Comparative Study of the Growth Rate and Wastewater Treatment Efficiency of (*Caulerpa sertularioides)* and *(Ulva intestinalis)* in Shrimp Pond Effluent

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Abstract:

This study aimed to compare the growth rate and wastewater treatment efficiency of (*Caulerpa sertularioides)* and *(Ulva intestinalis)* in shrimp pond wastewater. The experiment was conducted under two water conditions: seawater (control) and shrimp pond wastewater. Each condition consisted of three treatments: (*C.sertularioides*), (*U.intestinalis)*, and a mixed culture, with three replicates per treatment over a four-week period. Algae were cultured in 40-liter basins with an initial biomass of 25 g. Water quality parameters, including dissolved oxygen (DO), pH, temperature, and salinity, were monitored, and growth rate was determined by weekly biomass measurements.The results indicated that (*U.intestinalis)* exhibited the highest wastewater treatment efficiency, with DO increasing from 6.40±0.00 mg/L to 7.25±0.37 mg/L, significantly higher than (*C.sertularioides*)and the mixed culture ($p<0.05$). The pH in the (*U.intestinalis)* treatment was 8.0±0.05, within the optimal range. In terms of growth rate, (*U.intestinalis)* showed the highest value (54.40%), followed by the mixed culture (51.60%) and (*C.sertularioides*) (42.80), with significant differences among treatments ($p<0.05$).These findings demonstrate that (*U.intestinalis)* has high potential as an effective and environmentally friendly biological treatment for shrimp pond wastewater.

Keywords: (*Caulerpa sertularioides*), (*Ulva intestinalis),* **wastewater,** shrimp pond

Research Question:

1. Which species, between Feather algae (*Caulerpa sertularioides*) and Gut weed (*Ulva intestinalis*), demonstrates higher efficiency in treating shrimp farm wastewater over a one-month period?
2. How does the pollutant reduction efficiency in shrimp farm wastewater correlate with the growth rates of Feather algae (*Caulerpa sertularioides*) and Gut weed (*Ulva intestinalis*)?

Hypothesis

The efficiency in treating shrimp pond effluent was highest for *Ulva intestinalis*, followed by a combination of Ulva intestinalis and *Caulerpa sertularioides*, and *Caulerpa sertularioides*, respectively.

Introduction and Review of Literature

Currently, Trang province is a major hub for shrimp farming due to its geography being highly suitable for fisheries in Thailand. However, the shrimp farming process often generates wastewater with high levels of pollutants, particularly regarding Biological Oxygen Demand (BOD) and suspended solids. If not properly treated, this effluent flows into natural water sources, causing water pollution, foul odors, and ecosystem destruction, ultimately adversely affecting the quality of life for surrounding communities. Research on wastewater treatment indicates that Feather algae (*Caulerpa sertularioides*) and Gut weed (*Ulva intestinalis*) are fast-growing aquatic plants capable of absorbing excess nutrients, such as nitrogen and phosphorus, and reducing water contamination (Suleemas Sutthineam, 2009). Consequently, they have gained attention for potential use as biological agents in treating wastewater, particularly effluents with high organic content. Additionally, both *C. sertularioides* and *U. intestinalis* help increase Dissolved Oxygen (DO) levels, thereby improving water quality and creating a suitable environment for aquatic life.

Recognizing these issues, the researchers cultivated *C. sertularioides* and *U. intestinalis* in shrimp farm wastewater to study and compare their respective efficiencies in wastewater treatment. The objective is to establish guidelines for using plant-based treatment (phytoremediation) as an eco-friendly approach that can be further developed for sustainable environmental solutions.

Research Method and Materials *(including GLOBE Data!)*:

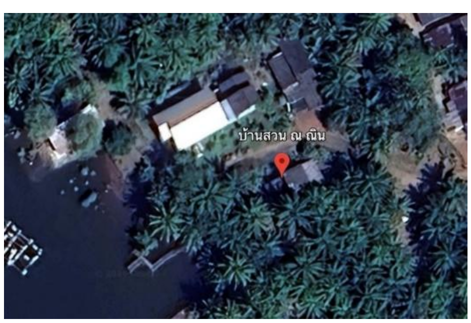
1) Chlorine powder
2) Shrimp farm wastewater
3) 40-liter plastic basins
4) Air pumps
5) Cheesecloth
6) Salinity meter
7) pH meter
8) Precission balance
9) DO meter
10) Thermometer
11) Plankton nets

Study site

The study was conducted in two locations as follows:

1. Princess Chulabhorn Science High School Trang, located in Bang Rak Subdistrict, Mueang Trang District,Trang Province (coordinates 7°33′13.1"N , 99°33′26.8"E).
2. Shrimp pond , located in Palian District, Trang Province (coordinates 7°10’23”N,99°40’37”E).

Picture 1 : Princess Chulabhorn Science High School Trang, located in Bang Rak Subdistrict, Mueang Trang District,Trang Province.

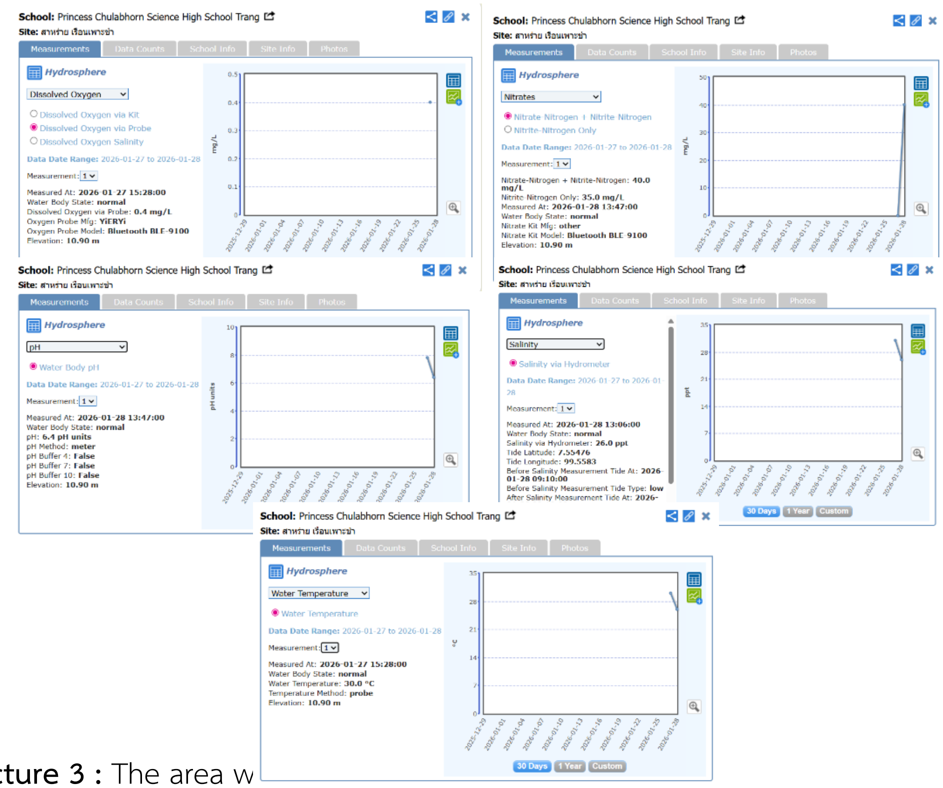


Picture 2 : Shrimp pond , located in Palian District, Trang Province

Data Collection of Water Quality

Measure water quality according to GLOBE protocols. So, we measured pH, DO, temperature, and surface temperature. As the following steps :

1) Located the point and collected the samples of the wastewater
2) Using Land Cover in GLOBE Observer Application
3) Collected the information about the water quality, such as pH by pH meter, dissolved oxygen by DO meter, temperature, and surface temperature by thermometer.
4) Repeated the previous step 3 times. Then, calculated to find the average.
5) Send the information to GLOBE Data Entry.
6) Submit the collected data to the GLOBE Data Entry system.



Picture 3 : The area w

Research Method

1) Preparation of Control Seawater

The seawater was sterilized using chlorine powder at a concentration of 30 mg/L and allowed to stand for 7–10 days. Prior to use, a chlorine test kit was employed to ensure zero residual chlorine. The water was then filtered through a 20-micrometer plankton net into the basins and set aside for the experiment.

2) Preparation of Shrimp Pond Effluent

The effluent was collected and allowed to settle in basins. The supernatant (top-layer water) was then filtered through a 20-micrometer plankton net into three separate basins reserved for the experimental treatments.

3) Initial Water Quality Analysis

Baseline water quality parameters—including Dissolved Oxygen (DO), pH, Electrical Conductivity, Turbidity, and Nitrogen/Phosphorus concentrations—were measured for both the control seawater and the shrimp pond effluent before the commencement of the experiment.

4) Algae Preparation

4.1 Selection and Cleaning: Healthy *Caulerpa sertularioides* (Feather Algae) and *Ulva intestinalis* (Gutweed) specimens were selected. They were washed multiple times with clean water to remove debris, sand, and contaminants.

4.2 Disinfection: The algae were soaked in a low-concentration chlorine solution for 5–10 minutes to eliminate pathogens without damaging the plant tissues.

4.3 Rinsing and Acclimatization: After disinfection, the algae were rinsed thoroughly to remove residual chlorine and soaked in clean water for 30 minutes for recovery and acclimatization.

4.4 Initial Weighing: The initial wet weight of each algae species was recorded before introducing them into the experimental basins.

5. Experimental Design and Setup

5.1 Control Group (Seawater): Three basins containing 40 liters of seawater each.

5.2 Experimental Group (Effluent): Three basins containing 40 liters of shrimp pond effluent, subdivided into three treatment replicates.

5.3 Treatments: Both groups followed three cultivation formats:

5.3.1 *Caulerpa sertularioides* only.

5.3.2 *Ulva intestinalis* only.

5.3.3 A polyculture of both species.

5.4 Stocking Density: A ratio of 2.5 g of algae per 1 liter of water was maintained across all treatments.

6. Experimental Procedures

6.1 Maintenance: All basins were covered with muslin cloth to prevent contamination while allowing aeration and light penetration. The experiment lasted for 4 weeks. Water clarity and intensity were observed and recorded daily.

6.2 Water Replacement: On a weekly basis, 30 liters of water were replenished in each basin. For the control group, chlorine at 30 mg/L was added to the replenishment water (ensuring neutralization before use).

6.3 Data Collection:

6.3.1 Water Quality: DO, pH, Turbidity, and Nitrogen/Phosphorus levels were measured weekly.

6.3.2 Growth Performance: Average length and weight gain were recorded weekly to calculate the Relative Growth Rate (RGR) based on the standard growth equation.

Data analysis

The data were analyzed using the following methods:

1) 1. One-Factor Analysis of Variance (ANOVA) with replication.
2) 2. Standard Deviation (S.D.).
3) 3. Mean ($\bar{x}$).

Results

1) Growth Rates of *C. sertularioides* and *U. intestinalis* in Control Seawater

The study analyzed the growth performance of *Caulerpa sertularioides* and *Ulva intestinalis* cultivated in seawater (control group) over a 4-week period. The results indicated a consistent increase in biomass for all treatments, as detailed in Table 1.

Total Biomass: The highest final weight was observed in the U. intestinalis treatment, followed by the polyculture (*C. sertularioides* + *U. intestinalis*) and the *C. sertularioides* monoculture, with weights of 33.1 ± 0.36 g, 32.5 ± 0.31 g, and 31.9 ±0.28 g, respectively.

Weight Gain: In terms of net weight increase, *U. intestinalis* showed the highest growth at 8.1 ± 0.36 g, followed by the polyculture at 7.5 ± 0.31 g, and *C. sertularioides* at 6.9 ± 0.28 g.

Percentage Weight Increase: The percentage weight increase followed the same trend: *U. intestinalis* yielded the highest percentage at 32.40%, followed by the polyculture at 30.00%, and *C. sertularioides* at 27.60%, as summarized in Table 1.

Table 1: Average weight, weight gain, and percentage weight increase of *C. sertularioides* and *U. intestinalis* cultivated in control seawater over 4 weeks.

Treatment	Weight			
	Initial Weight (g)	Final Weight (g)	Weight Gain (g)	Weight Increase(%)
C. sertularioides	25±0.00	31.9±0.28	6.9±0.28	27.60
U. intestinalis	25±0.00	33.1±0.36	8.1±0.36	32.40
Polyculture (*C.s+U.i*)	25±0.00	32.5±0.31	7.5±0.31	30.00

2) **Growth Performance of *C. sertularioides* and *U. intestinalis* Cultivated in Shrimp Pond Effluent**

The study on the biomass of *C. sertularioides* and *U. intestinalis* cultivated in shrimp pond effluent over a 4-week period showed a significant increase in weight for all treatments, as presented in Table 2. The *U. intestinalis* treatment achieved the highest final weight, followed by the polyculture (*C. sertularioides* + *U. intestinalis*) and the *C. sertularioides* monoculture, with weights of 38.6 ± 0.21 g, 37.9 ± 0.20 g, and 35.7 ± 0.18 g, respectively.

Regarding weight gain, the *U. intestinalis* treatment showed the highest increase at 13.6 ±0.21 g, followed by the polyculture at 12.9 ± 0.20 g and *C. sertularioides* at 10.7 ± 0.18 g. Similarly, the percentage weight increase was highest in *U. intestinalis* (54.40%), followed by the polyculture (51.60%) and *C. sertularioides* (42.80%).

Table 2: Average weight, weight gain, and percentage weight increase of *C. sertularioides* and *U. intestinalis* cultivated in shrimp pond effluent over 4 weeks.

Treatment	Weight			
	Initial Weight (g)	Final Weight (g)	Weight Gain (g)	Weight Increase(%)
C. sertularioides	25±0.00	35.7±0.18	10.7±0.18	42.80
U. intestinalis	25±0.00	38.6±0.21	13.6±0.21	54.40
Polyculture (*C.s+U.i*)	25±0.00	37.9±0.20	12.9±0.20	51.60

3) **Water Quality Analysis in Control Seawater (4 Weeks)**

The analysis of water quality in the control seawater group over the 4-week cultivation period revealed that the average pH ranged from 7.7 to 8.2, and average salinity was between 30 and 32 ppt. The average Dissolved Oxygen (DO) levels ranged from 6.5 to 7.6 mg/L. The average surface water temperature was between 30 and 31°C, while the sub-surface temperature ranged from 29 to 29.5°C, as detailed in Table 3.

Table 3: Water quality parameters in control seawater for *C. sertularioides* and *U. intestinalis* cultivation.

Parameters	Pre-experiment	Treatment		
		C. sertularioides	*U. intestinalis*	Polyculture
pH	8.1	7.9±0.07	7.8±0.08	7.7±0.06
Salinity)ppt(	30	31.2±0.30	31.40±0.35	31.30±0.25
DO)mg/L(	6.50	7.1±0.20	7.40±0.25	7.60±0.30
Surface Temp)°C(	30	30.2±0.50	30.3±0.50	30.2±0.45
Sub-surface Temp)°C(	29	29.2±0.40	29.3±0.40	29.2±0.35

4) **Water Quality Analysis in Shrimp Pond Effluent (4 Weeks)**

The water quality of the shrimp pond effluent group during the 4-week cultivation period showed average pH levels between 7.8 and 8.1, and average salinity between 20 and 20.3 ppt. The average DO ranged from 6.4 to 7.3 mg/L. The average surface water temperature was between 26.3 and 26.5°C, and the sub-surface temperature ranged from 25.5 to 25.7°C, as shown in Table 5.

Table 4: Water quality parameters in shrimp pond effluent for *C. sertularioides* and *U. intestinalis* cultivation.

Parameters	Pre-experiment	Treatment		
		C. sertularioides	*U. intestinalis*	Polyculture
pH	8	7.9±0.06	8.0±0.05	7.8±0.07
Salinity)ppt(	20	20.1±0.18	20.2±0.16	20.0±0.20
DO)mg/L(	6.40	6.92±0.34	7.25±0.37	7.01±0.35
Surface Temp)°C(	26.4	26.3±0.65	26.4±0.67	26.3±0.66
Sub-surface Temp)°C(	25.7	25.5±0.61	25.6±0.63	25.5±0.62

Discussion

Comparative Study of Growth Rates and Effluent Treatment Efficiency from Shrimp Ponds using *Caulerpa sertularioides* and *Ulva intestinalis*. The summary and discussion are as follows: The study of the weights of *C. sertularioides* and *U. intestinalis* was divided into 2 experimental groups: Experimental Group 1: Seawater (Control Group), and Experimental Group 2: Effluent from shrimp ponds. Each experimental group was divided into 3 sub-experimental groups: *C. sertularioides*, *U. intestinalis*, and a mixture of *C. sertularioides* and *U. intestinalis*. After 4 weeks of cultivation, it was found that *Ulva intestinalis* had the highest final weight, weight gain, and percentage weight increase in both the seawater (control) group, with values of 33.1±0.36, 8.1 ±0.36, and 32.40 respectively, and the shrimp pond effluent group, with values of 38.6±0.21, 13.6 ±0.21, and 54.40 respectively. This was followed by the mixture of *C. sertularioides* and *U. intestinalis*, which in the seawater (control) group had values of 32.5±0.31, 7.5±0.31, and 30.00 respectively, and in the shrimp pond effluent group had values of 37.9 ±0.20, 12.9 ±0.20, and 51.60 respectively. *Caulerpa sertularioides* had the lowest final weight, weight gain, and percentage weight increase compared to the other experimental groups. In the seawater (control) group, the values were 31.9±0.28, 6.9±0.28, and 27.60 respectively, and in the shrimp pond effluent group, the values were 35.7±0.18, 10.7±0.18, and 42.80 respectively.

When the data were statistically analyzed, a significant difference was found ($p < 0.05$) in the comparative study of effluent treatment efficiency from shrimp ponds.

Conclusion

From the experiment, it was found that *Ulva intestinalis* had the highest efficiency in treating effluent from shrimp ponds because it helped increase the amount of dissolved oxygen. The dissolved oxygen content increased from 6.40±0.00 mg/L before the experiment to 7.25±0.37 mg/L, which was higher than the cultivation of *Caulerpa sertularioides* (6.92±0.34 mg/L) and the polyculture (7.01±0.35 mg/L). When the data were statistically analyzed, a significant difference was found ($p < 0.05$). The increase in dissolved oxygen is an indicator that the water quality has improved and a high level of photosynthesis has occurred, as well as maintaining the pH value within the appropriate range and having the most stability. According to Table 5, it was found that the pH value of the effluent from shrimp ponds in the *Ulva intestinalis* group was 8.0±0.05, which was close to the value before the experiment of 8.00±0.00. When the data were statistically analyzed, a significant difference was found ($p < 0.05$).

Acknowledgements

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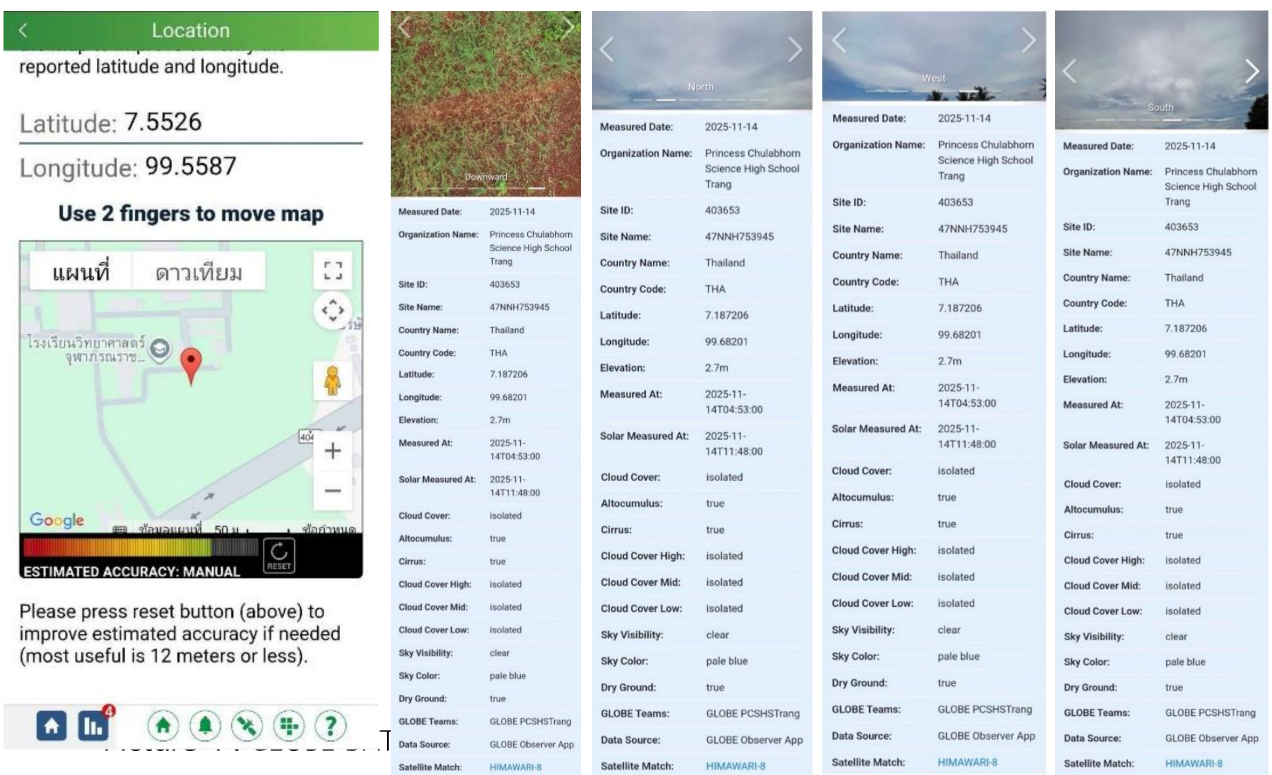
GLOBE's Database



(Optional) Badge Descriptions/Justifications

I am a collaborator

All team members, including students from the same school or schools from around the world, along with clearly defined roles, how these roles support each other, and a description of each student's role. The description clearly demonstrates the advantages of collaboration. If students collaborate with students from other schools, explain how working with other schools improves the research.

I make an impact

This report originated from observing the problem of wastewater from shrimp ponds, which is a cause of water pollution. Students analyzed the problem and designed an experiment to find a treatment method by studying the wastewater treatment efficiency of Caulerpa lentillifera (Sea Grapes) and Ulva intestinalis (Gutweed). The experiment allowed students to solve problems systematically and apply the study to real-life situations.

I am a Data Scientist

This report utilized a process of collecting and analyzing data from actual experiments. Students specified the types of algae used to treat wastewater from shrimp ponds, categorized into Caulerpa lentillifera (Sea Grapes), Ulva intestinalis (Gutweed), and a combination of both. Water quality measurements were recorded for each experimental set within a defined timeframe. The data was then calculated into percentages, comparing the results across each set and presenting them in a table format. Students also discussed data limitations to use the information as evidence for drawing conclusions and answering the research questions logically.