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Evaluation of Ground Water Quality for Irrigation Purpose of the Areas of District Bahawalnagar, Pakistan

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Abstract
Water is life line for all living creation including human beings. Economy of Pakistan is agricultural based and it mainly dependent on canal supplies. Before the introduction of irrigation system the water table was sufficiently deep but due to lack of drainage facilities and improper management practices, adopting by the farmers, the water table came up resulting water logging & salinity problems. Indus basin abundant resources of ground water, the quality of which various from sweets to very saline in different tracts. However a thin layer of good quality is present almost everywhere, where exists an immense potential for the use of these water resources for agriculture, municipal and industrial use. Keeping in this view a detailed study was carried out to provide guidelines to farmers and researches for better crop production by adopting water management practices. Total 23600 water samples were collected from all the five tehsils of district Bahawalnagar during the year July 2003 to June 2010. These samples were analyzed and categorized according to suitability criteria of water quality evaluation. 38.64 percent water samples were found fit, 7.65 percent were marginally fit and 53.7 percent water samples were found unfit for irrigation purpose. Majority of water samples were found hazardous for irrigation purpose. Almost all the area has highly saline water, which is affected yield of various crops.
Keywords: EC, SAR, RSC, Ground water, Bahawalnagar, 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. The country`s agriculture is almost wholly dependent on irrigated areas which produce more than 90% of agriculture production. In most of the country intensive agriculture is not possible because climate is arid to semi arid with low and variable rainfall. Therefore major consumption of water lies in agricultural sector where consume almost 95% of water diverted to the irrigation network. Other uses include municipal, industrial and hydropower. The main source of irrigation water is the network of surface canals. The quality of canal water in the country is excellent for growing agricultural crops as it contains salt far below the critical limits. At present canal water is not enough to exploit the potential of soils and crops. Ground water is the alternate source of irrigation, although ground water is present in abundance, most of it is hazardous for soils and crop health. (Malik *et al*., 1984). Unfortunately, the major portion of this water (75%) is brackish /unfits for irrigation due to amount of sodium and bicarbonates ions (Malik *et al.,* 1984). Continuous and prolong use of brackish ground water could include salination/sodication of soils and greatly hampers the growth of most of the agronomic crops (Singh *et al*., 1992). By now about 3.0 maf soils have developed surface salinity/ sodicity due to the use of poor quality irrigation waters (Rafique, 1990). However, low quality water can be used for irrigation if proper management practices are followed (Suarez & Lebron, 1993; Ghafoor *et al*, 2000; Qadir *et al*., 2001). As a result of arid climate of large parts of Pakistan ground water availability is limited and poses a severe problem for water supply. Water shortage has meant that access to potable drinking water is limited in many areas. Additional problems have arisen through poor tube wells design, construction and maintenance. The problems are exacerbated in the major cities by over abstraction of ground water and resulting falling water tables. As a result, ground water quantity has traditionally been a priority over quantity issues in Pakistan. This practice had led to the apprehension that there was growing dangers of ground water quality deterioration and salination of soil profile. Therefore, this study was conducted to assess the quality of ground water in the five tehsils of Bahawalnagar district for its suitability for irrigation. This study will also helpful to the local farming community in planning irrigation schedule and selection of crops according to the quality of available ground water resource.

Materials and Methods
All the five tehsils (Bahawalnagar, Chishtian, Haroon Abad, Minchin Abad, and Fort Abbas) of district Bahawalnagar were selected for this study. The ground water samples were collected from running tube wells of 119 union councils, 1126 villages and 5 tehsils of district Bahawalnagar covering four sides (north, east, west and south) of each village within the radius of 1 km of the village. A total of 23600 water samples were collected in plastic bottles after ½ hour of tube well operations. Clean bottles were used for sampling purpose. Labelling was done properly indicating date of sampling and location. 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 Bahawalnagar 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 23600 water samples collected, only 6843 were fit, 2865 were marginally fit and remaining 13892 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 Bahawalnagar

Parameter	Range	Mean	Standard Deviation
EC (µS cm^{-1})	140-23850	2297.25	2065.50
SAR	0.01-94.50	6.46	5.59
RSC (me L^{-1})	0-11.46	0.45	0.36

The classification of water samples on the basis of EC (Table 3) indicated that EC of 38.64% water samples were within safe limits (<1000 µs/cm) whereas, 53.7% samples were unfit (>1250 µs/cm) and 7.65% were marginally fit (1000-1250 µs/cm) for irrigation. The EC of all water samples ranged from 140-23850 µs/cm with a mean value of 2297.25 µs/cm & standard deviation of 2065.50

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.

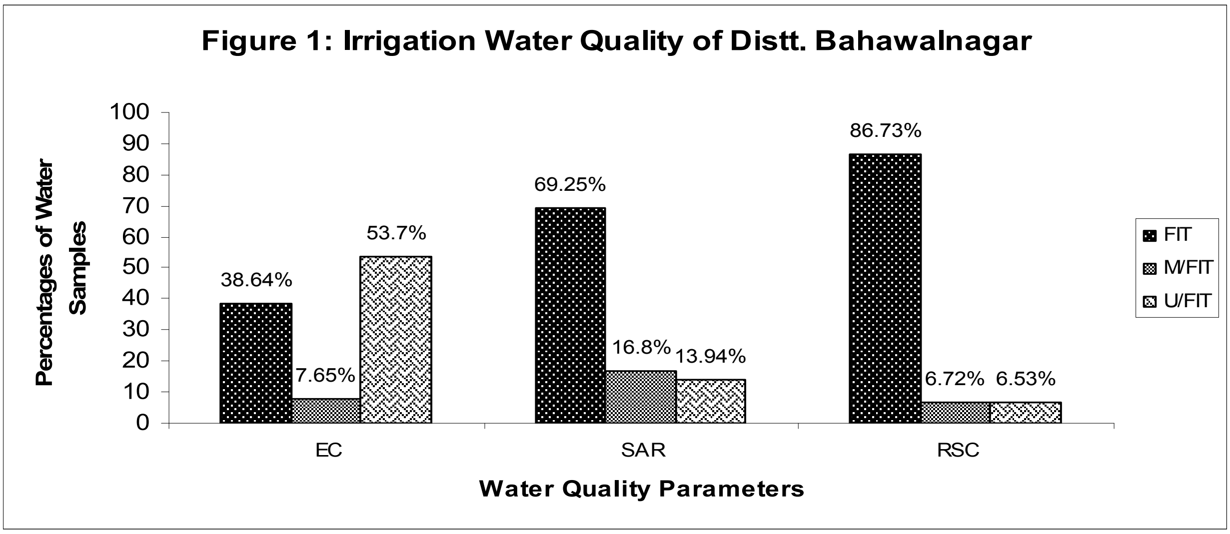
The classification of water samples on the basis of SAR (Table 3) indicated that SAR of 69.25 % water samples were within safe limits (<6) whereas, 13.94% samples were unfit (>10) and 16.8% were marginally fit (6-10) for irrigation. The SAR of all water samples ranged from 0.01-94.50 with a mean value of 6.46 & standard deviation of 5.59(Table 2).

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

Parameter	Class interval	Relative freq. distribution		Status
		No. of Sample	(%)	
Electrical conductivity, EC (µS cm^{-1})	<1000	9120	38.64	Fit
	1001-1250	1806	7.65	Marginally Fit
	>1250	12674	53.7	Unfit
Sodium Adsorption Ratio, SAR (m mol $L^{-1})^{1/2}$	<6	16343	69.25	Fit
	6-10	3965	16.8	Marginally Fit
	>10	3292	13.94	Unfit
Residual Sodium Carbonate, RSC (me L^{-1})	<1.25	20469	86.73	Fit
	1.25-2.50	1588	6.72	Marginally Fit
	>2.50	1543	6.53	Unfit

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 0-11.46 me L^{-1} with mean value of 0.45 & standard deviation of 0.36. Out of 23600 water samples, the RSC of 20469(86.73%) water samples was within safe limits (<1.25 me L^{-1}). Only 1543 water samples (6.53%) were unfit (>2.50 me L^{-1}) and 1588 (6.72%) were marginally fit (1.25-2.50 me L^{-1}) due to higher RSC. High value of water RSC must be used for monitoring of soil salinity by laboratory analysis and good irrigation techniques (Nishanthiny *et al.*, 2010).

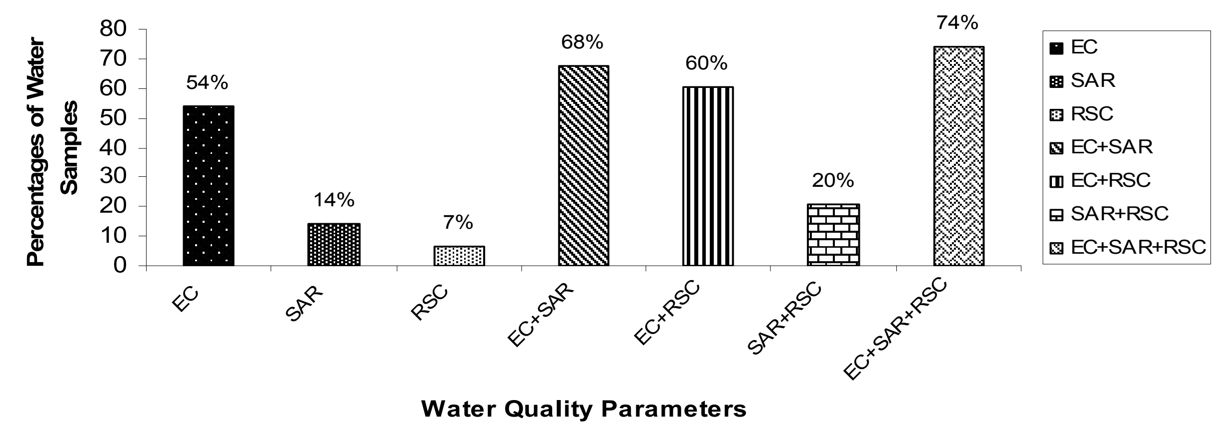


Conclusions and Recommendations

In the business-as-usual scenario, problems of groundwater overexploitation will only become more acute, widespread, serious and visible in the years to come. The frontline challenge is not just supply-side innovations but to put into operation a range of corrective mechanisms before the problem becomes either insolvable or not worth solving. Therefore Pakistan needs a serious debate about whether to pump their aquifers to the maximum and be very poor thereafter, or manage abstraction and be somewhat poor today. Adverse interactions are likely to turn into a serious situation if proper attention is not given to address the problems. Although irrigated agriculture is a unified subject, water and agriculture are treated as separate entities both for the purposes of planning and for the management of affairs pertaining to them. Coordination between different federal and provincial departments that are responsible for planning and management of groundwater resources in Pakistan also need to be enhanced.

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.

Figure 2: Characterization of Unfit Water Samples



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