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Impact of Groundwater Irrigation on the Chemical Characteristics of Soil at Shahzadpur in Bangladesh

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The fate of soil chemical characteristics as a function of ground water irrigation was observed at Shahzadpur Thana under the district of Sirajgonj. The chemical analyses *viz* pH, EC, organic carbon, N, P, K, Ca, Mg, S, Zn, Fe, Cu, Mn, B and Na were performed on 20 irrigated and respective 20 non-irrigated soils. Before irrigation, soil pH was neutral to slightly alkaline. Irrigation did not bring remarkable change on soil pH but increased EC significantly (EC of non-irrigated soil was 2.16-3.34 Scm^{-1} and that of irrigated soil was 2.66-4.34 Scm^{-1}). Potassium, calcium and magnesium contents of soils were also increased significantly by the irrigation whereas, the remaining nutrients were not affected significantly.

Key words: Groundwater, Irrigation, Soil characteristics, Bangladesh.

Introduction

In Bangladesh, most of the surface water sources like rivers and canals become dry during dry season and farmers are left with the only option of groundwater sources to irrigate their cropland. In the study area, about 80% of the arable lands are irrigated by groundwater from shallow and deep tubewells. Irrigation water quality is important for long-term irrigation system because the chemical composition of irrigation water has a profound influence on the relative quantity of cations and anions present in soil (Agarwal *et al* 1982). Irrigation water may dissolve or precipitate some of the soil chemical components. On entering the soil, irrigation water affects the concentration of soil solution and thereby soil properties such as pH, organic carbon, N, P, K, Na and EC are influenced (Cromer *et al* 1984; Kannan and Oblisami 1990). The concentration of Ca, Mg and Na in soils usually increases due to irrigation water containing high sodium adsorption ratio (SAR) and EC. Furthermore, farmers applying groundwater to irrigate their crop fields are always in suspicion about the effects of irrigation water on soil properties. They are doubtful whether groundwater irrigation is gradually improving or deteriorating the soil conditions. Therefore, the present investigation is conducted to study the effect of groundwater irrigation on the chemical characteristics of soils in comparison with rainfed one at farmers' field for efficient management of irrigated agriculture.

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Materials and Methods

Irrigated surface soil (0-15cm) samples were collected from eleven deep tubewell and nine shallow tubewell areas alongwith their respective non-irrigated soils at Shahzadpur Thana under the district of Sirajgonj, Bangladesh. The detailed informations for soil sampling were reported in Table 1. Soil pH was determined electrometrically by 1:2.5 soil water ratio after Jackson (1973). The EC values were determined electrometrically by 1:5 soil water ratio (Kalra and Maynard 1991). Organic carbon was determined after Walkley and Black as described by Ghosh *et al* (1983). The total N of soil was estimated by the modified Kjeldahl method (Anon 1980). Olsen's method was used to estimate available P (Kalra and Maynard 1991). Calcium and magnesium were determined by complexometric titration as outlined by Page *et al* (1982), whereas potassium and sodium were estimated by flame emission spectrophotometer (Ghosh *et al* 1983). Sulphur was determined turbidimetrically after Wolf (1982) and boron was analysed colorimetrically (Allen *et al* 1974). Zinc, iron, copper and manganese were determined by atomic absorption spectrophotometer (McLaren *et al* 1984).

Results and Discussion

Chemical analyses have been reported in Tables 2, 3 and 4. In the study area, both 20 irrigated and respective 20 non-irrigated soils mainly belonged to silty clay loam for 4 sites, clay loam for 24 sites and clay soils for 12 sites, reflecting medium to poor drainage without major change in the soil texture due to irrigation. The pH values of both non-irrigated and irrigated soils varied from 7.1 to 7.8 and 7.2 to 7.9 respectively. Irrigation neither increased nor decreased the soil pH (Pereira and Siqueira 1980; Hamdy 1989). The electrical conductivity of irrigated soils (2.66-4.34 Scm^{-1}) was higher than that of non-irrigated soils (2.16-3.34 Scm^{-1}), probably due to the after effect of irrigation (Pereira and Siqueira 1980; Cromer *et al* 1984). The average organic carbon content of irrigated soil (0.73%) showed marginal or no change over non-irrigated soil (0.72%). Vittum *et al* (1969) reported that irrigation did not show major change in organic carbon content on the silt loam soil. Similar observations were recorded in case of total-N where irrigated (0.14%) and non-irrigated (0.13%) soils indicated marginal or no change (Table 2). Similar observation was also reported by Razzaque (1995). Phosphorus in irrigated soils (10.80 $mgkg^{-1}$) was marginally higher than that of non-irrigated soils (10.15 $mgkg^{-1}$). The availability of soil phosphorus increased after submergence possibly because of the dissolution of calcium phosphate resulting from the accumulation of carbon dioxide (Goswami and Banerjee 1978; De Datta 1981). Applied irrigation water contained small amount of phosphorus (0.04-0.09 mgl^{-1}). The mean values of sulphur content in irrigated (14.70 $mgkg^{-1}$) and non-irrigated (14.50 $mgkg^{-1}$) soils showed no appreciable change. Another possible reason of such condition might be the lower amount of sulphate (0.03-0.07 mel^{-1}) in irrigation water used in the study area. Zaman and Nuruzzaman (1995) stated that impact of long-term irrigation on sulphur concentration of soil was not remarkable.

The average values of Ca, Mg, K, and Na concentrations of irrigated soils were 18.40, 3.45, 0.37 and 0.61 $cmolkg^{-1}$ respectively. On the contrary, the average contents of Ca, Mg, K and Na in non-irrigated soils were 15.15, 2.65, 0.32 and 0.54 $cmolkg^{-1}$ respectively (Table 3, 4). Perhaps, long-term irrigation increased Ca and Mg concentrations significantly in irrigated soils due to the presence of relatively higher amount of Ca (2.00-3.20 mel^{-1}) and Mg (1.10-1.59 mel^{-1}) in irrigation water (Rahman and Zaman 1995). Potassium concentration in the soil solution possibly increased as a result of soil submergence (Islam and Islam 1973) and the concen-

Table 1
Information on sampling sites

Sample No.	Sampling location: Union	Sampling location: Village	Irrigation sources	Depth of sinking (m)	Date of sinking	Duration of irrigation (Year-Month)
1.	Garadaha	Garadaha	DTW	70	30.6.1987	05-04
2.	Rupbati	Bhulbagutia	DTW	56	3.4.1980	12-07
3.	Porzona	Bashuria	DTW	73	1.6.1980	12-05
4.	Porzona	Baoykhola	DTW	58	28.1.1985	07-09
5.	Garadaha	Moshipur	DTW	70	16.6.1984	08-05
6.	Garadaha	Garadaha	DTW	54	30.6.1980	12-00
7.	Kaizory	Jogtola	DTW	76	9.1.1983	09-10
8.	Porzona	Basuria	DTW	66	21.5.1980	12-05
9.	Rupbati	Sotobinadair	DTW	73	16.2.1984	08-09
10.	Shahzadpur	Dariapur	DTW	64	30.11.1976	15-11
11.	Porzona	Nondalalpur	DTW	49	29.3.1980	12-07
12.	Rupbati	Bhulbagutia	STW	32	7.1.1982	10-10
13.	Shahzadpur	Kandapara	STW	37	5.1.1980	12-10
14.	Rupbati	Ahmadpur	STW	26	11.1.1984	08-10
15.	Beltoli	Kadaibadla	STW	29	31.12.1980	11-10
16.	Kayempur	Chitulia	STW	38	29.1.1981	11-09
17.	Potazia	Madia	STW	30	22.1.1983	09-09
18.	Rupbati	Dhunail	STW	31	20.1.1986	06-09
19.	Shahzadpur	Dabaria	STW	27	31.12.1982	09-10
20.	Porzona	Gigarbaria	STW	32	26.1.1986	06-09

DTW, Deep tubewells; STW, Shallow tubewells.
Samples were collected at the end of October, 1992.

Table 2

pH, EC, organic carbon and nitrogen status of both irrigated and respective non-irrigated soils

Sample No.	pH		EC (Scm^{-1})		Organic carbon (%)		Total N (%)	
	NIS	IS	NIS	IS	NIS	IS	NIS	IS
1.	7.8	7.8	3.17	3.17	0.72	0.70	0.14	0.13
2.	7.6	7.8	2.66	3.34	0.84	0.86	0.18	0.20
3.	7.4	7.5	3.17	3.34	0.72	0.72	0.15	0.15
4.	7.7	7.8	3.34	3.40	0.62	0.62	0.10	0.10
5.	7.6	7.7	2.66	3.00	0.60	0.60	0.11	0.11
6.	7.1	7.4	3.17	3.64	0.78	0.80	0.14	0.14
7.	7.4	7.4	2.66	2.66	0.66	0.65	0.10	0.10
8.	7.1	7.4	3.34	3.40	0.81	0.82	0.16	0.17
9.	7.1	7.4	2.16	2.66	0.87	0.87	0.18	0.18
10.	7.6	7.8	3.34	4.10	0.71	0.74	0.14	0.16
11.	7.5	7.8	2.84	4.34	0.64	0.66	0.10	0.13
12.	7.3	7.5	3.00	3.60	0.68	0.70	0.11	0.12
13.	7.5	7.8	2.84	3.34	0.72	0.76	0.13	0.16
14.	7.6	7.7	3.34	3.60	0.69	0.70	0.11	0.12
15.	7.7	7.9	2.66	3.34	0.70	0.72	0.13	0.15
16.	7.4	7.5	2.84	3.17	0.81	0.82	0.16	0.17
17.	7.6	7.7	3.34	3.60	0.63	0.64	0.10	0.12
18.	7.5	7.5	3.34	3.44	0.86	0.85	0.20	0.19
19.	7.1	7.2	3.00	3.17	0.63	0.65	0.10	0.12
20.	7.5	7.6	2.66	2.84	0.72	0.72	0.12	0.12
Range	7.1 to 7.8	7.2 to 7.9	2.16 to 3.34	2.66 to 4.34	0.60 to 0.87	0.60 to 0.87	0.10 to 0.20	0.10 to 0.20
Mean	7.46	7.61	2.98	3.36	0.72	0.73	0.13	0.14
SD	0.22	0.91	0.33	0.41	0.083	0.083	0.031	0.030
CV(%)	2.95	2.50	11.07	12.20	11.53	11.37	23.55	21.43

NIS, Non-irrigated soil; IS, Irrigated soil

Table 3

P, K, Ca, Mg and S concentrations of both Irrigated and respective non-irrigated soils

Sample No.	P ($mgkg^{-1}$)		K ($cmolkg^{-1}$)		Ca($cmolkg^{-1}$)		Mg ($cmolkg^{-1}$)		S ($mgkg^{-1}$)	
	NIS	IS	NIS	IS	NIS	IS	NIS	IS	NIS	IS
1.	9	9	0.35	0.36	19.24	19.04	4.77	4.98	10	10
2.	14	14	0.31	0.35	15.23	18.84	2.19	2.79	10	10
3.	9	9	0.29	0.34	14.03	17.23	2.38	2.98	13	13
4.	13	13	0.32	0.36	18.44	19.44	4.38	4.98	10	10
5.	8	9	0.34	0.37	17.64	19.24	2.56	3.18	13	13
6.	10	11	0.29	0.35	10.02	14.43	3.58	4.77	21	21
7.	14	13	0.28	0.29	14.03	16.83	1.79	2.19	18	18
8.	9	10	0.31	0.36	12.03	15.63	3.38	4.77	20	20
9.	8	9	0.35	0.38	12.83	15.23	1.59	1.99	20	20
10.	13	14	0.32	0.36	19.24	23.05	3.18	4.38	10	11
11.	11	12	0.40	0.44	15.63	20.04	1.79	3.18	13	13
12.	8	9	0.24	0.32	14.83	18.04	2.98	3.58	18	19

(Cont'd......)

(Table 3 cont'd......)

13.	9	11	0.36	0.40	12.03	20.04	1.99	3.98	18	18
14.	10	10	0.32	0.36	19.24	21.04	3.18	3.98	13	13
15.	10	12	0.37	0.44	14.03	19.64	1.99	3.18	10	10
16.	8	9	0.29	0.38	13.64	17.64	2.56	3.38	19	19
17.	12	13	0.35	0.37	19.24	22.04	2.38	2.98	10	11
18.	9	9	0.34	0.38	18.44	20.04	2.79	3.18	13	13
19.	8	9	0.31	0.41	10.02	15.63	1.99	2.79	21	22
20.	11	11	0.32	0.33	13.23	14.83	1.59	1.79	10	10
Range	8 to 14	9 to 14	0.24 to 0.40	0.29 to 0.44	10.02 to 19.24	14.43 to 23.05	1.59 to 4.77	1.79 to 4.98	10 to 21	10 to 22
Mean	10.15	10.80	0.32	0.37	15.15	18.40	2.65	3.45	14.50	14.70
SD	2.06	1.85	0.036	0.036	3.10	2.43	0.89	0.97	4.32	4.35
CV(%)	20.30	17.13	11.25	9.73	20.46	13.21	33.58	28.12	29.79	29.59

NIS, Non-irrigated soil; IS, Irrigated soil.

Table 4

Zn, Fe, Cu, Mn, B and Na concentrations of both irrigated and respective non-irrigatged soils

Sample	Zn ($mgkg^{-1}$)		Fe ($mgkg^{-1}$)		Cu ($mgkg^{-1}$)		Mn ($mgkg^{-1}$)		B ($mgkg^{-1}$)		Na ($cmolkg^{-1}$)	
No.	NIS	IS	NIS	IS	NIS	IS	NIS	IS	NIS	IS	NIS	IS
1.	1.10	1.00	24	25	3.60	3.50	10.50	10.52	0.22	0.22	0.68	0.70
2.	1.10	1.20	25	26	5.10	5.20	12.70	12.90	0.20	0.21	0.64	0.70
3.	1.50	1.50	35	36	6.70	6.70	20.00	21.00	0.22	0.22	0.58	0.64
4.	1.20	1.20	24	25	3.90	3.90	13.20	13.30	0.21	0.21	0.63	0.66
5.	1.00	1.10	27	28	5.00	5.10	12.00	11.90	0.20	0.22	0.67	0.70
6.	2.40	2.40	52	54	9.70	9.70	24.30	24.50	0.57	0.56	0.33	0.40
7.	1.40	1.40	39	38	7.10	7.10	11.80	11.70	0.28	0.28	0.55	0.60
8.	2.20	2.20	50	52	10.10	10.12	27.00	26.80	0.45	0.46	0.31	0.38
9.	2.30	2.40	45	46	10.00	10.10	28.00	27.80	0.45	0.45	0.28	0.40
10.	1.00	1.10	29	32	5.20	5.30	12.90	13.00	0.20	0.22	0.67	0.72
11.	1.20	1.30	33	35	5.80	5.80	17.10	17.50	0.21	0.24	0.53	0.65
12.	1.80	2.00	42	45	8.40	8.60	22.00	22.10	0.30	0.32	0.46	0.60
13.	1.30	1.20	34	36	6.10	6.20	14.40	14.50	0.22	0.24	0.64	0.68
14.	1.10	1.00	25	26	5.10	5.10	12.00	12.20	0.20	0.20	0.43	0.53
15.	1.00	1.10	24	28	4.00	4.20	11.10	12.00	0.22	0.24	0.67	0.70
16.	1.40	1.50	37	38	7.00	7.10	20.50	20.80	0.30	0.31	0.56	0.64
17.	1.20	1.30	30	34	4.70	4.80	10.00	10.10	0.22	0.22	0.58	0.67
18.	1.10	1.00	32	32	5.80	5.70	14.30	14.20	0.20	0.18	0.63	0.66
19.	2.40	2.40	54	56	10.20	10.15	26.20	26.70	0.50	0.52	0.36	0.56
20.	1.30	1.40	31	32	6.30	6.40	14.00	14.10	0.26	0.28	0.64	0.66
Range	1.00 to 2.40	1.00 to 2.40	24 to 54	25 to 56	3.60 to 10.20	3.50 to 10.15	10.00 to 28.00	10.10 to 27.80	0.20 to 0.57	0.18 to 0.56	0.28 to 0.68	0.38 to 0.72
Mean	1.45	1.49	34.60	36.20	6.49	6.54	16.70	16.88	0.28	0.29	0.54	0.61
SD	0.49	0.50	9.62	9.71	2.14	2.14	5.98	5.98	0.12	0.11	0.13	0.11
CV(%)	33.79	33.56	27.80	26.82	32.97	32.72	35.81	35.43	42.86	37.93	24.07	18.03

NIS , Non-irrigated soil; IS, Irrigated soil.

Table 5
Paired t-test of irrigated and non-irrigated soils

Soil chemical parameters	Calculated t-value
Nitrogen	0.939NS
Phosphorus	1.05NS
Potassium	3.86**
Calcium	3.69**
Magnesium	2.73*
Sodium	1.87NS
Sulphur	0.146NS
Zinc	0.224NS
Iron	0.523NS
Copper	0.071NS
Manganese	0.095NS
Boron	0.276NS
EC	3.20**
Organic carbon	0.370NS

** Significant at 1%; *Significant at 5%; NS, Not significant [Tabulated t-values at 0.05 (5%) = 2.093, at 0.01 (1%) = 2.861.]

tration of K in respective irrigation water was comparatively lower (0.02-0.38 mel^{-1}). These findings were in agreement with that of Cromer *et al* (1984) and Hamdy(1989). The concentrations of Fe, Mn, Cu, Zn and B of both irrigated and non-irrigated soils reflected no remarkable change because, irrigation water normally contained little amount of micronutrients (Fe = 0.24-0.40 mgl^{-1}; Mn = 0.034-0.062 mgl^{-1}; Cu = 0.031-0.061mgl^{-1}; Zn = 0.028-0.045 mgl^{-1} and B = 0.20-0.42 mgl^{-1}) and could hardly bring considerable change in soil micronutrient economy. Similar findings were also reported by Meshref *et al* (1989) and Zaman and Nuruzzaman (1994). In some cases, long-term irrigation marginally increased iron contents of soils possibly due to the kinetics of electrochemical changes during soil submergence (Ponnamperuma 1972).

Paired t-test comparison indicated that K, Ca, and Mg concentrations of irrigated soils were higher and differed significantly (P = 0.05 and P = 0.01) from non-irrigated soils, probably due to the presence of considerable amount of these cations in irrigation waters (Table 5). For this reason, EC value of irrigated soils was also higher and also differed significantly (P = 0.05 and P = 0.01) than non-irrigated soils. On the other hand, N, P, Na, S, organic carbon and some micronutrients like Fe, Mn, Cu, Zn and B failed to reach the level of significance as compared with non-irrigated soils.

Conclusion

In the investigated area, long-term irrigation helped to build-up the concentration of K, Ca, and Mg in irrigated soils leading to an increasing tendency of EC. On the contrary, the concentration of N, P, S and micronutrients like Zn, Fe, Cu, Mn and B reflected marginal or no change after irrigation. Finally, it may be concluded that irrigation did not pose remarkable impact on the available nutrient status of the soil in the study area. But in the long run, fertility status of the soils may be affected by the long-term use of groundwater for irrigation.

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