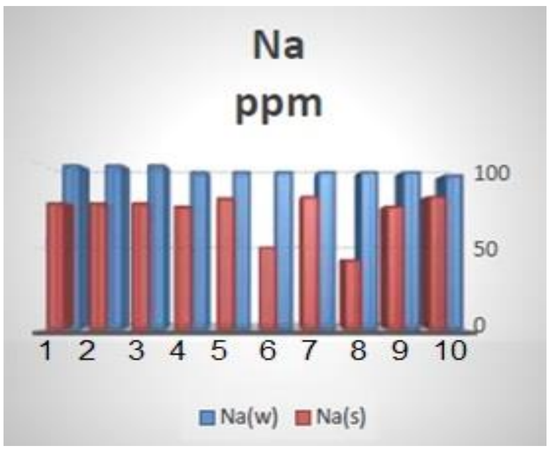


Fig. 7. Cadmium concentration during winter (w) and summer (s)

3. Results of the analysis of sodium and potassium concentrations

Fig. (8) shows the results of the analysis of sodium (Na) element in stream water during winter and summer. It was found that Na concentration was higher during winter than summer, revealing values of 95- 101mg/L, and 51-82 mg/L, respectively. These concentrations are within the permissible limits (231mg/ L) according to the official Iraqi standard specifications for irrigation (2010). Fig. (9) denotes the results of potassium (K) concentration in stream water during winter and summer. It was found that the K concentration exhibited higher levels in summer, reaching 6- 16mg/ L, while it ranged between 9 &12mg/ L in winter. These results are considered higher than the permissible limits (0- 3mg/ L) according to the official standard specifications for irrigation in Iraq 2010.



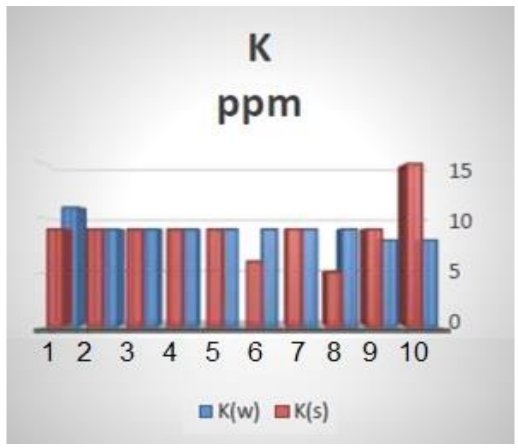


Fig. 8. Sodium concentration in stream water covering November to March during 2023

Fig. 9. Potassium concentration in stream water from April to September during 2023

4. Results of analysis of phosphorus and ammonium concentrations

Fig. (10) illustrates the analysis of the phosphorus (P) in the stream water indicating that the concentration in summer ranged between 13- 21mg/ L, while in the winter they ranged between 23- 29mg/ L.

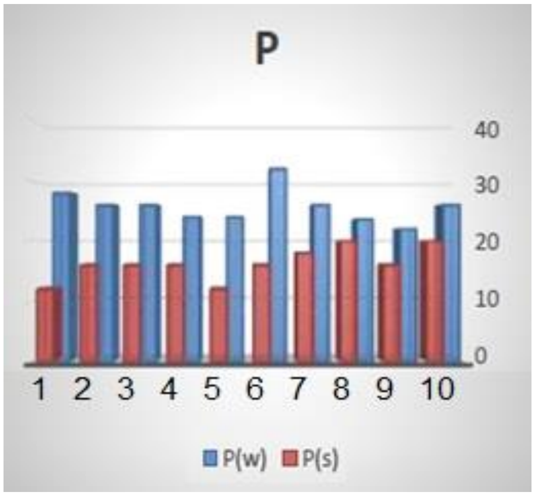


Fig. 10. Phosphorus concentration in summer and winter during 2023

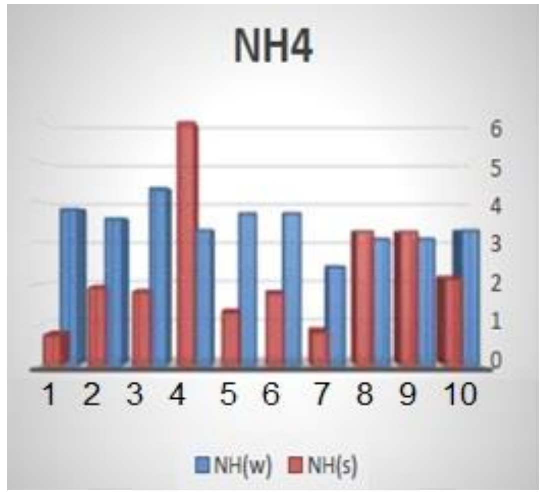
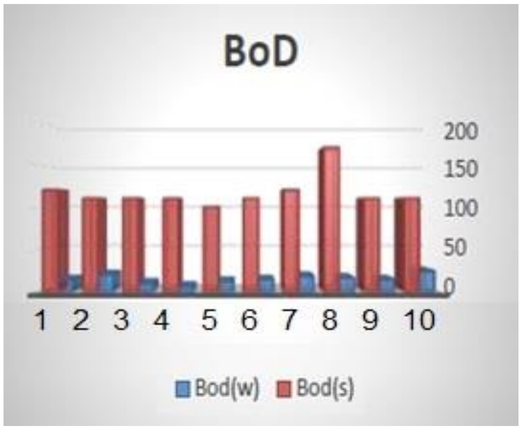


Fig. 11. Ammonium concentration in summer and winter during 2023

This concentration exceeded the permissible limits (0- 3mg/ L). Higher concentration in winter is due to greater dissolution (**Razali *et al.*, 2020; Ateshan & Talib, 2025c**), while in summer, this element is more fixed. Its high presence is due to fertilization, making this stream a part of agricultural land, which is often cultivated year-round. The results of the ammonium analysis in the winter and summer seasons are depicted in Fig. (11). The concentration ranged between (0.8- 5.9) mg/L in summer and (2.5 - 4.4) mg/L in winter. These limits are considered within the permissible limits of (0-6) mg/L according to Iraqi standard specifications 2010.

5- Results of some chemical tests (BOD- COD)

The results of biochemical oxygen demand (BOD) are shown in Fig. (12), while the results of chemical oxygen demand (COD) in the riverbed during both winter and summer are denoted in Fig. (13). The results show that COD values ranged between 101 – 941mg/ L in summer, while in the winter they ranged between 19 & 121mg/ L. The summer values were higher than the winter values because of the biological activity of bacteria and the high temperatures, where oxidation processes occur more extensively. In summer, the values were far from the permissible limits of 151mg/ L according to the Iraqi standard specifications for irrigation purposes. As for the biological oxygen demand (BOD) values, they ranged between 111 – 171mg/ L in summer and between 7– 25mg/ L in winter; these values exceeded the permissible limits of 15mg/ L according to the Iraqi standard specifications for irrigation purposes for the aforementioned reasons .



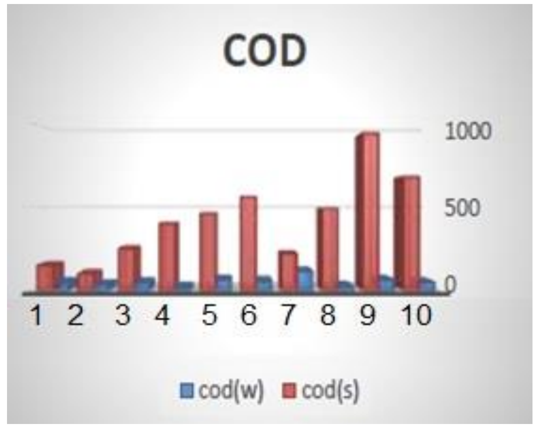


Fig. 12. BOD concentrations in winter and summer during 2023

Fig. 13. COD concentrations in winter and summer during 2023

6. Bacterial count

Regarding bacterial analyses, Figs. (14-16) reveal that the numbers of *E. coli*, *Salmonella* and *Shigella* (SS) and *Bacilli* count (Bac) were higher during summer than winter being favorable conditions for their growth and reproduction **(Pandey, 2020)**. *Salmonella* and *Shigella* egg counts ranged from 2,000 - 31,00 in summer, while in the winter eggs ranged from 2,000 - 30,000, all of which were beyond the permissible limits (at least one egg per liter) according to the Iraqi standard specifications for irrigation purposes 2010.

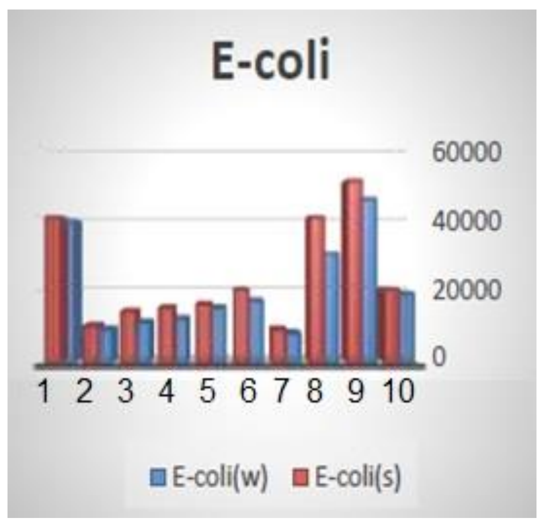


Fig. 14. *Salmonella* and *Shigella* counts(SS) in winter and summer during 2023

Fig. 15. *E. coli* count in winter and summer during 2023

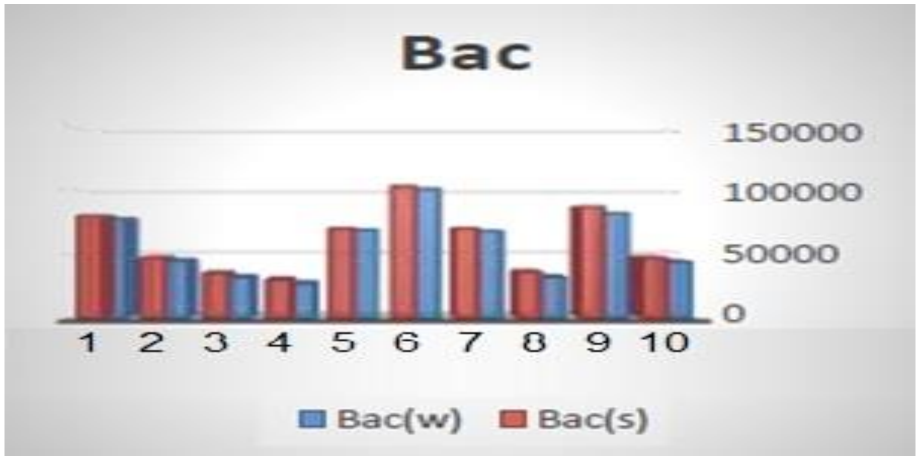


Fig. 16. *Bacilli* count (Bac) in winter and summer during 2023

The number of *E.coli* in summer was between 2000-30000 bacilli and in the winter 8000-39000 bacilli, which was outside the permissible limits (100-1000) bacilli/100ml according to the Iraqi standard specifications for irrigation purposes.

CONCLUSION

This study shows that the concentrations of heavy metals in the water were within the permissible limits for each heavy metals, lead (Pb), nickel (Ni), and chromium (Cr), while for cadmium (Cd), they were above the permissible limits of the WHO. Additionally, the concentration of both chemical and bacterial contamination of the water were beyond the permissible limits and therefore the water was unsuitable for irrigation. Additionally, this study indicates that the concentration of both phosphorus (P) and potassium (K) in the water exceeded the permissible limits due to the presence of these elements in the water. the importance of monitoring the operations of heavy water treatment facilities, performing regular maintenance, and refraining from disposing of waste in rivers, in addition to spearheading campaigns to educate people living in agricultural areas about the necessity of adhering to health regulations when using river water and refraining from discharging pollutants into it.

RECOMMENDATIONS

1- Rehabilitate the destroyed treatment plant as soon as possible in order to reduce the concentration of both BOD and COD and the concentration of heavy metals.

2- Do not grow crops that are eaten raw in areas irrigated with untreated wastewater.

3- Further studies in this area are recommended in addition to widen the study addressing other elements.

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