IRRIGATION WATER QUALITY OF DIFFERENT AREAS OF PUNJAB

By

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Abstract:
A detailed study was conducted in different areas of Punjab inorder to access the suitability of water for irrigation. Twenty samples were analyzed, that were collected from each of the reported area for electrical conductivity (EC), sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and chloride ions. Percentage of "Fit" samples from the areas of Chakwal, Sheikhupura, Bhai Pheru and Lahore were 37, 29, 49 & 16 respectively, while percentage of "Unfit" samples from these areas were 49, 50, 18, 59 respectively. Rest of the samples was declared as "marginally fit".

Key words: Water, EC, SAR, RSC, Chakwal, Sheikhupura, Bhaipehru, Lahore.

Introduction:
Fresh water is necessary for the survival of humans and most other land-based life forms. Ninety seven per cent of the earth's water is the salt water of oceans and seas. Most of the remaining three percent (3%) is in polar ice caps, glaciers, the atmosphere or underground and hard to reach. Only 0.4 per cent is available for use. This water supply is maintained by water evaporating from oceans and lakes and then falling to the earth as rain in a process called the 'water cycle'. In Pakistan, 69% of water is used for agricultural purposes but most of its agriculturally productive area falls in the arid and semi-arid climate. The rainfall varies considerably with less than 10 mm per annum in some parts of the country to more than 500 mm in other parts (Bhutta *et al.,* 2002).

The objective of this paper is to help the reader to a better understanding of the effect of water quality upon soil and crops. Conceptually water quality refers to the characteristics of a water supply that will influence its suitability for a specific use. Quality is defined by certain physical, chemical and biological characteristics. Even a personal preference such as taste is a simple evaluation of acceptability. In irrigation water quality emphasis is given on the chemical and physical characteristics of the water; any other factors are rarely considered important.

Irrigation water evaluation parameters are commonly selected considering their impact on crop production, livestock health and human health. The effect on crop production is evaluated by considering salinity (total dissolved solids or electrical conductivity), Sodicity (residual sodium chloride, sodium adsorption ratio, or adjusted sodium adsorption ratio) and toxicity due to specifications that affect sensitive crops. Salinity is important as it affects crop water availability and hence the growth. Sodicity affects soil structure and hence the rate of infiltration thus affecting crop growth. To avoid problems when using these poor quality water supplies, there must be sound planning to ensure that the quality of water available is put to the best use (WWF, 2007).

For successful crops production on sustainable basis without deteriorating soils, the quality of water is of main concern. The common quality characteristics considered are electrical conductivity (EC), sodium adsorption ratio (SAR) and residual sodium carbonate (RSC). The other parameters like nitrate, nitrite, sulphate, iron and potassium were also studied in order to assess the water quality in different areas for its irrigation suitability.

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Materials and Methods

Sampling:

Sheikhupura, Chakwal, Bhai Pheru and Lahore were selected for study. Water samples were collected in clean amber coloured 1-2 litre samples bottle that were previously rinsed out with distilled water. It is important that the samples must represent the water sources and special care may be needed to ensure that.

Methods of analysis:

Methods of analysis were used according to Standard Methods for Examination of water and waste water (APHA, 2005). Irrigation water quality is mainly determined by titrimetry, turbidimetry, electrical conductivity and of flame photometry. Additionally, pH measurements are routinely included, indicating whether acidity or alkalinity may be of a problem. Electrical conductivity measurements are made very easily and routinely to assess total salt concentration of water samples.

Major anions, carbonate (CO_3^{2-}), bicarbonate (HCO_3^{1-}) and chloride (Cl^{1-}) found in water are analyzed rather inexpensively with titration. Sulphate anion (SO_4^{2-}) is usually analyzed with turbidimetric method. Sulfate is precipitated out as barium sulfate with addition of $BaCl_2$ solution to the water sample. Intensity of barium sulfate suspension measured with either colorimeter or spectrometer is related with sulfate ion concentration in the sample. Calcium and magnesium of the major earth alkaline elements, present in irrigation water, can also be measured through titration. The easiest and the simplest method of analysis for sodium and potassium is to use flame photometer. The common anion like nitrate, nitrite and iron were determined by spectrophotometeric method (Charlet, G.R.1964).

Sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were calculated by following equations:

$$SAR = \frac{Na^{+1}}{\sqrt{\frac{Ca^{+2} + Mg^{+2}}{2}}}$$

$$RSC = (CO_3^{-} + HCO_3^{-}) - (Ca^{+2} + Mg^{+2})$$

Results and discussion:

Water used for irrigation can vary greatly in quality depending upon type and quality of dissolved salts. Since most water is being used by the agricultural sector, irrigation can cause waterlogging and salinity. This happens when the water table rises close to the surface of the soil. If plants do not use this water, it evaporates, leaving salts behind. Even in uncultivated, barren lands, a water table within 2 meters of the surface can cause salinity in the soil. If irrigation water containing high levels of contaminants evaporates, it can result in damage to the soil. The Punjab province draws its major share of drinking water from the natural ground water aquifer. Groundwater becomes contaminated when chemicals from surface water seep into soil and come in contact with the flowing groundwater. The movement of groundwater is through open spaces in soil and rock layers, which is usually very slow, indicating a very low dilution of contaminants. According to WHO, groundwater of Lahore up to 700-ft deep has been seriously contaminated and should not be used for human consumption. In 1989, pollution was found to a depth of 300-ft, and to 500-ft in 1992(WWF, 2007).

Irrigation water quality parameters are given in Table 1-6. In this study, water quality was assessed on the criteria given by (Richards, L.A.1954) while others are for comparison purpose. The data was analyzed statistically for mean, standard deviation and percentage following the procedure described by (Christian, G. D. 2004). The parameters TSS, SAR and RSC were calculated from primary data (i.e. EC, Ca + Mg, CO_3^{2-}, $HCO_3^{1-}$and Na).

Table1. Irrigation water quality criteria

Parameter	Status	Richards, L.A. (1954)	WAPDA (1981)	Muhammad (1996)	Malik et al. (1984)
EC (uS 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
Cl (me L^{-1})	Suitable	<4.5	-	0-3.9	-
	Marginal	-	-	-	-
	Unsuitable	>4.5	-	>3.9	-

Table 2. Conditions of water use and irrigation quality parameters by WWF

Conditions of Use	**EC** (uS cm^{-1})	**SAR**	**RSC** (me L^{-1})
Coarse Textured Soil	3000	10	2.5
Medium Textured Soil	2300	8	2.3
Fine Textured Soil	1500	8	1.25

Table 3.Irrigation quality parameters of Sheikhupura

Parameter	Range	Mean	standard deviation
EC (uS cm^{-1})	942-2711.3	2019	276.02
SAR	0.21-2.1	1.9	0.106
RSC(me L^{-1})	0.3-1.1	0.9	0.213
PH	7.35-8.2	7.85	0.226
Cl(me L^{-1})	4.22-15.07	13.8	2.899

Table 4.Irrigation quality parameters of Chakwal

Parameter	Range	mean	standard deviation
EC(uS cm^{-1})	881-2113	1635	329.2
SAR	1.1-10	7.2	2.378
RSC(me L^{-1})	0.2-6.1	5.6	1.57
pH	7.5-8.5	8.3	2.663
Cl(me L^{-1})	2.816-7.042	6.25	1.127

Table 5.Irrigation quality parameters of Bhai Pehru

Parameter	Range	mean	standard deviation
EC (uS $cm^{-1)}$	995-1742	1261	199.3
SAR	1.05-1.55	1.41	0.133
RSC(me L^{-1})	0.1-0.4	0.31	0.08
pH	7.7-8.1	7.95	0.106
Cl(me L^{-1})	2.881-5.098	3.12	0.61

Table 6.Irrigation quality parameters of Lahore

Parameter	Range	mean	standard deviation
EC (uS $cm^{-1)}$	700-7103	2802	782
SAR	1.41-7.8	3.153	1.464
RSC(me L^{-1})	0.9-10.39	3.378	2.165
pH	7.48-8.87	7.9	0.32
Cl(me L^{-1})	0.929-31.6	11.56	7.052

Electrical conductivity (EC)

Electrical conductivity of water samples collected from Sheikhupura ranged from 942 to 2711 us cm^{-1} mean of 2019 us $cm^{-1}$and standard deviation of 276.02. Electrical conductivity of water samples collected from Chakwal ranged from 881 to 2113 uS cm^{-1} mean of 1635 us $cm^{-1}$and standard deviation of 329.2. Electrical conductivity of water samples collected from Bhai Pheru ranged from 995 to 1742 us cm^{-1} mean of 1261 us $cm^{-1}$and standard deviation of199.3. Electrical conductivity of water samples collected from Lahore ranged from 700 to 7103 us cm^{-1} mean of 2802 us $cm^{-1}$and standard deviation of 782.0. (Tables 3- 6).

Sodium adsorption ratio (SAR)

Sodium adsorption ratio express 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 a 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 a decrease in infiltration and permeability 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 Tables 3- 6.

Residual sodium carbonate (RSC)

RSC of water samples collected from Sheikhupura ranged from 0.3 to1.1 me L^{-1} mean of 0.9 and standard deviation of 0.213. RSC of water samples collected from Chakwal ranged from 0.2 to 6.1 me L^{-1} mean of 5.6 and standard deviation of 1.56. RSC of water samples collected from Bhai Pheru ranged from 0.1 to 0.4 me L^{-1} mean of 0.31 and standard deviation of 0.08.RSC of water samples collected from Lahore ranged from 0.9 to 10.39 me L^{-1} mean of 3.38 and standard deviation of 2.16 (Tables 3- 6)..

pH

pH of water samples collected from Sheikhupura ranged from 7.35 to 8.2mean of 7.85 and standard deviation of 0.226.pH of water samples collected from Chakwal ranged from 7.5 to 8.5 mean of 8.3 and standard deviation of 2.66. pH of water samples collected from Bhai Pheru ranged from 7.7 to 8.1 mean of 7.95 and standard deviation of 0.106.pH of water samples

collected from Lahore ranged from 7.48 to 8.87 mean of 7.9 and standard deviation of 0.32 (Tables 3- 6)..

Chloride

Chloride of water samples collected from Sheikhupura ranged from 4.22 to15.07 me L^{-1} mean of 13.8 and standard deviation of 2.89.Chloride of water samples collected from Chakwal ranged from 2.81 to 7.04 me L^{-1} mean of 6.25 and standard deviation of 1.12.Chloride of water samples collected from Bhai Pheru ranged from 2.81 to 5.09 me L^{-1} mean of 3.12 and standard deviation of 0.61.Chloride of water samples collected from Lahore ranged from 0.93 to31.6 me L^{-1} mean of 11.5 and standard deviation of 7.05 (Table. 3-6).

The detected anion like nitrate, nitrite and iron were below the WHO specifications of drinking water.

Conclusion

There is an estimation of 4 billion m^3 (1.5 trillion galons) of contaminants that go into the ground each year that threaten ground water supply (Lia, M. 1989). Once these contaminants reach to groundwater, they can persist for many years causing major health concerns for those using ground water as their drinking water source. Irrigation water with high RSC values for extended time period sodicate the soils. On these experimental findings groundwater of the area should be used after mixing with canal water on the basis of RSC, SAR and TDS. There is usually no single way to achieve salinity control in irrigated lands and associated waters. Many different approaches and practices can be combined into satisfactory control system. The appropriate combination depends upon economic, climate and social as well as hydro-geologic situations (FAO, 1992).

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