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Studies on Low Productive Rainfed Brackishwater Culture Ponds Along the Periphery of Chilka Lake, Orissa

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ABSTRACT

A survey was conducted by collecting water and sediments from ten rainfed ponds of Khandualpur area situated along the periphery of Chilka lake to investigate the possible causative factors for the low production of *Penaeus monodon* (100-457.5 kg/ha/yr) and to consider ways and means to help augment production in such systems. Seasonal changes were studied during the monsoon and winter production cycles as also the resting summer period during the year 1988-89. The data on sediment characteristics reveal that organic carbon (0.17-0.66%), $CaCO_3$ (nil-2.0%), available nitrogen (11.37-23.83 mg/100 g soil) and available phosphorus (1.62-6.34 mg/100 g soil) are indicative of low productivity. Among other factors, the extremely low redox potential (Eh:-487 to -1600 mv) and very high iron content (0.90-1.85%) are probably limiting the production of prawn in these ponds. Further, the water quality and low nutrient status (phosphate 0.004-0.012, nitrate 0.020-0.050 and alkalinity 22.0-60.0 ppm), low salinity (5.0-10.0 ppt) and high iron content (0.92-2.68 ppm) also indicate low productivity. The very poor plankton and benthos density confirm the poor productivity of these ponds. The sandy clay soil with a pH range of 5.6 to 9.4 can be better utilized with suitable management practices to overcome the low nutrient status and high iron content of soil and water. Possible measures for improving the productivity of the rainfed ponds are discussed.

INTRODUCTION

The fringe areas of the Chilka lake which get inundated during flood season and remain dry for 6-8 months have been converted into confined rainfed ponds since 1983 under the Economic Rehabilitation of the Rural Poor (ERRP) Scheme. On the north-eastern fringe of the lake, a cluster of 147 ponds, 0.2 ha each in size were constructed in 1983 at Khandualpur and used for monoculture of *Penaeus monodon*. These confined ponds are generally low productive and the probable reasons for such low production have been indicated (Alagarswami *et al.*, 1988; Rajyalakshmi *et al.*, 1988). The productivity characteristics of brackishwater soils of the north-eastern coast were studied for West Bengal (Mandal, 1980; Chattopadhyay and Mandal, 1980). Rajyalakshmi *et al.* (1988) investigated the production and productivity pattern of the confined ponds of Mudiratha cluster on the north-eastern fringe of the Chilka lake during 1986. However, the problems of acidity, soil profile, the changes in the characteristics of the soil and water and their possible role in production during the two seasons of prawn culture were not studied in detail. The present study was undertaken in ten ponds of the Khandualpur cluster covering the mansoon and winter crops to understand the possible causative factors of low production and to suggest measures to improve prawn productivity.

MATERIAL AND METHODS

The Khandualpur cluster of confined ponds is located on the north-eastern fringe of the Chilka lake near to Sunamuhin, 30 km from Puri (Fig. 1). The ponds are protected by an outer ring of dyke about 2 m height from the lake bed. Ten ponds from this cluster (Nos. 2, 3, 4, 25, 26, 31, 32, 33, 34 and 54) were selected for the present study. The ponds have an average depth of 1.5 m and receive rain water during June-July. Two crops are normally raised in these ponds, one during monsoon (June-July to September-October) and the second during winter (October-November to February-March). The culture duration lasts about 3-4 months per crop. During 1988-89, juveniles of *P. monodon* in the size range of 20-80 mm collected from Paradip and Chilka were stocked in the ponds @ 7500 to 15,000/ha.

Before the rains, ponds were ploughed and treated with lime and cattle dung @ 50-250 kg/ha and 1000-2500 kg/ha respectively. Supplementary feeding was done with the meat of the freshwater snail, *Pila globosa* @ 10-15% of body weight of prawn during the first month and 20-30% subsequently.

The ten ponds were sampled for soil and water during the three seasons namely, monsoon (1st crop), winter (2nd crop) and summer, representing the entire period of 1988-89. The soil samples were collected with the help of a core sampler from depths of 0-10, 10-20 and 20-37 cm and analysed for various physico-chemical parameters. The pond water samples were collected from surface and bottom for physico-chemical features. Standard analytical procedures were followed as per Jackson (1967), Piper (1966) and Subbiah and Asija (1956) for soil and APHA (1971) and Strickland and Parsons (1972) for water. Fifty litres of the pond water was filtered through a plankton net (50 μ mesh) to collect plankton samples. Ekman's dredge (100 cm^2) was used to collect sediment

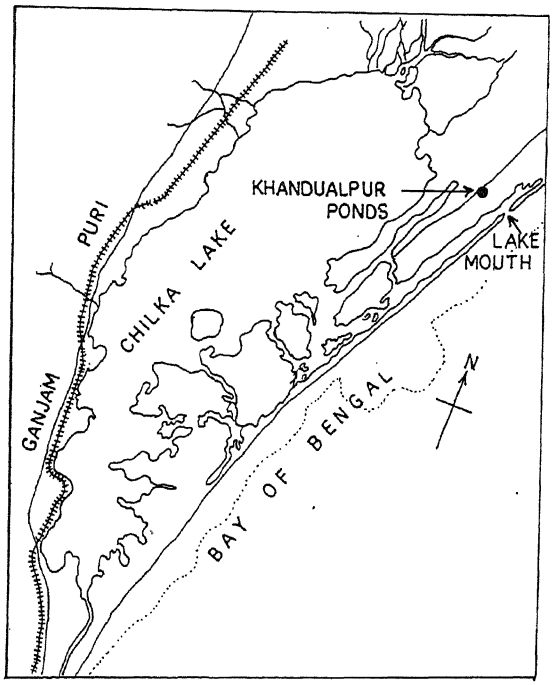

Fig. 1. Map showing the location of Khandualpur ponds

samples, they were sieved through seive No. 80 for analysis of benthos.

Results and Discussion

The physio-chemical characteristics of the soil of ten ponds and the nodules collected form dykes are presented in Table 1. The texture of the soil was sandy clay with sand 34.6 to 59.0%, silt 4.5 to 16.1% and clay 35.7 to 49.3%. The pH of soil was acidic to alkaline in reaction with a pH range of 6.9 to 9.4 in ponds 31, 32, 33, 34, 25 and 54 and 5.6 to 7.0 in ponds 3, 4 and 26. However, the pH of soil in the depth profile was found to vary considerably. A pH value of 5.2, 5.5, 5.3 and 4.8 was observed in ponds 2, 3, 4 and 26 respectively at the depth of 20-37 cm, where the content of calcium carbonate was nil. According to Thompson and Troeh (1975), strong acidity of the soils may be caused by the activity of the acid cations like aluminium ions when the pH drops below 5. Tamhane *et al.* (1966) reported that the acids liberated during microbial decomposition of the organic matter are not neutralised if the exchange complex of the soil is low in base saturation characterised by the absence or low content of free $CaCO_3$ and would cause acidity. According to Banerjea (1967), neutral to alkaline soils are favourable for fish production and this suggests that ponds 2, 3, 4 and 26 require heavy liming schedule. Alikunhi (1957) stated that in India, waters on acid soil

Table 1. Physico-chemical characteristics of pond soil[a]

Pond No.	Sampling period[b]	Texture%			Temp. (°C)	Redox potential (mv)	pH	E.C. (mmhos/cm)	Organic carbon (%)	$CaCO_3$ (%)	Available nitrogen (mg/100g)	Available phosphorus (mg/100 g)	Fe %
		Sand	Silt	Clay									
31	1	55.8	8.2	36.0	27.7	-1600	7.8	7.80	0.43	1.93	16.84	1.67	0.98
	2				29.7	-	7.5	13.50	0.51	0.47	21.53	1.65	
	3				32.0	-710	7.2	11.00	0.41	1.00	20.33	1.73	
32	1	46.7	10.1	43.2	-	-	8.9[c]	4.00	0.42	2.00	15.35	2.22	0.90
	2				34.0	-	7.7	10.08	0.54	0.35	18.92	1.38	
	3				32.3	-1200	6.9	7.35	0.43	1.15	15.92	6.34	
33	1	35.3	15.6	50.1	-	-	9.4[c]	3.00	0.51	1.75	17.40	2.12	1.60
	2				31.9	-	7.9	19.92	1.14	1.08	35.08	1.78	
	3				32.1	-1425	7.6	7.38	0.66	1.94	22.58	4.68	
34	1	55.2	4.5	40.3	27.0	-1515	7.1	4.78	0.48	1.81	18.47	1.62	1.23
	2				29.9	-	7.5	9.83	0.96	0.96	28.20	2.46	
	3				31.9	-1325	7.1	6.78	0.17	1.02	11.37	4.40	
54	2	59.0	5.3	35.7	29.7	-	7.5	7.08	0.51	0.92	20.58	4.74	1.18
	3				29.6	-625	7.2	10.27	0.42	1.12	16.67	4.05	
2	2	45.0	8.6	46.4	30.8	-	6.7	9.58	1.16	0.50	31.20	4.46	1.83
	3				29.0	-487	6.5	15.87	0.63	0.42	23.83	3.35	
3	2	48.2	5.7	46.1	30.8	-	7.2	18.18	1.32	0.52	30.08	7.62	1.85
	3				30.0	-1200	5.6	9.53	0.44	0.00	21.50	12.98	
4	2	50.4	7.4	42.2	31.0	-	7.1	11.00	0.54	0.49	21.57	6.72	1.03
	3				30.4	-687	6.3	14.30	0.50	0.33	21.67	3.51	
25	2	49.9	8.3	41.8	30.4	-	7.0	11.05	0.44	0.56	17.67	5.34	1.59
	3				30.0	-900	7.0	25.93	0.42	1.10	15.08	4.89	
26	2	34.6	16.1	49.3	30.6	-	6.2	15.50	0.43	0.28	19.63	4.20	0.90
	3				29.9	-1275	6.3	18.97	0.37	0.48	21.50	6.07	
Nodules[d]		56.5	11.5	32.0	-	-	6.9	7.25	0.15	0.70	5.88	2.93	1.48

a Average values for three segments of the soil depth profile
b 1-November, 1988, 2-March, 1989 and 3-August, 1989
c pH value for surface layer only
d Average of 4 estimations

Table 2. Physico-chemical characterisitcs of pond water[a]

Pond No.	Sampling period[b]	Depth (cm)	Temperature (°C)	pH	Dissolved oxygen (ppm)	Total alkali-nity (ppm)	Calcium (ppm)	Magnesium (ppm)	Salinity (ppt)	NO_3 (ppm)	PO_4 (ppm)	Fe (ppm)
31	1	82	29.0	7.7	6.0	22.0	86.4	210.6	10.0	0.050	0.004	-
	2	35	38.0	6.2	5.6	16.0	273.3	561.8	19.0	0.038	0.002	-
	3	57	30.0	9.0	5.6	60.0	64.8	170.8	9.0	0.040	0.006	1.00
32	1	78	28.0	8.4	7.6	40.0	-	-	10.0	-	-	-
	2	36	37.0	8.6	5.2	106.0	142.1	329.6	15.0	0.010	0.008	-
	3	67	30.0	9.2	5.6	56.0	68.0	169.0	8.0	0.022	0.010	0.92
33	1	65	28.0	8.4	7.6	60.0	-	-	10.0	-	-	-
	2	40	36.0	8.1	5.2	208.0	174.1	405.2	14.0	0.018	0.007	-
	3	67	32.0	9.1	8.0	50.0	84.0	178.0	8.0	0.027	0.008	1.90
34	1	71	28.0	8.3	7.4	26.0	103.7	203.6	10.0	0.050	0.004	-
	2	50	37.0	8.8	7.2	84.0	196.5	489.8	15.0	0.034	0.002	-
	3	65	33.0	7.6	5.6	36.0	22.0	318.4	9.0	0.035	0.010	1.82
54	3	70	32.0	9.3	8.4	48.0	36.0	79.0	5.0	0.022	0.008	1.80
2	3	81	34.0	9.1	14.4	48.0	84.0	142.0	5.0	0.020	0.008	2.60
3	3	90	34.0	8.9	12.0	40.0	157.6	232.0	5.0	0.020	0.006	2.68
4	3	83	30.0	8.1	4.0	44.0	74.4	107.8	5.0	0.025	0.012	2.36
25	3	92	31.0	7.6	4.8	44.0	149.8	239.2	6.0	0.025	0.010	1.83
26	3	87	31.0	8.5	4.4	43.0	116.0	205.0	5.5	0.020	0.010	0.92

a Average values for surface and bottom water
b 1-November, 1988, 2-March, 1989 and 3-August, 1989

are generally less productive than those on alkaline soils. In the present investigation, however, the effect of soil acidity on the water phase could not be observed due to application of lime. The pH of water was in the range of 7.6 to 9.3 (Table 2). This fact has also been supported by the presence of high concentration of calcium (22.0 to 157.0 ppm) and magnesium (79.0 to 318.4 ppm) in the water of the ten ponds. Similar trend in the concentration of calcium and magnesium was recorded in the Bheries of West Bengal (Anon. 1985).

The electrical conductivity ranged from 3.00 to 25.93 millimhos/cm. Salt accumulation at the surface was noticed which was due to clayey nature of soil. It did not contribute much to the water salinity in any of the ponds which had only 5 to 10 ppt salinity during the two seasons of study. However, as the culture progressed, the salinity gradually rose to 19 ppt in March (Table 2).

In the present investigation, all the ponds showed low levels of organic cabon (Table 1). Most of the pond soils contained less than 0.5% organic carbon. Chakraborty *et al.* (1985) reported that brackishwater pond soils with more than 1% organic carbon show better production of *P. monodon.* Tang and Chen (1967) opined that an increase in organic carbon content of pond soil increases the yield. Available nitrogen was low and ranged from 11.37 to 23.83 mg/100 g soil which may be due to slow rate of mineralisation of organic nitrogen in pond soils under high salinity (Chattopadhyay and Mandal, 1980). The nitrate (0.02 to 0.05 ppm) in the water was also low. Available phosphorus in soils ranged from 1.62 to 6.34 mg/100 g soil. Low value of this critical nutrient was noticed in most of the ponds which may be due to the formation of insoluble compounds with calcium in alkaline and with iron and aluminium in acidic condition. In general, the available phosphorus was found to be high at the surface where extremely low redox potential was observed. However, the concentration of phosphate in water was very low (0.004 to 0.012 ppm), indicating phosphate fixation with calcium and magnesium already present in the water. According to Rajyalakshmi *et al.* (1988), the Mudiratha ponds also showed poor nutrient status in terms of phosphorus and nitrogen. The redox potential (Eh) of the sediments play an important role in determining the productivity of the culture system (Pearsall and Mortimer, 1939). In the present investigation, the ponds showed extremely low Eh ranging from -487 to -1600 mv, indicating anaerobic conditions. Aeration of such ponds in early hours to prevent mortality has been suggested (Ghosh and Mohanty, 1980). The total iron content in the pond sediments and water was high in the present study. It was 0.90 to 1.85% in soils and 0.92 to 2.68 ppm in water which might affect the growth of *P. monodon.*

The concentration of plankton and bottom biota was poor. The volume of plankton ranged form 0 to 0.7 ml./50 l. The concentration of phytoplankton varied from nil to 1800 no/l and that of zooplankton from nil to 1600 no/l. The phytoplankton was represented by species of *Gyrosigma, Nitzschia, Oscillatoria, Anabaena, Synedra, Lyngbya and Coscinodiscus. Brachionus,* mysids, copepods and their nauplii were the common zooplankters. Benthos was absent in most of the ponds and its concentration was in the range of nil to 850 no/m^2. Gammarids, taneids, polychaetes and tubifex were the common benthic organisms recorded in the ponds. The yield of *P. monodon*

Table 3. Production of *P. monodon* in ponds of Khandualpur during 1988-'89

Pond No.	Yield kg/ha 1st crop	Yield kg/ha 2nd crop	Annual yield kg/ha
31	287.50	72.50	360.00
32	287.50	-	287.50
33	252.50	-	252.50
34	100.00	-	100.00
2	150.00	187.50	337.50
3	-	-	-
4	-	-	-
25	225.00	162.50	387.50
26	142.50	125.00	267.50
54	295.00	162.50	457.50

Source: Department of Fisheries, Puri, Orissa.

ranged from 100 to 457.5 kg/ha/yr with an average of 278.7 kg/ha/yr (Table 3). The production was higher in monsoon than winter season corroborating the observation made by Rajyalakshmi *et al.* (1988).

The confined pond culture system has been designed at the artisanal level and hence management measures for improving its productivity have to be within the means of the farmers operating the system. Water quality management, particularly during the winter crop, will certainly result in higher production rates if it can be arranged. Other measures which can be considered would relate to improving the quality of the soil and water to neutralise the adverse conditions. Although lime application is prevalent, the quality and dosage are found to vary widely. The suggestion here is application of lime ($CaCO_3$) at the rate of 1000 kg/ha as a basal dose in all the ponds and an additional 1240 kg/ha in ponds where soil pH is less than 6.0. This can be followed by a basal dose of raw cattle dung at 1000 kg/ha and urea and single superphosphate each at 50 kg/ha. The ponds may be stocked thereafter. During the course of culture, the ponds may be further fertilized with urea at 20 kg/ha at fortnightly intervals and single superphosphate at 20 kg/ha at weekly intervals. Since iron content is high both in the soil and water, phosphatic fertilizer may be applied in the liquid form than in the usual granular form so that the fertilizer will be directly available in the water medium for enhancing primary production (Boyd *et al.*, 1980).

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