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ESTIMATION OF IONIC STRENGTH FROM ELECTRICAL CONDUCTIVITY OF PUNJAB GROUND WATERS

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Water samples from 36 hand pumps (13-20 m deep) and 76 tube wells (30-40 m deep) were collected from Daska. Faisalabad and Multan Tehsils during 1998 and 1999. These samples were analysed for EC, soluble ions. and then total soluble salts. sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and the ionic strength (I) were computed. The EC. SAR. RSC and I ranged from 0.24 to 5.97 dS m', 0.86 to 22.08 (mmoVL)II2.0.0 to 6.4 mmol.L" andO.Om to 0.083 mol L-Jrespectively. Regression model "I=O.00049 + 0.0 129EC" was computed with correlation coefficient (r) value ofO. 997**. It is concluded that 1==0.013EC can safely be followed for estimating the I from ground water EC in the Punjab. Pakistan.
Key words: ground water, ionic strength. regression. SAR prediction

INTRODUcnON

The electrical conductivity (EC). sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) are the established parameters for assessing the suitability of irrigation waters. The SAR is a measure of sodicity hazard, for calculation of which Ca^{2+} and Mg^{2+} are conventionally treated together but there are no chemical grounds to do so except divalent nature of both the cations. The behaviour of Ca^{2+} in soils is altogether different from that of Mg^{2+}. Hence in many recent models/equations to estimate the soil SAR from SAR_{iw} (Suarez, 1981: Ayers and Westcot, 1984: Jurinak. 1990). Ca^{2+} has been separated from Mg^{2+} and a term 'effective concentration' of Ca (Ca_X) has been introduced in these models. The CaX is estimated from the ratio of HCO_3 : Ca^{2+} and ionic strength (Suarez, 1981) or ECi~ (Aycrs and Westcot, 1984). The ionic strength (I) is a measure of the intensity of the electrical field of an electrolyte in solution. Accurate means of estimating I from easily measured EC is of great value in both practical and theoretical consideration of the thermodynamic models. In Pakistan. about 70-75% of the 46 MAF ground water pumped is hazardous with respect to EC. SAR and/or RSC (Ahmad. 1993). It is essential to assess the impact of ground waters used for irrigation on the physical and chemical properties of soils and crops. especially the sodicity hazard. It has been found that the models of Suarez (1981), Ayers and Westcot (1984) and Jurinak (1990) gave better predictions. of SAR_{iw} impacts on soil SAR (SAR_{dw}) under field conditions (Ghafoor, 1997). For these models, Ca_X has to be determined for which ionic strength is required. To facilitate such computation. this paper evaluates the determination of ionic strength from EC_{iw}.

MATERIAL AND METHODS

The water samples, 112 in number were collected from 36 hand pumps and 76 tube wells from Daska. Faisalabad and Multan Tehsils of the Punjab (Pakistan) during 1998 and 1999. The pumping depths of tube wells were 30-40 m and those of hand pumps were 13-20 m. Samples were collected in plastic bottles after running the hand pumps/tube wells for 15 to 20 minutes. These bottles were labeled according to their locations. All the samples were analyzed for EC (Jenway EC meter. model 4(70). CO_3)2'.HCO_3)'. CL $Ca^{2+}$and Mg2+by titration against standard solutions of H_2S0_4. AgNO) and EDTA respectively while Na" and K+were determined with the help of flame photometer (Jenway PFP-7) and then TSS. SAR and RSC were computed according to the US Salinity Lab. Staff (1'.>:'4). From t111~ analysis, ionic strength for each sample was computed following the formula described by Bohn et al. (I'.>X:'i)i.c.

$$1=1/2\sim(C\ IZI2+C\sim22+\text{"""""""}+CnZJ$$

Parameters like EC., SAR RSC and I were computed for range. mean and standard deviation, scparntcty for tube wells and hand pumps of each Tehsil, and combined analysis was also done. In addition. simple regression and correlation between EC and I were computed following the procedures described by Beg and' Mirza (1998).

RESULTS AND DISCUSSION

A total of 112 water samples from 36 hand pumps and 76 tube wells were investigated. Overall. the Et' ranged from 0.24 to 5.97 with a mean value of I 12 dSm^{1} (Table 1). The SAR range was 0.06 to 22.08 with a mean value of 4.15. The RSC was 0.0 to 6.40 with a mean of 1.24 mmol$_c$ L'I. On the basis of limits set by the US Salinitv Lab, Staff (1954). Ayers and Westcot (I'.>X4l. Agricultural Department of the Punjab (Pakistan) and WAPDA (reported by Yunus. 1977). these parameters fall in safe, marginal and unfit classes i.e. a good scatter existed in the data. In general, the water samples from Daska area were of relatively better quality than those from Multan or Faisalabad area most probably due to higher rainfall and canal water irrigation for rice cultivation in Daska Tchsil than in the other two sampling areas.

Ionic strength (I) was calculated following the method described by Bohn et al. (1985). It ranged from 0.0030 to 0.083 mol V (Table 2). The highest mean value of

I was 0.0246 for Faisalabad tube well waters followed by 1l,(1I18 (Daska hand pumps). 0.0106 (Daska tube wells) and 0.008 for both the hand pumps and tube wells of Multan area. The corresponding standard error values for I were 0.017. 0 no 1. 0.002 and 0.002 mol L·'- respectively which again indicated a good scatter in the data.

Simple correlation and regression coefficients (Table 3 and Fig. I) were highly significant i.e. the I was highly dependent upon EC (dS m'), The 'Y' intercepts for water samples collected from Daska. Faisalabad and Multan were found < 0.00446. For 112 samples. the mean value of slope was 0.0129 with 'r' value of 0.0997** which coincided well with those reported by Griffin and Jurinak (1973) for 124 river water samples from USA. The relation "l = 0.0127EC" was found by them. However. Ponnampemrnaet al. (I %(,) reported I = 16 EC for saturation extract of flooded soils \\ here extracts had I values up to 0.06 mol L-'. This higher slope than the present one is most probably due to variation in the chemical composition of waters/extracts

Conclusions: There was a wide range III EC (0.24 to 5.97 dS m'), SAR (0.86 to 22.oX). RSC (0-6.40 mmol L-') and I (0.0030 to 0.083 mol L') of ground water samples in the Punjab province i.c, a good scatter in these chemical characteristics. The I (mol L,') correlated statistically with EC (dS m') with a 'r' value of 0.997** Thus I can be estimated from the relationship"'! = 0.0 129EC (dS m")" or with the help of Fig. I for Punjab ground waters which may be used in other scientific computation.

Table 1. Electrical conductivity, SAR and RSC of ground waters in the Punjab area

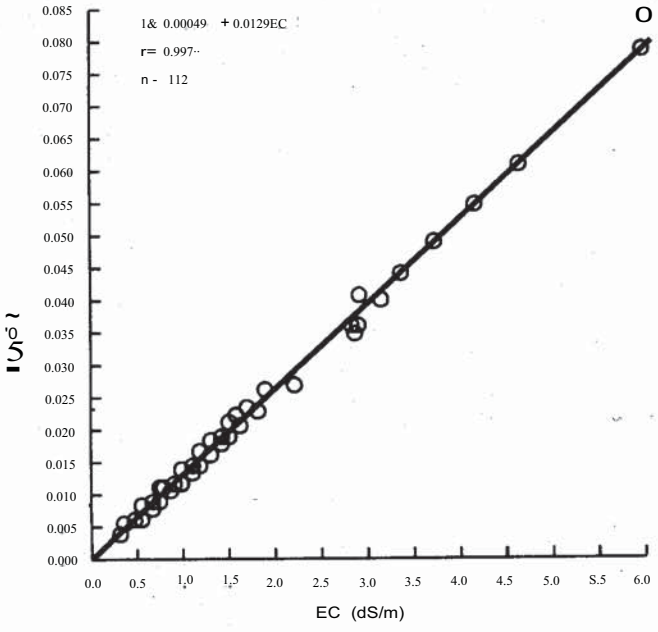
Area	Source	Range	Mean	Standard error
Electrical conductivity (dS m-I)				
Daska	Tube well	0.56 - 1,11	0.80	0,12
	Hand pump	0,59 - 1.04	0.60	0,13
Faisalabad	Tube well	0.24 - 5.97	1,89	1,32
Multan	Tube well	0,43 - 1,19	0,55	0.16
	Hand pump	0.37 - 1,26	0.63	0.21
Mean		0.24 - 5.97	1,12	"0.98
Sodium adsorption ratio (mmol VI)111				
Daska	Tube well	1.90 - 10.50	4.21	2.66
	Hand pump	1,30 - 9.80	3,50	2,20
Faisalabad	Tube well	1,45 - 22.08	9,41	5,54
Multan	Thbe well	0.37 - 3,41	1,44	0.88
	Hand pump	0.06 - 5.55	2.19	1,55
Mean		0.06 - 22.08	4.15	4.88
Residual sodium carbonate (m mole L-I)				
Daska	Tube well	0.00 - 6,40	2,55	1,81
	Hand pump	0.00 - 5.70	2.20	1,81
Faisalabad	Tube well	0.00 - 3.90	1,02	1,12
Multan	Tube well	0,40 - 1,40	0.11	0,33
	Hand pump	·0.20 - 1,90	0,33	0,58
Mean		0.00 - 6,40	1,24	1,47

Table 2. Ionic strength (mol L-[1]) computed from ionic composition of ground water samples

Area	Source	Range	Mean	Standard error
Daska	Tube well	0.007 - 0.014	0.0106	0.002
	Hand pump	0.009 - 0.014	0.0118	0.001
Faisalabad	Tube well	0.003 - 0.083	0.0246	0.017
Multan	Tube well	0.005 - 0.017	0.0080	0.002
	Hand pump	0.005 - 0.017	0.00018	0.002
Mean		0.003 - 0.083	0.0118	0.013

Table 3. Correlation and regression analysis of Punjab ground water EC (dS m-I) and I (mol L0[1])

Area	Source	Regression equation	Correlation (r)	Observation (No.)
Daska	Tube well	1=0.00113 + 0.0119EC	0.837··	16
	Hand pump	I = 0.00446 + 0.0087EC	0.981··	16
Faisalabad	Tube well	1= 0.00017 + 0.0131EC	0.997··	40
Multan	Tube well	1= 0.00006 + 0.0146EC	0.981••••••	20
	Hand pump	1= 0.00049 + 0.0130EC	0.980•••	20
Mean		1= 0.00049 + 0.0129EC	0.997··	112



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