Journal of
The Marine Biological Association of India

ABBREVIATION : *J. mar. biol. Ass. India*

Vol. 41 **June and December 1999** **No. 1 & 2**

SOIL-WATER CHARACTERISTICS IN CERTAIN SHRIMP FARMS ALONG THE COASTS OF TAMIL NADU AND PONDICHERRY, INDIA

P. KALADHARAN, A. NANDAKUMAR, L.R. KHAMBADKAR AND G.S.D. SELVARAJ
Central Marine Fisheries Research Institute, Cochin-682 014, India

ABSTRACT

Alkalinity, salinity, hardness and total suspended solids (TSS) in water and organic carbon (OC) content, salinity and cations like sodium and calcium in soils were studied from certain shrimp farming areas along Sirkhazhi, Myladuthurai and Nagapattinam taluks of Tamil Nadu and Karaikal of Pondicherry during September 1995. The culture ponds registered higher levels of total suspended solids (133 mg/l), salinity (32 ppt) and hardness (6571 mg/l) in water and cation content (4166 ppm Na^{+}; 2411 ppm Ca^{++}) and salinity (6.77 ppt) in soil samples. The levels of all these parameters were compared with the adjoining non-culture sites. The variations in the properties of water and soil samples of stocked and non-stocked farms were also studied. The results were analysed statistically to understand any possible inter-relationship between water and soil within the pond as well as among the ponds, their inlets and outlets.

INTRODUCTION

THE INTERACTION of soil and water in culture ponds is a subject of scientific and ecological interest. Sediment is an integral part of the pond interacting in all the metabolic processes. While relatively more comprehensive information is available on the water quality of culture ponds in India, there has been very little attention devoted to the soil of culture ponds and its interaction with the water. The water quality of fish ponds in India was studied by Sewell (1927), Ganapathy *et. al.*, (1945, 1953), Menon *et. al.*, (1959), Rajyalakshmi (1980), Poernomo and Singh (1982) and several others. Hardness, alkalinity and salinity are certain parameters to define important properties of the water. Water soluble cations like Mg, Ca, Na and K have an important role in soil and water interaction. Lyzimetric investigations of ponds (Wrobel, 1967) proved that calcium is the most washed out factor in culture ponds. A few studies available on soil and water characteristics of fish culture ponds (Golterman, 1967; Banerjea, 1967) are devoted mainly to freshwater fish ponds and such studies on brackish-water counterparts are scanty.

To assess the impacts of shrimp farming on the neighbouring environment and on the coastal population, an environment impact

assessment (EIA) study was undertaken by the Central Marine Fisheries Research Institute in Nagapattinam district, Tamil Nadu and Karaikal of Pondicherry (Fig. 1) during September 1995

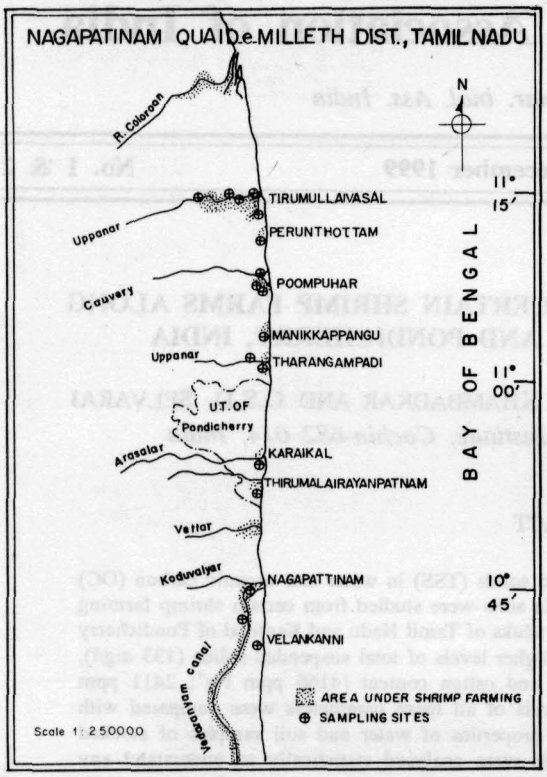

FIG. 1. *Prawn farming areas along the coast of Nagapattinam District (Tamil Nadu) and Karaikal (U.T. Pondicherry).*

(Paul Raj *et al.*, 1997). The main object of the present study was to analyse the physico-chemical properties of water and soil of shrimp culture farms and the neighbouring non-culture site such as bathing ponds, paddy fields, domestic wells etc. and to study their possible correlation in certain onshore prawn farms along the coastal areas.

The authors are grateful to Dr. M. Devaraj, former Director C.M.F.R.I., for evincing the ideas and for extending constant support. The authors acknowledge Dr. V.N. Pillai, Director for his encouragement and for providing necessary facilities. They thank Dr. R. Paul Raj, Officer-in-charge, Dr. M. Vijayakumaran, Sr. Scientist and Mr. K. Ahmed Basha, Sr. Technical Assistant of the Kovalam Research Centre of CMFRI for their co-operation extended during the fieldwork. The help rendered by Dr. P.K. Krishnakumar and Shri T.V. Sathiyanandan, Sr. Scale Scientists in carrying out statistical analyses and Mrs. Leela Bhai, Technical Officer in analysing soil samples are gratefully acknowledged.

MATERIAL AND METHODS

The study area included several small and large onshore farms in the nine coastal villages (Fig. 1) *viz.* Thirumullaivasal, Perunthottam, Poompuhar, Manikkapangu, Tharangampadi, Karaikal, Thirumalairayanpattinam, Nagapattinam and Velanganni. All the farms were located in close proximity to the coast or in the vicinity of estuarine systems. The total geographical area of Sirkhazhi, Tharangampadi and Nagapattinam taluks is about 1.07 lakh hectares in which the area under shrimp farming was about 2000 ha which was less than 2% of the total area (Paul Raj *et al.*, 1997).

During the study period, many of the farms were operational. After the disease outbreak on shrimps during the first half of 1995, most of the ponds had been restocked and were in different stages of cultivation and a few were yet to stock shrimps (non-stocked ponds). All the farms had water inlet mainly from sea or estuary and proper outlet with weekly removal of 30-50% water from the stocked ponds. Soil and water samples were collected from inlets, ponds and outlets of culture farms and from the non-culture sites.

Water samples collected in polythene bottles were utilized for the determination of pH, salinity, hardness, alkalinity and total suspended solids (TSS). Soil samples were

collected with the help of augar to a depth of 50 cm from the surface. The pooled soil samples were dried, powdered and sieved. These samples were analysed for soil salinity, OC and cations. Soil pH was measured *in situ* with the help of a portable pH meter (Takemurae & Co., Japan). Salinity, hardness and alkalinity of water samples were determined by titrimetry and TSS by gravimetry using standard methods (APHA., 1980). Weighed 5 g of soil samples and treated separately in 50 ml of neutral ammonium acetate solution for the extraction of cations. The concentrations of Na^+ and Ca^{++} were determined flame photometrically (Chemito, Toshniwal) against suitable standards. The OC was determined according to the method of Walkley and Black (1934).

RESULTS AND DISCUSSION

In Nagapattinam district of Tamil Nadu and Karaikal of Pondicherry, the shrimp farms were spread over 31 villages in the areas mentioned in the map (Fig. 1). The shrimp farming activity in these areas commenced in 1991 on a small scale and became intensive to improved extensive culture from 1993 onwards (Paul Raj *et al.*, 1997; Shivanandamurthy, 1997). All the shrimp farms studied were dug-out ponds receiving salt water from sea or lagoon and creeks of backwater. It is reported that soil in the shrimp farming areas are mostly sandy or coastal alluvial, excessively drained and rapidly permeable (SSLUO., 1984).

Water characteristics

From the data on culture farms pertaining to water properties (Fig. 2) it could be observed that the salinity, pH and hardness were the highest in ponds (32.07 ± 7.75 ppt, 7.82 ± 1.38 and 6571 ± 63 mg/l respectively), while these parameters in their inlets and outlets did not show much variations (Fig. 2). Alkalinity remained lowest in ponds (118 ± 18 mg/l), and that of inlets and outlets showed 127 ± 25 mg/l and 134 ± 18 mg/l respectively. TSS on the other hand remained highest in the outlets (65.68 ± 21.78 mg/l) and the corresponding lowest values were observed in

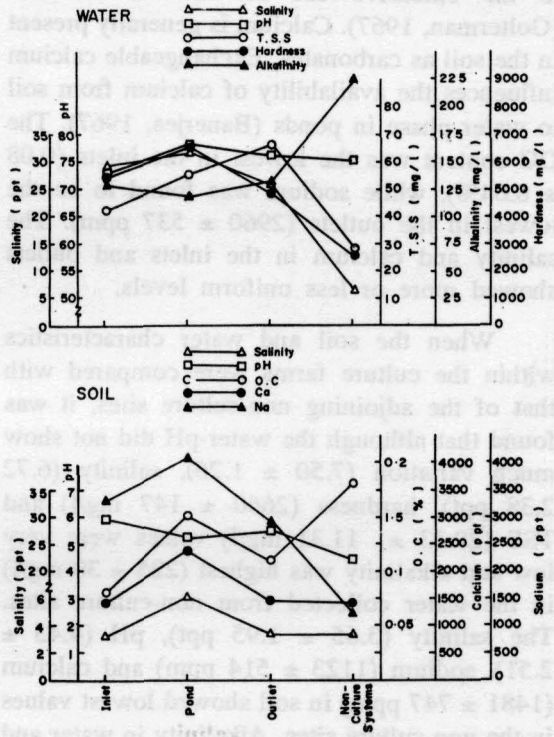

FIG. 2. *Characteristics of water (above) and soil (below) in inlets, ponds and outlets of prawn farms and non-culture areas.*

the inlets (42.8 ± 13.33 mg/l). This increase in the levels of TSS in the outlets was considered due to the presence of unutilized feed particles and excreta of the organisms being cultured in the ponds.

Soil characteristics

While studying the soil characteristics of the culture farms it was observed that (Fig. 2) the soil parameters such as salinity, OC, sodium and calcium showed the maximum values within the ponds (6.78 ± 3.52 ppt, 0.15 ± 0.09%, 4166 ± 890 ppm and 2411 ± 486 ppm

respectively) when compared with their inlets and outlets. However, pH showed highest value (5.91 ± 1.80) in the inlets (Fig. 2). The higher levels of calcium in the ponds can be attributed to the extensive use of lime as fertilizer (Golterman, 1967). Calcium is generally present in the soil as carbonates. Exchangeable calcium influences the availability of calcium from soil to water phase in ponds (Banerjea, 1967). The OC content was the lowest in the inlets (0.08 ± 0.04%), while sodium was found to be the lowest in the outlets (2960 ± 537 ppm). The salinity and calcium in the inlets and outlets showed more or less uniform levels.

When the soil and water characteristics within the culture farms were compared with that of the adjoining non-culture sites, it was found that although the water-pH did not show much variation (7.50 ± 1.26), salinity (6.72 2.38 ppt), hardness (2660 ± 147 mg/l) and TSS (29.33 ± 11.31 mg/l) values were very low and alkalinity was highest (225 ± 30 mg/l) in the water collected from non-culture sites. The salinity (3.65 ± 1.95 ppt), pH (4.43 ± 2.51), sodium (1123 ± 514 ppm) and calcium (1481 ± 747 ppm) in soil showed lowest values in the non-culture sites. Alkalinity in water and OC content in soil recorded comparatively higher values (225 ± 30 mg/l; 0.18 ± 0.11%) in the non-culture sites (Fig. 2). According to Banerjea (1967) OC content above 2.5% is not desirable for a pond soil and this affects the production.

In general, most of the parameters during the present study showed higher values within the ponds, while more or less uniform values were observed in the inlets and outlets in water as well as in soil, except the alkalinity in water and pH in soil (Fig. 2). This may be indicative of the culture manipulations and management practices made within the ponds towards improving the shrimp production. Similarly most of the water properties (salinity, hardness and TSS) and the soil parameters (salinity, pH, sodium and calcium) studied within the ponds showed considerably low values in the non-culture sites when compared to the culture farms. Only water-alkalinity and soil – OC content registered higher values in the non-culture sites, which need not be due to any impact of shrimp farming as the soil and groundwater in this coastal area is already affected by surface and subsurface salinity and alkalinity (SSLUO., 1984; Paul Raj *et. al.*, 1997). In both the culture farms as well as in the non-culture sites, pH remained alkaline in water and acidic in soil. It is noted from certain estuarine fish ponds that in general the soil pH is slightly acidic while water pH is slightly alkaline (Kadam and Bhosale, 1985). Weak alkaline pH (7-8) has been found in most of the productive ponds (Nees, 1949). The pH of soil also influences inorganic transformation of nutrients and controls the adsorption and release of ions of essential nutrients at soil-water interface (Schaeperclaus, 1933).

Stocked and non-stocked farms:

While attempting a comparative study between the shrimp stocked and non-stocked farms, it was observed that the stocked farms during the study period exhibited in water (Fig. 3) maximum values for salinity (35.40 ± 8.5 ppt), hardness (7019 ± 608 mg/l), pH (8.0 ± 2.8) and TSS (57.50 ± 6.7 mg/l) and the lowest value for alkalinity (114.69 ± 18.79 mg/l) in the ponds. While the corresponding lowest values were for pH (7.6 ± 1.8), salinity (27.24 ± 6.18 ppt) and TSS(37.50 ± 7.02 mg/l) in the inlets and for hardness (5474 ± 490 mg/l) in the outlets. In the non-stocked sector, pH (7.58 ± 1.7) within the ponds, salinity (33.62.62 ± 8.73 ppt) and hardness (6829 ± 544 mg/l) in the inlets and alkalinity (119.77± 16.86 mg/l) and TSS (86.46 ± 8.3 mg/l) in the outlets were observed highest, whereas,

pH(7.1 ± 1.5), alkalinity (104.47± 20.50 mg/l) and TSS (43.15 ± 10.14 mg/l) in the inlets and hardness (4879 ± 397 mg/l) in the outlets

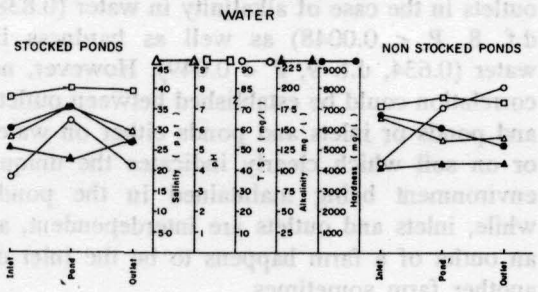

FIG. 3. *Water characteristics in the stocked and non-stocked farms.*

and salinity (27.24 ± 6.18 ppt) in the ponds were found to be the lowest.

As regards the soil characteristics (Fig. 4), pH did not show much variations among the inlets, ponds and outlets (5.5 ± 1.3 to 5.6 ± 2.7) of the stocked farms. While in the non-stocked farms, pH showed higher values (6.05 ± 1.05) in the inlets than their outlets (4.8 ± 0.9). The ponds of both stocked and non-stocked sector registered maximum levels of salinity (5.63 ± 1.75 and 6.29 ± 2.11 ppt); OC (0.19 ± 0.08% and 0.55 ± 0.19%) and calcium (2150 ± 210 ppm and 2775 ± 195 ppm respectively). Sodium levels did not show much variations among the ponds and their inlets and outlets of stocked farms (3140 ± to 3410 ± 305 ppm). On the other hand calcium exhibited variations between the stocked and non-stocked ponds (2150 ± 210 and 2775 ± 195 ppm), their inlets (1175 ± 190 and 1550 ± 210 ppm) and outlets (1600 ± 180 and 1293 ± 185 ppm; Fig. 4).

In general the levels of pH, salinity, hardness and TSS in water were higher in the stocked ponds when compared to their inlets and outlets, while alkalinity showed a reverse trend. This indicates the general pattern that in the stocked ponds the water characteristics are adequately maintained than in the non-stocked ponds. As regards the non-stocked farms,

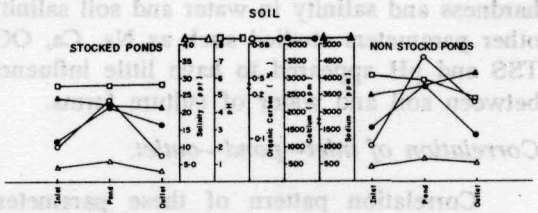

FIG. 4. *Soil characteristics in the stocked and non-stocked farms.*

salinity and hardness values were higher in the inlets and the alkalinity and TSS were higher in the outlets. Only pH values showed a trend similar to that of the stocked farms. As regards soil salinity, calcium and OC, highest values were observed within the ponds of both the stocked and non-stocked farms. In the stocked farms, pH of soil showed an increase and sodium a decreasing trend from inlet to pond and to the outlet. However, pH and sodium exhibited a reverse trend in the non-stocked farms.

Soil-water inter-relationship:

To examine the relationship between the physico-chemical properties of water and soil, correlation coefficients were computed and their significance were tested using students't' test (Cochran and Cox, 1957: Freund and Walpol, 1987). Salinity of water and soil in the culture ponds, inlets and outlets as well as non-culture sites showed a significant positive correlation (0.3625, $p < 0.05$). Similarly total hardness in water exhibited a significant positive correlation (0.3328, $p < 0.05$) with salinity of their bottom soil. However, a negative correlation was indicated between the alkalinity in water and sodium in the soils (-0.3379, $P < 0.05$). As the soil is alkaline, saline and rapidly permeable (SSLUO., 1984), any rate of alteration in the water salinity, alkalinity and hardness can

directly and rapidly effect the salinity of the soil and *vice versa*. Correlation among other parameters between soil and water were not significant indicating that except alkalinity, hardness and salinity in water and soil salinity other parameters studied such as Na, Ca, OC, TSS and pH appeared to have little influence between soil and water of culture farms.

Correlation of inlet—pond—outlet:

Correlation pattern of these parameters among inlet, pond and outlet of shrimp farms was also studied through simple regression analysis. A positive correlation at 1% level significance was observed in the case of salinity in water between inlets and that of outlets (0.889, $P < 0.007$). Similarly a positive correlation was recorded between inlets and outlets in the case of alkalinity in water (0.838, d.f. 8, $P < 0.0048$) as well as hardness in water (0.634, d.f. 9, $P < 0.049$). However, no correlation could be established between outlets and ponds or inlets and ponds either on water or on soil which clearly indicates the unique environment being maintained in the ponds while, inlets and outlets are interdependent, as an outlet of a farm happens to be the inlet of another farm sometimes.

REFERENCES

APHA. 1980. American Public Health Association. *Standard Methods for the Examination of water and waste water* Eds., M.A. Stand and H. Franson, 15th edition 57-137.

BANERJEA, S.M. 1967. Water quality and soil condition of fish ponds in some States of India in relation to fish production. *Indian J. Fish.*, **14** : 115-144.

COCHRAN, W.G. AND G.M. COX 1957. *Experimental Designs* Wiley, New York.

FREUND, J.E. AND R.E. WALPOLE 1987. *Mathematical Statistics.* Prentice Hall, New Delhi, 608 pp.

GANAPATI, S.V., K.H. ALIKUNHI AND F. THIVY 1945. Hydrobiological investigations of the Stanley reservoir at Metur Dam Madras. *Proc. Indian Sci. Congr.*

CHACKO P.I. AND R. SRINIVASAN 1953. Hydrobiological conditions of the Gangadareswar temple tank. *Madras J. Asiat. Soci. (Sc).*, **19** (2) : 149-158.

GOLTERMAN, H.L. 1967. Influence of soil on the chemistry of water in relation to productivity. In *Proc. World Symp. warm-water pond fish culture.* FAO F.R. **44** : Vol. II/R-4, 27-42.

KADAM, S.D. AND L.J. BHOSALE 1985. Variations in different physical and chemical parameters of estuarine water and soils at different places in Ratnagiri District. *The Mangroves*: *Proc. Nat. Symp. Biol. Util. Cons. Mangroves.* Shivaji University, Kholhapur, India. 356-361.

MENON, M.D., R. SRINIVASAN AND B. KRISHNAMURTTY 1959. Report on the Madras rural piscicultural scheme 1942-1952.

NEES, J.C. 1949. Development and status of pond fertilization in Central Europe. *Trans. Amer. Fish. Soc.*, **76** : 355-358.

PAUL RAJ, R., M. RAJAGOPAAL, M. VIJAYAKUMARAN, G.S. DANIEL SELVARAJ, E. VIVEKANANDAN, R. SATHIADAS, B. NARAYANAKUMAR, P. KALADHARAN, A. NANDAKUMAR, R. THANGAVELU, L. JAYASANKARAN, L.R. KHAMBADKAR AND A. AHMED KAMAL BASHA 1997. Environmental impact assessment in the shrimp farming areas of Nagapattinam, Quaid-e-Milleth District, Tamil Nadu. *Mar. Fish. Infor. serv., T & E Ser.*, 147 : 1-9.

POERNOMO, A. AND V.P. SINGH 1982. Problem, field identification and practical solution of acid sulphate soils for brackishwater ponds. *Proc. Seminar on Coastal Fish. pond Engineering.*, 49-61.

RAJYALAKSHMI, T. 1980. *Manual of brackishwater Aquaculture in India.* Bull. No. 31 CICFRI., Barrackpore.

SCHAEPERCLAUS, W. 1933. Test book of pond culture. *U.S. Fish. & Wildl. Serv.*, 311, 261 pp.

SEWELL, R.B.S. 1927. On mortality of fishes. *J. Asiat. Soc. Bengal.* **22** : 177-204.

SHIVANANDAMURTHY, H. 1997. Impact of the Supreme Court Judgement on shrimp culture in India. *Infofish international*, 3/37 30-34.

SSLUO 1984. Soil Survey and Land Use Organisation, Thanjavur, Govt. of Tamil Nadu.

WALKLEY, A. AND I.A. BLACK 1934. Method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.*, **37** : 29-38.

WROBEL, S. 1967. The role of soils in fish production in ponds. FAO F.R. **44** (4) : 153-163.