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Sediment and water characteristics of selected prawn farming sites at Cochin during premonsoon months

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Abstract

This paper deals with the studies on sediment and water characteristics of selected shrimp farming ponds located at Puthuvyppu and Valappu villages of Vypeen in the vicinity of Cochin carried out during premonsoon period (March-May 2001). Areawise distribution of sediment and water characteristics revealed that smaller and medium sized ponds were relatively more fertile than the larger sized ponds. Overall mean values of nutrients in sediment and water indicated that ponds at Puthuvyppu village (with high tidal influence) were relatively more fertile than those ponds at Valappu. TSS and primary productivity values also showed the same trend. Highly significant positive correlation was observed between clay and silt, organic carbon and available potassium, nitrite-N in sediment and water, salinity and TSS and water pH and dissolved oxygen.

Introduction

Cochin backwater is the common source of water for tide fed traditional culture of brackish water fishes and prawns on low-lying fields around Cochin. Sediment and water play an important role on the productivity and fluctuation in the yield. Sediment quality of these culture ponds is altered periodically by tidal influence and biogeochemical processes. In the Cochin backwater ecosystem, studies on sediment and water characteristics in relation to prawn culture for the monsoon and postmonsoon seasons have been carried out by earlier workers and no detailed information is available on this aspect for premonsoon period. The present work deals with the sediment and water quality, productivity and fertility of selected culture ponds at Cochin during premonsoon period.

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Material and methods

Two prawn farming villages namely Puthuvyppu and Valappu located in the Vypeen landmass at the northern part of Cochin backwater were selected for the present study. The source of water for these ponds is chiefly through the Puthuvyppu canal. Eight ponds having different water-spread areas (four from Puthuvyppu and four from Valappu villages) were selected and stations were fixed at each pond for regular sampling of water and sediment during March - May 2001

(Fig.1). Another station (Control) was fixed in the backwater near bar mouth. Average tidal amplitude of the selected ponds at Puthuvyppu and Valappu were 70 cm and 30 cm respectively. The water-spread area of these ponds ranged between 800 m^2 and 32000 m^2. Sediment samples were collected at fortnightly interval from the selected stations using a Vanveen grab covering an area of 0.038 m^2, while the water samples were collected in plastic bucket at stations with the depth of 50-70 cm. Water temperature and salinity were measured in the field itself. The sediment and water characteristics were estimated adopting standard methods.

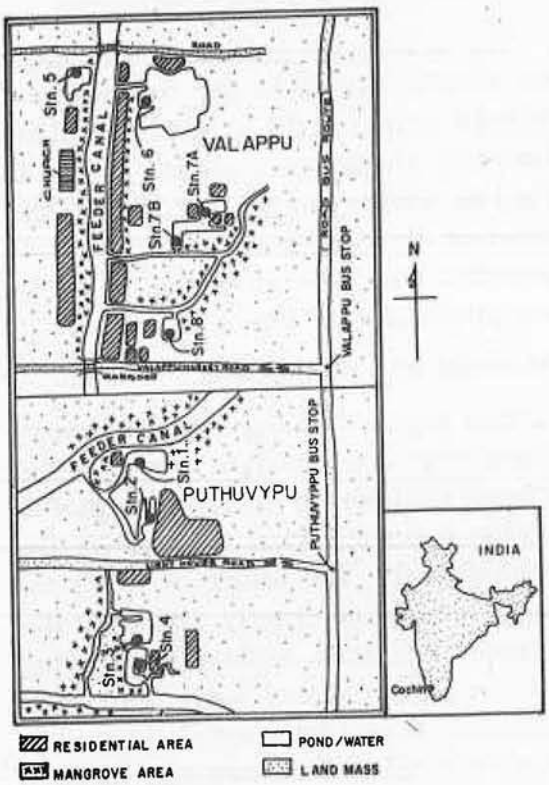

Fig. 1. *Map showing selected stations at Puthuvypu and Valappu villages (Cochin)*

Results and discussion

The areawise distribution of mean values of sediment and water characteristics based on the size of ponds is given in Tables 1 and 2 and the overall mean values of sediment and water characteristics of the shrimp ponds of Puthuvyppu, Valappu and Control stations are presented in Tables 3 and 4 respectively.

Sediment characteristics

Texture

Data on soil texture collected during premonsoon period indicated that the ponds were coming under diverse textural classes ranging from sandy loam to clayey. Most of the ponds belonged to

Table 1. *Overall mean values of sediment characteristics in relation to size of ponds*

Sediment characteristics	Area of the culture pond		
	<2000 m^2	2000-4000 m^2	>4000 m^2
Clay (%)	43.45	47.22	39.44
Silt (%)	32.59	39.67	29.51
Fine sand (%)	22.61	12.04	29.92
Coarse sand (%)	1.36	1.07	1.13
pH	7.13	7.16	7.12
Organic matter (%)	5.77	7.06	6.64
Organic carbon (%)	2.58	3.15	2.97
Phaeopigments (mg/g)	9.032	9.076	7.92
Available Phosphorus (ppm)	60.73	61.46	43.39
Available Potassium (ppm)	1313	1594	1152
Nitrite-N (ppm)	0.029	0.022	0.017
Nitrate-N (ppm)	0.391	0.432	0.279
C/P ratio	608.37	577.13	764.84

Table 2. *Overall mean values of water characteristics in relation to size of ponds*

Water quality	Area of Culture Pond		
	<2000 m²	2000 - 4000 m²	>4000 m²
Salinity (ppt)	21.72	21.2	18.8
Dissolved Oxygen (ml/l)	4.71	5.25	3.43
TSS (mg/l)	71.5	69.5	55.8
N.P.P. (g.C/m³/d) [0.8(L-D)] 12 hrs.	6.994	7.72	4.558
Bacterial prod./cons. of oxygen (ml/l/d) [(L-I) - 0.8 (L-D)] 12hrs	-2.257	-5.035	-0.079
Net biochemical prod./cons.of oxygen (mlO_2/l/d) [(L-I) + (D-I)] 12hrs	3.383	5.321	7.814
pH	7.79	7.65	7.7
NO_2-N (µg at/l)	0.198	0.250	0.19
NO_3-N (µg at/l)	0.78	0.78	0.12
PO_4 - P (µg at/l)	7.46	10.68	6.09
NO_3/PO_4 ratio	0.105	0.073	0.02

clay to silty clay types. Tang and Chen (1967) have observed that aquaculture ponds having sandy loam to silty clay texture are fairly good in productivity. Highly significant positive correlation (r = 0.6429**) was found between percentages of clay and silt and negative correlation (r = -0.9103**) between the percentages of clay and sand as well as between silt and sand.

Sediment pH

The pH of sediment varied between 6.9 to 7.5. According to Alikunhi (1956), culture systems with acidic soils are generally less productive than alkaline soils.

Organic Carbon

Organic Carbon is the most important factor determining the fertility status of soil which ranged from 1.05 to 5.13%. This observation goes well with the range recorded by Remani *et al.* (1980) in the Cochin backwater. Positive correlation has been obtained between fish production and organic carbon by Banerjea (1967). Mean values indicated that Puthuvyppu ponds were relatively more fertile in organic carbon content than at Valappu (Table 3). The Control station showed the minimum mean value because of higher percentage of sand content in sediment.

Nitrite-Nitrogen

Among the prawn farming sites at Puthuvyppu and Valappu Villages, mean Nitrite - N values in the sediment ranged from 0.014 to 0.043 ppm indicating normal values. Sediment NO_2 - N showed positive correlation with water NO_2-N (r=0.4091**) as well as NO_3 - N (r=0.3877**). This indicates that sediment NO_2 - N is contributing significantly to water NO_2 - N and NO_3 - N fractions in the ponds.

Nitrate - Nitrogen

Nitrate-N values in sediment fluctuated from 0.12 to 2.36 ppm during the period of study. No direct correlation between NO_3 - N of sediments and that of water could be noticed in the present study. Mollah *et al.* (1979) obtained an insignificant negative correlation between NO_3 -

N of the soil and that of water in their studies. Relatively lower concentrations of nitrite and nitrate contents recorded in the pond sediments indicate that the recycling process in the nitrogen cycle is very slow in these ponds. Mean values of the farms of the two villages showed that the Nitrate-N content was relatively more in Puthuvyppu farms than at Valappu (Table 3).

Available phosphorus

The capacity of sediment to retain or release phosphorus is one of the important factors influencing the concentrations of inorganic and organic phosphorus in the overlying water. In the present investigation, the range of available phosphorus was found between 19.6 and 111.01 ppm. Higher amount of available phosphorus in brackishwater pond soil have been documented by Chattopadhyay and Chakraborthi (1986) and Chattopadhyay (1978). Increase in phosphorus content in the sediment of the ponds than in the open backwater (Control) in the present study revealed that the biogeochemical processes responsible for the release of phosphate are more effective in the ponds during premonsoon period. In general, prawn farming sites of Puthuvyppu village showed higher phosphorus content than at Valappu (Table 3).

Table 3. *Overall mean values of sediment characteristics*

Sediment characteristics	Puthuvyppu	Valappu	Control
Clay (%)	48.27	40.45	16.45
Silt (%)	37.36	32.36	12.97
Fine sand (%)	13.32	25.81	65.36
Coarse sand (%)	1.05	1.39	5.21
pH	7.17	7.11	7.29
Organic matter (%)	6.57	6.17	3.16
Organic carbon (%)	2.94	2.75	1.41
Phaeopigments (mg/g)	8.22	9.6	9.62
Available Phosphorus (ppm)	68.73	48.85	28.51
Available Potassium (ppm)	1532	1265	492
Nitrite - N (ppm)	0.024	0.025	0.075
Nitrate - N (ppm)	0.487	0.297	0.23
C/P ratio	473.72	758.71	517.31

Available potassium

Available potassium in sediment ranged from 420 to 1960 ppm. This shows that sufficient quantity of potassium is present in the bottom sediment of these ponds. According to Chattopadhyay (1978), the nature of clay mineral appeared to be the main factor for the presence of high amount of cations like potassium. The present study revealing high amount of potassium in sediment is in conformity with the earlier report of Mollah *et al.* (1979) who observed potassium content of brackishwater pond soil in Bangladesh upto 640 ppm while Easwaraprasad (1982) has observed the range of 350-1002 ppm of potassium in brackish water culture ponds. According to Pillay *et al.* (1962), the productivity of brackishwater ponds depended largely on exchangeable potassium. Relatively higher values of potassium and phosphorus recorded in the ponds at Puthuvyppu should be of

Table 4. *Overall mean values of water characteristics*

Water quality	Puthuvyppu	Valappu	Control
Salinity (ppt)	23.4	19.0	25.2
Dissolved Oxygen (ml/l)	5.81	3.7	4.18
TSS (mg/l)	85.1	58.46	64.48
N.P.P. (g.C/m^3/d) [0.8 (L-D)] 12hrs.	7.239	6.685	3.705
Bacterial prod./ cons.of oxygen (ml/l/d) [(L-I) - 0.8 (L-D)] 12 hrs	-5.12	-0.933	-0.254
Net biochemical prod./ cons. of oxygen (mlO_2/l/d) [(L-I) + (D-l)] 12hrs	3.056	9.917	5.972
pH	7.76	7.69	7.72
NO_2-N (µg at/l)	0.22	0.208	1.75
NO_3 - N (µg at/l)	1.038	0.355	4.656
PO_4-P (µg at/l)	9.17	7.82	1.5
NO_3/PO_4 ratio	0.113	0.045	3.104

interest in terms of productivity of the ponds.

Phaeopigment

Phaeopigment values in the surface layer of bottom sediment ranged from 3.65 to 21.7 mg/g. Lucas and Holligan (1999) have also recorded phaeopigment in the upper 2 cm of the sediments. In the statistical analysis, phaeopigment values showed positive correlation with available phosphorus (r= 0.3869**) and primary production (r=0.2938*) in the present study indicating their inter-relationship within the pond ecosystem.

Water characteristics

Salinity

In the present study, range of salinity in the pond water was between 15 and 31 ppt. Gopinathan (1982) observed the annual salinity range of 1 - 27 ppt in the seasonal and perennial prawn culture fields of the Cochin estuarine system. Negative correlation was noticed between salinity and NO_2-N (r= -0.3438*) and also NO_3-N (r=-0.2982*) in water and positive correlation between salinity and TSS (r=0.4545**). It might be due to the fact that increase in water salinity in the estuarine system promotes the growth and multiplication of primary and secondary producers resulting in the increase of TSS value in the pond water and also reduction in nitrite and nitrate values due to their utilization by primary producers.

Water pH

The range of pH was found to be varying from 7.0 to 8.4. According to Boyd (1990), water with pH range of 6.5 to 9.0 is considered as good for fish production in the culture ponds.

Total suspended solids (TSS)

The result showed that the total suspended solids (TSS) in water was found to be varying between 28 and 126.8 mg/l. According to Alabaster and Lloyed (1980), maintenance of moderate to good fisheries is possible in water containing 25 to 80 mg/l suspended solid particles while TSS values of 80-400 mg/l and above do not support good fisheries. According to the above view, more than 50% of ponds

in the present investigation could be treated as moderate to good in which the mean TSS values varied between 25 and 80 mg/l.

Dissolved oxygen

According to Boyd (1990), more than 5 mg/l (>3.5 ml/l) of dissolved oxygen is desirable for healthy survival of culture organisms. In the present investigation, nearly 50% of ponds showed more than 3.5 ml/l of oxygen in water during premonsoon period indicating the desirable range.

Primary production

Gross primary production (GPP) was observed to be between 0.578 and 16.339 g.C/m^3/d. According to Selvaraj (2000), 80% of the GPP would contribute to net primary production (NPP). Mean NPP values of the prawn culture ponds in the present study at Puthuvyppu and Valappu were almost double as compared to the value recorded in the backwater (Control) station (Table 4). The increase in primary production values might be due to the enclosed nature of pond ecosystem. It was noticed that the primary productivity was relatively more in Puthuvyppu ponds (Table 4). This might be due to the relatively higher tidal influence observed at Puthuvyppu than at Valappu which might bring in more nutrients for the growth and multiplication of phytoplankton from the open estuarine system which was having relatively higher concentrations of NO_2-N and NO_3-N during premonsoon period (Table 4).

Bacterial consumption/production of oxygen

In the present investigation, consumption of oxygen was found to be more than production or release of oxygen by biochemical processes other than photosynthesis in the prawn culture ponds. This observation goes well with the observations of Nirmala (1999) in the semi-enclosed 'Mangalvanam' water. It was also observed that biochemical (bacterial) consumption of oxygen was relatively more in Puthuvyppu ponds than at Valappu (Table 4). This might perhaps be due to the higher intensity of bacterial action in the biochemical oxidation process of organic matter at Puthuvyppu ponds than at Valappu. This could also be related to the relatively higher TSS content of water observed at Puthuvyppu than at Valappu which could act as the substrate for more bacterial population and their activity.

Net biochemical consumption/production of oxygen

In the present investigation, the assessment of net loss/gain of oxygen per day due to photosynthetic and bacterial actions indicated that most of the ponds had net gain of oxygen except in two ponds, which recorded net loss of oxygen. The main cause for the net loss of oxygen in these two ponds could be that the role of photosynthetic production of oxygen in the water body of these ponds is not able to compensate the loss of oxygen resulted by other biochemical (bacterial) processes. These observations and conclusion are in agreement with the findings of

Nirmala (1999) in the 'Mangalvanam' waters at Cochin.

Nitrite-N

Nitrite originates by the reduction of nitrate by bacterial action in water and by conversion of ammonia into nitrites. In the present investigation, NO_2-N in water was found to be fluctuating between 0.01 and 2.95 µg at/l. This is in accordance with the results obtained by Panigrahi (1993). Highly significant positive correlation was observed between NO_2-N and NO_3-N (r=0.8662**). This correlation clearly substantiates the conversion of NO_3-N from NO_2-N through microbial activity.

Nitrate-N

The range of NO_3-N in water during premonsoon period was found to be between 0.03 and 7.43µg at/l which is relatively low as compared to the range obtained by Panigrahi (1993). Smith (1984) has stated that biologists tend to favour nitrogen over phosphorus as the limiting factor controlling primary productivity in the brackishwater and marine environments. However, in the present investigation, these nutrients did not appear as the limiting factor as evidenced by the almost double fold increase in the primary production at both Puthuvyppu and Valappu farms (Ponds) as compared to the primary productivity values of Control station (Table 4).

Reactive phosphorus

Reactive phosphorus in water during the premonsoon period was found to vary from 0.97 to 19.69 µg at/l. This range falls within the range observed by Panigrahi (1993) . Relatively higher values of phosphate, nitrate and NPP recorded in the Puthuvyppu ponds than at Valappu and Control station (Table 4) indicated the higher fertility status of Puthuvyppu farms.

Although some conclusions could be derived through the present study, further studies on the above cited parameters related to sediment and water qualities in culture ponds are desirable covering all seasons to derive at definite conclusions on the fertility aspects as well as to find out the causative factors for the wide fluctuations in the parameters occurring within the seasons.

References

Alabaster, J.S. and R. Lloyed, 1980. *Water quality criteria for freshwater fish.* FAO, U.N. Butter worth, London.

Alikunhi, K.H., 1956. *Agricultural situation in India,* Govt. of India, publication.

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.

Boyd, C.E. 1990. *Water quality in ponds for Aquaculture.* Alabama agricultural experiment station., Auburn University, pp.480.

Chattopadhyay, G.N. 1978. Studies on the chemistry of brackishwater fish pond soils and water. *Ph.D.Thesis Bidhan Chandra Krishi Viswa Vidyalaya,* W.B., 173 pp.

Chattopadhyay, G. N and R. K. Chakroborti, 1986. A comparitive study on the nature and properties of some brackish water and nearly freshwater fish pond soils. *Proc. Symp. Coastal Aquaculture* **4** : 1110-1114.

Easwaraprasad, P., 1982. Studies on soils of some brackishwater prawn culture fields around Cochin. *M.Sc Dissertation submitted to the Cochin University.*

Gopinathan, C.P., P. V. Ramachandran Nair, V.K Pillai, P. Prameswaran Pillai, M. Vijayakumaran, and V.K. Balachandran, 1982. Environmental characteristics of the seasonal and perennial prawn culture fields in the estuarine system of Cochin. *Proc. Symp. Coastal Aquacult.*, 1:369-382.

Lucas, C.H., and P.M. Holligan, 1999. Marine ecology program series. Implications of algal pigment diversity on the Molenplaat tidal flat (Westerschelde estuary, SW Netherlands). *MEPS 180*:51-69.

Mollah, M.F.A., A.K.M. Aminul Haque, M.E. Eaqub, M. Idris, and M.Y. Chowdhury, 1979. Interaction between pond-bottom and water qualities. *Indian J. Fish.*, 26: 101-113.

Nirmala, K., 1999. Studies on microbio-chemical production and consumption of oxygen in the estuarine waters of Mangalvanam, Cochin. *Dissertation submitted for M.E.M. Degree (Mahatma Gandhi University)*, 42pp.

Panigrahi, A., 1993. Influence of different types of soil on the water quality in culture ponds. *M.Sc Dissertation submitted to the Cochin University.*

Pillay, T.V.R., M.R. Vijayaraghavan, and S.C. Thakurta , 1962. An ecological study of benthic flora in brackish water bheris. *Proc. Nat. Inst. Sci. India*, 28B:416-431.

Remani, K.N., P. Venugopal, K. Sarala Devi, S. Lalitha, and R.V. Unnithan, 1980. Sediments of Cochin backwaters in relation to pollution. *Indian J. Mar. Sci.*, 9: 111-113.

Selvaraj, G.S.D., 2000. Validity of net primary productivity estimation by light and dark bottle oxygen technique in tropical inshore waters, with a note on Primary productivity of the surf zone at Cochin. *J. Seaweed Res. & Utln.*, 22:81-88.

Smith, S.V., 1984. Phosphorus versus nitrogen limitation in the marine environment. *Limnol. Oceanogr.*, 29: 1149-1160.

Tang, Y.A., and S.H. Chen, 1967. A survey of algal pasture soils of milk fish ponds of Taiwan. *FAO Fish. Rep.*, 44 : 198-209.