

## Spatializing Groundwater Quality Parameters and Their Impacts on Land Value in Khushab City, Punjab, Pakistan

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**Abstract:** This research was designed to examine the spatial variation in land value in response to ground water quality in Khushab city, Punjab Pakistan. There were four Physical and five chemical parameters such as pH, Electric Conductivity (EC), Calcium (Ca), hardness, Magnesium (Mg), Total Dissolved Solids (TDS) concentration, taste, color and odor were tested for groundwater quality appraisal in the study area. There were one hundred water samples collected from different wells in the study area. Thereafter, the water quality parameters were processed in ArcGIS for analyzing spatial distribution of groundwater quality parameters by using interpolation and geostatistical tools. It was found that all the groundwater parameters were higher than the permissible limit by WHO except pH concentration. It was further revealed that the ground water was unsafe for drinking and domestic purpose. Variation in land price was also studied with special reference to ground water quality. It was concluded that the groundwater quality has a significant effect on land value in the study area. The deteriorated groundwater quality was proved to be a potent determinant for decreasing land price in the study area.

**Keywords:** Groundwater, GIS, land value, water quality, Khushab.

### Introduction

Currently groundwater is the largest available source of freshwater. It has huge potential and ensure for great demand of water in future (Priyantha, 2011). Quality of groundwater seems to decrease the price of adjacent property because ground water is vital source for drinking use in the world. Ground water has become contaminated through human activities and climate change. Its quality is deteriorating day by day and by municipal, commercial, industrial, and agriculture waste. Contamination of groundwater has created different problems such as poor quality of drinking water, high clean-up cost and health problems (Nas and Berkday, 2010). Assessment of groundwater quality involve estimation of chemical, physical and biological water nature (Engle and Navulur, 1999).

The quality of groundwater is a vital resource of human being. Due to industrialization, urbanization and population explosion, the disposal of large volume of waste from urban centers and major cities which deteriorate the quality of ground water (Balogum et al., 2012). Groundwater pollution occur when any foreign substance or waste products alters the chemicals and biological characteristics of water and damages the qualities so that humans, plants and animals are affected. Various studies have observed this association between groundwater contamination and land use (Eckhart and Stackelberg, 1995).

Use of GIS technology has greatly shortened the environment, commonly used for estimation of groundwater suitability (Engle and Navulur, 1999). Assessment of groundwater quality has greatly simplified by using GIS technology (Khan et al., 2011).

Use of GIS technology is very helpful tool to determine the ground water quality of an area, its problems, solutions, implementations, recommendations and management at local and regional scale (Shabbier and Ahmed, 2015). Spatial distribution of ground water, its quality, depth etc. can easily find out by GIS which is an essential tool for ground water planning and management strategies (Adhikary et al., 2012). The objectives of this research were, to find out the effect of groundwater quality on land value of the study area, to identify the status of groundwater quality in study area and to monitor the water quality in Khushab city by using GIS.

### Study Area

The present study was conduct in sub-urban area of Khushab city, Punjab, Pakistan (Figure. 1). Khushab city is located at 32.30°N, 72.34°E. Khushab is situated between the District of Mianwali and Sargodha. The Jhelum River flows in the east of the study area which separates Khushab from Shahpur Tehsil of Sargodha district. Khushab city lies in District Khushab. Its climate is the arid to semi-arid Jhang district lies on the south- east in Khushab district. Mianwali and Bhakkar district lies in the west of study area. The total area of Khushab is 6,511Km<sup>2</sup> areas. There are three Tehsil of the district that are Khushab, Noorpur and Quaidabad. The maximum temperature goes up to 45.6°C in summer and 5.5 to 13°C in winter and average annual precipitation is 150 to 350 mm (Chaudhari. *et al.*, 2014).

### Materials and Methods

This study included primary data of groundwater sampling which is collected from hand pumps. GPS

was used for recording exact location of the sample's points. In the research geographical and statistical techniques have been used to analyze the data and to identify the quality of groundwater and its spatial distribution. Different maps are created in ArcGIS software. A field survey was conducted and data was collected by using rational sampling. Hundred groundwater samples have been collected from the Khushab city. Majority of the peoples have used electric pumps to fetch water while few used hand pumps. After collection, all of samples were tested for physical parameters and chemical parameters in District Water Testing Laboratory Public Health Engineering Division Khushab in Khushab city. In this research, total nine (9) parameters of groundwater were tested in which four were physical parameters and five were chemical parameters. Physical parameters were taste, color, odor, and pH. While, important chemical parameters have been tested, were magnesium (Mg), calcium (Ca), Total Dissolved Solids (TDS), Electrical Conductivity (EC) and hardness. These results were with World Health Organization (WHO) guideline. These parameters were used to observe the quality of water for drinking use. Result of these parameters were compared with WHO standards. The data of land value has been received by using a questionnaire through survey in the same points where the water samples were collected. Hundred questionnaires were filled in by people of these areas.

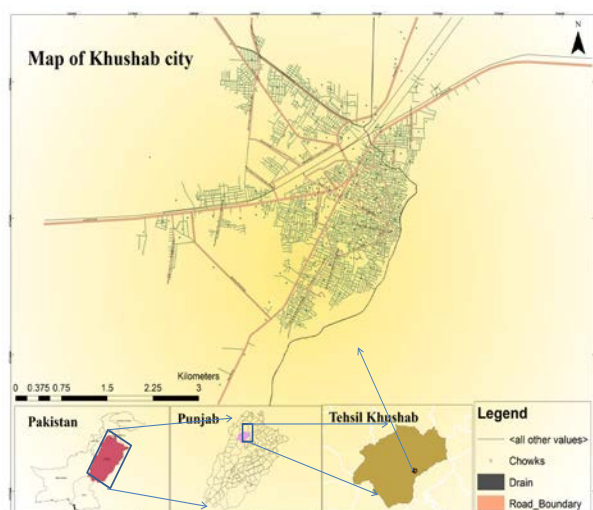


Fig. 1 Khushab city (study area) District Khushab, Punjab, Pakistan.

Results of laboratory tests were first arranged in MS Excel for tabulation and calculation of results, and then plotted in ArcGIS for the evaluation of spatial distribution of these ground water parameters. Interpolation method was used to plot point data of water. Groundwater depth which was marked by asking people, was analyzed and seven classes of map were generated using equal interval classification method. Geostatistics methods through kriging module in ArcGIS 10.1 were used to generate the spatial distribution of groundwater parameters in the study area.

## Results and Discussion

This section the result of groundwater quality, which were tested from the district water testing laboratory public health engineering division Khushab in Khushab city and per Marla land value and relationship between ground water and land value. This section covers the water quality analysis of Khushab city. Results of physiochemical and spatial distribution of parameters are presented and describe individually according to Performa. Location for the sample collection in different area of cities was selected, keeping in view the source from where most of the people consumed water for drinking purpose. Total 100 permanent locations were selected for the collection of the water samples and for per Marla land value.

### Physiochemical Parameters of Groundwater

Water quality has physical, chemical and organic attributes of water in to the set of standards or guidelines. These parameters or guidelines directly associate to the safety of the drinking water for human use. Water quality parameters give vital data about the health of water body. These parameters are used to observe the quality of water for drinking use. During field survey the physical and chemical parameters of water collected. These 9 parameters are such as, Ca, Mg, TDS, hardness, EC, taste, color, odor which was included in the World Health Organization standards. These parameters Ca, Mg, total dissolved solids fall under the category of chemically derived contaminants. The result of these parameters was compared with WHO standards.

### Physical Parameters

Water has no colure. It is a colorless liquid, however. It has some level of color. Color in groundwater can start from decay of natural matter and spillage through sewage. In 100 water samples only 9 samples are safe and clear water for drinking and only 10 residents have used slightly yellow water (Figure: 2). The primary reason for the change in water color was the over extraction of water and lowing water table with passage of time.

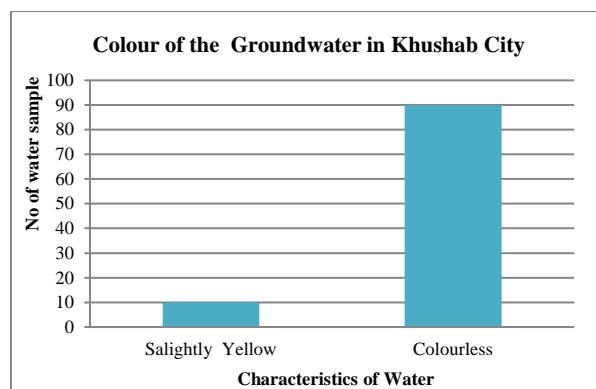


Fig. 2 Color of the groundwater in Khushab city.

Different factors are affecting to change the taste of water such as including rotting organic matter, living organisms, iron, mixing waste and so forth. Quality of water is good except some patches. Resident have only 14 out of 100 water quality samples which have normal and brackish water (Figure: 3). Major sources of changing ground water taste were observed as sewer spillage, drainage of canals and over extraction of groundwater. The poor residents of this slum area were forced to utilize lethal water because they were not able to manage the cost of mineral water and so on.

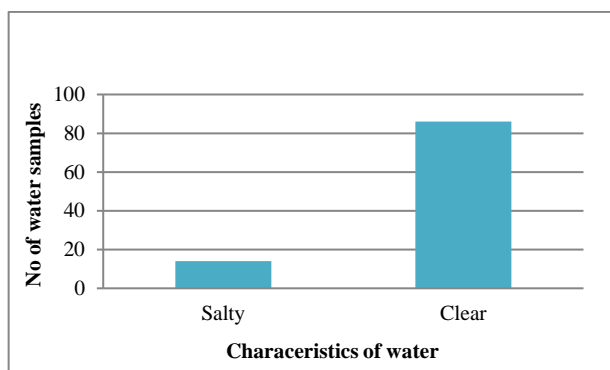


Fig. 3 Taste of the groundwater in Khushab city.

There, the water was light smell, no smell and fast smell water (Figure: 4). In Khushab city, water has no smell except few patches. These patches are affecting by sewage canal. The sewage canal/ drainage is passing into city and drain into the Jhelum River. The level of fast smelled water in this area is additionally higher as compare to other study areas.

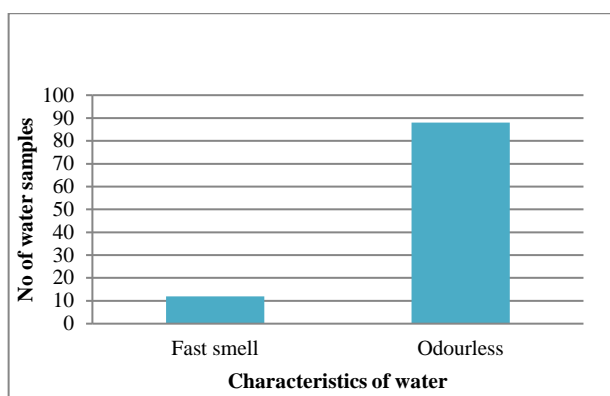


Fig. 4 Odor in groundwater in Khushab city.

The pH of unadulterated water is referring to the measure of hydrogen water fixation in water. Generally water pH ranges from 6 to 8.5. It seems that water with low pH tend to be harmful and with high level of pH, it is transforming into harsh taste. Standard of pH of water according to WHO to be 6.5 to 8.5. pH value observed at 6.9-8.7 in Khushab city (Figure: 5). Hence, in the study area the pH value was not crossed the standard limits however these were falling in basic or alkaline range.

### Chemical Parameters

Chemical parameters are five: Total dissolved solid (TDS), Electrical Conductivity (EC), Magnesium (Mg) and Hardness, which have been tested for the analysis of chemical quality of water.

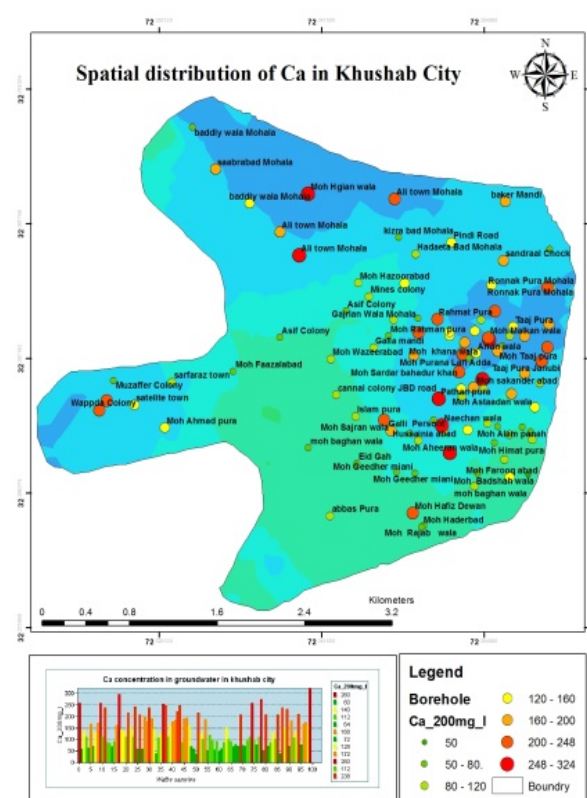


Fig. 6 Spatial distribution of TDS in Khushab.

Water can dissolve an extensive variety of inorganic and some natural (organic) minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides,

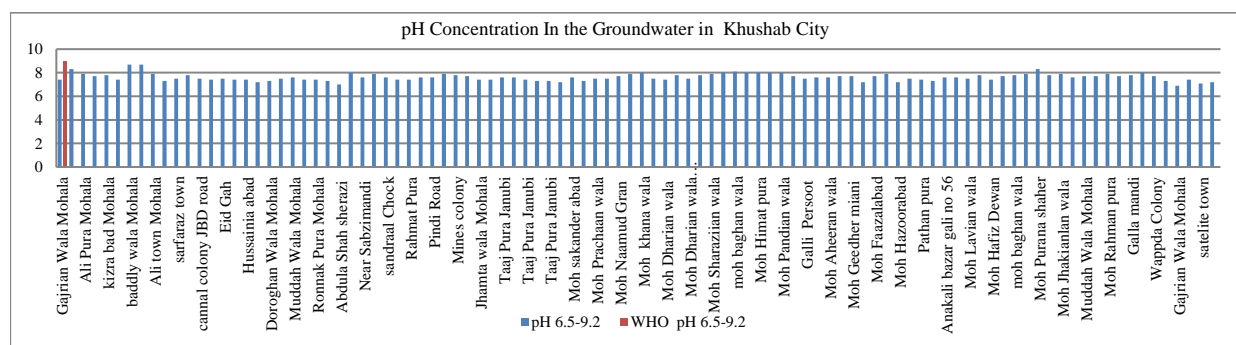


Fig. 5 pH concentration in groundwater in Khushab city.

magnesium, sulphates etc. These minerals produced undesirable taste and color in appearance of water. TDS in drinking water are originate numerous courses from sewage to urban industrial waste water We recorded very low range 290 and very high value 5600mg/l in Khushab city (Figure: 6). Hence, these ranges were not acceptable and concentration of TDS is very harmful. Show in graph (Figure: 6) that the concentration of TDS is high in all colonies of Khushab city. TDS cross the WHO standard limits. Only few colonies have below the WHO standard. WHO standard of TDS is 1000 mg/l.

Generally, the amount of dissolved solid in water determines the electrical conductivity. EC is measuring the ionic process of solution that make possible it to transmit current. According to WHO standard EC value should not exceeded 800 uS/cm. In study area, EC value esteem high as compared to WHO standard (figure 7). As shown in graph (Figure 7), the EC concentration is very high in almost all Mohala of the city. WHO standard is 800 uS/cm but EC is above the WHO standard which is very harmful for wellbeing.

162mg/l and very low in Latifabad Mohala 2.6mg/l (figure 8). The quality of magnesium is significant low in other Mohalla in Khushab city. Shown in graph (Figure:8) Mg concentration in Khushab are below the standard limits only Gajrian wala Mohala and Sardar Bhadur shah have crossed the limits of Mg.

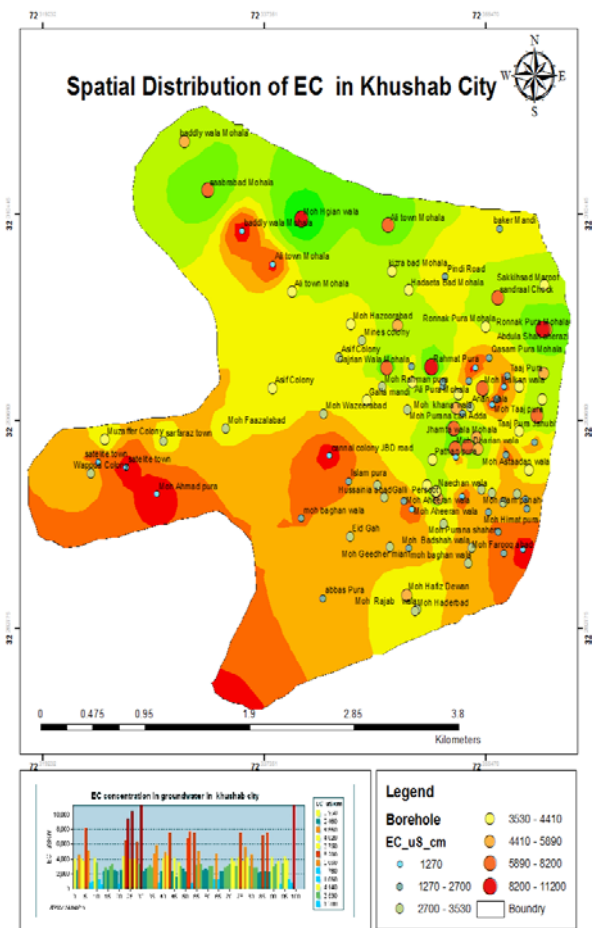


Fig. 7 Spatial distribution of EC in Khushab city.

Magnesium is the natural element of water. According to WHO standard the satisfactory range of magnesium in water should be 150 mg/l. In study areas lowest range of magnesium from 2.6 to high range 162mg/l (figure 8.), but very high in Gajrian wala Mohala

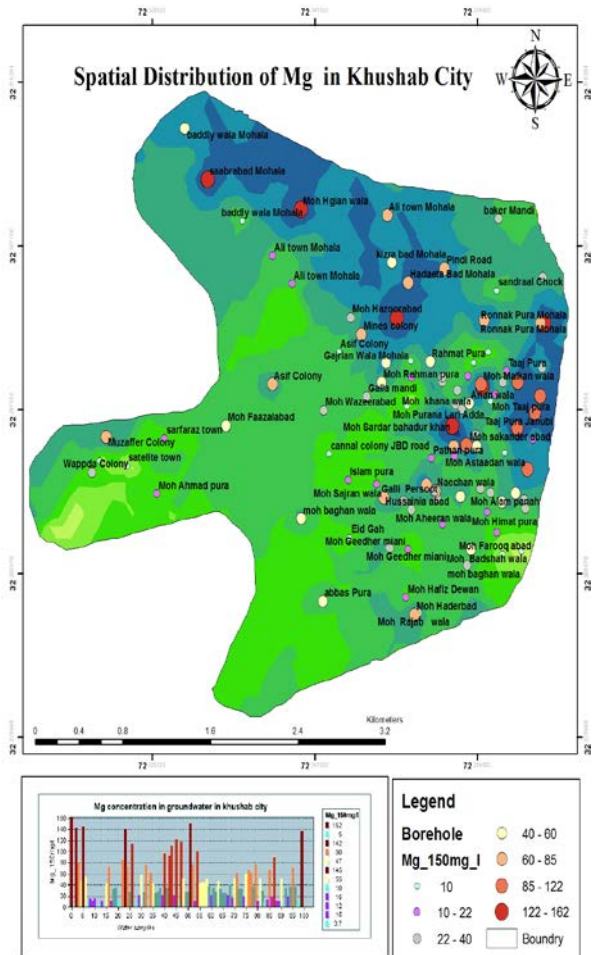


Fig. 8 Spatial distribution of Magnesium in Khushab city.

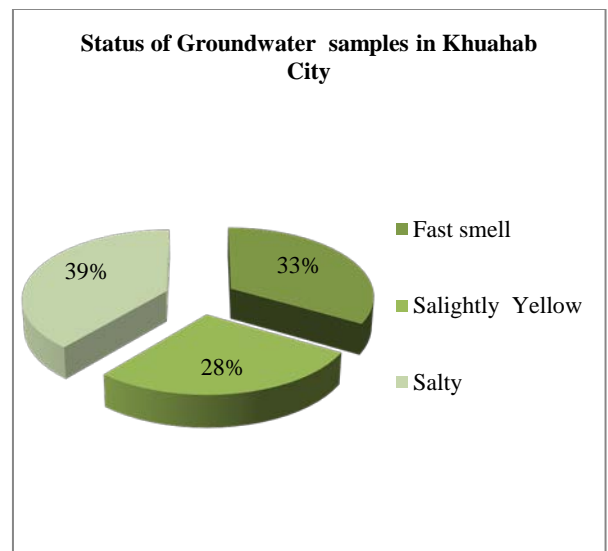


Fig. 9 Spatial distribution of Calcium in Khushab city.

According to WHO standard, Ca acceptable range is 200mg/l in drinking water (figure 9). In study areas where results shown that the 36 mg/l very low concentration of calcium range and 324mg/l very high range of calcium (figure 9). Calcium amount was exceeding the limit by WHO and may unsafe for local residents. Mostly Mohalals of the Khushab have high concentration of Calcium which is not good for health. Calcium is very useful for health if it below the level of WHO standard 200mg/l. Mohala Aheeran wale, Hagian wala and Pathan pura have very high concentration of Ca, which is shown in graph (Figure. 9).

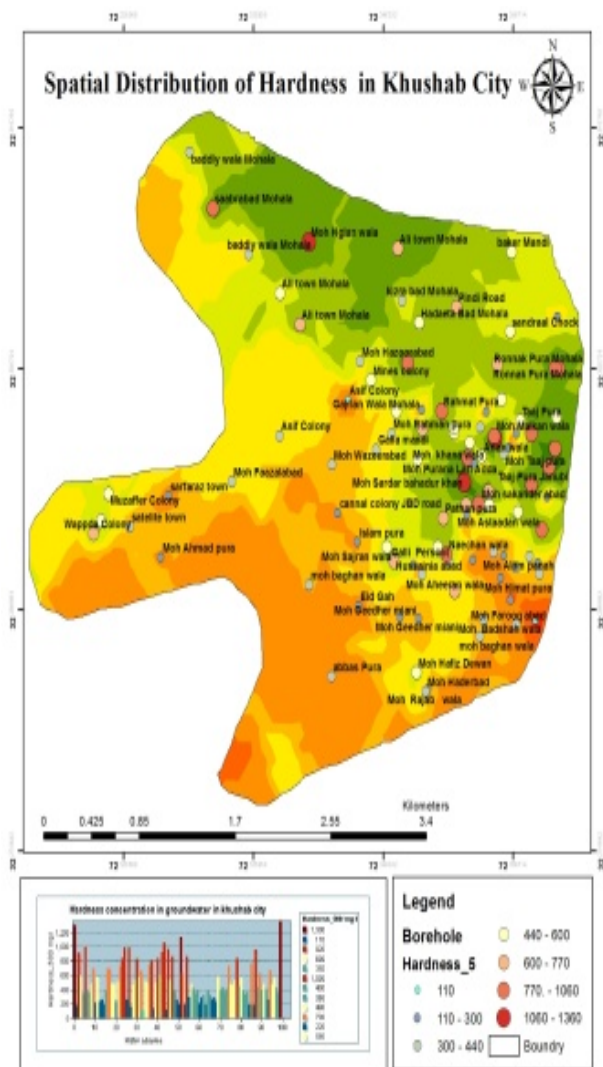


Fig. 10 Hardness concentration in the groundwater in Khushab city.

Hardness of water is normally measured as calcium carbonate (CaCO<sub>3</sub>) in light of fact that it comprised its predominantly calcium and carbonates the most dissolved ions in hard water. As per WHO hardness of water should be 500mg/l (figure 10). In study areas, hardness ranges from 110 to 1300mg/l. These outcomes clear that hardness of water is very high according to the WHO standard. Shown in graph (Figure. 10), the concentration of Hardness is very high in Khushab city. Which is very dangerous for the

human health? Only few Mohalals of the city have low hardness, but mostly areas exceed the standard limits of hardness.

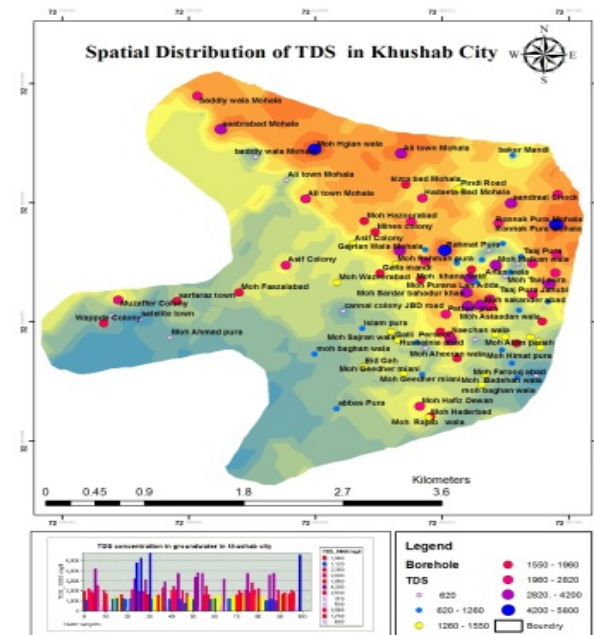


Fig. 11 Status of groundwater samples in Khushab city.

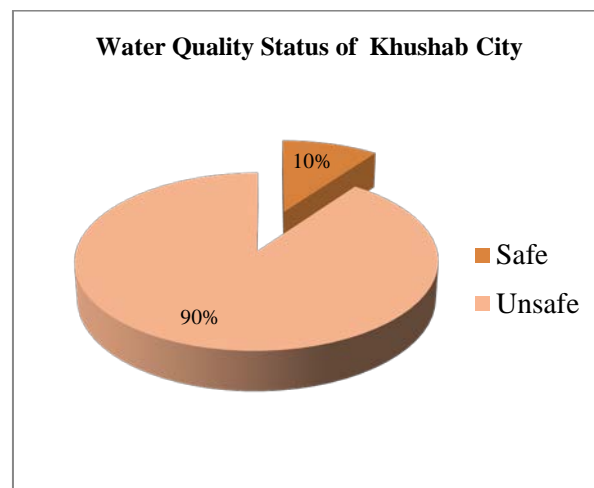


Fig. 12 Water quality status of Khushab city.

### Over All Status of Groundwater Quality in Khushab City

Overall status of groundwater quality is that 33% is fast smell, 39% saltish and 28% slightly yellow in groundwater (Figure: 11).

The underground water of the most of the Khushab city was saltish in nature. There were different numbers of fit and unfit samples (figure. 12). There were 100 samples of water. 10 samples were safe and the unsafe samples were 90 (figure. 12). The unfit samples were due to having high amount of EC conductivity in micro Simon per cent meter hardness and high level of TDS. And some peoples use portable

water and government water supply water in Khushab city.

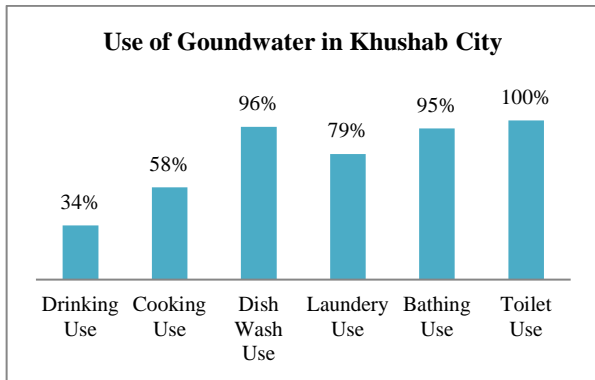


Fig. 13 Use of groundwater in Khushab city.

After result of serving the overall the water of Khushab city are unsafe for drinking purpose due to high level of hardness. Mostly people used portables water or water supply water and the groundwater are used for other purpose like drinking use, cooking, dish wash, laundry, bathing and toilet used (Figure 13).

**Comparison of Difference in Per Marla Land Prices Due to Water Quality**

We studied the spatial distribution of land value of Khushab city. The land value in Khushab city is not equally distributed. It is different from one place to another place (Figure 14). The final data set indicated that the water quality has significant effect on land value.

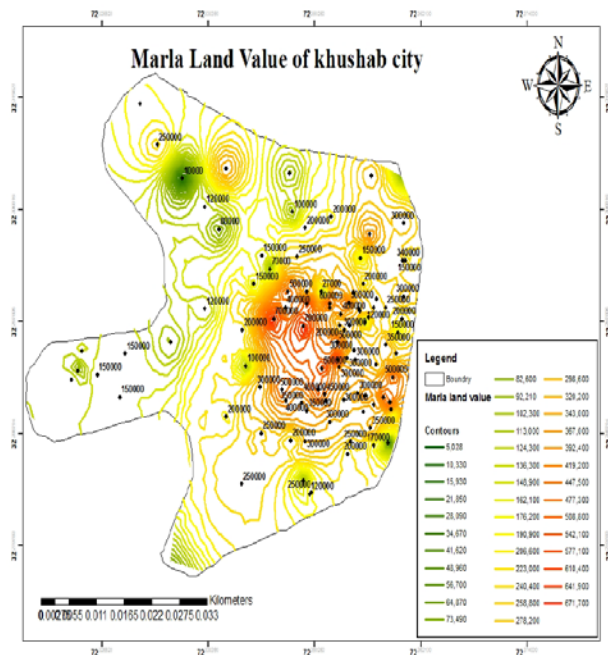


Fig. 14 Land value in Khushab city.

Spatially, the central part of the study area has high land prices and the land price is low as we go beyond

the central part of the Khushab city because the central part has many facilities. The land prices are also affected by the availability of facilities but there the quality of water is the main factor in the difference of land prices. The central part of the study area has the price range of land from 300,000 to 700,000. The fluctuations in land prices at same location is due the change of water quality. Overall, the main central part of the city has almost the medium range of physio-chemical parameters of water has been found. Almost, the concentration of all parameters remained high in the study area according to the standard of WHO (Figure: 14). In the eastern side of central side, there are two Mohala which have the prices of 500,000 and 600,000 but around these two, there are few points where the land price is 300,000 at the same location. So, the water quality is the reason behind the variations in land prices.

The range of parameters in most sample points in the northern side of the study area has been remained high from WHO standard. These points have almost lowest range of land prices from 10,000 to 100,000. Northern side is a peripheral area but the water quality is main reason behind its low land value because there are some points at the same location which has high land prices due to the better water quality from 100,000 to 350,000 (figure: 14). The western side of the study area has almost same water quality so the piece is also same as 150,000. Water quality is better here. That's the reason, the price is most high than the north-western side of the study area. Sothern side of the study area has same price of land because there the water quality is also same here. The eastern side of the study area has many fluctuations in water quality. So, this is the reason the land value has great variations in the eastern side of the study area. There, the land price is from 500,000 to 150,000. So, the analysis showed that land value has many fluctuations due to its water quality (Figure 14).

**Conclusion**

The study estimated the variability in land values due to its water quality. The results of physio-chemical parameters showed the significant spatial variation in the Khushab city. Groundwater quality in Khushab is deteriorating like in other main cities of Pakistan. All most all area of Khushab city has high concentration of TDS and hardness. The results of all parameters crossed the allowable values built by WHO. Correspondingly, the pH value of water tests was the neutral limit. Ground water quality is unsafe for drinking use due to highly toxicity in Khushab city. Decreasing property values, due to continue deteriorating of ground water and its quality, has been affected the land price. The north and north-eastern side has many points where the water quality is very poor, there the prices are very low than the surrounding where the water quality is better. Water quality is better in southern and western side of the

study area. There, the land value is almost same at every point. But the north, east and central parts of the study area has many fluctuations in land prices because there, the water quality has also many variations from point to point. Protection of water quality is important for the land prices in city. There, land price is different to each other due to its water quality.

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