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Assessment of Groundwater Resources in Kirana Hills Region, Rabwah, District Chiniot, Pakistan

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Abstract: This study was planned to assess the groundwater quality of the area adjacent to Precambrian Kirana Hills, Pakistan. The majority of the people in the area use groundwater from private wells for drinking and domestic use. Therefore, it is important to provide an overview of the groundwater quality. This information would be beneficial to local people and the administration for selecting suitable water treatment methods. Samples were collected from different wells of Rabwah town, close to the Kirana Hills. Parameters like EC, pH, alkalinity and total dissolved solids (TDS) were determined for 142 samples. While 40 samples were analyzed for hardness, Ca, Mg, Cl, SO_4, NO_3, and F. standards set by the World Health Organization (WHO) were considered to evaluate the quality of groundwater. Geographic Information System (GIS) was used to interpolate analyzed physicochemical parameters. The results showed that EC, TDS, hardness, Cl, SO_4, and Ca were very high in the water samples of the area. Fifty-two percent of samples had pH values lower than the permissible limits. Results suggest that the water quality is extremely adverse close to the hills. The poor water quality in the area near the hills may be due to the limited recharge of aquifers because of the hills and shallow basement, which may act as a barrier to subsurface water movement. Some physical and chemical parameters indicated that the quality of water at deeper levels (i.e. >150 ft) is relatively better. This may be due to limited exploitation of water from deeper aquifers as compared to shallow aquifers. Hence, proper aquifer management is required to prevent water quality deterioration due to over exploiataion. NO_3 was found within the acceptable limits and all water samples were found free of any significant contamination by human activities.

Keywords: Kirana hills, GIS, water analysis.

Introduction

Groundwater is the only source of drinking water for many rural areas in developing countries. In many areas of developing countries, people are using groundwater without knowing its suitability for drinking and household purposes. In most of the cases, water quality is not within the safe limits. The groundwater can be contaminated due to natural processes or human activities. Drinking water quality management is the fundamental pillar in the control and prevention of waterborne diseases. Reduction in the number of people, who do not have access to safe drinking water has been enlisted as one of the targets of the Millennium Development Goals (MDGS) (WHO, 2001). Quality analysis of water sources in developing countries can help to achieve this objective.

The purpose of this study was to evaluate and map the physicochemical characterization of groundwater in the area close to Precambrian rocks exposed in district Chiniot of Punjab province. These rocks are termed as Kirana Hills and comprise of a series of isolated bedrock hills exposed in the study area. This area totally relies on groundwater for drinking and domestic use. Mostly, local population draws water from private wells due to lack of adequate or no water supply by the local administration. No study has yet been conducted to assess the water quality in the area. Therefore, it was required to evaluate the suitability of groundwater from private wells for drinking and domestic use. Key physicochemical parameters were analyzed and mapped using Geographic Information System (GIS). These maps provide useful information for the local community and the government departments for planning safe and clean water supply.

Study area

This study was conducted in Rabwah town, Chiniot district of Punjab province (Figs. 1, 2). Precambrian rocks of the Kirana Hills are exposed in the northern part and the Chenab River borders the east of the town (Fig. 2). The Kirana Hills are one of the oldest rocks exposed in the plains of Punjab. These hills comprise of volcanics and meta-sedimentary rocks (Ahmad and Chaudary, 2009). In the area, Quaternary alluvium has been deposited on basement rock of Precambrian age (Greenman et al., 1968). Wells drilled close to outcrops penetrated bedrock at a shallow depth. The northwesterly alignment of the Kirana Hills indicates a trend of the bedrock ridge buried by the alluvium. The areas close to the hills and shallow basement comprise of fine sediments.

Material and Methods

Geographic locations of sampling sites were observed

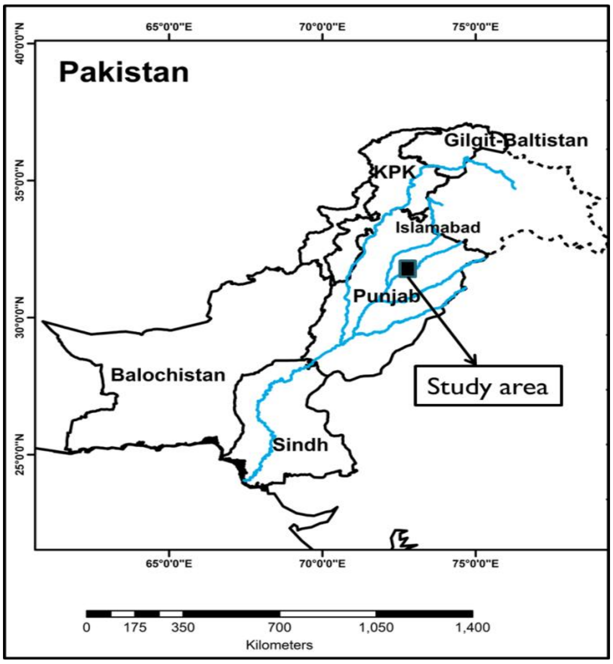

Fig. 1 Location of the study area.

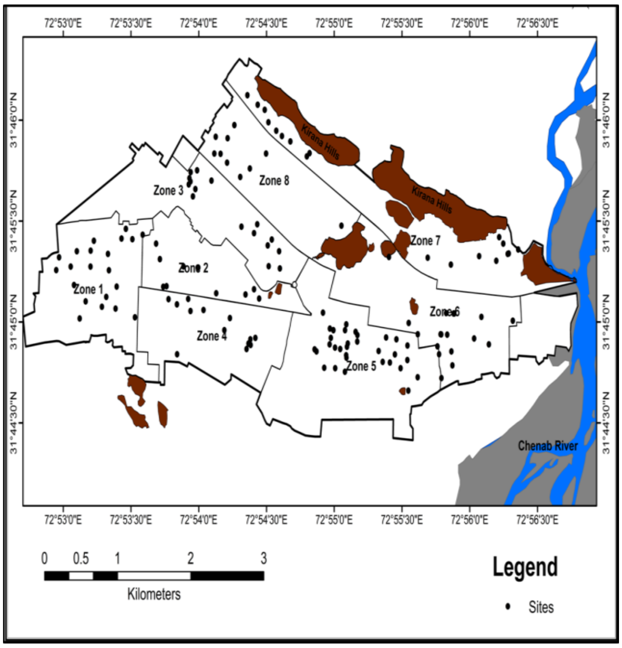

Fig. 2a Sampling locations for 142 samples analyzed for pH, EC, TDS and alkalinity.

by GARMIN GPS receiver. The area is divided into eight administrative blocks. Samples were collected from all of these blocks. Procedures adopted for quality analysis and GIS mapping are discussed below.

Physical and Chemical Analysis

A total of 142 samples were collected from private water wells. The depth of these wells varied from 35 to 213 feet. Before sampling, pumps were allowed to run for 5 minutes. All 142 samples were analyzed for EC, pH, total dissolved solids (TDS) and alkalinity. We selected 40 samples for analysis of hardness, Ca, Mg, SO_4, Cl, NO_3, and F. Electric conductivity (EC) and pH were recorded by using conductivity and pH meters respectively. TDS was calculated by an evaporation method. Hardness, Ca, and Mg were analyzed by complexometric titration. Concentrations of SO_4, NO_3, and F were determined by the spectrophotometric method.

The results were compared with standards set by the World Health Organization (WHO, 2008).

GIS mapping

ArcGIS software was used to plot sampling locations and to interpolate analyzed different parameters. Based on the data obtained from each location a map was prepared showing the positions of sampling sites (Figs. 2a, 2b). Analyzed results were imported as attributes of the point layer. Interpolation was performed by Inverse Distance Weight (IDW) method to generate spatial distribution maps of analyzed physical and chemical

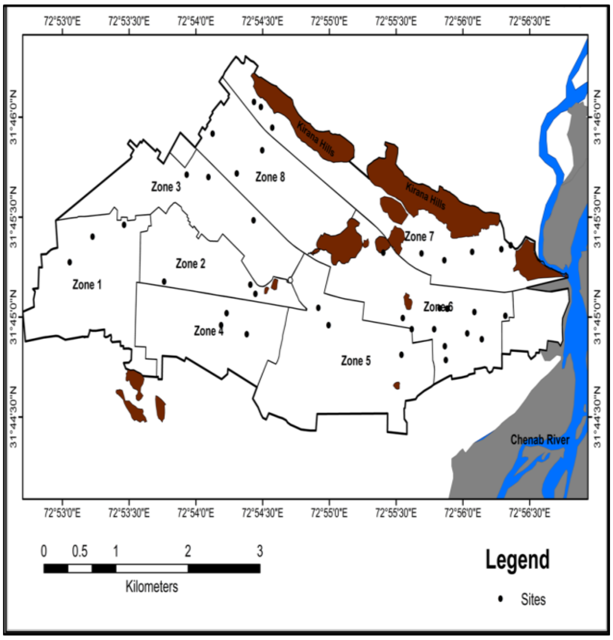

Fig. 2b Sampling locations for samples analyzed for Hardness Ca, Mg, Cl, SO_4, NO_3 and F.

parameters. In IDW method, a weight was assigned to each point and the amount of weight was dependent on the distance of the point to another unknown point. The IDW derived the value of a variable at some locations using values obtained from a known location (Watson and Philip, 1985).

Results and Discussion

The results of different physicochemical parameters analyzed are given in Table 1. Electric conductivity (EC) in the groundwater samples of the study area is very high. Only 3% of the samples showed EC values less than the maximum permissible limit. Extremely high values of EC (i.e. > 7000 uS/cm) were observed in the samples of Zone 7 and Zone 8 (Fig. 3). The

Table 1 Results of analyzed water quality parameters.

Parameters	No. of samples	Min	Max	Average	Standard Deviation	WHO guidelines	Fit % Samples
pH	142	5.8	8.3	6.97	0.45	7 to 8.5	52
EC (uS/cm)	142	420	19920	4584	3572	600	3
HCO3 mg/L	142	50	550	195	95	500	99.2
TDS mg/L	142	240	12160	2505	2059	500	9
Hardness mg/L	40	140	3700	827	636	500	32
Calcium mg/L	40	48	680	209	139	100	25
Magnesium mg/L	40	5	500	82	95	150	90
Chloride mg/L	40	90	8048	1241	1482	250	20
Sulfate mg/L	40	201.6	2131	884	258	250	2.5
Nitrate mg/L	40	1.66	8.89	4.24	2.75	50	100
Fluoride mg/L	40	0.029	0.074	0.047	0.009	1.5	100

maximum and minimum values of pH were 8.3 and 5.8 respectively. The average pH of water samples of the area was 6.97. Only 52% of the samples showed pH within the permissible limits of the WHO and the rest of the samples had pH values less than the lower recommended limit of 7 (Table 1, Fig. 5). Low pH may cause irritation to eyes, skin and has corrosive effect on fixtures (WHO, 2003). Carbonate alkalinity was not found in the samples tested. Hence, the total alkalinity was due to the presence of bicarbonate. All samples except one showed bicarbonate alkalinity within the permissible limit.

High values of Total Dissolved Solids (TDS) were observed in samples obtained from wells close to the hills. However, samples from the western and eastern parts of the region had relatively lower values of TDS (Fig. 5). Hardness is one of the important parameters of water quality used for drinking and domestic uses. Only 13 samples (32%) showed values within the permissible limits (500 mg/L). Very high hardness (i.e. >1000 mg/L) was observed in samples from Zone 8 and western part of Zone 7 (Fig. 6). According to Bellizzi et al. (1999), hard water may produce urinary track calcium stone. The average value of Ca was 209 mg/L, which was higher than the permissible limits set by the WHO (100 mg/L). Most of the samples (75%) showed higher values of Ca than permissible limits. Whereas, ninety percent samples showed Mg values within the permissible limits (Table 1). High concentration of Cl was observed in water samples of the area. The average value of Cl in the samples was 1241 mg/L, which was far above the maximum permissible concentration of 250 mg/L. Interpolated GIS map showed high values throughout the area. However, extremely high values (i.e. > 4000mg/L) were observed in areas close to hills (Fig. 7). High chloride levels cause corrosion and shorten the life of pipes, pumps, hot water heaters and other such fixtures (Adeloju and Hughes, 1986). The average value of sulfate concentration was 884 mg/L, which was significantly higher than the WHO prescribed upper limit of 250 mg/L. Except for one, all samples showed higher values compared to WHO standards. IDW

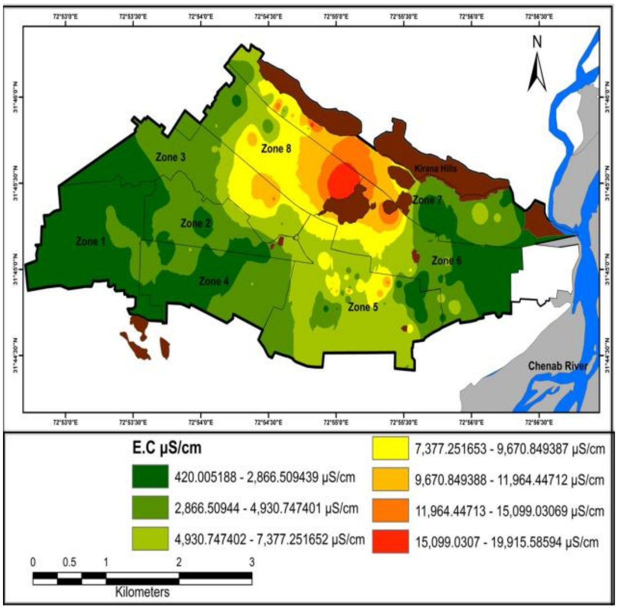

Fig. 3 IDW map of EC for 142 samples. Very high values were observed along the hills.

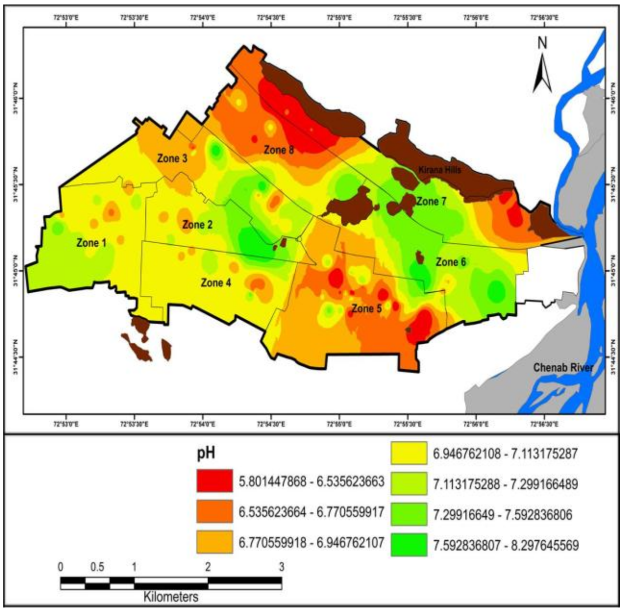

Fig. 4 IDW map of pH values for 142 samples. Relatively low pH was observed in Zone 8, 7 and 5.

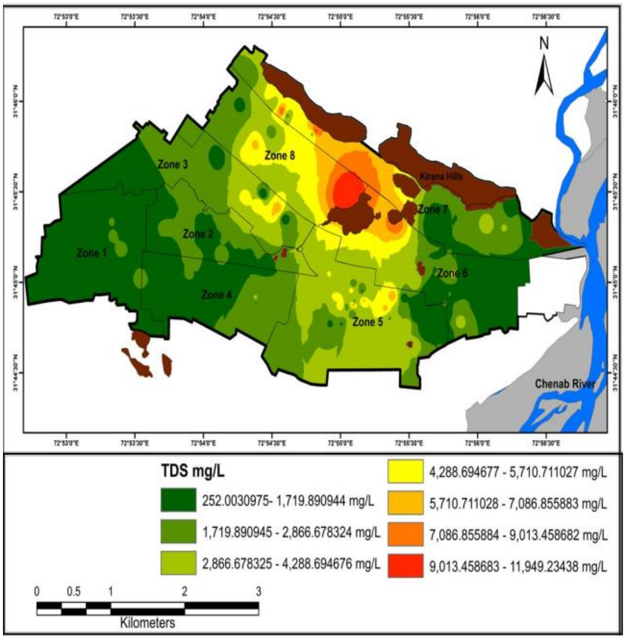

Fig. 5 IDW map of TDS for 142 samples. Generally, high values of TDS were observed in the area.

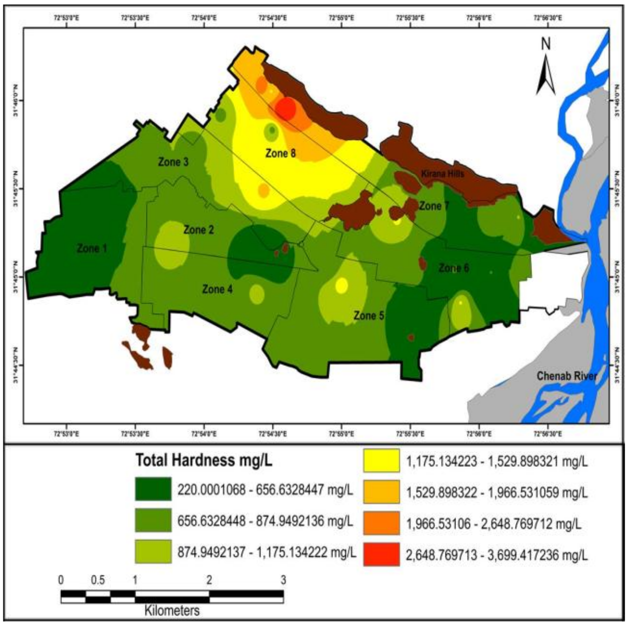

Fig. 6 IDW map of hardness. Very high values were observed in Zone 8 and the western part of Zone 7.

interpolated map showed higher values throughout the area (Fig. 8). High concentration of SO_4 in drinking water may have laxative effects on the digestive system of human beings (WHO, 2004). The presence of sulfate in drinking water also results in a noticeable change in the taste. Elevated sulfate levels can cause health concerns, when there is an abrupt change from drinking water with low sulfate concentration to drinking water with high sulfate concentration. The high concentration of sulfate may also contribute to the corrosion of water pumps and other equipment used to pump water out (WHO, 2004). Nitrate and Fluoride levels were within the permissible limits (Table 1).

High values of EC, TDS, Cl, Ca, SO_4, and hardness were observed in water samples of the area. Some parameters were particularly high close to the hills. Water quality was relatively better in the western and eastern parts of the area. The possible recharge of aquifers in the area is through flooding and horizontal recharge by the Chenab River. The areas close to the hills are higher ground and thus rarely flooded, whereas eastern and western parts are sometimes flooded when the river overflows. Moreover, the area close to hills has fine sediments and shallow basement. The combination of relatively impermeable alluvium and the shallow bedrock may locally impede the movement of groundwater. Therefore, the rate of recharge is less than the rate of withdrawal and this makes the quality of water poor. Values of EC and Cl were relatively low at > 150 ft depth (Figs. 9, 11). The pH was also within the permissible limits at greater depths (>150 ft) (Fig. 10). Hence, deeper aquifers may

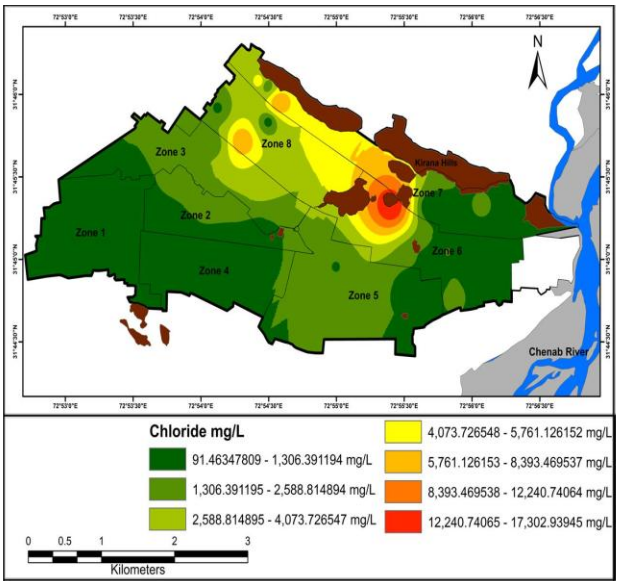

Fig. 7 IDW map of chloride. High values were observed in some parts of Zone 7, 8 and 6.

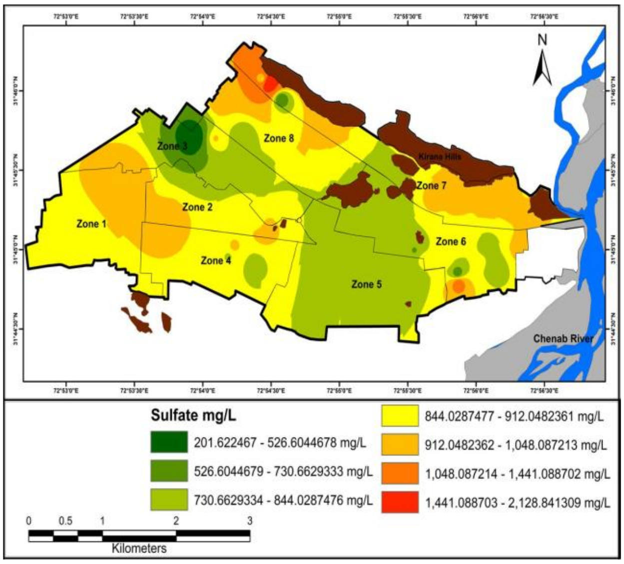

Fig. 8 IDW map of sulfate. High values were observed throughout the area.

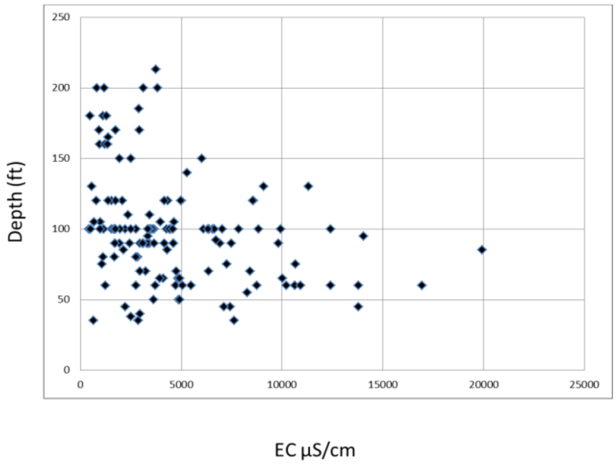

Fig. 9 EC and depth plot. Relatively low EC values were observed at greater depths (>150 feet).

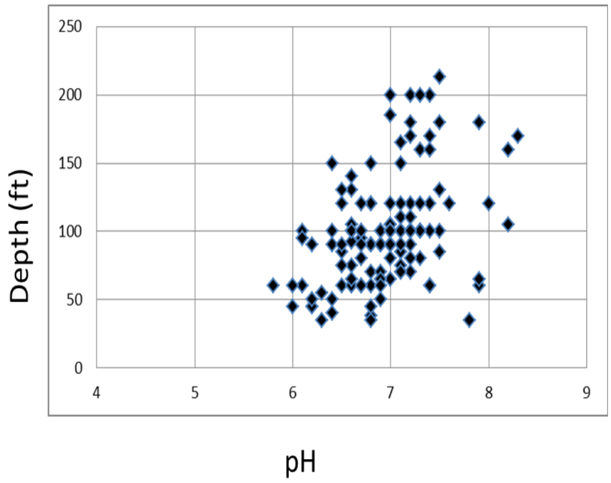

Fig. 10 pH and depth plot. At greater depths (>150), pH values were within the permissible limits.

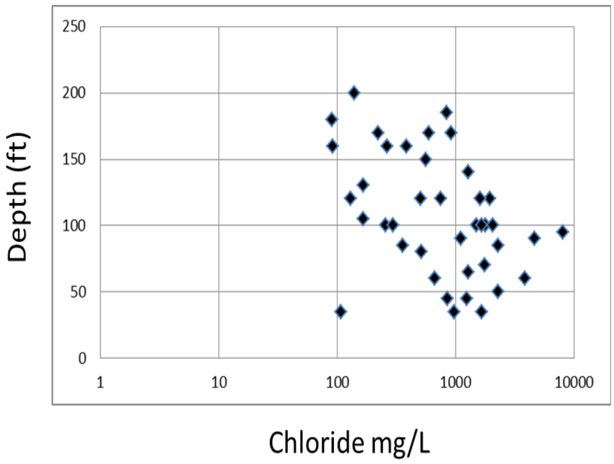

Fig. 11 Chloride and depth plot. Chloride concentration was inversely proportional to depth. X-axis is in logarithmic scale.

be a better source of water. However, extensive withdrawal of water from these aquifers may cause deterioration in water quality at this level.

Conclusions

The average values of EC, TDS, hardness, Ca, Cl, and SO_4 were extremely high in water samples of the area with respect to the permissible limits set by the WHO. More than 50% of the samples revealed lower pH values than the WHO prescribed limits. The poor water quality may have severe economic and health consequences on the local population. The groundwater of the area should be treated to remove excessive salts and neutralize the pH for drinking and domestic use. GIS maps of physicochemical parameters identify zones of poor quality groundwater. This information will help the local community and the administration to select an appropriate water treatment method. Spatial distribution maps of various parameters can assist to plan wells in future as well.

References

Adeloju, S. B., Hughes, H. C. (1986). The corrosion of copper pipes in high chloride-low carbonate mains water. *Corrosion Science*, **26**, 851-870.

Ahmad, S. A., Chaudary, M. N. (2009). Crystallization history of the Kirana Volcanics Sargodha. *Geol. Bull. Punjab Univ.*, **44**, 1-8.

Bellizzi V., De Nicola L., Minutolo R., Russo D., Cianciaruso B., Andreucci M., Conte G. (1999). Effects of water hardness on urinary risk factors for kidney stones in patients with idiopathic nephrolithiasis. *Nephron*, **81**, 66-70.

Greenman, D. W., Swarzenski, W. V and Bennett, G. D. (1968). Groundwater Hydrology of the Punjab, West Pakistan With Emphasis on Problems Caused by Canal Irrigation. *United States Geological Survey Water Supply Paper, 1608-H.*

Watson, D. F., Philip, G. M. (1985). A refinement of inverse distance weighted Interpolation. *Geo-Processing*, **2**, 315- 327.

WHO, (2001). Water health and human rights. The World Water Day.

(http://www.who.int/water_sanitation_health/humanrights/en/).

WHO, (2003). pH in Drinking-water. WHO/SDE/ WHO/03.04/12.

(http://www.who.int/water_sanitation_health/dwq/chemicals/en/ph.pdf).

WHO, (2004). *Sulfate in Drinking-water*. WHO/SDE/ WSH/03.04/114.

WHO, (2008). Guidelines for drinking water quality, 3rd ed. **1**, Geneva.