SCIENCE REVIEWS JOURNALS

Volume 8, 2021

# Quality of groundwater for irrigation in Tehsil Vehari of District Vehari, Punjab Pakistan

Atta-Ur-Rehman[1], Muhammad Saleem[1], Muhammad Bilal Khan[2], Amjad Tariq[1], Abdul-Sattar[1] and Xiaoqiang Cui[2]

[1] Soil and Water Testing Laboratory Vehari, Punjab Pakistan

[2] MOE Key Laboratory, College of Environmental and Resource Sciences Zhejiang University China.

**Abstract:** A study was conducted in twenty two union councils of Tehsil Vehari of District Vehari to assess the suitability of underground water for irrigation purposes. For this purpose, samples were collected and analyzed for Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonates (RSC), Carbonates ($CO^-_3$), Bicarbonates ($HCO^-_3$), Calcium+ Magnesium ($Ca^{+2}$+$Mg^{+2}$), Sodium ($Na^+$) and Chlorides ($Cl^-$) concentrations. The results showed that Electrical Conductivity (EC) ranged from 934.67 to 5608.57 (μ$Scm^{-1}$), Sodium Adsorption Ratio (SAR) ranged from 2.62 to 18.86, Residual Sodium Carbonates (RSC) ranged from 2.04 to 11.50 ($meqL^{-1}$), Sodium ($Na^+$) ranged from 2.57 to 27.27($meqL^{-1}$) and Chlorides ($Cl^-$) ranged from 1.10 to 30.98($meqL^{-1}$). This was concluded from study that 23.15% water samples were free from salinity hazards and declared fit for irrigation purpose, while 12.81% water samples were found marginally fit. While 64.04% water samples were found unfit for irrigation purpose. Provision of necessary technical assistance to farming communities should be available to guide them at what depth they should extract fresh water instead of saline water. In severally affected areas bio-saline agriculture should be promoted to mitigate ill-effects of salinity hazardous. Cropping pattern and crop varieties should be fairly modified to produce those crops in sensitive areas which are salinity resistant.

**Keywords:** Groundwater quality, Water analysis, EC, SAR, RSC, Vehari district

## 1. Introduction

To meet the food demand of ever increasing population of the country and to earn foreign exchange from the agriculture sector, it is essential to enhance agricultural productivity, both through the increase in cropped areas as well as in crop yields. But limited availability of fresh water and soil salinity/sodicity are the major bottlenecks in the sustainable development of agricultural sector in the country. In arid and semi-arid regions of the world including Pakistan, evapotranspiration is several times higher than rainfall, which is responsible for net upward movement of salts through capillary action. In order to supplement the present canal water availability at farm gate (43 MAF), more than 531,000 tube wells are pumping 55 MAF in Pakistan. Estimates show that about 70-80% of tube well water in Pakistan is unfit for irrigation. It is estimated that development of surface salinity and/or sodicity on an area of about $3×10^6$ ha in the country as a result of using marginal quality drainage and groundwater without appropriate management practices. Unfortunately, canal water is not sufficient to exploit the potential of soil and crop cultivars under intensive cropping system. The scarcity of good quality surface water is becoming more acute day by day therefore; one has to rely on irrigation through tube wells. To increase the productivity of agricultural sector, abandoned land and marginal quality groundwater will have to be managed. Pakistan's groundwater aquifer consists of joint layers of fresh and saline waters and the proportional percentage of these layers varies from place to place. The bio - saline technology is to be promoted. The investment will be required in future for adoption of biosaline agricultural technology (Economic Survey 2009-10). The situation of groundwater quality is deteriorating fast, due to rapid growth of tube wells in the private sector. In Punjab alone, the number of private tube wells has increased from about ten thousand in 1960 to about five hundred thousand in 2000. These ground waters have different types of salts, which deteriorate the soil accordingly (Masood and Gohar, 2000).

Determination of water quality through analysis is pre requisite for its better utilization by crops, as it is essential for the maintenance of turgidity, absorption of nutrients and metabolic processes of plants (Rehman. *et al*;2011). According to estimate, 25% of tube well discharge in the Punjab province is useable, while 25% and 50% is marginal and unfit respectively, for irrigation purpose (Ashfaq *et al*., 2009). Ali *et al.* (2009) reported that quality of available ground water in most (76.6%) of the villages of Lahore district was not suitable for sustainable crop production and soil health. According to Soil Fertility Survey and Soil Testing Institute, Rawalpindi (2006-

07), 73% of water samples analyzed, were fit for irrigation during 2006-07. A water quality study has shown that out of 560,000 tube wells in Indus basin, about 70% are pumping sodic water which in turn is affecting the soil health and crop yield (Kahlown *et al.*, 2003). In another study by Zahid *et al.* (2003) out of 680 water samples, 33% were fit, 19% were marginally fit and the rest of 48% were unfit. Rizwan *et al.* (2003) reported that the ground water quality for irrigation in Rawalpindi district, Out of 96 water samples, 71% were fit, 9% were marginally fit and 20% were found unfit for irrigation purpose. According to Shakir *et al.* (2002), 64 water samples were collected from new tubewell bores from various locations of District Kasur to check the quality of underground water for irrigation purpose. The results showed that electrical conductivity of the samples varied from 524 to 5700 µS $cm^{-1}$, sodium adsorption ratio of the samples ranged from 0.49 to 26.00 while residual sodium carbonate ranged from zero to 17.00 me $L^{-1}$. Out of 64 samples, 26 samples were fit, 8 were marginally fit and 30 samples were found unfit for irrigation. The sodic groundwater containing high amount of sodium, carbonates and bicarbonates enhances sodicity in soil, deteriorates the soil-permeability and hydraulic conductivity of soil (Haider *et al.* 1976, Ghafoor *et al.* 1997). Thus, it was very important to ascertain the quality of underground water used for irrigation. Voluminous work has been done for Punjab but very little information is available at district/ tehsil/ union council level. More over information available regarding the quality of tube well water are general (fit, marginally fit and unfit) and no comprehensive study has been made. The objective of this study was to monitor the quality of water of tube wells of 22 union councils of tehsil Vehari and to find out the extent of various parameters contributing individually or collectively to the quality of tube well water.

## 2. Material and Methods

During 2015-16, a total of 203 tube well water samples were collected from 22 union council of tehsil and district Vehri. Tubewells selection was made randomly in whole tehsil. The samples were taken in polythene bottles after thirty minutes of tubewell operation. The depth of tubewells ranged from 30 to 120 feets. The tubewells water is being used for raising crops, vegetables, ornamental plants, forests trees and nurseries. The water samples were analyzed at Soil and Water Testing Laboratory Vehari for electrical conductivity (EC), cations ($Ca^{+2}$ + $Mg^{+2}$, $Na^{+}$) and anions ($CO_3^{-2}$, $HCO_3^{-}$, $Cl^{-}$) by the methods described by Page *et al.* (1982) and U.S. Salinity Lab. Staff (1954). Residual sodium carbonates (RSC) and sodium adsorption ratio (SAR) were determined by following formulas of U.S. Salinity Lab. Staff (1954).

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

## 3. Results

Water used for irrigation can vary greatly in quality, depending upon the type and quantities of salts dissolved in it. The suitability of water is determined not only by the total amounts of salts present in it but also the kind of the salts. Water quality is judged on the potential severity of problems that can be expected to develop by its long use. Irrigation water quality parameters of twenty two union councils of tehsil Vehari of district Vehari are given in table 1. In this study the water quality was assessed on the basis of criteria given by Soil Fertility Research Institute Punjab (Malik *et al*; 1984). The data was analyzed statistically for mean, standard deviation and percentage following the procedures described by Steel and Torrie (1980). The analytical data regarding cations, anions, EC, SAR and RSC of tube well water in tehsil Vehari are presented in following paragraph.

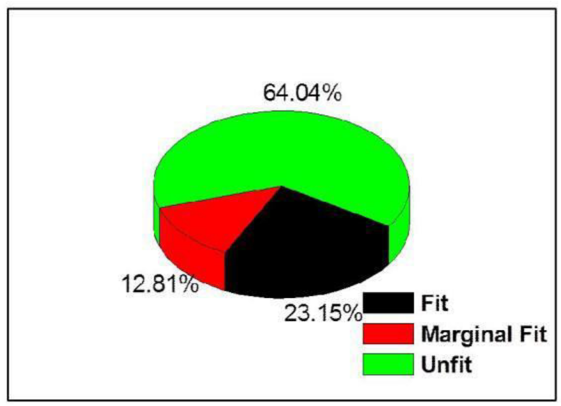


Figure 1. Irrigation Water Quality of Tehsil Vehari

### 3.1 Electrical Conductivity (EC)

A measure of water salinity that is important for crop yield is Electrical Conductivity (EC), which increases the concentration of soluble salts in soil, therefore, the primary effect of high EC water on crop productivity is the inability of the plant to compete with ions in the soil solution for water (physiological drought). The higher the EC, the less water is available to plants, even though the soil may appear wet, because plants can only transpire pure water and usable plant water in the soil solution decreases dramatically as EC increases. The Electrical Conductivity of water samples ranged from 420 to9160 (µS$cm^{-1}$) with mean of 934.67 to 5608.57

($\mu Scm^{-1}$) and standard deviation of 275.66 to 2644.37($\mu Scm^{-1}$). 47 samples out of (203) have EC< 1000 $uScm^{-1}$, 26 samples have EC between 1001 to 1250 $uScm^{-1}$, whereas 130 samples have EC< 1250 $uScm^{-1}$. The classification of water samples on the basis of EC (Table3) indicated that 23.15% of the total analyzed water samples were within the safe limits and declared fit for irrigation, whereas 64.04% were unfit and only 12.81% were marginally fit for irrigation. As water salinity increase great care must be taken to leach the salts out of root zone for better crop growth. Water for irrigation generally 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 (FAO, 1992).

**3.2. Sodium Adsorption Ratio (SAR):**

It represents the relative proportion of Na to Ca + Mg. The sodium hazard is typically expressed as the sodium adsorption ratio (SAR). Calcium will flocculate, while sodium disperses soil particles. This dispersed soil will readily crust and have water infiltration and permeability problems. The Sodium Adsorption Ratio (SAR) of water samples ranged from 0 to 26.39 with mean of 2.62 to 18.86 $(mmolL^{-1})^{1/2}$ and standard deviation of 1.12 to 7.87$(mmolL^{-1})^{1/2}$. 127 (62.56%) samples out of 203 water samples were fit, 44 water samples (21.68%) were marginally fit and remaining 32 samples (15.76%) were unfit. Sodium adsorption is stimulated when Na proportion increases as compared to Ca+Mg resulting in soil dispersion (Emerson and Bakker, 1973). At high levels of sodium relative to divalent cations in the soil solution, clay minerals in soils tend to swell and disperse and aggregates tend to slake, especially under conditions of low total salt concentration and high pH. As a result, the permeability of the soil is reduced and the surface becomes more crusted and compacted under such conditions. Soil's ability to transmit water is severely reduced by excessive sodicity (FAO, 1992).

**Table 1.** Irrigation Water Quality Criteria

| Parameter | Status | Richards, L.A. (1954) | WAPDA (1981) | Muhammad (1996) | Malik *et al.* (1984) |
|---|---|---|---|---|---|
| **EC ($\mu S\ cm^{-1}$)** | 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 | - |

**3.3. Residual Sodium Carbonate (RSC):**

The irrigation water containing excess of $CO^{-}_{3}$ and $HCO^{-}_{3}$ will precipitate calcium and hence sodium will increase in soil solution. It leads to saturation of clay complex with sodium and consequently decreased infiltration rate. The irrigation water containing excess of $CO_3$+$HCO^3$ will precipitate Ca+Mg and hence sodium will increase in soil solution. It leads to saturation of clay complex with sodium and consequently decreased infiltration rate. The RSC of water samples ranged from 0 to 12.94 ($meq.L^{-1}$) with mean of 2.04 to 11.50 ($meq.L^{-1}$) and standard deviation of 0.90 to 4.97 $meq.L^{-1}$). The data of water samples analyzed indicated that 56.65% of the total analyzed water samples were within the safe limits and declared fit, whereas 33.01% were unfit and only 16.24% were marginally fit for irrigation. It was observed that most of the water samples unfit due to high RSC. Farmers can use this water after gypsum amendment. Gypsum requirement can be calculated by the following formula;

Gypsum Requirement (kg) = RSC ($meq.L^{-1}$) **X** discharge (in cusecs) **X** working hours **X** 8.8

Water quality also depends upon the texture of the soil. Irrigation water that is unfit for fine textured soils can be used for coarse textured soils (Table 3). Farmers can use marginal and unfit water for salt tolerant crops like wheat, sorghum etc as these crops have physiology for moderating the ill effects of salts. Efficiency of irrigation water must be increased by the adoption of appropriate management practices through education and training.

**Discussion and recommendations**

Water used for irrigation can vary greatly in quality depending upon type and quantity of dissolved salts. Salts are present in irrigation water in relatively small but significant amounts. They originate from dissolution of weathering of the rocks and soil, including dissolution of lime, gypsum and other slowly dissolved soil minerals. The suitability of water for irrigation is determined not only by the total amount of salts present but also by the kind of salts. Water quality or suitability for use is judged on the potential severity of problems that can be expected to develop during long-term use. The problems that result vary in both kind and degree and are modified by soil, climate and crop, as well as by the skill and knowledge of the water user. The soil problems most commonly encountered and used as a basis to evaluate water quality are those related to salinity, water infiltration rate, specific ion toxicity and a group of other miscellaneous problems (Ayers and Westcot, 1994). An integrated, holistic approach is needed to conserve water and prevent soil salinization and water logging while protecting the environment and ecology. Firstly, source control through the implementation of more efficient irrigation systems and practices should be undertaken to minimize water application and reduce deep percolation. Conjunctive use of saline groundwater and surface water should also be undertaken to aid in lowering water table elevations, hence to reduce the need for drainage and its disposal, and to conserve water (FAO, 1992). Efficiency of irrigation must be increased by the adoption of appropriate management strategies, systems and practices and through education and training. 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 systems. The appropriate combination depends upon economic, climatic and social as well as hydro-geologic situations (FAO, 1992). It was observed that most of the water samples were unfit due to higher electrical conductivity indicating no sodicity problem in these waters.

It was observed that most of the water samples were unfit due to their higher Electrical Conductivity (EC) values and having no sodicity problems in these waters. This might be due to the minerals and dissolved salts have been leached to a lower profile over a period of time. The soils of Vehari district are medium textured. However the effect of different qualities of water on soil health and crop yield is also governed by the soil type, climate of the region and the management practices (Singh *et al.*, 1992). It is therefore, important to point out that water having EC up to 1.25 $dSm^{-1}$ may be used to raise most of the crops on light textured soils without affecting soil quality (Pervaiz *et al.*, 2003). Chaudhry and Rana (1975) reported that water having (<7.5) SAR and 1.25 $meqL^{-1}$ RSC did not create problems for the soils and crops. Irrigation water having EC (<3.0 $dSm^{-1}$), SAR value of (<10) (mmol $L^{-1})^{1/2}$ and RSC (<2.50 $meqL^{-1}$) is safe for coarse textured soils without creating any potential hazard (WWF, 2007). In general, waters of Ec values below 0.75$dSm^{-1}$ are satisfactory for irrigation and the use of these waters will not create any problem except some salt sensitive crops. However, the use of unfit water due to high EC will cause salinization. To avoid salinization, it was proposed to increase/decrease the depth of bore to find good quality water (Younus, 1977). The farmers can use marginal and unfit water for salt tolerant crops (wheat, sorghum and barley) and fruit (Guava) tress etc. It is also recommended that, the poor quality irrigation water may be used (alternatively with good quality irrigation water or with canal water) and to grow crops on beds, successfully. On degraded soils the *Acacia* and other trees for timber and fuel can be grown. This was concluded that, quality of irrigation water in most of the union councils of Vehari is unfit for irrigation purpose and need amendment before application.

**Acknowledgements:**

The author would like to acknowledge the District Government for providing laboratory facility for analyses purposes to complete this study.

**Corresponding Author:**
Muhammad Bilal Khan
MOE Key Laboratory,
College of Environmental and Resource Sciences,
Zhejiang University China.
Tel: +86-13120761808

**References**

1. Ali, S. Mahmood, M. N. Chaudhary and M. Sadiq.2009. Irrigation quality of gorund water of twenty villages in Lahore district. *Soil and Environment.28(1):17-23.*
2. Bhutta, M.N., M.R. Chaudhary and C.A. Hafeez; 2003, Water Quality issues and status in Pakistan. Proceedings of seminar on strategies to address the present and future water quality issues. Pakistan Council of Research in Water Resrources Islamabad. Publication No.;123-2003.
3. Chaudhary, H.G. and G.M. Rana.1975. Effect of tubewell irrigation on the SCARP-I, CMC Pub. No. 27, WAPDA, Lahore.

4. 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 sub-soils. *Australian Journal of Soil Research* 11:151-157.
5. Hussain. N.A., A. Khan, K.K. Tanveer, M. Ahmad and A. Sattar, 1991. Suitability of Punjab under-ground water. *Journal of Agricultural Research* 29:519-529.
6. Idris, M. and M. Shafiq.1999. Irrigation quality of ground water in Quetta division of Balochistan. *Pakistan Journal of Soil Science* 16:119-122.
7. Kahlown, M.A., M.A. Tahir and M. Ashraf.2003. Water quality issues and status in Pakistan. Proc. Seminar on Strategies to Address the Present and Future Water Quality Issues. *Pakistan Council of Research in Water Resources, Islamabad. Publication No.123-2003.*
8. Malik. D.M... M.A. Khan and T.A. Chaudhary. 1984. Analysis method for soil, plant and water. Soil Fertility, Survey and Soil Testing Institute, Punjab, Lahore, Pakistan.
9. McMurry J. and Fay. R.C. (2004)Hydrogen, Oxygen and water. In Mc Murry Fay Chemistry. K.p. Hammann(Ed) 4$^{th}$ Edn. (pp.575-599) (New Jersey. Pearson Education).
10. Muhammad, S. 1996. Soil salinity and water logging P.472-506. In: Soil Science, Rashid, A. and K.S. Memon. (eds.). National Book Foundation, Islamabad, Pakistan.
11. Page, A.L., R.H. Miller and D.R. Keeney.1982. Methods of Soil Analysis Part_II, 2$^{nd}$ Edition, American Society of Agronomy.No. 9. Madison, Wisconsin, USA.
12. Rehman O.B. Ahmad and S Afzal 2011. Sopuces and quality of irrigation water in district Attock J. Agric Res.49(2) 203-220.
13. Pervaiz, Z., S.S.H. Kazmi and K.H. Gill. 2003. Characterization of ground water in Gujrat district. *Pakistan Journal of Soil Science* 2248-54.
14. Rizwan. K., T. Mahmood, Z. Abbas, M. Dilshad and M.I. Lone. 2003. Ground water quality for irrigation in Rawalpindi district. *Pakistatn Journal of Soil Science* 22(1):43-47.
15. Richards 1.A. 1954 Diagnosis and improvement of saline and alkali soils. USDA Agriculture handbook No. 60, U.S. Government printing office Washington, D.C. U.S.A.
16. Singh, R.B., P.S. Minhas and R.K. Gupta. 1992. Effect of high salinity and SAR waters on salinization, sodication and yield of pearl-millet and wheat. *Agriccultural Water Management* 213-105.
17. Steel. R.G.D. and J.H. Torrie 1980 principles and procedures of statistics 2$^{nd}$ ed McGraw hill book company New York.
18. Water and Power Development Authority, 1981. Atlas-Soil salinity survey of irrigated area of Indus basin 41-million acres. Survey and Research Organization, Planning Division. WAPDA, Lahore.
19. W.W.F. 2007. National surface water classification criteria and irrigation water quality guidelines for Pakistan, Hudiara drain project phase-II funded by UNDP under GEF small grants programme.
20. Younus, M., 1977. Water quality in Indus plain. Keynote paper. P.283-292. in: Proceeding Seminar on Water Management for Agriculture, November 15-7.1977, Lahore, Pakistan.
21. Zahid P. S.S.H. Kazmi and K.H. Gill, 2003 Characterization of irrigation quality of ground water in Gujrat district Pakistan Journal of soil science 22(1) 48-54.