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Effect of irrigation water on physico-chemical properties of soil as influenced by sea water intrusion

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Abstract: A study was undertaken to find out the quality of irrigation water as influenced by sea water intrusion on physico chemical properties of soil. A significant positive correlation was observed between pH of the irrigation water and surface soils and also between the EC of irrigation water with EC of soil water suspension, saturated soil water extract (SWE) of irrigated surface soil. The chloride, sulphate, bicarbonate and sodium content of irrigation water were found to be positively associated with water soluble chloride, sulphate, bicarbonate and sodium content of the irrigated surface soil. The total soluble salts of irrigation water were closely related with EC of SWE, soil suspension and also the sodium adsorption ratio (SAR) of irrigation water with SAR of the SWE, in all the samples analysed suggesting a evidence for the intrusion of sea water into the fresh ground water aquifers of coastal region.
(Key words: Irrigation water, Sea water intrusion, Physico chemical properties, water quality).

The ground water aquifers situated along the shoreline have hydraulic contact with sea. Normally the fresh water from land is moving into the sea, when the balance is disturbed by over exploitation and if the rate of extraction exceeds critical value depending upon the hydrology of the aquifers, the seaward flow of water completely ceases and reversal of flow sets in. Due to this intrusion, salinity levels of out flow from the wells shoot up. The well water quality deteriorates beyond the tolerance limits to crops. In Tamil Nadu, problem of salinity exist both in coastal areas and inlands. The soils of coastal areas offer many problems like salinisation, water logging, clay pan formation and sea water inundation. The salt affected soils occurs in extensive areas all along the East Coast from Chengalpet, South Arcot, Nagapattinarn, Thanjavur, Pudukkottai, Ramanathapuram, Thirunelveli and Kanyakumari districts. It has been estimated that about one lakh ha. in the coastal belt suffers due to salinity hazards. The low lying areas along the East Coast of Ramanathapurarn district are either saline or sodic. The present investigation has been formulated with a view to make a systematic analysis on influence of sea water intrusion on soil physico chemical properties in the coastal belt of Ramanathapuram district.

Materials and Methods

The investigation has been carried out in the coastal belt of Ramanathapuram district. Places have been marked from the coast to the inland at various distances for the collection of water samples. Existing open well in the places marked had been utilised for the collection of water samples. From each place about 1 kg of soil samples had been collected for the laboratory analysis. The water table in the study area and the distances from the sea had been recorded. The soil had been analysed for their soil reaction (pH), Electrical conductivity (EC), total soluble salt (TSS). Individual anions *viz.* Carbonate, Biocorbonate, Chloride, Sulphate and cations *viz.* Calcium, Magnesium, Potassium and Sodium by standard methods.

Results and Discussion

Effect on Electro chemical properties

The pH of the soils in the study area ranged from 7.2 to 9.1 with mean value of 8.2. The pH of soil water extract (SVTE) varied from 7.0 to 8.9 with mean value of 8.2. There was a close association between pH of irrigation water (iw) and pH of the irrigated surface soils ($r = 0.402^{**}$) and pH of SWE of the irrigated surface soils ($r=0.621^{**}$). The use of irrigation water with high sodium (17 per cent SSP) in these soils increased the pH as revealed by the significant positive correlation between the pH of irrigation water and the pH of irrigated surface soils. ($r=0.421^{**}$). Similar results were earlier reported by Paliwal and Gandhi (1973). The pH of the

Table 1. Chemical properties of the irrigated surface soils as influenced by sea water intrusion.

Name of the place	Distance from sea (km)	Water table (m)	Soil		Soil water Extract		Soil Anions (Cmol(P$^+$) Kg^{-1})					Soil Cations (Cmol(P$^+$) Kg^{-1})				
			EC	pH	pH	EC	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Sum of anions	Ca^{2+}	Mg^{2+}	K^+	Na^+	Sum of cations
1. Devipattinam	1.C	10.0	0.7	7.5	8.3	0.6	Trace	1.25	2.0	0.10	3.35	0.6	0.2	0.07	0.36	1.23
2. Athiyoothu	1.0	2.0	0.4	8.1	8.1	0.3	Trace	0.75	0.5	0.06	1.31	0.5	0.4	0.03	0.13	1.06
3. Keelakkarai	1.0	11.0	3.6	7.8	7.5	3.3	0.5	1.75	25.0	0.15	27.40	5.8	6.0	6.0	5.25	17.47
4. Neelamadai	1.5	2.0	0.2	8.3	8.3	0,.2	Trace	1.0	0.5	0.03	1.53	0.8	0.8	0.02	0.09	1.71
5. Erwadi	1.5	2.0	1.8	7.8	7.7	1.4	0.5	1.5	8.0	0.11	9.61	3.1	3.5	0.16	3.8	10.56
6. Mangammal salai	2.0	1.0	0.4	8.2	8,6	0.3	Trace	1.0	0.5	0.12	1.62	0.5	0.7	0.02	0.07	1.29
7. Tiruppullani	3.0	10.0	3.2	7.8	7.9	2.9	Trace	1.50	24.0	0.13	25.63	4.7	4.9	0.39	4.72	14.71
8. Pathratharavai	3.0	5.0	2.2	8.2	8.2	1.9	Trace	0.75	12.0	0.10	12.85	2.0	2.4	0.27	0.85	5.52
9. Vannangundu	4.0	2.0	3.2	8.0	7.6	2.7	Trace	1.75	21.0	0.12	22.87	3.1	3.4	0.31	3.92	10.73
10. Kanjan Kudi	5.0	22.0	3.6	8.1	7.5	3.1	0.5	1.75	21.0	0.15	22.90	6.2	5.8	0.37	6.20	18.57
11. Ethampadal	6.0	10.0	0.3	7.8	8.7	0.2	Trace	0.	0.5	0.02	1.02	0.3	0.5	0.05	0.09	0.94
12. Palanivalasai	7.0	1.0	0.2	8.5	8.6	0.2	Trace	0.75	0.25	0.10	1.10	0.5	0.4	0.02	0.03	0.95
13. Sumaithangi	8.0	8.0	0.3	7.7	8.7	0.3	0.5	1.0	0.5	0.12	1.62	0.,1	0.7	0.03	0.13	0.96
14. Kuttanendal	10.0	8.0	0.3	8.2	8.9	0.2	Trace	0.75	0.5	0.006	1.26	0.1	0.7	0.02	0.09	0.91
15. Sembadachi	10.0	15.0	0.5	9.1	8.7	0.3	Trace	1.25	0.5	0.78	2.53	0.1	0.5	0.03	0.19	0.82
16. Karumal	10.0	22.0	1.4	8.2	8.0	0.9	0.5	1.5	2.5	0.43	4.43	0.3	0.5	0.07	0.13	1.00
17. Notchivayal	10.0	25.0	0.8	8.2	8.2	0.6	Trace	0.50	23.0	0.04	2.54	0.7	0.6	0.06	0.37	1.73
18. Shanmuganathapuram	10.0	7.0	1.4	8.7	8.6	1.0	Trace	0.75	1.5	0.05	2.30	1.4	1.6	0.18	0.61	3.79
19. R.S.Mangalam	11.0	20.0	0.3	8.1	8.3	0.2	Trace	0.5	0.5	0.02	1.02	0.3	0,.4	0.02	0.31	1.03
20. Chinnakeeramangalam	11.0	10.0	1.1	8.5	8.5	0.7	Trace	0.50	1.5	0.04	2.04	0.8	1.2	0.07	0.69	1.76
21. Sathankulam	12.0	10.0	2.1	8.3	8.3	1.7	Trace	1.25	6.0	0.09	7.34	1.9	2.2	0.28	3.16	7.54
22. Paranoor	12.0	10.0	1.2	8.1	8.1	1.0	Trace	0.58	2.5	0.05	3.05	1.2	1.5	0.18	0.43	3.31
23. Sethukkarai	14.0	2.5	0.9	8.2	8.0	0.7	Trace	0.50	2.0	0.05	2.55	0.9	1.2	0.07	0.51	2.68
24. Kavanoor	15.0	12.0	0.3	8.7	8.3	0.2	Trace	1.0	0.5	0.08	1.58	0.4	0.9	0.03	0.43	1.76
25. Kavanoor	15.0	12.0	1.2	7.9	7.9	0.9	Trace	0,.25	2.5	0.07	2.82	1.1	1.3	0.08	0.47	2.95
26. Keelakkottai	15.0	11.0	2.5	8.8	8.8	1.9	Trace	1.0	7.0	0.11	8.11	2.1	2.5	0.29	0.92	5.81
27. Kulathoor	16.0	10.0	0.3	8.3	8.5	0.2	Trace	1.25	0.5	0.07	1.82	0.5	0.4	0.05	0.15	1.10
28. Keelakkottai	16.0	15.0	1.7	8.5	8.7	1.4	Trace	0.75	2.0	0.09	2.84	1.6	1.7	0.19	0.47	3.96
29. Terinuveli	17.5	10.0	0.4	8.3	8.2	0.3	Trace	0.5	0.5	0.02	1.02	00.4	0.5	0.03	0.40	1.33
30. Thethangal	18.0	7.0	0.6	8.8	8.2	0.5	Trace	0.75	1.0	0.06	1.81	0.6	1.2	0.03	0.15	1.98

Table 1. (*Contd...*)

31. Pandielugai	20.0	21.0	0.3	8.3	8.4	0.3	Trace	1.25	0.5	0.12	1.87	0.7	0.3	0.03	0.09	1.12
32. Mallal	20.0	17.0	2.8	8.3	8.1	2.4	0.5	1.5	21.5	0.10	23.60	3.6	3.8	3.8	4.13	11.87
33. Atchuthanvayal	21.5	5.0	1.7	8.1	8.1	1.4	Trace	0.75	4.0	0.08	4.83	0.9	1.0	0.18	2.80	4.88
34. Chinnakaramesi	22.0	25.0	0.6	8.3	8.3	0.4	Trace	1.00	0.5	0.12	1.62	0.1	0.9	0.06	0.13	1.19
35. Puliyangudi	22.0	30.0	0.2	7.5	8.6	0.2	Trace	0.75	0.5	0.08	1.33	0.3	0.4	0.02	0.43	1.15
36. Nainar Koil	23.0	11.0	0.9	8.0	8.3	0.5	Trace	0.75	1.5	0.08	2.33	0.2	0.6	0.04	0.28	1.12
37. Udayar Kudiyiruppu	25.0	26.0	6.8	7.9	7.6	3.8	Trace	1.00	23.3	0.08	24.33	5.8	5.6	0.47	4.9	16.77
38. Nedunguruchi	25.0	11.0	0.5	8.9	8.3	1.0	Trace	2.5	0.5	0.08	3.08	0.8	0.9	0.09	0.47	2.26
39. Tinaikulam	26.0	7.0	2.1	7.5	7.0	1.7	Trace	1.50	5.0	0.09	2.09	1.2	1.5	0.27	0.72	3.69
40. Vanniyavannam	27.0	10.0	1.6	7.6	8.5	1.0	Trace	0.5	4.0	0.05	4.55	0.5	1.5	0.03	0.43	2.46
41. Veerammal Thottam	27.0	8.0	1.0	8.2	8.2	0.7	0.5	0.5	2.5	0.04	3.04	0.7	0.8	0.03	0.35	1.88
42. Kunappanendal	27.5	12.0	0.4	8.4	8.5	0.4	Trace	2.0	1.0	0.03	2.03	0.7	0.5	0.30	0.43	1.93
43. Tiruvarangam	30.0	13.0	1.6	7.8	7.7	1.2	Trace	0.75	2.5	0.07	3.32	0.6	0.8	0.21	0.53	2.14
44. Emaneswaram	35.0	20.0	0.4	8.3	8.4	0.3	0.5	1.25	0.5	0.03	2.28	0.4	0.7	0.22	0.31	1.63
45. Mean			1.31	8.17	8.22	1.03	0.5	1.02	4.92	0.110	1.34	1.49	1.54	0.33	1.58	4.17

soil and water are interrelated and correlated with CO_3^- and HCO_3^- content of soil. These ions in the irrigation water when continuously used, could cause a increase in the. soil pH. The EC of irrigation water and irrigated soils varied from 0.22 to 6.8 dSm^{-1} with mean value of 1.2 dSm^{-1}. The EC of SWE varied from 0.1 to 3.8 dSm^{-1} with mean value of 0.95 dSm^{-1}. Similar trend was also observed between the EC irrigation water and of SWE (r=0.438**). The degree of correlation between EC of irrigation water and soil water suspension (r = 0.404**) and EC of irrigation water and of SWE of irrigated surface soil (r=0.350**) was highly significant. The salt accumulation in soil was closely related to the salt concentration of irrigation water. A close relationship between the salt content of the soil and irrigation water was reported by Vyas *et al.* (1982). Highly significant correlations were observed between TSS of irrigation water and EC of irrigated surface soils (r=0.396**), and EC of SWE of the irrigated surface soil (r=0.414**). This shows that there is a possibility for build up of salinity in the irrigated soils (Marain *et al.* 1977).

Effect on anionic concentration

Traces of carbonate were found in SWE irrigated soils and also in irrigation water. Hence, there is no possibility for the accumulation of carbonate in the irrigated soils. The bicarbonate concentration SWE was ranged from 0.25 to 2.50 Cmol(p+) Kg^{-1} with mean value of 0.99 Cmol(p+) Kg^{-1}. Significant positive correlation was noticed between bicarbonate of irrigation water and SWE (r=0.224**). It shows that there is a possibility for HCO_3^- build up in the irrigated soils due to continuous use of ground water with high salt content. The chloride content of SWE varied from 0.25 to 26.5 Cmol(p+) Kg^{-1} with mean value of 4.68 Cmol(p+)Kg^{-1}. The Cl^- content of irrigation water and of irrigated surface soils were closely associated (r=0.434**). The Cl^- accumulation in soil was closely related to Cl^- concentration of irrigation water (Gopalachari *et al.* 1968). The SO_4^{--} content of SWE varied from 0.006 to 0.78 Cmol(p+) Kg^{-1} with mean value of 0.12 Cmol(p+) Kg^{-1}. Significant correlation was observed between SO_4^- content of irrigation water and that of irrigated

surface soils (r=0.334**). It shows that there is a possibility for SO_4^- build up in irrigated soils due to continuous use of ground water with high salt content.

Effect on cationic concentration

The water soluble Ca^{2+} content of irrigated soils varied from 0.1 to 6.8 Cmol(p+) Kg^{-1} with mean value of 1.25 Cmol(p+) Kg^{-1}. The accumulation of Ca^{2+} in the irrigated soils might be due to the fact that the Ca^{2+} along with different anions in the irrigation water on reaching the soil surface would have been precipitated as Ca $(HCO_3)_2$ first, then as $CaCO_3$, due to the presence of bicarbonate in the irrigation water. The water soluble Mg^{2+} content of irrigated soils g varied from 0.2 to 6.4 Cmol(p+) Kg^{-1} with mean value of 1.44 Cmol(P+) Kg^{-1}. There was no correlation between the Mg content of irrigation water and that of SWE. The mean K^+ content of irrigated surface soil is 0.31 Cmol(p+) Kg^{-1} and varied between 0.02 to 6.40 Cmol(p+) Kg^{-1} and correlation was found non-significant. The water soluble Na^+ content of the soil varied from 0.03 to 6.43 Cmol(p+) Kg^{-1} with a mean value of 1.12 Cmol(p+) Kg^{-1}. The sodium content of irrigation water and the irrigated surface soils were closely associated and the degree of correlation was highly significant (r=0.520**). This might be due to the presence of sodium in the irrigation water. A continuous irrigation with saline water with the normal soil increased the salt concentration and exchangeable Na^+ in the soil and it was more so in the 0-15 cm soil depth (Sharma *et al.* 1981).

Effect on quality parameters

The relationship between the RSC of irrigation water and the water soluble sodium content of surface soils was negative. A significant correlation was noticed between the SAR of irrigation water and SWE of irrigated surface soils (r=0.213**). The negative relationship was also noticed between the RSC of irrigation water and the SAR of SWE of irrigated surface soils (Kanwar & Kanwar 1971). The positive correlation might be due to the loss of calcium and magnesium from soil solution either by precipitation or by adsorption. The possibility of precipitation reaction was relatively lower than that of adsorption, as majority of the irrigation water samples of the present study recorded a negative RSC values. There observed no correlation between SAR and ESP of coarse textured soil. However with increase in finess of soil texture, the ESP also increased simultaneously. There was no positive correlation between the potential salinity of irrigation water and EC of SWE.

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