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Assessment of Changes in Irrigation Water for Its Fitness in Crop Production

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Abstract Sustainability of agriculture and irrigation practices plays a key role in alleviating rural poverty. Water is critical input for crop production and the most essential natural resource for sustenance of life. The water demand from agriculture is very high in Punjab due to adoption of water intensive crops. In Punjab, availability of water from rainfall is highly uneven. Irrigated agriculture is dependent on adequate supply of water of usable quality. Almost 95% of the cultivated area is tubewell irrigated. The over exploitation of groundwater for agriculture has resulted in continuous decline of water table in most parts of the State. The present study is an attempt to assess the groundwater quality of Gurdaspur district of Punjab using ten years data (2005-2014). Five hundred and eighty one tubewell water samples received at Soil and Water testing laboratory, PAU, Regional Research Station, Gurdaspur were analyzed and assessed for the possible changes in water quality parameters over a period of time. The irrigation water samples have been classified into fit, marginal and unfit categories. Water quality parameters carbonate (CO_3^{2-}), bicarbonate (HCO_3^{2-}), chloride (Cl^-), residual sodium carbonate (RSC) and electrical conductivity (EC) were taken into consideration for fitness assessment. The most influential water quality is the water salinity hazard as measured by electrical conductivity. On the basis of criteria laid down by Soil and Water testing laboratory, Department of Soil Science, PAU, Ludhiana, EC of 96%, 2.9% and 1.0% tubewell water samples was safe, marginal and unsafe. RSC is an index of sodicity hazard and its value indicates the tendency of Ca and Mg to precipitate in the irrigation water. Water having RSC values less than 2.5 (safe), 2.5 to 5.0 (marginal), 5.0 to 7.5 (unsafe) and more than 7.5 (m.e/L) (unsafe), respectively of the sample. Among the samples tested for RSC parameters, 98%, 1.4%, 0.5% were safe, marginal and unsafe. Thus, on the basis of two important parameters of water quality, it can be concluded that majority (97%) of the samples of irrigation water analyzed were fit for irrigation, only 2.2% were marginal and 0.8% were unsafe for irrigation purpose. At the end, it is concluded that irrigation water must got tested to know the changes in groundwater quality over a period of time. Good water quality has the potential to allow maximum yield under good soil and water management practices to maintain or restore maximum soil production and production capability. Thus, present study is conducted to assess irrigation water for its quality and its suitability for use in agriculture.

Keywords Ground water, Irrigation water quality, Electrical conductivity, Residual sodium carbonate.

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Table 1. Irrigation water quality criteria.

Sl. No.	Parameter	Value	Status
1	EC (µmhos/cm)	< 2000	Fit
		2000-4000	Marginal
		>4000	Unfit
2	RSC (m.e/L)	>2.5	Fit
		<2.5-5.0	Marginal
		>5.0	Unfit

Introduction

Due to improper land use, crop choice, irrigation practices and over fertilization for short term and easy gains in agriculture is directly or indirectly responsible for degrading water quality. To maintain water quality and its fitness for irrigation is a matter of concern in recent years. Water quality for agricultural purpose is determined on the basis of the effect of water on the quality and the yield of the crops, as well its effect on the characteristic changes in the soil (FAO, 1985). Irrigation water quality may affect the soils and crops, especially in the saline alkali soil areas. The contamination of water creates hazards to human health, plant and animals. Specific water may be suitable for irrigation but may not be suitable for drinking and industrial uses due to presence of some ions at toxic level [1]. Salinity and sodium hazard indicators can be used as a criterion to find the suitability of irrigation waters [2]. Irrigation with poor quality waters may bring undesirable elements to the soil in excessive quantities affecting its fertility. Indiscriminate use of chemical fertilizers resulting in water quality deterioration is not new. The chemical parameters of groundwater play a significant role in assessing water quality which is suitable for irrigation. The concentration and composition of dissolved salts determine the quality for irrigation purpose. Continuous monitoring of irrigation water quality parameters is highly crucial because changes in the quality of water have far reaching consequences in terms of its effects on man and biota and can be used successfully to grow crops without long-term hazardous consequences to crops or soils, with the use of improved farming and management practices. Thus, there is a need to assess the quality of irrigation water.

Materials and Methods

Five hundred and eighty one tube well water samples received at Soil and Water testing laboratory, PAU,.Regional Research Station, Gurdaspur were analyzed and assessed for the possible changes in water quality parameters over a period of time. The irrigation water samples have been classified into fit, marginal and unfit categories.

Water quality parameters carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), chloride (Cl^-), residual sodium carbonate (RSC)and electrical conductivity (EC) were taken into consideration for this assessment. Residual sodium carbonate (RSC) was calculated with following equations :

$$\text{RSC (m.e/L)}=(CO_3^{2-} + HCO_3^-)- (Ca^{2+}\ Mg^{2+})\ [2].$$

RSC is an index of sodicity hazard and its value indicated the tendency of Ca and Mg to precipitate in the irrigation water. Several researchers used differ-

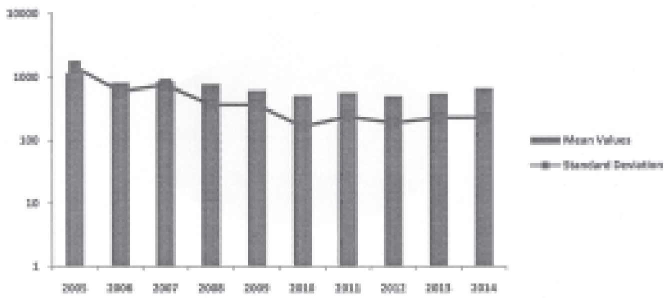

Fig. 1. Mean and standard deviation of electric conductivity of water samples.

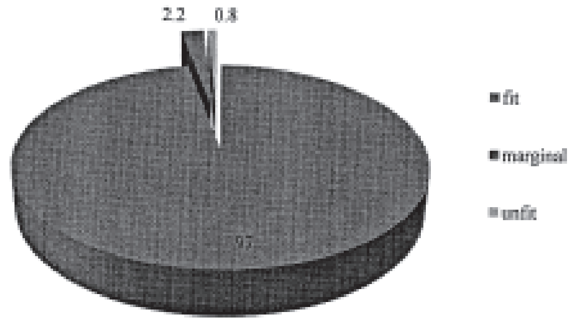

Fig. 2. Percent water sample fitness for irrigation based on EC and RSC.

ent index values to assess the suitability of surface and ground waters for irrigation [3–5].

Results and Discussion

Water analysis

Five hundred and eighty one tubewell water samples were analyzed and assessed for the possible changes in water quality parameters over a period of time. Among water quality parameters, EC and RSC was determined.

Electrical conductivity represents the total concentration of soluble salts dissolved in water soil solution. In our study, the electrical conductivity (EC) ranged from 50 to 4750 µmhos/cm. Among the water samples tested, 96% had EC below 2000 µmhos/cm and thus could be used for irrigation without any possible risk of soil salinization. About 2.9% of water samples had EC between 2000-4000 µmhos/cm whereas 1.0% water samples had EC more than 4000 µmhos/cm (Fig.1). Salts which accumulate in soil depends upon irrigation water quality, management practices and the adequacy of drainage. Irrigation water classified as saline or unsuitable, can be used successfully to grow crops without long-term hazardous consequences to crops or soils, with the use of improved farming and management practices.

Residual sodium carbonate (RSC) contains ex-

Table 2. Range, mean and standard deviation of residual sodium carbonate (RSC) of irrigation water.

Parameter	Residual sodium carbonate (RSC)				
Year	2005	2006	2007	2008	2009
Range	-3.5 to 3.0	-2.6 to 3.4	-12.2 to 4.6	-15.6 to 8.3	-13.0 to 9.8
Mean	-1.1	-1.0	-2.8	-3.0	-4.7
SD	1.71	1.16	2.64	4.08	4.08

Table 2. Continued.

Parameters	Residual sodium carbonate (RSC)				
Year	2010	2011	2012	2013	2014
Range	-9.6 to -0.6	-14.0 to -0.2	-8.4 to -0.5	-8.6 to -1.0	-7.2 to -1.2
Mean	-4.2	-5.4	-4.3	-4.0	-4.2
SD	2.41	2.95	1.83	2.12	1.52

cess of CO_3^{2-} and HCO_3^- which precipitates calcium and hence sodium is increased in soil solution. It leads to saturation of clay complex with sodium and consequently decrease infiltration rate. The results revealed that RSC value of water samples ranged from -15.6 to 9.8 m.e/L and most of water samples were fit. Out of total water samples tested, 98%, 1.4% and 0.5% were safe, marginal and unsafe. Wanda et al. [6] also assessed the suitability of ground water by taking water samples of 106 villages of district Jhang for its fitness.

Thus, on the basis of two important parameters of water quality, it can be concluded that majority (97%) of the samples of irrigation water analyzed were fit for irrigation only 2.2% were marginal and 0.8% were unsafe for irrigation purpose (Fig. 2). Furthermore, information inferred from the study is that irrigation water quality should be monitored on regular basis to know the changes over a period of time. Shafiq and Saleem [7] also reported that the continuous monitoring of water quality is necessary to help farmers and irrigation department for making water policy. Long-term water quality records are crucial as well as important to develop environmental management strategies [8, 9].

Conclusion

On the basis of five hundred and eighty one tubewell water samples analyzed over a decade for two basic water quality parameters, it is concluded that on an average groundwater is fit for irrigation purpose for all the crops growing in the district. To keep a check on deterioration and changes in water quality for irrigation purpose it is suggested that water quality should be monitored on regular basis.

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