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RELATIONSHIP BETWEEN ELECTRICAL CONDUCTIVITY AND TOTAL DISSOLVED SALTS DETERMINED GRAVIMETRICALLY

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Fifty tubewell (deep) and forty four hand pump (shallow) water samples from Faisalabad District were anlysed for electrical conductivity, total dissolved salts and soluble cations and anions. Electrical conductivity of 44 per cent of the tubewell and 6.8 per cent of the hand pump waters was less than 0.750 dSm^{-1} (had low salinity hazard), and could be used for irrigation without special management practices. Sodium adsorption ratio of 76 per cent of the tubewell and 36 per cent of the hand pump waters was less than 10 and had low sodium hazard. Precipitation index was positive for all water samples indicating that calcium carbonate will tend to precipitate from soil solution and increase the Na/(Ca + Mg) ratio.

Out of 50 tubewell and 44 hand pump water samples studied, 74 per cent of the tubewell and 90.9 per cent of the hand pump waters had conversion factor from electrical conductivity d Sm^{-1} to parts per million between 650 and 775, the average of these water samples being 709 and 712, respectively. The average factor for converting the electrieal conductivity in dSm^{-1} to parts per million of the soluble salts for 82% of the water samples studied came to 710.

INTRODUCTION

Quality of irrigation water is an extremely important factor for planning a permanent irrigation project. The total dissolved salts, the main criterion used for determining the salinity class of water, were previously estimated by gravimetric methods which are time consuming and laborious:

Electrical conductivity measurements to assess total soluble salts being simple, rapid and precise, has become popular. The electrical conductivity depends among other factors, on the nature, composition and concentration of salts and therefore, may vary from place to place because of variation in the composition of salts. Similarly, the factors for converting the electrical conductivity readings in dSm^{-1} to concentration in parts per million of salts will vary depending upon the nature and composition of salts. At present, an average conversion factor of 640 worked out by U. S. Salinity Laboratory Staff (1954) and Thorne and peterson (1954) is being used in Pakistan.

According to Moodie *et al.* (1959), approximate parts per million of salts in a soil saturation extract can be obtained by multiplying the electrical conductivity of the saturation extract in mmhos/cm by 700. Pratt *et al.* (1960) found that fraction of applied bicarbonates that precipitated in the soil to be highly related to the modified Langelier (1936) saturation index, Bower *et al.* (1965) and Bower and Wilcox (1965a) reported that when waters having appreciable concentrations of bicarbonates are applied to soil, a variable fraction of this constituent precipitates in the soil as calcium carbonate according to the equation :

$$Ca^{++} + 2HCO_3^{-} \longrightarrow CaCO_3 + H_2O + CO_2$$

As a result of the precipitation of calcium carbonate from irrigation water a decrease in the salt burden of irrigation system but an increase in the Na : (Ca + Mg) ratio of soil solutioon and on soil exchange complex will occur. The present study was undertaken to determine the factor for converting the electrical conductivity readings to parts per million under the conditions existing in Pakistan with special reference to those in the Faisalabad District.

MATERIALS AND METHODS

The research work reported in this paper was carried out in the research Laboratories of the Department of Soil Science, University of Agriculture, Faisalabad during 1968-69. Fifty water samples were collected either from running tubewells or after running the tubewells for about two hours, and forty four hand pump water samples collected after running the pumps for about ten minutes. These samples were analysed for dissolved salts using the following methods :-

pH (method 21a), sodium (method 80b), potassium (method 81c), sulphate (method 83) and total dissolved salts (method 74) were determined as described by U. S. Salinity Laboratory Staff (1954). Electrical conductivity (method 62-2.2), calcium and magnesium (62-3.2.2), carbonates, bicarbonates (method 62-3. 4.2) and chlorides (method 62-3. 5.2) were determined according to the methods of Bower and Wilcox (1965b). Corrections were made for the losses of carbon dioxide and water from bicarbonates when the salts were oven dried in the gravimetric method. Correlations were worked out between electrical conductivity and total dissolved salts. By following the technique of Bower and Wilcox (1965a), precipiation indices were calculated for all the water samples.

RESULTS AND DISCUSSION

Electrical conductivity is a function of concentration, degree of ionization and mobility of ions in a solution. The degree of ionization generally decreases with increasing concentration because of the increased inter-ionic attraction.

Electrical conductivity of 50 tubewell water samples varied from 0.283 to 5.315 dS m^{-1} (44 percent had values from 0.250 to 0.750, 36 percent from 0.750 to 2.250 and 20 percent greater than 2.250 dS m^{-1}) and that of hand pump water samples varied from 0.457 to 7.286 dS m^{-1} (6.8 percent had values from 0.250 to 0.750, 36.4 percent from 0.750 to 2.250 and 56.8 percent greater than 2.250 dS m^{-1}, respectively) (Table 1). If recommendations of U. S. Salinity Laboratory Staff (1954) and Thorne and Peterson (1954) were followed, 44 percent of the tubewell water and 6.8 percent of the hand pump waters would be classified as having low salinity hazard and could be used for irrigation without any special management practices. Thirty six percent of the tubewell and 36.4 percent of hand pump waters were classified as high salinity hazard waters requiring special management practices for profitable and permanent irrigated agriculture. The rest of the tubewell and hand pump waters could be used after mixing with good quality water depending upon soil and plant characteristics, and management practices to be adopted.

Electrical conductively of waters bore significant correlation with total dissolved salts and the value of 'r' was + 0.994 for tubewell waters (Fig-I). Similarly, for handpump water $r = 0.992$ and $y = 714.9\,x - 3.46$ were calculated where x was EC in dS-m^{-1}.

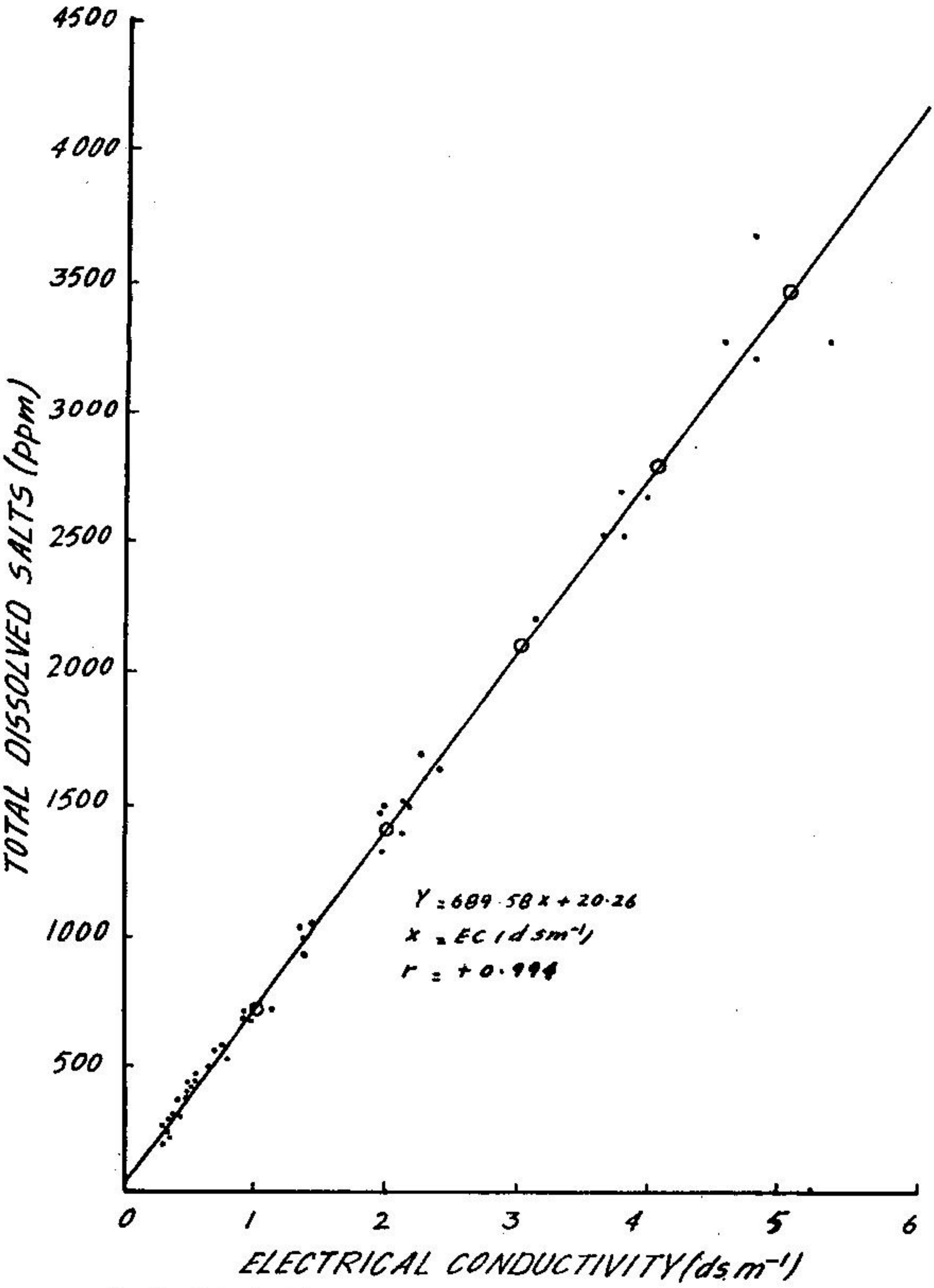

Fig. 1. Relationship between electrical conductivity (dS m^{-1} and total dissolved salt parts per million) of tubewell waters.

Sodium Adsorption Ratio (SAR) :

Sodium adsorption ratio seems a better indicator of sodium hazard of water than soluble sodium percentage. According to U. S. Salinity Laboratory Staff (1954) the SAR is calculated by the following equation, which is a modification of Gapon equation (1933).

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

where the concentration of soluble cations is expressed in mel^{-1}. As it is clear from (Table I) 76 per cent of the tubewell and 36 per cent of the hand pump waters had less than 10 SAR (low sodium hazard) and can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. Twenty four per cent of the tubewell and 64 per cent of the hand pump waters were expected to have medium to high sodium hazard, depending upon the electrical conductivity, and may present appreciable sodium hazard in fine textured soils with high cation exchange capacity. The waters with high SAR values may produce harmful levels of exchangeable sodium in most of the soils (U. S. Salinity Laboratory Staff, 1954), resulting in very low or no productivity.

Precipitation Index :

At equilibrium there will be a tendency for calcium and magnesium to precipitate from all the tubewell and hand pump waters when applied to the soil as the precipitation index was positive for all water samples (Table 1). Pratt *et al.* (1960) and Bower *et al.* (1965) reported that the precipitation index was useful for predicting the possible precipitation of $CaCO_3$ from soil solutions. As a result of precipitation of $CaCO_3$ (Bower and Wilcox, 1965a) there will be a decrease in the salt burden of irrigation system but an increase in the Na : (Ca + Mg) ratio of the soil solution and on the soil exchange complex.

Relationship between Electrical Conductivity and Total Dissolved Salts :

The factor for converting the electrical conductivity readings in $d\,Sm^{-1}$ to parts per million for 50 tubewell water samples varied from 617 to 788. For 74 per cent of the samples factor lied within the range of 650 to 775 (Table 1) and the average (for 74% samples) being 709.

Table I : Frequency distribution of ground waters under *various estimations*

Estimations	Class Intervals	Tubewells (50 samples)		Hand pums (44 samples)	
		Freq-uencies	%freq uency	Freq-uencies	%freq-uency
Electrical	0.0 —0.25	0	0	0	0.0
conductively	0.25—0.75	22	44	3	6.8
(EC dS m^{-1})	0.75—2.25	18	36	16	36.4
	>2.25	10	20	25	56.8
Sodium adsorption	0—8	34	68	15	34
ratio (SAR)	8—10	4	8	1	2
	> 10	12	24	28	64
Relationship	600—635	1	2	2	4.5
between EC (dS m^{-1})	625—650	4	8	1	2.3
and TDS (ppm) i. e.	650—675	9	18	6	13.6
TDS/EC	675—700	7	14	6	13.6
	700—725	9	18	13	29.6
	725—750	6	12	2	4.5
	750—775	6	12	13	29.6
	>775	8	16	1	2.3
Total dissolved	0—500	20	40	3	6.8
salts (ppm).	500—1000	11	22	6	13.6
	1000—1500	8	16	10	22.7
	1500—2000	2	4	2	4.6
	>2000	9	18	23	52.3
Precipitation	0.0—0.5	4	8	0	0.0
index	0.5—1.0	24	48	9	20.5
	1.0—1.5	16	32	18	40.9
	>1.5	6	12	17	38.6

The factor for 44 hand pump water samples varied from 616 to 787. The factor for 90.9 percent of the samples lied within the range of 650 to 775 (Table 1) with average (for 90.9% samples) of 712.

The averege conversion factor for 77 tubewell and hand pump water samples studied (82% of total samples) came to be 710. From these results it is clear that there was a minor difference in the conversion factor inspite of the fact that the tube well and hand pump water samples were taken from different depths of soils. U. S. Salinity Laboratory Staff (1954) and Thorne and Peterson (1954) reported 640 as the average factor for converting the conductivity readings in mmhos/cm (d Sm^{-1}) to parts per million as against the results obtained in this study. This difference may be due to the variations in the amount and proportion of the dissolved salts in the water samples studied. Modie *et al.* (1959) reported 700 as the average factor for converting the electrical conductivity readings in mmhos/cm to parts per million of salts and this factor is very close to the one found in this study.

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