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Isolation and Identification of Some Algal Species from the Discharges of Samarra Thermal Power Station in Al-Ishaqi District and Their Relation to Selected Physicochemical Variables

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ABSTRACT

This study assessed the impact of effluents from the Samarra Thermal Power Station on the physicochemical properties of the Tigris River in the Al-Ishaqi district, Salah Al-Din Governorate, Iraq. Algae were also investigated as bioindicators to evaluate water quality and ecological changes caused by industrial discharges. Water samples were collected from four sites along the Tigris River within the Al-Ishaqi area during autumn and winter (November 9, 2024–February 20, 2025). On-site measurements of selected parameters were conducted immediately after collection, while other samples were preserved for laboratory analysis. Additional samples were used for the isolation and identification of algal species. pH values were generally within the Iraqi permissible range (6.5–8.5), except for a minimum value of 5.97. Electrical conductivity reached a maximum of 1075µS/ cm in winter, likely due to runoff and sediment erosion. Total dissolved solids ranged from 221 to 956.25mg/ L, showing spatial and temporal variation indicative of external pollution inputs. Dissolved oxygen decreased in certain locations, suggesting organic waste influence. Chloride levels showed no significant differences, while sulfate concentrations peaked at 240ppm in winter. Alkalinity ranged from 87.93 to 212ppm with clear spatial differences. Algal genera identified included *Navicula*, *Zygnema*, and *Cladophora*, with greater diversity observed in autumn, reflecting seasonal nutrient shifts. Effluents from the Samarra Thermal Power Station significantly influenced several physicochemical parameters of the Tigris River, especially during the winter season. Variations in water quality and algal diversity highlight the combined effects of seasonal changes and surrounding pollution sources.

INTRODUCTION

Water is the essence of life on Earth and an indispensable element for all living organisms. It plays a crucial role in the formation of biological cells, constituting 75–95% of the protoplasmic mass of living cells, and is a key component of human tissues as well as plant and animal structures. Digestive, absorptive, and metabolic processes cannot occur without water **(Barisha & Sharif, 2018)**.

Drinking water quality criteria are generally classified into three categories: physical, chemical, and biological. Physical properties include temperature, suspended solids, turbidity, color, taste, and odor; chemical properties involve pH, hardness, and undesirable elements; and biological properties encompass viral, bacterial, and parasitic indicators **(WHO, 2017)**.

Today, environmental pollution—especially water pollution—has become one of the most pressing global issues, requiring urgent attention due to its direct link to human survival, health, development, and economic stability. Despite Iraq's social, industrial, and agricultural development, the country still lags behind developed nations in addressing environmental challenges. The absence of strict environmental regulations and the limited scope of sustainable development initiatives have contributed to accelerating environmental degradation that may reach critical levels **(Al-Saffawi, 2018)**.

In arid and semi-arid regions, including countries such as Iraq, Egypt, and Sudan, water scarcity has emerged as a critical factor in both national and regional security. Climate change, declining rainfall, and upstream water management practices intensify these challenges. Rising demand for water may turn shortages into political and economic tools, increasing the risk of tensions and conflicts. In addition to pollution and inefficient water use, external threats such as dam construction and irrigation projects in upstream nations could have severe long-term consequences for Iraq **(Al-Hamdany *et al.*, 2021)**.

The primary objective of water treatment facilities is to produce clean water suitable for human consumption by removing or inactivating pathogenic microorganisms, eliminating undesirable taste, odor, excessive color, turbidity, dissolved metals, and harmful chemical compounds. Filtration—widely applied in both large-scale purification plants and small domestic units—is one of the most effective processes for improving the physical, chemical, and biological quality of drinking water. It functions as a physical separation process that retains suspended solids on a porous medium, preventing them from passing through **(Zhu, 2022)**.

The present study aimed to evaluate selected physicochemical characteristics of the Tigris River in the Al-Ishaqi subdistrict, Salah Al-Din Governorate, and to assess the potential impact of effluents from the Samarra Thermal Power Station. It also sought to isolate and identify algal species associated with the station's discharges in Al-Ishaqi, and to determine the river water's suitability for drinking, domestic uses, and livestock watering.

MATERIALS AND METHODS

1. Study area description

The study was conducted in the Al-Ishaqi subdistrict of Salah Al-Din Governorate, located south of the city of Samarra, on the eastern bank of the Tigris River, near the Samarra Thermal Power Station (Al-Jalisiyah). Al-Ishaqi lies approximately 20km from the center of Samarra. The area is characterized by flat plains and a semi-arid climate, with land use dominated by agricultural and pastoral activities. Significant industrial facilities are also present, the most notable being the Samarra Thermal Power Station.

The Samarra Thermal Power Station is one of the largest thermal power plants in central Iraq. It uses water from the Tigris River for cooling operations, operating under either a closed or semi-open system. The discharge of heated cooling water and industrial effluents into the river can potentially degrade water quality by increasing salinity, raising water temperature, and introducing chemical pollutants and heavy metals. Fig. (1) shows the location of the Samarra Thermal Power Station.

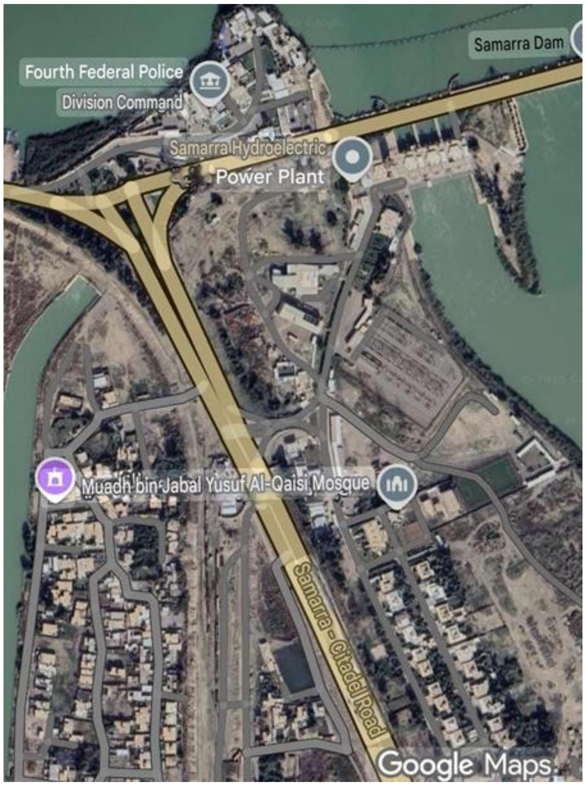

Fig. 1. Illustrative map of the station location

2. Sample collection

The purpose of this study was to evaluate the effects of effluents from the Samarra Thermal Power Plant (Al-Jalsiyah) on the water quality of the Tigris River in the Al-Ishaqi district, Salah Al-Din Governorate. Water samples were collected from four major locations along the river:

- **Upstream:** A reference site not directly influenced by the plant's effluents.
- **Downstream:** It represents potential changes after the river passes near the discharge point.

- **Storage Unit:** The location where water is retained or regulated within the plant.
- **Discharge Unit:** The final point where treated or untreated water is released into the river.

In addition to physicochemical analyses, algal samples were collected from the same four sites to isolate and identify algal species, serving as bioindicators of water quality. Sampling took place during the autumn and winter seasons, from November 9, 2024 to February 20, 2025, with multiple samples collected during each season. An average representative value was calculated for each site and season separately.

Physicochemical parameters analyzed included pH, electrical conductivity, total dissolved solids (TDS), alkalinity, dissolved oxygen (DO), chloride, and sulfates. Data were statistically analyzed using Minitab software. One-way ANOVA was applied to test for significant differences among sites and seasons, and Duncan's multiple range test was used to determine which means differed significantly at $P \leq 0.05$.

RESULTS

1. pH Levels (Hydrogen ion concentration)

The results illustrated in Fig. (2) showed no statistically significant spatial or temporal differences in pH values at the $P < 0.05$ significance level. The lowest pH recorded was 5.97 during winter at the treatment unit, while the highest value, 8.84, was observed during autumn at the same site. These findings are consistent with those of **Hussein and Al-Salman (2014)** and **Jarllah (2016)**. However, the present study reported lower pH values compared to the finding of **Al-Sahan (2019)**, who documented a range of 7.3–8.4. At $P < 0.05$, statistical analysis revealed significant differences between months but no significant variation between sampling sites. These fluctuations are characteristic of the naturally alkaline or slightly alkaline conditions of Iraqi rivers. Furthermore, all recorded pH values—except for the winter low of 5.97—fell within the Iraqi drinking water standards range of 6.5–8.5 established in 2001 **(Hussein & Al-Salman, 2014)**.

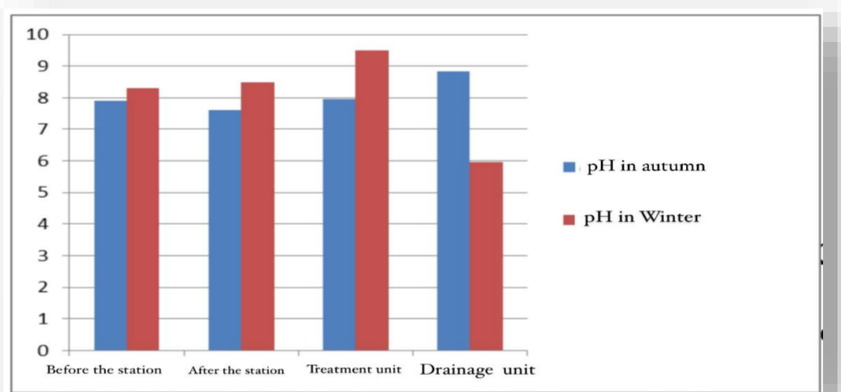

Fig. 2. The pH values at the study sites during the autumn and winter seasons

1. **Electrical conductivity (EC)**

As shown in Fig. (3), electrical conductivity (EC) values varied both temporally and spatially; however, only the temporal differences were statistically significant at the $P < 0.05$ probability level. EC values ranged from 320– 450µS/ cm during autumn, with the lowest value (320µS/ cm) recorded upstream of the station in autumn, and the highest value (1075µS/ cm) also recorded upstream during the winter season.

Electrical conductivity is influenced by seasonal changes, particularly during the rainy season, when floodwaters transport sediment and dissolved materials into the river. Various anthropogenic activities, such as agricultural practices, can also increase EC levels by elevating the concentration of dissolved salts. EC is directly proportional to the concentration of dissolved salts and serves as an indicator of the quantity and type of ions present in the water **(Bhat *et al.*, 2018)**.

In this study, EC values were generally higher during the winter season, likely due to increased soil erosion along riverbanks during rainfall events, which elevated the salt content in the river's main channel.

The EC values obtained in this study are lower than those reported by **Mahmoud (2021)**, who recorded values between 380– 955µS/ cm in a study of aquatic plankton in selected locations along the Tigris River in Nineveh Governorate. They are also lower than most values reported by **Al-Ta'i and Abdulqadir (2024)**, except in the Al-Dibs district of Kirkuk Governorate, where EC ranged from 264– 543µS/ cm. Additionally, our findings are lower than those of **Al-Ani *et al.* (2019)**, who recorded EC values between 580.5 and 1108.75µS/ cm.

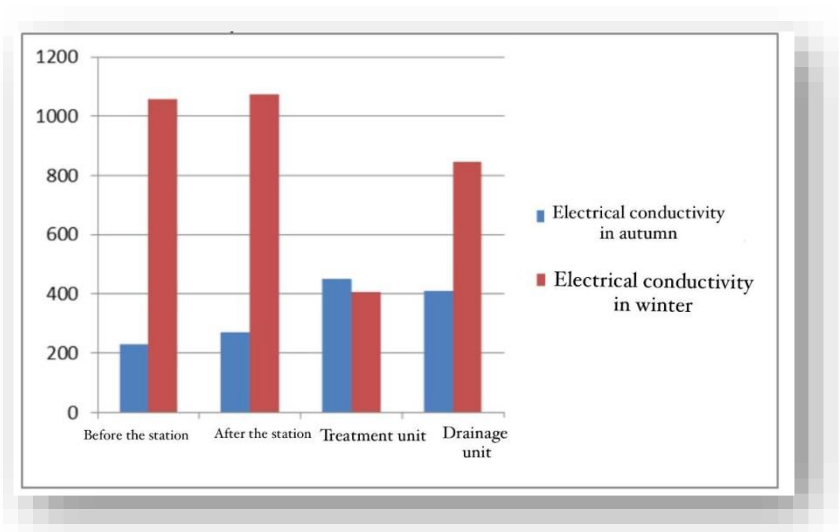

Fig. 3. The variation in electrical conductivity (µS/cm) across the studied sites

2. Total dissolved solids (TDS)

At the *P*< 0.05 significance level, total dissolved solids (TDS) values showed statistically significant temporal and spatial variation (Fig. 4). The highest value, 956.25mg/ L, was recorded at the discharge unit during winter, while the lowest value, 221mg/ L, was observed at the downstream site during autumn.

TDS concentrations are generally positively correlated with electrical conductivity **(Bhat *et al.*, 2018)**. Seasonal rainfall and subsequent runoff can influence TDS levels in both positive and negative ways. River discharge volume and the velocity of alternating currents also play important roles in determining TDS concentrations **(Al-Mashhadani *et al.*, 2018)**. Reduced precipitation can lead to increased TDS levels due to enhanced surface runoff and soil erosion, ultimately adding to the river's solid load **(Woldw *et al.*, 2020)**.

The results of the present study are consistent with those reported by **Ismail (2018)** and **Mansour (2019)**, who documented TDS values ranging from 277– 255mg/ L and 282– 202mg/ L, respectively. In contrast, **Mohammed (2021)** reported higher values of 183– 119mg/ L, while **Al-Dulaimi (2021)** reported even higher ranges of 823– 1600mg/ L and lower ranges of 190– 325mg/ L, depending on the specific sampling sites and conditions.

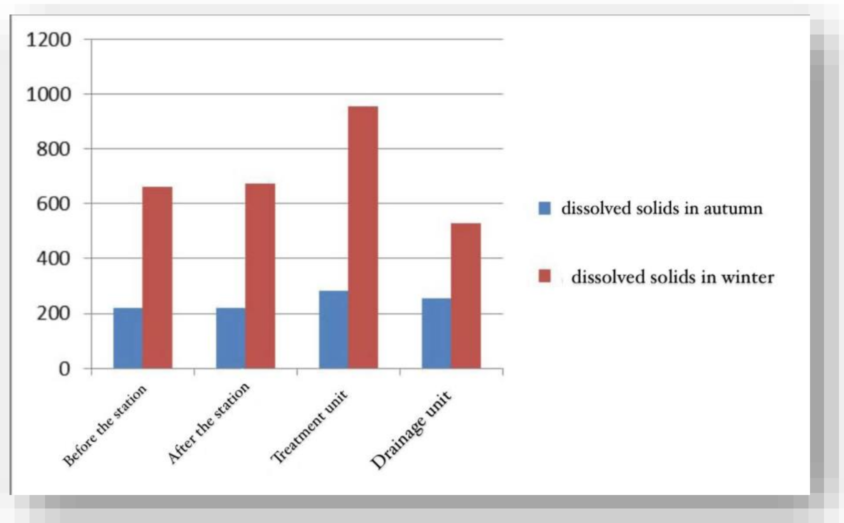

Fig. 4. The results of total dissolved solids (TDS) during the autumn and winter seasons

5. Dissolved oxygen (DO)

According to the results shown in Fig. (5), dissolved oxygen (DO) levels exhibited spatial variation. The lowest value, 3.83mg/ L, was recorded at the upstream site during autumn, while the highest value, 6.68mg/ L, was observed in the downstream location during winter.

Several factors influence DO concentrations in drinking water sources, including the origin of the water and surrounding environmental conditions. As a general reference, DO concentrations in unpolluted freshwater systems typically range from 7 to 9mg/ L (about 70–90% oxygen saturation), with an average of approximately 88.8% saturation under normal conditions. Cold water bodies, such as rivers and lakes during winter, tend to have higher DO concentrations due to increased oxygen solubility at lower temperatures. In contrast, DO levels may drop below natural thresholds in water bodies contaminated by organic matter or impacted by industrial effluents **(Awad *et al.*, 2020)**.

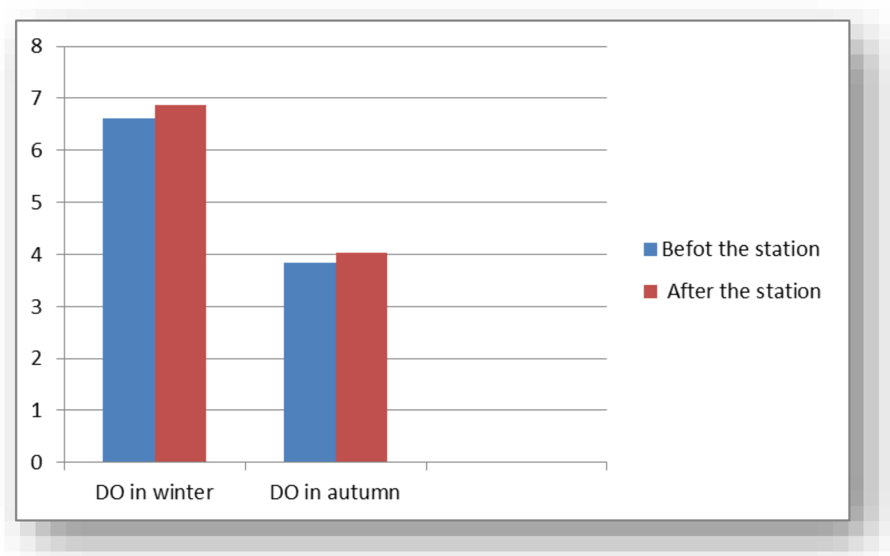

Fig. 5. The dissolved oxygen (DO) levels during the autumn and winter seasons at the two study sites

6. Chloride Ion (Cl^-)

According to the findings presented in Fig. (6), there were no statistically significant variations in chloride ion concentrations across sites or between seasons. The highest concentration, 27.55 ppm, was recorded at the discharge unit during autumn, while the lowest concentration, 20 ppm, was observed at the downstream site during winter.

The elevated chloride concentrations in some samples may be attributed to the natural presence of this ion in nearby soils and rock formations. Dissolution processes resulting from contact between water and certain geological materials can increase chloride levels. Additionally, wastewater and sewage effluents—often rich in chloride—can contribute to higher concentrations **(Grode & Jadhav, 2013)**.

These results are consistent with previous findings by **Abawi and Elia (2012)** and **Al-Hadidi (2018)**, as well as **Hussein (2018)**, who reported chloride concentrations ranging from 15– 30, 13.8–33, and 20.6– 37mg/ L, respectively. However, the values obtained in the present study are lower than those reported by **Al-Sultan (2019)**, who found levels between 17.7– 58.5mg/ L; **Al-Douri (2020)**, who recorded concentrations of 17.75–170mg/ L; and **Ibrahim (2020)**, with 30– 60mg/ L.

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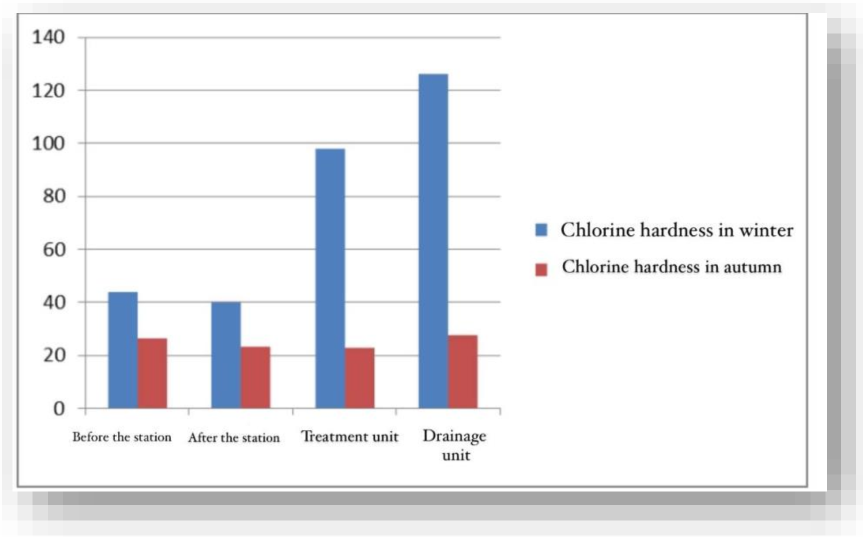

Fig. 6. Chloride hardness values at the study sites

7. Sulfates (SO_4^{2-})

The results presented in Fig. (8) indicate that sulfate concentrations exhibited temporal variation. The lowest value recorded was 102.45ppm during the winter season at the upstream site, while the highest concentration was 240ppm during the autumn season at the discharge unit.

The natural source of sulfates in water is primarily atmospheric deposition from rainwater **(Ghazali & Zaid, 2013)**. In groundwater or surface water, sulfates may also originate from the dissolution of gypsum layers as water percolates through sulfate-bearing rock formations, or from the oxidation of sulfide minerals such as iron sulfide **(Al-Kindi, 2009)**. According to the **World Health Organization (WHO)**, the acceptable sulfate concentration in drinking water ranges from 200 to 400mg/ L **(Al-Hayek, 1989)**.

In the present study area, the primary source of sulfates appears to be the dissolution of gypsum-rich soil components **(Mahmoud, 2008)**, likely resulting from ion exchange processes between sulfate ions in the soil and water molecules **(Al-Kindi, 2009)**.

Additionally, rainwater leaching of the soil contributes to the elevated sulfate levels **(Mahmoud, 2009)**.

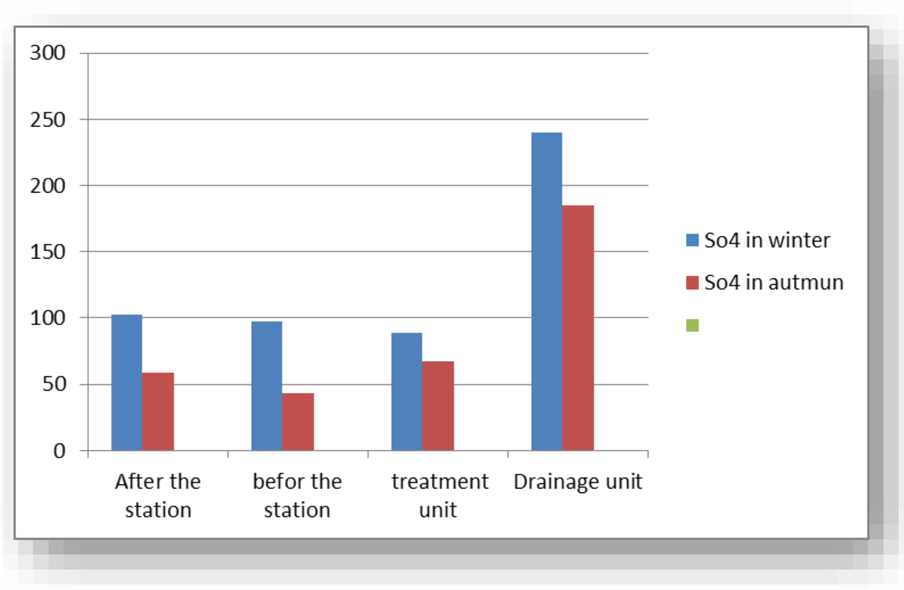

Fig. 7. Sulfate concentration results at the study sites

8. Alkalinity

The results illustrated in Fig. (8) indicate that total alkalinity exhibited clear spatial variation. The lowest recorded value was 87.93ppm during the autumn season at the upstream site, whereas the highest value reached 212ppm during the winter season at the discharge unit.

The alkalinity range observed in this study is broader than that reported by **Furtam (2018)**, who recorded values between 146 and 230mg/ L for the Tigris River in Mosul, Salah Al-Din Province. These findings are consistent with those of **Al-Sultan (2019)**, who reported a range of 145– 240mg/ L for the same river and location.

In contrast, the present results are higher than those reported by **Al-Bajari (2023)**, who measured alkalinity levels between 60 and 120mg/ L for the Tigris River in Salah Al-Din Province within designated economic utilization zones. Similarly, they exceed the values reported by **Nu’man (2019)**, who documented a range of 140– 168mg/ L when examining selected chemical and physicochemical parameters of the Tigris River in the same region. The results also surpass those of **Al-Laheebi (2021)**, whose comprehensive evaluation of the chemical, physicochemical, and bacteriological quality of drinking water in Salah Al-Din Province revealed values between 125 and 200mg/ L.

Alkaline compounds play a critical role in regulating water pH, and their excessive presence may result in the formation of salts such as carbonates, bicarbonates, hydroxides, and chlorides. The elevated values recorded in this study are likely due to the calcareous nature and geological composition of the region **(Roder *et al.*, 2009)**.

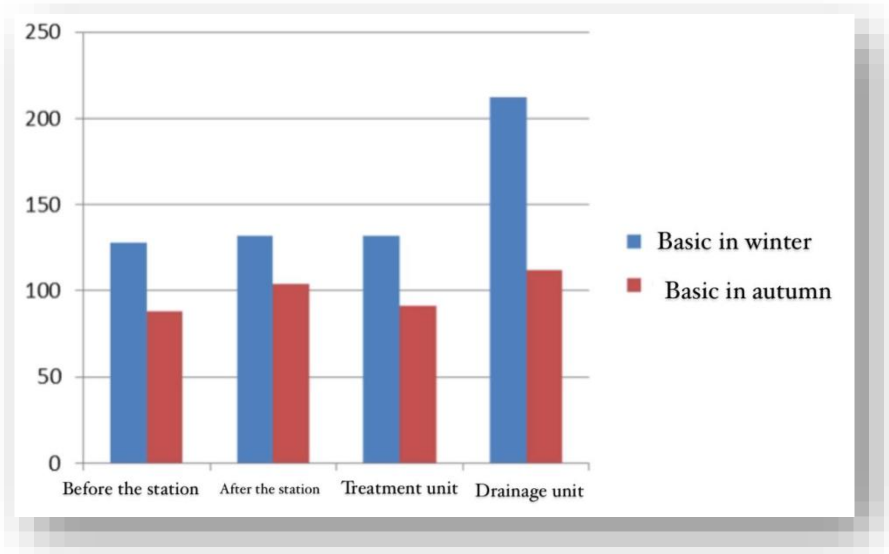

Fig. 8. Alkalinity levels at the study sites during autumn and winter

Identified algal species from the studied stations

Several types of algae were found in the water sources at the study sites. Algae occur in all bodies of water that receive sunlight and often thrive both on the surface and at certain depths. They can also be present in soil or on surfaces exposed to air, though typically in smaller amounts. Nevertheless, ponds, lakes, reservoirs, rivers, and oceans are the primary habitats for the majority of aquatic algae **(Omar, 2010)**.

Algae are well known for their ability to generate substantial amounts of organic matter in aquatic environments. For example, Lake Winnebago in Wisconsin, USA, contributes more than 130 tonnes of algae per day to the Fox River, while one Ohio River has recorded suspended microalgae concentrations as high as 8,000ppm. Similarly, algae concentrations in Lake Michigan, near Chicago, have exceeded 4,000 cells/mL **(Necchi, 2016)**.

In contrast, recent Iraqi studies have predominantly focused on the qualitative aspects of algal communities in local freshwater systems, emphasizing biodiversity and ecological health rather than quantitative biomass estimates. For instance, research on the Shatt al-Arab River documented nine newly recorded algal species spanning multiple phyla—Chlorophyta, Cyanophyta, Dinophyta, and Euglenophyta—thereby expanding the known regional biodiversity **(ResearchGate, 2022)**. A comprehensive review of Iraqi inland waters revealed more than 2,700 identified algal species, highlighting the rich taxonomic diversity across various aquatic habitats **(ResearchGate, 2021)**. Furthermore, studies such as those conducted on the Khreisan River in Diyala utilized algal community composition as bioindicators, applying Palmer and Nygaard indices to assess organic pollution levels and overall water quality **(JournalCRA, 2023)**.

One of the major operational issues in water treatment plants is excessive algal growth. Certain algae, such as diatoms (*Melosira*, *Synedra*, *Tabellaria*), can significantly reduce filter lifespan by clogging filtration systems, even in small quantities. Brown flagellates like *Synura* can impart unpleasant tastes and odors **(Keeling, 2004)**. However, in small amounts, many algal species are beneficial in raw water, contributing to ecological balance.

Algae can also form thin, slimy gelatinous layers on gravel used in filtration systems. While these layers can gradually reduce water flow, they also enrich the water with dissolved oxygen, enhancing aerobic bacterial decomposition of organic matter. This is preferable to anaerobic activity, which often impairs water taste and quality. For this reason, identifying phytoplankton in aquatic environments is essential, as their presence serves as a key indicator of pollution levels.

For example, a study by **Al-Safi and Al-Moussawi (2012)** at one treatment plant found high algal diversity, with the output water's diversity index peaking at 2.9 in autumn. Moderate temperatures likely promoted algal growth and proliferation. In clean water bodies, algal diversity tends to be high and not restricted to one or two dominant species **(Macleod, 2009)**. In contrast, no diversity was recorded at the same site during summer, most likely due to chlorination, the use of other disinfection chemicals, and elevated temperatures that suppress algal growth.

As noted by **Antonio (2009)**, excessive algal growth can lead to toxin production, although these compounds are typically broken down during the chlorination process in water treatment.

Table 1. The types of algae isolated from the sites under study

Location	Autumn Season	Winter Season
Upstream of the station	- *Navicula* sp. - *Netrium* sp. - *Zygnema* sp. - *Geleocapsa* sp. - *Nitzschia* sp. - *Navicula standeriella* - *Cladophora crispata* - *Bacillaria paxillifer* - *Cladophora glomerata*	- *Geleocapsa* sp. - *Navicula* sp. - *Zygnema* sp. - *Nitzschia* sp. - *Navicula standeriella* - *Cladophora glomerata* - *Netrium* sp. - *Chroococcus turgidus*

	- *Netrium* sp. - *Chroococcus turgidus*	
Downstream of the station	- *Netrium* sp. - *Netrium diatome* - *Synedra* sp. - *Clorella* sp. - *Navicula standeriella* - *Surirella robusta* - *Zygnema* sp. - *Cladophora* sp. - *Geleocapsa* Sp.	- *Synedra* sp. - *Clorella* sp. - *Netrium* sp. - *Zygnema* sp. - *Cladophora* sp. - *Navicula standeriella*

DISCUSSION

The study results revealed clear seasonal variation in the physicochemical properties of the Tigris River, reflecting the combined influence of climatic factors and the environmental impact of discharges from the Samarra Thermal Power Station.

pH values ranged from 5.97 to 8.84 and generally remained within the acceptable limits for drinking water according to Iraqi standards, with no significant spatial or temporal differences observed. Electrical conductivity (EC) showed statistically significant temporal differences, with the highest value (1075µS/ cm) recorded during winter, indicating increased accumulation of dissolved salts due to surface runoff and erosion from seasonal rainfall. Total dissolved solids (TDS) varied significantly by site and season, with a maximum of 956.25mg/ L at the discharge unit during winter, suggesting the influence of power plant effluents and other anthropogenic activities in the area.

Dissolved oxygen (DO) levels decreased at certain sites, particularly downstream of the station, indicating the impact of organic and industrial pollutants. The reduction in DO is primarily due to the increased biological oxygen demand (BOD) associated with the decomposition of organic matter introduced by these pollutants. When effluents containing organic substances enter the river, bacteria and other microorganisms use oxygen to break down this material, intensifying oxygen consumption and lowering DO concentrations **(Wetzel, 2001)**. Elevated water temperatures from thermal discharges may further exacerbate this decline by reducing oxygen solubility. These combined effects negatively impact aquatic ecosystem health and limit the river’s capacity to support sensitive aquatic species.

Chloride ion concentrations showed no significant differences and remained within natural limits. In contrast, sulfate concentrations exhibited notable temporal variation, with the highest value (240mg/ L) recorded during winter. This increase is attributed to the dissolution of gypsum-rich soil components and leaching processes triggered by seasonal rainfall. Alkalinity displayed clear spatial variation, reaching 212mg/ L during winter at the discharge unit, reflecting the calcareous geological characteristics of the region.

Biologically, several algal species were isolated, including *Navicula*, *Zygnema*, and *Cladophora*. Algal diversity was higher in autumn, reflecting the influence of environmental conditions and nutrient availability on phytoplankton communities. This underscores the role of algae as effective biological indicators of water quality and pollution.

Overall, the findings demonstrate that discharges from the Samarra Thermal Power Station directly affect multiple water quality parameters in the Tigris River. The results highlight the need for continuous environmental monitoring and the implementation of improved wastewater treatment measures before effluent discharge.

CONCLUSION

The Tigris River water in the study area exhibited clear variations in its physical and chemical properties between the autumn and winter seasons, reflecting the influence of climatic and seasonal factors. A tangible environmental impact of the Samarra Thermal Power Plant's effluents was detected, particularly affecting the levels of total dissolved solids (TDS) and electrical conductivity. The pH and chloride concentrations remained within acceptable limits for drinking water, whereas other parameters—such as sulfate and alkalinity—showed elevated values in certain locations .The diversity of algae indicates spatial variation in water quality and serves as a valuable biological indicator for environmental assessment .Continuous monitoring of the power plant's discharges and improvements in treatment processes are necessary to mitigate its impact on the riverine ecosystem

Author Contribution:

Design and development: Riyam Kareem Nassef Al-Majmaei, Raghad Mukdad Mahmood.
Data collection and organization: Riyam Kareem Nassef Al-Majmaei
Statistical analysis and comprehension: Raghad Mukdad Mahmood.
Composition of the article: Raghad Mukdad Mahmood.
Reviewing the essay critically for key conceptual points: Riyam Kareem Nassef Al-Majmaei
Proficiency in statistical analysis: Raghad Mukdad Mahmood.
Ultimate endorsement and guarantee of the article: Riyam Kareem Nassef Al-Majmaei

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Conflicts of interest
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