

SAFETY AND QUALITY EVALUATION OF COMMUNITY TAP WATER PURIFICATION PLANTS IN HARIPUR REGION, PAKISTAN

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Abstract

Under the Guidelines of World Health Organization (WHO) and National Institute of Health (NIH), various community-based water filtration plants were installed in many parts of Pakistan. Majority of residents of the areas preferred to take water home from these purification plants. The current investigation of drinking water quality and safety of these water filtration plants installed at Khalabat Township (KTS) and Haripur city of Khyber Pakhtunkhwa province was carried out to assess conditions for public health protection. A number of parameters such as pH, total dissolved solids (TDS), free chlorine, total hardness, calcium, magnesium, sodium, potassium, chlorides, sulfates, nitrites, and microbial parameters such as total plate count (TPC), total coliforms and E.coli were analyzed for each water sample. Results showed that in water samples collected, pH ranged between 7.00 to 7.66, total dissolved solid ranged between 341 to 420 mg/l, hardness ranged between 242.6 to 288.6 mg/l, calcium ranged between 81.06 to 98.93 mg/l, magnesium ranged between 4.53 to 5.02 mg/l, chlorides ranged between 30.76 to 53.96 mg/l and alkalinity ranged between 87.33 to 102.66 mg/l, sodium ranged between 19.33 to 34 mg/l, potassium ranged between 0.2 to 0.8 mg/l, sulfates ranged between 55.74 to 61.28 mg/l and nitrites ranged between 1.92 to 2.03 mg/l. In microbiological parameters and total plate count ranged between 2 to 48 CFU/1ml, total coliforms ranged between 0 to 3 CFU/250 ml and E.coli ranged between 0 to 2 CFU/250 ml. The results obtained were compared with permitted levels approved by World Health Organization (WHO), Pakistan Standards and Quality Control Authority (PSQCA) and Environment Protection Agency (EPA). The results showed that all the filters are non-significant biological parameters that can be improved by additional processes in these filters to make them effective against the microbes which will make this water fit for human consumption.

INTRODUCTION

Water is one of the most vital elements present on earth's surface which maintains human health and welfare. As a human being it is considered as a basic and fundamental right to be provided with clean and safe drinking water. (WHO & UNICEF, 2023). As a result of which the death

rate associated with water related issues is around 6-8 million. In countries under development it a major challenge to provide people clean and safe drinking water. The Joint Monitoring Program (JMP) working under WHO and UNICEF states that around 783 million people around the globe lack proper acquire safe and clean drinking water

and most of these people (84%) live in rural areas. (WHO; UNICEF, 2012).

It is generally accepted that water contamination is irreversible, indicating that once it is contaminated, it is difficult to restore the original water quality over a short time span. In several situations ground water is being directly used for human consumption without any treatment the general consideration that the soil cleans it when it passes through it acting as a filter and removes the harmful substances, is not always true. Ground water contamination can occur from several sources. There are industrial waste, solid waste disposal sites, waste water treatment lagoons, agricultural areas, tank tile fields, etc. The type of contaminants added depends on situation. Excessively suspended and dissolved solids can accumulate in the pores of the soil and block the sources which prevents ground water recharge. Some soluble impurities may be removed by ion-exchange properties of soils and rocks (Tebutt, 1998, Li et al., 2021).

The primary source of water contamination is waste material storage areas. Out of these waste materials certain water-soluble stuff is dissolved with water and because its concentration is high it seeps through soil and may reach underground water sources the most problem creating waste material which is responsible for water contamination is the waste from industrial sector (Jaini, 2003, UNEP, 2022).

In Pakistan all types of water sources including lakes, ground water and rivers are undergoing increasing chances of water contamination (Parent *et al.*, 1996). Some contaminant are also introducing into water through environment making drinking water unsafe for consumption due to poor quality of drinking water in Pakistan more than three million of population are ill out of which each year 0.1 million population die due to intake of highly polluted water used for drinking purposes (Kahlow *et al.*, 2006). People obtain expensive mineral water due to unavailability of water used for drinking purposes available for public. Due to lack of monitoring system and processing mineral water is not comply with drinking water standard (PSQCA, 2022).

Water is one of the most prized necessities of life. It is the key of survival of any biotic life, without water life is not possible. Continual assessment of water quality is extremely necessary to examine

whether the water being used is consumable or not. Based on this idea this study is conducted in which water from the filtration units installed in KTS and Haripur is analyzed. The data obtained from this research work can be used as a guideline by several departments related to public health to improve the water quality for public use. Furthermore, this study may provide a suitable platform for understanding the quality of drinking water which is consumed by thousands of people on daily basis.

The objectives of this research work were:

- Analysis of drinking water before and after filtration and comparison of results with approved PSQCA, WHO and EPA standards.
- To suggest whether the analyzed water is fit for consumption.

MATERIALS AND METHODS SAMPLES COLLECTION AND PROCESSING FOR ANALYSIS

Samples were collected randomly from Haripur region from public filters installed in Haripur city and Khalabat Township (KTS) from which filtered water can be obtained during any hour of the day. These filters are installed in densely populated areas of Haripur and KTS.

Sample collection

Untainted bottles were used to collect test samples from sampling locations by grab methods before and after filters installed in Haripur city and Khalabat Township. In total 7 filters were involved for study and samples were collected from each water filter having three replications of unfiltered and three replications of filtered water. These samples were immediately transferred to water Food Testing laboratory NIFA Peshawar.

PHYSIOCHEMICAL PARAMETERS

Determination of pH

The negative log of hydrogen ion concentration present in any solution is called pH. It gives us the value of alkalinity or acidity of that solution. Standard calibrated pH meter (LAQUA twin pH meter) was used to measure pH values under room temperature according to the method described in AOAC, 2007.

Determination of Total dissolved solids (mg/L)

The combination of all the organic and inorganic solids present in water is categorized as total dissolved solids (TDS). TDS of samples was determined by TDS portable pen meter under room temperature according to method described by Islam *et al* (2016) in which electrode of TDS meter is dipped in water sample and direct reading is noted on stabilization.

Determination of Total Hardness (mg/L)

Water hardness is the amount of dissolved calcium and magnesium in the water. Total hardness was determined by EDTA titrimetric method using hardness buffer and hardness indicator under controlled conditions. In this method water samples were titrated against 0.02M EDTA solution using ammonia buffer and Mordant black T indicator. This method was also used by Adams (2017). Hardness was calculated by using the following formulae:

$$\text{Total Hardness} = \frac{\text{Volume of titer used} \times \text{Normality of EDTA} \times 100 \times 1000}{\text{Volume of sample}}$$

Determination of Calcium and Magnesium (mg/L)

Calcium and magnesium are present naturally in water, they add in total hardness of water. Calcium can also be determined by titration with EDTA using murexide as indicator. In this method sample is titrated against standard 0.2 M EDTA solution using NaOH as buffer. Values of calcium in mg/l were calculated using the following formulae:

$$\text{Calcium} = \frac{\text{Volume of titer} \times 16}{\text{Volume of sample}}$$

However, magnesium is determined by formulae methods as the combination of calcium and magnesium values results in total hardness values. The formulae used to calculate the value of magnesium is as follows:

$$\text{Magnesium} = \frac{(\text{total hardness titer volume} - \text{calcium titer volume}) \times 4.86}{\text{Volume of sample}}$$

Determination of Chlorides (mg/L)

Chlorides are present in water in the form of salts which are formed by the reaction of metals with chlorine (Van Benschoten & Edzwald, 1990). Chlorides were determined by standard silver nitrate titration method (Mohar's method) as described by Mbui *et al* (2016). In this method

water is titrated against silver nitrate solution and chlorides in mg/l are calculated by using:

$$\text{Chlorides} = \frac{\text{Volume of titer} \times 14.28}{\text{Volume of sample}}$$

Determination of alkalinity (mg/L) in terms of H₂SO₄

Alkalinity is a measure of the capacity of water to neutralize acids. Alkaline compounds in the water such as bicarbonates, carbonates, and hydroxides remove H⁺ ions and lower the acidity of the water (Boman *et al.*, 2002). Alkalinity is measured by using acid base titration method as described by Readcivil (2017). In this method water is titrated against standard acid solution and total alkalinity is determined by using:

$$\text{Total alkalinity} = \frac{\text{Volume of titer used} \times \text{Normality of acid used} \times 50 \times 1000}{\text{Volume of sample used}}$$

Determination of Sodium and Potassium (mg/L)

Sodium and potassium are present in water as salts of sodium and potassium like sodium chloride and potassium chloride. They were calculated by using flame photometer (FP 640) using the method described by Medical chemistry standard method (2012). In this method a standard sample of known concentration is run in flame photometer and then test sample is analyzed to detect the level of sodium and potassium in water sample in mg/l.

MICROBIAL PARAMETERS**Determination of Total plate count (CFU)**

The total plate count is the enumeration of aerobic organisms that grow in aerobic conditions under moderate temperatures of 20-45°C. This includes all aerobic bacteria, yeast, molds and fungi that grow in the specific agar. Total plate count was determined by using standard method described in AOAC (2007). In this method media is prepared and sterilized in autoclave at 121°C under 15 lbs pressure for 15 minutes. After setting of media, sample of 1 ml is added to the plate using sterilized pipet. The plate is autoclaved for 24 hours and colonies are counted using standard colony counter.

Determination of Total coliforms (CFU)

Total coliforms include bacteria that are found in the soil and in human or animal waste. Total

coliforms were determined by using M-Endo broth media and membrane filtration method under aseptic conditions as described by Geissler *et al* (2000). In this method a sample of 250 ml is taken in filtration assembly and sample is run through 0.45 μm membrane filter. At this filter size the bacteria are left on the filter paper as filtrate. This filter is then transferred to incubation plates having M-Endo broth media on it. The plates are incubated for 48 hours and colonies are counted by using standard colony counter.

Determination of *E. coli* (CFU)

Escherichia coli (*E.coli*), otherwise known as fecal coliforms are the group of the total coliforms that are present specifically in the gut and feces of warm-blooded animals. *E.coli* was determined by using LB media and membrane filtration method under aseptic conditions as described by Geissler *et al.* (2000). In this method a sample of 250 ml is taken in filtration assembly and water is filtered through membrane filter having pore size of 0.45 μm . At this filter size the bacteria are left on the filter paper as filtrate. This filter is then transferred to incubation plates having LB media on it. The plates are incubated for 48 hours and colonies are counted by using standard colony counter.

STATISTICAL ANALYSIS

Results were subjected to statistical analysis by using one-way analysis of variance (ANOVA). Statistical differences with p-value under 0.05 were considered significant and comparison of mean values was carried out by Completely

randomized design (CRD) using Statistix 8.1 software (Steel *et al.*, 1997).

RESULTS AND DISCUSSIONS

PHYSIOCHEMICAL EVALUATION OF WATER SAMPLES

pH

Negative log of hydrogen ion is called pH and considered as determining the water quality. As the pH of human body is 7.4, and the human body needs to maintain this pH value to function properly. Acceptable limit for pH by PSQCA, WHO and EPA is 6.5 to 8.5. The analysis of variance (ANOVA) of pH values of water manifested that results were found non-significant ($P > 0.05$) which means that pH values before and after filtration have no significant change suggesting that the filters installed are not efficiently working in lowering pH values. The mean values for pH of water have been presented in Figure 1. pH of water samples ranged between 7.13 to 7.66. The maximum pH was observed in sample taken from Haripur city park, which was 7.66, minimum value (7.13) was observed in sample taken from KTS sector 4. The results concluded that all the values were below the permitted limits given by PSQCA, WHO and EPA and even though the results are non-significant. Still, it is not necessary yet to lower the pH value as it is at a very good level. The small change in pH is because of presence of the ionic and hydroxyl components of water. Because of the same ionic composition of ground water in sampling areas the results had very small variations. These results are also in accordance with the study conducted in Rawalpindi by Farooq *et al* (2008).

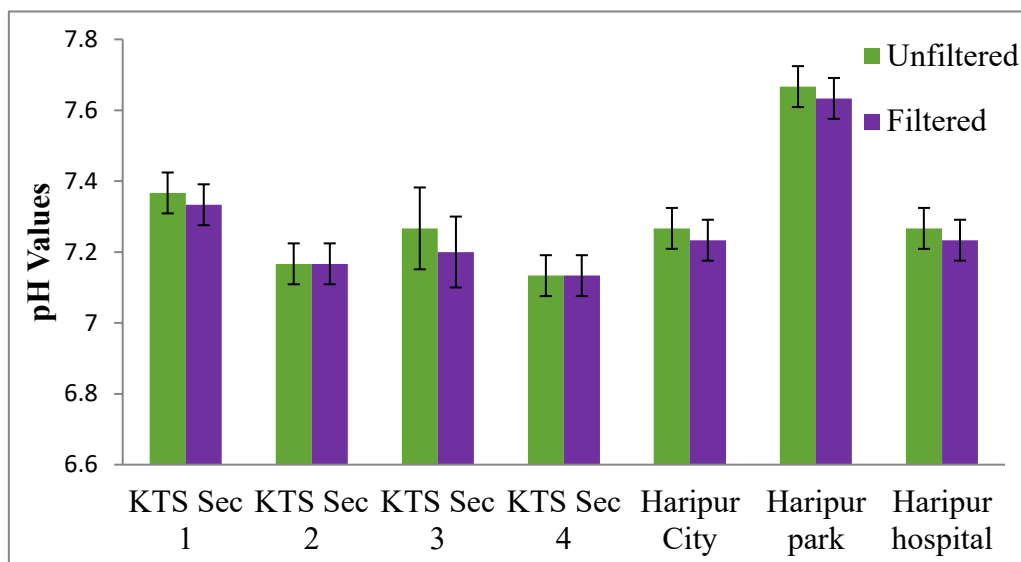


Figure 1: pH of drinking water samples from various locations

Total dissolved solids (mg/L)

Total dissolved solids (TDS) are the mineral content of the water, which is important for the survival of human being. For total dissolved solids 500 mg/l is the acceptable limit according to Pakistan Standards Quality Control Authority, 500 mg/l is the acceptable limit according to World Health Organization and 1000 mg/l is the acceptable limit according to Environmental Protection Agency. The analysis of variance (ANOVA) for TDS manifested that TDS was found non-significant ($P > 0.05$). The mean values for TDS have been presented in Figure 2. TDS in water samples were found within 341.3 to 420.6 mg/l. the results of test samples collected from KTS Sec 2 showed the maximum level of total dissolved solids was 420.6 mg/l, the

lowest result of total dissolved solid was 341.3 mg/l observed in sample from Haripur city hospital, so the results obtained by the study are all under the acceptable limits. The lower level of TDS is not suitable for drinking purposes as it can disturb the normal salts concentration in blood, moreover human body needs water soluble salts to maintain its smooth functioning. So, it is very important for drinking water to have a suitable number of salts present in it. Similarly, the higher values of TDS in water may cause diversion in normal functioning of human body. As it may increase the salts level in blood and ultimately may disturb normal blood pressure (Islam *et al.*, 2016).

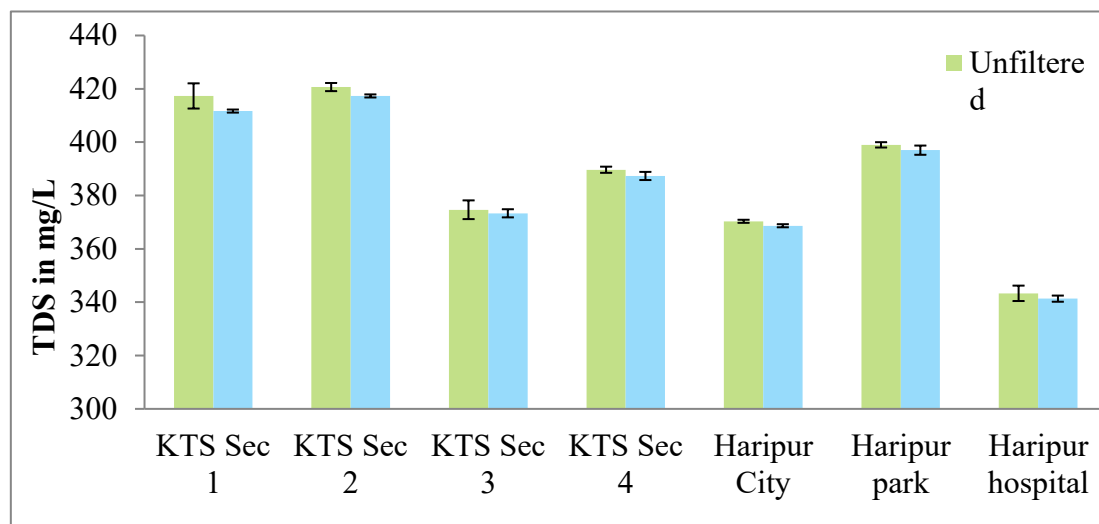


Figure 2. TDS mg/L of drinking water samples from various locations

Total Hardness (mg/L)

Total hardness can be explained as carbonates and bicarbonates of calcium and magnesium ions. These are significant minerals found in drinking water which increases hardness. According to Pakistan Standards and Quality Control Authority (PSQCA) and World Health Organization (WHO), the values of portable water must be lower to 500 mg/l and according to Environmental Protection Agency it should be below 300 mg/l. The analysis of variance (ANOVA) for water hardness has shown that hardness in drinking water was found non-significant ($P < 0.05$). The mean values for hardness in water have been presented in Figure

4. Hardness in drinking water samples ranged between 242.6 to 288.6 mg/l. Maximum hardness in drinking water was detected in drinking water sample from KTS sec 2 (288.6 mg/l). Lowest result of hardness was 242.6 mg/l detected in sample from Haripur City hospital. Hardness in water is associated with the presence of magnesium salts and calcium salts. Although it is necessary to drink water that has magnesium and calcium, however intake of water which is higher in concentration of calcium and magnesium may cause certain issues in body, resulting in diseases related to heart and kidneys. Similar results were reported by (Akram and Rehman, 2018).

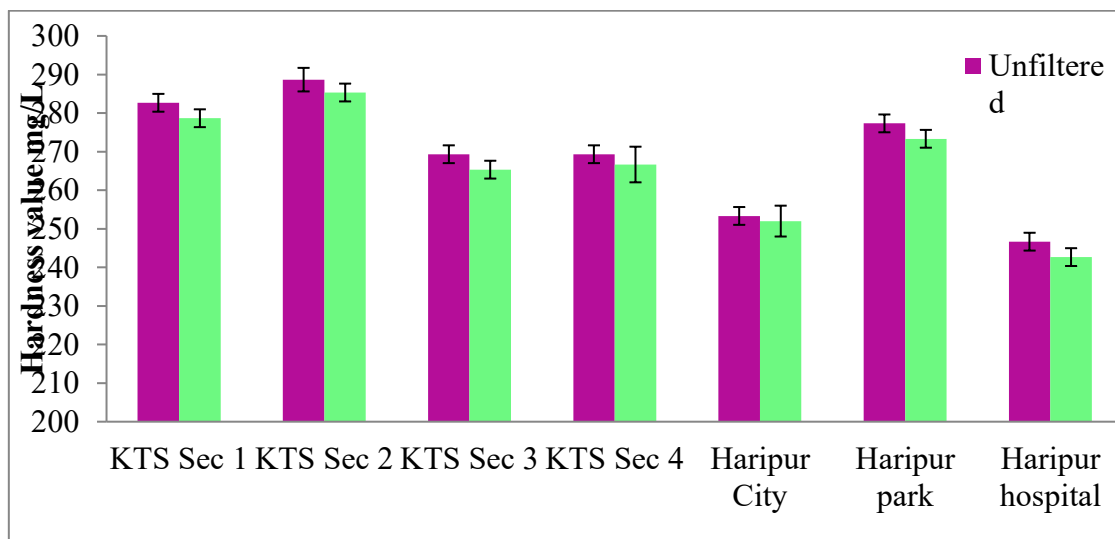


Figure 3. Hardness mg/L of drinking water samples taken from various locations

Calcium (mg/L)

Calcium in water is present mainly in the form of salts of chlorides and sulfates. Calcium must be present in water as it is required by human body in order to function properly. According to PSQCA the acceptable level of calcium is 100 mg/l and according to EPA is 75 mg/l respectively. The analysis of variance (ANOVA) showed that calcium in water was found non-significant ($P < 0.05$). The mean values for calcium in water have been presented in Figure 5. Calcium in water samples ranged between 81.06 to 98.93 mg/l. The result for portable water sample of KTS sec 2 shows the peak level for calcium in portable water was 98.93 mg/l, the

lowest results of drinking water was observed in sample from Haripur City Hospital which is 81.06 mg/l. The results of the study manifested that calcium in water exceeds the acceptable limits given by EPA however all the results are within the range of PSQCA. Inadequate levels of calcium in water may result in lowering the calcium value in human body and ultimately may result in certain disorders related to bones and teeth, moreover if calcium is excessively taken in it is excreted by kidneys and if this intake is on the regular basis, then it may cause disorders related with excretory system. These results are in accordance with (WHO 2012).

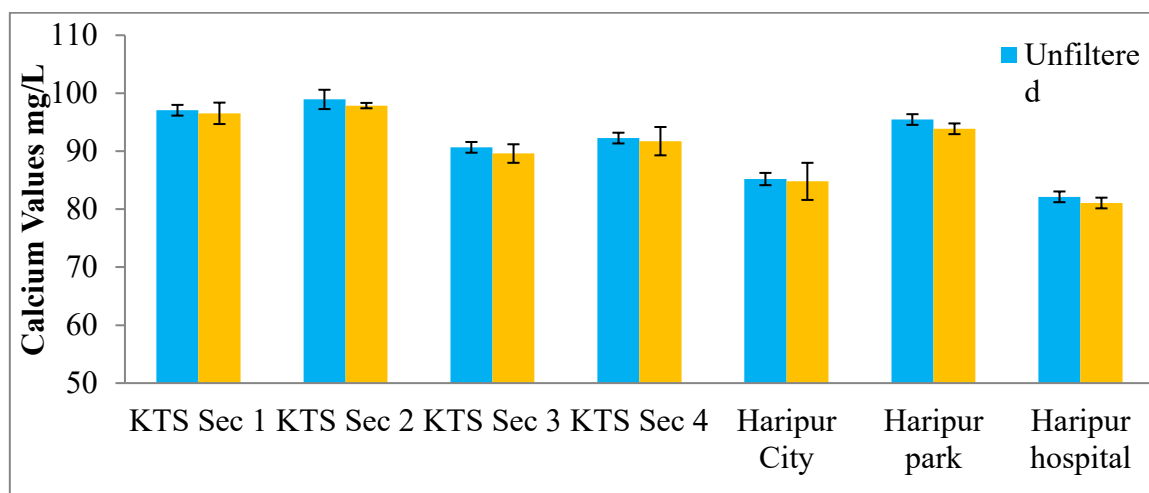


Figure 4. Calcium mg/L of drinking water samples taken from various locations

Magnesium (mg/L)

Magnesium deficiency may cause certain issues related to insulin production in human body and its excess may result in problems related to the digestive system but as it is present in very small quantity in foods and water, so these issues are very rare (WHO 2012). The analysis of variance (ANOVA) for magnesium in portable outlined that magnesium in water was found significant ($P < 0.05$). The mean values for magnesium in water have been presented in Figure 5. Magnesium in

water samples were ranged between 4.53 to 5.03 mg/l. The result Of test sample collected from Haripur city filter show the utmost value of magnesium in portable water was 5.03 mg/L, the lowest results of drinking water was observed in sample number taken from KTS sec 4 which is 4.53 mg/l. According to PSQCA, WHO and EPA the results of all drinking water samples were under the acceptable level which is 100, 50 and 20 mg/l respectively.

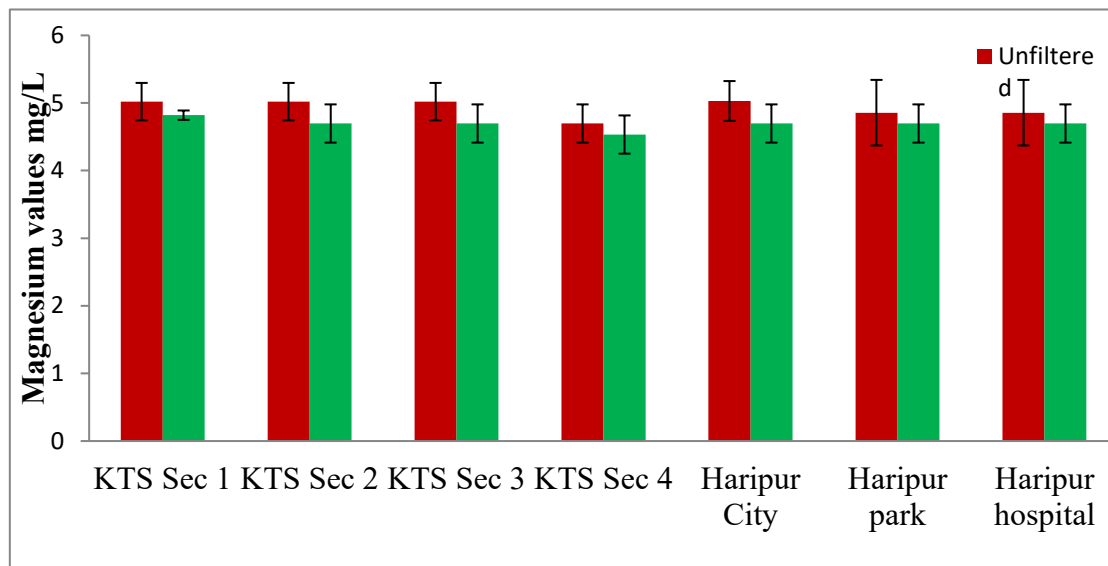


Figure 5. Magnesium mg/L of drinking water samples taken from various locations
Chlorides (mg/L)

Chlorides are comprised of all body fluids and act as a regulator for these body fluids in their movement from the cells. So they must be present in drinking water in a specific amount so that the body keeps performing in a suitable manner. The analysis of variance (ANOVA) demonstrated that chlorides in water were found non-significant ($P > 0.05$) which indicates that there is no significant change in the values of chlorides before and after filters are not lowering the values of chlorides present in water. The mean values for chlorides in water have been presented in Figure 6. Chlorides in water samples

ranged between 30.76 to 53.72 mg/l. The result of sample collected from KTS sec 4 show the maximum level of chlorides was 53.72 mg/l, the lowest results was observed in sample from Kts sec 1 was 30.76 mg/l. According to PSQCA, WHO and EPA all the results were under the acceptable level which is 250 mg/l and is considered fit for human use in accordance with chlorides in water. These results were in accordance with the study done by (Khalid *et al.*, 2012) in Abbottabad district.

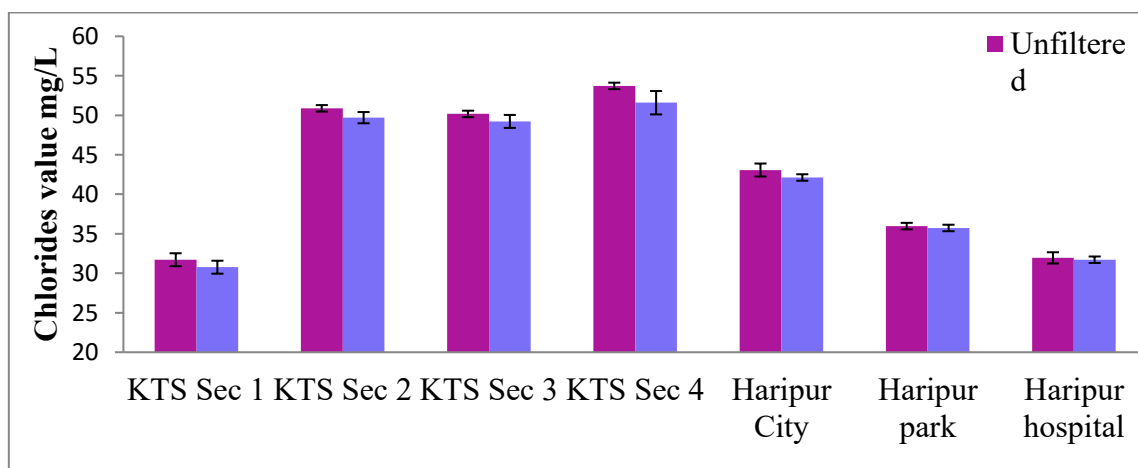


Figure 6. Chlorides mg/L of drinking water samples taken from various locations

Alkalinity (mg/L)

Alkalinity refers to the ability of water to neutralize acid or in other words it is the ability

of water to resist the change in pH value. Alkalinity is often related to water hardness as

well because the main source of water alkalinity is carbonates and bicarbonates of calcium and magnesium (Cox 2017). The analysis of variance (ANOVA) expressed that alkalinity of samples were found non-significant ($P > 0.05$) which indicates that filters are not effective against alkalinity present in water. The mean values for alkalinity of water have been presented in Figure 7. Alkalinity of water samples were ranged from 87.33 to 102.66 mg/l. The result of sample taken from Haripur city park show the maximum level of alkalinity was 102.66 mg/l, the lowest results was observed in sample taken from KTS sec 4 (87.33 mg/l). According to Mohammad, Khan,

& Mahmood (2016), the key reason for the high levels of alkalinity is contamination of ground water with the waste water from household activities. According to World Health Organization (WHO) the entire samples were contained by acceptable perimeters. Alkalinity of drinking water should be lower to 130 mg/l. Drinking natural alkaline water is generally considered safe, since it contains natural minerals. However drinking water with a high alkalinity may disrupt the body's normal pH. This can lead to an undesirable condition in body's metabolism.

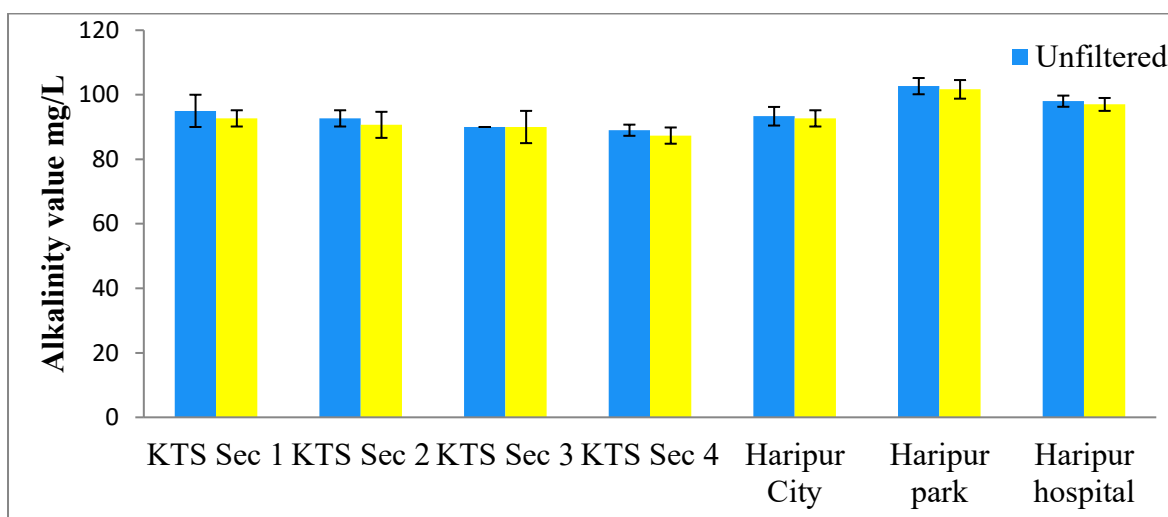


Figure 7. Alkalinity mg/L of drinking water samples taken from various locations

Sodium (mg/L)

Sodium is an essential mineral in our diet and is found in all our body tissues and fluids which help us to regulate blood pressure and other metabolic functions. The analysis of variance (ANOVA) for sodium in portable water samples was found non-significant ($P > 0.05$) concluding that the values for sodium before and after filtration do not have a significant difference in them and the filters are not significantly resisting against sodium present in water. The mean values for sodium in water have been presented in Figure 8. Sodium in drinking water samples ranged between 19.33 to 34 mg/l. The results of

sample collected from Haripur city hospital show the maximum level of sodium was 34 mg/l, the lowest result was observed in samples from Haripur City Hospital (19.33 mg/l). According to the PSQCA, WHO and EPA the results of all drinking water samples were under the acceptable level, which is 50, 200 and 200 mg/l respectively. In human body sodium is associated with the control of blood pressure, body fluids and muscle functions. However, there are certain disorders related to kidneys and digestive system that may occur due to intake of high sodium containing water. The results obtained are in accordance with Bashir, (2005)

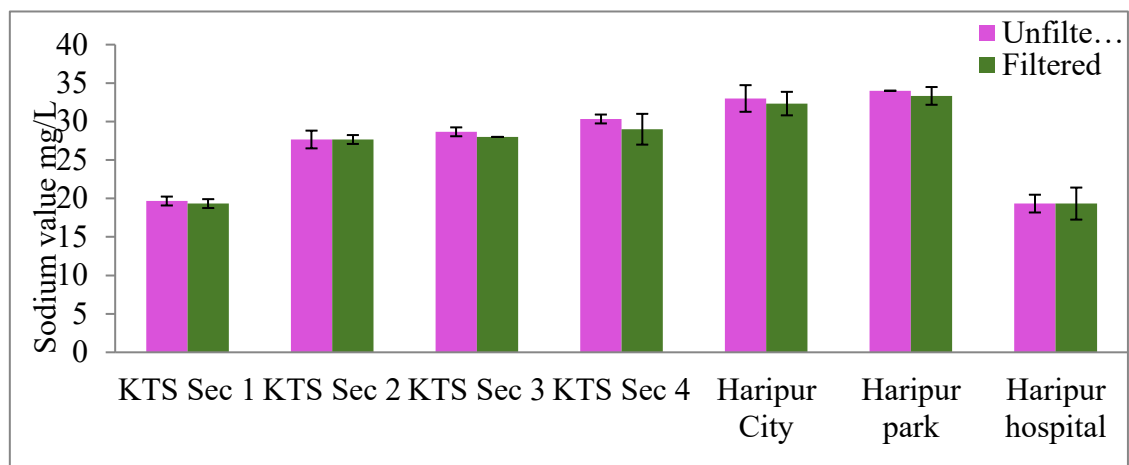


Figure 8 Sodium mg/L of drinking water samples taken from various locations

Potassium (mg/L)

Potassium is not that much, particularly required by human body besides it regulates the osmotic pressure in the cells of body which regulates the intake and excretions of salts and fluids from the body cells. But as it is needed in a very small amount, thus the requirement is fulfilled in the body by the diet. According to the Pakistan Standards and Quality Control Authority (PSQCA) and World Health Organization (WHO) the acceptable level for potassium in water is 10 mg/L. The analysis of variance (ANOVA) for potassium in drinking water samples manifested that potassium in drinking water was found non-significant ($P > 0.05$) concluding that the filters are not efficient against potassium as the values for potassium before

filtration and after filtration do not have a significant difference. The mean values for potassium in water have been presented in Figure 10. Potassium in drinking water was found in between range of 0.23 to 0.83 mg/l. The results of sample collected from Haripur city filter show the maximum level of potassium was 0.83 mg/l, the lowest result was observed in samples number in KTS sec 1 (0.23 mg/l). Excessive potassium may result in serious disorders related to kidneys and metabolic systems. These issues are very rare to be found as excess potassium is excreted by the body by means of kidneys, however if this excessive intake is on the continual base, then there might be issues related to kidneys as described by (Gosselin et al., 1984).

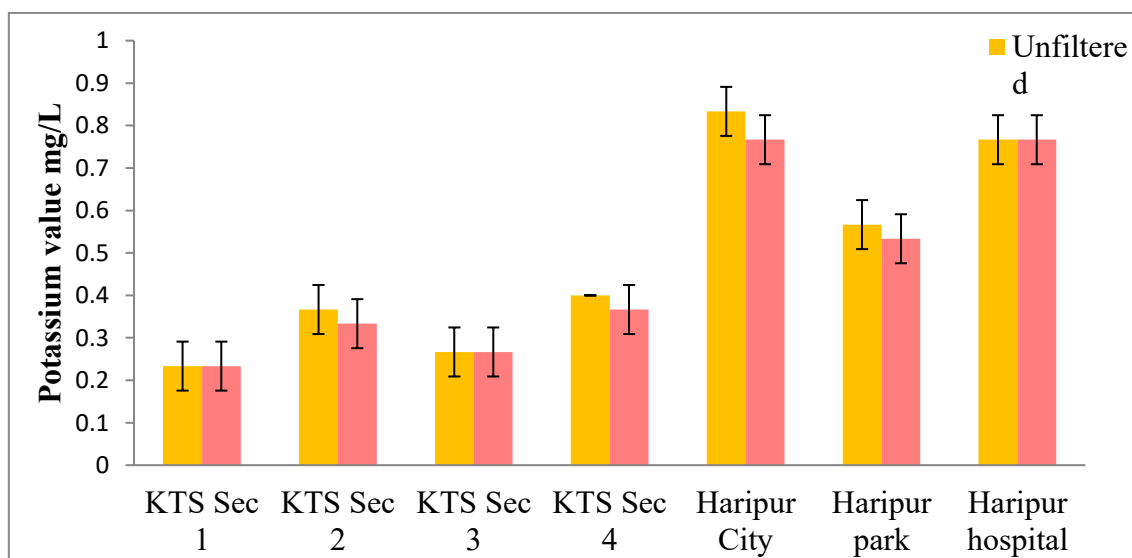


Figure 09. Potassium mg/L of drinking water samples taken from various locations

MICROBIAL EVALUATION OF WATER SAMPLES

Total Plate Count (CFU)

Total plate count also called as total plate count is a quantitative estimate of microorganisms such as bacteria, yeast and molds etc to conclude whether the water is safe for human consumption or not. The allowable limits by PSQCA for total plate count in drinking water was 20 CFU/1 ml, allowable limits permitted by WHO and EPA are 10 CFU/1ml. The analysis of variance (ANOVA) manifested that the total plate count content in water was found non-significant ($P > 0.05$) concluding that the filters installed are not working efficiently against microorganisms. The mean values for total plate count in water have been presented in Figure 10. Total plate count in water samples was ranged from 2 to 45 CFU/1ml. The lowest value of total plate count

among samples was 2 CFU/1ml in sample taken from KTS sec 2. While the highest value of total plate count was 45 CFU/1ml was observed in sample taken from Haripur City filter. The samples from Haripur city and Haripur park are exceeding the permitted limits from all three discussed standards however the samples taken from KTS sec 1, 3 and 4 are within acceptable limits set by PSQCA but exceeding the limits set by WHO and EPA. The high value of microorganisms in water is because the ground water is being contaminated by sewerage water. Another main reason can be the open heaps of waste material from houses as the rain water seeps through the soil taking harmful microorganism with it. The results were in accordance with the study done by Khalid et al (2012) Abbottabad region.

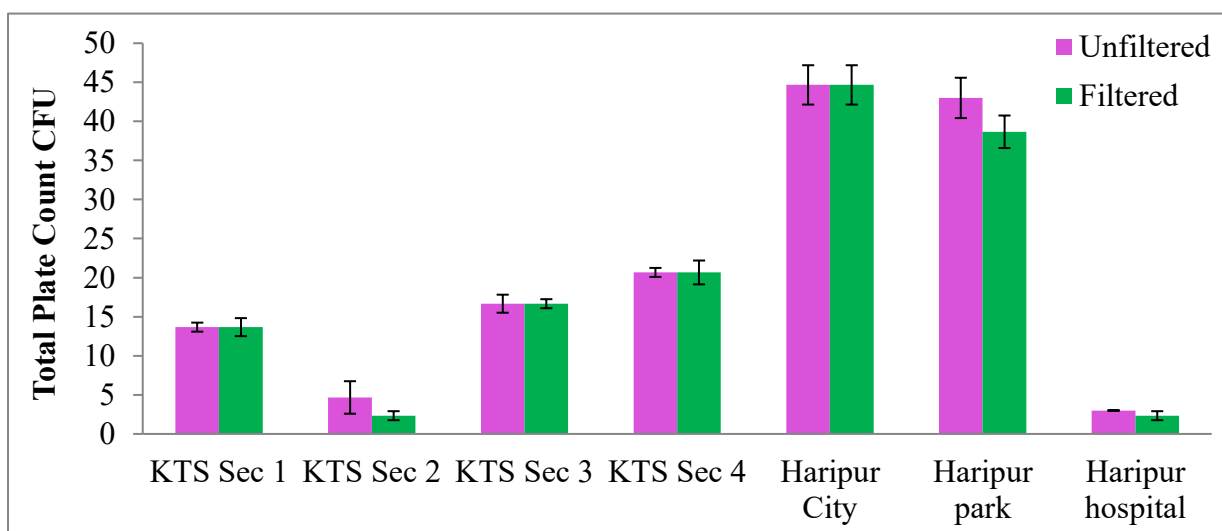


Figure 10: Total Plate Count of drinking water samples taken from various locations

Total Coliform Count (CFU)

The bacteria of coliforms are naturally found in soil and guts of human beings and animals. Their presence in water is one of the clear indications that water has been polluted with pathogens and these pathogens should be eliminated from water. In such context coliforms presence is one of the key parameters in determining water quality. The analysis of variance (ANOVA) for total coliform revealed that total coliform count content in water was found non-significant ($P > 0.05$) concluding that the filters installed are not working efficiently against total coliforms. The mean values for total coliform count in water

have been presented in Figure 11. Total coliform count in water samples ranged from 0 to 3 CFU/250 ml. The lowest value of total coliform count of sample 1,2,3,4 and 7 was 0 CFU/250ml. While the highest value of total coliform count was 3 CFU/250 ml was observed in sample Haripur park filter. Sample taken from Haripur city filter was also found contaminated with coliforms. These results were out of limit which is 0 CFU/250ml defined by PSQCA, WHO and EPA, due to less effective water purification system raw water being contaminated by the sewerage system as the key reason of

contamination is the mixing of fresh water with sewerage water. The results are in accordance

with the work done by Sanderson *et al* (2005).

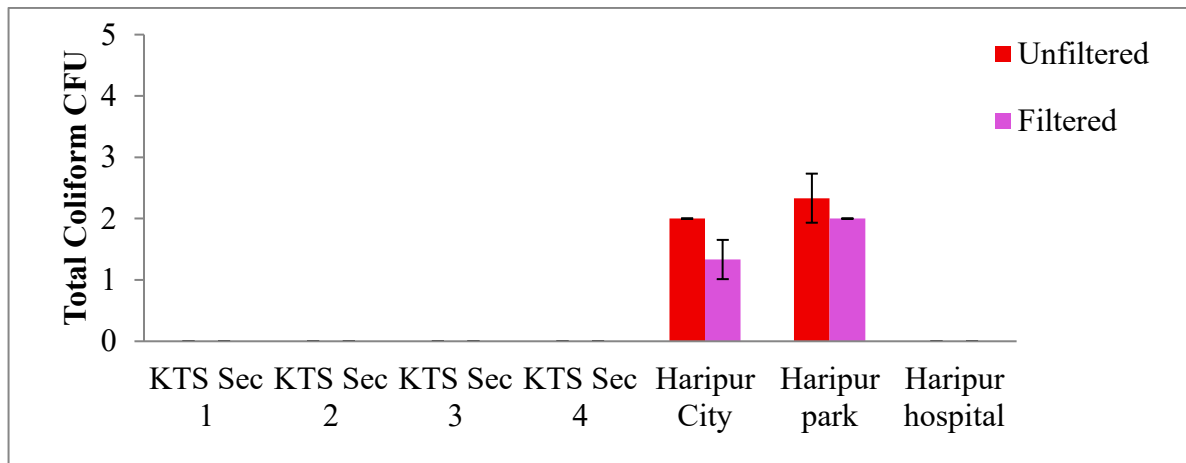


Figure 11. Total coliforms of drinking water samples taken from various locations

E.coli Count (CFU)

Escherichia coli (*E. coli*) is a type of coliforms also known as fecal coliforms. These bacteria are one of the most hazardous types of species that is a major indication that the water is not fit for the consumption for human beings and animals. The analysis of variance (ANOVA) for *E. coli* counts manifested that *E. coli* count content in water was found non-significant ($P > 0.05$) concluding that the filters installed are not working efficiently against *E. coli*. The mean values for *E. coli* count in water has been presented in Figure 12. *E. coli* count in water samples ranged from 0 to 2 CFU/250 ml. The lowest value of *E. coli* count among samples was 0 in samples taken from KTS

sec 1, 2, 3, 4 and Haripur hospital. While the highest value of *E. coli* count was 2 CFU/250 ml observed in samples from Haripur City Park and Haripur city filter. These results were out of limit which is 0 CFU/250ml defined by PSQCA, due to less effective water purification system and dirty source of raw water which may interfere with the sewerage system. The main sources of water contamination with *E. coli* are the contact of fresh water with sewerage water. Major cause is the disposal of waste material near water reservoirs as the rain water seeps through the earth to the ground water it takes these bacteria with it and thus the ground water may get contaminated (Rock and Reviea, 2014).

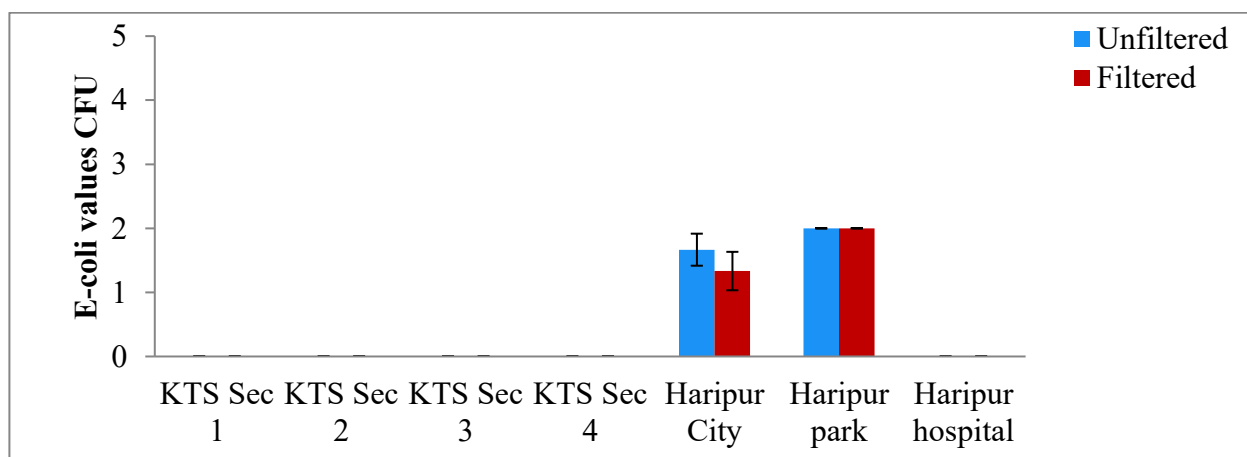


Figure 12. *E. coli* CFU of drinking water samples taken from various locations

CONCLUSIONS

The results showed that samples collected from Khalabat township and Haripur region ranges within the acceptable limits set by PSQCA, WHO and EPA excluding a few parameters in which the results were beyond acceptable limits as results of calcium were exceeding the limits of EPA but within the range provided by PSQCA and WHO. Total plate count for sample no. 4, 5 and 6 were exceeding the limits provided by PSQCA, WHO and EPA, Coliforms were found in sample no. 5 and 6. And the presence of *E. coli* was determined in sample no 5 and 6. Moreover, the results obtained showed that all the filters are showing non-significant results against biological parameters so there must be additional processes in these filters to make them effective against the microbes which will make this water fit for human consumption.

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