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# USING ALGAE AS A BIOLOGICAL INDICATOR OF WATER POLLUTION IN SALAH AL-DIN CITY

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## Abstract

Water quality is a key indicator of the health of aquatic ecosystems. This study aimed to assess the water quality of the Tigris River in Salah al-Din Governorate based on physical, chemical, and biological characteristics, using algae as bioindicators of organic pollution.

The results showed that water temperature ranged from 7.5–22.5 °C, influenced by climate and other environmental factors such as wind, solar radiation intensity, and current speed. The pH reached alkaline values due to the soil's richness in calcium carbonate, while the specific electrical conductivity ranged from 338.1–472.5 $\mu s.cm^{-1}$, influenced by the geological structure of the area and human activities. Alkalinity values ranged from 127–190 mg $CaCO_3$/L, and the water was classified as hard due to high concentrations of calcium and magnesium.

Varying concentrations of nitrate were recorded, with the highest average at site (4) and the lowest at site (1). This is associated with domestic sewage discharge and agricultural runoff. Phosphate was primarily sourced from municipal wastewater, fertilizers, and agricultural waste, with the highest value recorded at site (2).

Biologically, the contaminated sites were characterized by an abundance of pollution-tolerant algal genera such as Oscillatoria, Euglena, Chlorella, and Ankistrodesmus, which are clear indicators of eutrophication. The Palmer Organic Pollution Index confirmed that the species Euglena viridis, Euglena gracilis, Oscillatoria limosa, Oscillatoria chlorina, and Oscillatoria tenuis are reliable indicators of deteriorating water quality. The study concluded that human activities and the discharge of domestic and agricultural waste are the main causes of pollution in the Tigris River, and that combining physical and chemical measurements with the use of algae as bioindicators provides an effective tool for diagnosing pollution levels and assessing the health of aquatic systems.

**Keywords:** Bioindicators, Euglena gracilis, Oscillatoria, Tigris.

## Introduction

Water is necessary for every biological process. Freshwater organisms are impacted by both abiotic and biogenic causes. Both short-term and long-term water assessments benefit from monitoring an aquatic ecosystem [1]. Climate and geography have an impact on water quality [2]. Micronutrients and water fertilisers have an impact on industrial, agricultural, and bio-geochemical processes [3]. The primary producers and the first rung of the aquatic food chain are algae. Therefore, studies of algal flora, both quantitative and qualitative, are essential. Algal dispersion patterns, both quantitative and qualitative, differ significantly between sites [4].

Communities of organisms known as biomonitors are examined for their normal responses in order to evaluate a situation and determine the state of an ecosystem [5]. Biota measurements that offer long-term biologically significant information on the condition or trends of an ecosystem are known as bioindicators. They differ from natural variability and human impact when supported by ecological theory and predictive models. All holophytic organisms and their numerous colourless derivatives without archegoniate plant differentiation genomes are classified as algae [6]. These straightforward, non-vascular, photosynthetic plants have basic reproductive systems and chlorophyll. Algae are massive, non-flowering plants that lack branches, roots, leaves, and vascular structures but have chlorophyll. Algae can be found in lakes, streams, ponds, rivers, and seas [7]. Fragillaria, Spirogyra, Peridinum, and Nodularia diatoms are examples of biomonitoring algae. Aquatic algae are essential to the ecology since they are important basic producers in both inland and coastal water. Algae are a sign of quality in most waterways [8]. The production and utilisation of photosynthetic energy, cytochroma decrease, cellular mutation, putrescence, and death are among the biological processes and metabolism that can be directly disrupted by algae subjected to different contaminants and gravity. Health issues may arise from bioaccumulation in addition to primary producers [9]. Algal biomonitors monitoring changes in the environment over time and space exhibit a variety of characteristics. Short life cycles, rapid reproduction, ease of sampling, economic effectiveness, and user influence on other species are all characteristics of algae, particularly functional and structural varieties. Diatoms, dinoflagellates, cyanophytes, chlorophytes, and periphyton are examples of pollution biomonitoring algae [10].

Algae are a good indicator of water quality because they are among the fastest-acting organisms in the aquatic environment, have a short lifespan, react quickly to pollutants, and are simple to collect and identify [11]. Algae prevent tissue bioaccumulation and ecosystem pollutants. Environmental pollutants can be concentrated by the algae cells and stored inside their bodies [12]. Since algae are the food chain's initial meal, inorganic pollutants in cells have an impact on nutritional levels [13]. Algae are therefore great markers of organic pollution.

## Materials and Methods

### Studied area

Salah al-Din is situated in central Iraq. It is divided into nine districts: al-Dour, al-Shirqat, Balad, Baiji, Fares, Samarra, Thethar, Tuz (disputed territory), and Tikrit.

### Sampling Stations

For present study, Tigris River water were collected from five sampling stations, which have been selected within Tigris River passing through the section of Tikrit city.

## Collection and analysis of Algal samples

Samples of water and algae were taken every month between November 2024 and April 2025. For every site, some physical measurements were measured in the field, while other chemical parameters were examined in a laboratory. In the field, a pH/Cond. metre (JENWAY 430) was used to monitor the temperature, pH, and conductivity of the water. The lab performed both biological and chemical analyses, with the majority of the chemical analyses being conducted in accordance with A.P.H.A. [14]. A phytoplanktonic nett with pore sizes of 30 cm was used to gather the phytoplankton. 40% formaldehyde was used to preserve the collected algae samples. Most of the time, algae were identified and classified at the species level, relying on the following sources [15–18].

**Table 1: Palmer's Algal Genus Pollution Index [32]**

| Genus | Palmer pollution index | Genus | Pollution index |
|---|---|---|---|
| *Closterium* | 1 | *Pandorina* | 1 |
| *Anacystis* | 1 | *Micractinium* | 1 |
| *Chlamydomonas* | 4 | *Nitzschia* | 3 |
| *Cyclotella* | 1 | *Phacus* | 2 |
| *Lepocinclis* | 1 | *Stigeoclonium* | 2 |
| *Euglena.* | 5 | *Phormidiume* | 1 |
| *Gomphonemae* | 1 | *Scenedesmuse* | 4 |
| *Ankistrodesmus* | 2 | *Navicula* | 3 |
| *Chlorella* | 3 | *Oscillatoria* | 5 |
| *Melosira* | 1 | *Synedra (=Ulnaria)* | 2 |

*0–10 indicates no organic contamination, 11–15 indicates moderates' pollution, 16–20 indicates likely high organics pollution, and 21 or more indicates confirmed high organicpollution.

**Table (2): Algal species pollution index of Palmer [32**

| species | Palmer pollution index | species | Pollution index |
|---|---|---|---|
| *Arthrospirae jennerii* | 2 | *Oscilatoria chlorine* | 2 |
| *Chlorela vulgaris* | 2 | *Oscilatoria limosa* | 4 |
| *Navicula cryptocephala* (=*N. veneta*) | 1 | *Stigeoclonium tenue* | 3 |
| *Cyclotella meneghiniana* | 2 | *Oscilatoria princeps* | 1 |
| *Euglena gracilis* | 2 | *Oscilatoria pulrida* | 1 |
| *Gomphonemaa parvulum* | 1 | *Pandorina morum* | 3 |
| *Melosira varians* | 2 | *Scenedesmuss quadricaudae* | 4 |
| *Ankistrodesmus falcatus* | 3 | *Nitzschia palea* | 5 |
| *Euglena viridis* | 6 | *Oscillatoria tenuis* | 4 |
| *Nitzschia acicularise* | 1 | *Synedra ulna* (=*Ulnaria danica*) | 3 |

*0–10 indicates no organic contamination, 11–15 indicates moderate pollution, 16–20 indicates likely high organic pollution, and 21 or more indicates confirmed high organic pollution.

## Statistical analysis

Microsoft SPSS Version 22 was utilised for the statistical analysis, which employed a complete randomised design (C.R.D.). The Duncan test multiple ranges at level 0.05 was used to compare the mean.

## Results and discussion

Physical and chemical parameters recorded during the investigation (Table 3) show that the water temperature ranged from 7.5 to 22.5 °C. Iraq's Irano-Turanian climate means air temperature always affects water temperature [19]. Water temperature varies with local climate. Wind, sunlight direction, height, water current velocity, and annual atmospheric temperature variation affect this [20]. Water pH affects its biological and chemical qualities. The chemical states of many water chemicals change. pH affects metal dissolution and precipitation, as well as the toxicity, ionisation, and volatility of several dissolved substances to aquatic life [21]. Because the minerals, soil, and geological formation of the analysed area are primarily $CaCO_3$, hydrogen ion concentrations during the sampling time were inclined towards alkalinity [22]. The Tigris River flooding brought allochthonous minerals to the lake, lowering its pH. The lake's humic and acidic components may have caused this [23]. Specific electrical conductivity measures an aqueous solution's ability to convey electrical current based on ion concentration and mobility [14]. Geology has the greatest impact on river and stream conductivity [24]. The specific electrical conductivity did not drop below 338.1 (µs. cm-1) or climb over 472.5 (µs. cm-1). Changing climate, geological formation, lithology, and calcium and magnesium concentrations likely caused this variation over the analysed period. In Dokan Lake, Toma [25] observed similarly. Site 1 showed that human activities enhanced water conductivity. Alkalinity was 127–190 mg $CaCO_3$/L. This showed similar patterns in alkalinity, total hardness, and specific electrical conductivity, as Hassan et al. [26] found. Site 2 had the highest mean total hardness and site 3 the lowest, which was similar to the other locations. Hard water is caused by dissolved calcium and magnesium. It is usually stated as calcium carbonate equivalent [27]. Temporal oscillations throughout research determine hardness. The lake under studied contained hard water, according to Spellman [28].

The most prevalent form of inorganic nitrogen in water is nitrate [28]. Because it is the byproduct of the aerobic breakdown of organic nitrogenous materials, nitrate—the most widely oxidised form of nitrogen compounds—is commonly found in surface and ground waters [29]. Nitrate ions dissolve very well in water. Because of this, too much nitrate can readily seep into soils and aquifers [30]. Drainage from cattle feedlots and animal dung storage facilities, runoff from farmed, cultivated, and fertilised land, and wastewater from residential, sewage, and some industrial waters are some of the sources of nitrates [28]. Site 1 had the lowest mean nitrate value, while Site 4 had the highest mean nitrate value. These two sites were not substantially different from the other sites under study. With the greatest mean value recorded in October, the study's results revealed a clear regional variability that might be connected to sewage and municipal wastewater flows into the river. My findings supported Adedokun et al.'s [31] assertion that there is substantial nitrate contamination of surface water in areas with high population pressure and agricultural expansion. Walker et al. [30] demonstrated that while surface water typically has a low nitrate level, pollution from animal and human waste as well as agricultural runoff can cause it to rise. During this study, temporal variability was also observed; the highest mean value was found in October, possibly due to allochthonous nitrate compounds from land runoff and agriculture or a high concentration of dissolved oxygen.

Phosphorus is found as phosphate and is a limiting nutrient in aquatic habitats. Detergents, fertiliser and feedlot runoff, and municipal wastewater discharges are the main sources of phosphates [28]. Orthophosphate quickly binds to clay and produces extremely insoluble compounds when it combines with a variety of cations (A1, Fe, and Ca). Compared to nitrogen, it is far less mobile in the sediments and precipitates more readily. Site 2 was where the lowest and maximum phosphate values were noted.

**Table (3): : Maximum and Minimum value, Mean of physical and chemical parameters between studied sites for Tigris River.**

| **Parameters** | **Site1** | **Site2** | **Site3** | **Site4** | **Site5** |
|---|---|---|---|---|---|
| **Water temperature °C** | (7.2-22.5)<br>14.40 a | (7.2-21.6)<br>15.00 a | (8.0-21.6)<br>16.45 a | (7.9-21.5)<br>16.00 a | (8.5-22.1)<br>15.45 a |
| **pH** | (7.5-8.5)<br>8.00 a | (7.50-8.61)<br>8.2 ab | (7.6-8.6)<br>8.21 a-c | (7.23-8.57)<br>7.78 c | (7.03-8.04)<br>7.34 bc |
| **Alkalinity (mg/L CaCO3)** | (127-181)<br>175.50 a | (129-185)<br>178.33 a | (130-189)<br>178.39 a | (135-185)<br>161.9 a | (135-190)<br>175.00 a |
| **Specific E.C (µs. cm1)** | (338.1-462.6)<br>425.5 a | (340.8-459.7)<br>428.31 a | (334.5-476.5) 461.4 a | (372.5-471.5)<br>424.60 a | (365.2-469.7)<br>471.5 a |
| **Total Hardness (mg/L CaCO3)** | (200-250)<br>221.00 a | (201-251)<br>223.25 a | (190-244)<br>224.27 a | (191-248)<br>229.30 a | (197-248)<br>229.72 a |
| **Nitrate (mg/L)** | (2.6-5.7)<br>4.08 a | (2.8-5.8)<br>4.18 a | (2.8-5.6)<br>4.25 a | (2.9-5.9)<br>4.15a | (2.7-5.74)<br>4.11 a |
| **Phosphate (mg/L)** | (0.03-0.35)<br>0.26 ab | (0.01-0.73)<br>0.17 ab | (0.04-0.53)<br>0.23 a | (0.05-0.41)<br>0.17 a | (0.07-0.71)<br>0.25 a |

The first attempt to identify and compile a list of algae taxa and species that are tolerant of organic contamination was conducted by Palmer [32]. He compiles a list of 80 species and 60 genera that can withstand organic contamination. Palmer states that high levels of organic pollution are indicated by scores of 20 or higher. Five Tigris River stations were used to record the pollution-tolerant genera and species of four categories of algae.

Tables 4 and 5 contain records for all 15 genera and 15 species. As indicators of organic pollution, Oscillatoria, Melosira, Navicula, Nitzschia, Gomphonema, and Euglena were the most prevalent among the algae from station 4, which was found to have the highest level of organic pollution. Ahmed came into similar observations [33]. According to Sladecek [34], oscillatoria were a sign of eutrophic water. According to Table 4, the current investigation revealed that 15 pollution-tolerant algae genera, which were part of the Chlorophyceae family and belonged to the groups Cyanophyceae, Bacillariophyceae, and Euglenophyceae, were discovered at every sampling station. Stations 1, 2, 3, 4, and 5 had corresponding total scores of 18, 18, 16, 23, and 15 on the Algal Genus Pollution Index (Table 4). However, stations 1 through 5 have corresponding total scores of 11, 11, 17, 18, and 7 on the algal species pollution index (Table 5).

As a result, station 4's higher Palmer index score was shown to indicate high levels of organic pollution. Palmer [32] has determined that Oscillatoria, Euglena, Scenedesmus, Navicula, Nitzschia, and Ankistrodesmus are taxa present in organically polluted waters, corroborated by Al-Nashy [35]. The present analysis identifies analogous genera. According to Khan and Tisha [36], Oscillatoria, Euglena, Chlorella, and Ankistrodesmus are prevalent in environments characterised by significant water pollution. The present investigation documented comparable genera with elevated grade points on Palmer's scale, including Euglena viridis, Euglena gracilis, Oscillatoria limosa, Oscillatoria chlorina, and Oscillatoria tenuis.

Celekli et al. [37] concluded that these genera are highly pollution tolerant and thus reliable indicators of eutrophication. Pearsall [38] was the first to demonstrate a direct link between centric diatoms and bluegreen algae and organic contamination. Because the planktonic forms—Pandorina, Scenedesmu, Navicula, and Melosira—that are indications of the species that can withstand organic contamination are seen in this study. Bacillariophyceae such as Navicula, Nitzschia, Gomphonema, and Synedra were found to be prominent at the downstream station in the current study. In his detailed description of the main diatom species used as markers of water quality, Al-Ankush [39] has made comparable observations. So, the algae from the polluted water at station 2 were dominated by four species throughout the year: Ankistrodesmus falcatus, Euglena viridis, Oscillatoria tennis, and Synedra ulna. These species are regarded to be indicators of organic pollution.

**Table (4): Pollution index of algae genus according to Palmer [32] at five stations of Tigirs**

| *NO.* | *Genus* | *Palmer pollution index* | *Site* | | | | |
|---|---|---|---|---|---|---|---|
| | | | *1* | *2* | *3* | *4* | *5* |
| *1* | *Anacystise* | *1* | | | | | |
| *2* | *Ankistrodesmus* | *2* | | *2* | | *2* | |
| *3* | *Chlamydomonas* | *4* | *4* | | | *4* | |
| *4* | *Chlorella* | *3* | *3* | | | *3* | |
| *5* | *Closteriume* | *1* | | *1* | | | |
| *6* | *Euglena* | *5* | *5* | *5* | *5* | *5* | *5* |
| *7* | *Gomphonemae* | *1* | 1 | 1 | 1 | 1 | 1 |
| *8* | *Lepocinclis* | *1* | | | | | |
| *9* | *Melosira* | *1* | | 1 | 1 | | 1 |
| *10* | *Navicula* | *3* | | *3* | | | *3* |
| *11* | *Nitzschia* | *3* | | | *3* | *3* | |
| *12* | *Oscillator* | *5* | *5* | *5* | *5* | *5* | *5* |
| *13* | *Pandorin* | *1* | | | *1* | | |
| *14* | *Phormidium* | *1* | | | | | |
| *15* | *Synedra* | *2* | | | | | |
| *Total score* | | | *18* | *18* | *16* | *23* | *15* |

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**Table (5): Pollution index of algae species according to Palmer [32] at five stations of Tigris river**

| *No.* | *Species* | *Palmer pollution index* | *site* | | | | |
|---|---|---|---|---|---|---|---|
| | | | *1* | *2* | *3* | *4* | *5* |
| *1* | *A. falcatus* | *3* | | *3* | | *3* | |
| *2* | *Ch. vulgaris* | *2* | *2* | | | *2* | |
| *3* | *E. gracilis* | *1* | | *1* | | | *1* |
| *4* | *E. viridis* | *6* | *6* | | *6* | *6* | |
| *5* | *G. parvulum* | *1* | *1* | *1* | *1* | *1* | *1* |
| *6* | *Melosiravarians* | *2* | | *1* | *1* | | *1* |
| *7* | *N. cryptocephala (=N. veneta)* | *1* | | *1* | | | *1* |
| *8* | *N. acicularis* | *1* | | | *1* | *1* | |
| *9* | *O. chlorina* | *2* | | *2* | | | *2* |
| *10* | *O. limosa* | *4* | | *1* | | | |
| *11* | *O. princeps* | *1* | *1* | *1* | *1* | *1* | *1* |
| *12* | *O. pulrida* | *1* | *1* | | | | |
| *13* | *O. tennis* | *4* | | | *4* | *4* | |
| *14* | *P. morum* | *3* | | | *3* | | |
| *15* | *S. ulna* | *3* | | | | | |
| | *Total score* | | *11* | *11* | *17* | *18* | *7* |

## Conclusions

The current study demonstrated that the water quality of the Tigris River in Salah al-Din was impacted by home usage downstream. Oscillatoria, Euglena, Chlorella, and Ankistrodesmus are characteristic of heavily polluted aquatic environments, indicating that Euglena and Oscillatoria are highly pollution-tolerant genera. Consequently, they serve as reliable indicators of eutrophication in the present study, akin to these genera with elevated scores on Palmer's scale, including Euglena viridis, Euglena gracilis, Oscillatoria limosa, Oscillatoria chlorina, and Oscillatoria tenuis.

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