Indian J. Fish., **46**(4) : 391-396, Oct.-Dec., 1999

Suitability of coastal saline soils of Gopalapuram, Nellore for shrimp farming

B.P. GUPTA, M. MURALIDHAR, K.O. JOSEPH AND K.K. KRISHNANI

Central Institute of Brackishwater Aquaculture, 141, Marshalls Road, Egmore, Chennai-600 008, India

ABSTRACT

Soil samples collected from various depths, at different sites of Gopalapuram farm area, Andhra Pradesh were analysed for their physico-chemical characteristics for the suitability of brackishwater aquaculture. The soils are poor in organic carbon (0.23 to 0.5 %). Average pH values ranged from 5.2 to 8.4. Low pH values are associated with higher values of iron and lower values of $CaCO_3$. Textural class of soil varies from sandy loam to sandy clay loam. Sand/silt ratio values ranged from 4.0 to 10.3. Organic carbon, available nitrogen and phosphorus content of soil decreased with increasing depth of soil sampling. Iron content of soils was positively correlated with increasing depth and negatively correlated with pH and $CaCO_3$ content. Some important satistical correlations among soil characteristics were also worked out. The farm area was suitable for brackishwater aquaculture with suitable management of moderate limitation properties of the soils.

Introduction

Successful shrimp culture depends on two essential ingredients of aquaculture, namely good bottom soil condition and high quality water. The properties of soil should be considered in selecting a site, designing earthwork and specifying construction methods to provide a watertight pond (Hajek and Boyd, 1994). Presence of nutrients in adequate amounts in pond water is essential for successful aquaculture. The bottom soil is the reserve source of nutrient elements which through the activity of several groups of microorganisms are released in soluble forms (Mandal, 1962). The soil properties depend on the characteristics of the parent material from which it has been derived by the action of natural resources. Sometimes lack of attention on soil properties results in aquaculture ponds being not used to their full potential.

Interpretations of soil analyses data for use in aquaculture are difficult, because few data are available on relationship between some chemical and physical properties of soils and aquatic animal production (Boyd, 1995). Considering the importance of the bottom soils in the selection of suitable site and in determining the productivity of brackishwater aquaculture system, it has been considered worthwhile to determine some relevant properties of coastal saline soils. In the present investigation, a survey was conducted during 1995 to determine the suitability of land for backishwater aquaculture at Gopalapuram farm site allocated for shrimp culture ponds at Nellore.

Materials and methods

The Gopalapuram farm site was located in Muthukur Mandal, Nellore District, Andhra Pradesh. The location lies at 14° 05'N latitude and 79° 08'E longitude. The area receives mean annual rainfall of 543.7 mm, more than 60% of which is received during June to September. The mean annual temperature was 29.2°C. The soil temperature and moisture regimes for this area are hyperthermic and ustic, respectively. The saline water source for this farm is Kandaleru creek, which is a flood drain creek and has brackishwater almost throughout the year except during the times of flood.

The total area of land was 90 acres in four survey numbers and here, these are represented as site 1 (21.5 acres), site 2 (12.3 acres), site 3 (18.2 acres) and site 4 (38.0 acres). 40 pits were made in a zig-zag pattern in 4 sites (10 pits in site 1, 5 pits in site 2, 8 pits in site 3 and 17 pits in site 4). The soil samples were collected from 0, 50, 100 and 150 cm depth from each pit in a scientific manner. Thus the total soil samples collected were 160 in numbers from the four sites. The soil samples were analysed for physico-chemical characteristics. The analysed data of same depth from all the pits of each site are presented in ranges and averages.

Soil pH, electrical conductivity, calcium carbonate, available phosphorus, organic carbon and iron content were analysed by following the standard methods mentioned by Jackson (1973). Available nitrogen content in soil was determined by the alkaline permanganate distillation procedure of Subbiah and Asija (1956). The texture of soil has been analysed following International pipette method described by Piper (1966).

Results

Physical characteristics

Average values of soil textural analysis along with sand/silt and silt/clay ratios from all the four sites are presented in Table 1. Textural class of first two sites belongs to loamy sand and sandy loam whereas for sites 3 and 4 it is sandy clay loam. The average values of sand, silt and clay ranged from 52.5 to 80.0%, 7.5 to 14.0% and 10.0 to 35.0%, respectively. High clay content was observed at sites 3 and 4. The surface horizons of all the soils contain higher amounts of sand fractions.

Soil samples from all the four sites did not show the uniform sand/silt ratio indicating a lesser intensity of weathering. Silt/clay ratio was found to be less than 1.0 at all the sites, except at 50 cm depth soil samples of site 2 in comparison to sand/silt values of 4.0 to 10.3. The difference of sand/silt ratio was always more than 0.2 between the adjacent depths.

Chemical characteristics

The range and average values of chemical characteristics of soils are presented in Table 2. Average electrical conductivity (EC) values for all the four sites ranged from 2.68 to 39.92 dSm^{-1}. Soil samples from site 2 registered lower EC values (2.68 to 7.68 dSm^{-1}) as compared to higher values at other sites. There was no difinite trend in EC with depth. pH values ranged from moderately acidic (5.2) to alkaline range (8.4). Soil samples from site 4 registered low pH values. Increase in pH values with depth was observed at site 2.

TABLE 1. *Soil texture of Gopalapuram land site, Nellore, Andhra Pradesh*

Depth (cm)	Sand (%)	Texture silt (%)	Clay (%)	Sand/silt ratio	Silt/clay ratio	Textural class
SITE 1						
0	80.0	9.5	10.5	8.42	0.84	
50	80.0	10.0	10.0	8.0	1.0	Loamy sand
100	77.5	7.5	15.0	10.3	0.5	and sandy loam
150	70.0	10.0	20.0	7.0	0.5	
SITE 2						
0	78.0	11.0	11.0	7.09	1.0	
50	77.5	12.5	10.0	6.2	1.25	Loamy sand
100	75.0	10.0	15.0	7.5	0.66	and sandy loam
150	67.5	12.5	20.0	5.4	0.625	
SITE 3						
0	56.0	14.0	30.0	4.0	0.46	
50	57.5	12.5	30.0	4.6	0.42	Sandy clay loam
100	62.5	12.5	25.0	5.0	0.5	
150	65.0	10.0	25.0	6.5	0.4	
SITE 4						
0	55.0	12.0	33.0	4.6	0.36	
50	52.5	12.5	35.0	4.2	0.36	Sandy clay loam
100	57.5	10.0	32.5	5.75	0.31	
150	60.0	12.5	27.5	4.8	0.45	

Calcium carbonate ($CaCO_3$) content ranged from nil to as high as 1.60%. The average calcium carbonate values ranged from 0.1 to 1.23 and were high at surface horizons and decreased with the depth except at site 2. Iron content in soils ranged from 0.57 to 2.01 %. High values of iron were observed at site 4.

Organic carbon content decreased with increasing depth at all the sites. The average values of organic carbon ranged from 0.23 to 0.5%. Available nitrogen and phosphorus average values ranged from 8.91 to 20.1 and 0.75 to 2.03 Cmol (p^+) kg^{-1}, respectively and showed a decreasing trend with depth indicating that surface horizons are rich in nutrient status.

Important statistical correlation coefficient values for all the sites are represented in Table 3. Organic carbon, available nitrogen and phosphorus content at all the sites were negatively correlated whereas, iron content was positively correlated with increasing depth of soil. Similar negative correlations were observed for pH and $CaCO_3$ except at site 2. Iron content was negatively correlated with pH and $CaCO_3$, whereas pH was positively correlated to $CaCO_3$ content. The available nitrogen and phosphorus content of soil were positively correlated with organic carbon content of soil.

Discussion

The importance of soil texture on the production of the brackishwater fish ponds has been emphasised by Djajadiredja and Poernomo (1972). The higher amounts of sand fractions in surface horizons of all the soils may be

TABLE 2. *Soil characteristics of Gopalapuram land site, Nellore, Andhra Pradesh*

Depth (cm)	EC (dsn^{-1})	pH	Org. carbon (%)	$CaCO_3$ (%)	Iron (%)	Av. nitrogen [C mol $(p)^+$ kg^{-1}]	Av. phosphorus [C mol $(p)^+$ kg^{-1}]
SITE 1							
0	0.75 - 69.0 (23.97)	4.6 - 7.9 (5.7)	0.35 - 0.45 (0.35)	0 - 1.2 (0.41)	0.48 - 1.50 (1.13)	12.0 - 18.0 (14.90)	0.80 - 1.8 (1.26)
50	0.75 - 69.5 (29.85)	4.3 - 6.8 (5.5)	0.30 - 0.44 (0.36)	0 - 1.2 (0.40)	0.50 - 1.60 (1.20)	10.0 - 17.0 (13.37)	0.50 - 1.8 (1.15)
100	1.00 - 40.0 (23.97)	4.2 - 6.8 (5.4)	0.28 - 0.42 (0.32)	0 - 0.6 (0.13)	0.70 - 1.80 (1.35)	8.0 - 15.0 (11.16)	0.40 - 1.6 (0.95)
150	0.75 - 40.0 (22.70)	4.0 - 6.1 (5.2)	0.25 - 0.40 (0.29)	0 - 0.5 (0.10)	0.80 - 1.80 (1.49)	7.5 - 11.5 (8.91)	0.40 - 1.2 (0.75)
SITE 2							
0	0.75 - 9.0 (2.68)	5.8 - 8.4 (6.9)	0.28 - 0.35 (0.31)	0.20 - 0.80 (0.47)	0.45 - 1.00 (0.72)	14.0 - 17.0 (15.27)	0.90 - 1.6 (1.34)
50	0.75 - 13.0 (4.52)	7.0 - 9.1 (7.9)	0.25 - 0.33 (0.29)	0.40 - 0.95 (0.61)	0.40 - 0.95 (0.69)	12.0 - 17.0 (14.50)	0.80 - 1.6 (1.23)
100	1.25 - 26.2 (7.68)	6.7 - 9.3 (7.8)	0.75 - 0.30 (0.27)	0.25 - 0.95 (0.61)	0.50 - 0.95 (0.76)	7.5 - 15.0 (11.11)	0.80 - 1.8 (1.21)
150	1.0 - 18.7 (7.43)	4.6 - 9.3 (7.8)	0.70 - 0.28 (0.23)	0.25 - 0.95 (0.54)	0.50 - 1.20 (0.85)	6.0 - 13.0 (9.03)	0.20 - 1.5 (1.00)
SITE 3							
0	0.50 - 50.0 (31.11)	7.2 - 9.1 (8.3)	0.45 - 0.60 (0.50)	0.50 - 1.10 (0.81)	0.25 - 0.95 (0.60)	15.0 - 22.0 (18.61)	1.80 - 2.30 (2.03)
50	0.50 - 40.0 (24.83)	7.6 - 9.0 (8.4)	0.40 - 0.60 (0.50)	0.60 - 1.00 (0.81)	0.25 - 0.90 (0.57)	12.5 - 20.0 (16.72)	1.50 - 2.10 (1.82)
100	0.50 - 38.0 (24.25)	4.5 - 9.2 (7.4)	0.28 - 0.50 (0.37)	0.15 - 1.10 (0.70)	0.30 - 1.50 (0.66)	11.0 - 20.0 (13.72)	1.00 - 2.20 (1.60)
150	2.50 - 52.5 (33.44)	5.0 - 9.2 (7.5)	0.25 - 0.35 (0.33)	0.10 - 1.10 (0.65)	0.30 - 1.40 (0.66)	7.0 - 14.5 (9.97)	0.80 - 1.5 (1.14)
SITE 4							
0	21.0 - 63.0 (36.25)	7.2 - 8.2 (7.4)	0.45 - 0.54 (0.49)	0.78 - 1.60 (1.23)	0.90 - 1.70 (1.43)	17.5 - 24.0 (20.50)	1.80 - 2.20 (1.96)
50	22.5 - 69.0 (39.92)	3.9 - 7.9 (6.6)	0.40 - 0.52 (0.45)	0 - 1.10 (1.70)	1.20 - 2.30 (1.70)	17.5 - 24.0 (17.35)	1.00 - 2.0 (1.82)
100	18.0 - 56.2 (36.57)	2.8 - 7.9 (5.7)	0.30 - 0.50 (0.42)	0 - 1.50 (0.41)	1.50 - 2.30 (1.87)	14.0 - 22.0 (17.35)	0.80 - 2.0 (1.46)
150	20.0 - 47.5 (33.95)	3.1 - 8.2 (5.9)	0.20 - 0.53 (0.37)	0 - 1.50 (0.36)	1.80 - 2.30 (2.01)	11.0 - 23.0 (15.2)	0.80 - 2.2 (1.25)

Values in parantheses are average values. EC - Electrical conductivity. Org. - Organic. Av. - Available.

due to impoverishment of finer particles by surface runoff water. The difference of sand/silt ratio was always more than 0.2 between the adjacent depths, confirming the lithological discontinuity, instead of homogeneity of parent material. Qureshi *et al.* (1996) also reported similar findings.

Higher electrical conductivity in these soils may be due to inundation of saline water as reported by Mazi and Bandopadhyay (1996). The low pH values at site 4 may be due to high amount of iron and low amount of $CaCO_3$. Increase in pH values with depth was observed at site 2, which may

TABLE 3. *Some important statistical correlations among soil characteristics*

			Site 1	Site 2	Site 3	Site 4
Depth	vs.	pH	–0.992[a]	0.715	–0.839	–0.905
		Org. carbon	–0.922	–0.983[a]	–0.937	–0.995[a]
		Iron	0.989[a]	0.854	0.775	0.998[a]
		Av. nitrogen	–0.996[a]	–0.976[a]	–0.989[a]	–0.994[a]
		Av. phosphorus	–0.992[a]	–0.945	–0.979[a]	–0.987[a]
		$CaCO_3$	–0.923	0.404	–0.945	–0.959
PH	vs.	Iron	–0.973[a]	0.225	–0.977[a]	–0.943
		$CaCO_3$	0.867	0.891	0.942	0.998[a]
CaCO3	vs.	Iron	–0.945	–0.125	–0.930	–0.983[a]
		Av. phosphorus	0.939	–0.233	0.938	0.948
Org. carbon	vs.	Av. N	0.932	0.968[a]	0.951	0.995[a]
		Av. phosphorus	0.946	0.983[a]	0.917	0.975[a]

Critical value at 5% = – 0.961.
The values denoted by symbol 'a' are significant correlations.

be due to migration of bases from high to lower elevation. The results are corroborated with the findings of Singh and Mishra (1996) and Walia and Rao (1997).

Chattopadhyay and Mandal (1980) reported that high alkaline earth carbonates would be useful in counteracting some of the possible harmful effects of organic manuring. In the present study high content of $CaCO_3$ would be useful in neutralizing organic acids released from organic matter decomposition. High accumulation of iron at lower depths may be due to illuviation of iron compounds to lower layers of soil profile. Bhaskar and Subbiah (1995) reported high content of iron and its accumulation in B-horizon of soil profiles.

Organic carbon content decreased with increasing depth at all the sites. Similar findings were reported by Raji *et al.* (1996). Chattopadhyay and Mandal (1986) reported that soils with organic carbon content below 0.5 % are poor and needs organic manuring. In the present investigation organic carbon content is poor (average values ranged from 0.23 to 0.5%) and needs organic manuring. Chakraborti *et al.* (1985) suggested that available phosphorus range of 1.08 to 2.86 Cmol (p^+) kg^{-1} was poor for *Penaeus monodon,* accordingly the present soils are pooor in phosphorus. Chattopadhyay and Mandal (1980) reported that brackish-water with high amounts of calcium ions may react readily with water soluble phosphorus to render it into inisoluble calcium phosphate.

Some of the properties of Gopalapuram farm area such as low pH, high sand content and low organic carbon comes under moderate rating according to the classification of Hajek and Boyd (1994) i.e. these soils have one or more properties that will require special attention for the designated use. This degree of limitation can be overcome or modified by special planning and management such as liming, organic manuring and additional compaction of soils. The soils may be

considered suitable for brackishwater aquaculture upon managing these moderate limitation properties.

Acknowledgments

The authors are grateful to Dr. K. Alagarswami and Dr. G.R.M. Rao, former and present Directors respectively of Central Institute of Brackishwater Aquaculture, Chennai for encouragement and inspiration.

References

Bhaskar, B.P. and Subbiah, G.V. 1995. Genesis, characterisation and classification of laterites and associated soils along the east coast of Andhra Pradesh. *J. Indian Soc. Soil Sci.,* **43**(1) : 107-111.

Boyd, C.E. 1995. *Bottom Soils, Sediment and Aquaculture.* Chapman and Hall, New York, USA.

Chakraborti, R.K., P. Ravichandran, D.D. Halder, S.K. Mandal and D. Sanfui 1985. Some physico-chemical characteristics of Kakdwip brackishwater ponds and their influence on the survival, growth and production of *Penaeus monodon. Indian J. Fish.,* **32**(2) : 224-235.

Chattopadhyay, G.N. and L.N. Mandal 1980. Inorganic transformation of applied phosphorus in brackishwater fish pond soil under different water salinity levels. *Hydrobiologia,* **17** : 125-130.

Chattopadhyay, G.N. and L.N. Mandal 1986. A study on the physico-chemical characteristics of some brackishwater fish pond soils of West Bengal. *Proc. Symp. Coastal Aquaculture,* **4** : 1053-1058.

Djajadiredja, R. and A. Poernomo 1972. Requirements for successful fertilisation to increase milk production. In: *Coastal Agriculture in the Indo-Pacific Region.* Fishing News (Books) Ltd., London.

Hajek, B.F. and C.E. Boyd 1994. Rating soil and water information for aquaculture. *Aquacultural Engg.,* **13** : 115-128.

Jackson, M.L. 1973. *Soil Chemical Analysis.* Prentice Hall of India Pvt. Ltd., New Delhi, 498 pp.

Mandal, L.N. 1962. Effect of salinity on the transformation of introgen in the brackishwater fish farm soils. *J. Indian Soc. Soil Sci.,* **10**(4) : 225-261.

Mazi, B. and B.K. Bandopadhyay 1996. Characterization and classification of coastal soils of Balasore, Orissa. *J. Indian Soc. Soil Sci.,* **44**(4) : 722-726.

Piper, C.S. 1966. *Soil and Plant Analysis.* Hans Publications, Bombay.

Qureshi, F.M., S.K. Singh, S.K. Chaudhary and K. Das 1996. Genesis and taxonomy of some saline and sodic soils in Bharatpur (Rajasthan). *J. Indian Soc. Soil Sci.,* **44**(1): 130-135.

Raji, B.A., I.E. Esu, V.O. Chude and C.D. Dedzoe 1996. The aggeric epipedon: A proposed amendment to soil taxonomy. *J. India. Soc. Soil Sci.,* **44**(3) : 461-464.

Singh, V.N. and B.B. Mishra 1996. Pedogenetic characterisation of some typical soils of Gandak command area of Bihar for evaluation of land suitability. *J. Indian Soc. Soil Sci.,* **44**(1) : 136-142.

Subbiah, B.V. and G.R. Asija 1956. A rapid procedure for estimation of available nitrogen in soils. *Current Science,* **25** : 259-260.

Walia, C.S. and Y.S. Rao 1997. Characteristics and classification of some soils of trans-Yamuna plain. *J. Indian Soc. Soil.,* **45**(1): 156-161.