Microalgae For Waste Water Treatment With Biomass And Oxygen Production

Baby Suruthi.N[1], Sathiesh Kumar.T[2], Karthikeyan.M[3]
[1]Dept of Environmental Engineering
[2, 3]Assistant Professor, Dept of Environmental Engineering
[1, 2] Gnanamani College of Technology, Namakkal.
[3]AVS College of Technology, Salem.

Abstract- *Conventional methods for treating wastewater can be pretty energy-hungry and often fall short when it comes to getting rid of nutrients and pollutants. That's where microalgae-based systems come into play, offering a greener alternative for wastewater treatment, biomass production, and oxygen generation. This study dives into how effective these microalgae systems can be at cleaning up wastewater while also generating biomass and oxygen. The findings reveal that microalgae can eliminate as much as 90% of nitrogen and phosphorus from wastewater, all while producing biomass at a decent rate. The research showcases how viable microalgae-based systems are for sustainable wastewater treatment and biomass production, and it points out their potential for scaling up and fitting into current wastewater treatment setups. Additionally, this study looks into how microalgae can be integrated into wastewater treatment systems, highlighting their knack for removing pollutants like nitrogen, phosphorus, and heavy metals through bioremediation processes.*

Keywords- Wastewater Treatment, Nutrient, Biomass Production, Oxygen Generation, Sustainability.

I. INTRODUCTION

The rising global interest in sustainable and eco-friendly wastewater treatment solutions has sparked a lot of curiosity around microalgae-based systems. These tiny, photosynthetic organisms are proving to be quite effective in treating wastewater because they can absorb nutrients, eliminate contaminants, and flourish in nutrient-rich settings. Unlike traditional wastewater treatment methods that often depend on energy-hungry processes and chemical additives, using microalgae presents a more natural and budget-friendly option.

One of the standout benefits of incorporating microalgae into wastewater treatment is their ability to serve a dual purpose: they not only clean the water by removing nitrogen, phosphorus, and heavy metals but also produce valuable biomass in the process. This biomass can be repurposed for a variety of uses, including biofuel production, animal feed, and biofertilizers. Plus, through photosynthesis, microalgae release a significant amount of oxygen, which can boost aerobic bacterial activity in treatment systems and lessen the need for additional aeration.

This paper delves into the potential of microalgae in integrated wastewater treatment systems, emphasizing their effectiveness in pollutant removal, biomass production, and oxygen generation. It also sheds light on recent advancements, challenges, and future prospects in this exciting field.

A.MICROALGAE FOR WASTEWATER TREATMENT

Microalgae efficiently remove excess Nitrogen and Phosphorus from wastewater. This occurs via assimilation, where algae absorb these nutrients to grow and produce biomass(Zhao et al.,2018). For example, (Nguyen et al.,2020) Chlorella Vulgaris and Scenedesmus sp. have been shown to effectively remove nitrogen and phosphorus from both municipal and industrial wastewater.

B.ORGANIC MATTER DEGRADATION

Microalgae involves organic matter degradation (Chinnasamy et al., 2010) Microalgae degrade organic matter present in wastewater through assimilation and metabolic process. Chlorella Vulgaris and Spirulina platensis have demonstrated high efficiency in degrading organic pollutants. Both are have demonstrated remarkable potential in degrading organic pollutants through their natural biological processes.

C.BIOMASS PRODUCTION FROM MICROALGAE

Microalgae is potential source of biomass production(Xue et al., 2021). Microalgae have gained significant attention as a sustainable and renewable source of biomass production. Many microalgal species studied, Nannochloropsis and chlorella stand out for their potential in biomass production, primarily because of their lipid-rich composition and adaptability to various environmental conditions.

D.OXYGEN PRODUCTION FROM MICROALGAE

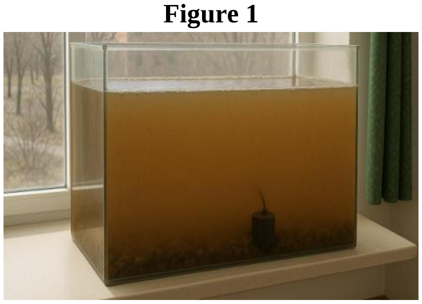
As photosynthetic organisms, microalgae produce oxygen during daylight, improving the O_2 levels in wastewater treatment systems, especially in ponds or lagoons (Sialve et al., 2009).

II. MATERIALS

A. Sample collection

Sewage water samples were collected from a nearby domestic sewage outlet. Used sterilized 2 liter plastic containers for collecting samples to prevent any contamination. To get the best results, took samples during peak flow hours, specifically between 8 and 10 AM, when the pollutant load is at its highest.

Figure 1



To keep the samples in good condition, they were stored at 4° C until we were ready to use them and measured basic parameters like pH, temperature and turbidity. Also removed any large debris by pre-filtering with fine mesh gauze.

B.Microalgae Strain Selection

Choosing the right microalgae strain is essential for effective wastewater and biomass production. The perfect strain needs to handle high nutrient levels and adapt to changing environmental conditions. While Spirulina palatensis is a bit more delicate, it boasts a high protein content and contributes to oxygen generation.

Figure 2

III. METHODOLOGY

A.Experimental Setup

Choose the container like Aquarium tank(10-20 litres). By using LED Light for lighting (20-30 µmol photons) and aquarium air pump with air stone for aeration. To maintain the temperature between 20˚-30˚ C.

B.Inoculation and Cultivation

After treating the domestic sewage water, it became the main culture medium for growing microalgae. We added a 10% (v/v) inoculum of Spirulina platensis to each photobioreactor, making sure to do this under aseptic conditions to keep everything consistent and free from contamination. The cultures were kept at a cozy temperature of 25 ± 2°C, which mimics typical indoor conditions. We used LED light strips to provide illumination, following a 12-hour light and 12-hour dark cycle to replicate natural day-night rhythms. To ensure proper mixing and a good supply of CO_2, we maintained aeration with aquarium pumps at a flow rate of 1 L/min. In setups without pumps, we stirred the cultures manually twice a day. pH between 6.5 and 8.0, which is ideal for algal growth. Each day, we observed the cultures for any changes in color and density, which indicated how well they were growing. We didn’t add any external nutrients, relying entirely on what was available in the wastewater. The cultivation process lasted between 10 to 14 days until the biomass reached the maximum density that was suitable for harvesting.

C. Monitoring and sampling

Carried out sampling every 48 hours in a sterile environment to keep an eye on how the microalgae were growing and how well the wastewater treatment was working. To measure biomass concentration, we used optical density at 680 nm (OD_{680}), and we did dry weight analysis on a weekly basis. We kept track of pH levels with a digital pH meter to make sure the growth conditions were just right. During the light phases, we monitored dissolved oxygen (DO) with a DO meter to evaluate how much oxygen was being produced. We recorded and analyzed the data to track trends in nutrient removal and biomass accumulation over time.

D. Oxygen Production Estimation

Evaluated how much oxygen was produced by checking the levels of dissolved oxygen (DO) during the brightest parts of the day, using a digital DO meter. We took readings at specific times—morning, midday, and evening—to observe how oxygen output changed throughout the day. In closed-system setups, we also collected oxygen in gas collection tubes and measured it by volume. The increase in DO levels was linked to the photosynthetic activity of the microalgae. To get a clearer picture of specific oxygen productivity (in mg O_2/L/day), we normalized the data against biomass concentration. These measurements shed light on how microalgae could potentially improve indoor air quality by naturally generating oxygen.

E. Biomass Harvesting

After about 10 to 14 days of cultivation, harvested the microalgal culture once it hit the stationary phase. To separate the biomass from the treated wastewater, we used gravity sedimentation, followed by centrifugation at 4000 rpm for 10 minutes. Ten rinsed the collected biomass with distilled water to get rid of any leftover contaminants. After that, it was dried in a hot air oven at 60°C until it reached a constant weight. We recorded the dry biomass weight (g/L) to calculate productivity and evaluate its potential for use as a biofertilizer or biofuel.

IV. EXPERIMENTAL RESULT

Spirulina Platensis thrived in domestic sewage water, demonstrating a remarkable boost in biomass over a span of 14 days. By the end of the experiment, the dry biomass yield hit around 1.8 g/L, showcasing impressive productivity. The nutrient removal process was quite effective, achieving reductions of 78.5% in ammonium, 64.7% in nitrate, and 81.3% in phosphate. Throughout the study, the pH stayed stable (between 6.7 and 7.9), creating ideal conditions for algal growth. The gas collection systems recorded a daily oxygen output of 40 to 50 mL. After treatment, the wastewater appeared noticeably clearer and free of odors. There were no signs of contamination or algal crashes during the cultivation process. These findings underscore the dual advantages of treating wastewater while generating oxygen. Home-based photobioreactor systems hold great potential for sustainable environmental solutions.

V. CONCLUSION

This study shows that Spirulina Platensis is quite effective at treating domestic sewage while also producing valuable biomass and oxygen. The system managed to achieve impressive nutrient removal rates and maintain stable algal growth in conditions that are friendly for home use. This method is not only low-cost and sustainable but also adaptable for households. All in all, using microalgae for treatment presents a promising option for managing wastewater and recovering resources in a decentralized way.

REFERENCES

[1] Chia, S. R., et al. (2020). "Microalgae as biofilters for wastewater treatment: A review." Environmental Science and Pollution Research, 27(3), 2966-2981.
[2] Chinnasamy, S., et al. (2010). "Microalgae for biofuels production and wastewater treatment: A review." Bioresource Technology, 102(1), 14-22.
[3] Gorib, A. H., et al. (2017). "A review on the potential of microalgae in the production of nutraceuticals." Algal Research, 24, 289-302.
[4] Hannon, M., et al. (2010). "Microalgae as feedstocks for biofuels production." Trends in Biotechnology, 28(5), 263-271.
[5] Kumar, M., et al. (2020). "Microalgae: A potential source for industrial production of biofuels and bioactive compounds." Energy Conversion and Management, 225, 113394.
[6] Li, Y., et al. (2019). "Microalgal biofuels production: A review of recent developments and technological advances." Renewable and Sustainable Energy Reviews, 110, 37-53.
[7] Liu, J., et al. (2020). "Microalgae: A promising feedstock for the production of biofuels and high-value bioproducts." Bioresource Technology, 303, 122947.
[8] Mata, T. M., et al. (2010). "Microalgae for biodiesel production and other applications: A review." Renewable and Sustainable Energy Reviews, 14(1), 217-232.
[9] Nguyen, T. T., et al. (2020). "Microalgae-based wastewater treatment and nutrient recovery: A review." Journal of Environmental Management, 267, 110530.

[10] Pahl, S., et al. (2013). "Microalgae-based biofuels and bioethanol: An integrated approach to green energy." Biofuels, 4(3), 243-251.
[11] Park, J. Y., et al. (2011). "Microalgae-based biofuel production and wastewater treatment: A review." Journal of Environmental Engineering, 137(8), 813-819.
[12] Richmond, A., et al. (2004). "Handbook of Microalgal Culture: Biotechnology and Applied Phycology." Wiley-Blackwell.
[13] Sialve, B., et al. (2009). "Microalgae and wastewater treatment." Bioresource Technology, 100(1), 189-196.
[14] Wu, M., et al. (2019). "Microalgae-based wastewater treatment and biomass production." Water Research, 154, 320-328.
[15] Xue, S., et al. (2021). "Microalgal biomass production for biofuels: Progress and challenges." Renewable and Sustainable Energy Reviews, 138, 110461.