A Study on the Efficiency of Wastewater and Oil Remediation Using *Chaetomorpha* Algae

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Abstract

This study aimed to investigate the efficiency of *Chaetomorpha* algae in treating wastewater and oil-contaminated seawater. The experiment was conducted by cultivating *Chaetomorpha* algae in controlled seawater conditions and exposing them to different types of pollutants. Four experimental treatments were established: (1) a control group containing only seawater, (2) seawater mixed with synthetic wastewater, (3) seawater contaminated with engine oil, and (4) seawater containing both synthetic wastewater and engine oil. Each treatment was performed in triplicate to ensure experimental reliability.

The efficiency of *Chaetomorpha* algae in water treatment was evaluated by observing changes in water quality parameters and the growth response of the algae throughout the experimental period. The results of this study are expected to demonstrate the potential of *Chaetomorpha* algae as a natural and environmentally friendly biological agent for the remediation of wastewater and oil pollution in marine environments. This research provides fundamental information that may contribute to the development of sustainable bioremediation approaches for coastal and marine pollution management.

Keywords: *Chaetomorpha* algae, wastewater treatment, oil contamination, bioremediation, seawater, synthetic wastewater

Research Questions

1. To what extent does synthetic wastewater affect the treatment efficiency of *Chaetomorpha* algae in seawater, and in what ways does this effect occur?
2. To what extent does engine oil contamination affect the remediation efficiency and growth of *Chaetomorpha* algae, and in what ways does this effect occur?
3. To what extent does the combined contamination of synthetic wastewater and engine oil affect the bioremediation efficiency of *Chaetomorpha* algae, and in what ways does this effect differ from single-pollutant conditions?

Hypothesis

1. *Chaetomorpha* algae significantly reduce pollutants in seawater containing synthetic wastewater.
2. *Chaetomorpha* algae significantly reduce oil contamination in seawater contaminated with engine oil.
3. The combined presence of synthetic wastewater and engine oil affects the treatment efficiency of *Chaetomorpha* algae differently from single-contaminant conditions.

Introduction

Coastal and marine environments are increasingly threatened by a range of anthropogenic pollutants, among which industrial wastewater and petroleum-derived oils are particularly damaging. Discharges from manufacturing facilities introduce high loads of organic matter, nutrients, and toxic compounds that degrade water quality, stimulate harmful algal blooms, and disrupt aquatic food webs. Oil contamination — from engine oil leaks, accidental spills, or urban runoff — further impairs gas exchange, smothers organisms, and introduces persistent hydrophobic compounds that are difficult to remove by conventional treatments. Together, these contaminants pose ecological, economic, and public-health risks for coastal communities.

Bioremediation using algae has emerged as a promising, low-cost, and environmentally friendly approach to mitigate aquatic pollution. Macroalgae can remove dissolved nutrients and certain organic pollutants through uptake, adsorption to biomass, and by stimulating associated microbial degradation. In addition, many macroalgal species tolerate a wide range of salinities and can be cultivated in seawater, making them attractive candidates for in situ or ex situ treatment of marine and estuarine waters. *Chaetomorpha* (a filamentous green macroalga) is of particular interest because of its rapid growth habit and large surface area, properties that may enhance contaminant uptake and foster pollutant-degrading microbial communities on its thallus.

This study evaluates the remediation potential of *Chaetomorpha* cultivated in seawater under controlled laboratory conditions. Four treatments are compared: (1) control seawater (no added pollutant), (2) seawater amended with synthetic wastewater, (3) seawater contaminated with engine oil, and (4) seawater containing both synthetic wastewater and engine oil. Each treatment is conducted in triplicate to allow statistical comparison. Water quality indicators (for example, pH, dissolved oxygen, turbidity, chemical oxygen demand (COD), ammonia and nitrate concentrations, and oil concentration) and algal responses (growth rate, biomass accumulation, and physiological status) are monitored throughout the experimental period to quantify treatment efficiency and potential stress effects on the algae.

By integrating pollutant measurements with algal performance data, the study aims to determine whether *Chaetomorpha* can significantly reduce pollutant loads in seawater and under which contaminant scenarios its remediation capacity is greatest. The findings are intended to inform the feasibility of using macroalgal cultivation as a sustainable component of coastal pollution-management strategies and to provide baseline data for scaling up bioremediation applications in affected marine environments.

Materials

1. *Chaetomorpha* algae, collected from a clean marine environment and acclimated in seawater prior to experimentation
2. Natural seawater, filtered to remove debris and suspended particles
3. Vegetable oil 1 L
4. Cassava starch 0.5 kg
5. Granulated sugar 0.5 kg
6. Engine oil (commercial grade) used as a representative petroleum-based contaminant
7. Plastic cultivation basin with a capacity of 10 L
8. Aeration equipment, including air pumps and air stones
9. Light source to provide consistent illumination during algal cultivation
10. Thermometer for monitoring water temperature
11. pH meter or pH test kit
12. Dissolved oxygen (DO) meter
13. Equipment and reagents for water quality analysis (e.g., COD test kits, ammonia and nitrate test kits)
14. Analytical balance for measuring algal biomass
15. Measuring cylinders and pipettes for accurate volume measurements

Methods

1) Study sites

The study was conducted through a field visit to a learning resource that serves as a cultivation site for *Chaetomorpha* algae. Algal samples were collected from Ban Suan Na Nin, located in Palian District, Trang Province

2) Experimental Design

This study employed a completely randomized experimental design to evaluate the efficiency of *Chaetomorpha* algae in treating wastewater- and oil-contaminated seawater. Four experimental treatments were established:

2.1) control seawater without added pollutants,

2.2) seawater mixed with synthetic wastewater

2.3) seawater contaminated with engine oil, and

2.4) seawater containing both synthetic wastewater and engine oil.

Each treatment was conducted in triplicate, resulting in a total of twelve experimental units.

3) Preparation of Algal Samples

Fresh *Chaetomorpha* algae were rinsed thoroughly with filtered seawater to remove debris and epiphytes. The algae were then acclimated in clean seawater under controlled

laboratory conditions for several days prior to the experiment. Equal initial wet biomass of algae was weighed and introduced into each experimental container to ensure consistency among treatments.

4) Preparation of Seawater and Pollutants

Natural seawater was used as the base medium for all experimental treatments. synthetic wastewater was added to the designated experimental containers at a volumetric ratio of 1 L per cultivation basin. For the oil-contaminated treatments, 0.2 L engine oil was added to simulate petroleum contamination. For the treatments supplemented with synthetic wastewater, the synthetic wastewater was prepared by mixing 50 mL of vegetable oil, 50 mg of cassava starch, and 2 mg of granulated sugar. In the treatments with combined pollutants, both synthetic wastewater and engine oil were added at the same concentrations as those used in the single-pollutant treatments.

5) Cultivation Conditions

All experimental containers were maintained under identical environmental conditions throughout the experimental period. Aeration was continuously provided to ensure adequate mixing and dissolved oxygen levels. Temperature and light intensity were kept constant to support algal growth. The experiment was conducted for a predetermined duration, during which no additional pollutants were added.

6) Water Quality Analysis

Water quality parameters were measured at regular intervals. These included pH, dissolved oxygen (DO), turbidity, chemical oxygen demand (COD), ammonia (NH_3/NH_4^+), nitrate (NO_3^-), and oil concentration, using standard analytical methods and test kits. Changes in these parameters were used to assess the pollutant removal efficiency of *Chaetomorpha* algae.

7) Algal Growth Measurement

Algal growth was evaluated by measuring changes in biomass. At the end of the experimental period, algae were harvested, gently blotted to remove excess water, and weighed using an analytical balance. Growth rate and biomass changes were compared among treatments.

8) Statistical Analysis

Data were expressed as mean ± standard deviation. Differences among treatments were analyzed using appropriate statistical tests to determine significant differences in treatment efficiency. A significance level of $p < 0.05$ was applied for all analyses.

Results

Percentage Removal of Chemical Oxygen Demand (COD)

This graph illustrates the percentage removal of chemical oxygen demand (COD) in seawater treated with *Chaetomorpha* algae under different experimental conditions. The results show that treatments containing synthetic wastewater and engine oil exhibited a substantially higher COD removal efficiency compared to the control. This indicates the potential of

Chaetomorpha algae to reduce organic pollutant loads in contaminated seawater through biological uptake and associated microbial activity.

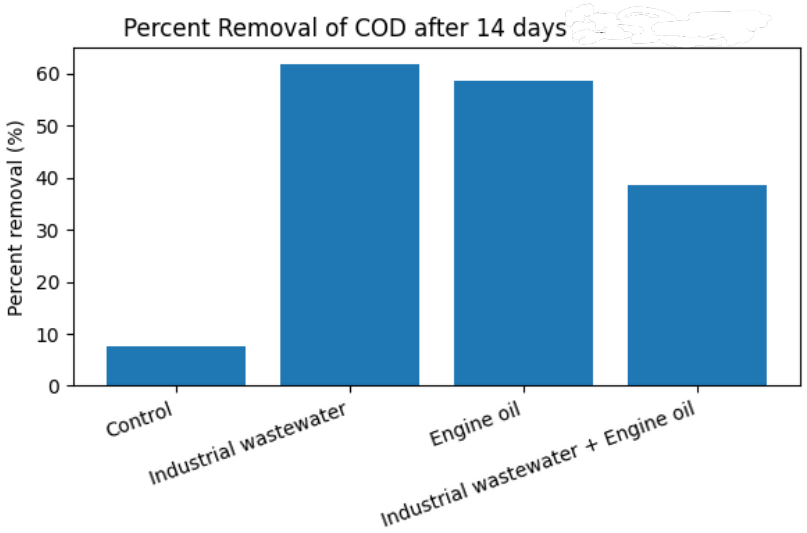

Figure 1: Percent removal of COD after 14 days

Percentage Removal of Ammonia (NH_3)

This graph presents the percentage reduction of ammonia (NH_3) concentration in seawater during the experimental period. The highest ammonia removal was observed in the treatment containing synthetic wastewater, followed by the engine oil treatment. The control showed minimal change. These results suggest that *Chaetomorpha* algae effectively assimilate nitrogenous compounds, particularly in nutrient-rich wastewater conditions.

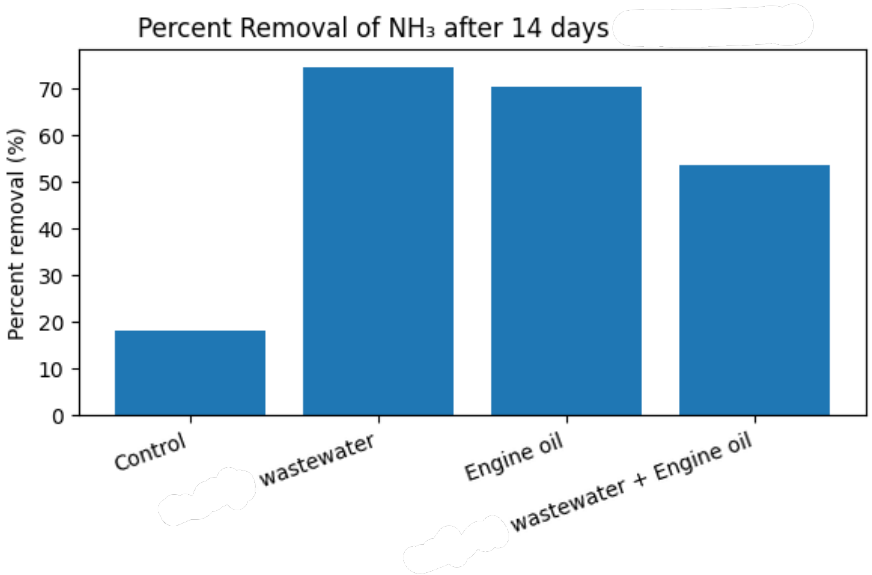

Figure 2: Percent removal of NH_3 after 14 days

Percentage Removal of Nitrate (NO_3^-)

This graph shows the percentage removal of nitrate (NO_3^-) in the experimental treatments. Significant nitrate reduction was observed in all contaminated treatments compared to the control, with the highest removal occurring in the engine oil treatment. This trend indicates that *Chaetomorpha* algae play an important role in nutrient uptake and contribute to the reduction of dissolved inorganic nitrogen in pollute seawater.

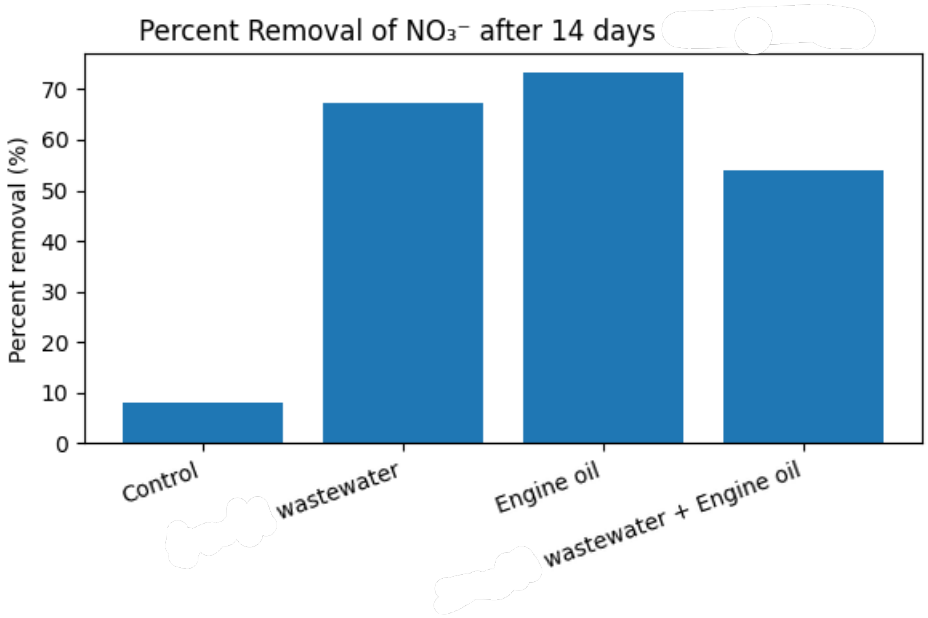

Figure 3: Percent removal of Nitrate ion after 14 days

Percentage Reduction of Oil Concentration

This graph demonstrates the reduction in oil concentration in seawater contaminated with engine oil. A higher oil removal efficiency was observed in the engine oil–only treatment compared to the combined wastewater and oil treatment. This suggests that the presence of multiple pollutants may reduce the overall bioremediation efficiency, possibly due to increased physiological stress on the algae.

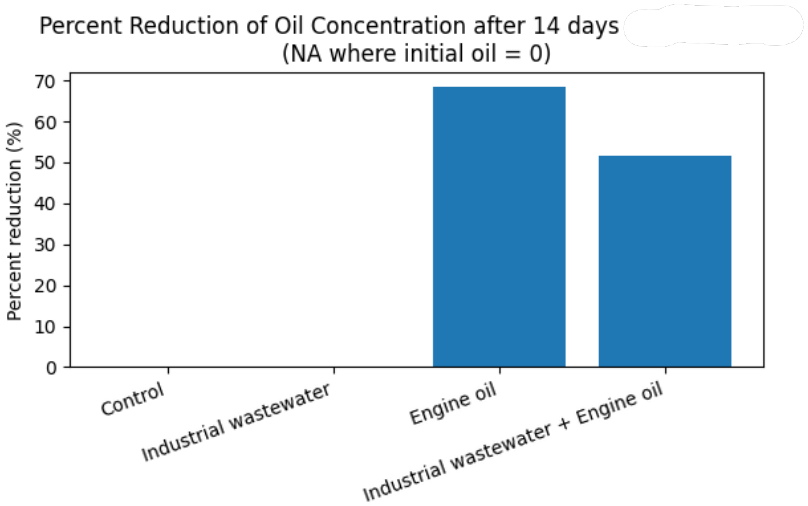

Figure 4: Percent of oil concentration after 14 days

Changes in *Chaetomorpha* Biomass (Wet Weight)

This graph compares the initial and final wet biomass of *Chaetomorpha* algae across all treatments. The greatest biomass increase was observed in the synthetic wastewater treatment, indicating enhanced algal growth under nutrient-rich conditions. In contrast, treatments containing engine oil showed reduced biomass growth, suggesting inhibitory effects of oil contamination on algal development.

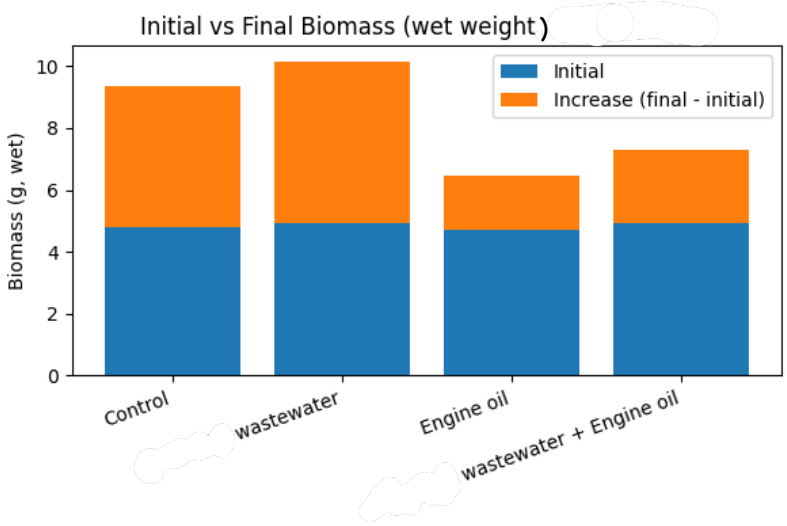

Figure 5: Initial and final biomass

Discussion and Conclusions

This study concludes that *Chaetomorpha* algae are effective biological agents for the remediation of wastewater- and oil-contaminated seawater. The algae significantly reduced organic pollutants, nitrogen compounds, and oil concentration while exhibiting measurable biomass growth under nutrient-rich conditions. Synthetic wastewater enhanced algal growth

and treatment efficiency, whereas engine oil exerted inhibitory effects on algal performance, particularly when combined with wastewater.

The findings suggest that *Chaetomorpha* algae have strong potential for use in environmentally friendly and sustainable water treatment systems, especially in coastal and marine environments affected by industrial effluents. However, the reduced efficiency observed in mixed-pollutant conditions indicates that further studies are required to optimize treatment parameters and evaluate long-term performance. Future research should focus on varying pollutant concentrations, extended cultivation periods, and the integration of algal systems with other treatment technologies to enhance overall bioremediation efficiency.

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Citations

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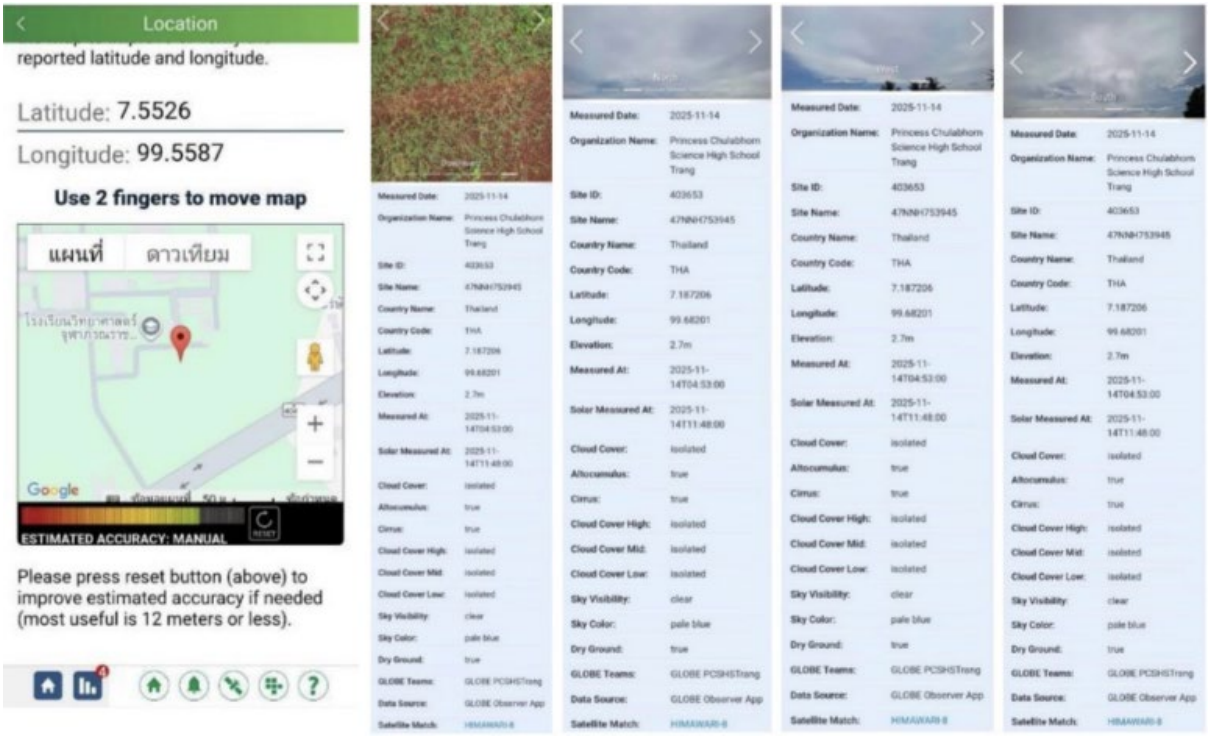
GLOBE's databases



Globe Data Entry

Badges

I Make an Impact

Coastal and marine pollution from industrial wastewater and engine oil causes serious environmental problems and degrades seawater quality. *Chaetomorpha* algae have the ability to absorb nutrients and reduce pollutants in seawater. In this study, *Chaetomorpha* algae were cultivated in seawater contaminated with industrial wastewater and engine oil to evaluate their treatment efficiency. Therefore, this study has an impact on society by promoting an environmentally friendly and low-cost biological approach for wastewater and oil remediation, which can help reduce marine pollution and support the protection of coastal ecosystems without causing negative effects on the environment.

I am a Data Scientist

Environmental experiments require accurate data collection and analysis to evaluate treatment efficiency. In this study, data on water quality parameters, including COD, ammonia, nitrate, oil concentration, and algal biomass, were systematically collected from

different experimental treatments and replicates. The data were organized into tables and analyzed using statistical methods to compare pollutant removal efficiency among treatments. Therefore, this study demonstrates data science skills by transforming experimental data into meaningful information, supporting scientific conclusions, and enabling evidence-based decision-making for environmental management.

I am a Problem Solver

Marine pollution from industrial wastewater and oil contamination is a significant environmental problem that affects seawater quality and marine ecosystems. In this study, the problem was identified and addressed by designing an experimental approach using *Chaetomorpha* algae as a biological treatment method. Different experimental conditions were established to evaluate the effectiveness of the algae in treating various pollutants. Therefore, this study demonstrates problem-solving skills through identifying an environmental issue, planning systematic experiments, testing solutions, and using the results to evaluate effective and sustainable approaches for pollution reduction.