Int. J. Econ. Environ. Geol. Vol. 14 (1) 10-15, 2023
Journal home page: www.econ-environ-geol.org
Open Access
ISSN: 2223-957X

Spatial Variation of Heavy Metals Concentration in the Drinking Water of Rajanpur

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Received: *21 February, 2023* ***Accepted:*** *26 May, 2023*

Abstract: Punjab is the most populous area of Pakistan with around 100 million individuals and is confronting significant issues of groundwater exhaustion and water quality deterioration. Groundwater quality in Rajanpur district of Punjab is also deteriorating like other urban areas of Pakistan. Analysis of the chemical parameters of collected water revealed the notable contamination in Rajanpur. Samples were taken from different tube wells of Rajanpur over different locations. A mapping of the total concentration of Arsenic (As), Iron (Fe), and Fluoride (F^-) was carried out on drinking water through GIS. Multiple locations exhibited water quality issues, surpassing both NEQ'S and WHO standards for Arsenic (41% of samples), Iron (68% of samples), and Fluoride (21% of samples) out of a total of 41 locations surveyed. The maximum contents of As, Fe, and F^- were observed to be 1.6, 1.6, and 1.85 respectively. A suitable and powerful removal innovative technology for these metals is required to save a huge number of individuals in Rajanpur from these metals hazardous effects. In the present era, a collective awareness has emerged, recognizing the profound significance of ensuring access to pristine drinking water, advanced sanitation infrastructure, and elevated standards of personal hygiene. Governments have to take further steps to improve quality standards for drinking water and to promote GIS technology. Thus GIS mapping and estimation would help us to estimate the smaller observations and to take precautionary measures to prevent and control the contamination in drinking water.

Keywords: GIS, water quality, toxic elements, Rajanpur

Introduction

Potable water can be sourced from either surface water bodies or underground aquifers. The groundwater is of massive significance. Surface and ground waters are vital sources of water since they are giving numerous helpful assistances to life (Morales et al., 2000; Fatmi et al., 2009; Balamurugan et al., 2020). Groundwater can be discovered all around. The water table might be deep or low and may rise or fall depending on many components. Groundwater supplies may likewise get restored or revived, by rain and snow melting that leaks down into the breaks and split underneath the land and surface (Ning et al., 2007; Arain et al., 2008; Su et al., 2013). In a few domains of the world, people are facing genuine water insufficiencies in spite of the fact that groundwater is used faster than it is naturally recharged (Calderon et al., 2001; Mukherjee et al., 2003; Das et al., 2004). To various extents, groundwater is polluted by human activities. Groundwater contamination remains a persistent and growing concern as a primary source of drinking water supply. Its prevalence continues to expand daily, posing significant challenges to ensuring the safety and quality of drinking water resources (Guha et al., 2000; Brima et al., 2006). There are following wave's courses by which toxins enter groundwater, the dishonorable capacity of unsafe substances, improper waste disposal, transportation accidents, and the infiltration of contaminated rainwater and fertilizers further contribute to the escalating groundwater contamination issue. These factors add to the complexity of addressing and mitigating the risks associated with ensuring clean and safe drinking water sources (Haydar et al., 2009; Kazi et al., 2010; Yuan et al., 2011). Groundwater contamination is primarily attributed to the process of industrialization and urbanization, which has gradually developed over time without adequate consideration for its environmental consequences. The unchecked growth and expansion of industries, urban areas, and related infrastructure have resulted in the release of harmful pollutants and contaminants into the groundwater system. This lack of environmental consciousness has played a significant role in exacerbating the issue of groundwater contamination and its far-reaching implications (Ayoob and Gupta, 2006; Longe and Balogun, 2010; Abdel et al., 2013). The distinctions and number of current and probable sources of chemical contamination are vast. It is evaluated that there are in the vicinity of 90000 and 100000 chemicals in standard utilization however that as few as 2000 records for around 90 % of the aggregate mass utilized (Camargo 2003; Brima et al., 2006; Jiang et al., 2014). More research is expected to survey the connection between drinking water science and human health. It introduces a portion of the principle parts of the risk to human sources related to the conceivable presentation through guzzling water to chemical substances and biological agents (Buschamann et al., 2007; Baig et al., 2010). The heavy metals found in water achieve from both characteristic and anthropogenic sources. Heavy metals contaminate the groundwater and surface water bringing about the distress of drinking and water system water quality (Aziz 2005; Armitage et al., 2007). The substantial metals are analyzed as horrific poisons attributable to their harmfulness, constancy, and bio-aggregate nature in an environment (Wasserman et al., 2004; Shemirani et al., 2005). Heavy metals fill in as a heart of numerous turmoil in plants, creatures, and people threatening both human and environmental well-being. Research on heavy metal extraction from potable water has a core largely on As, Fe, and ions (Bhutta et al., 2002; Das et al., 2004; Islam and Masunaga, 2014). Absorption and collection of heavy metal pollutants in consumable water is presently a general well-being concern. In any case, heavy metals are harmful to humanoids if metals reveal in significant volume (Guha et al., 2000; Longe et al., 2010; Uddin and Huda, 2011).

Spatial variations in groundwater quality in the enterprise zones of Pakistan have been learned in late decades utilizing Geographic data framework (GIS). GIS is an apparatus for storing, examining, and showing spatial information. Besides, GIS is normally utilized for overseeing site inventory information, site suitability examinations, groundwater vulnerability estimation to pollution, groundwater stream, solute transport display, and draining and coordinating groundwater quality evaluation models with spatial information to make spatial data to create spatial decision support system (Kazi et al., 2010; Su et al., 2013; Shakerkhatibi et al., 2019). Taking into consideration the above characteristics of groundwater defilement and utilization of GIS in water quality mapping, the present study which was held in Rajanpur was to determine the concentration of, As, Fe, and F^- in the public drinking water supply and compare them with national as well as international standards and to integrate GIS (ArcGIS 10.2) software in the water quality analysis to analyze the spatial distribution of these heavy metals and evaluate the most polluted areas of Rajanpur.

Study Area

Rajanpur Tehsil is situated in the Southwest of Pakistan (29.1044° N, 70.3301° E) and it has an area of 2380 km^2. It is located to the west of the Indus River. As exhibited by the National Census Report (2017), the district had a population of 1,995,958 of which 16.89 % were urban. Five rivers of Punjab after their confluences meet at Wang close to Mithankot, a tehsil of Rajanpur. These rivers provide water for irrigation and domestic use. Due to the rapid increase in population, Rajanpur City has become ever more dependent on groundwater. A schematic diagram (Fig. 1) has been represented to show the sampling points in the study area. Rajanpur is a perfect district with expansive lanes and an amazing sanitation foundation.

Material and Methods

Primary source data is the information obtained from the field area. It gives the exact location of village wells, Hand pumps, and preserved collected water in sampling bottles. A social survey was conducted to know the opinion about water quality.

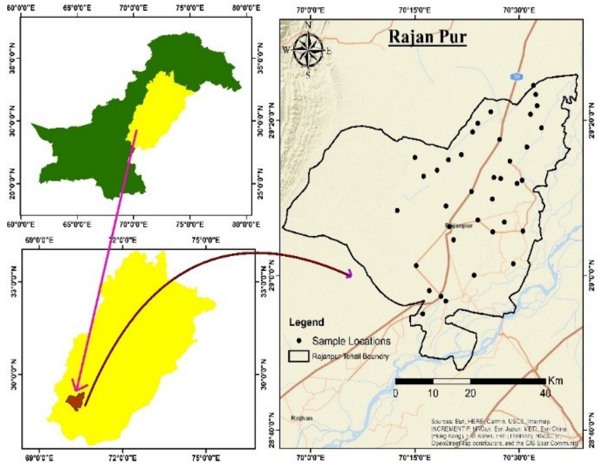

Figure 1: Location map of Tehsil Rajanpur.

The coordinates (latitudes and longitudes) were recorded at each sampling point using GARMIN e Trax 20 GPS Device. Samples of drinking water were collected from public groundwater supply tube wells, Water ponds, and Hand Pumps serving water to various domestic localities of Rajanpur as shown in Fig. 2. The testing, safeguarding, and treatment of tests were done by the standard ISO 5667-10: 1992, "Water quality - Sampling and ISO 5667-3:1985, Guidance on the conservation and treatment of tests" separately.

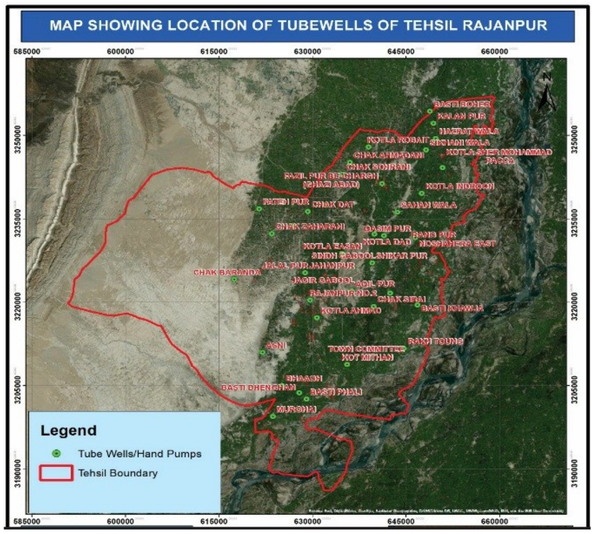

Fig. 2 Map showing sampling points of tehsil Rajanpur.

The collection of drinking water tests from the study territory was then exchanged to arrange to inspect bottles, i.e. pre-flushed with 10% nitric corrosive or just washed with cleansers, contingent on the parameters of intrigue. Moreover, at the season of examining, the detailed test distinguishing and engaging data and GPS Coordinates were dealt with alongside each specimen. The gathered samples were then taken to the ecological research center of the College of Earth and Environmental Sciences for analysis and the concentration of Iron, Arsenic & Fluoride was determined using the PerkinElmer, Inc. 8800 Atomic Absorption Spectrophotometer as per Standard No. 3111 (APHA, 2005) within the recommended periods. In order to determine the spatial distribution of As, Fe, and F^- in the public water supply of different areas of Rajanpur, ArcGIS 10.2 software was used.

Results and Discussion

Drinking water was analyzed for heavy metals i.e. As, Fe, and non-metal F^-. For this, samples of water from tube wells in Rajanpur were collected at different locations. Mapping was carried out of samples from different parts of Rajanpur tehsil. Groundwater quality in Rajanpur has deteriorated. In some sectors the quality of groundwater was toxic. The lab investigation of physical and chemical parameters of gathered water tests unveiled the reality of significant contamination in groundwater.

Out of 41 locations, 17 exceeded the NEQS and WHO standards for water quality with regards to As as shown in the Fig. 3. About 41% of the water samples contained As in excess of the NEQS and WHO standards. Some areas such as Basti Khawja, Rangpur, Naushera East, and others were found to have As levels exceeding the NEQS and WHO limits, putting the inhabitants in those areas at high risk.

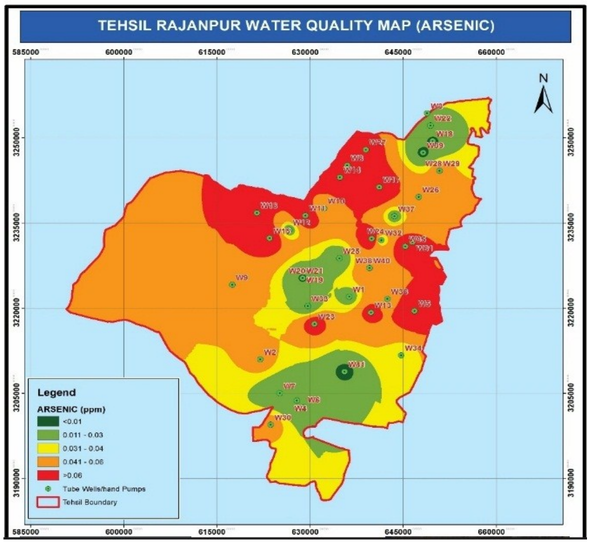

Fig. 3 Map showing water quality of (Arsenic) distribution in Rajanpur with sample code.

The iron levels in Rajanpur were also above the WHO standard limit of 0.3 mg/L, putting the health of the residents at risk. The waterborne diseases were affecting the inhabitants of those areas due to the poor quality of water. Out of 41 locations, 28 exceeded the NEQ and WHO standards regarding water quality identified with Fe as shown in Fig. 4. 68 % of water samples contained Fe above NEQ'S and WHO standards. The map given with legend shows that there are some areas e.g. Chak Barandha, Jalal Purjahanpur, Chak Datt, Kotla Dhatt, and Kotla Rubait, etc. on the map exceed with high limits of Fe. These inhabitants in those areas are at high risk of the exceeding limits of Fe.

Out of 41 locations, 9 exceeded the NEQ and WHO standards regarding water quality identified with F^- as shown in Fig. 5. 21 % of water samples contained F^- above NEQ'S and WHO standards. The map given with legend shows that there are some areas e.g. Chak Baranda, Jalal Purjahanpur, Fateh Pur, Murghai where F^- exceeds NEQ'S and WHO limits. The population in these areas is at high risk of the exceeding limits of Fluoride.

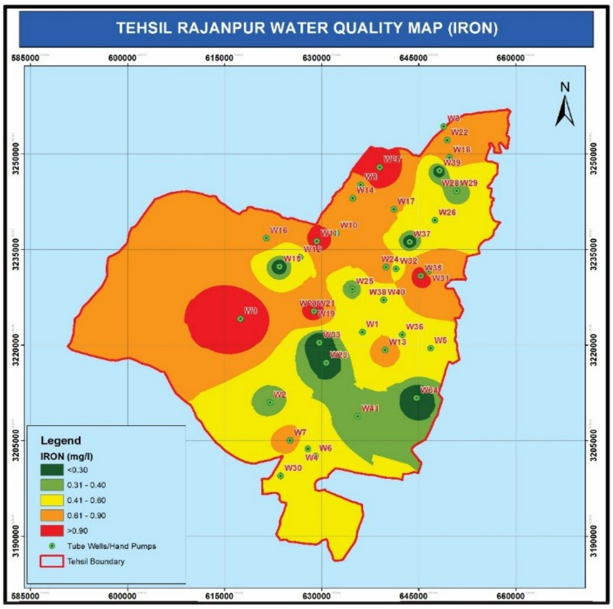

Fig. 4 Map showing water quality of (Iron) distribution in Rajanpur with sample code.

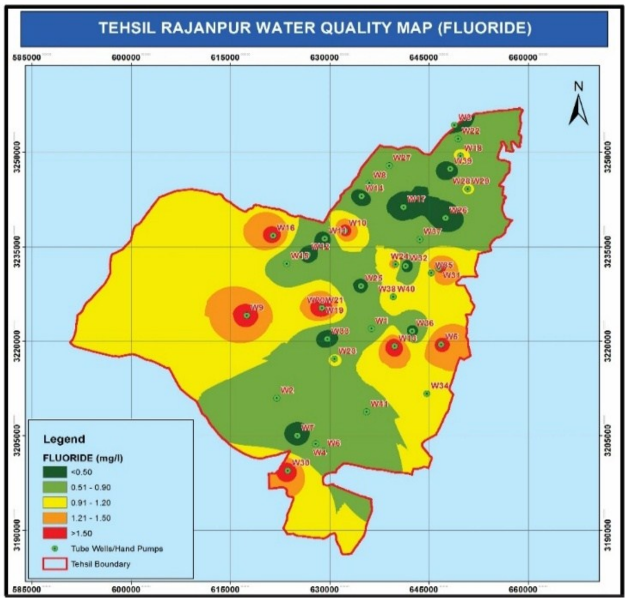

Fig. 5 Map showing water quality of (Fluoride) distribution in Rajanpur with sample code.

Fig. 6 shows the fitness status of sampling points of Tehsil Rajanpur where the samples were taken and the distribution of samples was shown. In these sampling points, some samples are giving good results and some samples exceed the standards.

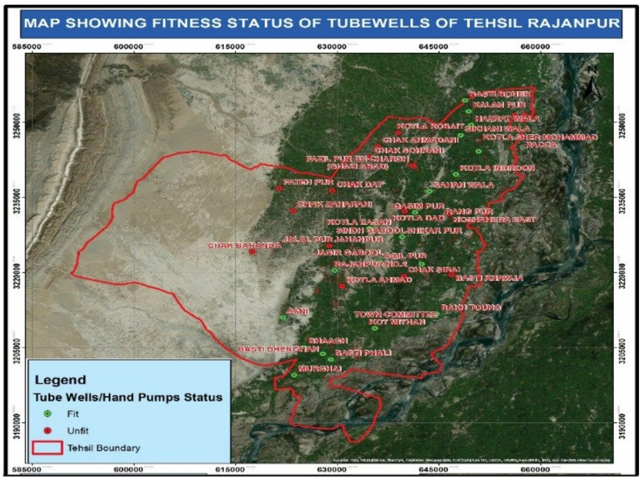

Fig. 6 Map showing the fitness status of tube wells of tehsil Rajanpur.

In Table 1 overall values of Tehsil Rajanpur are shown with the inhabitants. The status of fitness of values and the status of unfit values are measured according to the World Health Organization Standards and National Testing Laboratories of Pakistan Standards.

Conclusion

A comprehensive GIS mapping was conducted to analyze the total concentration of Arsenic (As), Iron (Fe), and Fluoride (F-) in drinking water sources in Rajanpur. Multiple samples were collected from various tube wells located across different areas to investigate the presence of these heavy metals in the water. This research reveals alarming results indicating that a substantial percentage of water samples from multiple locations surpassed NEQ'S and WHO standards for As (41%), Fe (68%), and F^- (21%) out of a total of 41 locations surveyed. It was observed that these naturally occurring heavy metals pose a significant threat to human health. To safeguard the large population of Rajanpur from the excessive and

Table 1 Fitness Status of Tube Wells of Tehsil Rajanpur.

Sample Code	Tehsil	Village Name	Iron	Fluoride	Arsenic	Fitness Status	Population
W1	Rajanpur	Aqi lPur	0.5	0.48	0.5	Fit	2416
W2	Rajanpur	Asni	0.3	0.7	0.3	Fit	3687
W3	Rajanpur	Basti Boher	0.7	0.2	0.7	Fit	1242
W4	Rajanpur	Basti Dhenghan	0.4	0.5	0.4	Fit	516
W5	Rajanpur	Basti Khawja	0.5	1.6	0.5	Unfit	3671
W6	Rajanpur	Basti Phali	0.4	0.85	0.4	Fit	1728
W7	Rajanpur	Bhaagh	0.8	0.25	0.8	Fit	4091
W8	Rajanpur	Chak Ahmadani	0.8	0.9	0.8	Unfit	2351
W9	Rajanpur	Chak Baranda	1.6	1.63	1.6	Unfit	698
W10	Rajanpur	Chak Burra	0.9	1.7	0.9	Unfit	945
W11	Rajanpur	Chak Dat	1.1	0.31	1.1	Unfit	1140
W12	Rajanpur	Chak Sadiq Abad	0.4	0.35	0.4	Fit	538
W13	Rajanpur	Chak Sirai	0.8	1.85	0.8	Unfit	1162
W14	Rajanpur	Chak Sohrani	0.9	0.3	0.9	Unfit	1009
W15	Rajanpur	Chak Zaharani	0.2	0.61	0.2	Unfit	1001
W16	Rajanpur	Fateh Pur	0.7	1.67	0.7	Unfit	6469
W17	Rajanpur	Fazil Pur Be-Chargh	0.6	0.21	0.6	Unfit	1442
W18	Rajanpur	Hazrat Wala	0.8	1.11	0.8	Fit	671
W19	Rajanpur	JagirGabool	1.1	1.85	1.1	Unfit	2634
W20	Rajanpur	Jahanpur	0.2	0.55	0.2	Fit	1539
W21	Rajanpur	Jalal Pur	0.7	1.85	0.7	Unfit	933
W22	Rajanpur	Kalan Pur	0.8	0.68	0.8	Fit	626
W23	Rajanpur	Kotla Ahmad	0.2	0.95	0.2	Unfit	2741
W24	Rajanpur	Kotla Dad	0.9	1.4	0.9	Unfit	1190
W25	Rajanpur	Kotla Easan	0.3	0.39	0.3	Fit	7321
W26	Rajanpur	Kotla Indroon	0.4	0.11	0.4	Fit	4265
W27	Rajanpur	Kotla Robait	1.5	0.83	1.5	Unfit	2516
W28	Rajanpur	Kotla Sher Mohammad Kacha	0.3	0.95	0.3	Fit	1511
W29	Rajanpur	Kotla Sher Mohammad Pacca	0.5	0.25	0.5	Fit	4193
W30	Rajanpur	Murghai	0.5	1.71	0.5	Fit	3290
W31	Rajanpur	Noshahera East	0.8	1.7	0.8	Unfit	4596
W32	Rajanpur	Qasim Pur	0.4	0.15	0.4	Fit	3540
W33	Rajanpur	Rajanpur No.2	0.1	0.2	0.1	Fit	637
W34	Rajanpur	Rakh Toung	0.2	1	0.2	Fit	1093
W35	Rajanpur	Rang Pur	1.2	1.11	1.2	Unfit	1546
W36	Rajanpur	Raqba Naseer	0.5	0.35	0.5	Fit	1556
W37	Rajanpur	Sahan Wala	0.2	0.8	0.2	Fit	4857
W38	Rajanpur	Shikar Pur	0.4	1.08	0.4	Fit	6878
W39	Rajanpur	Sikhani Wala	0.2	0.26	0.2	Fit	7721
W40	Rajanpur	Sindh Gabool	0.3	0.21	0.3	Fit	1047
W41	Rajanpur	Town Committee KotMithan	0.3	0.85	0.3	Fit	13653

dangerous poisoning caused by these metals, there is a pressing need for a user-friendly and cost-effective technology for their removal from drinking water. Advanced technologies were successfully tested for seven months to address this issue. The implementation of such technologies is crucial to ensure the provision of safe drinking water, improved sanitation, and better personal hygiene. These measures can significantly enhance the quality of life, overall human well-being, and productivity, and reduce mortality and morbidity rates in the region.

Recommendations

The level of As, Fe, and $F^-$are normal for some samples, but over some locations e.g. Basti Khawja, Rangpur, Kotla Robait e.t.c values of Fe and As are significantly high. Government should take further steps to improve quality standards for drinking water and to promote GIS technology. Thus GIS mapping and estimation would help us to take precautionary measures to prevent and control the contamination in drinking water.

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