COMMUNICATION III

Ground Water-Bottom Soil-Water Interactions in Tropical Carp Nursery Ponds.

Key Words: Physico-chemical properties, ground water, pond water, bottom soil of pond.

ABSTRACT

There was no significant combined effect ($p > 0.05$) of the physico-chemical properties of the underground deep tubewell water on increasing the nutrient contents of the nursery ponds' bottom soil. But the combined effect of seven chemical properties of bottom soil showed significant ($p < 0.05$) influence on increasing the amount of chemical constituents of pond water except pH and exchangeable K. Electric conductivity, pH and exchangeable Ca of deep tubewell water had inverse correlations with chemical properties of pond bottom soil but only dissolved O_2 was directly correlated with all the properties of pond bottom soil. All the correlation values between pH and chemical properties of bottom soil of nursery ponds were inversely significant ($p < 0.05$) in nature. Dissolved O_2 and phosphate P of water had almost direct correlations with bottom soil properties of nursery ponds where dissolved O_2 had significant ($p < 0.05$) correlation with pH of bottom soil.

INTRODUCTION

While underground water is the only water used in carp breeding operations, the monsoon rain is the main source of water for carp nursery ponds particularly in South Asian countries. Nowadays, most of the government and large scale commercial carp hatchery managers use deep tubewell water in the nursery pond, whenever necessary.

The addition of deep tubewell water to the nursery pond may change the physico-chemical properties of the pond ecosystem, exerting an influence on the primary and secondary productivity (Habib *et al.* 1984 and Ali *et al.* 1985). Maintenance of an optimal abudance of both phytoplankton and zooplankton in carp nursery ponds is a prerequisite for successful nursing of carp fry (Alam *et al.* 1985 and Habib *et al.* 1986). Information on the effects of nutrients of deep tubewell water on pond water and bottom soil, and vice-versa is lacking. Therefore, the present work was undertaken to determine the degree of probability of combined effects of physico-chemical characteristics of deep tubewell water on the bottom soil properties, pond bottom soil properties on the pond water characteristics and their inter- and intra-correlations.

MATERIALS AND METHODS

Sampling Area

Six nursery ponds, having an area of 404.70 m^2 and an average depth of 81.50 cm each, at the Freshwater Station of the Fisheries Research Institute, Mymensing 2201, Bangladesh were selected for the study for the period of 1st May to 30th September 1984. Ponds lying side by side were selected among the series of Institute's nursery pond complex, leaving a narrow embankment in between the ponds, to avoid the mixing of pond water with rain wash. All the ponds were dried, cleaned and treated with lime and cowdung at the rate of 247 kg/ha and 9142 kg/ha respectively by mid April. Underground water was supplied from the deep tubewell and N:P:K fertilizers were applied at the rate of 98, 98 and 49 kg/ha, respectively, on the next day.

Collection of samples

Samples of pond water and pond bottom soil were collected twice a month between 0900 h to 1200 h from two selected places of each experimental pond. Pond water samples from mid layer and bottom soil samples from soil water interface were collected using Kemmerer water sampler and Ekman dredge respectively. Ground water samples were collected from the outlet of the deep tubewell. Water samples were stored in black bottles of 500 ml capacity by adding 2 to 3 drops of toluene and subsequently carried to the laboratory for analyses. Pond bottom soil samples were air dried, ground, sieved and kept in plastic packets for chemical analyses.

a) Analyses of water samples.

pH, dissolved O_2, free CO_2, nitrate-N and phosphate - P were determined by digital pH meter, azide modification of iodometric method, titrimetric method, phenoldisulphonic acid method and ascorbic acid method, respectively. Exchangeable Ca and K of water were determined directly with the help of Eppendorf flame photometer after subsequent filtration. Conductivity test of deep tubewell water was done using conductivity bridge. Standard Methods for the Examination of Water and Wastewater (APHA *et al.* 1978) were followed for the chemical analyses.

b) Analyses of soil samples

pH of the soil sample was determined in a 1:2.5 soil:water suspension. The wet oxidation method (Black 1965), macro-Kjeldahl method (Jackson 1962), 0.5 M $NaHCO_3$ extraction method (Matt 1970); and ammonium acetate extraction method using Eppendorf flame photometer (Black 1965) were followed for analysing organic carbon, total N, phosphate-P, exchangeable K and exchangeable Ca, respectively.

c) Data analyses

Multiple and linear correlations of eight physico-chemical properties *viz.*, conductivity, pH, dissolved O_2, free CO_2, nitrate-N, phosphate-P, Ca and K (x_1, x_2,—x_8) of deep tubewell water with the chemical properties viz., pH, organic carbon, total N, nitrate-N, phosphate-P, exchangeable Ca and exchangeable K (y_1, y_2,—y_7) of pond bottom soil were analysed. The same analyses were also performed for the above mentioned chemical properties of bottom soil (x_1,x_2,——x_7) with the chemical properties of pond water viz., pH, dissolved O_2, free CO_2, available N, available P, Ca and K (y_1,y_2,——y_7). The characters (x_i) were considered as independent factors with (y_i) as dependent factor. The analyses were done using an IBM PC with STATGRAPHICS package.

RESULTS AND DISCUSSION

The mean values and standard errors of chemical properties of water and bottom soil of nursery ponds are presented in *Figures 1, 2* and *3*, respectively. During the study, the insignificant ($P > 0.05$) combined effect of physico-chemical properties of deep tubewell water on the amount of various nutrients of pond bottom soil was recorded (Table 1) with an indication of the poor nutrient status of deep tubewell water. The nutrient concentrations of deep tubewell water, particularly nitrate-N, phosphate-P, Ca and K were also very low

TABLE 1

Multiple correlation coefficients (R), MR^2, F values and estimated y ($\hat{y}$) of seven physico-chemical properties of deep tubewell water with seven chemical properties of pond bottom soil.

Soil properties	R	MR^2	F	Estimated y values ($\hat{y}$)
pH	0.237	05.62	0.23	$6.388 + 0.135x_1 - 2.204x_2 - 0.004x_3 - 0.005x_4 - 0.003x_5 + 0.008x_6 + 0.006x_7 - 0.008x_8$
Organic Carbon	0.518	26.83	1.33	$-5.525 + 1.620x_1 + 0.726x_2 - 0.224x_3 - 0.003x_4 - 0.003x_5 - 0.500x_6 + 0.004x_7 - 0.011x_8$
Total-N	0.432	18.66	0.92	$11.668 - 1.206x_1 - 1.190x_2 - 0.041x_3 - 0.005x_4 - 0.521x_5 - 0.024x_6 + 0.094x_7 - 0.092x_8$
Nitrate-N	0.586	34.34	1.88	$-1.659 + 0.367x_1 + 3.838x_2 + 0.022x_3 - 0.007x_4 + 0.125x_5 + 0.031x_6 + 0.020x_7 - 0.021x_8$
Phosphate-P	0.412	16.97	0.75	$-0.441 + 0.085x_1 - 0.837x_2 + 0.003x_3 - 0.003x_4 + 0.004x_5 + 0.004x_6 + 0.002x_7 - 0.001x_8$
Exchangeable-Ca	0.440	19.36	0.89	$13.887 - 0.574x_1 + 12.749x_2 - 0.044x_3 - 0.008x_4 + 0.004x_5 - 0.084x_6 + 0.081x_7 - 0.065x_8$
Exchangeable-K	0.455	20.70	0.96	$3.439 + 0.911x_1 + 27.810x_2 + 0.025x_3 - 0.003x_4 - 0.051x_5 - 0.170x_6 + 0.101x_7 - 0.138x_8$

$F_{0.05(15,8)} = 2.64$

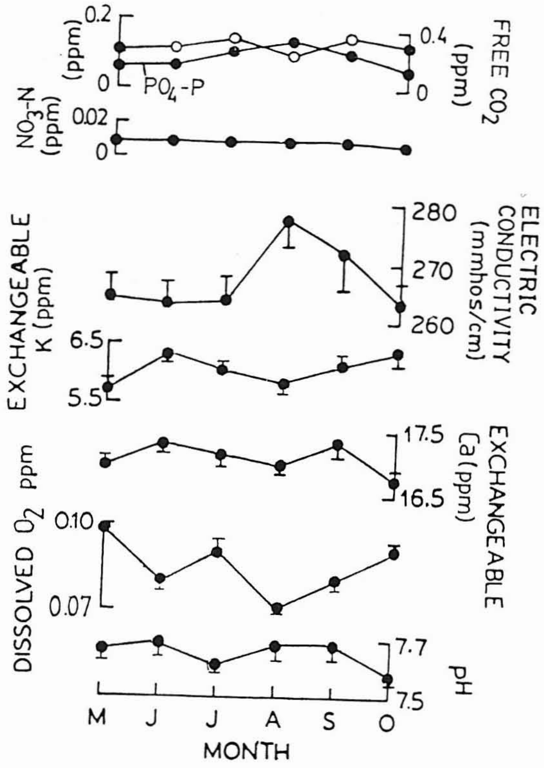

Fig 1: Monthly fluctuations of chemical properties (mean values) of deep tubewell water (vertical bar represents standard error).

(*Figure 1*). The chemical properties of pond bottom soil had a combined effect of increasing the amount of free CO_2 (R = 0.769) and Ca (R = 0.777) of pond water at 1% level of significance and of dissolved O_2 (R = 0.685), available N (R = 0.769) and phosphate-P (R = 0.704) at 5% level of significance. The per cent contribution of combined effect upon the above chemical constituents were 59.14, 60.37, 49.92, 45.83 and 49.56 respectively (Table 2). These results indicate that some pond bottom soil properties influence the nutrient status of pond water (Habib *et al.* 1986) through a significant nutrient exchange from the bottom soil to water (Habib *et al.* 1984; Ali *et al.* 1985 and Habib *et al.* 1986).

Exchangeable Ca, exchangeable K and pH of pond bottom soil all had inverse correlations with the pH, free CO_2 nitrate-N, phosphate-P and conductivity of deep tubewell water but only dissolved O_2 of deep tubewell water was directly correlated with all the properties of pond bottom soil. Again, the correlation values between pH of deep tubewell water and chemical porperties of pond bottom soil. viz., pH, organic carbon, total N, phosphate-P, exchangeable Ca and exchangeable K were inversely significant ($p < 0.05$) in nature (Table 3). Though dissolved O_2 and phosphate-P of water had almost direct correlations with pond bottom soil properties (Table 4), only dissolved O_2 showed significant ($p < 0.05$) direct correlation with pH of pond bottom. Similar findings were reported by Habib *et al.* (1986) and Habib and Rahman (1987).

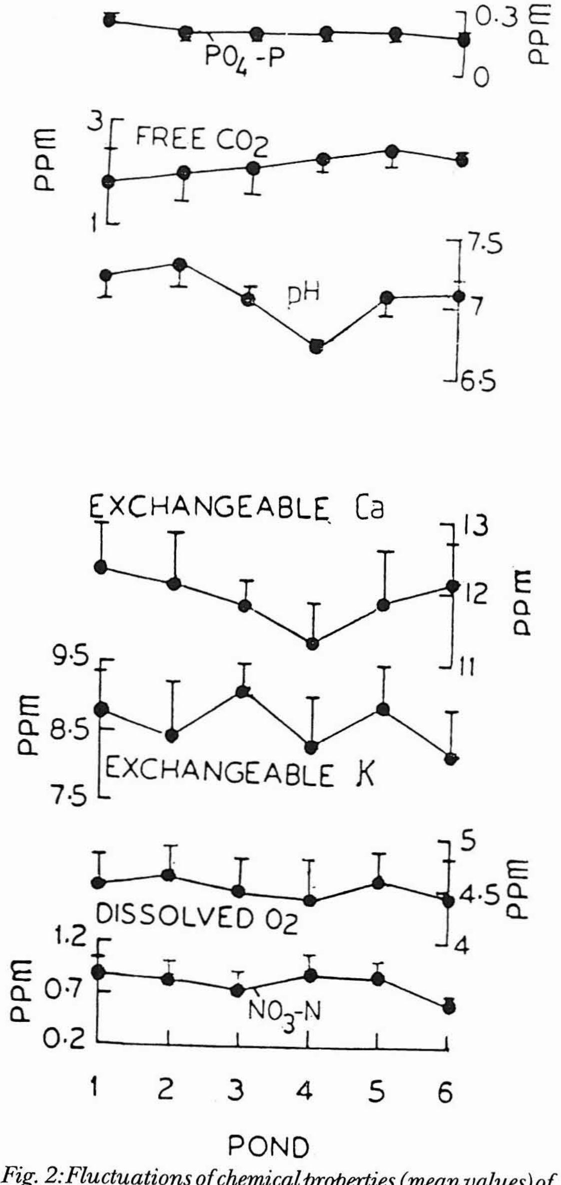

Fig. 2: Fluctuations of chemical properties (mean values) of water of six nursery ponds (vertical bar represents standard error).

CONCLUSION

From the present experiment, it is important to

TABLE 2

Multiple correlation coefficients (R), MR^2, F values and estimated $y(\hat{y})$ of chemical properties of water with chemical properties of pond bottom soil.

Water properties	R	MR^2	F	Estimated y values $(\hat{y})$
pH	0.624	38.94	2.29	$16.124 - 1.383x_1 + 1.825x_2 + 0.228x_3 - 0.215x_4 - 0.008x_5 + 0.657x_6 - 0.432x_7$
Dissolved O_2	0.685	46.92	3.18	$15.690 - 0.464x_1 - 0.096x_2 - 0.651x_3 + 0.114x_4 - 0.003x_5 + 0.231x_6 + 0.440x_7$
Free CO_2	0.769	59.14	5.22	$2.133 - 0.055x_1 - 0.179x_2 - 0.095x_3 - 0.023x_4 - 0.004x_5 + 0.202x_6 - 0.103x_7$
Nitrate-N	0.677	45.83	3.05	$218.07 - 5.215x_1 - 3.906x_2 - 9.436x_3 + 2.187x_4 - 0.069x_5 + 4.108x_6 + 3.646x_7$
Phosphate-P	0.704	49.56	3.53	$227.05 - 37.433x_1\ 123.00x_2 + 13.810x_3 - 15.652x_4 - 0.057x_5 + 6.320x_6 + 4.401x_7$
Exchangeable-Ca	0.777	60.37	5.48	$533.39 - 35.754x_1 + 154.196x_2 - 5.53x_3 - 12.447x_4 - 0.134x_5 + 3.102x_6 + 4.184x_7$
Exchangeable-K	0.404	16.32	0.70	$-129.71 + 4.740x_1 + 34.257x_2 + 11.957x_3 + 1.534x_4 - 0.217x_5 + 6.345x_6 + 7.405x_7$

$^{*}F_{0.05(16,7)} = 4.03$ and $^{**}F_{0.01(16,7)} = 2.66$

TABLE 3

Correlation coefficients between underground water and bottom soil properties in nursery ponds.

Underground water / Soil	pH	Dissolved O_2	Free CO_2	Available N	Available P	Exchangeable Ca	Exchangeable K	Conductivity
pH	–0.494*	0.291	–0.004	–0.125	–0.121	–0.221	–0.123	–0.245
Organic carbon	–0.484**	0.201	–0.003	–0.128	–0.108*	–0.583	0.124	–0.201
Total N	–0.497**	0.121	–0.006	–0.014	–0.241**	–0.662	0.165	–0.211
Phosphate-P	–0.406*	0.190	–0.010	–0.221	–0.292**	–0.548	0.163	–0.300
Exchangeable Ca	–0.412*	0.274	–0.008	–0.142	–0.214	–0.124*	–0.415	–0.049
Exchangeable K	–0.540**	0.383	–0.012	–0.284	–0.232*	–0.430	–0.347	–0.201

df = 22, $^*p < 0.05$, $^{**}p < 0.01$

TABLE 4

Correlation coefficient between the chemical properties of bottom soil and pond water.

Bottom soil / Pond water	pH	Total N	Organic carbon	Available P	Exchangeable Ca	Exchangeable K
pH	–0.003	–0.182	0.102	–0.137	0.036	–0.050
Dissolved O_2	0.474*	0.118	0.042	0.130	0.282	0.308
Free CO_2	–0.243	0.009	–0.089	0.003	–0.318	–0.198
Nitrate-N	0.316	–0.122	0.148	–0.004	0.327	–0.192
Phosphate-P	0.305	–0.033	0.188	0.051	0.264	0.225
Exchangeble-Ca	–0.190	–0.196	–0.132	0.285	0.128	–0.067
Exchangeable-K	–0.115	–0.103	–0.210	–0.230	–0.229	–0.189

df 22 and $^*p < 0.05$

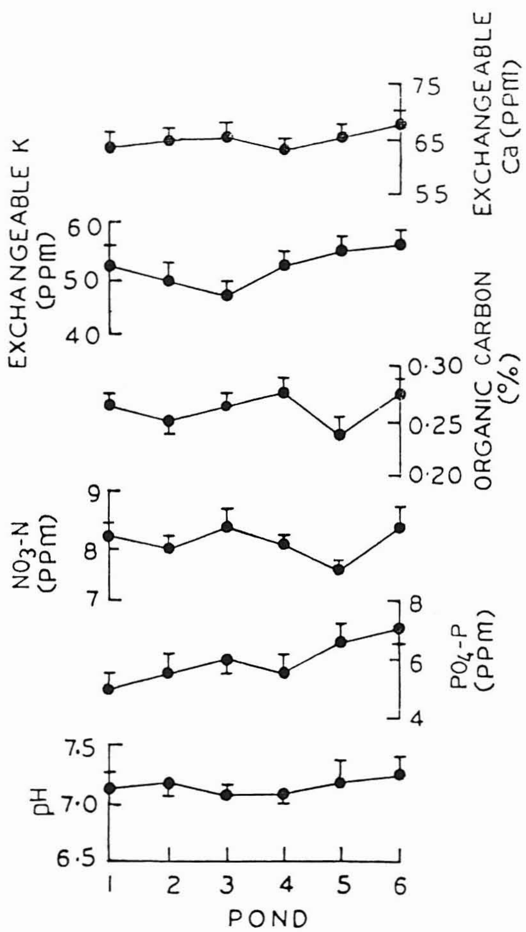

Fig. 3: Fluctuations of chemical properties (mean values) of bottom soil of six nursery ponds (vertical bar represents standard error).

mention that interactions between bottom soil and pond water in the carp nursery ponds play an important role for the availability of nutrients in the water. Underground water supply contributed to the increase of certain nutrients in the pond ecosystem.

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