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RESEARCH ARTICLE

WATER QUALITY ASSESSMENT FOR THREE DIFFERENT TYPES OF DRINKING WATER SOURCE IN FATA COLONY MALANA PARACHINAR KURRAM DISTRICT: WATER QUALITY INDEX

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ABSTRACT

Water is one of the most essential natural resources. Contaminated water can cause many adverse impacts on human health and on the environment. In this study, we conducted a comprehensive geochemical water quality assessment using the Water Quality Index (WQI) and health risk for three distinct locations. For this purpose, 45 samples were collected from three different locations and analyzed with different geochemical parameters. The results show that the Magnesium level in most of the samples was below the permissible limits. All analyzed parameters of samples were then compared with the drinking water quality standards set by W.H.O. The results indicated that all the analyzed parameters are under permissible limits set by the World Health Organization (WHO) and Pakistan National Standards for Drinking Water Quality. Moreover, the results show that all 3 locations collected samples (45) exhibited excellent water quality. This study highlights the importance of water quality assessment and the applicability of the Water Quality Index in evaluating water resources. The information provided can aid local people to protect themselves from polluted water.

KEYWORDS

Federally Administered Tribal Areas; Pakistan National Standards for Drinking Water; World Health Organization

1. INTRODUCTION

Water is an essential natural resource that is vital in sustaining life and supporting various human activities. However, the increasing population, urbanization, industrialization, and agricultural practices have put immense pressure on water sources, leading to concerns about water quality deterioration. Assessing water quality is crucial for ensuring the safety and usability of water resources for drinking, irrigation, and maintaining ecological balance. The analysis of water quality in various water sources is crucial for understanding the suitability of these sources for different purposes and identifying potential risks or sources of pollution. Access to safe drinking water is a fundamental human right, and maintaining its quality is crucial for public health. The World Health Organization (WHO) sets guidelines and standards for drinking water quality to protect against waterborne diseases and contaminants (WHO, 2017). These standards encompass parameters such as microbiological indicators, chemical substances, and physical properties that ensure the safety and palatability of drinking water.

Streams are natural watercourses that play a vital role in the hydrological cycle and support diverse ecosystems. Fresh rivers are flowing bodies of water that serve as important sources of freshwater for various human activities, including drinking water supply and irrigation. Tube well water, on the other hand, refers to groundwater extracted from underground aquifers using tube well systems. The analysis of water quality in these different sources involves the measurement of several physicochemical and biological parameters. Parameters commonly examined in water quality analysis include pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), turbidity, nitrate, phosphate, and microbiological indicators such as coliform bacteria.

By assessing these parameters, researchers can evaluate the overall quality and potential risks associated with each water source. This information is crucial for decision-making processes related to water resource management, human health, and ecosystem preservation. Previous studies have also highlighted the significance of water quality analysis in streams, fresh rivers, and water from tube wells. For instance, a study examined the water quality of streams in an agricultural region, assessing parameters such as pH, DO, EC, and nutrient concentrations (Neves et al., 2021). The study revealed elevated levels of nutrients in the streams, indicating potential agricultural runoff and the need for proper management practices to mitigate water pollution.

In another study, authors analyzed the water quality of a fresh river in Nepal, focusing on parameters such as pH, turbidity, nitrate, and microbiological indicators (Shrestha et al., 2023). The study identified areas along the river with poor water quality, likely influenced by human activities and inadequate wastewater treatment practices. The findings emphasized improving water treatment and pollution control measures to ensure a safe water supply. Furthermore, a study investigated the quality of Tube well water in a coastal region, examining parameters including pH, TDS, nitrate, and coliform bacteria (Rahman et al., 2023). The research highlighted the presence of high salinity and nitrate contamination in the Tube well water, posing risks to human health and indicating the need for appropriate water treatment interventions.

Understanding the distribution of water resources worldwide is crucial for

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effective water management, addressing water scarcity, and ensuring access to safe and clean water for all. This section provides an introduction to the global distribution of water resources. The water distribution on Earth is highly uneven, with variations in availability and accessibility across different regions. Most of the Earth's water is found in saltwater in oceans and seas, accounting for about 97.5% of the total water volume (Gleick, 2019). Only a tiny fraction, approximately 2.5%, is freshwater, which is essential for sustaining life. Freshwater resources are primarily found in the form of glaciers, ice caps, and underground aquifers. Glaciers and ice caps store about 68.7% of the world's freshwater, while groundwater accounts for approximately 30.1% (Gleick, 2019). The remaining freshwater is found in rivers, lakes, and atmospheric water vapor. Various factors, including climate, topography, and geological conditions, influence the distribution of freshwater. Regions with higher precipitation, such as tropical rainforests, tend to have greater freshwater availability compared to arid or semi-arid regions (Owuor et al., 2016). Similarly, areas with extensive river networks and large lakes often have more abundant water resources.

Nature has gifted Pakistan with both ground and surface water resources. Unfortunately, anthropogenic activities such as industrialization, population growth, and misuse reduce their quantity and damage their quality. Understanding the water resources of Pakistan is crucial for effective water management, addressing water scarcity, and ensuring sustainable development. Pakistan's water resources primarily come from two primary sources: surface water and groundwater. Surface water resources in Pakistan are mainly derived from the Indus River system, which includes the Indus River and its tributaries, such as the Jhelum, Chenab, Ravi, and Sutlej rivers. These rivers originate from the Himalayas and traverse through Pakistan, forming an extensive river network that supplies water for irrigation, drinking water, and hydropower generation (Cheema et al., 2019; World Bank, 2013). The Indus River, the lifeline of Pakistan, is one of the longest rivers in Asia and provides significant water resources for the country. Its annual flow primarily depends on the monsoon rains and the melting of glaciers in the Himalayas. The Indus River Basin has vast irrigation potential and has been extensively developed for agriculture through canal systems, such as the Indus Basin Irrigation System (IBIS) (World Bank, 2013).

Groundwater is another essential source of water in Pakistan, particularly in arid and semi-arid regions where surface water availability is limited. The Indus Basin Aquifer is the largest groundwater reservoir in Pakistan, with significant storage capacity. Groundwater is commonly accessed through tube wells for irrigation, domestic use, and industrial purposes (World Bank, 2013). Water resources in Pakistan face several challenges, including increasing demand due to population growth, inefficient water management practices, and impacts of climate change. Climate variability, such as changes in precipitation patterns and glacier melt, poses risks to water availability and sustainability in the long run (Khan et al., 2015).

Effective management and conservation of water resources are critical for Pakistan's socio-economic development, agriculture, energy generation, and ecosystem preservation. Integrated water resource management, including improved irrigation techniques, water storage facilities, and efficient water use practices, is essential for ensuring sustainable water supply and addressing water-related challenges in Pakistan. Water pollution is a pressing environmental issue that has far-reaching consequences for ecosystems and human health. It involves the contamination or degradation of water resources, resulting in adverse effects on aquatic life and the quality of water for various uses. This section provides an introduction to water pollution, drawing upon a research paper titled "Water Pollution: Causes, Effects, and Solutions" by (Shyamala et al., 2008).

According to a study, industrial activities contribute to water pollution by releasing various pollutants such as heavy metals, organic compounds, and pharmaceuticals (Rathi et al., 2021). These pollutants can harm aquatic ecosystems, leading to reduced biodiversity and ecological imbalances (Zhang et al., 2021). Additionally, agricultural practices, as highlighted can result in water pollution through the excessive use of fertilizers and pesticides (David et al., 2011). The runoff of these chemicals into water bodies can cause eutrophication, harmful algal blooms, and water quality degradation (David et al., 2011). Research by emphasizes the impact of urbanization on water pollution (Afzal et al., 2000). Rapid urban growth leads to increased urban runoff, which carries pollutants such as heavy metals, microplastics, and oil into waterways.

In this study, we aim to comprehensively analyze the water quality of the streams, fresh rivers, and tube well water. By measuring and evaluating relevant parameters, we seek to gain insights into these water sources' overall quality, potential pollution sources, and usability. The findings will contribute to informed decision-making processes related to water resource management, public health, and environmental protection. The specific objectives of the study are as follows. To analyze the drinking water of Fata colony Malana, District Parachinar. To determine the water quality index (WQI) of the Fata colony, Parachinar based on the weighted arithmetic index technique

2. Materials and Methods

2.1 Study Area Description

Kurram Agency, also known as Kurram District, is a region located in the northwestern part of Pakistan, as shown in (Figure 1). It is part of the Khyber Pakhtunkhwa province and shares borders with Afghanistan. The district is situated in the historic Kurram Valley, surrounded by rugged mountains and picturesque landscapes. Geographically, Kurram Agency is located between the coordinates 33°35' and 34°19' North latitude and 69°31' and 70°12' East longitude. It covers an area of approximately 3,380 square kilometers (1,305 square miles) (Hussain et al., 2012). The Kurram River originates in Afghanistan and flows through the district, providing a vital water source for irrigation and other uses. Kurram district takes its name from the Kurram River, with a population size of 619,553; it is the most scenic valley on the Durand Line in the entire tribal belt. It is located in the northwest of Pakistan, previously central FATA. The total area of the district is 3,380 square kilometers. FATA colony is a small village on Malana main road in Kurram Agency, Pakistan. It is located north of the central city of Parachinar. Parachinar is the capital of Kurram Agency, where the Political Administration offices are located. Malana village is divided into two parts by a small rainy canal called Malana Horr, which remains dry throughout the year. However, during the rainy season, the rainwater flows through Malana Horr. In Malana, stream water is mostly the primary source of drinking water. Fata colony includes almost 500 homes and uses three different drinking water sources. They used streams, fresh rivers, and underground water for drinking.

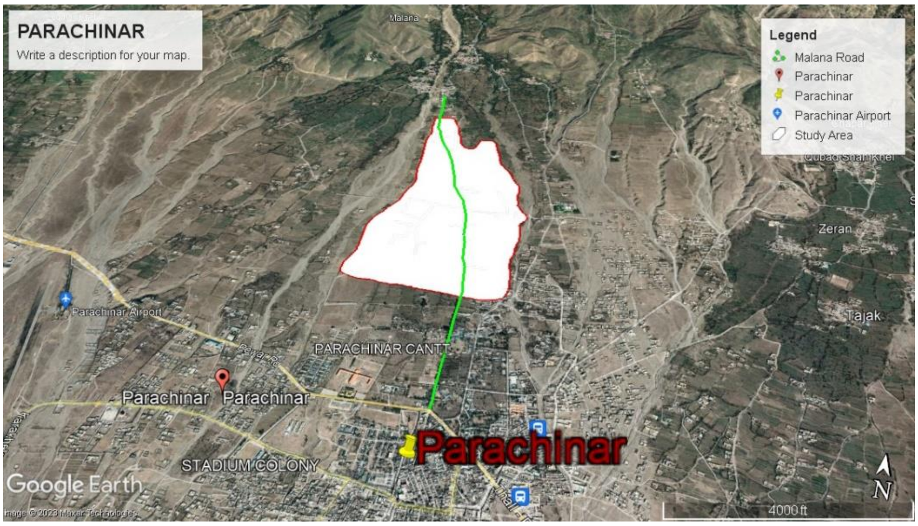

Figure 1: The location map of Malana FATA colony Kurram District, Khyber Pakhtunkhwa Pakistan

2.2 Sampling Collection Procedure

Drinking water samples were collected from three different sources, with three locations on each source. The following are three different sources: streams, fresh rivers, and underground water, which is one of the primary sources of drinking water in the FATA colony. As mentioned above, samples were collected three times at five different points at each of the three sites. Samples were aseptically collected from each sampling site in sterile glass bottles, transported to the laboratory in the ice box, and analyzed within six hours of sample collection. Forty-five (45) samples were collected from three different sources (Table 1).

2.3 Physical Quality Parameters

Physical parameters of drinking water, such as pH, Temperature, Electrical Conductivity, Taste, Color, and Odor, were analyzed in a laboratory (Sharma MR et al., 2004).

2.4 Chemical Quality Parameters

Chemical parameters like Total dissolved solids, Total hardness, Calcium, Magnesium, and Chloride were analyzed.

Table 1: Detail of Number of samples

Locations	Stream water	Freshwater	Tube-well water
Samples	15	15	15

2.5 Analytical Method

The following standard methods were used for analysis: The detailed parameters and methods used are given below.

2.6 Physical Water Quality Parameters

The list of physical parameters was analyzed in the laboratory of the Department of Environmental Sciences, University of Peshawar.

2.6.1 Color

Color is an essential parameter of drinking water. The color was observed through visual interpretation.

2.6.2 Taste and Odor

These two crucial water quality parameters were analyzed through sensory organs such as the tongue and nose.

2.6.3 Electric Conductivity

Conductivity was determined using the Conductivity & TDS Tester. It means the ability to conduct electric current. Water conductivity means how much current can be passed through water. It is measured primarily on a micro-Siemens per centimeter (µS/cm) unit (Khodapanah et al., 2009).

2.6.4 Turbidity

Turbidity was determined by the Turbidity meter. It is an indirect measure of the presence of suspended. Turbidity is a measure of the extent to which light is either absorbed or scattered by suspended material. It is measured in a unit known as the Nephelometry Turbidity Unit (NTU).

2.6.5 PH

pH was determined with a pH meter. After checking all the samples, the instrument was washed with distilled water.

Figure 2: Electrical conductivity meter

Figure 3: Turbidity meter

2.7 Chemical water quality parameter

The following chemical water quality parameters were identified in the laboratory during the current study.

2.7.1 Total Dissolved Solids (TDS)

The Gravimetric method determined the total dissolved solid in a laboratory of the Department of Environmental Sciences, University of Peshawar. We washed the TDS meter with Distilled water after each sample was analyzed.

Procedure: first of all, we take a china dish and wash it with distilled water. Dry in the oven for 25 to 30 minutes, cool it in a desiccator, and weigh the china dish (W1). Add the known volume of filter water to the China dish. Evaporate the sample in the oven at 110C for 24 hours. Cool in a desiccator. Weight again the China dish (W2) (Shah et al., 2005).

Calculation

W2-W1) * 1000

TDS (mg/L) = _________ml of Sample

2.7.2 Total Hardness of Water

Hardness in water is due to the presence of dissolved calcium and magnesium salts. Hard water is unfit for drinking, bathing, and washing purposes. Total hardness was determined by titration method.

Apparatus: Volumetric flask, Stand, Burette, Stirrer, Titration flask, Pipette, Graduated cylinder.

Reagents: EDTA (0.01M), 1ml Ammonia buffer10, Eriochrome black T indicator

Procedure: 20 ml of the samples were taken in a titration flask, and a few drops of EBT indicator were added to the sample. Then, 1ml Ammonia buffer solution was added to the sample to alleviate the sample's PH. After pH alleviation, 0.01M solution of standard EDTA was taken in the burette, and an initial point was noted. The sample was titrated against the standard solution of EDTA till the color of the sample changed from light purple to light blue. Then, titration was stopped, and the endpoint of the burette was noted. The difference between the initial and final points reading calculated the volume of standard EDTA solution of 0.01M. The hardness was then calculated in mg/L as $CaCo_3$ by using the following formula (Jayana et al., 2009).

Calculation

T. Hardness mg/L as $CaCO_3$=V of EDTA x Molarity of EDTA x wt of $_{CaCO3}$ x 1000 Volume of sample taken and divided by ml of sample

2.7.3 Calcium (Ca)

Calcium was identified using the titration method.

Reagents: Reagent EDTA (0.01M) solution. , Reagent Sodium hydroxide (NaOH 1M), Murexide indicators

KCN

Procedure: 20 ml of the sample was taken in a titration flask. A few drops of Buffer 12 (NaOH) were added to the sample to maintain the pH (12) of the sample, and a pinch of Murexide (ammonium purpurate) indicator and KCN were added. We shake the sample till the indicator is dissolved and a pink color is produced. The sample was titrated against the EDTA (0.01 M). EDTA solutions are added slowly with constant shaking until the color changes from pink to purple (endpoint) (Daud et al., 2017).

Calculation

Ca. Hardness mg/L as $CaCO_3$=V of EDTA x Molarity of EDTA x wt. of Ca. x 1000 Volume of sample taken and divided by ml of sample (Shahid et al., 2015).

2.7.4 Magnesium (Mg)

Once calcium and total hardness are analyzed using the EDTA titrimetric method, their results are used in the calculation of magnesium in the same sample using the formula written below. Calculate Magnesium by using the formula:

Mg mg/l= Total Hardness (as mg $CaCO_3$/l) - calcium hardness (as mg $CaCO_3$/L)

2.7.5 Chloride (Cl)

Chloride concentration was identified by titration method.

Reagents: The reagent silver nitrate (AgNO3) solution is 0.014N. Sodium chloride (NaCl) solution 0.014N, Potassium chromate ($KCrO_4$) indicator.

Preparation of $AgNO_3$ (0.014N): 2.395g $AgNO_3$ was dissolved in distilled water and diluted to 100 ml.

Procedure (Argentometric method): We took 20 mL of the sample in a titration flask and added a few drops of potassium chromate (K_2CrO_4). The sample was titrated against 0.0141N $AgNO_3$. When the sample color is changed from Yellow to Red-brown, the burette reading is noted.

Calculation

Cl mg/L= (A – B) × N ×molar wt. of Cl.35.5 X 1000 and divided by ml of sample

Where: A-B = Volume of $AgNO_3$ in Buratte, N = Normality of $AgNO_3$

2.8 Water Quality Index

Calculating the water quality index parameters, namely pH, total dissolved solids, turbidity, electrical conductivity, total hardness, calcium, magnesium, potassium, and chloride, were considered. The weighted arithmetic water quality index method was used to find surface and groundwater quality index (Changsheng et al., 2022).

Calculation

The weighted arithmetic index technique estimated the Water Quality Index (WQI). The following steps are followed to calculate the WQI.

Step 1: Each sample Wn factor is determined using the following formula:

$$Wn = K/Sn \quad (1)$$

Where Sn = standard desirable value of nth parameters.Wn = 1 (unity).

K = constant of proportionality. The value of K = 1; is constant and is used to calculate the standard desirable value of each chemical variable.

Step 2: The sub-index (Qn) value will calculated by using the expression.

$$Qn = [(Vn - Vo)]/[(Sn - Vo)] \times 100 \quad (2)$$

Where Vn = average concentration of the nth parameter. Sn = standard desirable value of the nth parameter. Vo = actual values of the parameters in pure water (generally V0 = 0 for most parameters, except for pH). For pH, we used Eq. 3.

$$QpH = [(VpH - 7)]/[(8.5 - 7)] \times 100 \quad (3)$$

Step 3: Step 1 and Step 2 were combined to determine WQI.

$$Overall\ WQI = \sum WQn/\sum Wn \quad (4)$$

3. Results and Discussion

Results show that most parameters are within the permissible limits of WHO and Pakistan NSDWQ. Magnesium levels in most of the samples are high. pH results show that stream water and tube well water are slightly basic but fit for drinking. Results also show that three type of water mean values is not hard. The results of the collected samples are shown in the table below.

Table 2: Mean of all parameters

Parameters	pH	Turbidity	EC	TDS	TH	Ca	Mg	Cl
Units		NTU	µS/cm	mg/l	mg/l	mg/l	mg/l	mg/l
Pak NSDWQ	**6.5-8.5**	<5	<1000	<1000	<500	200	150	<250
M. Stream S1	7.9	7	496	580	210	38	172	35
M. Stream S2	7.4	5.9	403	411	315	46	269	33
M. Stream S3	7.3	6.4	511	466	250	36	214	29
M. River S1	6.3	4.9	572	641	255	38	217	41
M. River S2	7	5.9	453	402	235	32	203	35
M. River S3	7.2	6.6	433	493	170	38	132	45
M. Well S1	7.9	7	485	670	205	50	155	55
M. Well S2	8	6.7	492	536	245	22	201	50
M. Well S3	8.2	5.1	690	542	275	18	214	45

3.1 Physical Parameters

3.1.1 Color in Three Different Locations

The colours of water indicate the presence of various chemical and organic pollutants such as copper from plumbing systems, rust from iron pipes, algae, bacteria, and so on. The unit of color is the True Color Unit (TCU). The color of the three selected locations was unobjectionable.

3.1.2 Taste in Three Different Locations

Taste is the perception stimulated when a substance in the mouth reacts chemically with taste receptor cells located on taste buds in the oral cavity, mainly on the tongue. For this study, all the samples from the three sites were tasteless.

3.1.3 Odor in Three Different Locations

The quality of something stimulates the sense of smell. For this study, all the samples of three sites were odorless.

3.1.4 Ph Level in Three Different Locations

Figure 4 shows that the mean value in-stream water pH for the measured samples was recorded within a range of 7.3 to 7.9, and in Tube well water pH was recorded within a range of 7.9 to 8.2 while the pH level in fresh river water was recorded within a range of 6.3 to 7.2. The smallest pH value was recorded in sample 1 of fresh river water at 6.3, and the highest mean value was in a sample of Tube well water. In 45 samples, the pH level was found to be within the permissible limit of WHO and Pakistan NSDWQ, except in the sample number point of fresh river water, which was below the allowable limit. The acceptable pH limit for WHO and Pakistan NSDWQ is 6.5 to 8.5.

3.1.5 Turbidity Level in Stream, Fresh River, and Tube Well Water

In Figure 5, the results of various stream water samples showed that the mean value in measured turbidity was within a range of 6.4 NTU to 7 NTU. In Tube well water, the Turbidity concentrations were within a range of 5.1 NTU to 7 NTU, while Turbidity concentrations in Fresh river water were within a range of 4.9 NTU to 6 NTU. The minimum level of turbidity concentration was recorded in sample 1 of fresh river water at 4.9 NTU, and the highest level of turbidity concentration was recorded at 7 NTU. The Turbidity level was above the permissible limit, while one was within the allowable limit of WHO and Pakistan NSDWQ. The acceptable limit for pH of WHO and Pakistan NSDWQ is <5 NTU.

3.1.6 Electrical Conductivity Mean Value in Three Different Sites

Figure 6 shows that In-Stream water, the result of various samples showed that the measured electrical conductivity was within a range of 403 μS/cm to 511 μS/cm. In Tube well water, the electrical conductivity was within a range of 485 μS/cm to 690 μS/cm, while electrical conductivity in Fresh river water was within a range of 433 μS/cm to 572 μS/cm. The smallest electrical conductivity value was recorded in sample 2 of stream water at 403 μS/cm, and the highest electrical conductivity value was recorded in sample 3 of Tube well water at 690 μS/cm. The results showed that electrical conductivity in overall samples was within the permissible limit of WHO and Pakistan NSDWQ. The allowable limit for electrical conductivity of WHO and Pakistan NSDWQ is <1000 μS/cm.

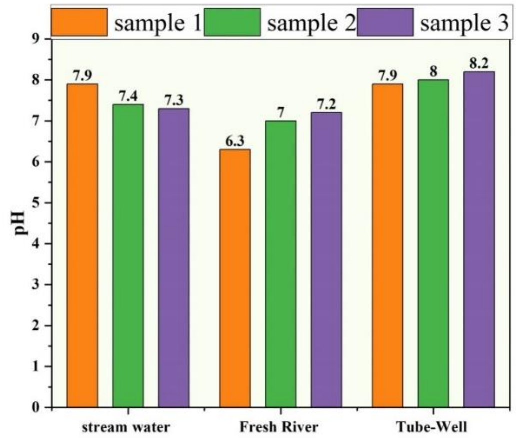

Figure 4: The pH concentration mean value in three collected samples on each sampling site.

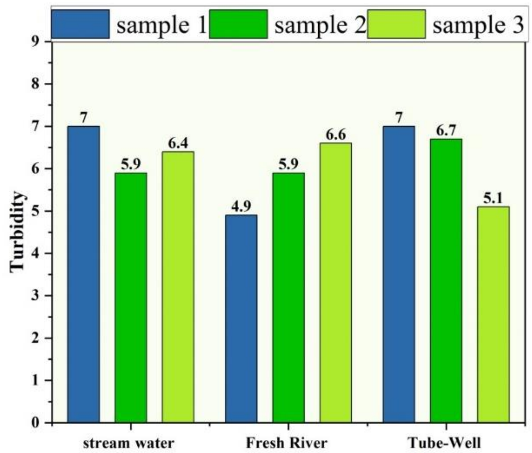

Figure 5: The Turbidity concentration in three collected samples on each sampling site

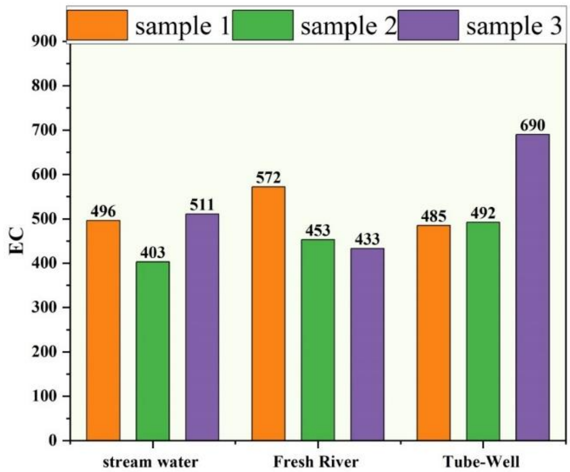

Figure 6: The EC of three collected samples mean value on each sampling site

3.2 Chemical Parameters

3.2.1 Total Dissolved Solid Level in Three Selected Sites

The total dissolved solids tests are considered to determine the general quality of water. The Total dissolved solids in three stream water samples range from 411 mg/l to 580 mg/l. The total dissolved solids in fresh river water were 402 mg/l to 641 mg/l, while the total dissolved solids in Tube well water were 536 mg/l to 670 mg/l. The smallest value of fully dissolved water was in sample 2 of fresh river water at 402 mg/l, and the highest recorded value of total dissolved solids was in sample 1 of tube well water at 670 mg/l. The Total dissolved solids in all Forty-five (45) models were found within the permissible limit of WHO and Pakistan NSDWQ. The allowable limit for total dissolved solids of WHO and Pakistan NSDWQ is <1000 mg/l.

3.2.2 Hardness Level in Three Selected Sites

In stream water, the total hardness of the drinking water samples was recorded within a range of 210 mg/l to 315 mg/l. In fresh river water, the total hardness for samples measured was 170 mg/l to 255 mg/l, while the total hardness in tube well samples was 205 mg/l to 275 mg/l. The highest total hardness value was in sample 2 of stream water at 315 mg/l, and the smallest value was in sample 3 of fresh river water at 170 mg/l. The total hardness in all the measured samples of three selected sites is within a permissible limit of WHO and Pakistan NSDWQ. The allowable limit for total hardness of WHO and Pakistan NSDWQ is <500 mg/l. The results are shown below in Figure 8.

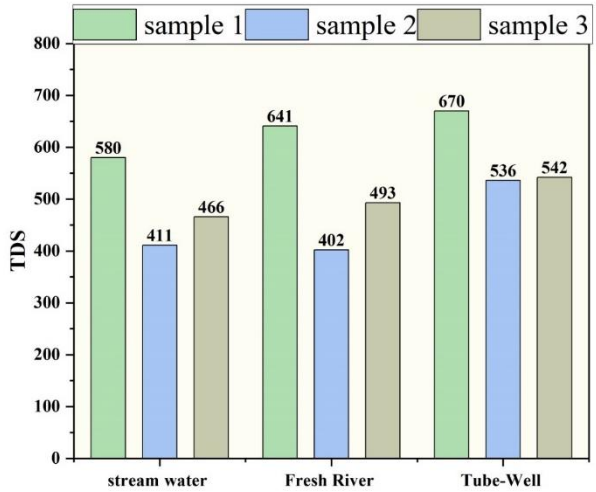

Figure 7: The TDS concentration in three collected samples on each sampling site

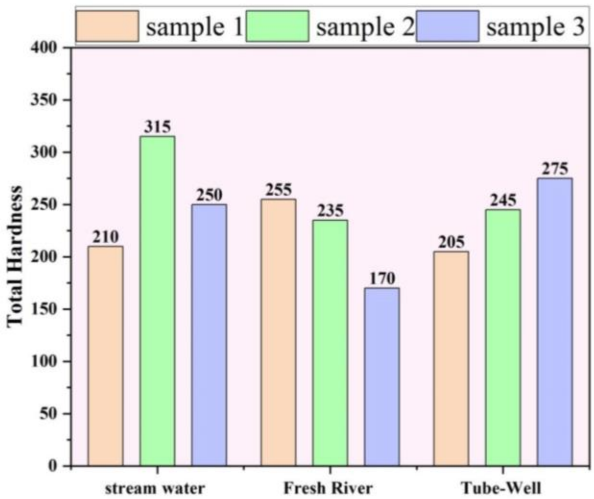

Figure 8: The total hardness of three collected samples on each sampling site

3.2.3 Calcium Hardness in Three Selected Sites

Calcium is an alkaline earth element and fifth in abundance. In Figure 9, it is shown that, in stream water, calcium hardness for the drinking water samples was recorded within a range of 36 mg/l to 46 mg/l. In fresh river water, calcium hardness for samples measured was 32 mg/l to 38 mg/l, while calcium hardness in tube well samples was 18 mg/l to 50 mg/l. The smallest value of calcium hardness was in sample 3 of Tube well water at 18 mg/l, and the highest value of calcium hardness was in sample 1 of Tube well water at 50 mg/l. Calcium hardness in all the measured samples of three selected sites is found within a permissible limit of WHO and Pakistan NSDWQ. According to WHO guidance, the maximum permitted limit of calcium in drinking water quality is 200mg/L for internationally acceptable value and 200 mg/L as an excessive limit. The permissible limit for calcium hardness Pakistan NSDWQ is 200 mg/l.

3.2.4 Magnesium Level in Three Selected Sites

Magnesium is a light silver-white metallic element. It is the eighth-most abundant element. Figure 10 shows that In-stream water magnesium hardness for the drinking water samples was recorded within a range of 172 mg/l to 269 mg/l. In fresh river water, magnesium hardness measured for samples was at 132 mg/l to 217 mg/l, while magnesium hardness in tube well samples was within a range of 155 mg/l to 214 mg/l. The smallest value of magnesium hardness was in sample 3 of fresh river water at 132 mg/l, and the highest value of magnesium hardness was in sample 2 of stream water at 269 mg/l, and one sample out of nine samples was within both WHO and Pakistan NSDWQ maximum acceptable standard (150 mg/L).

3.2.5 Chloride Level in Three Selected Sites

Chlorides are soluble in water and harmless at low levels. Therefore, they are reducible by dilution. Its concentration at a higher level in water is an indication of pollution. High chloride levels in water destroy structures and harm growing plants. Figure 11 shows that, in stream water, chloride level in drinking water samples was recorded within a range of 29 mg/l to 35 mg/l. In fresh river water, the chloride level measured for samples was 35 mg/l to 45 mg/l, while the chloride level in tube well samples was 45 mg/l to 55 mg/l. The smallest chloride value was in sample 3 of stream water at 29 mg/l, and the highest chloride was in sample mean value of Tube well water at 269 mg/l. The results showed that all the measured samples are within the permissible limit of WHO and Pakistan NSDWQ (250 mg/).

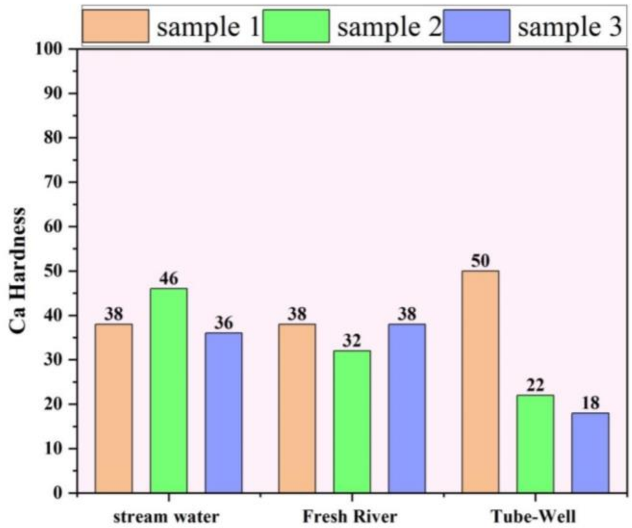

Figure 9: The Ca Hardness concentration means values in three collected samples on each sampling site.

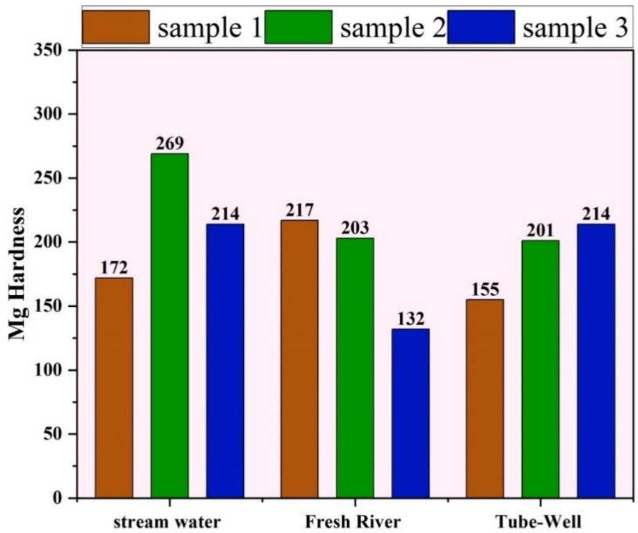

Figure 10: The Mg Hardness concentration mean values in three collected samples on each sampling site

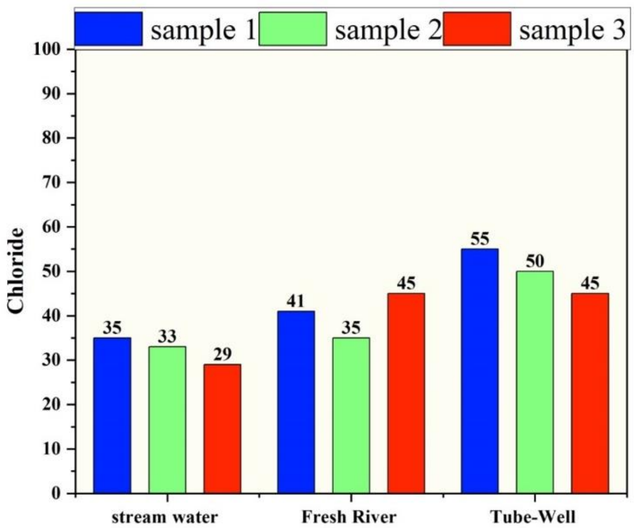

Figure 11: The Chloride concentration mean values in three collected samples on each sampling site

3.3 Water Quality Index Results

A Water Quality Index (WQI) is a means by which water quality data is summarized for consistent reporting to the public. This calculation produces a score between 0 and 100. After measuring all the samples from three selected sites, we applied the water quality index to each sample, and the results are shown below:

Table 3: Water quality index and its categorization for each sample in the study area

Samples types	S.NO	WQI Values		Category
Stream samples	1	5.195583		Excellent
	2	4.619247		Excellent
	3	4.801285		Excellent
Fresh river samples	1	3.868835		Excellent
	2	4.475927		Excellent
	3	4.842367		Excellent
Tube-well samples	1	5.218053		Excellent
	2	5.044155		Excellent
	3	4.262408		Excellent

Table 4: Classification of water quality based on WQI (Ramakrishnaiah et al., 2009)

Category	WQI	Water quality	Water Sample
A	0-25	Excellent	100%
B	25-50	Good	0%
C	51-75	Poor	0%
D	76-100	Very poor	0%
E	> 100	Not suitable	0%

According to the water quality index (WQI), all the samples fall in category a (0-25), which shows that all the samples are excellent, suitable, and safe for drinking.

4. Conclusion

The drinking water samples were collected from three sites: stream, fresh river, and Tube well in fata colony, Maulana, to analyze the physiochemical parameters like pH, turbidity, conductivity, total dissolved solids, taste, color, odor, total hardness, calcium, magnesium, and chlorides. After analysis, most parameters were within a permissible limit as suggested by the World Health Organization (WHO) and Pakistan NSDWQ. Although the Turbidity and magnesium concentration in most of the samples exceeded the limits, the pH concentration of the fresh river water was below the permissible limits. Therefore, based on the result, it is concluded that the drinking water of the Fata colony is suitable for drinking as far as physiochemical parameters are analyzed and concerned. However, the distribution of stream and fresh river water is not satisfied due to bursts and leakages of pipes in a way that provides the chance of mixing and contamination of water. After applying the water quality index to analyzed samples, it is concluded that all the collected samples from three different sites are excellent. Nevertheless, it is beneficial for us to know the importance of the water quality index when analyzing water quality.

This study plays a crucial role in protecting public health, enhancing access to clean water, empowering the community, influencing policy decisions, preserving the environment, improving livelihoods, and bolstering emergency preparedness. The outcomes of our research extend well beyond initial findings, offering the potential for sustained positive effects on the lives of Fata colony Malana Parachinar Kurram District residents. Based on the results of the present study, the following recommendations to consumers are made. Every household, village, or town should install a small filtration plant to ensure clean and clear water. Pakistan National Standards for Drinking Water Quality should be set and implemented. Awareness programs like seminars and workshops should be arranged to make people aware of the best quality of water and its importance for the betterment of society. Moreover, we recommend heavy metal analysis for further research.

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