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Ecological engineering - a tool for improving productivity in an integrated system of seaweed and shrimp

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ABSTRACT

Ecological engineering is the management of the system with human inputs which is more sustainable and environmental friendly with higher productivity. It involves the design, construction and management of ecosystems that have value to both humans and the environment. Phytoremediation is one of the important aspects of ecological engineering where the inputs of one can very well be utilized by others thereby improving the environmental condition of the system and higher productivity. Integrated approach can be applied where wastes from one crop are recycled within the farm as inputs for another crop. It is energy efficient, recycles wastes, minimizes environmental pollution and is integrated with other food production systems. Shrimp farming is one of the best examples of sustainability due to heavy pressure on environment. Shrimp farming has changed from traditional, small-scale businesses in Southeast Asia into a global industry because of high demand from USA, Japan and Western Europe. Shrimp has emerged as an important item in the world seafood production. Asian countries like Taiwan, Indonesia, Thailand and India have emerged as global leaders in shrimp production. Asia, which produces approximately 80 percent of the world's cultured shrimp. Over production, greediness to earn more money in less time and technological inputs lead to booming the industry changing from traditional to extensive then to semi intensive and intensive farming practice. Within few years of production the shrimp industries collapsed due to poor management practice and disease. Thus before practicing any activities if a comprehensive plan of action would have there with environmental sustainability there would not have been a huge loss of crop with environmental degradation and disease. The present paper deals with the nutrient recycling in the integrated culture system of seaweed and shrimps which gives a fragmentary work on sustainability of shrimp farming. A cohesive effort of farmers, industry, scientists and engineers will definitely help to give a comprehensive plan for sustainable aquaculture practice.

Introduction

Ecological engineering is the design of sustainable ecosystems that integrate any two systems for the benefit of both. It involves the design, construction and management of ecosystems that have value to both the candidate species and the environment. This has more opportunities to design the ecosystems as interfaces between technology and environment. In this definition, the ecological engineering reveals how to safely utilize the polluting components of unwanted residuals "wastes," to ultimately grow green plants or algae that have value as an alternate product from the system and benefit the aquatic or terrestrial ecosystems. Integrated farming of shrimps with seaweed is one of these types of system where the waste generated from farming operation will be utilized by the seaweed and provides additional income to the farmer.

Marine shrimp farming from a traditional aquaculture practice to an industrial revolution. The success in the mass production of hatchery-bred shrimp fry in the 1970's has accelerated shrimp farming development. With improved pond culture techniques, yield from traditional shrimp ponds has been raised to 500–800 kg/ha/year from 300 kg/ha/year without supplementary feeding. Pond yield could further increase to 5–10 tons through supplementary feeding and intensive pond management (FAO,1986). Due to an unlimited market demand, high export price shrimp farming changed from a traditional aquaculture practice to an industry. It generated lot of employment and increased foreign exchange earnings. Many

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countries were encouraged globally for industrial development of shrimp culture. In 1995 (FAO, 1995) the ASEAN Countries produced about 558,000 tons of *Penaeus monodon,* about 78% of the total world production of shrimp (Sanchez, 2014). Shrimp farming then developed into an important export-oriented food industry especially in South Asian countries.

Penaeus monodon, commonly called black tiger shrimp and *P. vennamei* the white shrimps are among the economically important brackish water species in the world. This industrial monoculture of shrimp is very susceptible to diseases, which have resulted in total wipe-outs of farm shrimp populations in many countries globally especially *P.monodon*. There are a variety of lethal viral diseases that affect the shrimp industry. After the disease outbreak there was an alarming signal for the shrimp growers due to huge loss of crops affecting the economy. Inappropriate and excess use of chemicals, fertilizers, accumulation of excess feed in the pond bottom, changes the soil quality to acidic which is unsuitable for any further use led to the problem of irreversibility (Krutilla and Fisher, 1985) of environmental damage created by this particular economic activity. This necessitates the inclusion of cost of negative externalities generated by each production systems in the economic analysis. The sustainability of shrimp culture systems does not only refer to the ecological sustainability but also the economic sustainability. Intensive aquaculture systems have been described as 'throughput-based systems' (Folke and Kautsky, 1992). They depend on large inputs of resources of which only a minor part is taken up by the cultured species, with the rest being released as wastes to the environment (Folke and Kautsky, 1989; Troell, 1996). The ecological foot prints of many of the intensive and semi-intensive production system are analyzed (Folke,1988; Larsson *et al*., 1994, Berg *et al*., 1996, Kautsky *et al*., 1996).

The quality and quantity of wastes from aquaculture depends mainly on culture system, its characteristics, species cultured and the feed quality and management. From intensive systems the principal wastes are uneaten feed and faeces, dissolved nutrients, dissolved organic compounds, chemicals and therapeutics, bacteria and pathogens and the farmed specimen itself (Iwama, 1991). Approximately 30% of the waste generated from the intensive farming is from uneaten feed. In shrimp pond farming the released ammonia is usually rapidly taken up and incorporated in phytoplankton biomass, followed by subsequent accumulation in pond sediment leading to bacterial load and toxins, which is released during pond cleaning or dumped on land or in the open system near to the sea. This also increases the chances of any disease to be spread from the existing pond.

Brackishwater farming in India is an age-old system confined mainly to the Gheries (man made impoundments in coastal wetlands) of Odisha and West Bengal and pokkali (salt resistant deepwater paddy) fields along the Kerala coast. With no additional input, these systems have a production levels between 500–750 kg/ha/year with shrimp contributing 20–25 percent of the total(FAO Bulletin). With the development of more commercial hatcheries, a phenomenal increase in the area under shrimp farming occurred between 1990–1994. Farmed shrimp production increased from 40 000 tonnes in 1991–1992 to 1,15, 000 tonnes in 2002–2003. Currently about 91 percent of the shrimp farmers in India own less than 2 ha, 6 percent between 2 to 5 ha and the remaining 3 percent have an area of greater than 5 ha.

Collection of seaweed from Chilka lake

Material and methods

Culture of shrimp in the soil saline pond in Odisha near Palur, Berhampur was carried out in the integrated system using seaweed *Gracilaria verrucosa* as nutrient trapper. The data were compared with the manmade impoundments in coastal wetlands (Gheri) of Chilka lake at regular interval of time from April to November for 225 days. Seaweeds collected from Chilka lake were introduced to the pond in hapa at different places and observations were made on the water quality parameters. The work was in farmer's field and the final technical input has gone to the farmer with better management practice. Water quality parameters from the shrimp culture pond and the gheri areas were analysed from the month of April to November till the end of the shrimp culture period. Two different stockings were made in the pond one during April and the other during July after the onset of monsoon. The pond was maintained with *Gracilaria verrucosa* throughout the observation period.

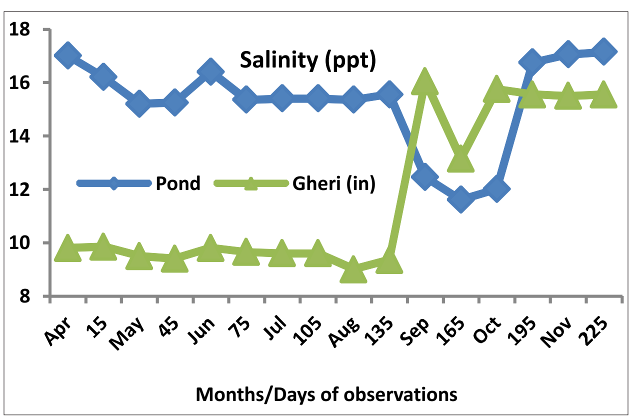
Results and Discussion

Along with the growth of seaweed, the associated fauna like zooplanktons, clams and other bivalves were also recorded from the pond, which are being used as food for the shrimp. In Odisha the farmers follow the most traditional way of shrimp culture practice. The seeds were collected from the nature near Chilka lake so differential growth was observed. Intermittent harvest was made based on their growth of the

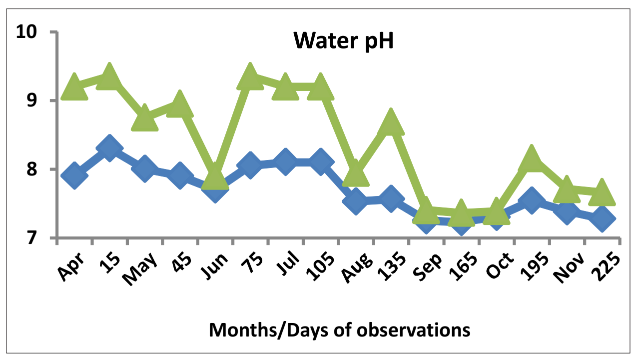
Technical guidance to farmer

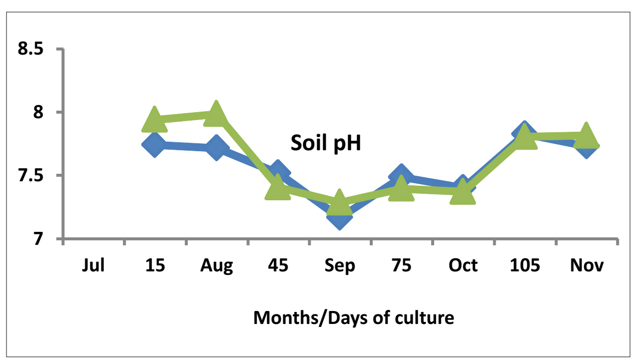
Shrimp culture in Gheri inside Chilka lake

shrimp. Further after a harvest few more seeds were stocked in the same pond which gives them an income throughout the year. Raw clam meat was given to the shrimp as food @ 1-2 kg/day. Shrimp was being harvested by putting plastic net locally called as Khanda or trap net. Netting was avoided because it would churn the pond bottom. The trap net was placed in the pond previous night of the harvest and the shrimps were collected in the early morning which is being sold either to the exporter or send to the domestic market.



While comparing the salinity of pond water and the gheri in the Chilka lake showed a perceptional change. The salinity was found to be very high in pond during the initial period of observations that is during April August and then declined during September. Gheri showed entirely an opposite trend. It remains within 10 in open system during April when the salinity in pond was within 15-17 ppt. The salinity declined during August-september and reduced to 11.6 ppt during post monsoon in pond when the open water salinity increased to 17 ppt. As the salinity in pond system depends on the soil saline condition of the pond and the open lake it depends upon the influx of tidal water and the river water this type of variation was observed. During October and November again the salinity increased to 17 ppt in pond. Mostly the culture period of shrimp in Odisha takes place during July to October in the pond system after the onset of monsoon and continued till November and December. During summer the shrimp farming is not possible in the pond due to excessive heat and reduction in water level as well as DO content.





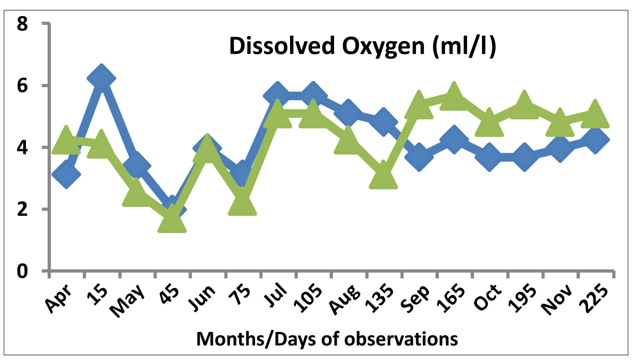
PH of the water both in Gheri and pond system remains above 7.0. The pH was found to be high in Gheri particularly during the period of monsoon and least during Sept and October. Although the pH value is lower in the pond system, the trend was almost similar in Gheri and ponds. The pH gradually decline from April to November with intermittent increase.

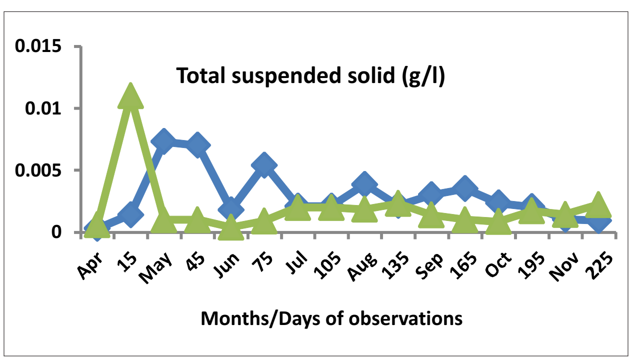
Observations on soil pH were taken in the second cycle of shrimp farming i.e from July to November. The soil pH was also higher in Gheri. Soil pH was found to be lowest in all the system during September in the post monsoon period.

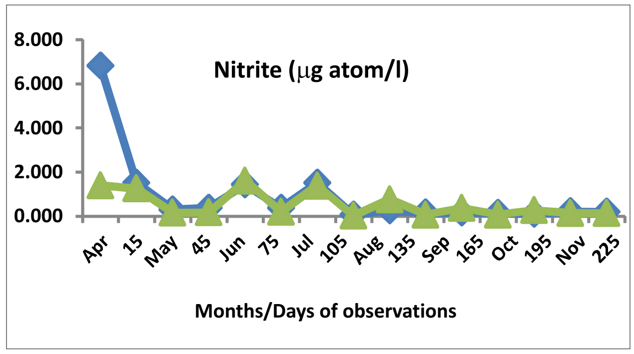
Dissolved oxygen content of the pond and gheri was almost similar throughout the period of investigation. The DO was found to be higher in the pond during 15 days of culture and then declined when the shrimps were grown to a reasonable size. Further from 45 to 90 days of observation the DO increased in the pond and then decline during the second period of growth. Due to continuous exchange of water the DO was found to be higher in Gheri.

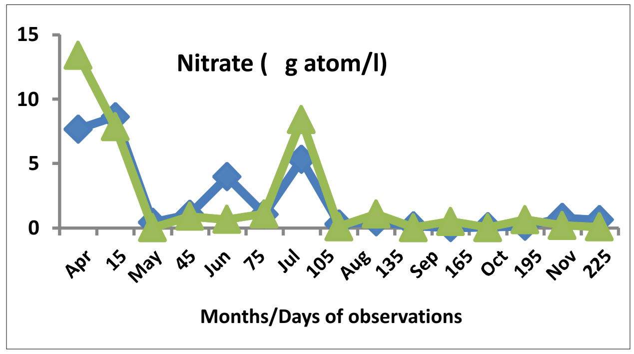
Total suspended solid was more in the Gheri during the month of April-May and then declined. TSS was found to be more in the pond during May and gradually declined from May to November with a zigzag pattern.

After a perceptible decline in the nitrate content during May in pond and gheri it reached to a peak value in July. Monsoon period had shown high nitrate content in pond and then declined. Nitrite content also showed a similar trend. Pond was having very high nitrite before introduction of seaweed and declined within 15 days of introduction. Except for a hike during





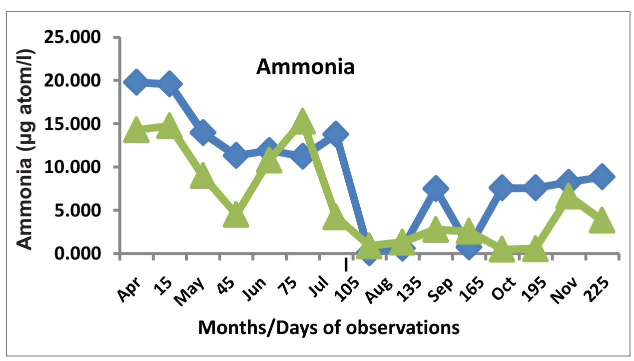




monsoon the nitrite was found to be very low in pond.

There was a decline of Ammonia in pond and gheri till May. In pond the ammonia reduced to almost zero during July-August due to introduction and the luxurious growth were associated with many clams and bivalve which are being consumed by the shrimp. The ammonia content further increased after September but maintained in optimal range till November. Gheri was showing lower ammonia level than pond system. In pond it was observed that after the introduction of shrimp larvae, the ammonia level found to be much higher and then gradually declined which showed that there was a stress of toxic ammonia to the shrimp larvae leading to death of few larval shrimp and necessitates reintroduction.

This explained that introduction of seaweed in the integrated farming can be done before the culture practice is initiated so that the pond condition can be maintained while introducing the larvae. Thus it is advisable to have seaweed stock in the pond in off season when there is no shrimp farming



and further the stocking density can be maintained based on the quantity of shrimp introduced for farming. In this particular experiment cum demonstration in the farmers field 70 kg of shrimp was harvested @ 40 counts per kg after 75 days of stocking of 3000 shrimps during March. Further during the month of July nearly 5000 seeds were stocked in the same pond and harvested during September @ 30 counts per kg and nearly 155 kg was harvested. According to the farmer, the shrimps were sold in the domestic market @ Rs.160/- for 40 counts, Rs.280/- per 30 counts and Rs.380/- per 20 counts. Due to differential growth few shrimps were harvested at 20 counts. The farmer was using raw clam meat 2kg/day @ Rs.20/- during advance stage of growth of shrimp. The farmers get Rs. 15,000/- profit from a crop after adopting the technology of integrated farming which was getting Rs.6000-7000/- per crop. The farmer is maintaining the seaweed stock in the pond throughout the year.

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