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Studies on soil and water conditions of coastal regions during shrimp farming

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Abstract

In India there has been a rapid expansion of shrimp culture activity in recent years. However, this activity has been concentrated only in certain specific areas, particularly in the East Coast bordering Andhra Pradesh and Tamil Nadu. The concentration of activities in certain specific localities may put severe strain on the resources available in the area as well as on the environment. Hence, the present studies were undertaken to investigate the changes in soil and water quality due to intensification of seawater and creekwater based shrimp farms in Andhra Pradesh and seawater based farms in Tamil Nadu. Soil and drinking water quality were also assessed in coastal areas surrounding shrimp farms. Suggestions have been made for soil and water quality management in shrimp farms.

Key Words : Soil and water conditions, Coastal area, Shrimp farming, Redox potential.

Introduction

Intensification of high density shrimp culture activity in many Asian countries, particularly, Taiwan, Philippines, Indonesia, China and Thailand has reported to cause degradation of land resources and deterioration of water quality threatening the long term sustainability of shrimp farming (Phillips *et al*, 1993). Poor water quality has also been linked to outbreak of shrimp diseases in culture ponds (Krishnani *et al*, 1997). In the present paper, changes in soil and water conditions due to intensification of shrimp farming adjacent to Kandaleru creek and coastal area of Nellore district of Andhra Pradesh and coastal area of Chidambarnar and Ramnad districts of Tamil Nadu have been investigated.

Materials and Methods

In Nellore district of Andhra Pradesh, out of the total area of 13915 ha, 4366.35 ha brackishwater area were under culture during 1993. Out of 816 farms, only 10 farms with a total area of 483 ha are seawater based farms while the remaining 800 farms with an area of 3882 ha are creek/canal water based farms. The Kandaleru creek in Nellore district has been identifies as potential area for large scale shrimp farming in India. Out of total potential area of 2500 ha, about 1000 ha of total area has come under shrimp production (Joseph *et al*, 1996).

Six farms in the Kandaleru creek area and three farms along the coastal area of Nellore district of Andhra Pradesh and four farms in Chidambarnar and two farms in Ramnad districts of Tamil Nadu were selected for the study. Samples were collected from each farm at monthly intervals during culture period from April to July 1993 and at the time of harvest during August 1993. Since the wastewater at the end of the harvest time has a much greater pollution potential (Schwartz and Boyd, 1994; Tookwinas *et al*, 1998), the sampling during harvest was done when

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the final 20% of water was drained out. Samples were also collected from Kandaleru creek and shrimp farms during 1994. Water and soil samples were analysed by following standards methods (APHA, 1989; Strickland and Parsons, 1972; Piper, 1966; Grasshoff *et al*, 1983).

The associated villages with the farms were selected randomly to assess the effect of shrimp farming on soil salinisation. Soil samples were collected in triplicate from villages adjoining the farms at a distance of 50 m, 100 m, 250 m and 500 m. The soil samples were dried and analysed for electrical conductivity (1:2.5 soil water ratio) following the method given by Richards (1968). Drinking water samples were analysed for two important parameters viz., total dissolved solids (TDS) and chloride content (APHA, 1989).

Results and Discussion

Sea based farms at Nellore district of Andhra Pradesh

Water characteristics

The results of water analysis from intake, pond and drainage during culture and harvest are presented in Figures -1, 2 and 3. There was not much difference among intake, pond and drainage with regards to salinity. pH and alkanity. Increased levels of turbidity (23.9 NTU) total suspended solids (35.5 ppm), phosphate (0.09 ppm), nitrate-nitrogen (0.133 ppm), ammonia-nitrogen (0.086 ppm), nitrite-nitrogen (0.14 ppm), chemical oxygen demand (22 ppm) and biochemical oxygen demand (11.6 ppm), total nitrogen (0.8 ppm) and total phosphorous (0.12 ppm) were recorded in discharge water during culture as compared to pond water (Turbidity-19.8 NTU, TSS-28.7 ppm, phosphate - 0.05 ppm, nitrate-nitrogen-0.103 ppm, nitrite-nitrogen- 0.13 ppm, ammonia-nitrogen- 0.079 ppm, COD- 18.6 ppm, BOD_5 - 10.8 ppm, total nitrogen- 0.6 ppm and total phosphorus-0.10 ppm). The increase in concentration of the above mentioned parameters in discharge water were greater in magnitude during the harvest than grow-out period.

The levels of all parameters in discharge water during culture and harvest period are well within the permissible limits as prescribed by the Ministry of Environment and Forests (MOEF, 1993) and guidelines suggested by the Ministry of Agriculture/ Department of Agriculture and Cooperation (MOA/ DAC, 1995).

During the final phase of harvesting, the harvesters enter the pond to rake the shrimps towards the sluice gate. These activities produce a slurry of water and pond sediment that raise the concentration of TSS, nutrients, metabolites and organic matter. Further, the solids, phosphorous, nitrogen and BOD_5 tend to concentrate at the bottom rather than at the surface of the ponds (Joseph *et al*, 1996). All these factors might have contributed to the high parameter concentration in drainage water during harvest. In the present study, the total nitrogen and total phosphorous concentrations were comparatively less than the values reported by Tiensongrusmee (1995) in shrimp culture ponds of Thailand during harvest time.

Soil characteristics

The results of soil analysis from intake, pond and drainage during culture and harvest are presented in Fig. 4. The redox potential of soil (Eh) shows an increased reducing condition from intake (-90 mV) through discharge point at harvest time (-163 mV). Further, organic carbon content shows a progressive increase indicating increase in organic matter. The organic carbon content in soil ranged from 0.21% at intake point through 0.80% at discharge point during harvest.

During culture period, the pH of soil was 7.8 and 7.3 at harvest time. Praphruttham (1985) reported that decomposition in sediments would liberate hydrogens ions and decrease the pH during harvest period. The changes in coastal soil following submergence of land with brackishwater are dealt in detail in an earlier communication (Joseph *et al*,

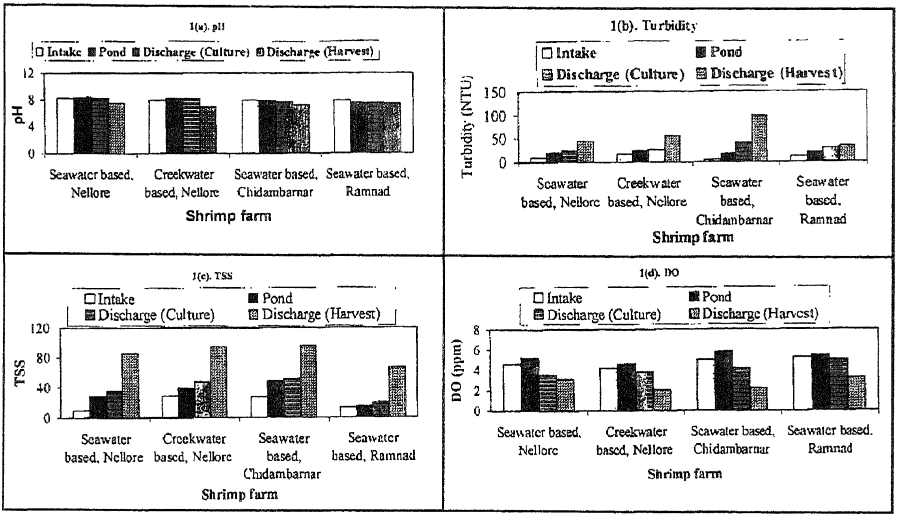

Fig. 1 : Water condition (pH, Turbidity, TSS and DO) of seawater and creek water based shrimp farms at Andhra Pradesh and Tamil Nadu.

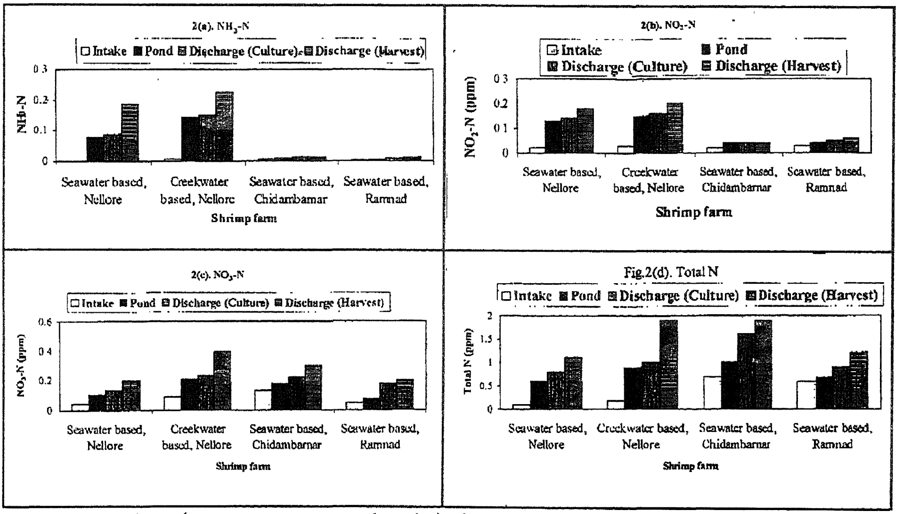

Fig. 2 : Water condition (NH_3-N, NO_2-N, NO_3-N and Total N) of seawater and creek water based shrimp farms at Andhra Pradesh and Tamil Nadu.

1997). The main changes are in electrochemical properties of soil, microbial reduction, changes in available nutrients and ionic equilibria, accumulation of metal sulfide and organic matter decomposition.

Kandaleru creek based farms at Nellore

An increase in values of most of the water quality variables was seen in the ponds and drainage during culture as compared to intake water (Figs. 1 - 3). The discharge water during harvest, when the pond is totally drained, showed higher concentration of values compared to those during culture period. The levels of all parameters except DO were within the permissible limits as prescribed by the MOEF (1993) and MOA / DAC (1995). The DO concentration was less than the prescribed level of 3.0 ppm in discharge water during harvest.

The comparative results of creek and seawater quality reveal that the nutrient and organic loading are more in creekwater. Joseph *et al* (1995) reported that the possible impact of Kandaleru creekwater based farms is higher than seawater based farms. In a study conducted by Muralidhar *et al* (2000) at Thanjavur district, Tamil Nadu, shrimp pond wastewater could not contaminate the natural creek, though the intake and discharge source are same, as the farmers practice only extensive system of culture. Unless the pollution load in pond wastewater exceeds the assimilative capacity of a water body, adverse environmental changes will not occur. Moreover, the environmental impact level due to wastewater depends on the location of the site, the tidal amplitude, the tidal flow, flushing rates, volume at high tide and low tide, the water retention period, morphology of the creek, the type of culture adopted and the management methods followed. The assimilative capacity of receiving waters is seldom known and unless a careful study is made, it is difficult to predict the effect of pond wastes on a given body of water.

Seawater based farms in Chidambarnar and Ramnad districts of Tamil Nadu

The results of water analysis from culture ponds, intake and discharge channels during culture and harvest (Figs. 1-3) showed an increase in values of most of the water quality variables in the ponds and drainage during culture, as compared to intake water. The discharge water during harvest showed higher concentration of values as compared to those during culture period. All the water quality parameters except D. O were within permissible range. The D. O concentration was 2.2 ppm in discharge water during harvest at Chidambarnar.

Study in Kandaleru creek during shrimp disease outbreak

Large-scale mortality of shrimps in the farms along the Kandaleru creek, Nellore district, Andhra Pradesh occurred during the third week of July, 1994.

The Kandaleru creek over a distance of about 30 km from Krishnapatnam (creek mouth opening to sea) through Pudiparthi to Tippaguntapalem (upstream) was surveyed for water quality parameters during 2-3 June 1994 (pre-disease period), 4-5 August 1994 (disease period) and 27-28 October 1994 (post-disease period). The study revealed a gradient in deterioration of water quality from Krishnapatnam to Tippaguntapalem on all the three surveys and also water quality deterioration from pre-disease period to post disease period.

Data on water quality parameters (Joseph *et al*, 1995) clearly showed highly degrading water quality in respect of significant parameters (TSS, COD, BOD_5, NH_3-N and H_2S) from normal conditions close to creek mouth to poor quality in the upper reach, with the highest levels of deterioration in the middle region of the creek. It, further, showed that even after about four months of the disease outbreak (July-October 1994), there has been no perceptible improvement in the water quality of Kandaleru creek.

The Kandaleru creek ecosystem had been subjected to environmental impact from the shrimp farms during July - October 1994 and since the intake and drainage systems of the shrimp farms are both based on the same creek, and since it was obviously beyond the capacity of natural processes to absorb the excessive organic and nutrient load and improve the water quality, there has been a serious negative feedback to the shrimp farming system resulting in poor water quality. The impact and negative feedback has been the most severe in the middle region of the

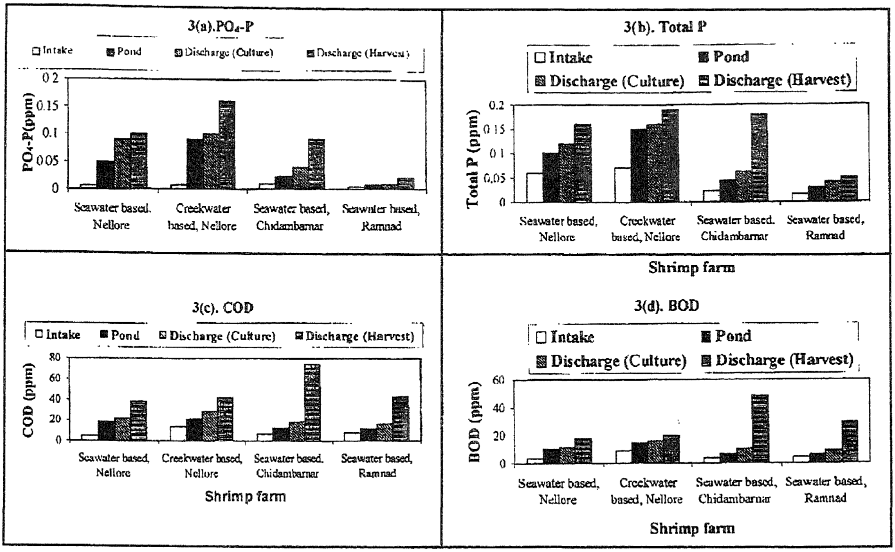

Fig. 3 : Water condition (PO_4-P, Total P, COD and BOD) of seawater and creek water based shrimp farms at Tamil Nadu and Andhra Pradesh.

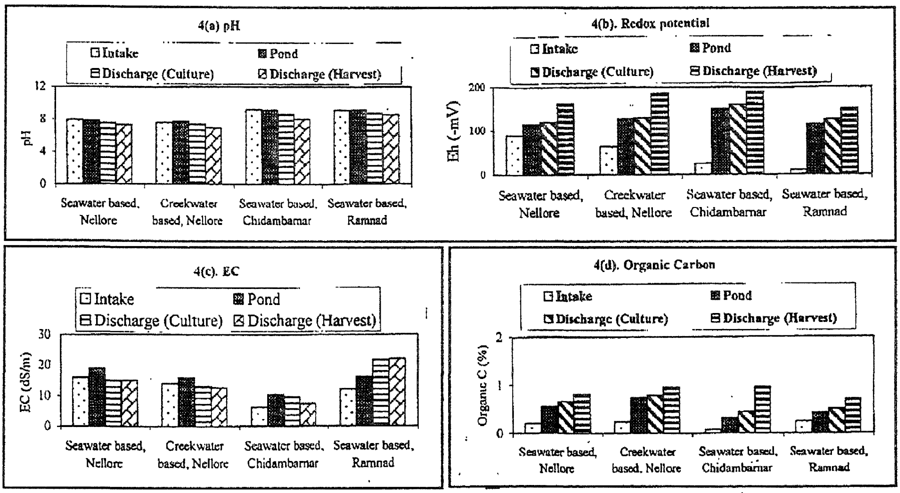

Fig. 4 : Soil condition of seawater and creekwater based shrimp farms at Andhra Pradesh and Tamil Nadu.

creek, where most of the semi-intensive shrimp culture farms with higher stocking densities and related higher levels of farm inputs are located.

The pattern of mortality of shrimp in the ponds is indicative of a primary viral infection which can be pre-disposing factor for the severe secondary bacterial infection. The environmental degradation as evidenced from highly deteriorated water quality in the Kandaleru creek and the ponds, would have triggered viral infection followed by high degree of infection by several gram negative species of bacteria which would have caused the large-scale mortalities in shrimp farms.

Soil salinisation

The average electrical conductivity (EC) of soil samples from lands surrounding shrimp farms of Nellore district reveal that as the distance from the farm increases there was decrease in EC values. However, there is practically no soil salinisation even at a distance of 50 m away from the farm, whereas the EC values exceed the limit of 4.0 dS/m in four villages out of 14 villages studied (Joseph *et al*, 1996). The EC values were less than 4.0 dS/m at 100 m away from the farm as it ranged from 1.1 to 3.9 dS/m.

The salinisation of soil, if any, is not solely due to shrimp farms, but due to combined effect of the creek/sea (source water) and the farm. The problem of soil salinity is dominant in coastal areas in dry season due to high evapotranspiration (Gupta *et al*, 1999). The backflow of seawater during high tides may also inundate the land causing accumulation of salt. Since most of the shrimp farms in coastal areas are located in already salinated soils, it is not proper to blame the shrimp farming activity as the sole cause of soil salinisation.

Drinking water quality

The concentration of chloride and total dissolved solids (TDS) in bore well waters of Nellore district ranged from 410 to 4900 ppm and 800 to 9600 ppm, respectively (Joseph *et al*, 1996). The levels of chloride and TDS registered a decreasing trend as the distance increases from the shrimp farm.

Considering the permissible levels of chloride (maximum 200 - 600 ppm) and TDS (maximum 500 - 1500 ppm) for potable water, only five bore wells out of twelve are not suitable for drinking purpose. In all other cases, though there was a slight increase in the levels of chloride and TDS closer to the farms, they are still within tolerable limits.

Water quality management

One way to reduce the risk of water contamination from shrimp culture ponds is to apply standards for wastewater discharge. The simplest standards have criteria regarding the permissible concentrations of selected water quality variables in effluent. A standard must specify the acceptable ranges of pH, minimum dissolve oxygen concentration and maximum concentrations of COD, BOD_5, TSS and other variables. Further, physical regulations of shrimp farming with respect to land, water, seed, feed, chemicals/drugs etc. are to be considered seriously to mitigate likely environmental changes (Algarswami and Joseph, 1995).

The best method for preventing soil and water quality problems in aquaculture pond environment is to select a site with good soil and adequate supply of good quality water and to maintain moderate levels of shrimp production. Avoid over feeding and a high quality feed that contains no more nitrogen and phosphorous that actually needed by shrimp. Water and soil conditions of ponds can be maintained through proper aeration, liming of acidic ponds and treatment of pond bottoms to enhance organic matter decomposition. Proper pond management is the key to sustainability in aquaculture which in turn can improve soil and water quality in ponds and reduce the volume and pollution potential of pond discharges.

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