AQUACULT Vol. 3 (1), 51-59, 2002 ISSN - 0972 - 2262

Characterisation of intake, pond and outlet water of creek and Seawater based shrimp farms in Nellore district of Andhra Pradesh

K. O. Joseph, M. Muralidhar, B. P. Gupta, and K. K. Krishnani
Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, R.A. Puram, Chennai - 600 028, India.

(Accepted For Publication - 24th January, 2002)

Abstract

Environmental impact of shrimp farming has become a major issue in many countries with development of shrimp culture industries. The present study was taken up to assess the physical and chemical characteristics of water from two shrimp farms along the Kandaleru creek area and three seawater based shrimp farms along the coastal area of Nellore District of Andhra Pradesh. The water samples were collected from intake, pond during culture period and outlet point at harvest time from coastal culture systems. An increase in value of water quality parameters was seen from source to outlet point. The average values of different parameters in intake are 0.07 ppm NH_3-N, 0.03 ppm NO_2-N and 14 ppm COD in creekwater based farm and 0.001 ppm NH_3-N, 0.02 ppm NO_2-N and 4.8 ppm COD in seawater based farm. The values of above mentioned parameters at outlet point are 0.266 ppm NH_3-N, 0.2 ppm NO_2-N and 68 ppm COD in creekwater based farm and 0.086 ppm NH_3-N, 0.15 ppm NO_2-N and 64 ppm COD in seawater based farm. All the observed water quality parameters are within permissible range. The redox potential of soil at outlet point showed more reduced condition during harvest time in general. Organic carbon content in soil showed progressive increase in sea water based farms (0.21, 0.76 and 0.80% in intake, pond and outlet point, respectively) indicating increase in organic load at the pond bottom. Similar trend was observed in creekwater based shrimp farms. Suggestions have been made for proper water and soil management in shrimp farms for stress free pond environment.

Key words : Shrimp farms, Soil and water quality, Intake, Pond, Oulet.

Introduction

Commercial shrimp farming has gained global attention not only on account of its role in strengthening the economy of a country but also by its sudden collapse in certain countries. In India there has been rapid expansion of shrimp culture activity in recent years. Aquaculture being a biological production activity, the interaction of inputs such as shrimp seed, feed etc. with the ambient water result in growth and production of shrimp as well as changes in water quality. The unutilized feed is likely to increase the concentration of nutrients, organic matter and suspended matter in pond water and alterations in bottom soil condition (Boyd, 1995).

The present study was taken up to monitor the changes in the quality of water and soil during one cycle of shrimp farming in creekwater and seawater based coastal shrimp farms and to suggest measures for management of stress free pond environment.

Materials and Methods

The present study on environmental changes due to shrimp farming was taken up in the coastal belt of Nellore district of Andhra Pradesh which has a coastline

Table 1 Water quality parameters in creekwater based shrimp farms

Parameter	Intake	Pond	Outlet**
Salinity (ppt)	23 25^a (±12 01)	29 23^a (±3 54)	27 45^a (±3 49)
pH	7 93^a (±0 28)	8 23^a (±0 22)	8 25^a (±0 17)
Temperature (°C)	27 0^a (±4 24)	26 78^a (±4 13)	26 9^a (±4 26)
Alkalinity (ppm)	97 5^a (±33 04)	102 75^a (±21 09)	97 0^a (±25 26)
Turbidity (NTU)	10 0^b (±2 31)	50 23^a (±18 02)	56 75^a (±15 44)
T S S (ppm)	2 94^c (±1 17)	60 25^b (±10 07)	95 13^a (±23 39)
Phosphate (ppm)	0 008^b (±0 001)	0 147^b (±0 15)	0 321^a (±0 05)
Nitrate N (ppm)	0 093^c (±0 02)	0 215^b (±0 05)	0 297^a (±0 04)
D O (ppm)	3 83^a (±0 33)	4 23^a (±0 39)	3 10^a (±0 41)
Ammonia N (ppm)	0 007^c (±0 01)	0 148^b (±0 03)	0 226^a (±0 04)
Nitrite N (ppm)	0 032^b (±0 01)	0 150^a (±0 04)	0 199^a (±0 07)
Total N (ppm)	0 36^c (±0 10)	2 71^b (±0 76)	4 01^a (±1 27)
Total P (ppm)	0 08^c (±0 02)	0 29^b (±0 11)	0 56^a (±0 26)
COD (ppm)	14 08^c (±0 56)	61 0^b (±12 13)	68 25^a (±15 59)
BOD_5 (ppm)	9 11^c (±0 88)	31 08^b (±2 12)	40 8^a (±4 09)
H_2S (ppm)	BDL	0 012^a (±0 002)	0 023^b (±0 005)

* - Average values of 4 collections along with standard deviation The values with different alphabets are significantly differnt ($P \leq 0\ 05$)

** - Sample collected during harvest when the final 20% water was drained out, BDL - Below detection level

of 169 km During 1993 a total of 4366 35 ha of brackishwater area was under farming in this district, out of the total available area of 13915 ha Out of 816 farms, only 10 farms with a total area of 483 ha are seawater based while the remaining 800 farms with an area of 3882 ha are creek/canal water based The seawater-based farms were mainly under corporate sector and draw water from the sea through long concrete jetties with length varying from 150 to 1500 m

The 34 km long Kandaleru creek beginning from Tippaguntapalem on the west to Krishnapatnam on the east before joining the Bay of Bengal in Nellore district has been identified as an area with potential for large-scale shrimp farming in India This is a flood drain creek which has brackishwater for almost through out the year, except during times of flood (northeast monsoon) The brackishwater creek traverses a distance of about 34 km The width of the creek varies from 20 to 60 m The barmouth is always open to the sea The average tidal amplitude is 0 75 m, not exceeding 1 0 m during high tide regime The creek is deeper in some parts measuring 3-4 m depth During the wet season (November to December) the creek has essentially freshwater, but during the dry season (May and June) the salinity is around 25 ppt For the remainder of the year the salinity varies from 10-18 ppt

Shrimp farms with drainable ponds have been constructed on both sides of the creek About 1000 ha of total area has come under shrimp farms during

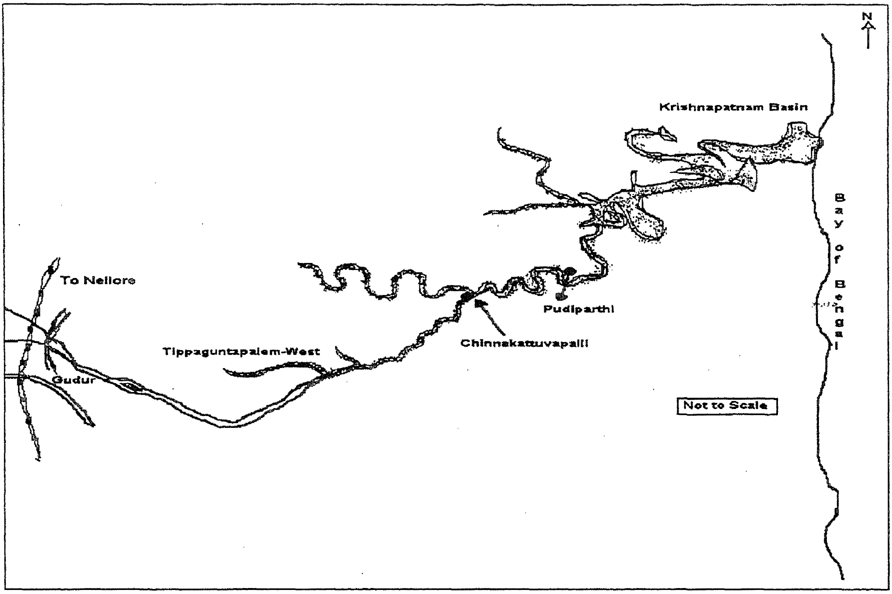

Fig. 1 : Shrimp farms selected for the study along the Kandaleru creek, Nellore District.

1993, out of the total potential area of 2500 ha. The white shrimp *P. indicus* was cultured in some farms when tiger shrimp seed was not available. The stocking density varied from 5-30 PL/m^2 in different farms, with production ranging from 1-6 t/ha/crop. Concentration of farms was largely seen in the middle region of the creek at Pudiparthi area.

Two farms in the Kandaleru creek area (Fig. 1) and 3 farms along the coastal area (Fig. 2) of Nellore district were selected for detailed study. Water and soil samples were collected from the intake (adjoining creek/sea), ponds during the progressive phase of the culture period (August/September, 1993) and outlet during the harvest period (October, 1993) when the final 20% of water was drained out. The number of collections for each sampling station was 4 in creekwater based farms and 6 in seawater based farms. Water and soil samples were analysed for various parameters viz., Water - salinity, pH, temperature, alkalinity, total suspended solids (TSS), phosphate, nitrate nitrogen (NO_3-N), dissolved oxygen (DO), un-ionised ammonia nitrogen (NH_3-N), nitrite nitrogen (NO_2-N), total nitrogen (TN), total phosphorus (TP), chemical oxygen demand (COD), 5 - day biochemical oxygen demand (BOD_5), hydrogen sulphide (H_2S) and Soil - texture (sand, silt and clay), pH and electrical conductivity (1:2.5 :: soil : water ratio), redox potential (E_h) and organic carbon following standard methods (Strickland and Parsons, 1972; Grasshoff *et al*, 1983; APHA, 1989; Piper, 1966; Jackson, 1967). Statistical analysis was done by one-way ANOVA, two-way ANOVA and Duncan's multiple range test (Gomez and Gomez, 1984).

Results and Discussion

Water quality

Creekwater based farms : The results of water analysis from intake, pond during culture period and outlet at harvest (during final 20 % water drain out phase) from creekwater based shrimp farms are presented in Table 1. There was no significant difference among intake, pond and outlet water for salinity, pH, temperature and alkalinity in all sampling

Table 2 : Water quality parameters in seawater based shrimp farms*.

Parameter	Intake	Pond	Outlet**
Salinity (ppt)	28.58[a] (±6.62)	29.68[a] (±5.38)	27.82[a] (±3.95)
pH	8.23[a] (±0.10)	8.42[a] (±0.28)	8.27[a] (±0.15)
Temperature (°C)	29.75[a] (±1.60)	29.57[a] (±1.56)	28.72[a] (±1.73)
Alkalinity (ppm)	110.0[a] (±45.89)	130.0[a] (± 47.23)	130.83[a] (±41.28)
Turbidity (NTU)	9.0[b] (±1.05)	47.98[a] (±7.4)	53.88[a] (±8.41)
T.S.S. (ppm)	0.972[c] (±0.07)	58.75[b] (±6.23)	85.58[a] (±8.73)
Phosphate (ppm)	0.005[c] (±0.001)	0.25[a] (±0.03)	0.21[b] (±0.05)
Nitrate N (ppm)	0.042[b] (±0.01)	0.183[a] (±0.03)	0.193[a] (±0.03)
D.O. (ppm)	4.0[b] (±0.28)	5.18[a] (±0.26)	3.52[c] (±0.38)
Ammonia N (ppm)	0.001[b] (±0.001)	0.079[a] (±0.02)	0.086[a] (±0.03)
Nitrite N (ppm)	0.023[b] (±0.01)	0.160[a] (±0.03)	0.152[a] (±0.04)
Total N (ppm)	0.10[c] (±0.05)	1.20[b] (±0.46)	1.86[a] (±0.84)
Total P (ppm)	0.06[b] (±0.02)	0.27[a] (±0.09)	0.39[a] (±0.10)
COD (ppm)	4.82[b] (±0.92)	58.1[a] (±12.9)	64.0[a] (±6.42)
BOD_5 (ppm)	3.5[c] (±0.76)	28.55[b] (±2.81)	37.45[a] (±5.37)
H_2S (ppm)	BDL	0.011[b] (±0.001)	0.019[a] (±0.002)

* - Average values of 6 collections along with standard deviation. The values with different alphabets are significantly differnt ($P \leq 0.05$).

** - Sample collected during harvest when the final 20% water was drained out, BDL - Below detection level.

tations which ranged from 23.25 to 29.23 ppt, 7.93 to .26, 26.78 to 27.0°C and 97.0 to 102.75 ppm, espectively.

Compared to intake water significantly ($P \leq 0.05$) ncreased levels of turbidity, total suspended solids TSS), nitrate N (NO_3-N), ammonia N(NH_3-N), nitrite (NO_2-N), chemical oxygen demand (COD), 5 - day iochemical oxygen demand (BOD_5) and hydrogen ulphide (H_2S) were observed in pond water. The above entioned parameters along with phosphate were ignificantly ($P \leq 0.05$) higher in outlet water as ompared to intake water. Increased levels of TSS 95.13 ppm), Phosphate (0.321 ppm), NO_3-N (0.297 pm), NH_3-N (0.226 ppm), COD (68.25 ppm), and BOD_5 (40.8 ppm) were recorded in outlet water as compared to pond water (TSS - 60.25 ppm, Phosphate - 0.147 ppm, NO_3-N-0.215 ppm, NH_3-N-0.148 ppm, COD - 61.0 ppm, and BOD_5 - 31.08 ppm). Total nitrogen (TN) and phosphorus (TP) values were significantly different ($P \geq 0.05$) between intake, pond and outlet waters at harvest time and their respective concentrations were 0.36, 2.71 and 4.01 for TN and 0.08, 0.29 and 0.56 ppm for TP.

Seawater based farms : The average values of water parameters of intake, pond during culture period and outlet at harvest when the final 20% of water was drained out from seawater based shrimp farms are given in Table 2. With regard to coastal

Table 3 Comparison of water quality in creek and seawater based shrimp farms

Parameter	Creekbased shrimp farm	Sawater based shrimp farm	LSD at 5%	Significance
Salinity (ppt)	26 64	28 69	7 06	NS
pH	8 13	8 34	0 24	NS
Temperature (°C)	26 89	29 34	1 37	S
Alkalinity (ppm)	99 08	123 61	27 14	NS
Turbidity (NTU)	38 99	36 96	2 01	S
T S S (ppm)	52 77	48 44	11 21	NS
Phosphate (ppm)	0 159	0 155	0 27	NS
Nitrate N (ppm)	0 202	0 139	0 053	S
D O (ppm)	3 72	4 23	0 396	S
Ammonia N (ppm)	0 127	0 055	0 061	S
Nitrite N (ppm)	0 127	0 112	0 012	S
Total N (ppm)	2 36	1 05	1 01	S
Total P (ppm)	0 31	0 24	0 18	NS
COD (ppm)	54 44	42 31	27 23	NS
BOD_5 (ppm)	26 99	23 16	2 97	S
H_2S (ppm)	0 012	0 009	0 028	NS

NS - Not significant S - Significant

seawater based farms, a similar trend of creekwater based farms was observed with increased levels of water quality parameters during culture phase and in outlet at harvest time The outlet water during harvest registered higher concentration of nutrients, phosphate (0 210 ppm), NO_3-N (0 193 ppm), NH_3-N (0 086 ppm), COD (64 0 ppm), BOD_5 (37 45 ppm) and H_2S (0 019 ppm) compared to intake water (phosphate - 0 005 ppm, NO_3-N - 0 042 ppm, NH_3-N - 0 001 ppm, COD - 4 82 ppm, BOD_5-3 5 ppm and H_2S-BDL) Total N and Total P values in pond and outlet water were significantly higher than intake water TN and TP concentration at all sampling stations ranged from 0 1 to 1 86 ppm and 0 06 to 0 39 ppm, respectively However, levels of all parameters studied were well within the permissible limits as prescribed by the Ministry of Environment and Forests (MOEF, 1993)

During harvest when the final 20% of water was drained out, the harvesters enter the pond to rake the shrimps towards the sluice gate and these activities produce a slurry of water and pond sediment that probably raised the concentration of TSS, nutrients and metabolites The BOD_5 values were higher during shrimp harvest period, which was significantly ($P \leq 0\ 05$) different from the culture period Munsuri *et al*, (1996) also reported that solids, phosphorus, nitrogen and BOD_5 tend to concentrate at the bottom rather than at the surface of the ponds and the increase in the concentration of nutrients were greatest during the final phase of drainage In the present study, the nutrient concentrations observed are well within the permissible limits (MOEF, 1993)

Fig. 2 : Shrimp farms selected for the study along the coast of Nellore District, Andhra Pradesh.

Table 4 : Soil quality parameters in creekwater based shrimp farms*.

Parameter	Intake	Pond	Outlet**
Sand (%)	51.75[a] (±15.35)	49.88[a] (±14.44)	51.58[a] (±14.63)
Silt (%)	12.50[a] (±3.79)	11.25[a] (±7.32)	11.65[a] (±5.25)
Clay (%)	35.75[a] (±12.47)	38.88[a] (±7.12)	36.28[a] (±10.32)
pH	7.62[a] (±0.71)	7.73[a] (±0.49)	7.48[a] (±0.63)
E_h (mV)	-125 9[b] (±10.48)	-184.8[a] (±9.82)	-200.3[a] (±13.18)
EC (dS m^{-1})	15.90[a] (±6 42)	16.62[a] ± (5.35)	12.65[a] (±0.79)
Organic carbon (%)	0.22[b] (±0.07)	0.81[a] (±0.11)	0 89[a] (±0.08)

* - Average values of 4 collections along with standard deviation. The values with different alphabets are significantly differnt ($P \leq 0.05$).

** - Sample collected during harvest when the final 20% water was drained out

Table 5 Soil quality parameters in seawater based shrimp farms*

Parameter	Intake	Pond	Outlet**
Sand (%)	73 33[a] (±6 83)	71 38[a] (±3 76)	74 42[a] (±5 53)
Silt (%)	10 83[a] (±2 04)	8 7[a] (±2 45)	10 75[a] (±1 34)
Clay (%)	15 83[a] (±7 36)	19 92[a] (±3 28)	14 78[a] (±6 06)
pH	7 68[a] (±0 41)	7 81[a] (±0 35)	7 30[a] (±0 71)
E_h (mV)	-115[b] (±9 18)	-182 3[a] (±17 84)	-193 8[a] (±26 41)
EC (dS m^{-1})	13 07[a] (±2 67)	14 76[a] (± 5 99)	13 65[a] (±2 24)
Organic carbon (%)	0 21[b] (±0 05)	0 76[a] (±0 15)	0 80[a] (±0 13)

* - Average values of 6 collections along with standard deviation The values with different alphabets are significantly differnt ($P \leq 0\ 05$)

** - Sample collected during harvest when the final 20% water was drained out

Creekwater based versus seawater based farms : The results of two-way ANOVA analysis water quality parameters are presented in Table 3 There was significant difference ($P \leq 0\ 05$) between seawater and creekwater based shrimp farms with respect to all water quality parameters except salinity, pH, alkalinity, TSS, phosphate, COD and H_2S Seawater had more pH (8 34), temperature (29 34°C) and DO (4 23 ppm) and less turbidity (36 96 NTU), NO_3-N (0 139 ppm), NH_3-N (0 055 ppm), NO_2-N (0 112 ppm), BOD_5 (23 16 ppm) and H_2S (0 009 ppm) as compared to creek water (pH-8 13, temperature-26 89°C, DO-3 72 ppm, turbidity-38 99 NTU, NO_3-N-0 202 ppm, NH3-N-0 127 ppm, NO_2-N-0 127 rpm, BOD_5-26 99 ppm and H_2S-0 012 ppm)

Comparison of the water quality of the creek and seawater based farms clearly revealed that the nutrients and metabolites were more in creekwater based farms Joseph *et al* (1995) reported that the possible environmental impact of Kandaleru creekwater based farm is higher than seawater based farms Based on a study conducted in extensive shrimp culture systems of Thanjavur district-Muralidhar *et al* (2000) reported that shrimp pond wastewater did not contaminate the natural creek, though the intake and discharge sources are same 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 waste water depends on the location of the site, tidal amplitude, tidal flow rate, water retention period, type of culture adopted and management methods followed Since the assimilative capacity of receiving waters is seldom known, it is difficult to predict the effect of pond waste on a given body of water unless a careful study is done

Soil characteristics

Creekwater based farms : The sand, silt, clay, pH and electrical conductivity (EC) values were not significantly different among the soils of various sampling stations (Table 4) and ranged from 49 88 to 51 75%, 11 25 to 12 5%, 35 75 to 38 88%, 7 48 to 7 73 and 12 65 to 16 62 d S m^{-1}, respectively The redox potential (E_h) of soil was in significantly ($P \leq 0\ 05$) increased reducing condition from intake (-125 9 mV) through outlet point (-200 3 mV) Further, the organic carbon content showed progressive increase from 0 22 % from intake point to 0 89 % at outlet point indicating increase in organic matter

Seawater based farms : Sand content was higher in seawater based farms as compared to silt

Table 6 : Comparison of soil quality in creek and seawater based shrimp farms

Soil Parameter	Creekbased shrimp farm	Sawater based shrimp farm	LSD at 5%	Significance
Sand (%)	51.07	73.04	2.28	S
Silt (%)	11.80	10.09	2.51	NS
Clay (%)	36.97	16.84	3.89	S
pH	7.61	7.59	0.39	NS
E_h (mV)	-170.32	-163.7	29.14	NS
EC (dS m^{-1})	15.06	13.83	6.07	NS
Organic carbon (%)	0.64	0.59	0.28	NS

S - significant. NS - Not Significant.

and clay. There was no significant difference among the soils of intake, pond and outlet points for texture, pH and EC (Table 5). Organic carbon content in soil was highest during shrimp harvest time (0.80%) followed by culture period (0.76 %) and it was significantly different ($P \leq 0.05$) from soil at intake point (0.21%). Tookwinas *et al* (1998) also observed similar type of results during harvest and stated that clay was highest at the time of shrimp harvest and this was significantly different from the culture period. But in present study no such significant difference was observed with clay content in the soil.

During the culture period the pH of soil was alkaline and it decreased during the period of shrimp harvest from 7.73 to 7.48 and 7.81 to 7.3 in creek and seawater based shrimp farms, respectively. Praphrutthan (1985) reported that decomposition in sediments would liberate hydrogen ions and decrease the pH during harvest period.

Creekwater versus seawater based farms : There was a significant difference ($P \leq 0.05$) in the soils of creek and seawater based farms with respect to sand and clay contents (Table 6). The sand content (73.04%) was high in seawater based farm soil, where as the creekwater based farm soil contained high clay content (36.97%). Other soil quality parameters such as E_h (-170.32 mV), EC(15.06 dS m^{-1}) and organic carbon (0.64 %) were more in creek water based farm soil as compared to seawater based farm soil (E_h-163.7 mV, EC-13.83 dS m^{-1} and organic carbon 0.59 %) owing to high clay content in creekwater based farm soil.

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 might specify the acceptable ranges of pH, minimum dissolved oxygen concentration and maximum concentrations of BOD_5, TSS and other variables.

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

Acknowledgements

The authors are thankful to Dr G R M Rao, Dırector and Dr K Alagarswamı, former Dırector, Central Instıtute of Brackıshwater Aquaculture, for theır encouragement and ınspıratıon The fınancıal assıstance from ICAR AP Cess fund ıs duly acknowledged

References

APHA Standard methods for the examınatıon of water and wastewater 17th ed Amerıcan Publıc Health Assocıatıon Washıngton, D C , USA 1430 p (1989)

Boyd, C E Bottom soıls, sedıment and pond aquaculture, Auburn Unıversıty, Alabama, Chapman and Hall, New York, 348 p (1995)

Chıu, Y N Water qualıty management for ıntensıve prawn ponds In Technıcal consıderatıons for the monagement (eds Y N Chıu, L M Santos and R O Julıano), pp 102-128 Unıversıty of Phılıppınes ın the Vısayas, Iloılo Cıty (1988)

Gomez, K A and A A Gomez Statıstıcal Procedures for Agrıcultural Research, 2nd ed An Internatıonal Rıce Research Instıtute Book, Wıley, New York, NY, 680 p (1984)

Grasshoff, K , M Ehrhardt and K Kremlıng Methods of sea water analysıs Verlag Chemıe, Weınheım, 419 p (1983)

Jackson, M L Soıl chemıcal analysıs Prentıce Hall of Indıa Pvt Ltd New Delhı, 498 p (1967)

Joseph, K O , B P Gupta, M Muralıdhar, K K Krıshnanı, S V Alavandı, S S Mıshra and G Sıvakumar Impact of shrımp farmıng on the envıronment - a case study Proceedıngs of the Natıonal Workshop o '*Transfer of technology for sustaınable shrımp farmıng*' (ed) K Alagarswamı, pp 127-134 (1995)

MOEF Notıfıcatıon - *General Standards for dıscharge of envıronmental pollutants Part A - Effluents,* 19th May, 1993 (1993)

Munsırı, P, C E Boyd, D R Teıchert-Coddıngton and B F Hazek Texture and chemıcal composıtıon of soıls from shrımp ponds near Choluteca, Honduras *Aquaculture Int* 4 157-168 (1996)

Muralıdhar, M , B P Gupta, K O Joseph and K K Krıshnanı Impact of brackıshwater shrımp farmıng on surroundıng coastal soıl and water In Proceedıngs of the Natıonal Semınar on "Coastal Zone 2000 Ensurıng Pragmatıc Development, Pragmatıc Management, Food Securıty and Reducıng Poverty Can We Develop a Vısıon" held at Hyderabad durıng February 26-27, 2000 pp 2 (2000)

Piper, C S Soıl and plant analysıs Hans Publıshers Bombay, 368 p (1966)

Praphruttham, P Soıl Chemıstry Soıl Scıence Department, Faculty of Agrıculture, Kasetsart Unıversıty, Bangkok, 502 p (1985)

Strıckland, J D H and T R Parsons A practıcal hand book of seawater analysıs *Bull Fısh Res Bd Canada* (167) 310 pp (1972)