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Limnology of Kharland (saline) ponds of Ratnagiri, Maharashtra in relation to prawn culture potential

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Abstract: *The coastal saline soils, Kharlands, have great potential for their use in aquaculture. This study has been taken up to understand the limnology of the ponds in Kharland area for assessing their prawn culture potential. This study was carried out during September, 1999 to August, 2001. Each Kharland pond has an area of 0.045 hectare. During the study, depth of pond water was 47.7 to 120.0 cm, temperature varied from 25.7 to 34.5 ºC; transparency from nil to 65.0 cm; specific conductivity from1.78 to 94.5 µS.cm^{-1}; total dissolved solids from 0.89 to 27.55 ppt; pH 5.42 to 8.25; dissolved oxygen 1.6 to 8 mg.l^{-1}; free carbon dioxide 10.00 to 44.00 mg.l^{-1}; total alkalinity 5.00 to 142.00 mg.l^{-1}; salinity 0.45 to 39.55 ppt; total hardness 245.00 to 5945.00; calcium 56.05 to 1827.6; magnesium 110.74 to 4507.75 mg.l^{-1}; dissolved organic matter 1.45 to 9.68 mg.l^{-1}; ammonia 1.00-8.00 µg.l^{-1}; nitrite nil to 20.00 µg l^{-1} and nitrate 7.5 to 17.5 µg.l^{-1}. These Kharland ponds are unique in physio-chemical characteristics during their seasonal cycle. From July to October, these ponds have nearly freshwater while from November to May pond water becomes saline. Thus, there is a great possibility of taking up monoculture of both the freshwater and brackish water prawns as well as polyculture of prawns and fishes in the Kharland ponds.*

Key words: *Limnology, Physico-chemical characters, Kharland ponds, Ratnagiri.*

Introduction

Water quality management constitutes an integral aspect of aquaculture operations. Since maintenance of healthy aquatic environment for production of food organisms in ponds is of primary importance for higher yield, an understanding of the complex interactions between the environmental factors and stocked organisms is essential to enhance the survival and yield by appropriate manipulation of aquatic environment. Any characteristic of water that affects the survival, growth, reproduction etc. is important from point of view of culture of aquatic organisms (Boyd, 1982). The important physico-chemical factors, which influence the pond productivity individually or synergistically are depth, temperature, transparency, pH, dissolved oxygen, free carbon dioxide, total alkalinity, salinity and dissolved nutrients (Banerjee, 1971). Maintenance of the quality of waters is pre-requisite for all culture systems for better yield (Shigeno, 1978).

The Maharashtra state has 720 km coastal length. It comprises Thane, Raigad, Ratnagiri and Sindhudurg districts of Konkan region. These coastal saline soils, Kharlands have great potential for their use in aquaculture. Therefore, this study has been taken up in order to know about the limnology of ponds in Kharland area for assessing their prawn culture potential.

Materials and Methods

The present study was conducted in six ponds in Kharland. The ponds under study are located within the campus of the College of Fisheries, Ratnagiri, Maharashtra (16º 59' 10" N latitude 73º 16' 25"E longitude). Each pond is small in size, rectangular in shape with an area of 0.045 hectare (30 m x 15 m) and 1.5 m deep. The sub-surface water samples were collected from various ponds. Samples were taken from September, 1999 to August, 2001 from six ponds between 7.00 to 8.00 hrs fortnightly.

The water characteristics including depth, temperature, transparency, conductivity, total dissolved solids, pH, dissolved oxygen, free carbon dioxide and total alkalinity were estimated at the sampling sites. The further estimation of salinity, total hardness, calcium, magnesium, dissolved organic matter, ammonia, nitrate and nitrites were done in the laboratory. The water parameters were analyzed according to the methods of Jhingran *et al.* (1969), Boyd (1982) and APHA *et al.* (1986). The results of physico-chemical characteristics were statistically analyzed by analysis of variance and coefficient of correlation (Zar, 1974).

Results and Discussion

The range of variation of different physico-chemical characteristics of water in Kharland ponds and their mean along with standard deviation have been given in Table 1.

Depth: The depth of water in different ponds ranged from 47.7 to 108 cm during first year of the study and 47.5 to 120.0 cm during second year. It was relatively more during September and October. The depth of pond was influenced by both the tides and monsoon. Hence the fluctuation in water depth of all the ponds was recorded quite frequently. Das *et al.* (2001 a) observed the pond water depth ranging from 67 to 101 cm is favourable to prawn production.

Temperature: The temperature of pond water varied from 26 to 34.5 ºC during first year of the study and 25.7 to 32.7 ºC during second year. There occurred a gradual decline in the

Table – 1 : Range of variation, mean and standard deviation of various physico-chemical characteristics of Kharland ponds.

S.No.	Parameters	Fiducial limits	Mean ± SD
1	Depth (cm)	47.7 - 120	79.76 ± 17.86
2	Temperature (°C)	25.7 - 34.5	29.56 ± 2.17
3	Transparency (cm)	0.0 - 65.0	24.09 ± 25.61
4	Specific conductivity (µS.cm-1)	1.78 - 94.5	28.63 ± 20.04
5	Total dissolved solids (ppt)	089 - 27.55	14.15 ± 9.42
6	pH	5.42 - 8.25	7.03 ± 0.72
7	Dissolved oxygen ($mg.l^{-1}$)	1.6 - 8.0	3.06 ± 1.30
8	Free carbon dioxide ($mg.l^{-1}$)	10 - 44	21.29 ± 9.04
9	Total alkalinity ($mg.l^{-1}$)	5 - 142	45.43 ± 32.59
10	Salinity (ppt)	0.45 - 39.55	20.48 ± 13.70
11	Total hardness ($mg.l^{-1}$)	245 - 5945	2904.82 ± 2109.64
12	Calcium ($mg.l^{-1}$)	56.05 - 1827.6	667.26 ± 549.21
13	Magnesium ($mg.l^{-1}$)	110.74 - 4507.75	2160.60 ± 1611.70
14	Dissolved organic matter ($mg.l^{-1}$)	1.45 - 9.68	4.02 ± 1.76
15	Ammonia ($\mu g.l^{-1}$)	1.0 - 8.0	2.9 ± 1.3
16	Nitrite ($\mu g.l^{-1}$)	0.0 - 2.0	1.1 ± 0.5
17	Nitrate ($\mu g.l^{-1}$)	7.5 - 17.5	11.76 ± 1.85

temperature from September to January and thereafter, it increased till May. There was no significant difference between the temperatures of various ponds. In the present investigation, lower water temperature was observed from December to March and higher temperature was recorded from April to June. In the coastal ponds of Orissa, Das *et al.* (2000, 2001 a and b) and Das and Saksena (2001) have described water temperature ranging from 20 ºC to 31.5 ºC. In the present study the water temperature was ranging from 25.7 to 34.5 ºC. The temperature in all the ponds was influenced by the seasonal changes in ambient temperature.

Transparency: The Secchi disc transparency fluctuated between nil to 65.00 cm in various ponds during the present study. The transparency values were nil in ponds P3 and P4 during first year and this is indicative of the fact that the ponds are not that productive. Monsoon and tides influenced the transparency of the newly constructed ponds and soil colloids did not settle down throughout the first year. Rajyalakshmi *et al.* (1988) observed the transparency ranging from 14 to 36 cm in the brackishwater ponds of Chilka lake fringe area. Das *et al.* (2001 a) have suggested that in prawn culture ponds a transparency of 17.8 cm is quite useful. Kaliyamurthy (1993) has observed low transparency during pre-monsoon and high during monsoon period. Similar observations were recorded in our ponds also.

Specific conductivity: The specific conductivity of water ranged from 1.78 to 94.5 $\mu S.cm^{-1}$ in various ponds during the period of study. It was lowest during July and highest during January and March in all the ponds. There occurred a gradual increase in specific conductivity, which might be influenced by the salinity. It has been a general observation that the higher conductivity exhibit higher concentration of ions in the water. Rajyalakshmi *et al.* (1988) recorded specific conductivity between 8.70 to 8.90 m mhos/cm in the ponds of Chilka fringe area indicating the high salt contents. The relationship between months and specific conductivity was positive but there was no significant difference between the specific conductivity of the ponds.

Total dissolved solids: In four natural lakes located in Northwestern Indiana, Simon *et al.* (1967) reported that total dissolved solids varied from 48.6 to 67 ppt. In the present study, the total dissolved solids were ranging from 0.89 to 27.55 ppt. The total dissolved solids increased gradually from post-monsoon season to pre-monsoon season but decreased in monsoon season in all the ponds.

pH: Nobel (1968) recorded pH values ranging from 7.3-8.5 in the surface water of Kanara coast. Rajyalakshmi *et al.* (1988) recorded higher values of pH ranging from 8.3 to 8.9 in the ponds of Chilka fringe area. Chattopadhyay *et al.* (1988) reported pH between 7.2 to 8.4 in the coastal saline water ponds. In the present study, the variation in pH was from 5.42 to 8.19 and 6.30 to 8.25 during first and second year respectively. Thus, the pH of pond water was influenced by the monsoon, temperature and soil conditions.

Dissolved oxygen: Rajyalakshmi *et al.* (1988) reported dissolved oxygen concentration ranged from 3.40 to 6.52 $mg.l^{-1}$ in the brackishwater ponds of Chilka fringe area. The low dissolved oxygen and nutrients levels indicate the poor productivity of the pond (Schuster, 1952). Thampy *et al.* (1988) observed the dissolved oxygen concentration fluctuated between 1.4 to 8.2 $mg.l^{-1}$ in the saline ponds at Cochin. Devaraj (1988) noted concentration of dissolved oxygen from 3.7 to 8.2 $mg.l^{-1}$. In the present study, the dissolved oxygen ranged from 1.8 to 8.0 $mg.l^{-1}$ during the first year of study while during second year it ranged from 1.6 to 4.8 mgl^{-1}. The concentration of dissolved oxygen was higher during the monsoon season and lower during winter and summer seasons.

Table – 2: Correlation coefficient (r) between various physico-chemical parameters of Kharland ponds.

S. No.	Parameters	Correlation coefficient
1	Specific conductivity v/s total dissolved solids	0.993
2	Specific conductivity v/s salinity	0.886
3	Specific conductivity v/s total hardness	0.799
4	Specific conductivity v/s magnesium	0.789
5	Total dissolved solids v/s salinity	0.939
6	Total dissolved solids v/s total hardness	0.853
7	Total dissolved solids v/s magnesium	0.850
8	Total dissolved solids v/s calcium	0.750
9	Total dissolved solids v/s pH	0.700
10	pH v/s total hardness	0.768
11	pH v/s salinity	0.759
12	pH v/s magnesium	0.756
13	Salinity v/s total hardness	0.918
14	Salinity v/s magnesium	0.903
15	Salinity v/s calcium	0.800
16	Total hardness v/s magnesium	0.968
17	Total hardness v/s calcium	0.899
18	Calcium v/s magnesium	0.844

Free carbon dioxide: During the present study, the free carbon dioxide ranged from 10.00 to 44.00 mg.l$^{-1.}$ The increased concentration of free carbon dioxide was due to nature of soil and organic matter. It has also been shown that free carbon dioxide concentration is always associated with low level of oxygen. The analysis of variance showed that free carbon dioxide is significantly different from one pond to the other. Das *et al.* (2001a) have shown that free carbon dioxide fluctuate between 0.0 to 2.6 mg.l^{-1} in prawn culture ponds but the free carbon dioxide was mostly absent in the samples.

Total alkalinity: The total alkalinity of water ranged from 5.00 to 142.00 mg.l^{-1} during the period of study. It was low during monsoon period and higher during pre- and post-monsoon seasons. Rajyalakshmi *et al.* (1988) reported the total alkalinity values fluctuated from 35.2 to 110 mg.l^{-1}. Gupta *et al.* (1993) reported total alkalinity values ranged from 16.0 to 208.0 mg.l^{-1} in low productive rainfed brackishwater ponds along the periphery of Chilka Lake, Orissa.

Salinity: The salinity of pond water fluctuated from 0.45 to 39.5 ppt during the period of study. Thampy *et al.* (1988) reported the salinity was ranging from 23.1 to 43 ppt in saline ponds at Cochin during the prawn culture while James *et al.* (1993) recorded the salinity between 28 to 40.65 ppt in the saline ponds with reference to prawn culture. In the present study, it was observed that the salinity was low during monsoon season due to dilution of rainwater but it gradually increases from post-monsoon to pre-monsoon season. The increased salinity during August and onwards was due to intrusion of highly saline estuarine water into the ponds.

Total hardness: Hardness of water is due to the carbonate, bicarbonate, chloride and sulphate of calcium and magnesium. The total hardness as a water quality parameter from the prawn production point of view, has been studied by several workers (Adhikari, 2000; Mohanti and Subramaniyan, 2000; Chand, 1999). The total hardness of water varied from 265 to 5945 mg.l^{-1}. It was found that the total hardness of water depends upon the soil characteristics of ponds. The analysis of variance also indicates that the total hardness of water in different ponds was very much similar.

Calcium: The calcium content of water in ponds varied from 56.05 to 189.55 mg.l^{-1}. The lower value of calcium in the monsoon season was due to the dilution of rainwater. In the present study, there was a gradual increase in the concentration of calcium in the water in all the ponds from the post-monsoon onwards. Palanichamy and Balasubramanian (1989) have found that both the calcium and magnesium concentrations increased towards the marine zone of the estuary coinciding with high salinity condition. In the present study, summer period recorded higher values of calcium than the other seasons whereas lower values were encountered during monsoon period.

Magnesium: Palanichamy and Balasubramanian (1989) stated that the variations in magnesium concentration be attributed to different biogeochemical activities in the brackish water ecosystem. Magnesium concentration varied from 79 to 561.8 ppm in the culture ponds situated at the periphery of Chilka, Orissa (Gupta *et al.,* 1993). In the present study, the magnesium concentration ranged from 110.74 to 4507.75 mg.l^{-1}. It was observed that lowest amount of magnesium was recorded during July, September and October while peak value is obtained in March in all the ponds. During the study period, concentration of magnesium showed increasing trend during post and pre-monsoon while it was low during monsoon. The magnesium content of the ponds was not significantly different in various ponds.

Dissolved organic matter: It was observed that the highest values of dissolved organic matter were observed during pre-monsoon and post-monsoon period and lowest values observed during monsoon season in almost all the ponds in the present study. In the present study, the dissolved organic matter was ranging from 1.45 to 9.68 mg.l^{-1}. The temporal and spatial changes in dissolved organic matter depend mainly on physical process such as mixing between riverine and coastal waters (Cifuentes and Eldrige, 1998) and biological process such as secretions from phytoplankton (Aminot *et al.,* 1990). Relatively lower values of dissolved organic matter help towards more specific growth rate during initial phase of shrimp crops (Das and Saksena, 2001).

Ammonia: The ammonia showed a wide fluctuation during the period of entire study. During the first year, the values of ammonia were higher than the second year, which indicates that ponds are becoming more stable. Manzil and Spaeth (1962) reported that ammonia content increases considerably with the rainfall and decreases with its subsequent oxidation to nitrite and nitrate.

Nitrite: In the present study, the nitrite concentration was 0.0 to 2.0 µg.l^{-1} during the period of study. The analysis of variance has shown that trend of nitrite content in water was almost similar in all the ponds. Pradeep and Gupta (1986) reported from traces to 3.16 µg.l^{-1} nitrite in brackish water ponds of Mulki. The results of present study are quite similar to the study on Mulki ponds. Mathew (1994) observed ammonia values ranging from 0.02 to 3.08 µg.l^{-1} in the brackishwater ponds along the Nethravati estuary.

Nitrate: In the present study, the concentration of nitrate varied from 7.5 to 17.5 µg.l^{-1} throughout the investigation in ponds studied. Sankaranarayanan and Qasim (1969) have recorded higher values of nitrate during the monsoon months, which were attributed to the land drainage. Similar trends in the seasonal variations of nitrate content have been reported from Cochin backwater (Qasim, 1973). Nagrajaih and Gupta (1983) recorded two peaks i.e., one in June and the other in April in brackish water ponds near Netravati estuary. Singbal (1976) reported the low nitrate concentration during the monsoon months and high during the other seasons. Nitrate fluctuated from 1.12 to 18.48 µg.l^{-1} in culture ponds and a negative correlation exited between nitrate and shrimp growth (Das and Saksena, 2001).

The values of coefficient of correlation (r) were calculated between different physico-chemical characteristics of water in Kharland ponds and it was found that specific conductivity showed a very high positive correlation with total dissolved solids but it had moderate positive correlation with total hardness, magnesium, calcium and pH. Similarly, pH also showed a moderate positive correlationship with total hardness, salinity and magnesium. It was also observed that salinity exhibits a very high positive correlation with total hardness and magnesium while it was moderately positive with calcium. Total hardness showed a very high positive correlation with magnesium and moderately positive correlation with calcium. Calcium has, however, exhibited a moderate positive correlation with magnesium (Table 2).

From the above study, it is concluded that the Kharland ponds are unique in physio-chemical characteristics during their seasonal cycle. From July to October, the water in these ponds is freshwater and from November to May pond water becomes saline. Thus, there is a great possibility of taking up of monoculture of prawns and polyculture with fishes in the Kharland ponds after conducting pilot experiments.

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