J Krishi Vigyan 2014, 3(1) : 75-78 DOI: 10.5958/2349-4433.2014.01255.0

Quality of Groundwater for Irrigation in Phagwara Block of District Kapurthala

Kuldip Singh, Onkar Singh[1] and Gobinder Singh[2]

Department of Soil Science
Punjab Agricultural University, Ludhiana-141004 (Punjab)

ABSTRACT

Twenty groundwater samples were collected from Phagwara block of Kapurthala district of Punjab during the pre-monsoon season. These water samples were tested for major cations and anions which are important from irrigation point of view. To determine the suitability of groundwater of Phagwara for irrigation purpose, the parameters like electrical conductivity (EC) and residual sodium carbonate (RSC) were calculated on the basis of chemical data. Based on EC and RSC values together, it was found that 40 per cent water samples were fit, 40 per cent were marginal and 20 per cent were unfit for irrigation purpose. A large proportion of samples falling in marginal and unfit category indicate the need of water testing for sustainable crop production without deteriorating the soil health. Irrigation water having problem of sodicity should be used along with application of inorganic (gypsum) or organic (FYM) amendments.

Key Words: Groundwater Quality, Irrigation Water, Residual Sodium Carbonate, Electrical Conductivity.

INTRODUCTION

Groundwater is being used for irrigation purpose in the state of Punjab. Water is an essential natural resource for sustaining life and the environment that is typically thought to be available in abundance. Fresh water occurs as surface water and groundwater. Though groundwater contributes only 0.6 per cent of the total water resources on earth, it is the major and preferred source of drinking water in rural as well as urban areas, particularly in developing countries like India (Nash, 1995). It caters to 80 per cent of the total drinking water requirement and 50 per cent of agricultural requirement in rural India.

Irrigation water quality refers to the kind and amount of salts present in the water and their effects on crop growth and development. Salts are present in variable concentrations in all waters, and the salt concentrations influence osmotic pressure of the soil solution: higher the concentration, greater the osmotic pressure. Osmotic pressure in turn affects the ability of plants to absorb water through their roots. Plants can absorb water readily when osmotic pressure is low, but absorption becomes more difficult as the pressure increases. Even if the soil is thoroughly wet, plant roots have difficulty in absorbing water when the osmotic pressure is high. When the pressure is unusually high, it may even be impossible for plants to absorb sufficient water for normal plant growth. Under these conditions, plants may actually wilt when the roots are in water.

Irrigation water quality is determined in several ways, including the degree of acidity or alkalinity (pH), electrical conductivity (EC), residual sodium carbonate (RSC) and sodium adsorption ratio (SAR). The deterioration of groundwater quality as well as decline in water table is one of the factors responsible for various problems in central districts of Indian Punjab including Kapurthala. Therefore, the present investigation was undertaken to assess the quality of groundwater for irrigation purposes in Phagwara block of Kapurthala district of Punjab.

*Corresponding Author's Email: kuldip@pau.edu
[1]Agronomist , Regional Research Station, Kapurthala
[2]Assistant Professor (Soil Science) KVK, Kapurthala

Site description

***Physiography*:** Kapurthala district is situated in the Bist Doab and comprises two non-contiguous parts, separated by some 32 km. Kapurthala, Sultanpur Lodhi and Bholath tehsils form one part and Phagwara Tehsil, the second separated portion. The former area lies between north latitude 31^0 07' and 31^0 39' and east longitude 74^0 55' and 75^0 36'. Total geographical area of the district is 1633 sq.km. The climate of the district is characterised by general dryness except for a short period during south-west monsoon season. The normal annual rainfall of the district is 779 mm, which is distributed over 33 d in a year. The numerous hill streams coming down from Hoshiarpur District keep the soil moist all the year round. Some of these streams are silt laden and at first deposit fertile soil though their later deposits are more and more sandy.

***Hydrogeology*:** The district is occupied by Indo-Gangetic alluvial plain of quaternary age. In alluvium thin, granular zones exist down to the entire thickness. The top aquifer ranges from 20 to 45 m. The depth of the top aquifer in the north, south and central parts is 40, 45 and 20m respectively. The top granular zone is interspersed by 2 to 3 thin clay lenses. A thick clay bed of thickness from 15 to 35m is present beneath the Granular zone. Broadly it indicates that six to seven prominent sand horizons exist down to 300 m. and are separated by thick clay layers. The granular material is comprised of fine to coarse sand and are between 12 to 21m bgl. with deeper water levels in the southern part of the block places mixed with gravel and pebble. In Phagwara block ground water decline is 0.4 to 0.7 m yr^{-1} (CGWB, 2007). The overall flow of ground water is from north to southeast direction.

MATERIALS AND METHODS

Twenty groundwater samples were collected during March 2014 from Phagwara block of Kapurthala district. Water samples were collected from different alluvial aquifers representing soil associations of Phagwara block of Kapurthala district (Sidhu *et al* 1995). Water samples were collected in clean polyethylene bottles of 250 ml capacity. At the time of sampling, bottles were thoroughly washed 2–3 times with groundwater to be sampled. In the case of bore wells the water samples were collected after pumping for 30 min. This was done to remove groundwater stored in the well. Samples were analyzed for pH, EC, total dissolved solids, bicarbonate, calcium plus magnesium and chloride as per the standard procedures given in American Public Health Association (APHA, 1998) within 24 h of sampling. The reliability of pH analysis was checked after every ten samples using standard buffer solutions of pH 7.0 and 9.2, whereas that of EC analysis was checked using standard EC solution provided by M/s Crison Instruments SA having EC = 1413 µS cm^{-1}. Overall, measurement reproducibility and precision for each analysis was less than 2 per cent.

RESULTS AND DISCUSSION

Groundwater chemistry

The suitability of groundwater for agricultural purposes can be better understood by studying the effect of different factors such as seasonal variations. Statistical parameters derived from the chemical analysis of water samples collected from Phagwara block of Kapurthala district of Punjab are presented in Table 1.

pH

The hydrogen ion concentration (pH) of water is a measure of its acidity or alkalinity. A neutral pH, neither acid nor alkaline, is 7.0; waters with pH below 7 are acidic and above 7 are alkaline. A pH of 8.5 or higher is a good indication that the water is high in soluble salts. Using waters with high pH may require special cropping and irrigation practices. In Phagwara block, the groundwater was found to be alkaline in nature with an average pH of 7.6.

Electrical Conductivity (EC)

The total concentration of salts in the irrigation water is measured by the electrical current conducted by the ions in solution. This measurement is expressed as electrical conductivity or EC × 10^6. EC is an estimate of the quantity of salts in solution and is normally expressed in parts per million (ppm). The higher the salt concentration the higher the EC. In our study, the electrical conductivity (EC) ranged from

650 to 1300 µS cm^{-1} with a mean of 960 µS cm^{-1}. Hundred per cent water samples had EC < 2000 µS cm^{-1} and thus could be used for irrigation without any possible risk of soil salinization (Table 2). Therefore, electrical conductivity does not seem to be the major problem of this area.

Residual Sodium Carbonate (RSC)

Water containing a carbonate plus bicarbonate concentration greater than the calcium plus magnesium concentration have what is termed "residual sodium carbonate" [RSC = (CO_3 + HCO_3) " (Ca + Mg)]. The potential for a sodium hazard is increased as RSC increases, and much of the calcium and sometimes the magnesium is precipitated out of solution when water is applied to the soil. Salts become concentrated when the soil dries out, as less soluble ions such as calcium and magnesium tend to precipitate out and are removed from the solution. The sodium percentage increases when calcium and magnesium are removed from the solution, increasing the rate of sodium adsorption on soil particles. Waters having high chlorides and sulphates do not cause as much change in the RSC, as chlorides and sulphates are more soluble than carbonates and bicarbonates.

Alkalinity is a measure of the ability of groundwater to neutralize acids to the equivalence point of carbonate or bicarbonate. Carbonates were absent in all the samples. Bicarbonate represents the major source of alkalinity in the water. Bicarbonates ranged from 5 to 10.4 meqL^{-1} with a mean value of 7.8 meq L^{-1} (Table 1). Slight variations were generally observed in the spatial distribution of HCO_3^-, these variations were significant at certain locations. It may be due to contribution from carbonate lithology. Chloride showed a large variation between minimum and maximum values and expressed high standard deviation. This inference not only suggests that the water chemistry in the study region is not homogeneous but also reveal the influences of complex contamination sources and geochemical process. Calcium + Magnesium concentration varied from 3.8to 6.9 meq L^{-1} with an average value of 4.8 in the Phagwara.

The increasing concentration of carbonates and bicarbonates in irrigation water results in the precipitation of calcium and magnesium and thus enhance the sodium saturation of soil. Therefore the residual sodium carbonate (RSC) concept of Eaton (1950) has a merit of judging the suitability of water for irrigation. The RSC of underground irrigation water of Phagwara block varied from -1.7 to 6.1 meq L^{-1} with a mean value of 3.1 (Table 1). In this block 40, 40 and 20 per cent of the samples tested RSC < 2.5 (safe), 2.5 to 5.0 (marginal) and > 5.0 meq L^{-1} (unsafe), respectively (Table 2). In general irrigation water having RSC values greater than meq L^{-1} has been observed to be harmful for soil properties and crop growth and such water is declared unsafe for irrigation purposes (Bhumbla and Abrol, 1972).

The suitability of groundwater for agricultural purposes depends on the amount of various chemical constituents in it. Salts may harm plant growth physically by limiting the uptake of water through modification of the osmotic processes, or chemically by metabolic reactions such as those caused by toxic-constituents (Todd, 2007). The important chemical constituents that affect the suitability of water for irrigation are the total concentration of dissolved salts (EC), relative proportion of bicarbonate to calcium, magnesium (RSC) and relative proportion of sodium to calcium. Water quality problems in irrigation include salinity and alkalinity.

Various classification systems have been proposed for determining the quality of water for irrigation purposes. Three classification systems proposed by different research workers were used to classify water samples collected from the Phagwara block of Kapurthala district.

Water quality based on EC and RSC taken together

Bhumbla and Abrol (1972) proposed a criterion for assessing the quality of water for irrigation purpose by considering the EC and RSC together. Residual sodium carbonate is an excess quantity of sodium bicarbonate and carbonate over calcium and magnesium, which is detrimental to the physical properties of soils as it causes dissolution of organic matter in the soil, which in turn leaves a black stain on the soil surface on drying. It can be calculated as follows :

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

Table 1. Chemical composition of groundwater in Phagwara block of district Kaputhala.

Parameter	Mean	Standard deviation	Mini-mum	Maxi-mum
pH	7.61	0.2	7.2	7.9
TDS	566	108	384	767
EC	960	184	650	1300
$Ca^{2+} + Mg^{2+}$	4.8	0.9	3.8	6.9
HCO_3^-	7.8	1.6	5	10.4
CO_3^-	Nil	-	-	-
Cl^-	1.2	0.8	0.8	4.2
T.H	240	46	190	345
RSC	3.1	2.0	-1.7	6.1

All values are in meq L^{-1}except pH and EC is in µS cm^{-1}

ionic concentrations are expressed in meq L^{-1}.

Considering EC and RSC together, 40 per cent of water samples were fit for irrigation purpose and 40 per cent were marginal. All the Marginal samples showed sodicity problems. The remaining 20 per cent samples were unfit for irrigation use (Table 2, Fig. 1). Poor permeability of soil is commonly observed where irrigation water containing high RSC values are used. High saturation of soil with sodium deteriorates soil structure resulting in poor aeration, poor nutrition and water availability to plant roots. Application of gypsum is recommended when RSC of irrigation water exceeds 2.5meq L^{-1} and EC is <2000 µS cm^{-1} .The quantity of gypsum should be got calculated from a soil testing laboratory. For each meq L^{-1}lof RSC, the quantity of gypsum (70 %) pure works out to be 1.5 q $acre^{-1}$ for 4 irrigations of 7.5 cm each (Kumar *et al* 2010). When poor quality water to be used on long term basis, one should keep watch on build up of salts in soil by getting the soil tested at regular intervals.

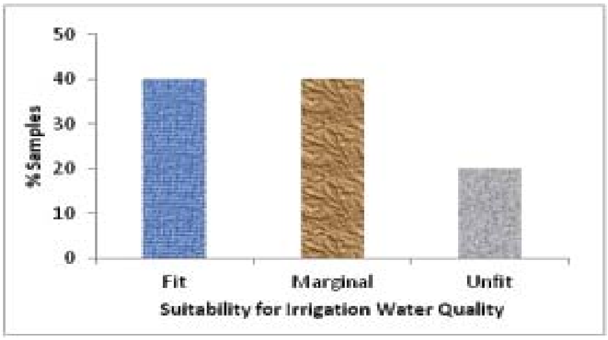

Fig. 1 Percent samples in different categories for irrigation use based on EC and RSC taken together.

Table 2. Distribution of water sample in various categories with respect to residual sodium carbonate (RSC) and electrical conductivity (EC).

Residual Sodium Carbonate (meq L^{-1})	
Range	**% of Samples**
<2.5	40
2.5-5.0	40
>5.0	20
Electrical conductivity(µScm-1)	
<2000	100
2000-4000	0
>4000	0

CONCLUSION

The quality of irrigation water available to the farmers and other irrigators has a considerable impact on which crops can be successfully grown, the productivity of these crops, and water infiltration and other soil physical conditions. The first step in understanding how an irrigation water source can affect a soil-plant system is to have it analyzed by a reputable lab.

REFERENCES

APHA (1998). Standard methods for the examination of water and waste waters, 20th edn. APHA, Washington DC, USA.

Aravindan S (1999). Integrated hydro-geological studies in hard rock aquifer system of Gadilam River basin, Tamil Nadu, India. pp 110. PhD thesis, Bharathidasan University, Thiruchirappalli.

Bhumbla D R and Abrol I P (1972). Is your water suitable for irrigation? *Indian Farming* **22**: 15–17.

CGWB Report (2007). Report on groundwater resources and development potentials of Bathinda district, Punjab.

Nash H and McCall G J H (1995). Groundwater quality. In: 17th Special Report. Chapman and Hall, London

Raj Kumar, Balwinder Singh, Hundal H S, Kuldip Singh, Yadwinder Singh (2010). Geospatial quality of underground water of Punjab, pp 72. Department of Soils, Punjab agricultural Univer-sity, Ludhiana.

Sidhu G, Walia C, Lal T, Rana K, and Sehgal J (1995). Soils of Punjab for optimizing land use. Soils of India Series 4. National Bureau of Soils Survey and Land Use Planning, Nagpur, pp 1–75.

Todd D K (2007). Groundwater hydrology. Wiley India edition,Mumbai, India.

Received on 2/9/2014 Accepted on 15/9/2014