Groundwater Quality Assessment of Industrial Zone of Faisalabad Using Geographic Information System

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Abstract: *Water is the basic element of social and economic infrastructure and is essential for healthy society and sustainable development. Groundwater is the favorite alternative is facing threats due to anthropogenic activities in Pakistan, which has lead due to deterioration in groundwater quality. Hence monitoring of ground water quality has become indispensable. In this study ground water quality analysis was carried out for industrial zone of Faisalabad city. Sixty water samples were collected all around the zone. The strategically analyzed results are presented in GIS based water quality mapping.The collected samples were analyzed for physio-chemical parameters such as total hardness, alkalinity,cadmium, arsenic, nickel, lead and fluoride and the results were compared with WHO guidelines. The values of these results were represented by mapping of quality parameters using ArcView GIS v9.3 and IDW was used for raster interpolation.It was concluded that water is partially not fit for drinking and direct use of this groundwater may cause health issues.*

Keywords: Groundwater, parameters, GIS, IDW, Contamination, Interpolation

1. 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 [1].

Water is the elixir of life [2] and plays a vital role in the earth's ecosystem. It is one of the most critical, scarce, precious and replenishable natural resource which cannot be created [3]. Groundwater serves as the main sources of water in the urban environment, which is used for drinking, industrial and domestic purposes and often, it is over exploited. Rapid industrialization, improper solid and toxic waste management practices in urban areas often lead to the degradation of groundwater, which then turns potable for future use. Ground water pollution not only affects the water quality but also threats human health, economic development and social prosperity [4].

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 [5]. These industrial effluents have leached down from the drain and pollute the groundwater [6].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 [7].Low-level trace-element data are necessary forwater-quality monitoring programs because of theincrease in understanding of the health risk tochildren and developing fetuses associated withsmall amounts of contaminants, such as mercury [8] lead, cadmium, and arsenic.

The purpose of the present study is to estimate the groundwater quality in the industrial zoneand thematically represent it using Geographic Information System (GIS) for understanding of the present scenario at a glance. It offers great opportunities for the simulation of groundwater mapping [9]. GIS can be used as a powerful tool for developing solutions for water resources problems for assessing water quality, determining water availability, preventing flooding, understanding the natural environment, and managing water resources on a local or regional scale [10, 11]

2. Materials and Methods

2.1 Study Area

The area of industrial zone of Faisalabad city was selected for this study with the criteria that industrial drains passes through the area which are expected to be the main source of contamination.
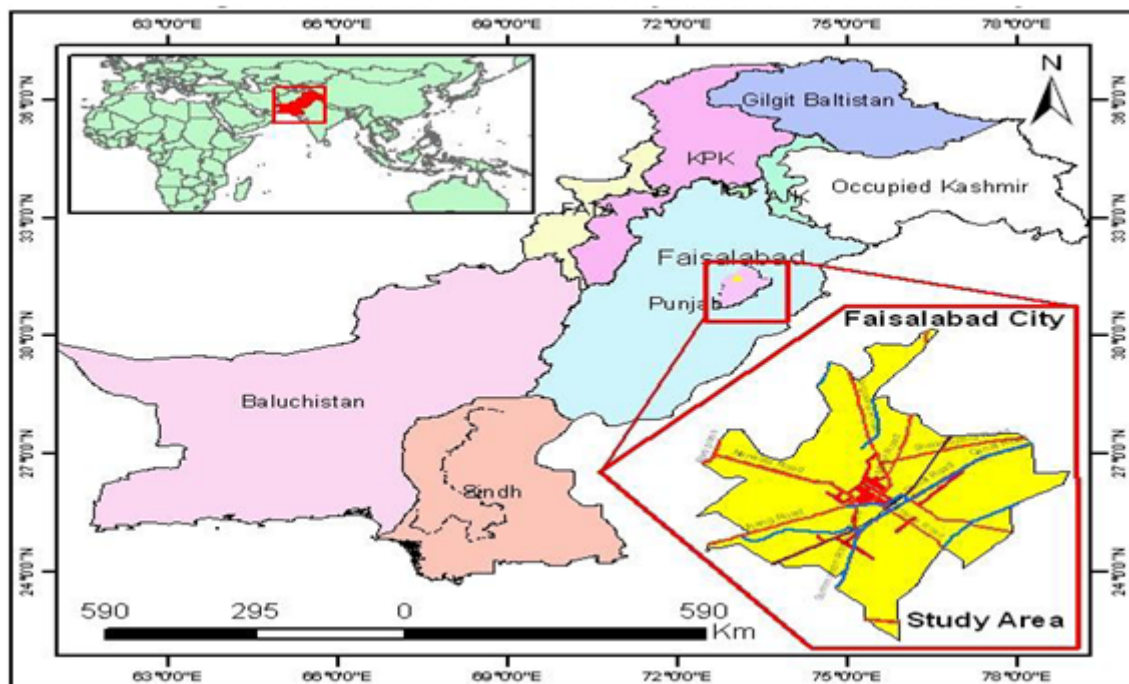
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Figure 1: Study Area of Faisalabad City

2.2 Sampling Plan

As part of the study, groundwater samples were collected from different areas. Samples were randomly taken from the whole area from newly installed pumps to investigate the different water quality parameters in the groundwater. The samples were taken in 500 ml bottles. The total 60 water samples were collected from whole area. After collection of the samples, the samples were preserved and analyzed in the Laboratory.

2.3 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 Positioning System receiver (GPS Receiver). For this purpose Explorist 210 GPS receiver was used.

2.4 Analysis of Sample

Water samples were analyzed for various physio-chemical parameters. Hardness was determined by titration method, alkalinity by using mathematical formula and trace elements with the help of atomic absorption spectrophotometer [12]

For the determination of hardnessEBT was used as an indicator in 10ml of water sample. The color changed into Wine Red. Added 1ml Buffer hardness solution in the sample by using syringe.Titrated it against the 0.01Molar EDTA solution. Stopped the titration when color changed to purple.Multiplied the used volume of EDTA by 100 to find the amount of hardness in milligram per liter [13]. Alkalinity value is found by using mathematical formula directly[14]

$$\text{Alkalinity (m. mole/l)} = \text{value of } HCO_3 \times 0.02N \text{ } HCl$$

3. Results and Discussion

3.1 Total Hardness Analysis

Total hardness in groundwater samples is varied from 97 mg/l to 961 mg/l. The permissible limit for T.H is 500 mg/l given by WHO. GIS analysis of T.H indicates that the most of the area has hardness value within the permissible limit. Yellow and Pink color indicates that the value of hardness is within the permissible limit. The high concentration of hardness is found in the village 197 R.B Baghianwala, 130 J.B sidhupur and 55 J.B Khurdpur that are indicated by purple color in a map. The areas which are near to these villages also having a high hardness value between 530 mg/l to 666 mg/l and indicated by blue color in a map.
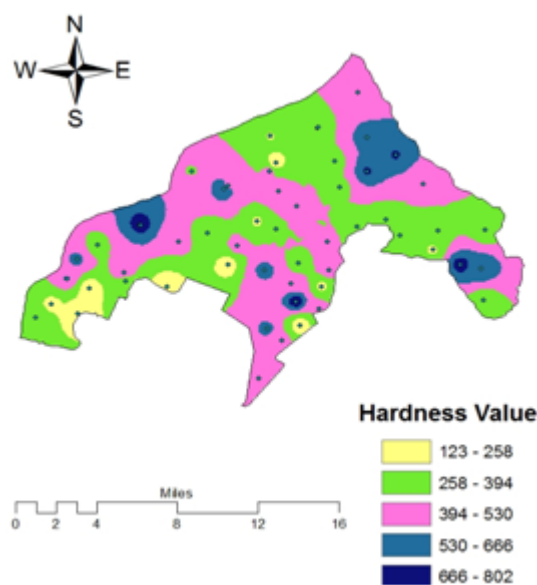

Figure 1: Hardness Variation in industrial zone

Paper ID: OCT14698

2017

3.2 Alkalinity Analysis

The capacity of some of the components of compound to accept proton.The principal anions for producing alkalinity of fresh water are sulphate, bicarbonates and chloride. Alkalinity of groundwater samples of area is varied from 1.34m.mole/l to 13.20 m.mole/l. All the samples have the alkalinity more than the permissible limit. GIS analysis for the spatial variability of alkalinity indicates that alkalinity value more than permissible limit that is 2.77 m.mole/l. Figure 2 shows the spatial variability in alkalinity. Purple color indicates the highest value of alkalinity in water samples of 55 J.B Khurdpur 11.2 m.mole/l. Green color in the map indicates that the samples in this area have alkalinity value from 3.57 m.mole/l to 5.79 m.mole/l.
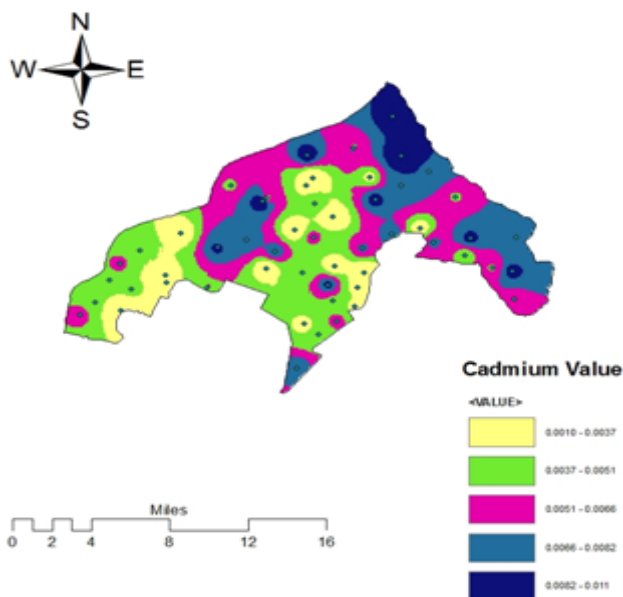

Figure 2: Alkalinity Variation in industrial zone

3.3 Cadmium Analysis

Cadmium in groundwater samples varied from 0.001 mg/l to 0.012 mg/l. Most of the samples have the cadmium value within the permissible limit.Figure 3 shows the spatial variability in cadmium. Green color in the map indicates that the samples in this area have cadmium within the permissible limit. The area of high concentration of cadmium is located in Chak # 105 JB and 110 JB having cadmium value 0.012 mg/l and indicated by purple color.
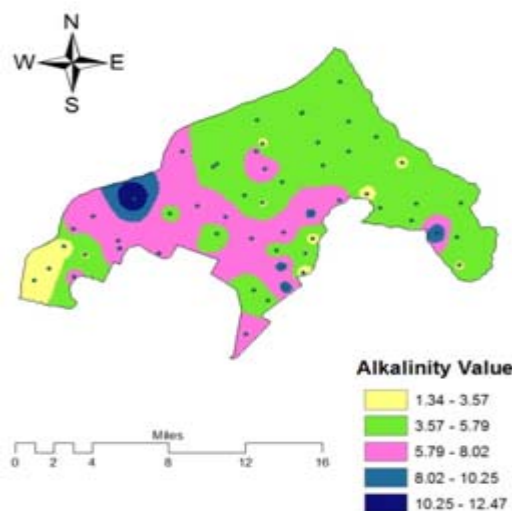

Figure 3: Cadmium Variation in industrial zone

3.3 Lead Analysis

The main sources of lead in water are paints, batteries waste, pipes, gasoline and manufacturing industries. It is a serious body poison. Guideline value for lead is 0.01 mg/l by WHO. Lead in groundwater samples of Lyallpur town is varied from 0.01 mg/l to 0.270 mg/l. Figure 4 shows the spatial variability in Lead. Yellow color indicates that the value of lead is within the permissible limit. The area having high concentration of lead is indicated by purple color in a map. Blue color in a map shows that the value of cadmium is more than permissible limit. Most of the industries lie in this area. Industrial drainage is also passed by from this area so there is more lead effect.
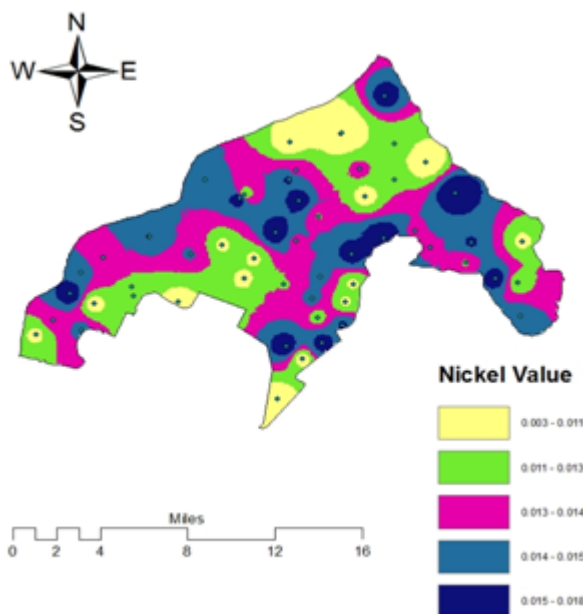

Figure 4: Lead Variation in industrial zone

3.4 Nickel Analysis

Nickel in groundwater samples of Lyallpur town varied from 0.001 mg/l to 0.019 mg/l. All the samples have the nickel value within the permissible limit. Figure 5 shows the spatial variability in nickel. Green color in the map indicates that

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the samples in this area have nickel within the permissible limit. The maximum concentration of nickel in the Lyallpur town is indicated by purple color in a map having nickel value 0.015 to 0.018 mg/ l.
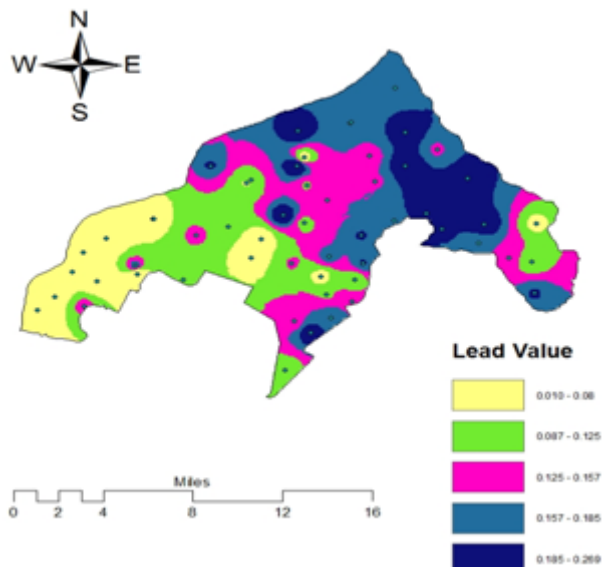

Figure 5: Nickel Variation in industrial zone

3.5 Arsenic Analysis

Arsenic in groundwater samples varied from 0 to 25 ppb. The permissible limit of arsenic by WHO is 10 ppb. In most of the samples arsenic is absent. GIS analysis for the spatial variability in arsenic indicates groundwater having no arsenic. Figure 6 shows the spatial variability in arsenic. Yellow color in the map indicates that the samples in this area have no arsenic. The area covering green color indicates that arsenic value is between 4 ppb to 10 ppb. The area of high concentration of arsenic is located at Chak # 196 RB Ghona having arsenic value 25 ppb and indicated by purple color. The area nearer to this point having arsenic value more than permissible limit.
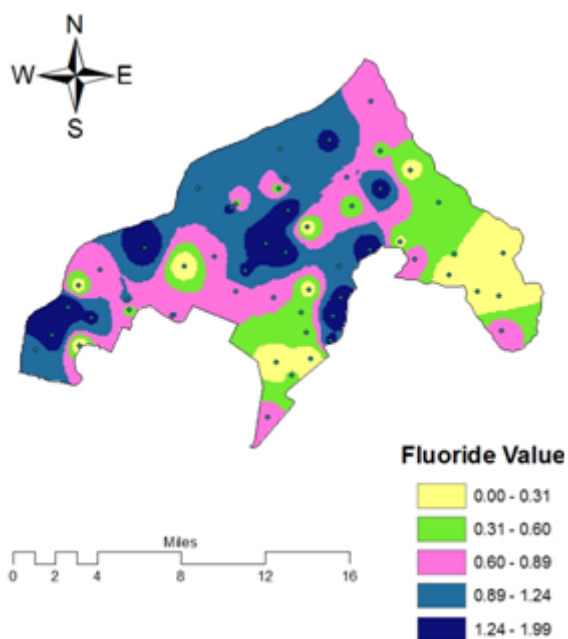

Figure 6: Arsenic Variation in industrial zone

3.6 Fluoride Analysis

Drinking water is the main source of fluoride intake. Favorable concentration in water is 1 mg/l however greater than 1.5 mg/l is linked to dental flourosis and also to cancer. Fluoride in groundwater samples of Lyallpur town varied from 0 mg/l to 2.0 mg/l. Most of the samples have the fluoride value within the permissible limit. GIS analysis for the spatial variability in fluoride indicates that major area of Lyallpur town has the groundwater which has fluoride near to permissible limit.

Figure 7 shows the spatial variability in fluoride. Green and pink color in the map indicates that the samples in this area have fluoride within the permissible limits. The area of high concentration of fluoride is indicated by purple color having fluoride value is more than permissible limit.
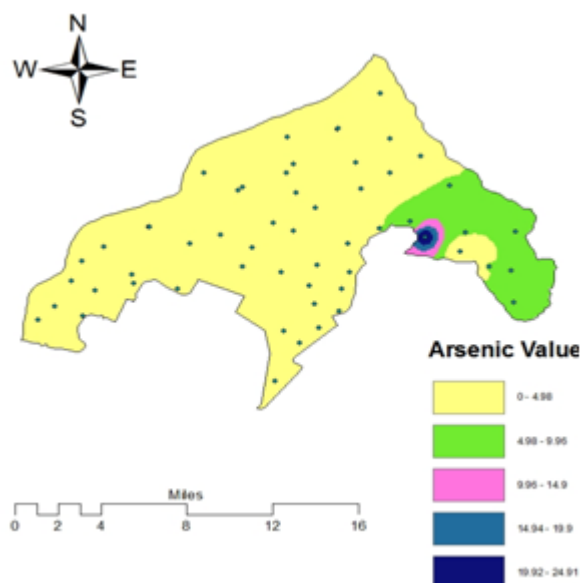

Figure 7: Fluoride Variation in industrial zone

4. Conclusion

This study has demonstrated the utility of GIS combined with laboratory analysis to assessand mapping of groundwater quality. The spatial distribution map of Hardness, Alkalinity,cadmium, arsenic, nickel, lead and fluoride shows that these parameters are vary accordingly in study area. The interpreted water quality with respect to alkalinity indicates that more than 90% of the study area groundwater lies in bad range for drinking purposes. The spatial distribution map of hardness concentrations illustrates that the majority of the samples are within the permissible limit. There is an increasing trend of trace elements in study area so there is need some strategic solution to overcome this trend.

It is recommended that the groundwater of industrial zone of 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 berepaired. The industry is also playing role in groundwater contamination so further studies should be done to evaluate the role of industry in contaminating groundwater. Drains should be lined and drinking water should use after treatment.

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