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Research Article

Research solutions biological activated sludge for seafood wastewater treatment

Vinh Son Lam[1*], Vu Phong Nguyen[1], Phu Huynh[1]

[1] Hochiminh University of Technology (HUTECH), Vietnam. Add: 475 A Dien Bien Phu Street, 25 Ward, Binh Thanh District, Hochiminh City, Vietnam; lv.son@hutech.edu.vn; nv.phong@hutech.edu.vn; h.phu@hutech.edu.vn

* Correspondence: lv.son@hutech.edu.vn; Tel: +84–903399800

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Abstract: This article presents aquatic wastewater treatment with the addition of probiotics. Due to the high salinity (5–10‰), the microorganisms are inactive because plasmolysis occurs in the presence of table salt, the contraction of the protoplasm away from the cell wall of the bacteria due to dehydration under the action of osmotic pressure, leading to gaps between the cells and the cell membranes. The use of probiotics containing *Saccharomyces* yeast in combination with some bacteria strains to treat aquatic wastewater with high salinity has drawn much interest, but there are no specific studies. By employing experimental method, using two synthetic preparations Microbe–Lift IND and EM–WAT1 contribute to improving the treatment efficiency of activated sludge at different salinity to give the appropriate dosage for application. into practice. Research results show that the optimal load is 4.5kg COD/m^3/day, with a retention time of 8 hours, the optimal salinity after the test is about 5 ‰ to 10 ‰, using 0,25mL Microbe–Lift IND and EM–WAT1 for a liters of wastewater.

Keywords: Halophilic microorganisms; High salinity; Salty favored microorganisms; Seafood wastewater.

1. Introduction

According to the Vietnam Association of Seafood Exporters and Producers (VASEP), Vietnam is among the top 5 countries in the world for aquaculture and seafood export, the brackish water shrimp farming area in Vietnam is more than 685,000 hectares, with an output of more than 660,000 tons and there are more than 500 seafood processing factories nationwide [1]. Many factories and processing factories were established and put into operation, environmental isuses and wastewater quality after treatment. Many seafood processing factories located on the coast often use seawater for many stages such as thawing, washing raw materials due to the lack of fresh water used…Besides, the usual pollution indicators type of wastewater, there is also an index of high salinity from 10 to 30 g/l NaCl) [2]. In such an environment, microorganisms will lose activity because the plasmolysis process takes place because of the presence of NaCl, which means the phenomenon of protoplasm is far away from the cell wall of the bacteria due to the lack of water [3–4].

There are many species of microorganisms that desperately need salinity for growth and development known as halophilic microorganisms, which often have low intracellular salt concentrations in order to maintain the osmotic balance between cytoplasm with the external medium, by accumulating high concentrations of organic osmoling agents [5].

Many studies of saline wastewater treatment have applied biological methods with the participation of oxygen and combination with halophilic microorganisms [6–7]. There has been a study to eliminate the chemical oxidation demand (COD) in saline wastewater by using a rotating biological disc system (RBC–Rotating Biological Contactor) with microbial sludge biomass supplemented with Halobacterium Halobium [8–11].

Nowadays, the use of probiotics in general and liquid probiotics in particular containing the yeast Saccharomyces strain, combining a number of bacteria strains to treat high–salt aquaculture wastewater are being interested in but no specific research. Currently on the market there are many different types of probiotics, but there are two types of probiotic products such as Microbe–Lift IND and EM–WAT1. Researching a biological solution of activated sludge suitable for treating aquatic wastewater with a high salt concentration, along with the addition of the yeast Saccharomyces strain combining some bacteria strains to enhance the treatment capacity is essential. This study contributes to the evaluation of the treatment efficiency of activated sludge when supplemented with 2 inoculants, Microbe–Lift IND and EM–WAT1 at different salinity levels and to give appropriate dosage for practical application.

2. Methods of research

2.1. Experimental method

a) Building aerobic bio–treatment model combining active sludge consisting of 7 tanks. With the operating parameters of the model include: tank volume of 36 liters, water storage time of 8 hours, wastewater flow of 1.25 ml/s, organic load of 4.5 kg/m^3.day. Seafood wastewater treatment with different concentrations from IND and EM–WAT1 bio–preparations. Sampling and analyzing COD, BOD$_5$, MLSS, S, pH targets to determine and evaluate the processing performance of the model.

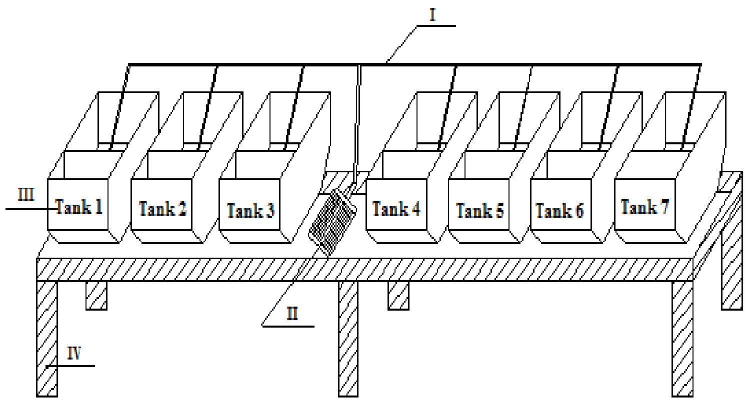

Figure 1. Model of experimental tank.

b) Model operation: Experiments 1, 2: During the test run, select the salinity and load limits: the total sample number is 126 samples with 5 indicators so there should be a total of 630 samples analyzed (126 samples x 5 indicators = 630 samples analyzed). The stage for determining the appropriate salinity: the stage determines the appropriate salinity: the total sample volume is 162 (54 + 108) samples, so there are a total of 324 samples analyzed (54 samples x 4 indicators + 108 x 1 indicators = 324 samples analyzed). Experiment 3: The optimal dosage determination phase of the supplement: with 294 samples analyzed (84 samples x 2 indicators + 42 x 3 indicators = 294 samples analyzed).

2.2. Sampling, preservation and analysis methods

Conduct measurement survey, sampling analysis of aquatic wastewater dynamic parameters for assessment of wastewater treatment capacity when supplementing preparations. Sampling, preservation and analysis methods.

– National standards TCVN 6663–1:2011 (ISO 5667–1:2006) with Water Quality–Sampling–Part 1: Sampling Program Guide and Sampling Techniques.

– National standards TCVN 6663–3:2008 (ISO 5667–3:2003) with Water Quality–Sampling. Guidelines for preservation and storage of water samples.

– National standards TCVN 5999:1995 (ISO 5667–10:1992) with Water Quality–Sampling. Instructions for wastewater sampling.

2.3. Comparison method

Assessment of the effectiveness of seafood wastewater treatment when supplementing preparations based on QCVN 11–MT: 2015/BTNMT; Level B National technical regulation on the effluent of aquatic products processing industry.

Table 1. Table on the analysis of seafood wastewater targets.

Parameter	**Analysis method**	**Unit**	**Maximum allowable value (B)**
Sample	TCVN 6663–3:2008 Water quality – Sampling, preservation	–	–
COD	TCVN 6491:1999 Water quality – Determination of chemical oxygen demand (COD)	mg/l	150
BOD_5	TCVN 6001–1:2008 Water quality – Determine biochemical oxygen demand after n days (BODn)	mg/l	50
Cl–	TCVN 6194 : 1996 Water quality – Determination of chloride salinity	mg/l	
pH	TCVN 6492:2011 Water quality – Determine pH	–	5.5–9
MLSS	TCVN 6625:2000 Water quality – Determination of suspended solids by filtration through a fiberglass filter	mg/l	100

2.4. Determined measurement method

– Statistical method and data processing: Running a data processing model to determine the accuracy of the experiment, making tables, charts to compare and evaluate model results.

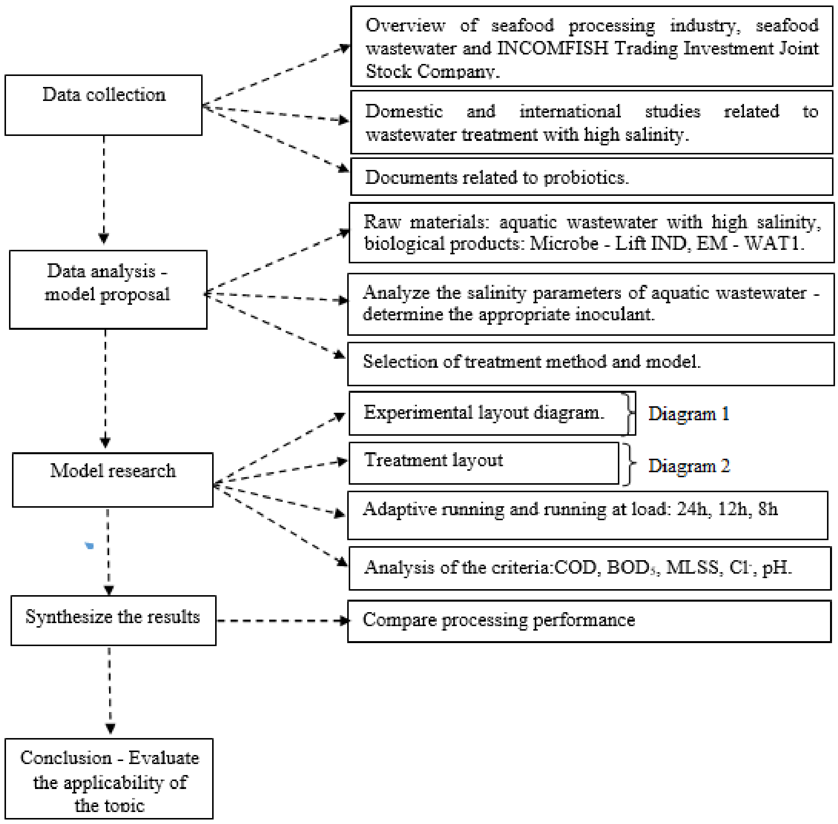

Figure 2. Research diagrams.

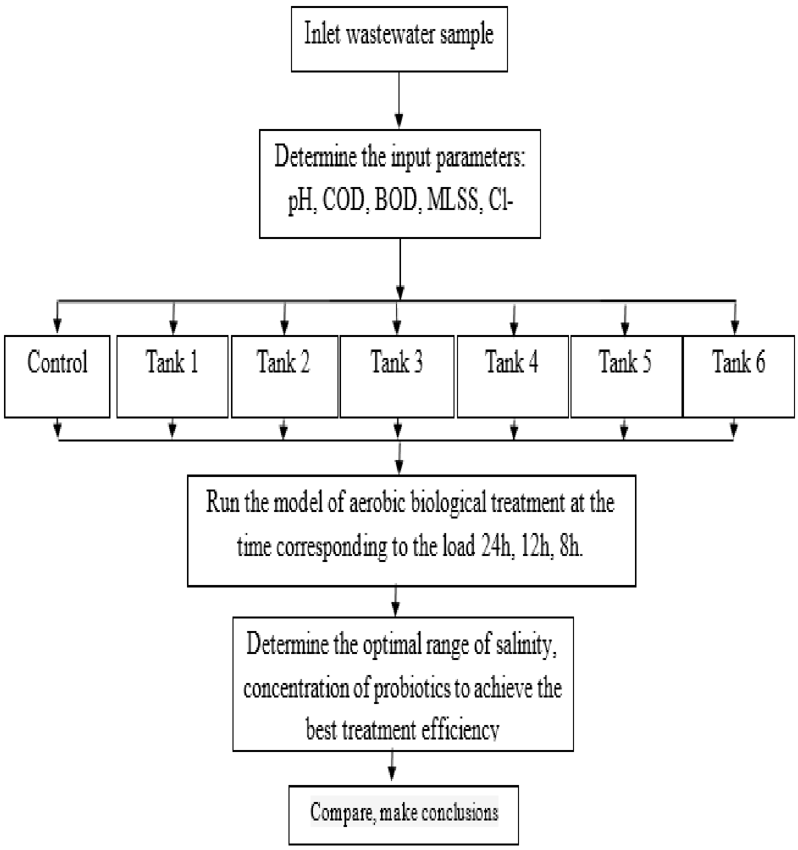

Figure 3. Experimental arrangement.

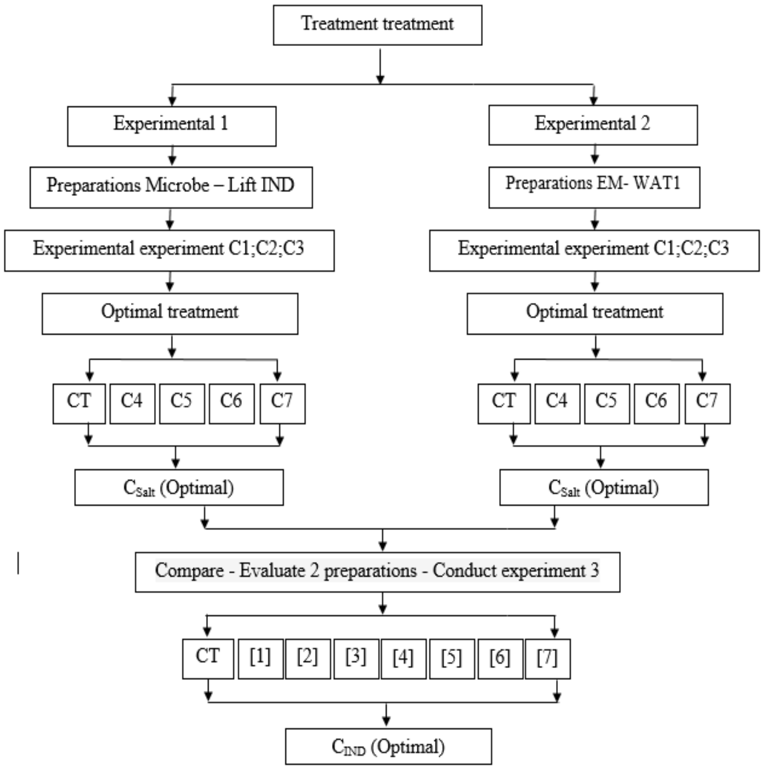

Figure 4. Experimental layout.

3. Results and discussion

To apply at a greater range wastewater sources with higher salinity, the study conducted experiments in 3 final tests corresponding to salinity of 1‰, 5‰, 10‰ and from selected the optimal processing value ranges from 6‰, 7‰, 8‰, 9‰, 10‰. From there, evaluate the treatment efficiency of the activated sludge method with bio–products and find out the optimal salinity range. Compare and select the most appropriate preparation, determine the optimal concentration of inoculants to apply in practice.

3.1. Determination of salinity value suitable for biological products

Conducting tests at 3 different salinity levels to find the most suitable treatment salinity range with the dosage of the supplement Microbe–Lift IND and EM–Wat1 recommended by the manufacturer.

The analysis results showed that Microbe–Lift IND inoculant was processed at higher salinity when compared with EM–WAT1. The evidence at 8‰ salinity, treatment efficiency after 6 days is more than 80%, approximately the treatment efficiency at salinity 6‰ and 7‰. And at 9‰ salinity the efficiency is lower than 80%. This shows that microorganisms still operate effectively at 8‰ salinity, 8‰ is chosen as the optimal salinity. Therefore, use Microbe–Lift IND probiotics to continue processing at optimal salinity to determine the most appropriate inoculant concentration. Based on research, we can choose probiotics suitable for wastewater with different salinity, to save treatment costs.

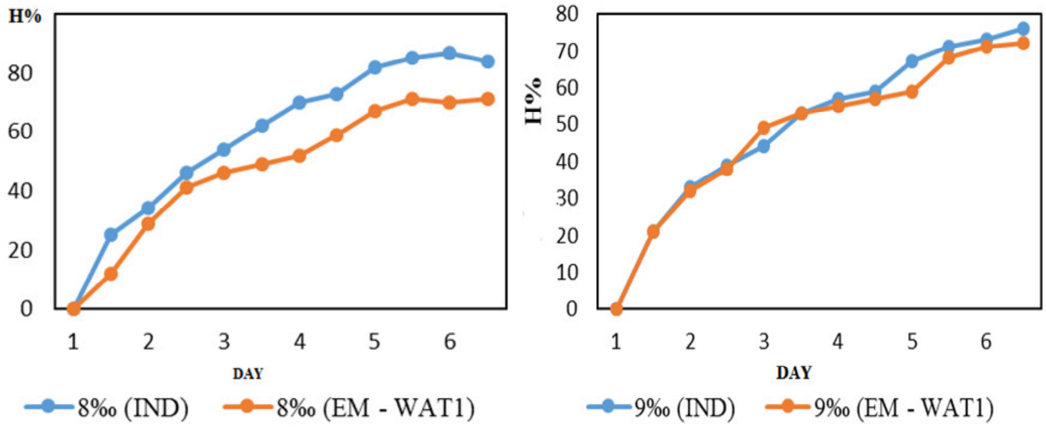

Figure 5. Processing efficiency of inoculants Microbe–Lift IND and EM–WAT1 at salinity 6‰, 7‰, 8‰, 9‰.

3.2. Test to determine the optimal concentration of the supplement at the appropriate salinity

Continue to experiment in different treatments to find out the optimal amount of probiotics: fix the salinity at 8‰, the retention time is 8 hours, added the tanks times the dosage Microbe–Lift IND supplement are 5 ml, 6 ml, 7 ml, 8 ml, 9 ml and 10 ml. Analyze the output samples, compare and conclude the dosage of probiotics to be used.

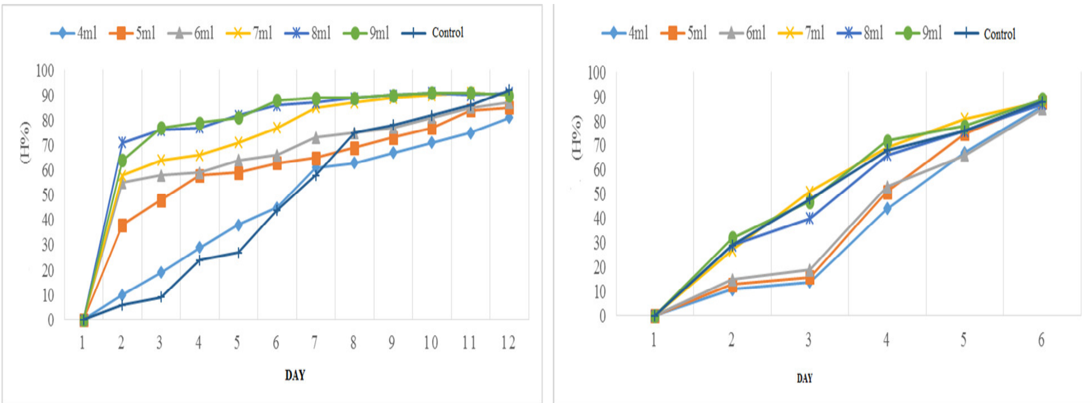

Figure 6. Evolution of COD and BOD_5 treatment efficiency by day when supplementing with Microbe – Lift IND probiotics at different dosages.

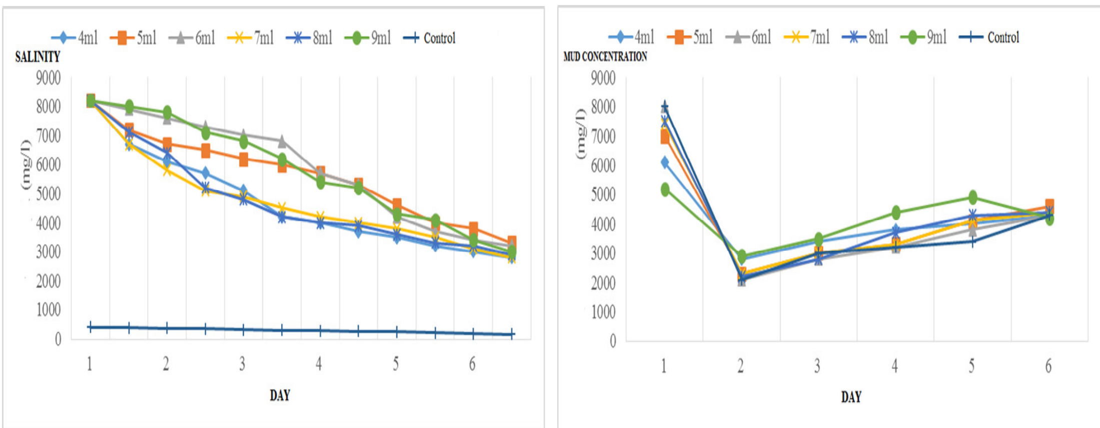

Figure 7. Performance of salinity treatment and MLSS by day when supplementing with Microbe–Lift IND probiotics at different dosages.

COD analysis results showed that the higher the dose of probiotics added, the higher the treatment efficiency. Therefore, the optimal concentration of probiotics is 0.25 ml of inoculant/L of wastewater (corresponding to 9ml/36L of study wastewater). BOD_5 analysis results show that treatment efficiency at 7 ml, 8 ml and 9 ml is better than 4 ml, 5 ml, 6 ml, in which it is at the most stable 7 ml.

Analysis results showed that the salinity in the tank decreases over time. It shows that the higher the volume of the inoculant is in proportion to the lower the salinity. The amount of sludge in the tanks increased during the first days of treatment but was corrected and remained stable at about 2000–4000 ml. The results show that microorganisms decompose organic matter present in wastewater and increase biomass and partly absorb salt from wastewater.

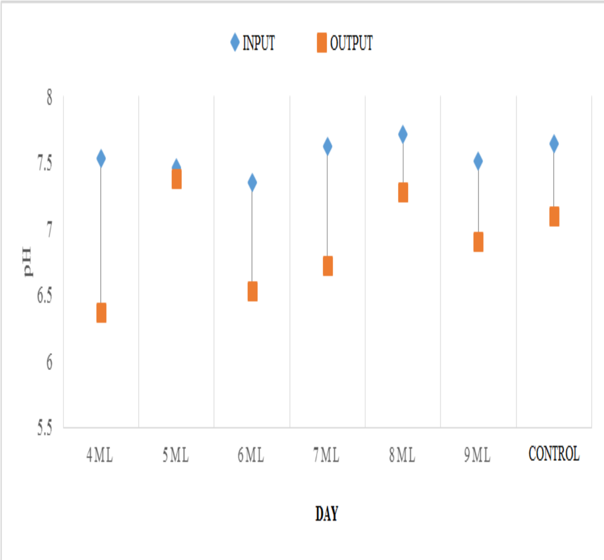

Figure 8. The evolution of pH by day when supplementing with Microbe–Lift IND at different dosages.

With low inoculant concentration, the pH range is wider. When the concentration of the inoculant is increased, the range of variation is reduced and lies at the effective level of treatment.

4. Conclusion

Compared in volumes, it was concluded that at 9 ml, wastewater treatment capacity at 8‰ salinity reach over 90% by 4 days, if the dosage supplement is low, the processing performance is not equal high dosage supplementation is expensive for the purchase of additional preparations.

Therefore, the preferred concentration of the composition is 0.25 ml of wastewater. Optimal handling load: 4.5kg COD/m^3.day for 8 hours of storage time for 2 preparations.

When running the model at 3 loads: 24–hour, 12–hour, 8–hour when the addition of 2 preparations then the 8–hour load achieves high processing performance abouve 80% at salinity 1‰ and 5‰ and 10‰ are the lowest processing efficiency.

Processing performance of Microbe–Lift IND preparations is high at salinity 6‰, 7‰ and 8‰ and decreased at salinity 9‰. The processing performance of EM–WAT1 preparations is most effective in salinity 6‰ and decreases when increasing salinity to 7‰, 8‰, 9‰. From there, it is concluded that the ability to process Microbe–Lift IND at high salinity better than EM–WAT1.

Wastewater after treatment in accordance with QCVN 11–MT: 2015/BTNMT; Column B National technical regulation on the effluent of aquatic products processing industry.

Author's contribution: Constructing research ideas: V.S.L., V.P.N.; Select research method: V.S.L., V.P.N., P.H.; Sampling: V.S.L., V.P.N.; Sampling analyze: V.S.L., V.P.N.; Data processing: V.S.L., V.P.N., P.H.; Write the draft of the article: V.S.L., V.P.N.; Article editing: V.S.L., P.H.

Conflicts of Interest: The authors declare no conflict of interest.

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