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Assessment and Characterization of Irrigation Quality of Ground Water in Bahawalpur District, Pakistan.

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Abstract
Ground water development has contributed significantly to food security and reduction in poverty in Pakistan. Due to rapid population growth, there has been a dramatic increase in the intensity of ground water exploitation leading to declining water table and deteriorating ground water quality. In such prevailing conditions, hydro geological appraisal of escalating ground water exploitation has become a paramount importance. Keeping in this view, a study was undertaken to categorize suitability of ground water in the area of Bahawalpur district for irrigation purpose. Total 19207 water samples were collected from all the five tehsils of district Bahawalpur during the year July 2011 to June 2013. These samples were analyzed and categorized according to suitability criteria of water quality evaluation. 39 percent water samples were found fit, 12 percent were marginally fit and 49 percent water samples were found unfit for irrigation purpose. Majority of water samples were found hazardous for irrigation purpose. The soils under study were heavy texture, medium alkaline, low to medium in P and high in K. It is suggested that there is urgent need to evaluate the effects of tube well water on crop yields.
Keywords: EC, SAR, RSC, Ground water, Bahawalpur, Pakistan.

Introduction

Agriculture is the backbone of the Pakistan, employing 45% of the labour force, accounting for 21% of GDP (GOP, 2011-12) and contributing to the export earning considerably. Pakistan has the largest contiguous gravity flow canal irrigation system, but is falling short of good quality water due to increase cropping intensity and increased demand for household and industry over the years (Mohtadullah *et al.,* 1993).Most of the agriculturally important areas are arid, receive average rainfall of 200 mm, which is not enough to grow a single crop, whereas fresh water supplies are not enough to meet crop water requirements. This shortage is being fulfilled by exploiting ground water resources. There is 35.19 % contribution from canal irrigation, 40.88 % contributions from canal + tube well and 19.9% from tube wells as irrigation source (GOP, 2011-12). There is a major contribution from ground water as irrigation source in Pakistan. For the successful crop production on sustainable basis, the quality of ground water is of main concern. The common quality characteristics considered are electrical conductivity (EC), sodium adsorption ratio (SAR), and residual sodium carbonate (RSC), (Idrees and shafiq, 19990). The concentration and composition of dissolved constituents in water, determine its quality for irrigation use. To avoid indiscriminate use of ground water, proper management practices are deemed necessary, keeping in view the crop to be grown and the soil to be used((Suarez & Lebron, 1993; Ghafoor *et al.,* 2000; Qadir *et al.,* 2001). The water quality research is also needed to develop management practices. In district Bahawalpur underground water is being used for irrigation regularly alone or along with canal water. Voluminous work has been done in Punjab but very little information available regarding the quality of tube well water in general (Fit, M/Fit, and unfit) and no comprehensive study at district/ tehsil/ union council level has been made. The objective of this study was to monitor the quality of tube well water of every village and to find out the extent of various parameters contributing individually or collectively to the quality of tube well water.

Materials and Methods

All the five tehsils of district Bahawalpur were selected for this study. The ground water samples were collected from running tube wells of 86 union councils, 752 villages and 5 tehsils of district Bahawalpur covering four sides (north, east, west and south) of each village within the radius of 1 km of the village. A total of 19207 water samples were collected in plastic bottles after ½ hour of tube well operations. The collected water samples were analyzed at Soil & Water Testing Laboratory for Research, Bahawalpur for EC, Ca + Mg, Na, CO_3, HCO_3 and Cl. Then the sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were computed (Anonymous, 1954) by following formulas of U.S .Salinity Lab. Staff (1954).Based on the values of EC, SAR, RSC, water samples were categorized using the international standards (Anonymous, 1954).

$$SAR = \frac{Na}{\{(Ca + Mg)/2\}^{1/2}}$$

$$RSC\ (me\ L^{-1}) = (CO_3^{2-} + HCO_3^{-}) - (Ca^{++} + Mg^{++})$$

Where the concentrations are expressed in milli equivalents per liter (me L^{-1}) (Richards, 1954).

Results and Discussions

Irrigation water quality parameters of five tehsils of Bahawalpur district are given in Table 1. In this study, water quality was assessed on the criteria given by Soil Fertility Research Institute Punjab (Malik *et al.,* 1984) while others are for comparison purpose. The data was analyzed statistically for mean, standard deviation and percentage following the procedure described by Steel and Torrie (1980). The parameters EC, SAR and RSC were calculated from primary data (i.e. EC, Ca + Mg, CO_3, HCO_3 and Na).

Table 1. Irrigation water quality criteria

Parameter	Status	Richards, L.A.(1954)	WAPDA (1981)	Muhammad (1996)	Malik *et al.* (1984)
EC (µS cm^{-1})	Suitable	750	<1500	<1500	<1000
	Marginal	751-2250	1500-3000	1500-2700	1001-1250
	Unsuitable	>2250	>3000	>2700	>1250
SAR	Suitable	<10	<10	<7.5	<6
	Marginal	10-18	10-18	7.5-15	6-10
	Unsuitable	>18	>18	>15	>10
RSC (me L^{-1})	Suitable	<1.25	<2.5	<2.0	<1.25
	Marginal	1.25-2.50	2.5-5.0	2.0-4.0	1.25-2.5
	Unsuitable	>2.5	>5.0	>4.0	>2.5

Out of total 19207 water samples collected, only 7435 were fit, 2331 were marginally fit and remaining 9441 samples were unfit for irrigation (Figure 1). Most of the samples were unfit due to high EC + SAR + RSC followed by high EC + SAR and EC + RSC (Figure 2).

Electrical Conductivity (µs/cm) Status: Conductivity is a measure of the ability of water to conduct an electric current **.**Water with high salinity is toxic to plants and poses a salinity hazard. Soils with high levels of total salinity are called saline soils. High concentrations of salt in the soil can result in a “physiological” drought condition. That is, even though the field appears to have plenty of moisture, the plants wilt because the roots are unable to absorb the water. Water salinity is usually measured by the TDS (total dissolved solids) or the EC (electrical conductivity).

Table 2. Range, mean and standard deviation (S.D.) of irrigation quality parameters of ground water, district Bahawalpur

Parameter	Range	Mean	Standard Deviation
EC (µS cm^{-1})	172-19900	2212.41	2038.15
SAR	0.01-85.79	6.59	5.6
RSC (me L^{-1})	0-14.82	0.52	0.38

The classification of water samples on the basis of EC (Table 3) indicated that EC of 35 % water samples were within safe limits (<1000 µs/cm) whereas, 53% samples were unfit (>1250 µs/cm) and 12% were marginally fit (1000-1250 µs/cm) for irrigation. The EC of all water samples ranged from 172-19900 µs/cm with a mean value of 2212.41 µs/cm & standard deviation of 2038.15

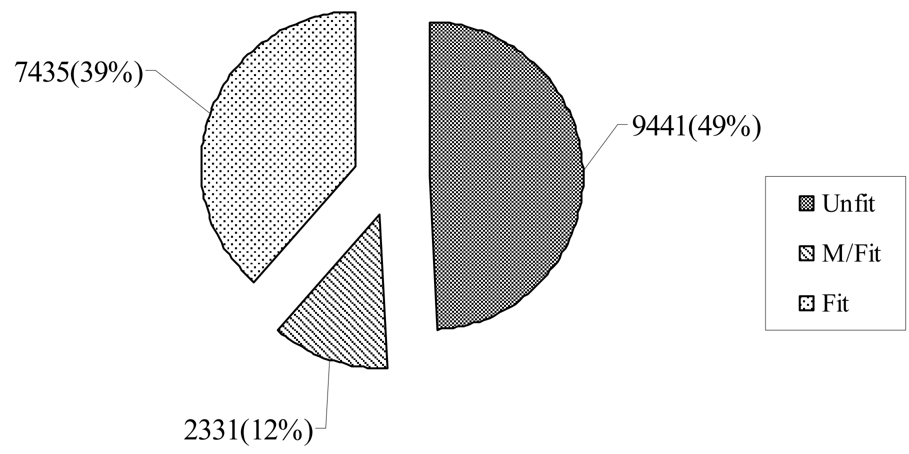
Table 3. Relative frequency distribution of tube well waters for different irrigation quality characteristics, Bahawalpur

Parameter	Class interval	Relative freq. distribution		Status
		No. of Sample	(%)	
Electrical conductivity, EC (µS cm^{-1})	<1000	6809	35	Fit
	1001-1250	2286	12	Marginally Fit
	>1250	10112	53	Unfit
Sodium Adsorption Ratio, SAR (m mol $L^{-1})^{1/2}$	<6	12402	65	Fit
	6-10	2757	14	Marginally Fit
	>10	4048	21	Unfit
Residual Sodium Carbonate, RSC (me L^{-1})	<1.25	16531	86	Fit
	1.25-2.50	1335	7	Marginally Fit
	>2.50	1341	7	Unfit

Sodium Adsorption Ratio (SAR) Status: Sodium Adsorption ratio expresses the relative activity of sodium ions in the exchange reactions with the soil. This ratio measures the relative concentration of sodium to calcium and magnesium (Emerson and Baker, 1973). If irrigation water with high SAR is applied to a soil, the sodium in the water can displace the calcium and magnesium in the soil .This will cause a decrease in the ability of the soil to form stable aggregates and loss of soil structure. This will also lead to decrease in permeability and infiltration of the soil to water, leading to problems with crop production (FAO, 1992). The SAR of water samples, mean and standard deviation are given in table 2.

The classification of water samples on the basis of SAR (Table 3) indicated that SAR of 65 % water samples were within safe limits (<6) whereas, 21% samples were unfit (>10) and 14% were marginally fit (6-10) for irrigation. The SAR of all water samples ranged from 0.01-85.79 with a mean value of 6.59 & standard deviation of 5.6(Table 2).

Figure 1: Irrigation Water Quality of District Bahawalpur

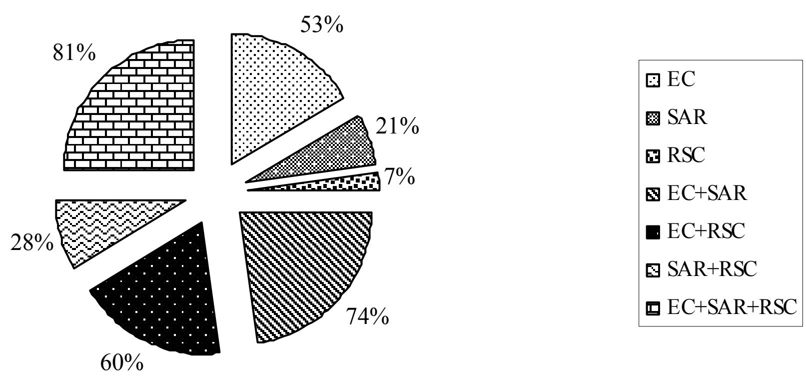


Residual Sodium Carbonates (RSC) Status:

Residual sodium carbonate (RSC) exists in irrigation water when the carbonate (CO_3) plus bicarbonate (HCO_3) content exceeds the calcium (Ca) plus magnesium (Mg) content of the water. Where the water RSC is high, extended use of that water for irrigation will lead to an accumulation of sodium (Na) in the soil. The results of this include 1) Direct toxicity to crops, 2) Excess soil salinity (EC) and associated poor plant performance, and 3) Where appreciable clay or silt is present in the soil, loss of soil structure and associated decrease in soil permeability.

Table 3 showed the classification of water samples on the basis of RSC. The RSC ranged from 0-14.82 me L^{-1} with mean value of 0.52 & standard deviation of 0.38. Out of 19207 water samples, the RSC of 16531(86%) water samples was within safe limits (<1.25 me L^{-1}). Only 1341 water samples (7%) were unfit (>2.50 me L^{-1}) and 1335 (7%) were marginally fit (1.25-2.50 me L^{-1}) due to higher RSC.

Figure 2:Characterization of Unfit Water Samples



Recommendations

Good quality water, if available, is required for irrigation to supplement tube-well water which will dilute its level of SAR. Other option for amelioration of excessive water (SAR) is through lining of water courses with gypsum stones. Management options for improving high water (RSC) include dilution with canal water and neutralization of carbonate and bicarbonates with the application of acids such as sulfuric acid or acid former such as elemental sulfur. Amendments such as gypsum, pressmud and manure should be applied to reduce the ill effect of ground water on soil. Growing of salt tolerant crops is also necessary to combat the effect of inferior irrigation water.

References

Anonymous, 2012. Pakistan Statistical Year Book , 2011-12. Federal Bureau of Statistics Division, Govt. Pakistan, Islamabad, Pakistan.

Anonymous, 1954. U. S. Salinity Lab. Staff. Diagnosis and Improvement of Saline and Alkali Soil. USDA Hand Book 60. Washington D.C. US

Emerson, W.W. and A.C. Bakker, 1973. The comparative effect of exchangeable Ca: Mg and Na on some soil physical properties of red brown earth soils. The spontaneous dispersion of aggregates in water. Australian J. Soil Res., 11:151–2

FAO.1992.The use of saline waters for crop production. Irrigation and drainage paper 48. FAO, Rome.

Ghafoor, A.,M.Rizwan and G. Murtaza,2000. Utilization of brackish water for reclaiming different textured saline-sodic soils having different ECe to SAR ratio. pp. 121-8.In: Natl. Seminar on Drainage in Pakistan. 16-17, 2000, Jamshoro, Hyderabad, Pakistan.

G. Ranganna, 2008. Hydrochemical analysis and Karnataka State, India. Intl. J. Environ. Research and Public health 5(3): 158-164.

Government of Pakistan, 2012. Economic Survey of Pakistan 2011-12, Econ. Advisors Wing, Finance Division, Islamabad, Pakistan.

Idris, M. and M. Shafiq. 1999. Irrigation quality of groundwater in Quetta division of Balochistan. Pakistan Journal of Soil Science 16:119-122.

Malik, D.M., M.A. Khan and T.A. Chaudhry. 1984. Analysis method for soil, plant, and water. Soil Fertility Survey and Soil Testing Institute, Punjab, Lahore, Pakistan.

Muhammad, S. 1996. Soil salinity sodicity and water logging. p. 472- 506. In: Soil Sci. A. Rashid and K.S. Memon. National Book Foundation Islamabad, Pakistan.

Qadir, M., A. Ghafoor and G. Murtaza, 2001.Use of saline-sodic waters through phytoremediation of calcareous saline-sodic soils. Agric.Water Manag., 47:1–14

Richards, L.A. 1954. Diagnosis and improvement of saline and alkali soils. USDA Agri. Hand Book No. 60, U.S. Government Printing Office, Washington, D.C., USA.

Steel, R.G.D and J. H. Torrie. 1980. Principles and Procedures of Statistics. 2nd Ed.,McGraw-Hill Book Company, New York.

Suarez, D. L. and I. Lebron, 1993. Water quality for irrigation with highly saline water.In: Towards the Rational Use of High Salinity Tolerant Plants, 2: 289–397

Water and Power Development Authority. 1981. Atlas – Soil salinity survey of irrigated areas of Indus basin 41 million acres. Survey and Research Organization Planning Division, WAPDA, Lahore.