Research Article

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Assessment of groundwater quality for drinking purposes in Jhang city, Punjab

Abstract

Groundwater, which is present in aquifers beneath the Earth's surface and is used for drinking purposes throughout Jhang City, is a crucial resource. The quality of drinking water is impacted by groundwater contamination in one way or another, which ultimately harms human health. The current study aims to evaluate the drinking water quality of the groundwater near culvert drainage in Jhang City, Punjab. With the aid of the standardized method APHA 23rd edition, samples that were collected from 9 different areas were examined for 20 parameters, including EC, pH, turbidity, alkalinity, bicarbonates, calcium, carbonates, chlorides, total hardness, magnesium, potassium, sodium, sulphate, nitrate, TDS, arsenic, and bacteria at the Environmental lab of IIUI and testing laboratory of PCRWR. The results of the sample analysis show that the overall quality of drinking water is unacceptable and exceeds PEQs and WHO requirements. The first three samples taken close to the drainage had the highest level of pollution.

Keywords: hydrochemistry, water quality, groundwater, surface water, Jhang

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Introduction

The water beneath the earth's surface in aquifers is known as groundwater. In a hydraulic cycle, surface water that is above the vadose zone (such as precipitation, lakes, reservoirs, rivers, and oceans) percolates into the ground and phreatic zone (Lapinski et al., 2007). Groundwater is used for domestic, industrial, and agricultural uses, and is a priceless source of drinking water. It usually has a greater quality than other sources of water because of the filtration that occurs in soil.[1] However, regional variations in groundwater quality rely on the geology of the groundwater basin and nearby human activity (Kawo & Karuppannan, 2018). Evaluation of groundwater quality is essential for resource planning and environmental management.[2]

About 71% of our planet is water (97.5 % in the ocean, 2.5% is freshwater), 74% of freshwater is trapped in ice caps and glaciers, 25.6% is in-ground and 0.4% is in lakes, rivers, and the atmosphere.[3] So, the major portion of freshwater that terrestrial organisms (especially humans) can utilize for their fluid requirement is under the ground.[2] In the world, about a third of the water used by humans comes from groundwater. More than half of all drinking water worldwide is supplied by groundwater in rural areas.[4,5] Although this useable portion of freshwater is limited, anthropogenic activities are diminishing its quality. Over the past two decades, groundwater pollution has emerged as the most crucial environmental issue.[6] One of the most important environmental and well-being-associated mater is the deterioration of water quality due to contamination.[1] The major source of drinkable water is present underneath the earth and almost everywhere in the world; this groundwater is being contaminated, which is a critical problem.[7,8,3]

As a result of dumping untreated wastewater from industries, waste disposal, agricultural activities, and urban runoff into the ground, groundwater quality has degraded.[9] There are numerous reasons for the contamination of groundwater which varies in the form of leakages from sewerage, mining activities, leachate infiltration from landfills and open dumping sites, industrial activities, etc.[10] But contamination is not the only threat, because our usage of this reservoir is now exceeding the recharging rate.[11] Due to dramatic environmental fluctuations and anthropogenic activities, the quality of groundwater is diminishing, and the consequences of these changes are adverse impacts on human health by taking contaminated water. In this modern age, groundwater pollution has increased.[12] Groundwater contamination has deleterious impacts on human health; the most noticeable adverse health-related issues are hepatitis and dysentery.[9] There has been extensive research on the quality of groundwater and its associated health risks that have been examined and evaluated throughout the world.[11]

Contamination of environmental compartments can affect human health adversely.[8] Around the world, arid and semi-arid regions are affected by this problem.[13] Anthropogenic activities are resulting in the alteration of groundwater quality in some areas of Pakistan.[10] Industrial and municipal waste can enter soil if not contained properly, infiltrate aquifers, and deteriorate groundwater quality.[14,15] This study is conducted to access the impact of sewer drainage on the major drinking water source of Jhang city.

Material and methods

Study area

Jhang is a district in the central part of Punjab province in Pakistan. About 250 km from Lahore and 72 km from Faisalabad, it is located on the eastern bank of the Chenab River. The urban area of the district is divided into two parts, City and Sadar. By population, it is Pakistan's 18th largest city. The population of Jhang is 445,000 in 2021, a 1.6% increase from 2020. It is located at 31.2780 N, 72.3180 E at an elevation of 285 meters above sea level. Jhelum is located in the Jhang District at the Timmy Barrage site. Chenab, the joint river, runs another 75 km before entering Khanewal and Multan. Both of these mentioned rivers are important tributaries of the Great Indus River. Thus, this land of great importance is part of "The Great Indus Valley Civilization", unequivocally ranked as one of the first great urbanized civilizations.

The climate of the district is arid to semi-arid subtropical continental with large seasonal variations in both temperatures and rainfall. Summers are usually hot and long, and winters are usually mild. More than half of the rainfalls in this area happen during the monsoon (July-August). In winter, during December and January, the remainder is received as a low-intensity shower. The hottest months are May and June with a mean maximum temperature of 118 F. The area is part of the Indus plains, an area of alluvial deposits. These deposits ranged from recent to sub-recent, with a few small inclusions of Pleistocene material and some Precambrian rocks. Through their floods and irrigation water, the Chenab, Jhelum, and Ravi rivers affect the hydrology of the region. The majority of the population relies on groundwater for drinking. This study will investigate the underground drinking water quality of the city area of the Jhang District near the safety band.

Selection of sampling sites

The locations of sampling are taken to examine the impact of nearby sources of pollutants and also to get a percentage difference in water contamination from different points. The first three samples are taken from the points of representative source contamination (Sewer drainage). Other six samples are taken to know the movement of contaminants in underwater channels. Locations of points are selected based on the availability of groundwater extraction facilities (i.e., water pumps). The Nala which is flowing north of the sampling area is the major concern for such distribution of collection points Figure 1.

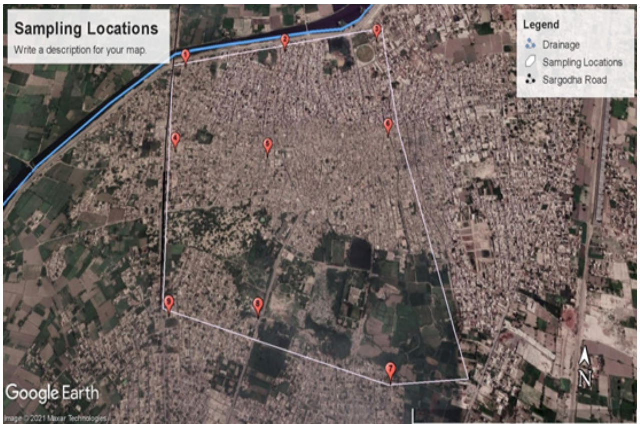

Figure 1 Map of the study area.

Data analysis

Water samples were collected in polyethylene bottles (one litter), by using a random sampling method. Using the Google Earth Pro software, groundwater sampling sites were selected, and after the selection of these sites, site visits were conducted to get permission from residents, during the sampling study locations of study areas were noted with the help of the Global Positioning System (GPS).

Physicochemical analysis

TDS and physical parameters like color, pH, turbidity, and EC were analyzed at the site by using the instruments provided by the Department of Environmental Science IIUI, and for further analysis, groundwater samples were transported to the Environmental lab of International Islamic University Islamabad where spectrophotometer was used to determine the quality of water, and as for biological analysis, groundwater samples were analyzed laboratory.

Results and discussions

Overall, the groundwater quality of Jhang (study area) is not suitable for drinking purposes, especially in areas near the sewer drainage (samples 1a, 2b, and 3c). The general trend was a decline in the contamination level as we move away from the sewer for most of the parameters, below table illustrates the general results of our study. Highlighted data indicate those values which are above the permissible level of NSDWQ or PEQs standards for drinking purposes Table 1.

Table 1 Statistical Analysis of Physicochemical & Biological parameters

Index	Unit	Min	Max	Mean	SD	SEQs	%Age
EC	µS/cm	840	7000	3228.4	2109.4	400	100
pH	-	7.17	7.49	7.29	0.11	6.5-8.5	0
Turbidity	NTU	0.91	1.25	1.08	0.24	5	56
CaCO3	Ppm	282	1612	737.5	442.2	<1000	0
Ca	Mg/l	61	121	89.2	19.03	75	77
Chlorides	Mg/l	36	1034	419.5	359.6	250	44
T.H	Mg/l	252	1342	630.8	389.3	<500	55
Mg	Mg/l	12	253	99	84.3	50	77
K	Mg/l	5.7	60	26.5	22.5	12	44
Na	Mg/l	72	970	405.7	310.7	200	66
SO4	Mg/l	63	397	205.5	110.3	<250	44
NO3	Mg/l	0.22	7.04	2.78	2.52	50	0
TDS	Mg/l	462	4200	1936.4	1296	1000	77
As	Mg/l	0.4	0.9	0.6	0.26	1.5	0
Coliform	Mg/l	2	4	3	1.4	0	22

All parameters in the first three samples along the sewer drainage show the maximum level of contamination, which comparatively reduces with the distance when we move away from the sewer drainage except for samples 6 and 9, whose value of contamination rapidly increases.

EC, color, pH, and turbidity

The levels of Turbidity, pH, and color were within the permissible range while on the other hand concentration of EC far exceed the standards of the World Health Organisation.[16] The concentration of ions in water increases its electrical conductivity. Electrical conductivity is determined by the number of dissolved solids in water, and EC values can be used to approximate TDS.[17] According to WHO standards, the EC value should not exceed 400µS/cm, but the average conductivity level in the study areas was recorded at 3228 µS/cm which is less than what is reported by another researcher.[8] EC is the only parameter in the case of physical analysis of groundwater samples, and the trend for this parameter is a decline in concentration level as we move away from the sewer drainage Figure 2.

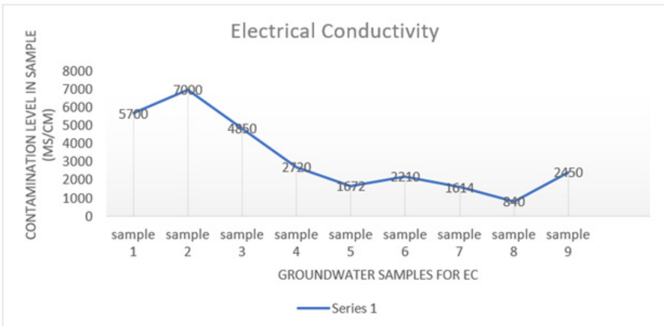

Figure 2 Concentration of Electrical Conductivity.

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Chloride, TH, and TDS

Below bar graph (fig) illustrates data relevant to chloride, total hardness, and TDS, according to the results, all of these chemical parameters are showing fluctuations as compared to the permissible limit of PEQs or NSDWQ, and these are the only chemical parameters whose values exceeds both PEQs and WHO standards Figure 3.

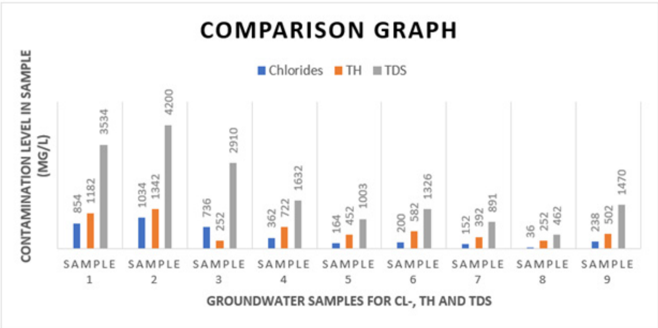

Figure 3 Comparison graph between chloride, TH, and TDS.

According to PEQs chloride concentration should not exceed 250 mg/L, but in the study area maximum value recorded was 1034 mg/L, which is less compared to other research done in China.[18] In the case of TDS, the value should be below 1000 mg/L but the highest result recorded was 4200 mg/L, other researchers had also recorded as high as 7514 mg/L in their studies related to water quality.[19,20] TH value must be below 500 mg/L, study area shows the highest value of 1342 mg/L, another researcher has recorded values higher than this.[21,22]

Values of all three of these parameters are at the maximum level near the sewer drainage, as we move away from the drainage or increase the distance from the drainage the values of these parameters start to show dramatic decline only by minor exception, for example in case of chloride sample 6c has a higher value than 7c which contain more contamination than 3c, in case of TH the trend is same as Cl.

Sodium and potassium

A silver-white metallic element, Na is found in less quality in water. WHO standards limit for sodium in water is 200 mg/L, in the study area the concentration of sodium range from 63-397 mg/L.[23] According to Sayyad and Bhosle (2011), the major source of sodium in water is sewage, mineral deposits, fertilizers, and agricultural wastes. In the case of the study area, the highest concentration was noticeable near the sewer drainage, which is also contaminated by agriculture runoff.

K is silver white alkali, and it is highly reactive in water, according to WHO standards limit should not exceed 12 mg/L, but in the study area, the average concentration was recorded at 26.577 mg/L, which was similar to the reports made by other researchers.[24,25]

In this case, potassium and sodium concentrations also decrease with the increase in distance, except for samples 1a, 4a, and 9a, which can be seen in the below graph Figure 4.

Calcium, magnesium, and sulphate

In the earth's crust, calcium is the fifth most abundant element and plays a key role in bone formation and cell physiology. Calcium is one of the key hydrochemical elements for human health in groundwater.[26] According to WHO standards, the permissible range of calcium in drinking water should not exceed 75 mg/L. In the study areas, the concentration of calcium ranges from 61 to 121 mg/L. So, most of the samples were above the permissible limit. In the research from[27,18] almost the same highest level of calcium was recorded.

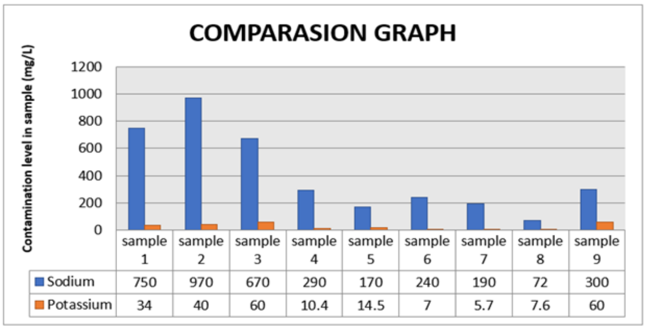

Figure 4 Comparison graph between Sodium and Potassium.

The 8th most abundant element on earth's crust and a natural constituent of water is magnesium, it is important for the proper functioning of living organisms and is found in minerals like dolomite, magnetite, etc. According to WHO standards, magnesium concentration should be below 50 mg/L in drinking water. The concentration of this element in the study area ranged from 12-253 mg/L, and the highest value which was recorded is almost four times higher than the permissible limit.

Sulphate is a salt of sulphuric acid, and its concentration in water should not exceed 250 mg/L by the standards of WHO.[15,28] In the study area, the minimum value of 63 mg/L was recorded, while the highest (397 mg/L) was above the permissible limit.

In the case of these parameters, only magnesium appears to have the same trend as calcium and TH, while the other two elements (calcium and sulphate) concentration in collected groundwater decreases with the distance from the sewer Figure 5.

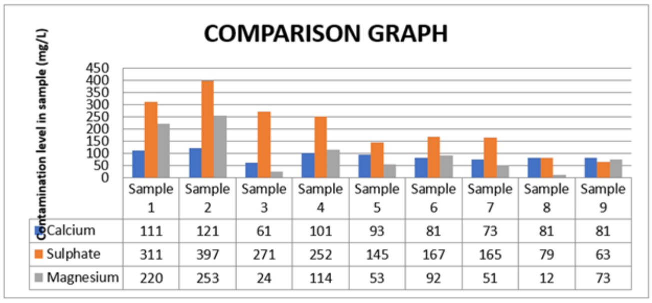

Figure 5 Comparison graph between calcium, sulphate, and magnesium.

The trend for this element is when we move away from the sewerage the contamination level decreases, as we can see sample 1, 4, and 9 show the decline in the concentration of these elements in order, only sample 6 and 9 deviate from this trend.

Total coliform

According to WHO and Punjab (Pakistan) standards, total coliforms, fecal coliforms, and E-coli should be absent in 100 ml of drinking water.[29,30] In the study area only samples 3 and sample 7 exceed the permissible limit. Samples collected from Daood Shah near Safety band (sample 3) contain 4 total coliforms this site is also near the water treatment plant, while samples collected from near Sargodha Road Amir town (sample 7) contain 2 total coliforms.

Nitrate, carbonate, and arsenic

All of these parameters were within the permissible range, in the case of arsenic the contamination level is increasing the Haideri

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Muhalla (sample 5b) which is alarming, the nitrate level in the sample from this site is also increasing but its concentration is not significant yet.

Alkalinity as CaCO3 and Bicarbonate

According to the results of the collected data, both the level of alkalinity as CaCo3 and bicarbonate was identical, sample 1 to 2 and 9 show the highest level of concentration of these parameters, overall, these parameters were recorded highest near the sewer drainage. In the case of alkalinity, values vary dramatically and deviate from the general trend Figure 6.

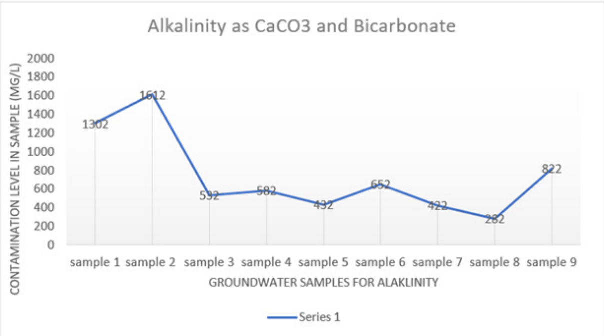

Figure 6 Alkalinity as CaCO3 and Bicarbonate.

Conclusion

In this study, the grab sampling technique is used to collect the samples and the results inferred that the water is unfit for drinking purposes. It is alkaline, contains a high level of hardness, EC, and same where have total coliform. The groundwater quality is below the standard (WHO) for drinking purposes. 20 parameters, including physical, chemical, and biological were subjected to analysis. Most of the chemical parameters are above the limits; in the case of physical parameters, EC was off the chart with the maximum value of 7000µS/cm. Two samples, samples 3 and 7 were recorded as contaminated with total coliform. The observation of data given in the table and graph shows the impact of pollutant sources on groundwater samples (i.e., safety Nala band). The comparison graph between TDS, chlorides, and total hardness (chemical parameters) which have relatively high concentrations in water shows a trend movement of contamination in underground water. The first three samples are taken horizontally near to safety Nala band (which is considered a huge source of vulnerable toxic materials) and contain 48.86% Total hardness, 69.49% Chlorides, and 61.07% TDS total. This high percentage of chemicals present in samples 1, 2, and 3 show the adverse impact of sewer drainage nearby. Same in physical parameters, the EC remains higher in all samples and the first three samples contain 57.11% of the total EC.

Acknowledgments

None.

Conflicts of interest

The author declares there is no conflict of interest.

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