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PHYSICAL ANALYSIS OF GROUNDWATER AT THICKLY POPULATED AREA OF FAISALABAD BY USING GIS

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Groundwater is the major source of drinking and soil pollution deteriorates its quality. The study was conducted in the area of Ghulam Muhammad Abad, the most thickly populated area of District Faisalabad, Pakistan. Primary information was collected by conducting the general survey of the area. Sampling was done by dividing the entire area into six zones. A total of 159 groundwater samples were collected from newly installed pumps at the depth of 90ft. The samples were then tested for physical parameters as EC (electrical conductivity), pH, TDS (total dissolved solids), TS (total solids) and TSS (total suspended solids). Test results were compared with the guidelines given by WHO (World Health Organization), and standards drafted by PSI (Pakistan Standard Institution). GIS analysis was done by using ArcGIS v 9.2. These parameters were analyzed in drinking water with respect to drinking purpose. EC of samples ranged from 0.07µS/m to 6.04µS/m. Only 8 samples were found within the permissible limit given by WHO, i.e. 2.50µS/m. GIS analysis showed that most of the area have EC greater than permissible limit. pH value ranged from 2.19 to 6.20. All the samples were found below the permissible limit given by WHO, i.e. 6.5 to 8.5. GIS map for pH indicated that almost 80% area has the pH value ranging from 4.90 to 5.21. TDS in groundwater samples ranged from 309mg/L to 3530mg/L. Only 2 samples were found within the permissible limit given by PSI, i.e. 1500mg/L. GIS analysis revealed that almost 50% area lies under high concentration of TDS. TSS in samples varied from 3mg/L to 2222mg/L. There were no guidelines for TSS in drinking water but are supposed to be near to 0mg/L in groundwater. TS in groundwater samples varied from 400mg/L to 5200mg/L. High value of TS effect the value of EC and TDS. Hence, all the values of physical parameters revealed that the groundwater of the area is not suitable for drinking purpose and needs to improve the groundwater quality of the area.
Keywords: Groundwater, spatial variability, Faisalabad

INTRODUCTION

Water covers almost 70.9% of the surface of earth, and is essential for all forms of life. On earth, it exists in oceans and other huge water bodies, with 1.6% of this water under ground in aquifers and 0.001% of water in the air in the form of vapors, clouds and precipitation. Oceans contain 97% of water on surface, 2.4% glaciers and polar ice caps and 0.6% other surface water such as rivers, lakes and ponds (Wikipedia, 2011).

Water is the elixir for life. Life without water cannot be imagined and is thought to be impossible. It is the major requirement of the whole world. Water exists naturally in two forms, surface water and groundwater. Groundwater plays an important role as it is the primary source of water. Groundwater is the mixture of various contents because it passes through the underground rocks and during its passage it comes in contact with variation in formation for residence, which makes it for serving into various purposes (Ramkumar *et al*., 2009).

Water quality of main cities of Pakistan like Sialkot, Gujarat, Faisalabad, Karachi, Qasur, Peshawar, Lahore, Rawalpindi and Shekhupura deteriorates due to the uncontrolled disposal of urban wastewater and untreated industrial and excessive use of fertilizers and insecticides (Bhutta *et al*., 2002)

Groundwater is the major source of drinking and industrial water use. In several cities, the level of groundwater is lowered due to the increased pressure on groundwater. Water table has dropped more than ten meters in several areas. Therefore, the quality of groundwater is also influenced by the continuous use of groundwater (Kahlown and Akram., 2003).

GIS is an effective tool for monitoring the groundwater quality, evaluating the spatial variability of groundwater quality and modeling of environmental change detection (Skidmore *et al*., 1999).

The exclusive nature of learning process through GIS based on inquiry is the attention on spatial characteristics and location. The base of geographical thinking is to understand "where something is, how its location influences its characteristics, and how its location influences relationships with other phenomena (ESRI, 2003).

GIS can be a powerful tool for developing solutions for water resources, determining water availability, preventing flooding, understanding the natural environment and managing water resources on local and regional scale

(Tjandra *et al*., 2003). Keeping this in view, GIS and field studies we have investigated for the evaluation of spatial variability in groundwater quality of Ghulam Muhammad Abad, Faisalabad.

MATERIALS AND METHODS

Study area: The area of Ghulam Muhammadabad Faisalabad was selected for this study with the criteria; i) The area is thickly populated, ii) a drain passes through the area which has some unlined portion that passes through some area of Ghulam Muhammad Abad Faisalabad, iii) there are jet pumps and the people are using groundwater for different domestic purposes including drinking, iv) water samples were taken from newly installed pumps.

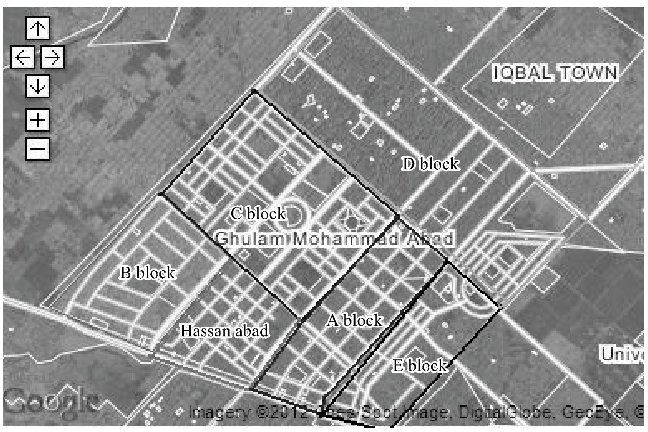

Figure 1. View of Ghulam Muhammad Abad Area, Faisalabad, Pakistan

Sampling plan: Plan was prepared to check the different water quality parameters in groundwater samples taken from different areas of Ghulam Muhammad Abad, Faisalabad. The whole area of Ghulam Muhammad Abad is divided by Union Council into five blocks namely A, B, C, D and E and a Mohallah named Hassan abad. Samples were randomly taken from the whole area from newly installed pumps to investigate the level of different water quality parameters in the groundwater. The newly installed pumps were selected to maintain same water level. A total of 159 samples were collected from entire area. 25 from Hasan abad, 25 from A block, 32 from B block, 21 from C block, 47 from D block & 9 from E block.

Location of sample points: The location of sample points was found with the help of co-ordinates of points. The co-ordinates of the sample points were taken with the help of Global Position System receiver (GPS Receiver). Explorsist 210 GPS receiver was used and the coordinates were recorded in UTM projection.

Testing of samples: Samples were tested for physical parameters. Electrical conductivity and total dissolved solids in groundwater samples was measured by using HACH CO 150 Conductivity meter (Tahir *et al*., 2003). The calibration was done by finding the cell constant. The KCl solution of known EC, i.e. 1413 micro Simens was used and the cell constant K was calculated by using the following formula,

K= (Observed EC of KCl solution)/1413

Measurement Procedure:

Turned the meter on by pressing ON/OFF button and then pressed the MODE key to switch in conductivity mode. After the current unit mS (milliSiemens) was displayed, inserted the probe into the sample solution. Immersed the tip beyond the vent holes and agitated the probe up and down. It was assured that air bubbles are not entrapped near the temperature sensor and then waited till readings became stable on screen before recording it and later multiplied it with the cell constant to get the final results. The probe was washed with distilled water before testing the TDS in each sample. Total solids in groundwater samples were analyzed by oven dry method. Weighed the empty china dish, recorded the reading and poured 25 mL of sample in it. The dish was placed in oven for 24 hours at 105 degree centigrade. Then again weighed the dish and recorded the final weight. TS were calculated by using the following formula.

$$TS\ (mg/L) = [(Final\ Wt. - Initial\ Wt)g \times 1000 \times 1000] / 25$$

Total suspended solids were calculated by subtracting TDS from TS.

$$TSS\ (mg/L) = TS - TDS$$

pH of collected groundwater samples was measured by using pH/EC/TDS/Temp. meter (HANNA). (Tahir *et.al.*, 2003).

pH Calibration: pH calibration was done by using the guidelines given in manual.

pH Measurement: pH measurement was done by using the procedure given in manual.

Data analysis by using GIS: Data was analyzed for spatial variations in different blocks by using ArcGIS v9.2. The results were uploaded to MS Excel Sheet. 3D Analyst Tools were selected from extensions and Raster Interpolation was done by using Kriging.

RESULTS AND DISCUSSION

Electrical conductivity: Electrical conductivity in groundwater samples varied from 0.07µS/m to 6.04 µS/m. Only 8 samples out of total 159 samples were laid approximately within the permissible limit, i.e. 2.50 µS/m given by WHO (2006).

The Figure 2 shows the statistical summary for EC of groundwater samples. Standard deviation serves as a basic measure of variability. The value of standard deviation is 1.6678, which shows that the EC value for the most of the groundwater samples lie close to the mean, i.e. 3.3248.

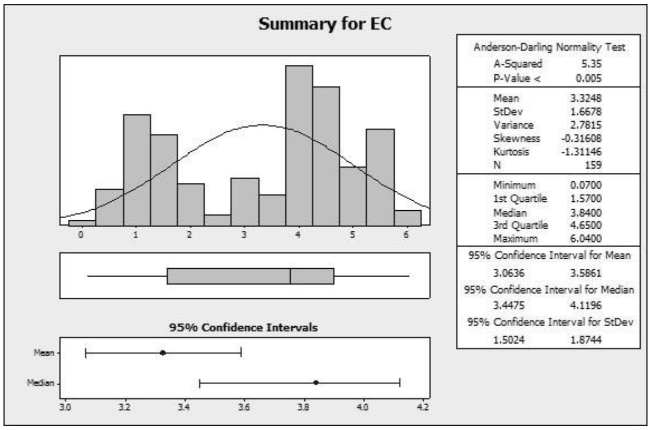

Figure 2. Statistical summary for EC of groundwater at Ghulam Muhammad Abad

The curve for EC is negatively skewed which shows that the model is greater than the median and the median is greater than mean (Fig. 2). It also shows that the value of EC for the samples is not symmetrical but varies from block to block within the research area. Figure 2 also shows that the curve is flat topped which mean that the curve is platykurtic. The platykurtic curve shows that the fourth standardized moment β_2 is less than 3 (Chaudhary and Kamal, 2003).

GIS analysis for the spatial variability in groundwater EC indicates that major area of Ghulam Muhammad Abad has EC lower or higher than permissible limit. Gray colour in the map (Fig. 3) indicates that the samples in this area are somewhat near to permissible limits. But not all the samples of this area lay under the range for drinking water given by WHO. The area of A block and some portion of D block lay under this range.

The area covering white colour in map indicates the EC is lower than permissible limit. Most of the research area lay under this zone. Some area of B Block and a large area of D block lay under this zone. Major area of C block lay in the zone of high EC indicated by black colour on the map. Some part of Hassan abad and B block also lay in zone of high EC.

Total dissolved solids**:** Total dissolved solids in groundwater samples varied from 309mg/L to 3530mg/L. Only 2 Samples out of total 159 samples lie within the permissible limit, i.e. 1000mg/L to 1500mg/L given by PSI. According to (Rout and Sharma, 2011) the acceptable range of TDS is 500 mg/L.

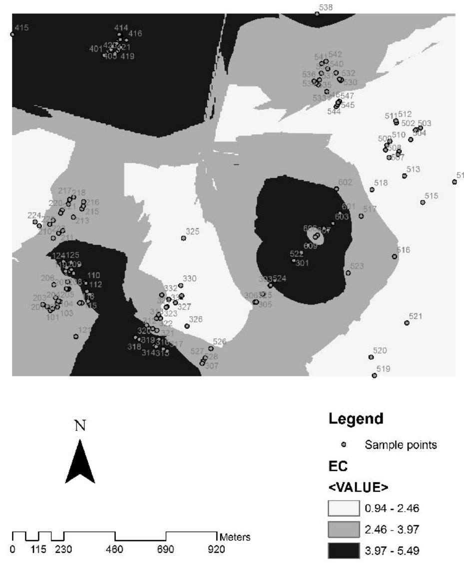

Figure 3. Spatial variability in EC of groundwater at Ghulam Muhammad Abad

Statistical summary for total dissolved solids in groundwater samples is presented in Figure 4. The value of standard deviation is 982.1, which shows that the TDS value of the most of the samples lay close to the mean, i.e. 1822.9. The curve for TDS is positively skewed which shows that the mean is greater than the median and the median is greater than mode (Fig. 4). It also shows that the value of TDS for the samples is not symmetrical but varies from block to block within the research area. Figure 4 also shows that the curve is flat topped which mean that the curve is platykurtic. The platykurtic curve shows that the fourth standardized moment β_2 is less than 3.

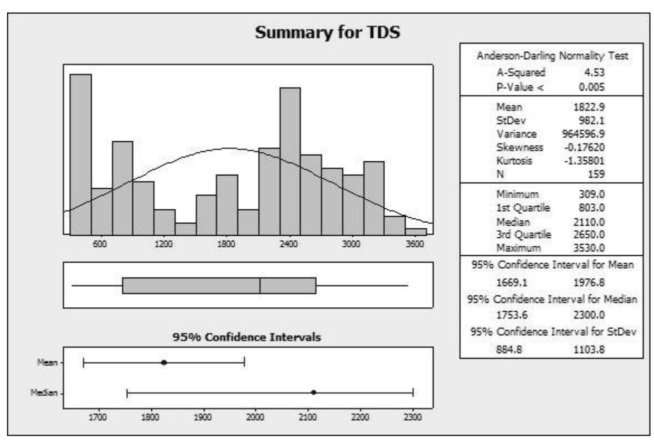

Figure 4. Summary for total dissolved solids in groundwater at Ghulam Muhammad Abad

GIS analysis for the spatial variability in TDS indicates that major area of Ghulam Muhammad Abad has the groundwater with TDS value higher than permissible limit.

Figure 5 shows the spatial variability in TDS. Gray colour in the map indicates that the samples in this area have TDS value between 1415mg/L to 2172mg/L. Only this zone contains some samples which are within the permissible limits. But not all the samples of this area lay under the range for drinking water given by PSI. The area of A Block and some portion of D Block lay under this range.

The area covering white colour in map indicates the TDS value lower than permissible limit. This zone contains the samples which lay in the range from 658mg/L to 1415mg/L. Some portion of B Block and D Block lay under this zone. Major area of C Block lies in the zone of high TDS indicated by black colour on the map. Some part of Hassan abad and B Block also lay in zone of high TDS, i.e. greater than 2172mg/L.

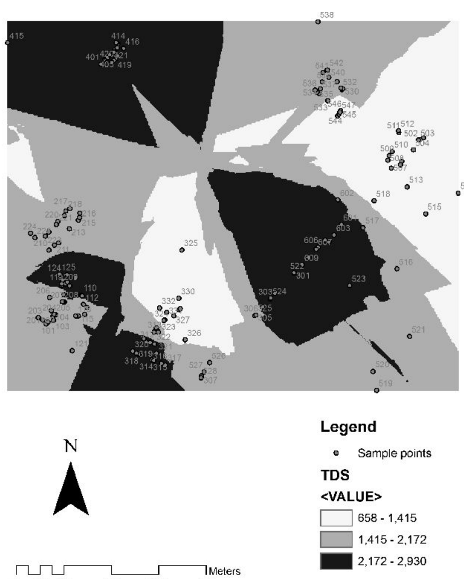

Figure 5. Spatial variability in total dissolved solids in groundwater at Ghulam Muhammad Abad

Total solids: Total solids in groundwater samples varied from 400mg/L to 5200mg/L. There are no guidelines given by any institution or organization for the TS value in drinking water; however, the level of TS in groundwater affects other parameters such as EC and TDS.

The value of standard deviation is 1138.3, which shows that the TS value of the most of the samples lie close to the mean i.e. 2588.7.

Figure 6 shows that the curve for TS is positively skewed which shows that the mean is greater than the median and the median is greater than mode. It also shows that the value of TS for the samples is not symmetrical but varies from block to block within the research area.

Figure 6 also a show that the curve is flat topped which means that the curve is platykurtic. The platykurtic curve shows that the fourth standardized moment β_2 is less than 3.

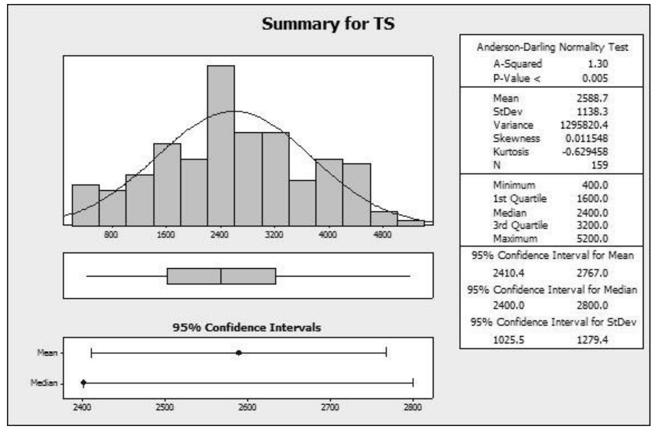

Figure 6. Summary for total solids in groundwater at Ghulam Muhammad Abad

GIS analysis for the spatial variability in TS indicates that major area of Ghulam Muhammad Abad has the groundwater which has TS value much higher.

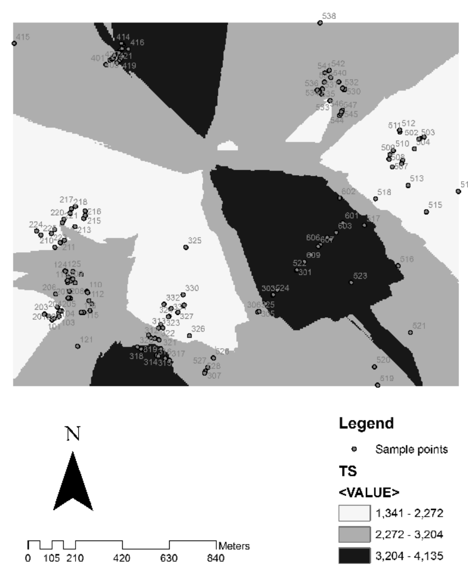

Figure 7. Spatial variability in total solids in groundwater at Ghulam Muhammad Abad

Figure 7 shows the spatial variability in TS. Gray colour in the map indicates that the samples in this area have TS value between 2272mg/L to 3204mg/L. The area of Hassan abad and some portion of B Block and D Block lie under this range.

The area covering white colour in map indicates the lower TS value. This zone contains the samples which lie in the range between 1341mg/L to 2272mg/L. A portion of A Block and some portion of B Block and D Block lies under this zone. Some area of C Block and E Block lies in the zone of high TS indicated by black colour on the map i.e. greater than 3204mg/L.

***Total Suspended Solids*:** Total suspended solids in groundwater samples varied from 3mg/L to 2222mg/L. The permissible limit for TSS in drinking water is 150 mg/L given by EPA. The level of TSS in groundwater affects other parameters.

Statistical summary for total suspended solids in groundwater samples is presented in Figure 8. Standard deviation serves as a basic measure of variability. The value of standard deviation is 601.83, which shows that the TSS value of the most of the samples lie close to the mean i.e. 814.31.

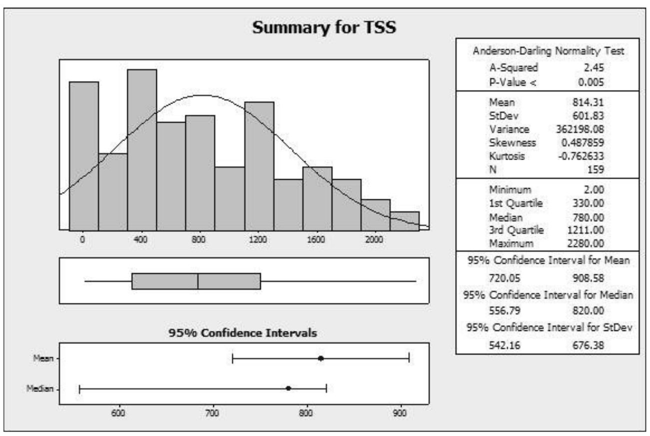

Figure 8. Summary for total suspended Solids in groundwater at Ghulam Muhammad Abad

Figure 8 shows that the curve for TSS is positively skewed which shows that the mean is greater than the median and the median is greater than mode. It also shows that the value of TSS for the samples is not symmetrical but varies from block to block within the research area.

Figure 8 also shows that the curve is flat topped which mean that the curve is platykurtic. The platykurtic curve shows that the fourth standardized moment β_2 is less than 3.

GIS analysis for the spatial variability in TSS indicates that major area of Ghulam Muhammad Abad has the groundwater which has TSS value of 600mg/L to 1100mg/L. Figure 9 shows the spatial variability in TSS. Gray colour in the map indicates that the samples in this area have TSS value between 653mg/L to 1107mg/L. The area of A Block and some portion of B Block and D Block lie under this range.

The area covering white colour in map indicates the lower TSS value. This zone contains the samples which lie in the range between 199mg/L to 653mg/L. A portion of A Block, Hassan abad some portion of B Block lies under this zone. The whole area of E Block and some area of D Block lie in the zone of high TSS indicated by black colour on the map i.e. greater than 1107mg/L.

Figure 9. Spatial variability in total suspended solids in groundwater at Ghulam Muhammad Abad

***pH*:** pH of groundwater samples varied from 2.19 to 6.20 All of the 159 groundwater samples have the pH lower than the permissible limits for drinking water i.e. 6.5 to 8.5 given by WHO..

Statistical summary for pH in groundwater samples is presented in Figure 10. Standard deviation serves as a basic measure of variability. The value of standard deviation is 0.4100, which shows that the pH value of the most of the samples lie close to the mean i.e. 5.1166. The low pH does not cause any harmful effect (Boominathan and Khan, 1994).

Figure 10 shows that the curve for pH is negatively skewed which shows that the mode is greater than the median and the median is greater than mean. It also shows that the value of pH for the samples is not symmetrical but varies from block to block within the research area.

Figure 10 also shows that the peak of the curve is relatively high which means that the curve is leptokurtic. The leptokurtic curve shows that the fourth standardized moment β_2 is greater than 3.

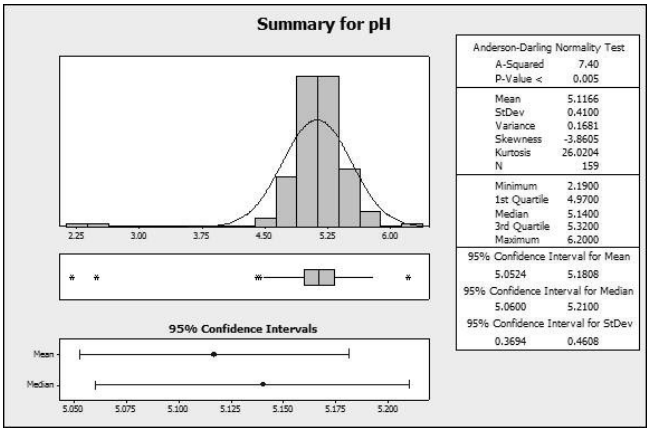

Figure 10. Summary for pH of groundwater at Ghulam Muhammad Abad

GIS analysis for the spatial variability in pH indicates that major area of Ghulam Muhammad Abad has the groundwater which has pH value from 4.90 to 5.21.

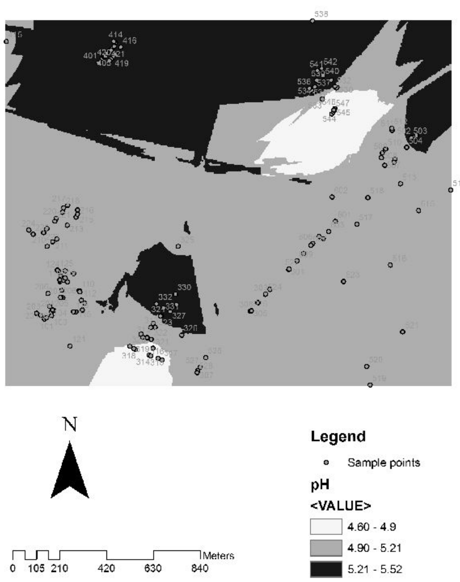

Figure 11. Spatial variability in pH of groundwater at Ghulam Muhammad Abad

Figure 11 shows the spatial variability in pH. Gray colour in the map indicates that the samples in this area have pH value from 4.90 to 5.21. Major portion of research area lies under this region except the area of C Block and a very small portion of B Block and D Block.

The area covering white colour in map indicates very acidic pH value. This zone contains the samples which lie in the range from 4.60 to 4.90. A very small portion of B Block and D Block lies under the zone of acidic pH. The whole area of C Block and some area of B Block and D Block lies in the zone of pH near the permissible limit indicated by black colour on the map i.e. greater than 5.21.

Conclusions**:** Only 8 Samples had the EC value within the permissible limit of 2.50µS/m so all the six zones don't had EC within permissible limit. Only 8 Samples have the TDS value within the permissible limit of 500 mg/L and the major area had high TDS value. TS value in all the zones was very high. The entire area had TSS value much higher. Most of the area had acidic pH. The whole area of Ghulam Muhammad abad Faisalabad has the groundwater unfit for drinking purpose.

It is recommended that the groundwater of Ghulam Muhammad abad Faisalabad should not be used for drinking purpose. The contamination in groundwater may be due to the old and worn out sewerage system so it should be repaired. The industry is also playing role in groundwater contamination so further studies should be done to evaluate the role of industry in contaminating groundwater. Some unlined portion of drain is passing through some area of Ghulam Muhammad abad which may contribute in groundwater contamination so this portion of drain should be lined.

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