The potential use of the diatom *Nitzschia palea* (Kützing) W. Smith For the Removal of Certain Pollutants from Al-Rustumeyah Wastewater Treatment Plant in Baghdad-Iraq

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Abstract. The ability of *Nitzschia palea* (Kützing) W. Smith to reduce the concentration of nitrogen (ammonia, nitrate), phosphorus (orthophosphate) and chemical oxygen demand (COD) in wastewater were examined. The wastewater was collected from the final sediment tank in the Rustumeyah wastewater treatment plant located south of Baghdad-Iraq. The diatom was cultured in wastewater after filtration. The culture was kept at 25 ± 2°C under the light intensity of 260 μE/m²/s. The tests were carried out in two cases (sterilized and non-sterilized) wastewater for ten days. For sterilized wastewater, the experimental results showed that the removal of ammonia and phosphor after 4-5 days of treatment was found to be 100%. At the same time, the removal of COD was found to be 85% 85%. For non-sterilized wastewater, higher efficiency of diatom was recorded. The study has covered the determination of algae in both treatments during the experiment period. In conclusion, the diatom *Nitzschia palea* has a good ability to treat ammonia, nitrate, phosphorus and (COD) in wastewater, and a higher efficiency was found in the non-sterilized sample. This study contributes to enhancing diatom’s growth and then its cost. Thus it can be used in the blue biotechnology context.

Keywords: Wastewater treatment, *Nitzschia palea*, Removal pollutants

1. Introduction

Rapid industrialization, population growth, and complete ignoring of environmental health have led to risks to availability and water resources quality, leading to Water pollution, forming a critical growing problem in many areas worldwide [1][2]. The most important natural resources on our planet are water. With an insufficient supply of clean water in many industrialized countries, water quality has reached an alarming state [3].

Water pollution with a large number of organic, inorganic pollutants, heavy metals, high concentration of nutrients, microplastics, xenobiotics, and carbon (C) compounds resulting from human activities such as municipal, agricultural, and industrial wastewater forms that pressure on the food chain of aquatic environments [4]. Simultaneously, with microalgae cultivation using wastes and wastewaters for biomass production, these pollutants could be removed from the aquatic environment [5]. In the tertiary treatment process to remove nitrogen and phosphorus from wastewater, algae are widely used in this process and CO₂ for their growth, as well as the photosynthetic bacteria, consume oxygen released by the microalgae to decompose the organic matter available in wastewater, thus releasing CO₂, ammonia, and phosphate, which are the same be assimilated by the microalgae [6].

Many species of microalgae have been acclimatized to grow efficiently in wastewater [1]. In this way, production may be reduced due to the simultaneous use of wastewater and the cultivation of specific nutrient-rich microalgae costs. Therefore, the biological dilution of CO₂ mediated by the microalgae can be more economical and effective. It cost-effective, eco-friendly when integrated into a wastewater treatment infrastructure [7,8]. Recently studies have indicated that many species of algae, such as *Chlamydomonas sp. Botryococcus sp.*, *Chlorella sp.*, *Haematococcus sp.*, *Spirulina sp.*, *Scenedesmus sp.*, *Nitzschia palea Navicula gregaria* were used for removing nutrients and organic matter from raw wastewater [9]. Diatoms are a species of microalgae planktonic or attached unicellular,
photosynthetic, belonging to the Bacillariophyceae, and are widespread in fresh and marine water. Diatoms are siliceous algae that make up the largest fraction of algal assemblages colonizing the streambed. The diatom taxa show specific tolerances to environmental stresses such as pH, salinity, temperature, nutrients, light availability[10][11], and the most widespread in Iraqi waters [12][13][14]. The diatoms varied capabilities which make them beneficial for many applications. The availability of diatoms in water bodies facilitates removing pollutants from wastewater originating from various industries, agriculture, and other anthropogenic sources. The photosynthetic of unique unicellular and characteristics of metabolic diatoms allows them to used pollutants like phosphate, nitrate, molybdenum, iron, silica, and heavy metals, such as copper, cadmium, chromium, lead, etc., which make diatoms splendid organisms for the treatment of wastewater. Also, the biomass of diatoms obtained from treatment can be turned into biofuels, biofertilizers, nutritional supplements for animal production, and pharmaceutical applications containing bioactive compounds such as pigments fucoxanthin, DHA, and EPA [15]. The abundance of Silicate (Si) can make diatom take N and P at a much faster rate than other species such as flagellates and blue-green algae, and nitrogen is critical for phytoplankton to build their cellular materials, including nucleic acids and proteins to support the growth and division of the cell [16].

This study aimed to investigate the diatom *Nitzschia palea* for removing nutrients (ammonia, nitrate and phosphate) in wastewater from the Al-Rustumeyah wastewater treatment plant located at the south of Baghdad-Iraq.

2. Material and methods

Algae culture of *Nitzschia palea* (Kützing) was obtained from the College of Science for Women, University of Baghdad. The wastewater from the final sedimentation basins in the Al-Rustamayeh plant was used as cultivation media for diatom *N.palea* by cultivation in sterile wastewater at one time and non-sterile wastewater at other times at constant laboratory conditions 268 μE / m² / s, 25 ± 2°C, and 16: 8 lights: dark condition. Batch culture was used, also to the use of autoclave device to sterilize wastewater at a temperature of 121°C and pressure 1.5 bars at 20 minutes. A 1700 ml of sterile wastewater and non-sterile wastes and add 35 mg L−1 Si was placed in a sterile 2.5-litre glass vial, then add 300 ml (0.03 grams dry weight) of the primary *N. palea*. Was added, 125 ml were taken daily for chemical tests for ten days [1]. Regarding chemical analyzes of nitrite, nitrate, effective phosphorus, total phosphorous, ammonia, and the chemical requirement of oxygen, the methods described by the American Public Health Association APHA[14] was followed. The results were statistically analyzed using ANOVA analysis of variance, and Duncan’s Multiple Range Test test was used to find the significant differences between the parameters. [15].

3. Results and Discussion

The results showed that the high efficiency of *N.palea* had reduced nutrient concentrations (ammonia, nitrite, nitrate, and phosphorus) from wastewater treated with sterile and non-sterile wastewater within ten days and showed significant differences between sterile and non-sterile samples (Table 1). The ammonia concentration decreased from 3.7 -6.3 mg / l before treatment to 1.00 and 0.02 mg / l on the fifth day for sterile and non-sterile samples, respectively. The statistical analysis result has shown a significant difference (P <0.05) between removing. The fifth-day percentage was 77.3% and 99.7% for the sterile and non-sterile samples, respectively, i.e. 9.8% was removed per day for the non-sterile sample (Figure 1A). For similarity pattern, the percentage of nitrate removal was also low during the treatment period, as it reached 3.5% and 6.8% on the first day and increased slightly to 17.2% and 21.8% on the tenth day for both sterile and non-sterile sample, respectively (Figure 1B). Also, nitrate concentrations before treatment decreased from 3.12 mg / L for a sterile sample and 5.6 mg / L for non-sterile to 2.66 and 4.4 mg / L on the tenth day for both samples.
Table 1: Average Concentrations of measured factors in sterile (Bold) and non-sterilized (Non-Bold) treated with diatom *N. palea*, Standard deviation (±)

| Factors | Pre-Treatment | Time (Days) |
|---------|---------------|-------------|
|         |               | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Mg l | ±3.7 0.00a 0.00a | ±3.00 0.00b 0.00c | ±2.8 0.00c 0.00d | ±2.6 0.00 e 0.00f | ±2.1 0.00 e 0.00f | ±1.00 0.00 f 0.00 g | ±0.26 0.00 f 0.00 g | ±0.009 0.00 f 0.00 g | ±0.03 0.00 f 0.00 g | ±0.02 0.00 f 0.00 g | ±0.03 0.00 f 0.00 g |
| NH₃ | ±3.12 0.01a 0.00a | ±3.10 0.00b 0.00c | ±3.00 0.00b 0.00c | ±2.99 0.014c 0.014d | ±2.90 0.014c 0.014d | ±2.85 0.00d 0.00e | ±2.85 0.00d 0.00e | ±2.76 0.014d 0.014e | ±2.73 0.028f 0.014f | ±2.69 0.00f 0.00g | ±0.02 0.00f 0.00g |
| NO₃ | ±0.63 0.024a± 0.14 3.7 0.00a | ±0.55 0.00b 0.00c | ±0.29 0.00b 0.00c | ±0.10 0.00b 0.00c | ±0.06 0.00b 0.00c | ±0.04 0.00b 0.00c | ±0.04 0.00b 0.00c | ±0.01 0.00c 0.00c | ±0.00 0.00c 0.00c | ±0.00 0.00c 0.00c | ±0.01 0.00c 0.00c |
| PPO₄ | ±84 2.8 a± 2.8 a± 12 | ±79 1.4b | ±73 2.8c | ±68 2.8 c | ±65.5 1.4d | ±57.3 0.7d | ±50.3 0.14 f | ±47 1.4f | ±42 1.4f | ±38 1.4f | ±38 1.4f |

Figure 1. Percentage of ammonia(A) and Nitrates(B) removal from sterile and non-sterile wastewater by *Nitzschia palea*

It has been proven that treating wastewater using algae to remove nutrients more efficiently than a conventional activated sewage process [16]. In this present study, the order of *N. palea* differs in the removal of nitrogen sources where the uptake of NH₃ was more than NO₃ [1][18]. In this study, complete ammonia removal was observed on the tenth day of all studied alga due to ammonia/ammonium was preferred as a source of inorganic nitrogen for microalgae because its uptake and assimilation need less amount of energy compared to the other sources of inorganic nitrogen like nitrate [20][21].

The mechanism included removing algal nutrients from wastewater which was an uptake by the cells of diatoms, and stripping of NH₃ or precipitation of P due to the rise of pH associated with photosynthesis [22]. The classical apparent negative effect of NH₃ on NO₃ uptake can be divided into two distinguished processes, both strongly influenced by the environment's conditions: (a) preference for ammonium and (b) inhibition uptake NO₃ of by NH₄. The relative preference for NH₄
is related to the lower Energetic costs associated with assimilation of \( \text{NH}_4^+ \) about assimilation \( \text{NO}_3^- \) [23].

The first four days of treatment, it was shown that \( N.palea \) had high efficiency in removing orthophosphates from wastewater, especially from the sterile sample, as the concentration decreased from 0.63 and 3.7 mg / l before treatment to 0.06 and 1.8 mg / l on the fourth day of treatment for both sterile and unsterilized forms, respectively. The removal ranged from 12.7% and 27% for both samples during the first 24 hours of treatment, while it has increased to 93.7% and 70% on the fifth day, equivalent to the removal of 18.7% and 14% per day (see Figure 2).

![Figure 2. Percentage of Orthophosphates removal from sterile and non-sterile wastewater by \( Nitzschia palea \)](image)

Phosphorus (P) is an essential element for all living organisms. It is a component of DNA and RNA's backbone and is also central in the transmission of chemical energy through adenosine triphosphate (ATP). Furthermore, P is also present in phospholipids, a major constituent of cell membranes [24].

As for the ability of \( N.palea \) to remove orthophosphate and total phosphorous, the results indicated a high potential of this alga in bio removal phosphorus from wastewater. As phosphorus is one of the major necessary nutrient elements, the result showed that removal of orthophosphate from unsterilized sample better than sterile, and this might be due to the presence of other microorganisms of algae, fungi, and bacteria that participate in the consumption of phosphorous, or sterilization may lead to phosphorous union with other elements and compounds that constitute complexes that cannot be consumed [25].

\( Nitzschia palea \) showed high susceptibility to reduction the chemical oxygen demand in wastewater. The chemical oxygen demand was reduced from 84 - 112 mg / l before treatment to 33 and 19 mg / L for sterile and non-sterile, respectively, on the tenth day. On the other side, the first-day removal rate was 6% and 22.4% in both sterile and non-sterile models, respectively. It increased to 60.8% and 83.1% on the tenth day, respectively (see Figure 3).

The chemical oxygen demand (COD) measures water and wastewater quality. Its test is often used to monitor water treatment plant efficiency, the amount of oxygen consumed to oxidize organic water contaminants to organic end products chemically. [26]. All the treatment indicated a decrease in the chemical oxygen demand from the first day to the tenth day, due to the relationship between bacteria and microalgae, where the bacteria analyze the organic materials to nitrogen and phosphorus salts that algae uses during their growth to perform photosynthesis and release oxygen as a by-product [27,28], observed that, due to the increased photosynthetic activity of microalgae, higher values of algal biomass growth are obtained with culture aeration. Thus, more oxygen was generated, helping to reduce the COD and making the treatment more effective. The results revealed that the increased continuously and gradually number of cells in sterile wastewater until the end of the experiment. Simultaneously, the non-sterile wastewater showed a decrease in the number of cells at the ninth and tenth days, which may be attributed to other organisms' consumption of nutrients [29].
4. Conclusion

In the present study, diatom Nitzschia palea’s effect on removing nutrients in wastewater from the Al-Rustumeya wastewater treatment plant was investigated. At sterilized wastewater, complete removal of ammonia and phosphorus was found. At the same time, 85% of COD was removed. Higher efficiency of diatom was found in non-sterilized sample. This study contributes to enhancing diatom’s growth and then reducing its cost. Thus, it can be used in the blue biotechnology context.

5. References

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