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Original Research Article

Assessing the Safety and Quality of Underground Drinking Water in Faisalabad

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Abstract

Pakistan has many plentiful water sources, including ice caps, rainwater, and groundwater, but these sources are continuously polluted. Fast growth, development, and continued industrial growth, especially in Faisalabad, have imposed immense pressure on the city's water resources. Its groundwater quality is worsening rapidly because of untreated wastewater from municipal and textile industries. Fifteen samples were collected from different colonies of Faisalabad for physical, chemical, and biological analysis. To regulate the quality of drinking water, physio-chemical parameters such as color, Odor, Taste, electric conductivity, Total dissolved solids, and chemical parameters like Ca, Mg, carbonates, bicarbonates, and chlorides were examined. After examining all collected samples, they were linked with the WHO values, Pakistan standards, and quality control authority standards (PSQCA). Out of these 15 samples, four samples were unfit for human use owing to the occurrence of E. coli. The remaining 11 samples were biologically fit for human consumption. All samples are colorless, but four have a pungent smell, and five have a terrible taste. The pH of all the samples was within the WHO and PSQCA limits (6.50-8.50) except for one. The highest EC was found at 6.206 ds/m from Noorpur, and the lowest was 0.062 ds/m from Millet town. Our research shows that about 46% of the underground water of Faisalabad is unhealthy for human drinking due to the high TDS, TSS, chlorides, bicarbonates, and presence of microorganisms.

Keywords: Water quality; Faisalabad city; Organoleptic Technique; Physical and Chemical Technique.

INTRODUCTION

Faisalabad is the third largest city in Pakistan. Water is essential for all living organisms. In Pakistan, water pollution is alarming place, and it is life-threatening for the public of Pakistan. Throughout the country, heavy metals and microorganisms pollute drinking water. Physiochemical and microbial factors established by the World Health Organization (WHO) are inadequate to fulfill, and chief issues are blamable due to numerous fitness issues. In the previous decades, water contamination or poisonous materials have gathered more significant consideration, as they threaten community well-being and marine life. (Memon *et al.*, 2016). The addition of pollutants to water increases continuously due to increased urbanization and production activities affecting the environment and human health (Wu *et al.*, 2020). The primary water contamination sources are landfill leachate, wastewater from agriculture, and urban runoff (Mokarram *et al.*, 2020). Heavy metals entering the environment are highly stable and somewhat non-degradable, contaminating ground and surface water (Mokarram *et al.*, 2020). Waterborne diseases like diarrhea, hepatitis, cholera, and dysentery are proven by research. They affect at least a thousand adults and children annually (Adekanmi *et al.*,).

There can be different sources of groundwater pollution, e.g., poorly managed municipal landfills, agricultural runoff, and industrial effluents (Singh *et al.*, 2021). In many developing countries, landfills have been dumped with non-segregated solid waste. This prevalent waste disposal caused improper generation of toxic leachates and management of landfills, significantly impacting groundwater and freshwater (Parvin and Tareq., 2021). Leachate is a solid waste effluent that is dumped into landfills and is considered a chemical soup of dissolved organic matter, anions and cations, xenobiotic organic compounds, and heavy metals; these leachates alter the physical, chemical, and biological properties around the landfills (Parvin and Tareq. 2021). While in the agricultural sector, different types of pesticides and fertilizers are used (Shahid *et al.,* 2020). Nitrogen is a significant constituent in fertilizers. Nitrate is a common pollutant in the form of nitrate, and it tends to leach down into the surface and groundwater from the root zone in agricultural soils (Craswell, 2021). Nitrate in the groundwater is unfit for drinking when it exceeds the permissible limits (Gugulothu *et al.,* 2020). Nitrogen and phosphorus in fertilizer runoff into the water and cause phytoplankton productivity, which causes eutrophication in water (Ngatia *et al.,* 2019). Eutrophication, in return, disturbs aquatic life, kills biodiversity, disturbs coral reef habitats, damages fisheries, and causes anoxia and hypoxia (Bashir *et al.,* 2019). On the other hand, the untreated industrial wastewater discharge in urban areas of developing countries is enhancing with the growing population (Ilyas *et al.,* 2019). Water is used for heating, generating steam, cleaning, as a solvent for dissolved substances, and cooling (Raja *et al.,* 2019). This withdrawal of water from waterbodies is larger than the amount of water being consumed in the production of industrial products. After all the processes, the leftover water contains many hazardous chemicals, dyes, and pollutants discharged untreated into the water (Saravanan *et al.,* 2021). All these sources are contributing to the global freshwater water scarcity issues.

The WHO has recommended an increased focus on water treatment at home as a potential solution to the water pollution problem. Rivers, streams, lakes, and underground water are the primary water sources for communities and municipalities, and they are heavily polluted by domestic, agricultural, and industrial waste. (Omoigberale *et al.,* 2013). In major Pakistani cities like Karachi, Lahore, Faisalabad, Sialkot, Rawalpindi, and Peshawar, water quality is deteriorating due to the mixing of untreated industrial water, uncontrolled mixing of municipal wastewater, and the leaching of fertilizers into the soil, which then contaminates the water.

It is important to stress the difficulty of cultivating and examining all waterborne pathogens, as it highlights the issue's complexity and keeps the reader engaged. Many intestinal bacteria and other disease-causing pathogens are released into the feces and urine of animals and Humans. In contaminated water, some bacteria like salmonella, shigella, vibrio cholera, and Yersinia enterocolitica are only present in water with stool. Cultivating all pathogens and routine examination of these pathogens is very difficult. (Prest *et al.,* 2016). In Pakistan, the textile industry is significant, and several small and large industries are in the country. This industrial waste contains chloride, sodium sulfate, total dissolved solids, sulfates, chemical biological oxygen demands (BOD) and (COD), heavy metals, and many other harmful matters. (Aleem *et al.,* 2018). Pathogenic disease is the most severe disease for human beings worldwide. Overall, 25 million losses yearly are attributed to this type of water-borne infection. Gastrointestinal toxicities result in diarrhea, mainly in children. About 25% of patients die at hospitals and health centers.

The leading cause of waterborne diseases in Pakistan is mixing sewage with drinking water. Different waterborne diseases in Pakistan are typhoid, cholera, diarrhea, intestinal worms, cryptosporidium infection, and gastrointestinal diseases. (Daud *et al.,* 2017). Faisalabad, a major city in Pakistan, is particularly affected by these issues due to its rapid urbanization and industrial growth. Our daily routine exerts pressure on our water resources. We do many things daily, like urbanization, forest practices, agricultural practices, and road construction, which pressure water resources. Applying fertilizers to lawns and our crops, as well as when we drive a car or use toxic chemicals, adds pollution to the surface and groundwater. (Beck *et al.,* 2018).

MATERIAL AND METHODS

Materials

The Soil Laboratory of Environmental Science, Government College University Faisalabad, provided all the materials used in this research, such as glassware and chemicals. The samples were accumulated in dedicated plastic bottles from water supply pipelines and transported to the research laboratory.

Sampling and collection of data:

Different water considerations were tested in the laboratory to determine the water excellence of Faisalabad. Samples were assembled from houses through surveys, and samples were collected from each site. These queries were elegant activities concerning the ingestion of water. Trials were gathered after one minute of running the water tap to stop the mixing of other constituents.

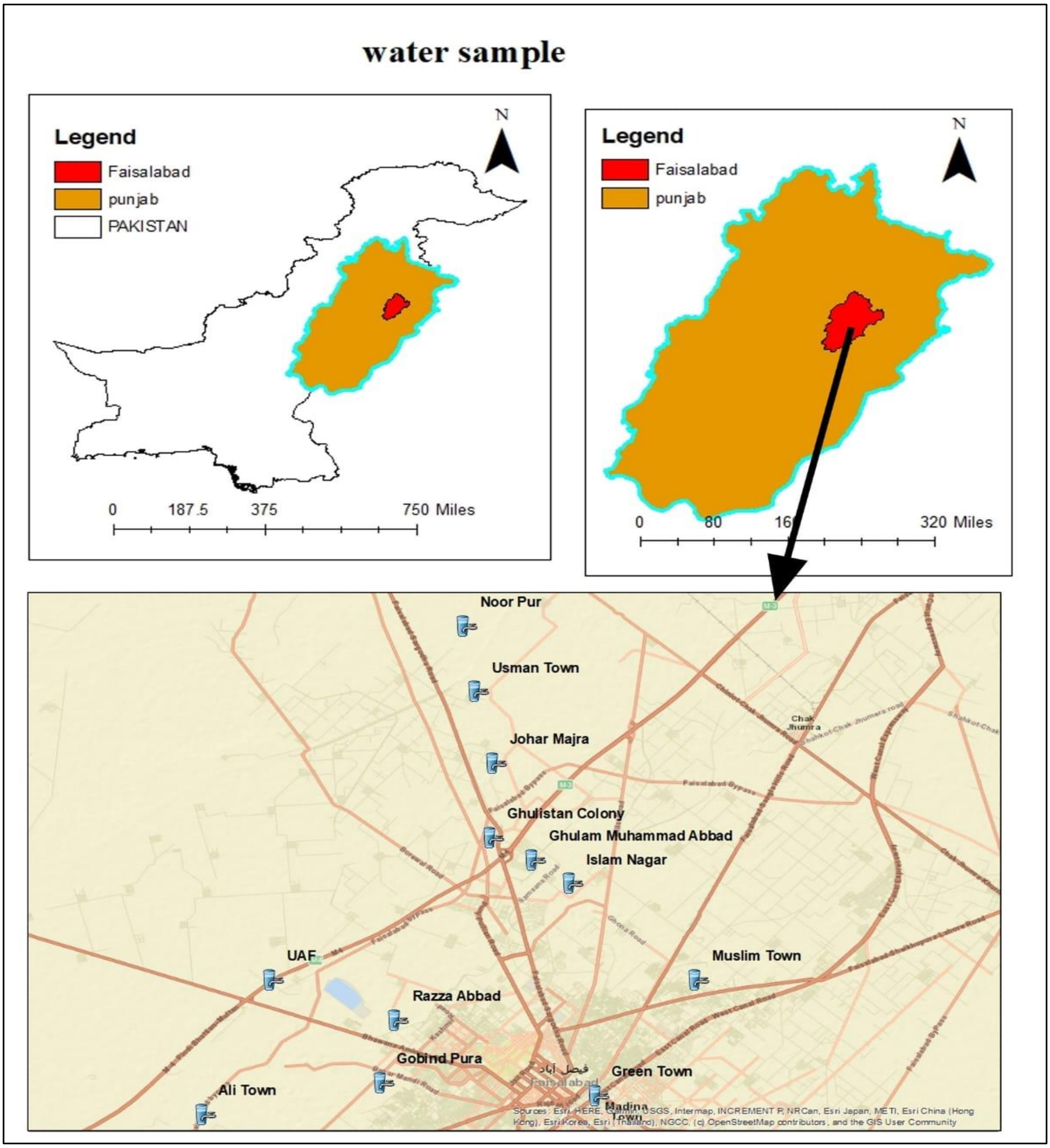

Figure 1. Map of water sample collections of different locations in Faisalabad

Physical Parameters

The water samples were detected with the naked eye for color, and then the taste and odor of the water specimen were crisscrossed through organoleptic valuation (Kerketta *et al.*, 2013).

Chemical Parameters

The chemical study analyzed seven factors in the lab using the titration method. Sulfuric acid was used for carbonate and bicarbonate, and AGNO3 was used for chloride (Naveen *et al.*, 2017). The sample pH and EC were determined at the sampling point using a portable hand pH meter (JENCO Model 3010) and JENCO Model 6010N.

Methods

The water samples were meticulously analyzed in a state-of-the-art research laboratory for various water quality parameters, such as pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), and Chloride (Cl-), using the highly reliable titration method. This rigorous approach ensures the accuracy and reliability of our findings.

Total Dissolved Solids

Total Dissolved Solids (TDS) are the total amount of mobile charged particles, including minerals, salts, or metals dissolved in a given volume of water, imparted in units of mg per unit volume of water (mg/L). TDS in drinking water comes from standard sources, such as sewage, urban runoff, industrial wastewater, different chemicals used in the water treatment process, and the nature of the channels used to convey the water, i.e., the funnels.

Total Suspended Solids (TSS)

Total Suspended Solids (TSS) are solids in water that filters can trap. TSS can consolidate a comprehensive combination of materials, such as residue, decaying plant and animal manure, industrial wastes, and sewage. High concentrations of suspended solids in drinking water can cause various medicinal issues.

Biological Parameters

In biological factors, E. coli and colony-forming units were tested in a microbial workroom. For this purpose, samples were gathered in small bottles and examined within 24 hours to avoid the decay of pathogens. (Bedasa *et al.*, 2018).

Coliforms total, Fecal and E.coli
Procedure

To check the presence of E. coli, 100 ml water was taken from each water sample, and a sterile absorbent was placed in a sterile petri dish using cleaned forceps. Then, close the lid, and to avoid contaminating the pad or inside the petri dish to sterilize the forceps, touch the forceps into the alcohol or flame them on the alcohol or Bunsen burner. Then, let the forceps cool before use. To make it convenient, Petri dishes with pads were used. A filter paper is placed gently on a petri dish, ready-made media. An m-Endo Broth Poured Rite Ampule is another type of culture media used for growing bacteria. 1-2 times to mix the stock. An ampule beaker was employed to open the ampule. Then, it is also important to pour the substance similarly over the retentive pad. Changed the petri dish top. Then, this process was repeated for 1 and 2 for each prepared petri dish, as shown in the following steps: Blue coloration on media indicated the growth of bacteria in the sample. Prepare membrane filter assembly. Sterile forceps were employed to place a layer channel, from side up, into the assembly. On the other hand, a sterile disposable filter unit may be used. Turned the channel upside down for 30 seconds to mix. Two hundred milliliters of the sample were poured into the pipe, and a vacuum was created to filter the sample. Vacuums were released. Washed the funnel walls with 20-30 ml sterile buffer dilution. Again, a vacuum was applied. This process was repeated 2 to 3 times. The vacuum was discharged when the filter was exhausted or out of filter paper. With the help of sterile forceps, the filter is immediately transferred to the previously prepared petri dish. Slightly rocking from side to side. The grid-side-up filter was placed on the absorbent pad in the filter's center. Ensured that no air was trapped under the filter and that the filter was in contact with the whole petri dish. The lid of the was replaced. The petri dish was turned upside down, and the fat was cultured at 35 ± 0. 5 C for 22-24 hours. After incubation, a 10 to 15x microscope was used to count the red colonies, or it might be restricted to the edge of the center.

RESULTS

Physical parameters

The results of this study show that water quality in six areas of Faisalabad, namely Ali Town, Agriculture University, Dhanola, Noorpur, Rezaabad, and Johor Majra, is not safe for drinking because of the high concentration of TDS, TSS, and chloride. This is a significant health concern for the residents, and it clearly shows that there is a need for water quality to be enhanced.

Odor, Color, and Test

The color should not be visible in the sample. There should be no organic or suspending particles in it. The sample should be free from any smell. The sample should be acceptable after the color and odor test (Gorge *et al.*, 2013).

Physical Parameters of all the samples.

Table 1: Physical parameters of all the samples

Sr. No.	Site Name	Color	Odor	Taste
1	Johar Majra	No	No	No
2	Gobindpura	No	Pungent smell	Yes
3	Razaabad	No	No	No
4	Gulistan Colony	No	No	Yes
5	Noorpur	No	No	No
6	Green Town	No	No	Yes
7	Millat Town	No	Pungent smell	No
8	Gokhowal	No	Pungent smell	Yes
9	Dhnola	No	No	No
10	UAF	No	No	No
11	Ali Town	No	No	No

Sr. No.	Site Name	Color	Odor	Taste
12	Islamabad	No	Pungent smell	No
13	Usman Town	No	No	Yes
14	Islam Nagar	No	Pungent smell	No
15	Muslim Town	No	Pungent smell	Yes

Chemical parameters:

pH

The pH quality of water is an indicator of the relative acidity or alkalinity of a solution. The pH of the water sample was in the range of 7.11 to 8.62, which is particularly acceptable for drinking. All of the samples were dissolvable. The alkalinity is the result of the presence of carbonates and bicarbonates. The pH of all the samples was within the WHO and PSQCA limits (6.50-8.50) except for one. The variation in pH of water supply in different regions of Faisalabad city is shown in Fig 2.

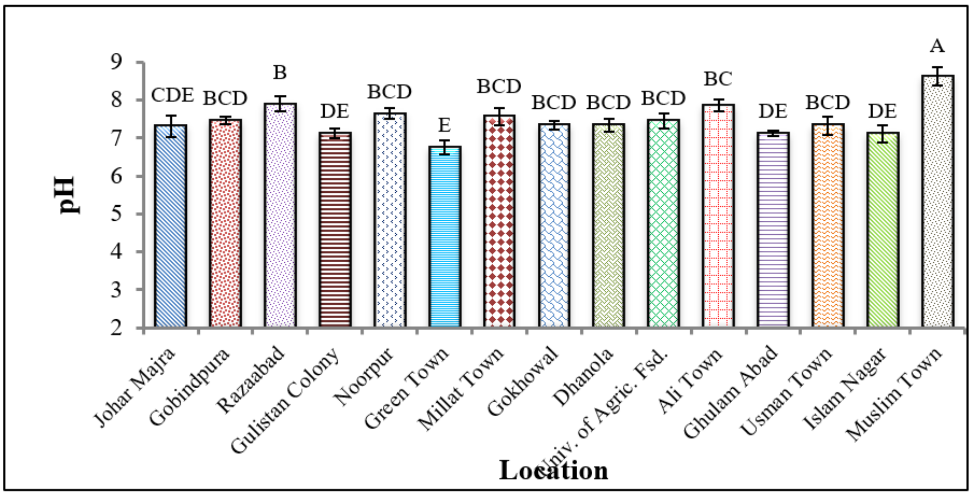

Fig. 2: The pH variation of water samples from different areas of Faisalabad city

Electrical Conductivity (EC)

Conductivity is significantly associated with ten parameters: temperature and pH value. (Navneet Kumar *et al.*, 2010) recommended that the underground drinking water quality of the study area be checked effectively by controlling water conductivity, which may be associated with the water quality management of another study area. It is evaluated with the help of an EC meter, which measures the restriction offered by the water between two platinized anodes. The instrument is standardized with known estimations of conductance observed with a standard KCl game plan (Gorge *et al.*, 2013). The variation of electrical conductivity of water supply in different regions of Faisalabad city is shown in Fig 3.

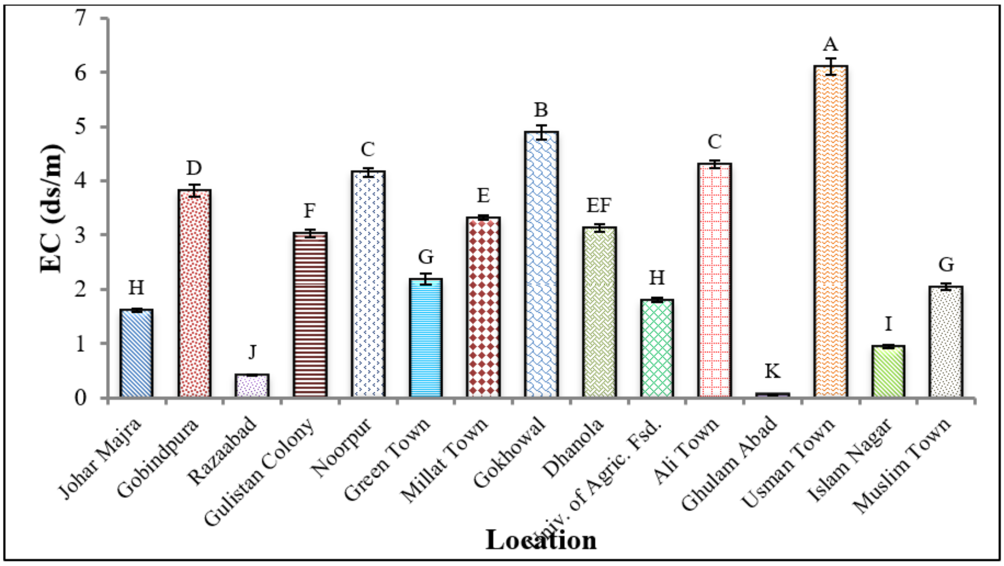

Fig. 3: The EC variation of water samples from different areas of Faisalabad city

Chloride:

Chloride ions are mainly derived from chloride salts, and sodium chloride is the most common source of chloride ions in water streams. Laxative effects are also observed from the high chloride concentrations in drinking water. Chloride is used to calculate the salinity of a water stream, as observed above. According to our assessment, the chloride concentration varied from 2. 5 to 32. 5 mg. L-1 is suitable given WHO and PSQCA norms (Cl-≤ 250 mg. L-1). The chloride concentration is not constant and differs in the various water streams. The variation in chlorides of water supply in multiple districts of Faisalabad city is given in Fig 4.

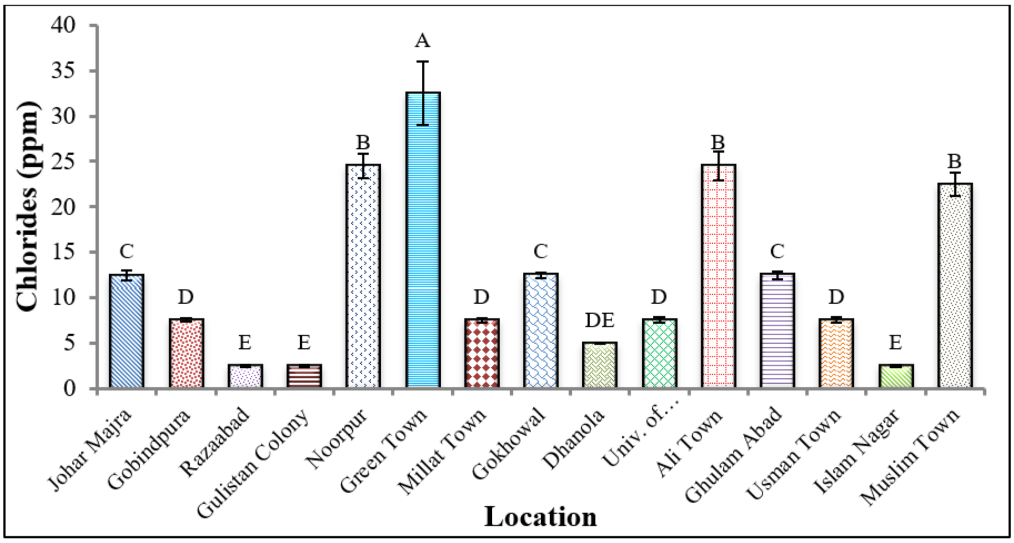

Fig. 4: The chlorides variation of water samples from different areas of Faisalabad city

Total Suspended Solids (TSS)

The WHO has set a recommended TSS limit of 30 mg/L. The TSS values of all the tested drinking water samples were checked. The highest value is 61. Seven milligrams per liter of this compound were detected in a water sample from the Rezaabad region. That was very high to the acceptable WHO 30 mg/L limit. The samples collected from four other areas, Millat Town, Gokhowal, Glamabad, and the University of Agriculture Faisalabad, were also observed to possess very high TSS (Rumanian *et al.*, 2015). The fluctuation in the TSS of water supply in different areas of Faisalabad city is presented in Fig 5.

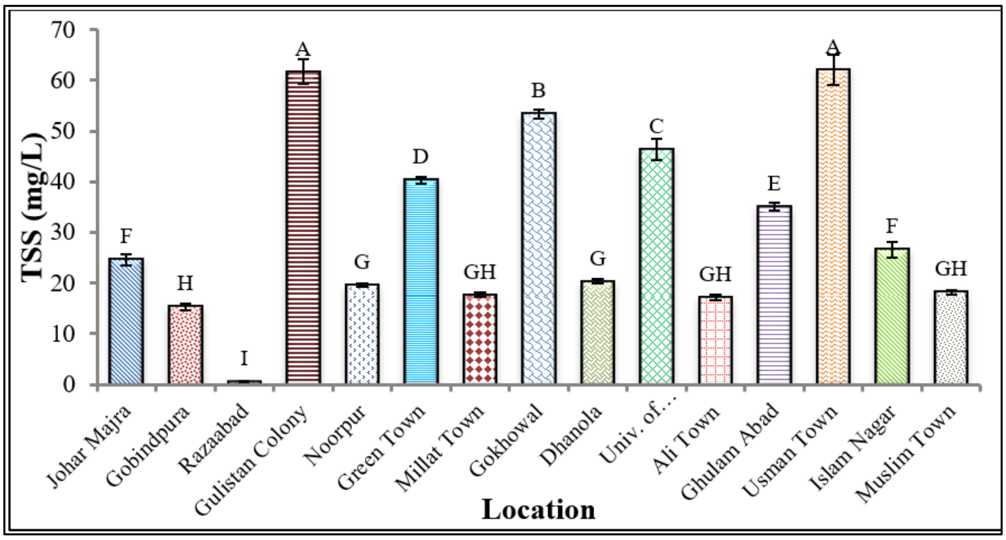

Fig. 5: The TSS variation of water samples from different areas of Faisalabad city

Total Dissolved Solids (TDS)

TDS are inorganic matter, and small amounts of organic matter present as a water solution. TDS values for all drinking water samples collected. The WHO recommends a standard or allowable estimation of the TDS to be 500 mg/L; 10 of the 15 samples were found to have high TDS. The maximum TDS recorded was 3971µS/cm. The mean value of TDS was 96 mg/L; the lowest value of TDS was 321. 28 mg/L was recorded. According to Rumanian *et al.*, 2015 the following are the main reasons for the increase in the number of older adults worldwide. The difference in TDS of water supply in different domains of Faisalabad city is depicted in Figure 6.

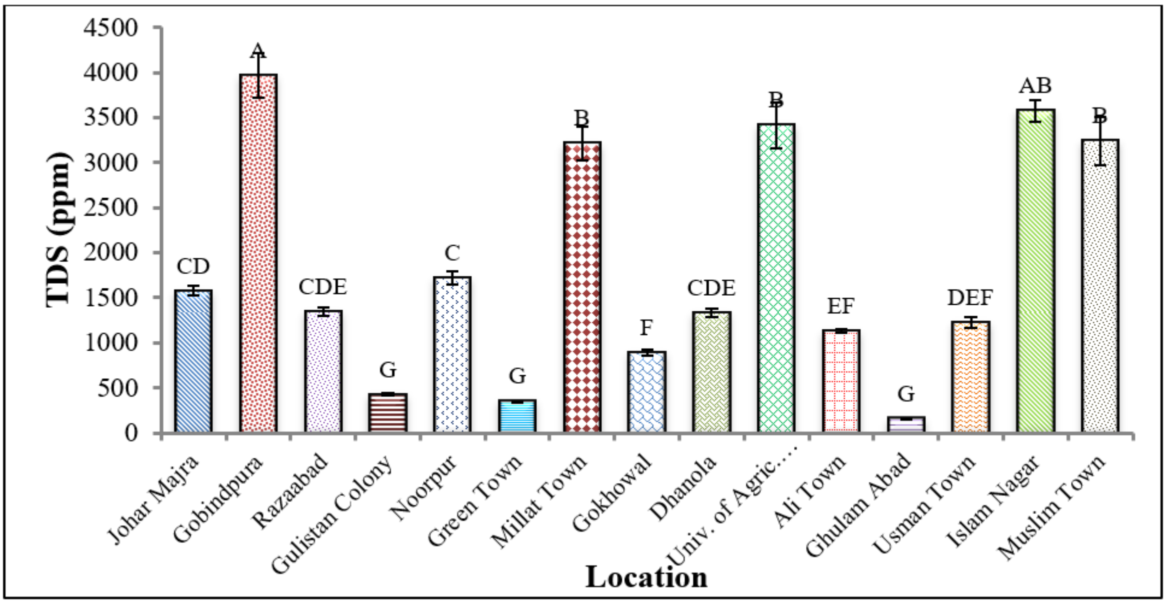

Fig. 6: The TDS variation of water samples from different areas of Faisalabad city

3.9 Carbonates:

According to the WHO and PSQCA, the allowable concentration of carbonates is 75 meq/l. All our samples have concentrations beyond the permissible limit of WHO and PSWCQ. This is shown in Fig 7.

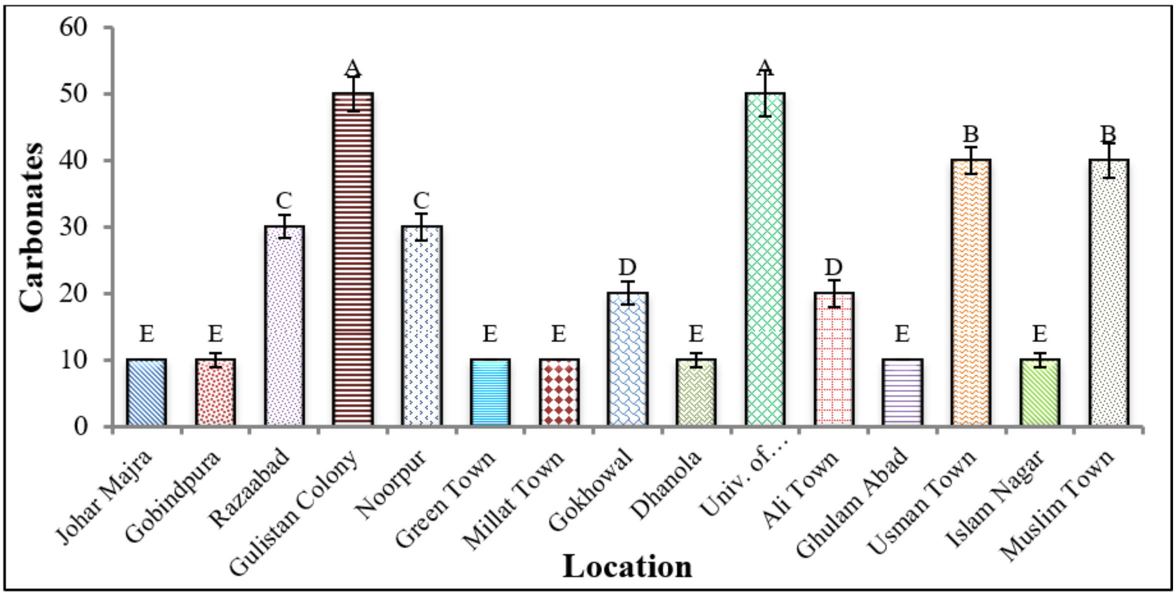

Fig. 7: The carbonates variation of water samples from different areas of Faisalabad city

4.0 Bicarbonates

Bicarbonate produces diverse roles in the human frame, such as acting as a buffer after lactic acid is made in our body, decreasing the acidity of food components, and acting as a saver in contradiction of dental hollows. According to WHO, the permitted limit of bicarbonate in drinking water is 150mg/L. The extreme value was established in the sample taken from Gulistan society, and the most negligible value was established in the sample from Ghulam Abad; nonetheless, all the trials were within the satisfactory limits of WHO and PSQCA. This is shown in Fig 8.

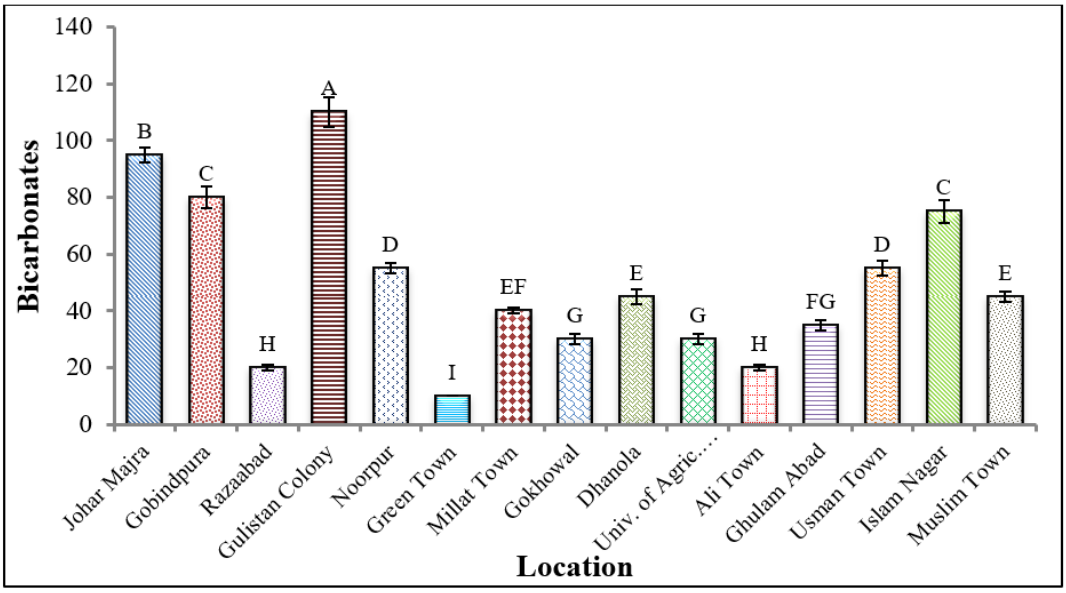

Fig. 7: The bicarbonates variation of water samples from different areas of Faisalabad city

Chemical parameters of all the samples.

Table 2: Chemical parameters of the collected samples

Sr. No.	Site Name	EC ds/m	pH	Carbonate meq/L	Bicarbonate meq/L	Chloride meq/L	TDS meq/L	TSS meq/L
1	Johar Majra	1.61	7.31	30	95	12.5	424.96	24.63
2	Gobindpura	3.82	7.47	10	35	17.5	352.64	5.42
3	Razaabad	0.423	7.89	10	45	2.5	721.13	61.7
4	Gulistan Colony	3.027	7.12	30	55	22.5	424.96	6.64
5	Noorpur	4.156	7.64	20	70	15.5	3133.44	4.23
6	Green Town	2.182	7.56	20	40	32.5	1036.8	13.93
7	Millat Town	3.32	7.56	10	50	19	3415.68	37.94
8	Gokhowal	4.89	7.34	20	60	12.5	3130.88	35.61
9	Dhanola	3.13	7.34	30	35	14.5	2581.76	20.34
10	UAF	1.80	7.45	40	80	32.5	3971.96	46.39
11	Ali Town	4.31	7.86	10	75	20.5	2968.96	26.51
12	Ghulam Abad	0.45	7.12	10	40	7.5	3244.8	50.7
13	Usman town	6.11	7.33	10	35	12.5	321.28	5.02
14	Islam nagar	0.94	7.11	20	45	18	355.84	5.56
15	Muslim town	2.04	8.62	40	65	13.5	2604.16	16.54

Average values of all chemical parameters.

Table 3: Average values of all chemical parameters

	EC ds/m	pH	Carbonate	Bicarbonate mg/L	Chloride mg/L	TDS mg/L	TSS mg/L
	1.61	7.31	30	95	12.5	424.96	24.63
	3.82	7.47	10	35	17.5	352.64	5.42
	0.423	7.89	10	45	2.5	721.13	61.7
	3.027	7.12	30	55	22.5	424.96	6.64
	4.156	7.64	20	70	15.5	3133.44	4.23
	2.182	7.56	20	40	32.5	1036.8	13.93
	3.32	7.56	10	50	19	3415.68	37.94
	4.89	7.34	20	60	12.5	3130.88	35.61
	3.13	7.34	30	35	14.5	2581.76	20.34
	1.8	7.45	40	80	32.5	3971.96	46.39
	4.31	7.86	10	75	20.5	2968.96	26.51

	EC ds/m	pH	Carbonate	Bicarbonate mg/L	Chloride mg/L	TDS mg/L	TSS mg/L
	0.45	7.12	10	40	7.5	3244.8	50.7
	6.11	7.33	10	35	12.5	321.28	5.02
	0.94	7.11	20	45	18	355.84	5.56
	2.04	8.62	40	65	13.5	2604.16	16.54
Mean	2.81	7.51	20.67	55	16.9	1912.61	24.07
Median	3.027	7.45	20	50	15.5	2581.76	20.34
Minimum	0.423	7.11	10	35	2.5	321.28	4.23
Maximum	6.11	8.62	40	95	32.5	3971.96	61.7
Stdev	1.67	0.39	10.99	18.61	8.06	1396.26	18.66

WHO standards

Table 4: WHO standards

Sr. No	Parameters	Minimum limit	Max limit	WHO Standard
1	pH	6.76	8.62	6.5-8.5
2	EC	0.062	6.206	3 S/m
3	TDS	159.36	3971.84	500 meq/l
4	CO3	10	50	75 meq/l
5	HCO3	30	110	150 meq/l
6	TSS	0.63	62.06	<30
7	Chloride	5	65	200 meq/l
8	E.coli			0/250 ml

Biological parameter:

The samples were analyzed in the microbial lab for biological analyses. For this purpose, the samples were collected in 50ml bottles, and then analyzed within two hours to avoid the decaying process; it is clear from the results that Gulistan colony, Gokhowal, Ghulam Abad, and Muslim town samples showed positive values of E. coli; the water of these areas is not fit for drinking purposes (Fig 9).

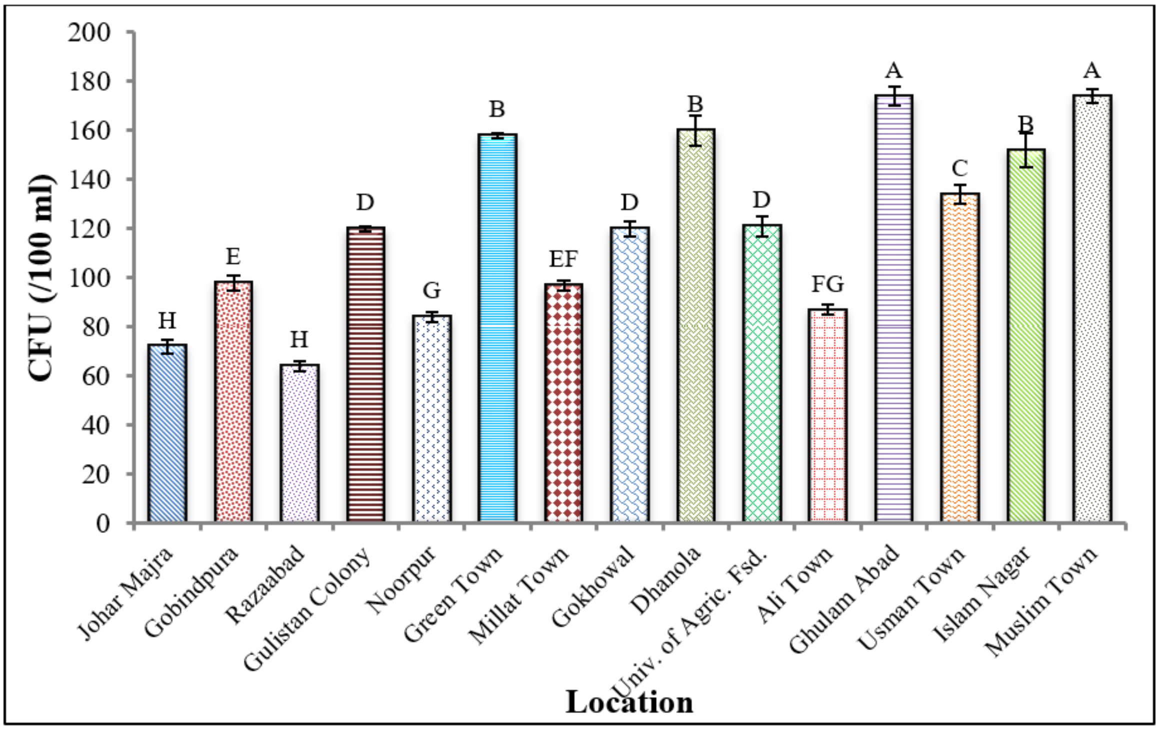

Fig. 9: The Biological parameters of water samples from different areas of Faisalabad city

Biological parameters

Table 5: Biological parameters of all collated samples

Sr. No.	Sample site	E.coli	CFU/100 ml	Remarks
1	Johar Majra	-ve	176 nonpathogenic	Fair quality
2	Gobindpura	-ve	156 nonpathogenic	Low quality
3	Ghaziabad	-ve	84 nonpathogenic	Fair quality
4	Gulistan Colony	+ve	160 pathogenic	Low quality
5	Noorpur	-ve	120 nonpathogenic	Low quality
6	Green Town	-ve	98 nonpathogenic	Fair quality
7	Millat Town	-ve	72 nonpathogenic	Fair quality
8	Gokhowal	+ve	64 pathogenic	Low quality
9	Dhanola	-ve	152 nonpathogenic	Fair quality
10	UAF	-ve	174 pathogenic	Low quality
1	Ali Town	-ve	180 nonpathogenic	Fair quality
12	Islamabad	+ve	112 pathogenic	Low quality
13	Usman town	-ve	140 nonpathogenic	Fair quality
14	Islam nagar	-ve	142 nonpathogenic	Fair quality
15	Muslim town	+ve	160 pathogenic	Low quality

DISCUSSION

Water is essential for human beings, plants, and animals and for business development. Due to fast growth, development, and continued industrial growth, particularly in Faisalabad, the city's water resources are under tremendous pressure. Its groundwater quality is degrading rapidly (Kahlown, 2005). In Faisalabad, there are three ways to source drinking water. WASA's water is said to be contaminated with wastewater because of the deep-rooted and closed tubes of both drinking water and wastewater. First, there is the pump, which is mainly situated at Rakli canal; it carries high total dissolved solids accompanied by some quantity of heavy metals like Chromium, Lead, and Copper – the cause of cancer disease and microbiologically unhealthy due to a high level of microbes. Research work was planned to evaluate drinking water quality in underground water tanks. Data could be produced for many purposes, such as for people, research workers, municipal establishments, and medical physicians. For this purpose, 15 samples were collected from different localities of Faisalabad, such as Millat Town, Green Town, Noorpur, Johar Majra Gobindpura, Ghulam Abad, etc. Analysis was done in the laboratory of the Institute of Soil and Environmental Science, University of Agriculture Faisalabad.

To control the quality of drinking water to be consumed by people. Some physicochemical parameters, like color, odor, taste, electrical conductivity, and TDS, as well as some chemical parameters, like carbonates, bicarbonates, and chlorides, were determined using different methods after analyzing all the collected samples. The samples were correlated with WHO (WHO) values, Pakistan standards, and quality control authority standards (PSQCA). Water is vital for the welfare of humans, plants, and animals and for the industry's growth. Fast growth, development, and continued industrial growth, especially in Faisalabad, have imposed immense pressure on the city's water resources. The quality of its groundwater is worsening rapidly (Kahlown, 2005). In Faisalabad, there are three methods for source of drinking water. WASA's water is stated to be contaminated with wastewater due to deep-rooted and closed drinking water tubes and wastewater tubes. First is the pump, which is mainly located at Rakli canal, taking high total dissolved solids with some amount of heavy metals of Chromium, Lead, and Copper, which are the source of cancer disease and also microbiologically unhealthy due to the high amount of microbes. Research work was planned to assess drinking water quality in underground water tanks. So that data could be generated by people, research workers, Municipal establishments, and medical physicians. For this purpose, 15 samples were collected from different parts of Faisalabad, including Millat Town, Green Town, Noorpur, Johar Majra Gobindpura, Ghulam Abad, etc. Analysis was performed in the laboratory of the Institute of Soil and Environmental Science, University of Agriculture, Faisalabad.

To control the quality of water used for drinking purposes, some physicochemical parameters, such as color, odor, taste, electrical conductivity, and total dissolved solids, and some chemical parameters, such as carbonates, bicarbonates, and chlorides, were determined after analyzing all the collected samples using different methods. The samples were correlated with the WHO (WHO) values, Pakistan standard, and quality control authority standard (PSQCA).

Faisalabad's primary underground water sources are hand pumps and crushed water tube wells. The implications of physical, chemical, and biological parameters identified from the analysis of drinking water from different underground water sources of Faisalabad are discussed below.

It was concluded that all the samples were colorless according to WHO standards. Out of 15 samples, five samples had a horrible smell and were not fit for human consumption. The bed smell is due to the seepage of wastewater from domestic and industrial sources into groundwater (Bashar & Fung, 2020). The Sample collected from Green Town had a chlorinous smell (Bazemo *et al.*, 2021). The sample from the Gulistan colony had a rotten egg smell due to the presence of Sulphur. A sample from Islam Nagar and Ali town had a horrible smell, so these areas use supply water for drinking purposes.

Six out of 15 samples from Gobindpura, Green town, Gulistan colony, Gokhuwal, Usman town, and Millat town showed a taste for the third parameter. This was due to unsafe hygienic conditions and sewage water mixing with underground reservoirs. Other samples were tasteless. For odor, five out of 15 samples had a horrible smell. These samples were collected from Johar Majra, Ghulam Abad, Noorpur, and Gokhuwal.

Compared to the survey results, it was clear that the pH values of all the samples except one sample collected from Muslim Town (8.62) were high according to the values of WHO and PSQCA. As discussed earlier, the high pH recorded in the Muslim Town sample showed the highest pH value (8.62) and the lowest (6.76) in a sample collected from Green Town. It was clear that the samples from Gobindpura, Noorpur, Millat town, Gokhuwal, Dhnola, and Agriculture University were all significant. At the same time, these results were insignificant for Razabad, Johar Majra, Ali Town, Islam Nagar Gulam Abad, and Green Town. The exact results of pH were also shown by (Iqbal *et al.*, 2013), who established that the pH of drinking water samples was under the permissible limits of WHO. All the samples showed a pH value between 6.76 and 8.62, having a mean of 7.69. The pH was measured according to WHO standards. The presence of cations and anions is relatively a tendency similar to EC. (Al-Salamah *et al.*, 2011)

The average value of EC is 1-5 ds/m, as set by WHO. The EC of water collected from Faisalabad city was 0.062-6.11 dS/m. The uppermost value was found in the sample collected from Usman Town, and the lowest EC was collected from Gulam Abad. In this study, it was clear that some samples showed higher values of EC about WHO and PSQCA. The higher EC is due to nitrates in water, which increase dissolved ions (Khosravi *et al.*, 2017). Samples collected from Gobindpura, Gulistan colony, Noorpur, Millat Town, Gokhuwal, Dhanola, Ali Town, and Usman Town showed high EC values. Only seven samples showed the acceptable limit of EC. Only two samples were significant, while all other samples were insignificant. The results opposed the study conducted in Karachi to examine physio-chemical parameters of underground water, which stated that the EC of the water collected from different water sources is within the limits recommended by WHO. (Daud., 2017). EC of the water of Multan was linked with WHO and found that it was beyond the permissible limits set by WHO (Senthilkumar *et al.*, 2007).

TDS concentration in the drinking water of Faisalabad was also not within the allowable limits as suggested by the WHO and PSQCA. The overall value ranges of all the samples were 159.36- 3971.84 mg/L. The highest concentration was found in the sample collected from Gobindpura, which was beyond the WHO's acceptable limit. UAF and Muslim Town samples were significant; similarly, Green Town and Gulistan Colony samples were substantial, while other samples were insignificant. TDS results were similar to those assumed by Joshi and Santani (2012) of TDS in groundwater samples according to WHO rules for drinking water. The high values of TDS are due to the presence of inorganic compounds, mainly the high amount of various anions and soluble salts (Maiti *et al.*, 2016).

The chloride concentration in drinking water samples was between 2. 5 and 65 mg/1. The minimum chloride concentration was observed in the Rezaabad and Gulistan Colony samples, while the maximum was observed in Green Town, but it was still less than the limit set by WHO and PSQCA. Therefore, the water is suitable for drinking in an apprehension of chloride. The chloride absorption in water inside the WHO was fit for drinking (Fytianos & christophoridis, 2004). In this parameter, samples of (Johar *et al.*,) were significant, and four samples from Gobindpura, Muslim Town, UAF, and Usman Town were substantial. The chloride results were similar to those presented by Abedin *et al.*, 2014 since they also set acceptable chloride limits in drinking water samples concerning WHO drinking water quality guidelines.

Bicarbonates detected in all the samples obtained from the various sites varied between 30 and 110 mg/L. The maximum value was observed in the sample from Gulistan Colony, while the minimum value was observed in Green Town, but all the samples were well below the permissible limit set by WHO and PSQCA. In Bicarbonates, Gobindpura and Islam Nagar were significant, Razabad and Ali Town were substantial, and Noorpur and Usman Town were significant. Bicarbonate results were correlated with those of (Taj *et al.*, 2013) because they also found that drinking water samples contained low levels of bicarbonate. The concentration of carbonates is usually higher than that of carbonate, but in the collected water, the bicarbonates are reduced to a higher degree. (Krouma *et al.*, 2008).

The Ca + Mg concentration range in all the samples taken from different sites of Faisalabad was 8-92 mg/1; maximum concentration was observed in samples taken from Johar Majra 92 mg/1, while minimum concentration was observed in the Green Town sample. The results obtained from analyzing all the samples collected from various areas were well within the prescribed limit set by WHO and PSQCA. These results were the same as those proposed by Ilyas *et al.,* (2012) within the acceptable range of WHO and PSQCA. The PSQCA, EPA, and WHO set a limit of less than one coliform in 100 of water. Dreeszen, 1996 and Khaliq *et al.,* 2001 identified the total number of drinking water sources that cause diseases in Faisalabad and got the same findings. In this parameter, the results of Johar Majra and Razabad, Gulistan Colony and Gokhuwal, Green Town and Dhnola, and Gulam Abad and Muslim Town were considerable. The results of the total count were linked with the results obtainable by Memon *et al.,* 2011 because they also found bacteria in drinking water samples. Four out of the fifteen samples tested positive for E. coli, hence indicating the presence of E. coli in water. All the other samples were negative, implying that the water is fit and no pathogen is in the water. This bacteria is found in the water because rainwater from the lawn and municipal and agricultural waste flows into the groundwater (Jadoon *et al.,* 2012).

CONCLUSION

From the discussion, we have concluded that city water features decreased due to increased industrialization in Faisalabad. Therefore, there is a need for appropriate water inspection and prior management.

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