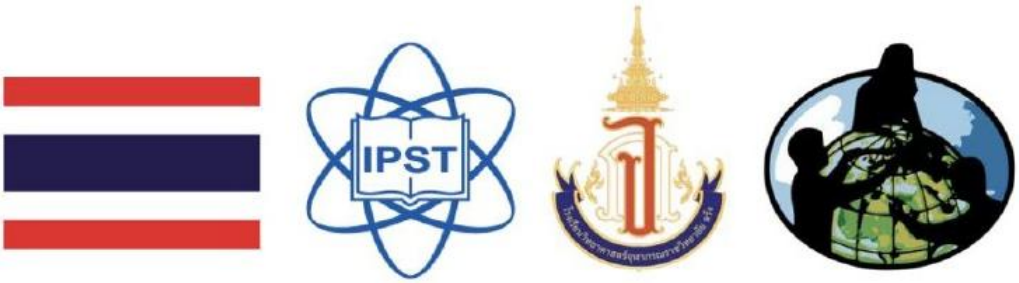

Evaluation of the Potential of Sea Lettuce, Sea Grapes , Red Algae and Blanket Algae for the Treatment of Shrimp Pond Wastewater

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Abstact:

This research aimed to compare the wastewater treatment efficiency and growth rates of four macroalgae species: Sea Lettuce (*Ulva lactuca*), Sea Grapes (*Caulerpa lentillifera*), Red Algae (*Gracilaria sp.*), and Blanket Algae (*Cladophora sp.*). Following the GLOBE Program protocols, the experiment utilized a Completely Randomized Design (CRD) with four treatments and three replicates. Each unit contained 20 grams of initial biomass in 14 liters of effluent, with an initial salinity of 26.33 ppt and continuous 24-hour light exposure over an 8-week period.

The results indicated that all macroalgae species significantly improved water quality. Blanket Algae (*Cladophora sp.*) demonstrated the highest efficiency in chemical pollutant reduction, lowering ammonia levels from 0.6 ppm to 0.1 ppm and nitrite to 0.1 ppm, while achieving the highest dissolved oxygen (DO) level at 10.5 mg/L. Regarding growth, Blanket Algae (*Cladophora sp.*). showed the maximum biomass increase to 50 grams (a 150% increase), followed by Red Algae (*Gracilaria sp.*) is 48.36 grams. Physical parameters shifted during the experiment: pH levels stabilized within the 7.5–8.0 range, while salinity tended to increase across all treatments due to evaporation. In conclusion, Blanket Algae (*Cladophora sp.*) and Red Algae (*Gracilaria sp.*) are highly suitable species for biological wastewater treatment systems in sustainable marine shrimp farming.

Keywords: Biological wastewater treatment, Macroalgae, Shrimp farm effluent, GLOBE Program, Water quality management

Research Questions

1. To what extent do different macroalgae species differ in their efficiency in treating shrimp farm effluent?
2. To what extent do the growth rates of different macroalgae species differ when cultured in shrimp farm effluent?

Hypotheses

1. Different species of macroalgae possess significantly different capacities for treating shrimp farm effluent.
2. Different species of macroalgae exhibit significantly different growth rates when cultured in shrimp farm effluent.

Introduction and Review of Literature:

Marine shrimp farming is a vital sector of Thailand's economy. However, its commercial expansion often leads to severe environmental challenges, particularly the discharge of effluent into natural water bodies. This wastewater contains organic residues from uneaten feed and shrimp excrement, resulting in nitrogen and phosphorus concentrations that exceed safety standards. Such high nutrient levels trigger eutrophication, a chain-reaction ecological issue characterized by depleted dissolved oxygen and loss of biodiversity. These concerns directly align with the Hydrosphere protocols prioritized by the GLOBE Program for environmental monitoring. Bioremediation, specifically using macroalgae as "Biofilters," offers an efficient and sustainable solution. Macroalgae possess physiological mechanisms to absorb nitrates and phosphates for photosynthesis and growth. This research focuses on comparing the potential of four species with distinct structural characteristics: Sea Lettuce (*Ulva lactuca*), Sea Grapes (*Caulerpa lentillifera*), Red Algae (*Gracilaria sp.*), and Blanket Algae (*Cladophora sp.*) the latter of which is commonly found in shrimp farm sedimentation pond. This study was conducted following GLOBE Program protocols to evaluate the wastewater treatment capacity of each species. The findings aim to provide a guideline for implementing recirculating aquaculture systems (RAS) that are environmentally friendly and promote long-term sustainability.

Research Methods and Materials:

Materials:

1. Sea Lettuce (*Ulva lactuca*)
2. Sea Grapes (*Caulerpa lentillifera*)
3. Red Algae (*Gracilaria sp.*)
4. Blanket Algae (*Cladophora sp.*)
5. Shrimp Farm Effluent
6. Salinity Meter
7. Aeration Tubing
8. Culture Containers
9. Liquid-in-Glass Thermometer
10. Digital Water Surface Temperature Meter
11. pH Meter
12. NPK Test Kit
13. Ammonia Test Kit
14. Nitrite Test Kit

Methods:

1. Study sites

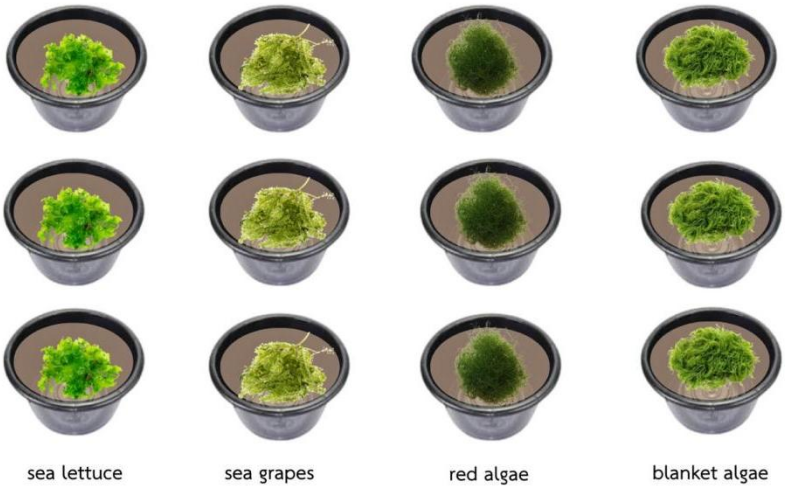
Shrimp pond Palian District, Trang Province Latitude 7.1875 °E Longitude 99.6823 °N

Figure 2: Shows the study sites

2. **Experimental Design**

The study was conducted using a Completely Randomized Design (CRD) to evaluate and compare the wastewater treatment efficiency and growth rates of four macroalgae species. The experiment was divided into 4 experimental sets with 3 replicates each, resulting in a total of 12 experimental units. The groups were organized as follows:

Experimental set 1: Sea Lettuce (*Ulva lactuca*)
Experimental set 2: Sea Grapes (*Caulerpa lentillifera*)
Experimental set 3: Red Algae (*Gracilaria sp.*)
Experimental set 4: Blanket Algae (*Cladophora sp.*)



3. Preparation of culturing system

1. Circular plastic containers with a 30 cm diameter were utilized. Each vessel underwent thorough cleaning and air-drying to prevent cross-contamination.
2. The vessels were filled with marine shrimp farm effluent, maintained at a constant salinity of 26 ppt, reaching a water depth of 20 cm.
3. A continuous 24-hour aeration system was installed using air stones to ensure sufficient dissolved oxygen levels in each experimental unit.
4. To simulate consistent photosynthetic conditions, LED lamps (Philips T8, 18W) were installed. The light intensity was strictly regulated within the range of 1,000–3,000 Lux throughout the entire experimental period.

4. Cultivation and Hydrosphere Data Collection

The cultivation process was conducted over a continuous period of 8 weeks. To maintain the water level and compensate for natural evaporation, 500 mL of distilled or deionized water was added to each experimental unit weekly.

The data collection was divided into two main parts, strictly following the GLOBE Hydrosphere Protocols:

Part 1: Water Quality Monitoring

Water quality parameters were measured and recorded on a weekly basis to monitor the chemical and physical changes in the shrimp effluent. The parameters included: Physical and Chemical Analysis: pH, Dissolved Oxygen (DO), Nitrate , Ammonia , and Salinity.

Protocol Adherence: All measurements were performed according to the standardized GLOBE Hydrosphere Protocols to ensure data accuracy and global comparability.

Part 2: Algae Growth Assessment

1. Weekly Measurement: The fresh weight (Wet Weight) of each algae sample was measured and recorded on a weekly basis throughout the 8-week period.
2. Sample Preparation (Blot-Drying): To ensure accuracy, the algae were gently blotted dry using absorbent paper to remove excess surface water before weighing.
3. Data Recording: The final measured value was recorded as the actual biomass for each experimental unit to minimize errors from external moisture.

Data Analysis and Reporting

1. **Water Quality and Algal Growth Analysis:** Statistical methods were used to calculate the mean values of water quality parameters, biomass weight, and the physical characteristics (thallus coloration) of the four macroalgae species throughout the experiment.

2.Growth Performance Comparison: A comparative analysis was conducted on the change in algal weight from the initial stage to the completion of the 8-week study period.

3.**Data Submission:** All validated environmental and hydrological data were officially submitted to the **GLOBE Data Entry** system for global database integratio.

Results:

Weter quality

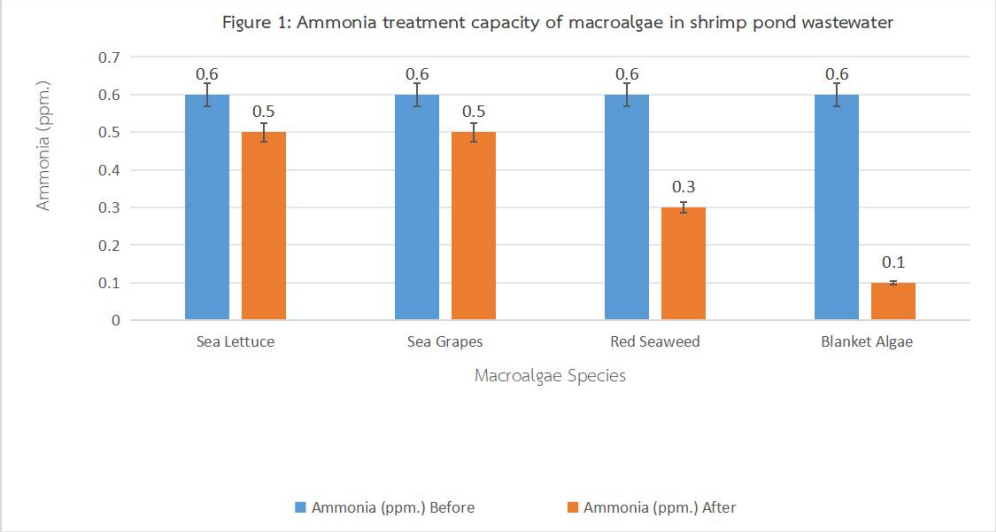


Figure 1: Ammonia treatment capacity of macroalgae in shrimp pond wastewater over a period of 8 week

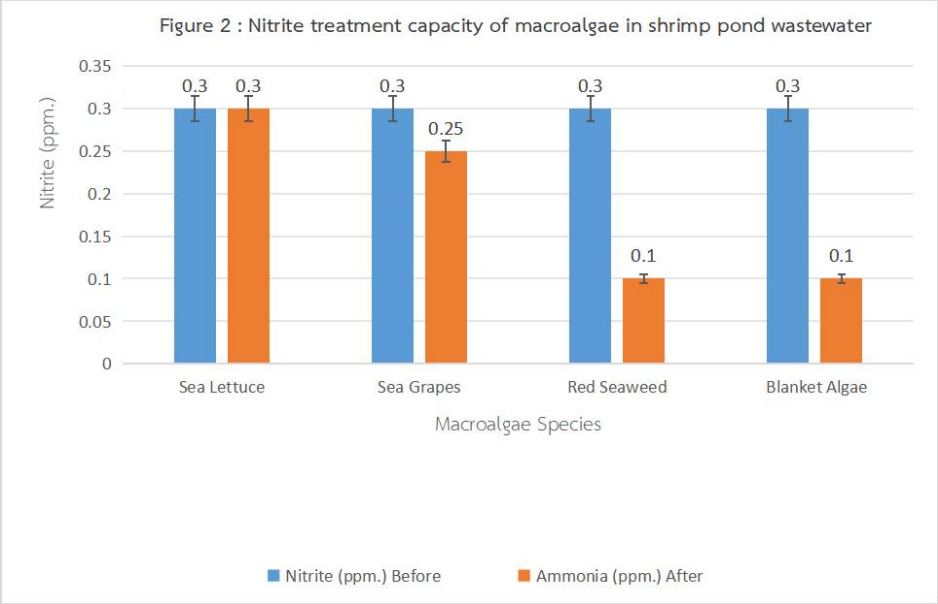


Figure 2 : Nitrite treatment capacity of macroalgae in shrimp pond wastewater over a period of 8 week

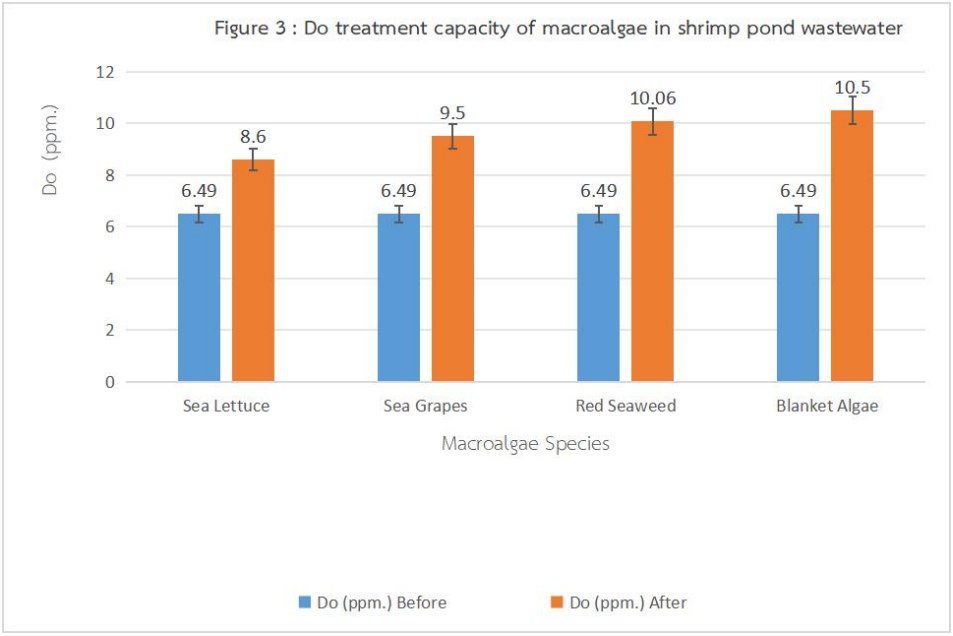


Figure 3 : Dissolved Oxygentreatment capacity of macroalgae in shrimp pond wastewater over a period of 8 week

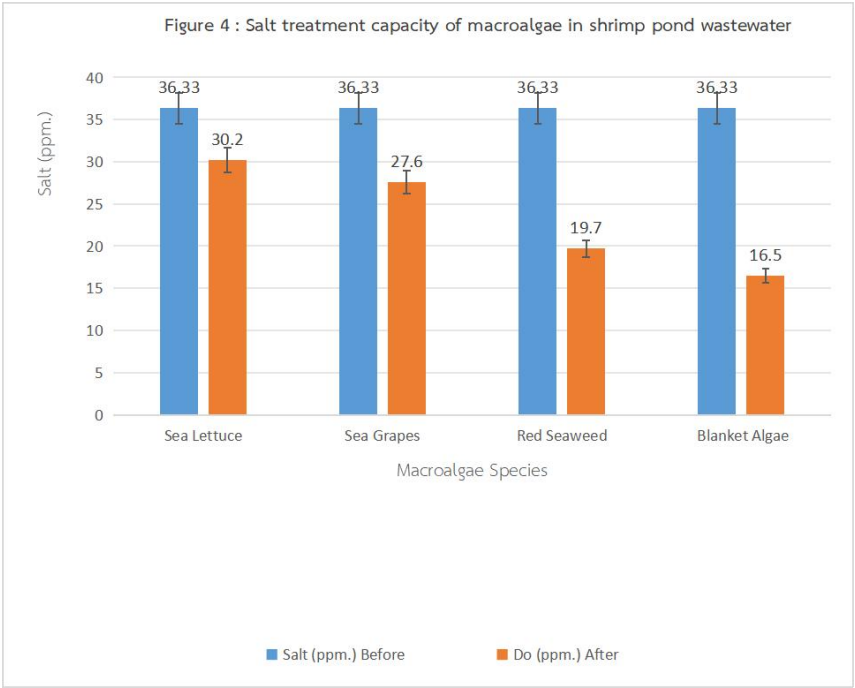


Figure 4 : Salt treatment capacity of macroalgae in shrimp pond wastewater over a period of 8 week

Algae Biomass

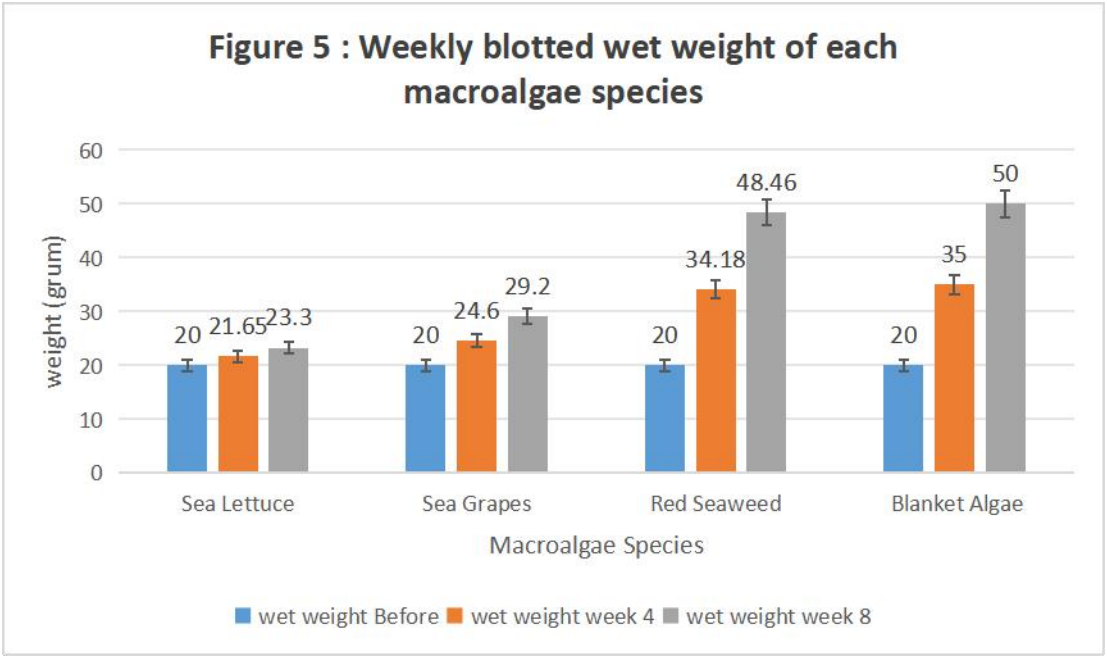


Figure 5 : Weekly blotted wet weight of each Macroalgea species

Conclusion and Discussion

Discussion

The experimental results indicate that Blanket Algae (*Cladophora sp.*) and Red Algae (*Gracilaria sp.*) exhibit significantly higher wastewater treatment efficiency and growth rates compared to the other species. The findings can be discussed based on the following factors:

1. Compound Treatment Efficiency: Blanket Algae (*Cladophora sp.*) reduced ammonia from 0.6 ppm to 0.1 ppm and nitrite to 0.1 ppm, the lowest levels recorded in the study. This is attributed to its filamentous structure, which provides a high surface area-to-volume ratio, facilitating rapid nutrient uptake for biomass production. This aligns with its substantial weight increase from 20g to 50g within two months a 2.5 fold increase.

2.Enhancement of Dissolved Oxygen (DO): DO levels exceeding 10 mg/L in the Blanket Algae (*Cladophora sp.*) and Red Seaweed (*Gracilaria sp.*) groups indicate high photosynthetic rates. The rapid biomass accumulation in these species (50g and 48.36g, respectively) led to high oxygen release, which is a crucial factor in restoring shrimp effluent to conditions that support aquatic life.

Conclusion

The study on the wastewater treatment capacity and growth performance of the four macroalgae species can be summarized as follows:

Treatment Efficiency: demonstrated the best performance, achieving the highest reduction in ammonia and nitrite, while increasing DO to a peak of 10.5 mg/L.

Growth Rate: Blanket Algae (*Cladophora sp.*) and Red Algae (*Gracilaria sp.*) showed superior growth, reaching final blotted wet weights of 50g and 48.36g, respectively, from an initial weight of 20g

Recommendation: Based on these findings, Blanket Algae (*Cladophora sp.*) and Red Algae (*Gracilaria sp.*) are the most promising species for application as biological filtration systems in sustainable shrimp aquaculture

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Acknowledgements

The study on the potential assessment of Sea Lettuce (*Ulva lactuca*), Sea Grapes (*Caulerpa lentillifera*),), Red Algae (*Gracilaria sp.*) and Blanket Algae (*Cladophora sp.*) for wastewater treatment in shrimp aquaculture was successfully completed with the support of many individuals.

I would like to express my sincere gratitude to Mrs. Sirikhwan Nuputthi for her invaluable mentorship, guidance, and insightful suggestions throughout the course of this project. Her expertise was instrumental in addressing various challenges and ensuring the success of this research.Special thanks are extended to the shrimp farm owners and the algae cultivation centers for providing access to the study sites, donating the four macroalgae species, and facilitating the data collection process.Furthermore, I am deeply grateful to the Director and the faculty members of Princess Chulabhorn Science High School Trang for their continuous support. Finally, I would like to thank my parents for their encouragement and support, which made the completion of this research possible.

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GLOBE Database

Nitrates	
Measured Date:	2026-01-28
Organization Name:	Princess Chulabhorn Science High School Trang
Site ID:	409386
Site Name:	บ่อเลี้ยงกุ้ง
Country Name:	Thailand
Country Code:	THA
Latitude:	7.1875
Longitude:	99.6832
Elevation:	7m
Measured At:	2026-01-28T14:27:00
Nitrate-Nitrogen + Nitrite-Nitrogen:	2 mg/L
Nitrite-Nitrogen Only:	0.5 mg/L
Water Body State:	normal
Nitrate Kit Mfg:	other
Nitrate Kit Model:	HANNA

pH	
Measured Date:	2026-01-28
Organization Name:	Princess Chulabhorn Science High School Trang
Site ID:	409386
Site Name:	บ่อเลี้ยงกุ้ง
Country Name:	Thailand
Country Code:	THA
Latitude:	7.1875
Longitude:	99.6832
Elevation:	7m
Measured At:	2026-01-28T14:27:00
Water Body pH:	7 pH units
Water Body State:	normal
pH Method:	meter
pH Buffer 7:	true

Optional Badge

I am an Earth System Scientist

Reason for Selection: This research clearly demonstrates the dynamic relationship between the Hydrosphere and the Biosphere by examining how the biological processes of living organisms (macroalgae) influence changes in water chemistry.

Academic Description: This project focuses on interdisciplinary Earth system studies by analyzing the interactions between the biological processes of macroalgae and the quality of aquaculture wastewater. The research team applied GLOBE protocols to monitor changes in Dissolved Oxygen (DO), pH levels, and nitrogen compounds. These measurements reflect the vital role of biological organisms in maintaining the equilibrium of aquatic environments and the cycling of nutrients within the ecosystem.

I make an Impact

Reason for Selection: The research originated from a local environmental crisis wastewater issues from shrimp farms and led to the proposal of practical, actionable solutions to mitigate impacts on the community.

Academic Description: This study bridges local environmental issues with sustainable natural resource management. By analyzing empirical experimental data, the research team identified the most efficient algae species Blanket Algae (*Cladophora sp.*) and Red Algae (*Gracilaria sp.*) for pollutant removal. These findings not only contribute to new scientific knowledge but also provide policy recommendations for farmers and coastal communities to adopt Nature-based

Solutions (NbS) for wastewater treatment. This approach positively impacts water pollution reduction and enhances the quality of life for local inhabitants.

I am a Problem Solver

Reason for Selection: This research goes beyond simple observation; it is an experimental endeavor to find a "solution" to the contamination of ammonia and nitrite in local water sources.

Academic Description: The research team demonstrated their role as problem solvers through Earth System Science by designing experiments to find low cost, eco friendly pollution treatment alternatives. Proving that macroalgae can reduce ammonia levels from 0.6 ppm to 0.1 ppm confirms the success in addressing ecological structural issues. Consequently, this research serves as a model for transforming pure scientific knowledge into tangible innovations for resolving localized environmental challenges.