A Seminar Paper on

Integrated fish, shrimp and seaweed culture as nature-friendly solution

Course Title: Seminar Course
Course Code: FBE 598
Term: Winter'22

Submitted to

Course Instructors

1. **Dr. A. K. M. Aminul Islam**
   Professor,
   Department of Genetics and Plant Breeding
   BSMRAU
2. **Dr. Satya Ranjan Saha**
   Professor,
   Department of Agroforestry and Environment, BSMRAU
3. **Dr. Shaikh Shamim Hasan,**
   Professor,
   Department of Agricultural Extension and Rural Development, BSMRAU
4. **Dr. Dinesh Chandra Shaha,**
   Associate Professor,
   Department of Fisheries Management, BSMRAU

Major Professor

Prof. Dr. S. M. Rafiquzzaman
Professor,
Department of Fisheries Biology
and Aquatic Environment, BSMRAU

Submitted by

Mst. Sharina Islam
Reg. no: 17-05-4305
MS student
Dept. of Fisheries Biology and Aquatic Environment
BSMRAU

Integrated Fish, Shrimp and Seaweed Culture as Nature Friendly Solution [1]

By

Mst. Sharina Islam [2]

ABSTRACT

In a fish farm produce a large number of effluents and feed waste having organic, inorganic ammonia, phosphate etc. As aqua farming industries develop successively, waste water management is a great challenge to conduct this system fruitfully. Nutrient recycling is the unique way to reuse water by decreasing nutrient, as well as produce high yield. Seaweed has capacity to filter water by their metabolic function with the thallus of it. For sustainable aquaculture, seaweed may be a good water purifier. In these integrated culture systems, seaweed use fish metabolized as nutrient and grow. Here, seaweed function as medication for fish not only water recycling but also decrease pathogenic load from water media. By different case studies, it can say that about 60-80% ammonia and 80% phosphate load decrease as compare to control. *Vibrio* sp. is one of the crucial problems for disease outbreak in shrimp culture which decrease here. Total production of fish also increases than control or monoculture of fish. These seaweeds are also providing some additional nutrient like vitamins, minerals, bioactive compounds through water. Seaweed-fish-shrimp culture in same tank, the organism consumes seaweed and functions as biomedicine readily and enhance immunity and survival rate.

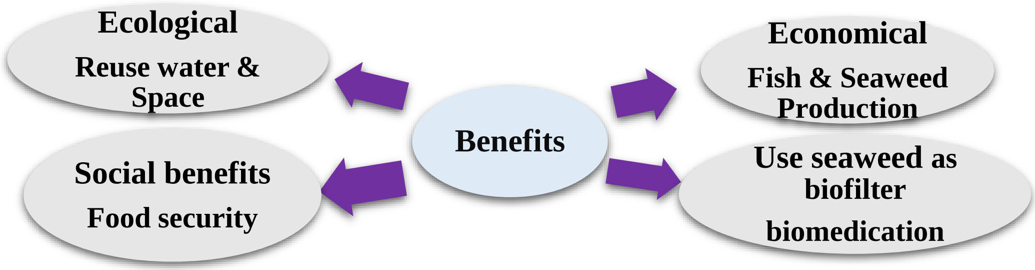


Figure 01. Benefits of seaweed integrated culture

Keyword: Seaweed, Bio-filter, Recycle, Pathogen load, Growth and immunity

---

[1] A seminar paper for the course FBE 598, winter' 22

[2] MS student, Dept. of Fisheries Biology & Aquatic Environment, BSMRAU, Gazipur-1706

BACKGROUND

Integrated fish farming: Integrated fish farming refers to the simultaneous culture of fish or shell fish along with other culture systems. It may also be defined as the sequential linkage between two or more culture practices. Generally integrated farming means the production or culture of two or more farming practices but when fish becomes its major component it is called as integrated fish farming. Fish culture can be integrated with several systems for efficient resource utilization. On farm waste recycling, an important component of integrated fish farming is highly advantageous to the farmers as it improves the economy of production and decrease the adverse environmental impact of farming.

Biofiltration: Biological filtration refers to the process by which beneficial bacteria break down ammonia and nitrite to transform them into nitrate, which is much less toxic. For beneficial bacteria to thrive, oxygen-rich water is needed, as well as a surface that bacteria can attach to, such as rocks or sand, or the media in the filter. All aquariums should have some provisions for biological filtration, and with very small fish populations, this alone might be sufficient to sustain the aquarium. However, in most aquariums, biological filtration will be just one method that is combined with others.

Seaweed: Seaweed, or macro algae, refers to thousands of species of macroscopic, multicellular, marine algae. The term includes some types of Rhodophyta, Phaeophyta and Chlorophyta macroalgae.

Nature-friendly solution: Another solution that can be integrated into the previous recommendation is to use a biofloc system where waste materials like uneaten feeds and feces are converted to feed fish and shrimp, thereby reducing waste output while driving down feed costs and enhancing farm productivity by up to 20 percent.

IMTA: Integrated multi-trophic aquaculture (IMTA) provides the byproducts, including waste, from one aquatic species as inputs (fertilizers, food) for another.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Over the last four decades, the global fish food system has changed and this transition has primarily been driven by monoculture, which is the very fast-growing food production sector in the world (FAO, 2018). In 1970, the global fish product was substantially caught in the wild and monoculture contribute 0nly 3% of total fish products (Asche *et al.*, 2015). During 2014, in monoculture fisheries became one of the major sources of fish food for consumption. In 2016, global monoculture product was estimated at 110.2 million metric tons (MT), which included 80.0 million MT of food fish, 30.1 million MT of aquatic plants, among them mostly seaweeds and 700 MT of non-food products (FAO, 2018). Along with them fisheries, the vibrant monoculture has played a critical part in fish product systems to be honored as an important contributor to global food and nutrition security. Meet the adding demand for fish in the future will continue to depend on the capacity to further expand monoculture product sustainably. (World Bank, 2013). In Asia produces the majority of the product of fish. Asia produces fish about 89% for all global consumers and the top 15 monoculture fish-producing countries counted for 95% of global monoculture output (FAO, 2019). It is necessary to punctuate the critical and continuing part of Asia in global fish food security.

Now, a lot of emphasis is being placed on encouraging more environment friendly aquaculture methods for coastal aquaculture. (Costa-Pierce *et al.,* 2010); (Neori *et al.,* 2004). One such technique for bioremediation of the waste-laden effluents in which seaweeds are cultivated downstream from animals is the integration of finfish aquaculture with macroalgae (seaweeds) culture. An integrated strategy that combines aquaculture of marine macroalgae with finfish can reduce eutrophic inputs of nitrogen and phosphorus from finfish farming. (Neori *et al.,* 2004) Due to their need for dissolved nitrogen and phosphorus, which are waste products in finfish aquaculture from uneaten feed and fish excretion, marine macroalgae gain from co-cultivating with finfish.

Seaweeds provides essential amino acids, essential fatty acids (methionine, valine, lysine, and phenyl alanine) and some necessary minerals such as sodium, iron, calcium, potassium etc. and vitamins. Some seaweeds produce commercial products like: *Gracilaria* produces agar, food bioactive compounds, food for consumers. So, the demand of seaweed increases in the world market gradually. In integrated fish seaweed culture, it will be economically beneficial for both cultures.

In addition to its ecological benefits, integrated aquaculture also offers financial advantages because valuable goods that would otherwise be flushed from the system could be produced using nutrients found in effluents, such as N and P. (Chopin *et al.,* 2001). Contemporary integrated mariculture systems, especially those based on seaweed, are certain to play a significant role in the long-term sustainability of coastal aquaculture (Neori *et al.,* 2004).

The findings of this experiment support those of prior studies of conventional systems that found that the inclusion of seaweed had a favorable impact on production metrics in shrimp culture. Further studies are required to assess the potential usage of additional species of seaweed and comprehend the potential contribution of seaweed to shrimp nutrition in an integrated biofloc system.

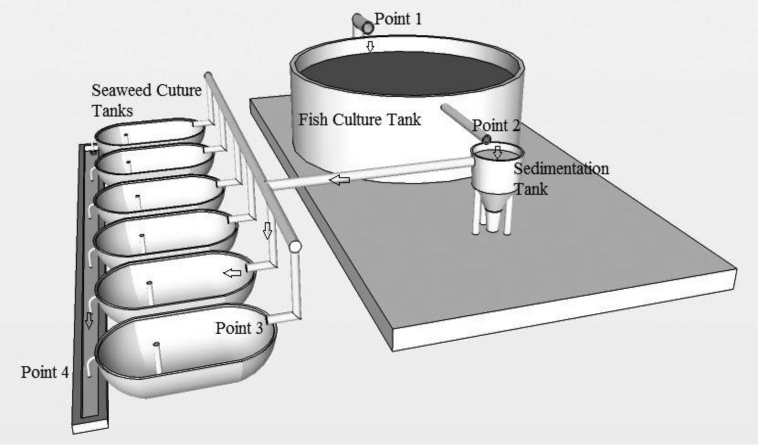


Figure 02. Diagrammatic presentation and layout of the integrated tank-based aquaculture system for the marine fish and seaweed culture experiments.

Source: (Hafedh *et al.,* 2015)

Based on above facts the objectives of this reviewed paper are-

- To find out the use of seaweed as a biofilter,
- To observe the condition of cultured species in this naturally purified water

CHAPTER II

MATERIALS AND METHODS

Scientific approach requires a close understanding of the subject matter. This paper mainly depends on the secondary data. Different published reports of different journals mainly supported in providing data in this paper. This seminar paper is exclusively a review paper, so all the information has been collected from the secondary sources. It is prepared by browsing internet, studying comprehensively various articles published in different journals, books, reports, publications, proceedings, dissertation available in the internet. The author would like to express her deepest sense of gratitude to her major professor and course instructors for their efficient and scholastic guidance, precious suggestions to write this manuscript from its embryonic stage. All the information collected from the secondary sources have been compiled systematically and chronologically to enrich this paper.

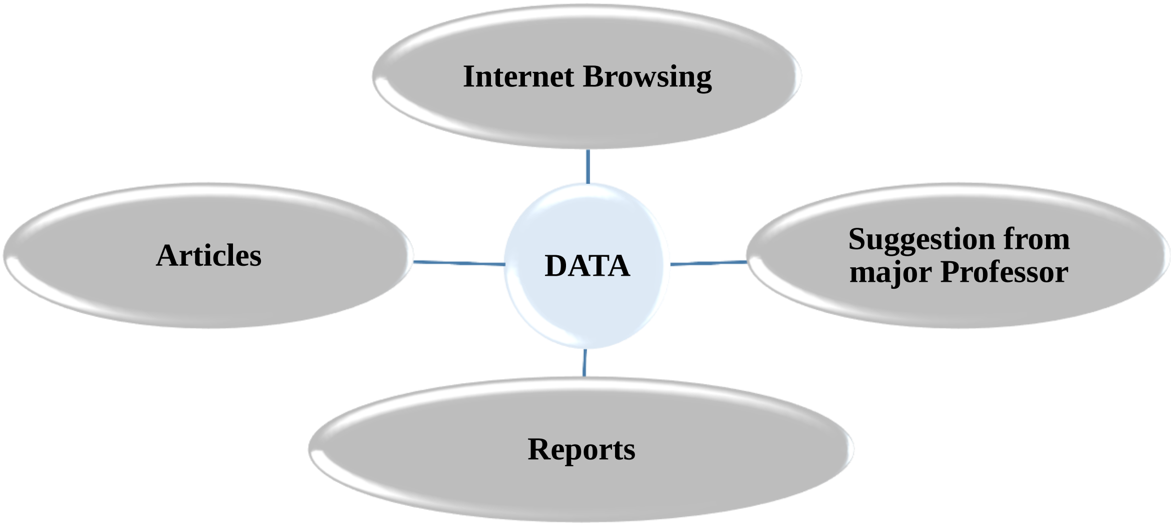


Figure 03. Sources of data and information used in the present paper

CHAPTER III

REVIEW OF FINDINGS

3.1 Integrated cultured sp.

Table 01. Different culture combination with seaweed

Sl. no.	Cultured fish, Shrimp, seaweed	Culture system	Reference
1	White shrimp (*Litopenaeus vannamei*); red seaweed (*Gracilaria birdiae*)	In biofloc	(Brito *et al.*, 2016)
2	Seabream and seabass, *Ulva sp.*	Land based, Pond culture	(Ghaderiardakani *et al.*, 2019)
3	White leg shrimp (*Litopenaeus vannamei),* *Gracilaria corticata*	Tank, Net culture	(Fourooghifard *et al.*, 2017)
4	Seaweed (*Agarophyton tenuistipitatum*), (*Hydropuntia edulis*)	A poly-house	(Sarkar *et al.*,2020)
5	Salmonids (*Oncorhynchus kisutch, O. mykiss*) and Seaweed (*Gracilaria chilensis)*	Tank cultivation	(Buschmann, *et al.*, 1996)
6	Shrimp (*L.* vannamei) clam, seaweed (*G. birdiae*) and fish (*Oreochromis niloticus*)	Biofloc tank	(Brito *et al.*, 2018)
7	Shrimp and macroalgae (*U. lactuca. Vermiculophyll, D. dichotoma*)	Aquarium	(Anaya-Rosas *et al.*, 2019)
8	Salmon cages, Mussels rafts and Kelp rafts	net culture	(Chopin *et al.*, 2017)
9	*Penaeus indicus* and seaweed, *Gracilaria tenuistipitata*	RAS	(Das *et al*., 2022)
10	Shrimp-tilapia-seaweed *(Gracilaria sp)*	------------	(Tran *et al*., 2020).
11	*Penaeus latisulcatus* and *Ulva lactuca,*	Tank	(Robledo *et al.*, 2012)
12	Fish (turbot, sea bass, Senegalese sole) and *G. vermiculophylla*	Commercial land-based	(Abreu *et al.*, 2011)

13	Marine shrimp (*Penaeus vannamei*), herbivorous fish (*Oreochromis sp*.) and seaweed (*Entermorpha sp)*	RAS	(Attasat *et al*., 2013)

3.2 Integrated culture system with seaweed

Integrated marine aquaculture system (IMAS) was set up at Fish Farming Centre of the Ministry of Agriculture at Obhur (Jeddah), Saudi Arabia as per the design depicted by using fiberglass tanks. The system comprises of one round conical bottom fish culture tank which connected with seaweed culture tank. In these seaweed tank use as biofilter chamber (Hafedh *et al.*, 2015).

The bio filter included several stages with a 50% size reduction between each of units.

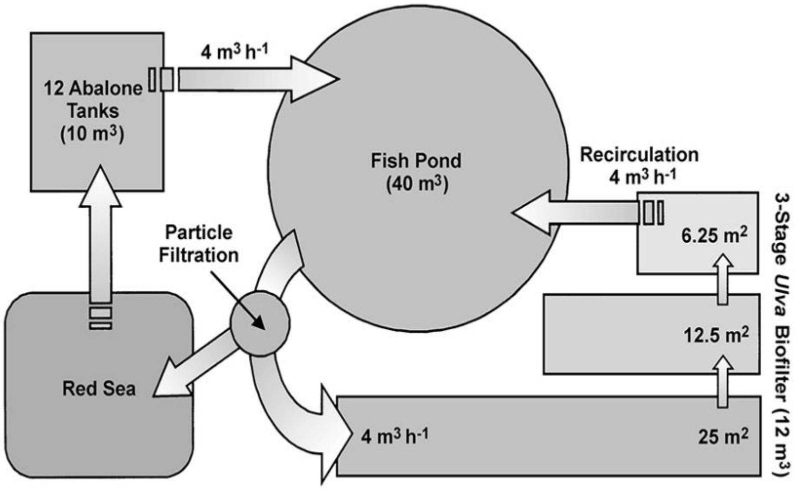


Figure 04. The integrated system recirculate water among abalone tanks, the primary fish pond and series of bio filter

Source: (Schuenhoff *et al.,* 2003)

3.3 Mechanism of seaweed in fish and shrimp integrated culture as nature based solution

Uneaten feed and feces are main sources of inorganic nitrogen, which re found in shrimp culture system by adding organic carbon to the water column. From shrimp feed and molasses about 39% of the nitrogen and 35% of the phosphorus in a biofloc culture contribute to shrimp biomass (Silva *et al.,* 2013)

In shrimp culture, wastes are a major problem because of natural toxicity to aquatic organisms. In intensive shrimp culture systems, water has high concentrations of nitrogen compounds, which impact on shrimp immunity. Thus, there need the balance between yield and capacity for environmental waste assimilation. The biological disperses of organic and inorganic matter causing by seaweed. (Neori *et al.,* 2015).

That is why effluents from biofloc systems can be treated using organisms or seaweed as bio-remediators. Many species of *Gracilaria* occur naturally in coastal region of Brazil and use in shrimp effluent treatment. As a bioremediator use seaweed, the higher eutrophic conditions of cultivation ponds. (Samocha *et al.,* 2015)

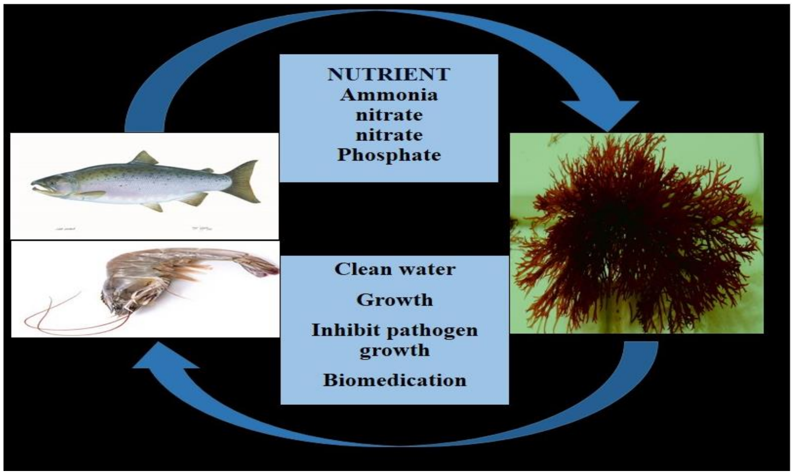


Figure 05. Mechanism of seaweed in fish and shrimp integrated culture as nature-based solution

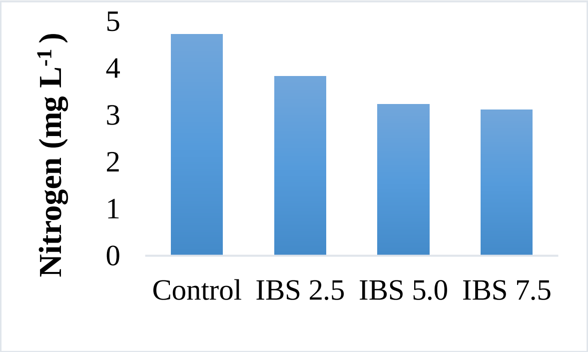
G. vermiculophylla are generate and dispel nutrients in seaweed biofilter tank. At a stocking density of 3 kg (ww)m^{-2} show the excellent result and produces 0.7±0.05 kg (dw)m^{-2} $month^{-1}$ of *G. vermiculophylla*. Moreover, it eliminates 221± 12.82 g m^{-2} $month^{-1}$ of C and 40.54± 2.02 g m^{-2} $month^{-1}$ of N.

3.4.1 Seaweed impact on water quality parameters as nature friendly solution

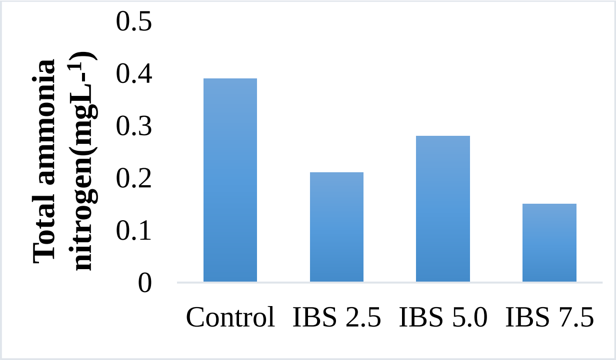
We know that that ammonia and nitrite are highly toxic to shrimp and fish, though their toxicity is species specific and depends on water characteristics and duration of exposure the toxicity of ammonia and nitrite for shrimp is greatly dependent on environmental factors such as pH, dissolved oxygen, salinity and temperature.

In excavated ponds, the phosphate ions are rapidly sequestered by the sediment as a result the concentration in the water column is low. On the other hand, in tanks and closed recirculation systems, an accumulation of this ion is expected during the culture period. Besides, it was also explained that the criteria concentration for PO_4-P in shrimp pond was 0.05-0.5 mg L^{-1}, so the amount of phosphate in the control was still in the acceptable range to experimental shrimp ranges. (Kasnir *et al.*, 2014).

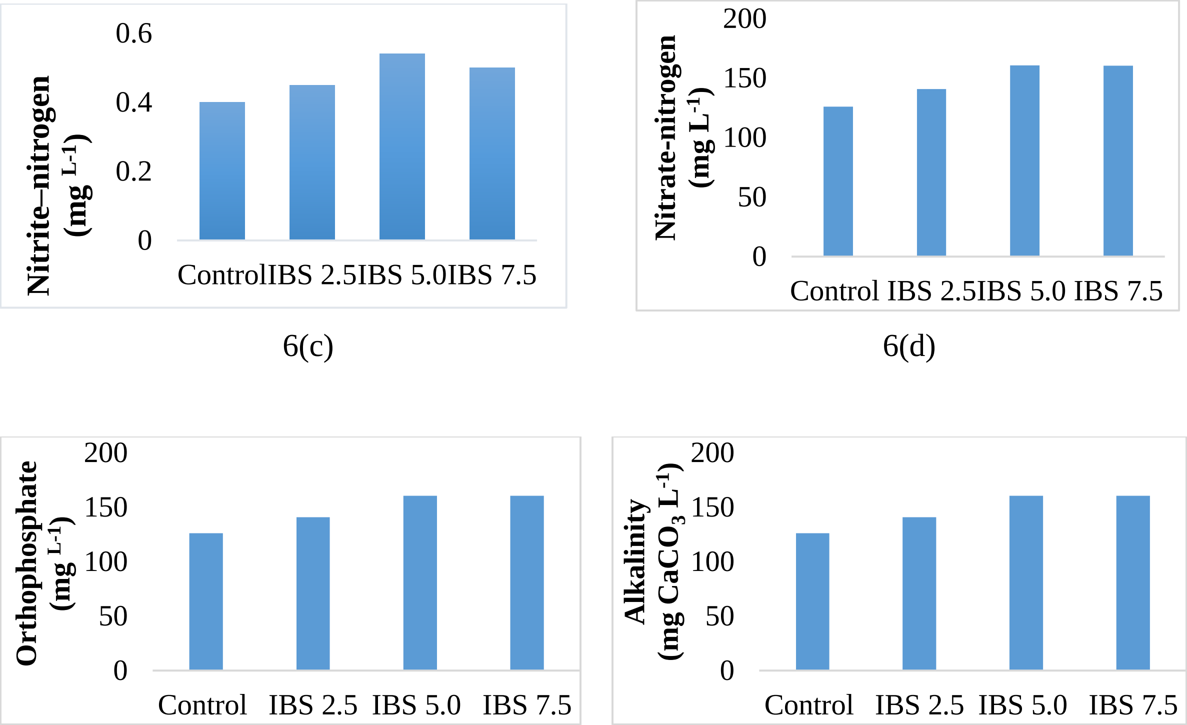
By studying different article and literature, here, do not detect differences in temperature, pH, salinity or other relevant environmental factors.



6(a)



6(b)

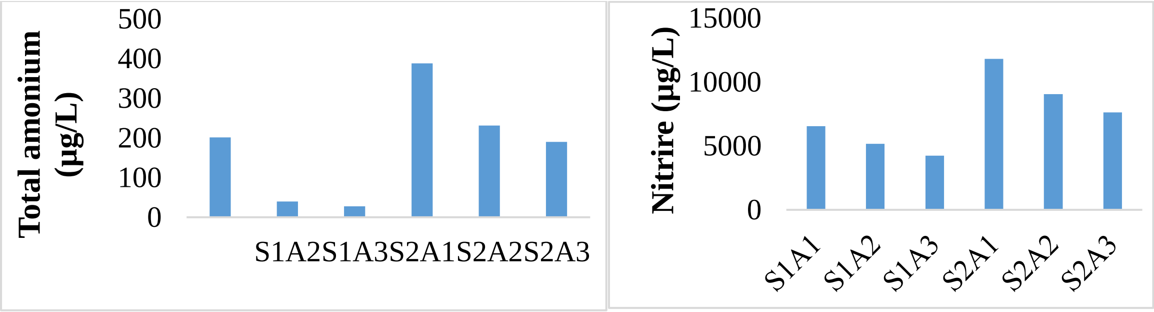


6(c) 6(d)

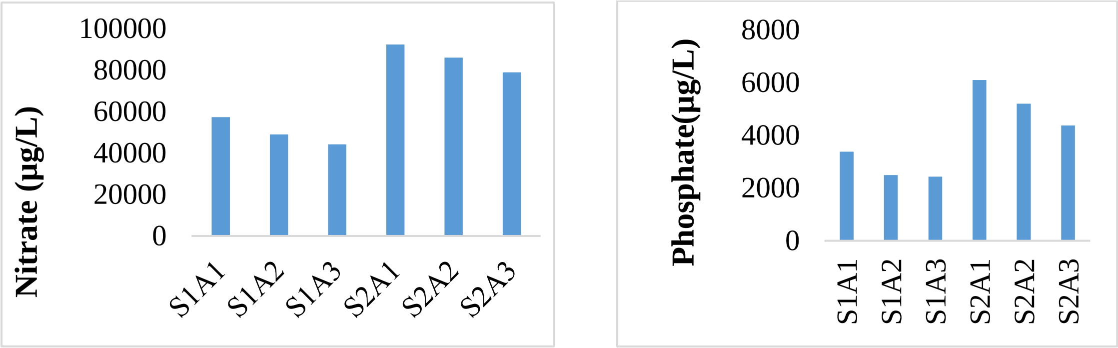
6(e) 6(f)

Figure 06. Different water quality parameter in biofloc 6(a) Nitrogen content; 6(b) Total ammonia nitrogen; 6(c) Nitrite–nitrogen; 6(d) Nitrate-nitrogen; 6(e) Orthophosphate; 6(f) Alkalinity Source: (Brito *et al.*, 2016)

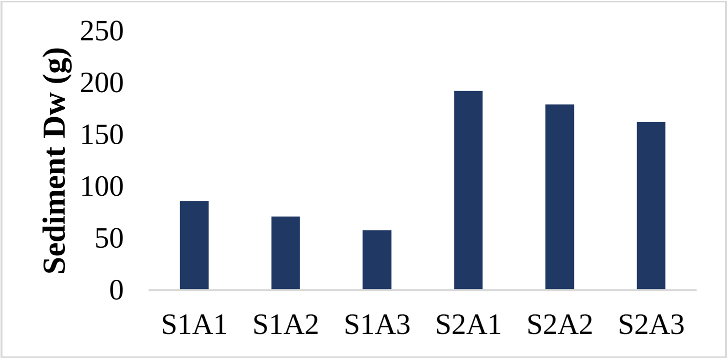
The nutrient removal in integrated culture treatments with seaweed demonstrated approximately high effect. Here, the NH_4–N removals in the polyculture systems were about 60% on day eight and the removals more than 80% on day 24, then decreased because thallus growth decline in lower temperature. In Polyculture system, PO_4–P removals occurred on day 24, about 60%. (Zhou *et al.*, 2006)



7(a) 7(b)



7(c) 7(d)

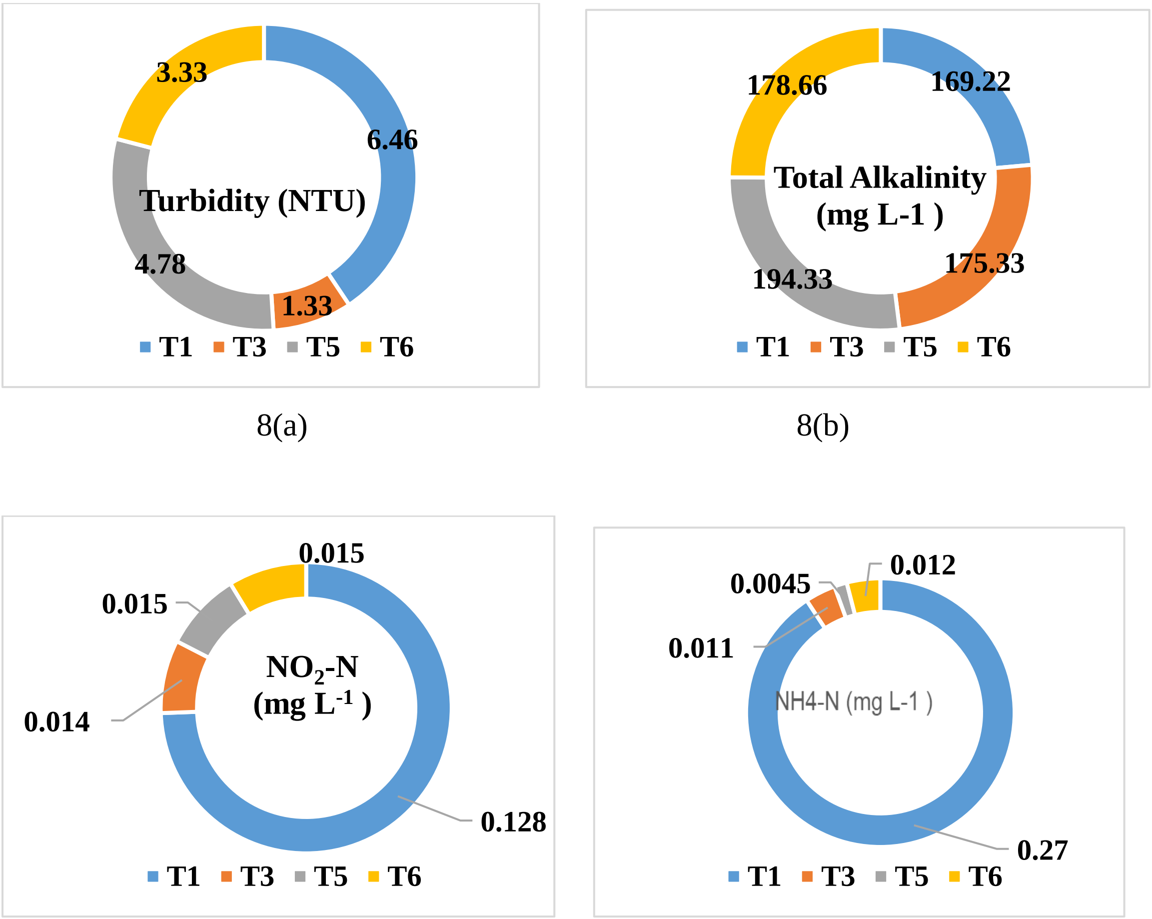


7(e)

Figure 07. Experimental data of Water quality parameter *L. vannamei* integrated cultured with *G. corticata* under zero-water exchange (S1A1; S2A2 control respectively 25 and 50 shrimp/m^2: A1=200g/m^2; A2=400g/m^2) 7(a) Total ammonium; 7(b) Nitrire; 7(c) Nitrate; 7(d) Phosphate; 7(e) Sediment Dw

Source:(Fourooghifard *et al.*, 2017)

The preference for Ammonium ions was noticeable in the seaweed biofilter unit under all grazing consistencies, and this preference was reflected in the decline. Decisions regarding integrated systems must be based on the rates at which each component of the system clears waste and releases nutrients. It has been demonstrated in recent studies that using seaweed in the design of recirculation biofilter systems outperforms using conventional bacterial biofilms. The researcher noticed that *H. cornea* had lower nitrogen obsession rates (1.54 mg N g dw day^{-1}) compared to green seaweed, which had higher nitrogen obsession rates (4.2–13.9 mg N g dw day^{-1}) (Yokoyama & Ishihi, 2010). Similar growth rates for *Gracilaria parvispora* were also established.



8(a) 8(b)

8(c) 8(d)

Figure 08. Seaweed effect on water quality in RAS (T1=Static, T3=RAS+*Gracilaria*, *T5*= RAS+ *Gracilaria*+Biofloc, T6= Static+*Gracilaria*+Biofloc) 8(a) Turbidity (NTU);8(b) Total Alkalinity; 8(c) NO_2-N; 8(d) NH_4-N

Source:(Das *et al*., 2022)

The concentration of NH_4-N and NO_2-N in the seaweed, biofloc treatment was well tolerated by *P. indicus*. The contents of PO_4-P in the culture tanks followed a similar pattern for NH_4-N and NO_2-N. This may occur due to the presence of heterotrophic bacteria and seaweed in the system. (Das *et al*., 2022)

During the study, the researcher observed that the seaweeds have bio-filtering ability in which decreasing inorganic nitrogen of shrimp-culturing ponds reveal that *G. manilaensis* able to decrease up to 83.65% of NH_4^+, 33.33% NO_2 and 68.42% NO_3 after 24 hr (Shukri & Surif, 2011). Here, found that an increase in the density of G. *corticata* were being enhance the water quality as well as decrease waste pollution released from the shrimp with increase the growth parameters of *L. vannamei* in integrated culture with seaweed.

Table 02. Record of physical-chemical factors of *L. vannamei* bioassay in co-cultivation with seaweeds:

Treatment	**Temp °C**	**DO**	**pH**	**Salinity(PSU)**	**Ammonium (mg·L $^{-1}$)**	**Nitrites (mg·L $^{-1}$)**
Control	29.86±0.18	5.70±.11	7.92 ±0.04	35.0±0	0.88^a ±0.13	0.15^a ±0.08
G. vermiculophylla (2 g·L-^{1})	29.78±0.08	5.77±.14	7.88 ±0.04	35.0 ±0	0.23^c ±0.09	0.11^b ±0.01
G. vermiculophylla (4 g·L-^{1})	29.79±0.06	5.86±.04	7.80 ±0.12	35.0±0	0.32^{bc} ±0.10	0.10^b ±0.04
D. dichotoma (2 g·L^{-1})	29.73±0.07	5.79±.07	7.88 ±0.04	35.0 ±0	0.45^b± 0.11	0.13^b ±0.04
D. dichotoma (4 g·L^{-1})	29.90±0.05	5.78±.05	7.89 ±0.03	35.0 ±0	0.51^b ± 0.16	0.15^b ±0.05

Source: (Anaya- Rosas *et al.,*2019)

Using clams and seaweed may be related to the stocking biomass and salinity. In the low concentration of effluent may show good performance. The control and seaweed treatments were not efficient for reducing solids concentrations. (Brito *et al.*, 2018) Similar result notice in TSS and IMTA concentrations (shrimp and seaweed) biofloc system. It proves that *Gracilaria* is not an efficient biofilter where high levels of suspended solids (>100 mg L^{-1}) (Brito *et al.*, 2016).

Ulva lactuca removed a large amount of total ammonia nitrogen (TAN) at removal rates 0.26 to 0.31 g m^{-2} day^{-1} and phosphate/phosphorus 0.32 to 0.41 g m^{-2} day^{-1}.

In statistical analysis, TAN removal efficiencies were significantly indifferent to the stocking rate of the seaweed. (54.36 at low-stocking density and 67.56% at high-stocking density under low rate of flow and 93.15 at low-stocking density and 92.69% at high-stocking density under high rate of flow) but were positively affected by the flow rate and were observed to be significantly higher. Phosphate removal efficiencies were also indifferent from either stocking density or flow rate and were ranging from 16.4 to 24.03% (Hafedh *et al.*, 2015).

3.4.2 Seaweed biofiltration and waste removal rate from water

Seaweed biomass and thallus density positively impact by the removal of ammonia and phosphate % on the way to up taking these nutrients.higher density of seaweed indicates higher removal of nutrient (Samocha *et al.*, 2015).

The red seaweed *G. birdiae* in the IBS decreased DIN (19–34%) and NO_3-N (19–38%) concentration than the control. By using *G. caudata* recorded DIN and NO_3-N removal of 17% and 70% respectively (Marinho-Soriano *et al*., 2011). Other experimental studies with *Gracilaria sp.* are recorded a NO_3- N removal of 47% (Huo *et al.*, 2012), 75% (Huo *et al.*, 2011) and between 61% and 88% (Robledo *et al.*, 2012).

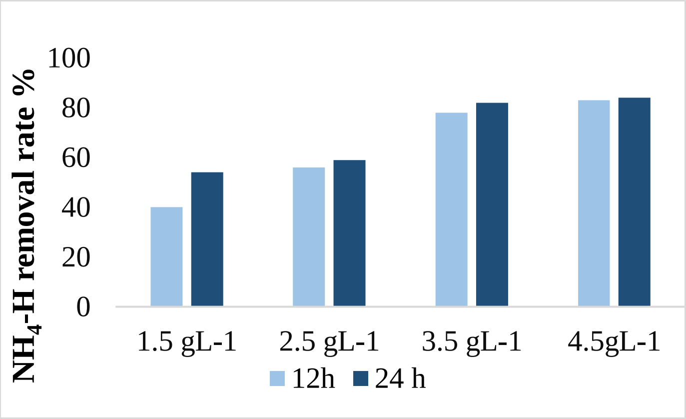


Figure 09. Ammonia reduction efficiency during 12 h and 24 h *A. tenuistipitatum* for different biomass densities

Source: (Sarkar *et al.*, 2021)

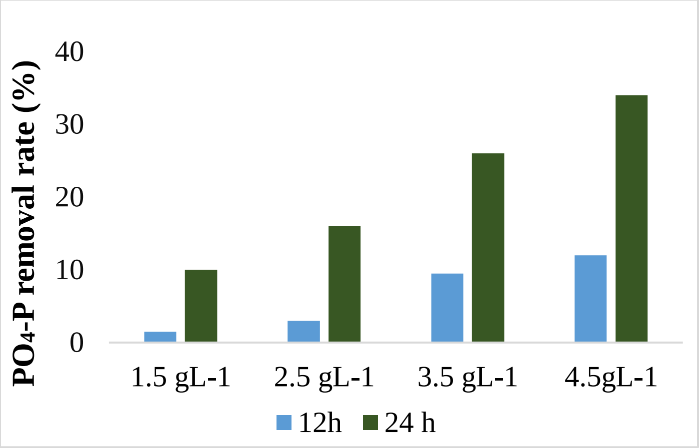


Figure 10. Phosphate reduction efficiency during 12 h and 24 h of *A. tenuistipitatum* for different biomass densities

Source: **(**Sarkar *et al.*, 2021)

3.4.3 Seaweed function in *Vibrio* bacteria in shrimp culture

Shrimp are prone to diseases especially viral and bacterial, like White Spot Virus Syndrome (WSSV) and *V. parahaemolyticus*. This integrated culture may be an appropriate solution to control such type of pathogenic organisms.

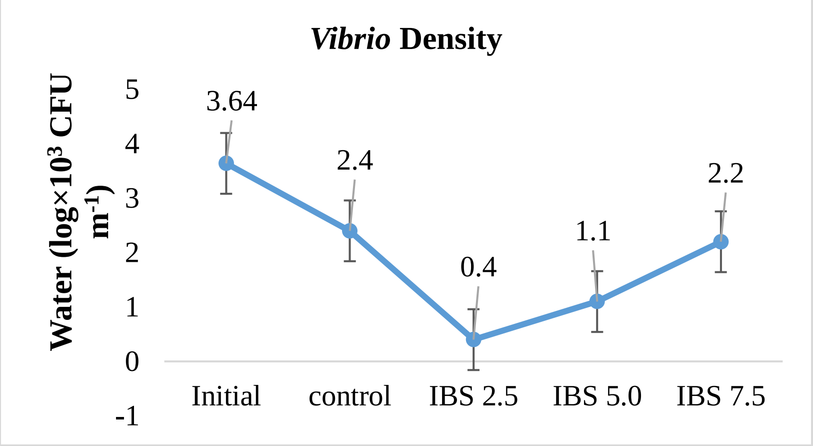


Figure 11. Vibrio density in (IBS) with *Litopenaeus vannamei* and *Gracilaria birdiae* during a 42-day experimental period

Source: (Brito *et al.*, 2016)

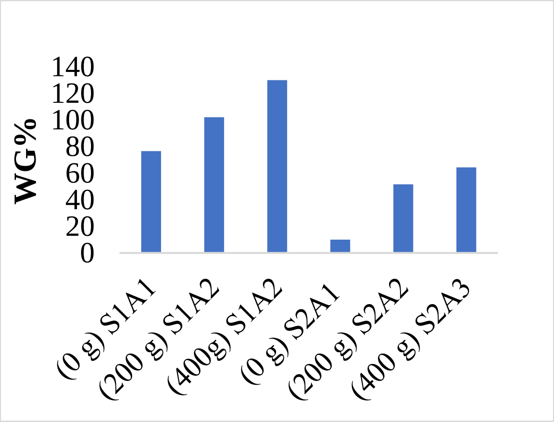
3.4.4 Integrated fish with seaweed culture in offshore water

The proximity of surrounding seaweed and bivalves, as well as the depth at which the corresponding structures will be deployed, will determine the availability of dissolved nutrients and particles delivered by submerged fish cages to those organisms. The flux of effluent nutrients/particles reaching surface waters would be decreased if fish cages were located at depth (to prevent wave stress and swell); hence, submerged systems would raise the seaweeds and bivalve growth. To create systems that will optimize the supply of effluents to the macroalgal and shellfish IMTA components, it will be necessary to model the flux of nutrients and particles. At this time, it is unknown what effects large or many offshore farms will have on the ecosystem. (Chopin *et al*., 2018).

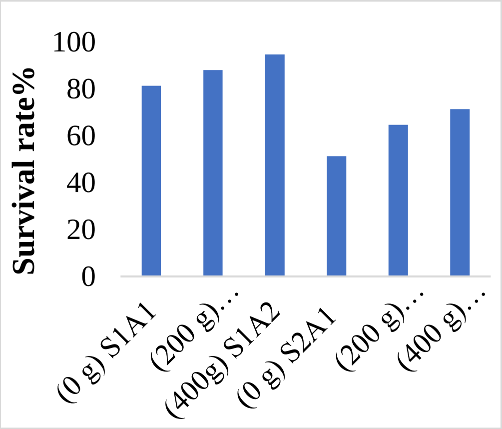
3.5.1 Growth performance of shrimp and fish

The researcher expresses a positive effect for DIN and NO_3- N removal for increased seaweed stocking biomass. For TAN and NO_3-N with *Penaeus latisulcatus* and *Ulva lactuca* show similar resulte (Khoi & Fotedar, 2011).

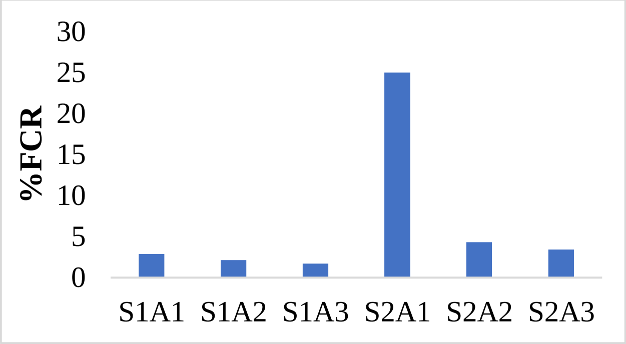
Shrimp weight was observed to determine shrimp growth and adjust the amount of feed and organic carbon offered. After the experiment, the researcher determined- biomass gain, specific growth rate (SGR), mean final weight, weekly growth, feed conversion ratio (FCR), survival and yield of shrimp.



(12a)



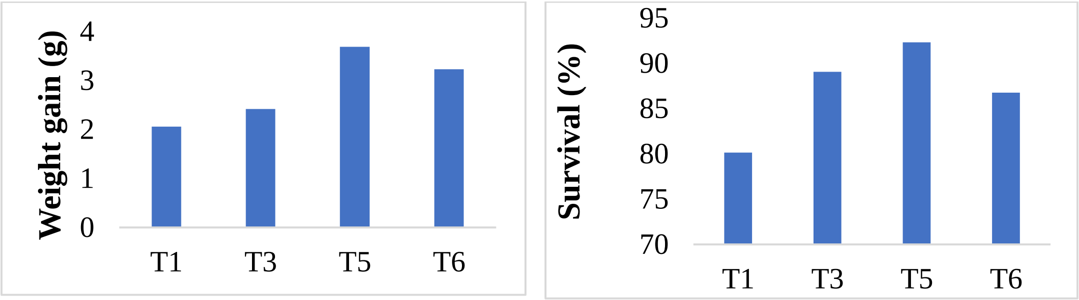
(12b)



(12c)

Figure 12. Experimental data of production and feed conversion ratio of *L. vannamei* integrated cultured with *G. corticata* under zero-water exchange. (S_1A_1; S_2A_2 control respectively 25 and 50 shrimp/m^2)

Source: (Fourooghifard *et al.*, 2017)



(13a) (13b)

Figure 13. Growth performance and survival rate of *Penaeus indicus* in RAS (T1=Static, T3=RAS+ *Gracilaria*, *T5*= RAS+ *Gracilaria*+Biofloc, T6= Static+*Gracilaria*+Biofloc).

Source: (Das *et al.*, 2022)

The integrated culture with *Gracilaria* showed higher survival but lower average body weight as well. Survival was higher in all seaweed and BFT consortium treatment than the control. It was ranged from 80.15 ± 1.52% to 90.33 ± 1.4%. The highest value observed in T5 where seaweed, biofloc and consortium were present and lowest observed in control. (Das *et al*., 2022).

In polyculture only and polyculture with biofloc, Biomass, mean final weight, and daily growth rate of shrimp were higher as compared to monoculture only and monoculture with biofloc. Same result show in fish biomass. Shrimp was 69–73%, whereas, fish was 74–82% of survival rate, FCR is the lowest (FCR = 1.07) as compared to other treatments. (Hoang *et al*., 2020)

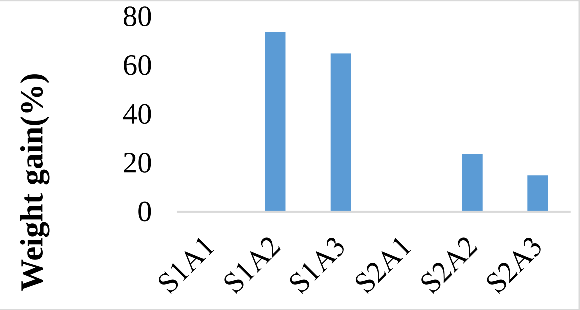
3.5.2 Growth performance of seaweed

The researcher found a significant negative correlation in between shrimp density and growth parameters of *G. corticata*. An increase in the density of shrimp indicate that increase in turbidity and decrease in the amount of light, which can limit the growth of algae. The seaweeds in treatment C_2 (200 g seaweed/m^2 with addition of shrimp feed to the tanks) decomposed gradually during the culturing time. The sedimentation of shrimp feed causes rotting of the thalli of *G. corticata* because they were covered by mold. In other treatments (400 g seaweed/m^2 with addition of shrimp feed to the tanks), the feed that settled on seaweed's thalli that was eaten by shrimps and were cleaned in the process.

Table 03. % WG of Seaweed biomass (C_1, C_2 monoculture of seaweed; S_1:25 Shrimp/m^2; S_2:50 Shrimp/m^2)

	(200 g) **C_1**	(200 g) S_1A_2	(400g) S_1A_3	**(200 g)** **C_2**	(200g) S_2A_2	(400 g) S_2A_3
WG%	-71.33	73.67	64.83	-100.00	23.05	14.92

Source: (Fourooghifard *et al.*, 2017).



(I)

Figure 14. Seaweed growth in different treatment

Source: (Fourooghifard *et al.*, 2017)

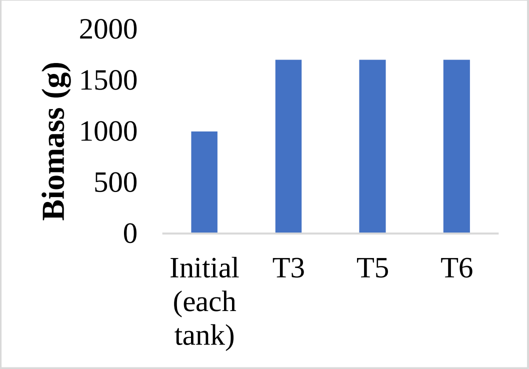


Figure 15. Total seaweed production (T1=Static, T3=RAS+ *Gracilaria, T5*= RAS+ *Gracilaria*+Biofloc, T6= Static+ *Gracilaria*+ Biofloc).

Source: (Das *et al*., 2022)

There increased production of seaweed to the extent of 50% compared to the initial biomass. This was around 1000g/treatment tank and the final harvest of seaweed was 1500-1600 g in each seaweed integrated tanks with biofloc system.

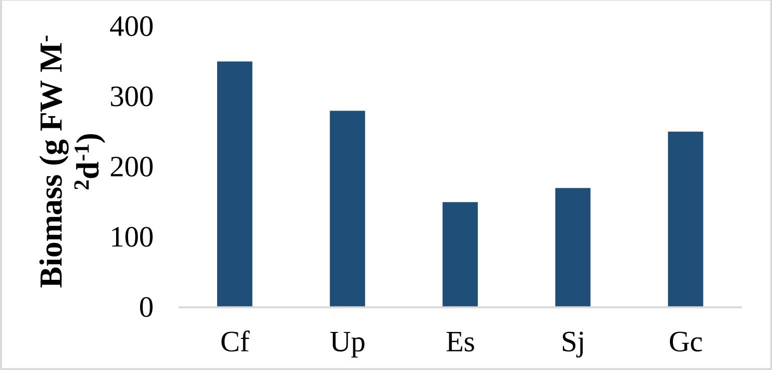


Figure 16. Specific growth rate (% day^{-1}) and biomass yield(g fresh weight m−2 day−1; (b) of five seaweed species. Data are expressed in terms of mean SE (n = 3); Cf, *Codium fragile*; Gc, *Gracilariopsis chorda*; Es, *Ecklonia stolonifera*; Sj, *Saccharina japonica*; Up, *Ulva pertusa.*

Source: (Kang *et al*., 2021)

There researcher observed that an increment of the fish effluent flow in the seaweed culture tanks allowed to duplicate the biomass of seaweed. Our results indicate that the specific growth rate of *U. lactuca* reached up to 12% day^{-1}.

3.6.1 Proximate composition of fish

By showing the experiment results corroborate with other research on traditional culture system of shrimp, it is found that here is a great influence in water quality parameters of shrimp culture by seaweed production. In biofloc systems develops water condition by reducing DIN and NO_3-N, and Vibrio density. Not only water condition it develops shrimp growth and body protein content. As these it increases proximate composition of shrimp body.

Table 04. Proximate composition of shrimp

Proximate composition of shrimp				
Components	**Control**	**IBS 2.5**	**IBS 5.0**	**IBS 7.5**
Curde protein	12.1±0.1	13.7±0.1	13.5±0.1	13.2±0.4
Curde lipid	1.6±0.2	1.5±0.2	1.4±0.1	1.6±0.2
Ash	2.4±0.1	2.6±0.1	2.2±0.1	2.1±0.1
Moisture%	81.5±0.4	81.2±0.1	82.1±0.1	81.8±0.7

Source: (Brito *et al.*, 2016)

3.6.2 Proximate composition of seaweed

Contrary to earlier estimates, the IBS helped to increase the crude protein content of seaweed. The higher concentration of nitrogen molecules (both inorganic and organic) in biofloc systems, which are used by seaweed to digest protein, is linked to this increase.

Table 05. Proximate composition of seaweed *(G. birdiae)* Dried

Proximate composition of seaweed *(G. birdiae)* Dried				
Components	**Initial**	**IBS 2.5**	**IBS 5.0**	**IBS 7.5**
Curde protein	9.2±011	13.6±2.0	16.1±0.3	13.6±0.8
Curde lipid	1.1±0.3	0.5±0.1	0.4±0.1	0.4±0.2
Ash	47.9±4.5	43.3±3.0	41.3±4.1	41.8±4.7
Moisture%	8.3±0.1	8.3±0.3	8.3±0.	8.2±0.9

Source: (Brito *et al.*, 2016)

3.7 Immune response and antioxidant activity

Survival rate is a great issue in shrimp production. For experimental purposes, infecting shrimp with pathogenic bacteria may show a greater defense mechanism against disease and survivability that are culture with seaweed than control. These microalgae have antibacterial, antiviral capacity along with immuno-stimulating properties; thus, the survival rate increases. These easily can be said that seaweed able to fight against disease of shrimp and other aquatic organism (Thanigaivel *et al.*, 2016).

In shrimp-seaweed integrated culture, shrimp uptake macroalgae as feed (if they culture in same tank). As a result, the immune response and enzymatic activity enhance. At the same time decrease oxidative stress because of the bioactive compound and antioxidant uptake from seaweed which prevents pathogenic organism. The bioactive compounds are specially sulfated polysaccharides, phenolic compounds and antioxidants.

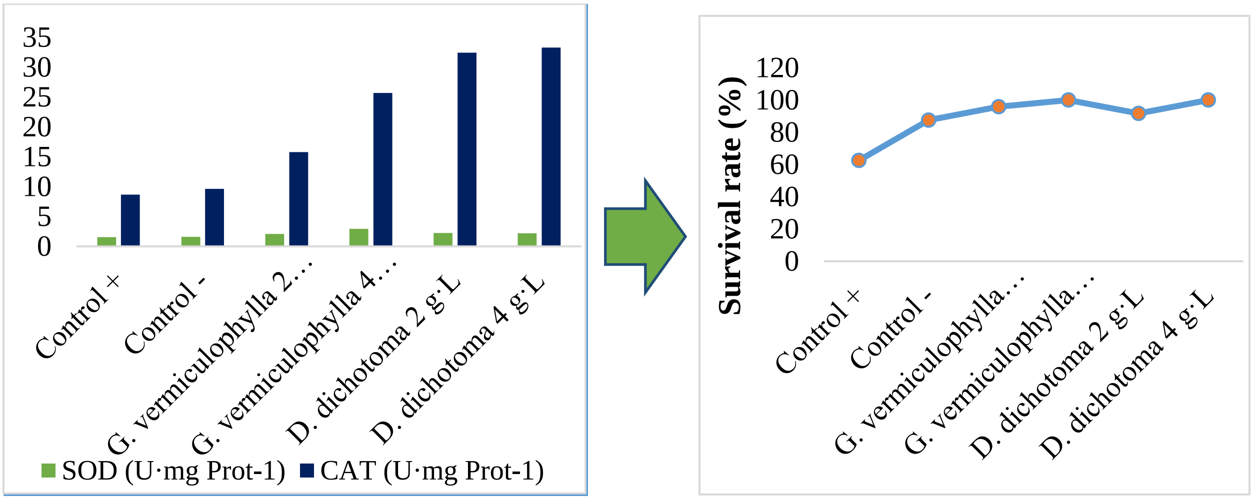


Figure 17. Antioxidant response and survival of *L. vannamei* in co-cultivation with macroalgae and infected with *Vibrio parahaemolyticus* (at a dose of 10 μL·g^{-1} of living organisms) Control + = monoculture shrimp; control - =negative control (Shrimp with ulva sp. As it has biomedicinal value) and other teratments.

Source: (Anaya *et al.*, 2019)

CHAPTER IV

CONCLUSION

Aquaculture is a rising trend moreover integrated aquaculture is one of the modern fish farming system. Integrated fish-seaweed culture seems to be a great opportunity to water recycling system. Different seaweed like *Gracilaria spp*. *Ulva spp.* are mostly cultured seaweed species use as biofilter. the seaweeds have bio-filtering ability in which decreasing inorganic nitrogen of shrimp-culturing ponds reveal that *G. manilaensis* able to decrease up to 83.65% of NH_4^+, 33.33% NO_2 and 68.42% $NO_{3.}$ The concentration of NH_4-N and NO_2-N in the seaweed, biofloc treatment were well tolerated by *P. indicus*. The contents of PO_4-P in the culture tanks followed a similar pattern for NH_4-N and NO_2-N. This may occur due to the presence of heterotrophic bacteria and seaweed in the system. *Vibrio sp* load is decreasing in shrimp and seaweed IMTA system.

By installing this farming system, it not only purified water by the metabolic function of seaweed and grows vigorously but also increase fish and shrimp health. As seaweed is a marine macroalgae, this culture system is appropriate for marine and coastal water species. Shrimp was 69–73%, whereas, fish was 74–82% of survival rate, Overall FCR is the lowest. It is ranged from 80.15 ± 1.52% to 90.33 ± 1.4% of survival rate of shrimps. Overall seaweed growth is also increase. So, it can easily be said that fish seaweed culture is mutual relations of cultural. Here, fish waste is nutrient for seaweed and seaweed filtered water use for fish and shrimp because they are heterotopic and auto-tropic.

REFERENCE

Abreu, M. H., Pereira, R., Yarish, C., Buschmann, A. H., & Sousa-Pinto, I. (2011). IMTA with *Gracilaria vermiculophylla*: productivity and nutrient removal performance of the seaweed in a land-based pilot scale system. *Aquaculture*, 312(1-4), 77-87.

Al-Hafedh, Y. S., Alam, A., & Buschmann, A. H. (2015). Bioremediation potential, growth and biomass yield of the green seaweed, *Ulva lactuca* in an integrated marine aquaculture system at the Red Sea coast of Saudi Arabia at different stocking densities and effluent flow rates. *Reviews in Aquaculture*, 7(3), 161-171.

Al-Hafedh, Y. S., Alam, A., & Buschmann, A. H. (2015). Bioremediation potential, growth and biomass yield of the green seaweed, *Ulva lactuca* in an integrated marine aquaculture system at the Red Sea coast of Saudi Arabia at different stocking densities and effluent flow rates. *Reviews in Aquaculture*, 7(3), 161-171.

Anaya-Rosas, R. E., Rivas-Vega, M. E., Miranda-Baeza, A., Piña-Valdez, P., & Nieves-Soto, M. (2019). Effects of a co-culture of marine algae and shrimp (*Litopenaeus vannamei*) on the growth, survival and immune response of shrimp infected with Vibrio parahaemolyticus and white spot virus (WSSV). *Fish & shellfish immunology*, 87, 136-143.

Andreas Schuenhoff, M.Sc. Muki Shpigel, Ph.D. Ingrid Lupatsch, Ph.D. Arik Ashkenazi Flower Msuya Amir Neori, Ph.D. (2003). *Integrated fish-seaweed culture systems Global Seafood Alliance's (GSA)*

Asche, F., Bellemare, N., & Rocheim, C. Smith, M. Y Tveteras, S.(2015).Food Security and the International Seafood trade. *World Development*, 67, 151-160.

Attasat, S., Wanichpongpan, P., & Ruenglertpanyakul, W. (2013). Design of integrated aquaculture of the Pacific white shrimp, tilapia and green seaweed. *Journal of Sustainable Energy and Environment,* 4, 9-14.

Atwood, H. L., Fontenot, Q. C., Tomasso, J. R., & Isely, J. J. (2001). Toxicity of nitrite to Nile tilapia: effect of fish size and environmental chloride. *North American Journal of Aquaculture,* 63(1), 49-51.

Bank, W. (2013). Fish to 2030 Prospects for Fisheries and Aquaculture World Bank Report Number 83177-GLB. Washington, DC.

Barajas Magallón, F. J., Servín Villegas, R., Portillo Clark, G., López Moreno, B., (2006). *Litopenaeus vannamei* (Boone) post-larval survival related to age, temperature, pH and ammonium concentration. *Aquac. Res.* 37, 492-499. https://doi.org/10.1111/j.1365- 2109.2006.01455.

Brito, L. O., Cardoso Junior, L. D. O., Lavander, H. D., Abreu, J. L. D., Severi, W., & Gálvez, A. O. (2018). Bioremediation of shrimp biofloc wastewater using clam, seaweed and fish. *Chemistry and ecology*, 34(10), 901-913.

Brito, L. O., Chagas, A. M., da Silva, E. P., Soares, R. B., Severi, W., & Gálvez, A. O. (2016). Water quality, V ibrio density and growth of Pacific white shrimp L itopenaeus vannamei (B oone) in an integrated biofloc system with red seaweed *G. racilaria birdiae* (*G. reville*). *Aquaculture Research,* 47(3), 940-950.

Buck, B. H., Troell, M. F., Krause, G., Angel, D. L., Grote, B., & Chopin, T. (2018). State of the art and challenges for offshore integrated multi-trophic aquaculture (IMTA). *Frontiers in Marine Science,* 5, 165.

Buschmann, A. H., Troell, M., Kautsky, N., & Kautsky, L. (1996). Integrated tank cultivation of salmonids and *Gracilaria chilensis* (*Gracilariales*, Rhodophyta). *Hydrobiologia*, 326, 75-82.

Chen, J. C., Liu, P. C. and Lie, S. C. 1990.Toxicity of ammonia and nitrite to Penaeus monodon adolescents. *Aquaculture* 89, 127-137. https://doi.org/10.1016/0044-8486(90)90305-7

Chopin, T. (2017). The renewed interest in the cultivation of seaweeds, as the inorganic extractive component of Integrated Multi-Trophic Aquaculture (IMTA) systems, and for the ecosystem services they provide. *Bulletin of Aquaculture Association of Canada*, (1), 42.

Costa-Pierce, B. A., Bartley, D. M., Hasan, M., Yusoff, F., Kaushik, S. J., Rana, K., & Yakupitiyage, A. (2010). Responsible use of resources for sustainable aquaculture. In Farming the Waters for People and Food. *Proceedings of the Global Conference on Aquaculture* 113-147.

da Silva, K. R., Wasielesky Jr, W., & Abreu, P. C. (2013). Nitrogen and phosphorus dynamics in the biofloc production of the pacific white shrimp, *Litopenaeus vannamei*. *Journal of the World Aquaculture Society,* 44(1), 30-41.

Das, R. R., Sarkar, S., Saranya, C., Esakkiraj, P., Aravind, R., Saraswathy, R & Panigrahi, A. (2022). Co-culture of Indian white shrimp, *Penaeus indicus* and seaweed, *Gracilaria tenuistipitata* in amended biofloc and recirculating aquaculture system (RAS). *Aquaculture*, 548, 737432.

Food and Agriculture Organization (FAO), Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) statistics database, Food Balance Sheets, Updated (2019) http://www.fao.org/faostat/en/data/FBS.

Food and Agriculture Organization (FAO), The State of World Fisheries and Aquaculture, Meeting the Sustainable Development Goals, Rome, 2018, p. 210.

Fourooghifard, H., Matinfar, A., Mortazavi, M. S., Roohani Ghadikolaee, K., & Mirbakhsh, M. (2017). Growth parameters of whiteleg shrimp *Litopenaeus vannamei* and red seaweed *Gracilaria corticata* in integrated culturing method under zero water exchange system. *Aquaculture Research,* 48(10), 5235-5242.

Hoang, M. N., Nguyen, P. N., & Bossier, P. (2020). Water quality, animal performance, nutrient budgets and microbial community in the biofloc-based polyculture system of white shrimp, *Litopenaeus vannamei* and gray mullet, Mugil cephalus. *Aquaculture, 515*, 734610.

Kang, Y. H., Kim, S., Choi, S. K., Lee, H. J., Chung, I. K., & Park, S. R. (2021). A comparison of the bioremediation potential of five seaweed species in an integrated fish seaweed aquaculture system: implication for a multispecies seaweed culture. *Reviews in Aquaculture,* 13(1), 353-364.

Kasnir, M., Harlina, R., & Rosmiati, R. (2014). Water quality parameter analysis for the feasibility of shrimp culture in Takalar Regency, Indonesia. *Journal of Aquaculture Research & Development,* 5(6), 5-7.

Khanjani, M. H., Zahedi, S., & Mohammadi, A. (2022). Integrated multitrophic aquaculture (IMTA) as an environmentally friendly system for sustainable aquaculture: functionality, species, and application of biofloc technology (BFT). *Environmental science and pollution research,* 29(45), 67513-67531.

Khoi LV, Fotedar R. Integration of blue mussel (*Mytilus edulis* Linnaeus, 1758) with western king prawn (*Penaeus latisulcatus* Kishinouye, 1896) in a closed recirculating aquaculture system under laboratory. *Aquaculture*. 2012;354–355:84–90.

Lu, G., Li, S., Guo, Z., Farha, O. K., Hauser, B. G., Qi, X. & Huo, F. (2012). Imparting functionality to a metal–organic framework material by controlled nanoparticle encapsulation. *Nature chemistry*, 4(4), 310-316.

Marinho-Soriano, E., Azevedo, C. A. A., Trigueiro, T. G., Pereira, D. C., Carneiro, M. A. A., & Camara, M. R. (2011). Bioremediation of aquaculture wastewater using macroalgae and Artemia. *International Biodeterioration & Biodegradation,* 65(1), 253-257.

Mishra, V. K., & Tripathi, B. D. (2008). Concurrent removal and accumulation of heavy metals by the three aquatic macrophytes. *Bioresource technology*, 99(15), 7091-7097.

Neori, A., Chopin, T., Troell, M., Buschmann, A. H., Kraemer, G. P., Halling, C. & Yarish, C. (2004). Integrated aquaculture: rationale, evolution and state of the art emphasizing seaweed biofiltration in modern mariculture. Aquaculture, 231(1-4), 361-391.

Nutrition, H. L. P. O. E. H. O. F. S. A. (2014). Sustainable fisheries and aquaculture for food security and nutrition. *A report by the high-level panel of experts on food security and nutrition.*

Robledo D., Navaro-Angulo L., Lozano D.V. & Freile-Pelegrin Y. (2012) Nutrient removal efficiency of Hydropuntia cornea in an Integrated closed recirculation systems with pink shrimp farfante *Penaeus brasiliensis*. *Aquaculture research.* doi:10.1111/are.12111

Samocha, T. M., Fricker, J., Ali, A. M., Shpigel, M., & Neori, A. (2015). Growth and nutrient uptake of the macroalga *Gracilaria tikvahiae* cultured with the shrimp *Litopenaeus vannamei* in an Integrated Multi-Trophic Aquaculture (IMTA) system. *Aquaculture*, 446, 263-271.

Sarkar, S., Rekha, P. N., Ambasankar, K., & Vijayan, K. K. (2021). Bioremediation efficiency of indigenous seaweeds of Chennai coast in brackishwater system. *Aquaculture International.* doi:10.1007/s10499-020-00621-1

Shukri, S. A., & Surif, M. (2011). The study of biofiltering ability of *Gracilaria manilaensisi* in reducing inorganic–N waste of shrimp culture. *Empowering Science, Technology and Innovation Towards a Better Tomorrow, LSP94*, 638-643.

Thanigaivel, S., Chandrasekaran, N., Mukherjee, A., & Thomas, J. (2016). Seaweeds as an alternative therapeutic source for aquatic disease management. *Aquaculture,* 464, 529-536.

Tran, N., Le Cao, Q., Shikuku, K. M., Phan, T. P., & Banks, L. K. (2020). Profitability and perceived resilience benefits of integrated shrimp-tilapia-seaweed aquaculture in North Central Coast, Vietnam. *Marine Policy*, 120, 104153.

Whetstone, J. M., Treece, G. D., Browdy, C. L., & Stokes, A. D. (2002). Opportunities and constraints in marine shrimp farming. *Southern Regional Aquaculture Center.*

Yokoyama, H., & Ishihi, Y. (2010). Bioindicator and biofilter function of *Ulva spp*.(Chlorophyta) for dissolved inorganic nitrogen discharged from a coastal fish farm—potential role in integrated multi-trophic aquaculture. *Aquaculture*, *310*(1-2), 74-83.

Zhou, Y., Yang, H., Hu, H., Liu, Y., Mao, Y., Zhou, H., ... & Zhang, F. (2006). Bioremediation potential of the macroalga *Gracilaria lemaneiformis* (Rhodophyta) integrated into fed fish culture in coastal waters of north China. *Aquaculture*, 252(2-4), 264-276.