DRINKING WATER QUALITY ASSESSMENT OF DEFENCE HOUSING AUTHORITY PHASE II, ISLAMABAD, PAKISTAN

By

JANITA ASIF

NIMRA NAYYER

SAJIDA MOMIN

Department of Earth and Environmental Sciences

Bahria University, Islamabad, Pakistan

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A thesis submitted to Bahria University, Islamabad in partial fulfillment of requirement for the degree of BS in Environmental Sciences

JANITA ASIF

NIMRA NAYYER

SAJIDA MOMIN

Department of Earth and Environmental Sciences

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ABSTRACT

The present study was conducted to assess the water quality of filtration plants situated in Defense Housing Authority 2, Islamabad, Pakistan. Total of 66 samples were analyzed for physicochemical, heavy metals and micro biological contamination. The results before and after filtration were obtained in the following order. pH ranged before treatment (7.25-8.38) and after treatment (6.72-8.35), EC ranged before treatment (461-678) µS/cm and after treatment (462-711) µS/cm, TDS ranged before treatment (340-545) mg/l and after treatment (351-568) mg/l, Chloride ranged before treatment (11.74-85.26) mg/l and after treatment (11.15-88.52) mg/l, Sulfate ranged before treatment (7.36-16.8) mg/l and after treatment (7.99-19.21) mg/l, Total Hardness ranged before treatment (125-287) mg/l and after treatment (124-311) mg/l, respectively. The results were compared with PAK-EPA standards. It was found that pH, TDS, EC, chlorides, total hardness an sulfates were within the permissible limits. The heavy metal such as Cd, Pb, Ni, Cr Fe, Zn, Mn and As were also tested in the same samples and results showed Cd, Pb, Ni, Cr were above the permissible limits in some samples while Fe, Zn and Mn were within the permissible limits. Arsenic was not detectable in the samples. The microbial analysis of the samples collected before from storage tanks in F1, F2, F6, F8, F9, F11 showed the presence of E. coli. Samples collected after filtration from F1, F4, F8 and F10 showed the presence of E. coli. The reason for higher number of bacterial colonies might be due to inadequate maintenance of water. These results suggest regular maintenance and monitoring of the filtration plants.

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ABBREVATIONS

WHO	World Health Organization
PCRWR	Pakistan Council of Research in Water Resources
PAK-EPA	Pakistan Environmental Protection Agency
EDTA	Ethylene Diamine Tetra Acetic Acid
TDS	Total Dissolved Solids
EC	Electrical Conductivity
E. coli	Escherichia coli
EBT	Eriochrome Black T
Fe	Iron
Cd	Cadmium
Pb	Lead
Ni	Nickel
Cr	Chromium
As	Arsenic
Mn	Manganese
Zn	Zinc
pH	Power of Hydrogen
Cl^-	Chloride
MCL	Maximum Contaminant Level
SMCL	Secondary Maximum Contaminant Level
KPK	Khyber Pakhtunkhawa
BDWQS	Bhutan Drinking Water Quality Standards
WASA	Water And Sanitation Agency
SO_4	Sulfate

NO_3	Nitrate
Ca	Calcium
Mg	Magnesium
GVs	Guide Values
NaCl	Sodium Chloride
$MgSO_4$	Magnesium Sulfate
Na_2SO_4	Sodium Sulfate
K_2SO_4	Potassium Sulfate
KCl	Potassium Chloride
PVC	Polyvinyl Chloride

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Throughout human life, water plays an essential role. Safe drinking water use is a significant prerequisite for good health and the maintenance of a natural ecosystem. Water is a tasteless, odorless material, and is the main factor in ground, air, lakes, and oceans. Because of their direct collaboration with the microbial growth, physiochemical parameters play an important role in water quality. For fact, 97% of water is seawater and only 3% is fresh water, 2% of which exists for glaciers and polar ice caps, and only 1% is drinking water (Kataria et al., 1996). According to the WHO, drinking water from the various drinking supplies is consumed by 89 % of the world population. Some enhanced drinking services include piped water connections, public pipes and covered wells, but there is the pollution issue, the presence of heavy metals from various sources also contaminates drinking water. (Guidotti et al., 2015). Access to safe drinking water in Pakistan falls below adequate standards, with only 25 per cent of the population having reliable access to good drinking water. (Hashmi et al., 2009). Drinking water should be free of any preservatives, the most important being color, turbidity, odor and the microbes affecting its purity. When water comes from the surface waters, drinking water must be made safe because chlorination is the most effective method of purifying water by disinfecting the diseases (Chilton et al., 2000).

1.2 Water quality assessment in the world

In developing countries contaminated water for drinking is one of the major concerns. For this reason, World is now facing a major challenge to drinking water, there are certain solutions used to access the drinking water quality. In many countries, including Pakistan, water quality is calculated by the measurement of three attribute classes: biochemical, physical, and mechanical. For each of those three types of attributes, water quality standards are set. The established drinking water guidelines were drawn up by an environmental protection agency of the federal government. Such requirements must be applicable to all municipal water supplies (Kreger, 2004). Some features are important for the protection of drinking water while others are of secondary importance. Hence the EPA requirements for drinking water are defined as basic standards for drinking water and secondary standards for drinking water. Primary standards for drinking water track organic and inorganic pollutants, microbial species, and radioactive elements which may affect the drinking water safety. Such standards set an MCL limit for the highest concentrations of some chemicals approved by a public water system in the drinking water. Secondary drinking water criteria monitor chlorine, color, copper, corrosivity, foaming agents, iron, manganese, odor, pH, sulfates, total dissolved solids, and zinc, all of which may affect the quality of drinking water such as taste, smell, color, and appearance. The limit of concentration of such contaminants is called the SMCL. Examine legal standards for potable water at the EPA (Kreger, 2004). Water pollution is the deterioration of the water quality caused by the introduction of waste from development, urbanization and agriculture. Using such water for beneficial use causes the reverse effects on the environment and public health. Industrialization and urban unit development put enormous stress on water resources and discharged waste water into natural water systems which reduced soil and surface water quality (Awan et al., 2002).

1.3 Water quality assessment in Pakistan

In Pakistan, drinking water quality is decreasing day by day due to industrial growth and increasing population. This report summarizes results for different studies on the condition of drinking water quality in different areas of Pakistan, taking into account the physicochemical properties of drinking water and the presence of unique pathogenic micro organisms (Daud et al., 2017). Approximately 20% of Pakistan's entire population has access to safe drinking water. Due to lack of safe and healthy drinking water sources, the remaining 80 per cent of the population is forced to use polluted drinking water. The main source of pollution is sewerage (fecal), which is widely pumped into rivers through the potable water system. Secondary cause of pollution is the discharge of toxic chemical compounds into the water bodies from industrial effluents, pesticides and fertilizers from crop sources (Daud et al., 2017). Anthropogenic activity induces waterborne diseases, accounting for about 80% of all diseases and 33% of all deaths. A study highlights drinking water health, contamination sources, sanitation situation, and the human effects of polluted drinking water. Protective measures and treatment methods to remedy the unhygienic state of drinking water sources in various regions of Pakistan need to be taken immediately (Soomro, 2011). According to the world statistics on drinking water quality assessment Pakistan being ranked 80th in the world and 11th in the Asia. Water supply and sanitation are every single individual's two basic needs. Clean water must be supplied to every user at the door step and the wastewater produced must be disposed of safely. Contamination of drinking water is one of the major problems in underdeveloped countries. Given the lack of clean and fresh drinking water, tens of thousands of deaths were reported. In underdeveloped countries, an estimated 5 million children die each year due to an insufficient water supply network. Growth in population creates many problems while maintaining water quality. (Huang and Xia, 2001). Statistics show that by 2025, the population will rise to 221 million and water availability per capita will decline from 5,600m^3 to 1,000m^3.

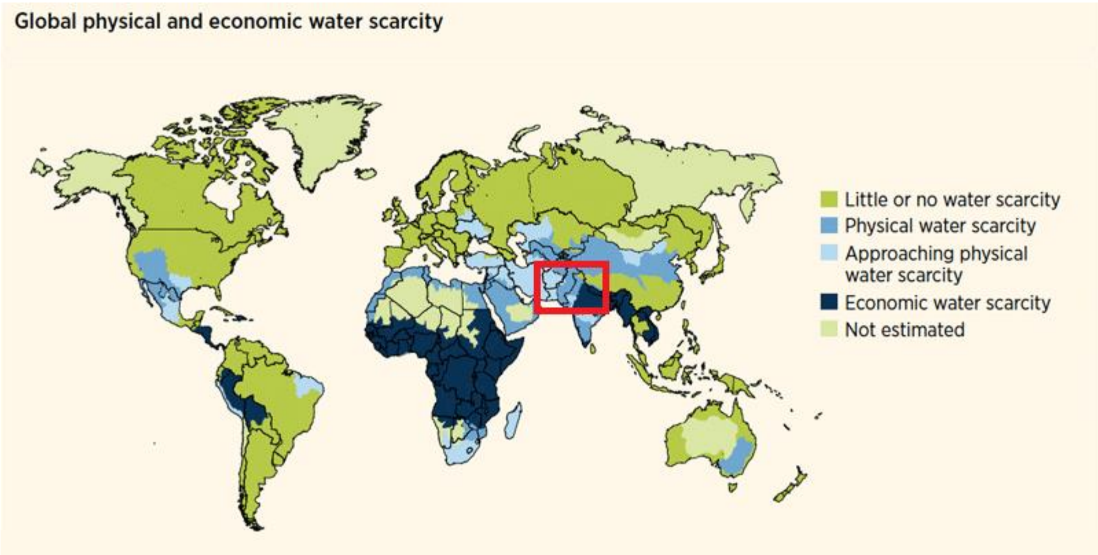


Figure 1.1. Water scarcity of Pakistan in last five years according to world water development report.

World Health Organization defines "safe drinking water" as water that presents no significant health risks throughout the lifetime of its consumption, including multiple sensitivities that may exist during life stages. Water is regarded as the greatest source of transmission of disease, being the most potable material. According to the WHO, 80% of all human diseases occur in developing countries due to biological water contamination. The main sources of water pollution are direct discharge of household waste, industrial waste, agricultural run-offs, septic tank leakages and poor farm waste management (Nabeela et al., 2014).

1.4 Present study on water quality assessment

The evaluation could be better divided into components according to UN water analytical brief for the present study on water quality problem with the global water quality challenge. A comparative water quality status assessment to provide a summary of the relative state of water quality in different parts of the world, and to identify hot spot areas that require special attention. This baseline assessment discusses the gaps in knowledge observed in the snapshot analysis. A scenario analysis of trends in water quality to identify dynamic trends in water quality over the next 10 to 50 years, especially for locations of declining water quality and of particular importance for changing social, economic or ecological driving forces on water quality (Maybeck et al., 2012). An assessment and analysis of mitigation options available to developing and developed countries to avoid water discrimination that would include consideration of both technical measures and management approaches. An overview and review of management strategies to define the options for legal, cultural and behavioral management (Maybeck et al., 2012).

1.5 Sources of contamination

Microbial pollution has been found among the most serious problems in both rural and urban areas in Pakistan. This is due to contamination of the pipes, entry of waste from sewage lines into drinking water sources, and so on. Chemical pollutants, i.e. pesticides and fertilizers, come from agriculture, soil sediments and agricultural runoff and join water resources. Groundwater is the highest salt content, due primarily to drainage, degradation of soil salts, infiltration of seawater, and chemical industries. Salinity is affecting the main Baluchistan, KP, and Punjab regions. Industrial and domestic effluent contains high arsenic concentrations which are becoming a serious problem (Daud et al., 2017). Drinking water main supplier is groundwater and rivers. Approximately 70 % of water comes from groundwater. When river flow is high, solid suspensions are produced which lead to pollution of the water. Low groundwater levels are also a major cause of water pollution, as water table decreases and saline water quantities increase. Drinking water quality is determined by the quality of its main sources, their volume, treatment efficiency and the quality of the water supply lines. Metal pipes used in water supply line develop major corrosions with significant public health concerns. Corrosion of these pipes results in increased microbial growth and increased emissions in the pipes (Saleem et al., 2018).

1.6 Deleterious effects of contaminated water on health

In Pakistan, it is estimated that 40% of all deaths and 30% of all diseases are associated with contaminated water. Every fifth person suffers from illness because of the contaminated water. According to figures, three million Pakistanis suffer and 0.1 million die each year from waterborne diseases. A waterborne disease, diarrhea is reported to be the leading cause of death in infants and children worldwide, whereas every fifth person suffers from polluted water disease and disease (Akbar et al., 2013).

Waterborne diseases in drinking water in Pakistan are the introduction to distribution of urban sewage and industrial wastewater, as well as the lack of water disinfection and water quality control at treatment plants. Poor treatment facilities enable transmission of waterborne diseases. The drinking water treatment system and drainage lines run parallel in Pakistan, resulting in pollution and intermingling resulting in depletion of the water quality. The primary source of supply in most cities in Pakistan is groundwater supply, which includes numerous pathogens including many infectious, bacterial and protozoan agents causing 2.5 million deaths each year from endemic diarrheal disease (Daud et al., 2017).

Contaminants in water consist mainly of heavy metals, microorganisms, fertilizers and thousands of organic compounds poisonous to them. Within water heavy metals exist only at trace levels but are more harmful to the human body. Considering the dangerous nature of pollution of heavy metals in water, it was important to undertake this study to evaluate the issue and recommend ways and means to reduce the risk of contamination of potable water by toxic heavy metals. Heavy metals can affect the aquatic life which can further cause effect to human life also (Mohod and Dhote, 2013).

1.7 Objectives

The study objectives were:

i. To assess the concentration and analysis of microbial contamination of the physicochemical parameters (pH Total dissolved Solids, Electric conductivity, Total hardness, chlorides and sulfates) and metals of high concentration such as Arsenic, Cadmium, Chromium, Zinc, iron, Manganese, Nickel and lead
ii. To check the filtration plants efficiency

1.8 Literature review

A case study was conducted by the water and sanitation agency to determine water quality. In the study area physicochemical (pH, turbidity, hardness and TDS) and bacteriological (T.C and F.C) parameters at all sources were within the drinking water quality limits defined in WHO guidelines. Therefore it can be assumed that the groundwater is appropriate for all the necessities (Haydar et al., 2009).

A study was conducted to assess chemical drinking water quality in urban areas of district Peshawar, Pakistan. It was found that drinking water samples have a chemical content from the selected areas of study was not in line with the WHO requirements and was therefore unfit for drinking and use. However, according to WHO guidelines, the quality of Hayatabad drinking water was appropriate, while the remaining areas reported higher concentrations beyond the overall permissible limits of the WHO (Iftikhar et al., 2016).

According to the study, the physio-chemical property of bottled drinking water currently available in Dhaka City, Bangladesh. The results revealed that the physical parameters of the bottled waters, namely EC and TDS are within the permissible limit of the WHO and BDWQS standards whereas the DO values and most of the pH values are out of reach. TH and anions (Cl^-, SO_4^{2-} and $NO^{3-}$are below the permissible limit values of WHO and BDWQS. Nevertheless, during transportation or storage, the chemistry of bottled water can change, especially when containers are exposed to sunlight or are stored for an extended period. The values of Ca and Mg ions still remain within the permissible value but that of Fe ions exceeds the permissible WHO and BDWQS standards (Alam et al., 2017).

Others in Bahawalpur City conducted a study to assess and compare groundwater quality with WHO requirements and related diseases. The risk of significant groundwater contamination was identified by laboratory analysis of physical and chemical parameters of the collected water samples. The results of these criteria either met or were below the permissible values set by WHO. Between physical parameters, for example, EC in water samples was very far from the acceptable limit of 400 μS/cm. TDS and groundwater hardness also increased in Islamic colony and satellite, and caused harmful diseases. The water sample pH values were also above the neutral limit (> 7) and fell within the simple (alkaline) range (Mohsin et al., 2013).

Low metal content was observed for most of the water samples analyzed in Bangladesh. In some rural settlements for Nigeria, in residential areas near the municipal dumps, Adekunle et al. found that most water samples from hand dug wells contained Pb and Cd above the WHO drinking water limits. Iron and manganese can also be present in surface and ground water in different concentration. WHO GV concentrations above were found in Cambodia, Zimbabwe, Ghana, Cameroon, Pakistan and Bangladesh, respectively, at 0.3 Mn mg/l (Sharaky et al., 2015).

They indicated the presence in the Pleistocene sediments of iron produced from iron oxides, and that the remaining trace elements (Zn, Pb, Cd, Cr, and Cu) were most likely due to secondary minerals in aquifer rocks. The presence of iron in these boreholes could be attributed to its percolation into the groundwater from granite and metamorphosed rocks (Sabrina et al., 2013). Turbidity, as observed in studies in Cameroon, Malawi, Ghana, Pakistan and Bangladesh, is a typical problem of surface waters and shallow open wells, but it can also affect boreholes, as reported in Zimbabwe and Ghana. Ketchemen's research on surface waters in far north Cameroon has shown that nitrate levels are above average and that this high high content is related to human activity (Sabrina et al., 2013).

CHAPTER 2

MATERIALS AND METHODS

2.1 Study Area

Water sampling area taken from various filtration plants is situated in various sectors of the Defense Housing Authority Phase II. We have collected water samples from filtration plants and tube well along with latitude and longitude of each filtration plant and tube well located in different sectors of DHA phase II. The map of study area is given below.

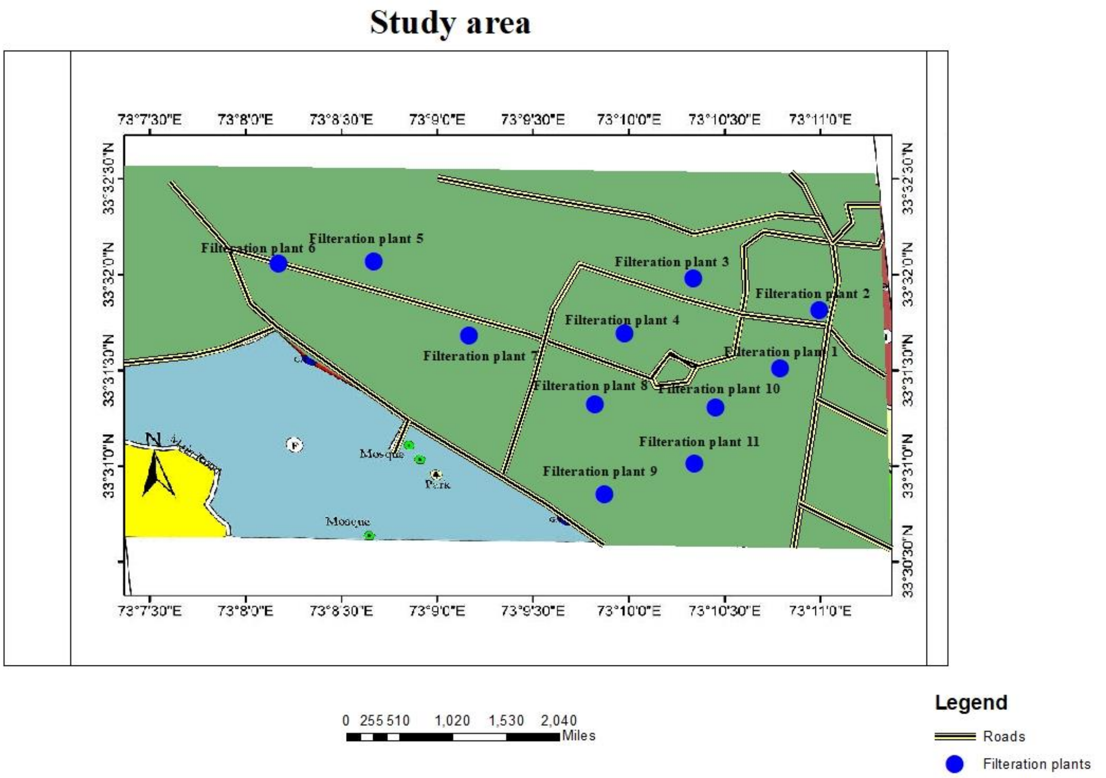


Figure 2.1 Map of the study area.

(Map taken from Google Earth, modified in Arc GIS)

2.2 Samples collection

66 pre-and post-filtration water samples were obtained from various sectors including different sectors of the Phase II, Islamabad Housing Authority. Most filtration systems were in good condition, gathered samples in the month of August. The bottles had been washed first with distilled water. Before the final extraction the bottles were rinsed thoroughly from the source water. After collection of samples, the bottles were tightly sealed, placed in an ice box and purchased back to the EPA laboratory for further analysis (Zan and Zaw, 2019).

Table 2.1 General characteristics of filtration plants and their sources.

Sample ID	Sectors (DHA-II)	Height of tank (ft)	Source	Location	
				Latitude	Longitude
F1	G	100	Tube well	33˚31’45.40”N	73˚10’34.31’’E
F2	J	90	Tube well	33˚31’58.08”N	73˚10’43.75’’E
F3	D	116	Tube well	33˚32’10.02”N	73˚9’58”E
F4	E	100	Tube well	33˚31’51”N	73˚9’42.01”E
F5	B	100	Tube well	33˚31’55”N	73˚8’55”E
F6	A	110	Tube well	33˚31’48.02”N	73˚8’8.02”E
F7	C	100	Tube well	33˚31’43”N	73˚9’13”E
F8	St.13, F	100	Tube well	33˚31’36.02”N	73˚9’39”E
F9	St. 1, F	100	Tube well	31˚31’12”N	73˚9’50”E
F10	Power Ave., H	100	Tube well	33˚31’37.02”N	73˚10’5.02”E
F11	St.8, H	100	Tube well	33˚31’18.70”N	73˚10’7.07”E

2.3 Sample storage

Three types of bottles were used for analysis of different parameters in water samples. Polyethylene bottles were used for physical and chemical parameters (Khan et al., 2019), Sterilized Glass bottles for analysis of microbial contamination (Khalid et al., 2018) and Plastic bottles for heavy metals analysis (Muhammad et al., 2011).

2.4 Sample preservation

By using their respective portable instruments, pH, dissolved solids and electrical conductivity were measured on site. Other parameters were analyzed in the labs. For heavy metals, 3 ml of HNO_3 was added in each sample for its preservation. Samples were placed in refrigerator maintained at 4°C for further analysis (Patil and Patil, 2010).

2.5 pH

Right after the samples were collected, a portable pH meter by was used to determine the sample pH. This was measured on the spot because of the atmospheric conditions which change with time like some gases add up, sorption, absorption or due to oxidation. But before this the pH meter was calibrated. The sample was poured into a 250 ml beaker. The value of each sample was taken after the pH probe was immersed in the water sample and retained for a few minutes in order to obtain a stabilizing reading. (Rahmanian et al., 2015).

2.6 Total dissolved solids

Inorganic salts, such as calcium, sodium, potassium cations and carbonates, chlorides, sulphate and nitrate ions, are dissolved solids. TDS was measured in water samples using a conductivity probe to measure specific conductivity by detecting the ions in the water samples. The conductivity tests are converted into the principles of the TDS. We take 20 ml of water in a beaker and dipping the meter's electrodes into the sample, and the TDS values were displayed on the screen. Senso Direct 150 by LOVIBOND was used for research (Zan and Zaw, 2019).

2.7 Electrical conductivity

Electrical conductivity is the water's ability to conduct electricity. The EC depends on the amount of chemicals and salts in the water. The EC of the samples were measured by a meter of LOVIBOND company. 200 ml of the sample was placed in a 250 ml beaker and the electrode was dipped in and screen readings were noted. Repeated the same procedure for all of the samples (Panezai et al., 2018).

2.8 Total hardness

Total hardness is defined as water with very high minerals or in another way you can say the dissolved chlorides, sulfates of magnesium and calcium ions in water, hardness in the samples was checked by titration. The samples are titrated against the normal EDTA solution, the criterion used being EBT. 50 ml of water sample was taken in 250 ml of glass beaker. 2 ml of NH_4Cl buffer was added. Then, 2-3 drops of the EBT indicator was added to it with the help of a dropper so the color was purplish. It was titrated with the EDTA in the 50 ml of burette and the color change to bluish. The reading of the burette was noted and this was repeated three times with the same sample to take mean value of it for the efficacy of the results. This method was done for all the 22 water samples (Khan et al., 2019).

The formula of the total hardness = titration value * 1000 / volume of sample

2.9 Chlorides

Chlorination process is done for killing bacteria in all filtration plants. The device used in chloride testing was burette, Erlenmeyer flask, graduated cylinder, funnel, $AgNO_3$ solution with potassium dichromate indicator was used as the reagents. With distilled water, Burette, Erlenmeyer flask, funnel and graduated cylinder were thoroughly washed in. Funnel was put inside the office and $AgNO_3$ solution was once passed through it. Burette has been retrofitted to zero and filled with $AgNO_3$ solution. 50 ml of water sample was collected in graduated cylinder and transferred to Erlenmeyer flask. Four to five drops of K_2CrO_4 were put in the flask and mixed in. Titration was taken against $AgNO_3$ and color change from yellow to orange red, its end point being (Penazai et al., 2018).

2.10 Sulfate

One of the component which dissolves in rain is the sulfate. In combination with the hardness (calcium and magnesium) in water, drinking water containing high sulfate can have a laxative effect. The sample sulfate was determined using the method of UV visible spectrophotometry. Firstly, 1000ml stock solution was made using Na_2SO_4. 5 standards (10ppm, 20ppm, 30ppm, 40ppm and 50 ppm) were made from this stock solution and calibration curve was drawn from them. Taken in a flask 25ml of the sample under observation. 2ml of buffer was added and well stirred. 0.5g of barium chloride was added, stirred well and kept for one hour. After that the solution was run in the spectrophotometry of the wavelength 420 nm. The absorbance was shown on the screens which were compared to the standard to determine the concentration in it. This method is sensitive and accurate and permit determination of microgram amounts of sulfate in water (Tabatabai., 1974).

2.11 Heavy metals

Heavy metals like cadmium, lead, iron, manganese, nickel, chromium and Zinc are extremely dangerous. These can affect the nervous system, and can cause cancer. The most effective and widely used method for determining the heavy metals is present in water or not, is the atomic absorption spectroscopy. SHIMADZU Flame Atomic Absorption Model AA-7000 was used to assess the presence of Cd, Pb, Fe, Mn, Ni, Cr and Zn (Baig et al., 2019).

2.11 Microbial testing

By Merck "water check kit" the qualitative analysis of microbial contamination of coliform and E.coli bacteria was done. E.coli is the indicator if the water quality is not good will be detected by the human feces. The kit has sterile container and a blister pack. 50 ml of water sample is poured into the container up to the red line marked by opening its top. Take the blister pack after that and press it to hold the granules at the bottom. Then break the neck by hands and add blister pack content to the water container. Close the container with a top, and shake the granules to dissolve. Do not touch fingers or hands on the inter part of the container or on top. Now leave the bottle for 48 hours at room temperature, and then test the water colour. If the color changes to any shades of blue or green, it means that it is contaminated with sewerage and if there is no color, it means that water is suitable for drinking. (Hisam et al., 2014).

CHAPTER 3

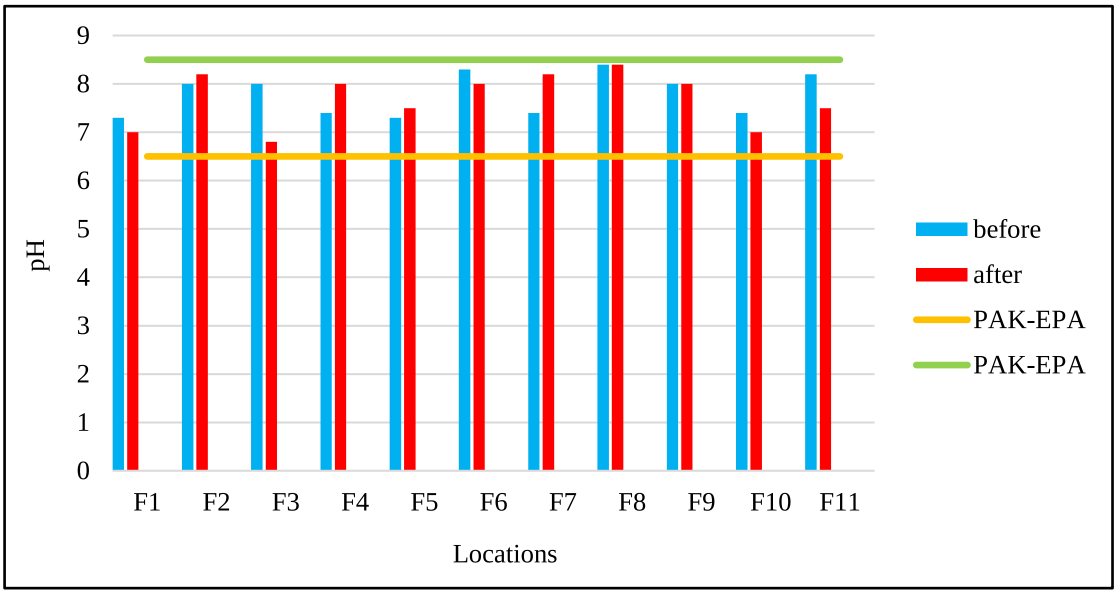
RESULTS AND DISCUSSIONS

3.1 Physical parameters

3.1.1 pH

Water samples collected from water supply to filtration plant of various sectors of Defence Housing Authority phase 2, Islamabad. The results indicated a range of 7.25 –8.38 pH with the mean value of 7.7, whereas water samples after filtration from filtration plants indicated a range of 6.72 – 8.35 pH with the mean value of 7.6 shows in the graph below. Samples taken are indicated pH within the standard limit of PAK-EPA which is 6.5 – 8.5. The pH is very important factor in determining water's corrosiveness (Patil et al., 2012).

Figure 3.1. pH concentration of water samples of study area.



F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.1.2 Total dissolved solids

Samples collected from the filtration plants of various sectors in Defence Housing Authority phase 2, Islamabad were analyzed for TDS concentration as shown in figure 3.2. concentrations of TDS were compared with the standard limit of PAK-EPA which is 1000mg/l. The findings of the TDS for the water samples analysis obtained from water supply to the filtration plant showed a concentration range of 340–545 mg/l with value of 401.8 mg/l, while water samples have concentration of 351–568 mg/l with value of 411.7 mg/l after treatment from filtration plants. All water samples showed TDS within the PAK-EPA permissible limit. Higher concentrations of TDS can cause both acute myocardial and ischemic heart diseases (Appavu et al., 2016)

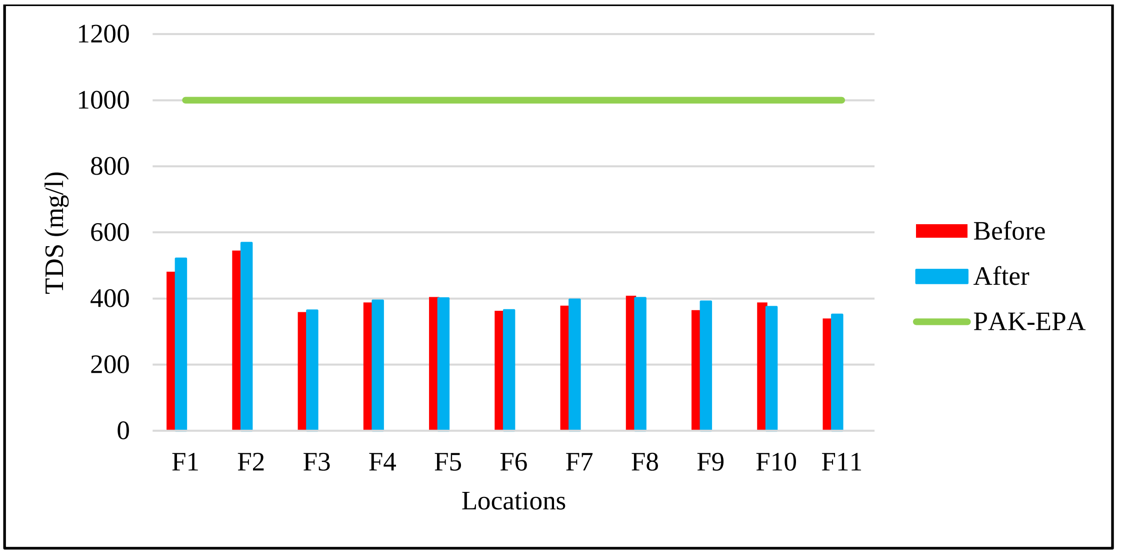


Figure 3.2. TDS concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8

3.1.3 Electrical conductivity

Pure water is rather a good insulator not a good conductor of electric current. Before filtration, the electrical conductivity of all water samples ranged from 461–678 (µS/cm) with value of 522.5 (µS/cm). While samples collected after filtration indicated a range of 472–711 (µS/cm) electrical conductivity with a mean value of 536 (µS/cm) as shown in Figure 3.4. The electrical conductivity values have been compared to the 1000 (µS/cm) national standard limit. All the water samples collected from the filtration plants indicated electrical conductivity within the PAK-EPA limit before and after treatment. Electrical conductivity doesn't affect human health directly (Soylak, 2001).

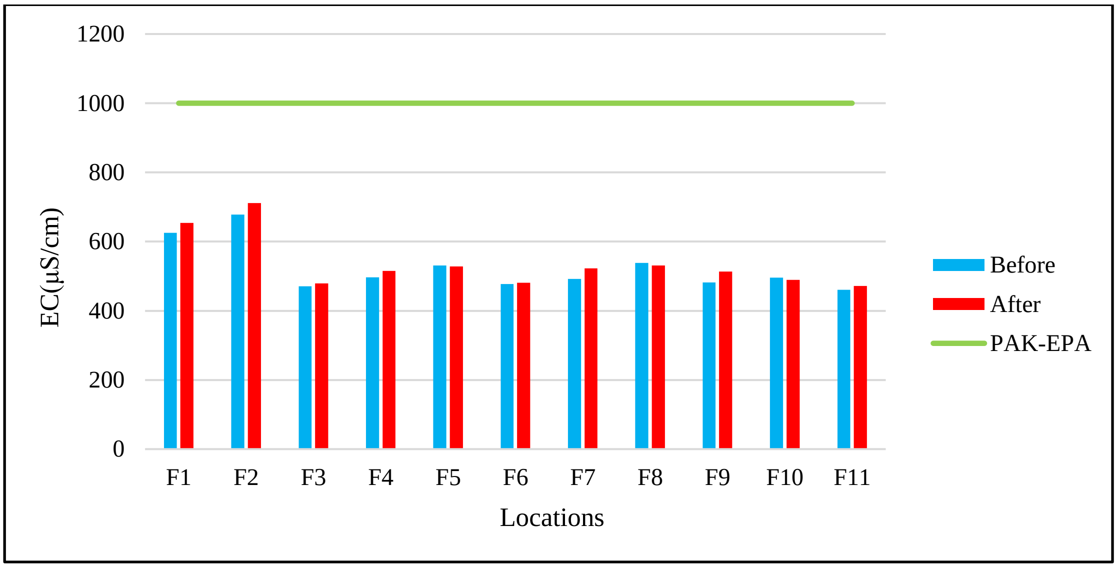


Figure 3.3. EC concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

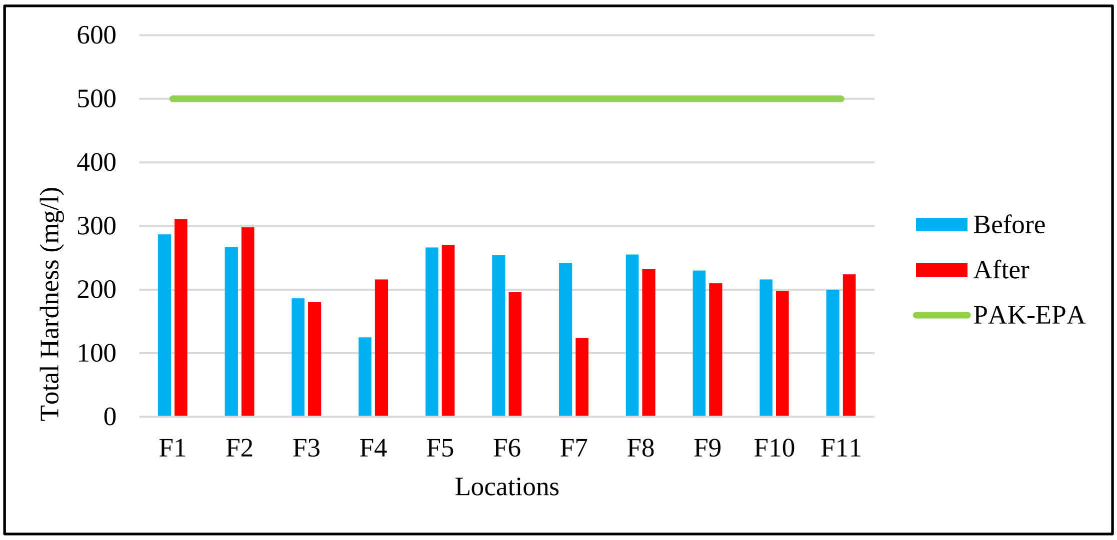
Table 3.2. Physical parameters of drinking water samples before and after filtration.

Sectors	before			After		
		Concentration (mg/l)	Concentration (µS/cm)		Concentration (mg/l)	Concentration (µS/cm)
	pH	TDS	EC	pH	TDS	EC
F1	7.3	481	625	7	494	654
F2	8	545	678	8.2	518	711
F3	8.2	359	471	6.8	364	479
F4	7.4	388	497	8	394	515
F5	7.3	405	531	7.5	401	528
F6	8.3	363	477	8	365	481
F7	7.4	678	492	8.2	397	523
F8	8.4	408	538	8.4	402	531
F9	8	365	482	8	391	513
F10	7.4	388	496	7	375	489
F11	8.2	340	461	7.5	351	472
PAK-EPA	6.5-8.5	1000	1000	6.5-8.5	1000	1000

3.2 Chemical parameters

3.2.1 Total hardness

Therefore we have analyzed water samples from filtration plants in different sectors. Total hardness concentrations have been compared with the PAK-EPA standard value that is 500 mg/l. The Total hardness analysis of samples from water supply to filtration plant showed concentration ranging from 125 to 287 mg/l with value of 229.8 mg/l whereas water samples collected after filtration showed concentration ranging from 124 to 311 mg/l with value of 223.5 mg/l. Before and after treatment, the water samples obtained from filtration plants showed complete hardness within the



PAK-EPA limit .

Figure 3.4. Total Hardness concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.2.2 Calcium

Water samples from filtration plants of the various calcium sectors were analyzed. The calcium concentration was compared to the standard limit of PAK-EPA 200 mg/l. The results of the calcium analysis from water supply to filtration plants in different sectors showed a concentration of 47-94 mg/l with value of 69.9 mg/l, while water samples obtained after filtration showed a concentration of 36 - 128 mg/l with value of 72 mg/l as shown in Figure 3.6. Calcium is very important for the physiology and human bones. Most of the calcium is contained in bones and teeth within the human body. High concentration of calcium cause blood clotting (WHO, 2011).

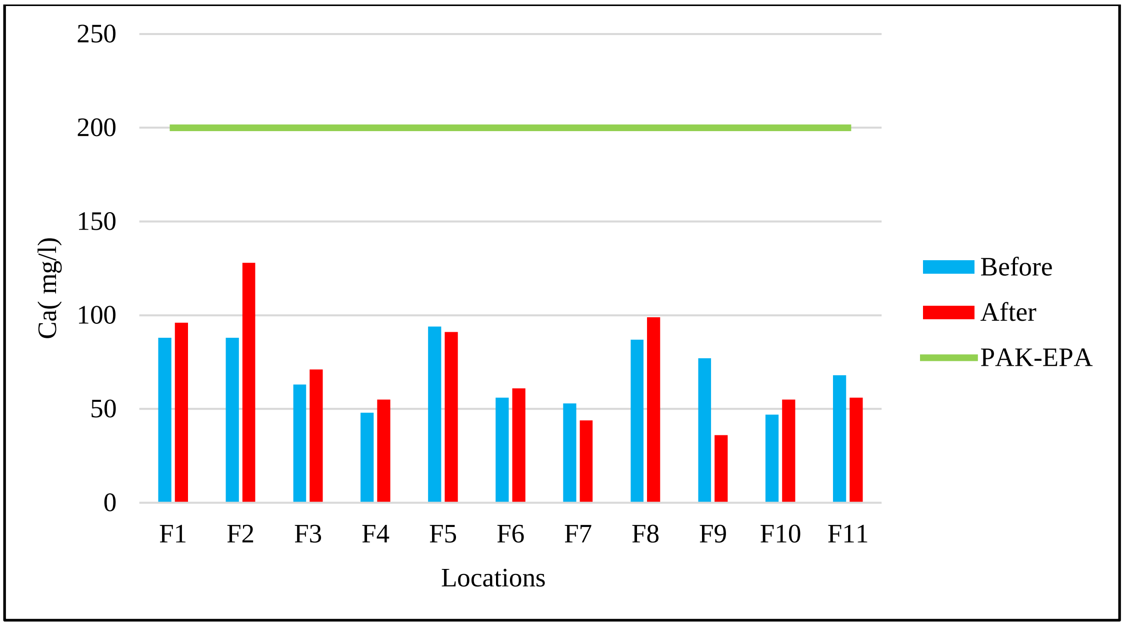


Figure 3.5. Ca concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.2.3 Magnesium

The water samples for Magnesium were extracted from filtration plants of the different sectors. The magnesium concentration has been compared with the PAK-EPA value of 100 mg/l. The findings of the water supply study for filtration plants in different sectors showed concentration 9.12 - 26.5 mg/l with value of 17.6 mg/l, while water samples obtained after filtration showed concentration 11.8 - 29.7 mg/l with value of 18 mg/l, respectively. About 25 g of Magnesium is found in the human body out of this 60 percent is found in bones and the remaining 40 percent is found in tissues and muscles. Magnesium's importance in the human body is that it helps in the proper functioning of living organisms such as membrane functions, replication of DNA etc. It is important for the working of living organisms and contains in minerals such as magnetite and dolomite (Soylak, 2001).

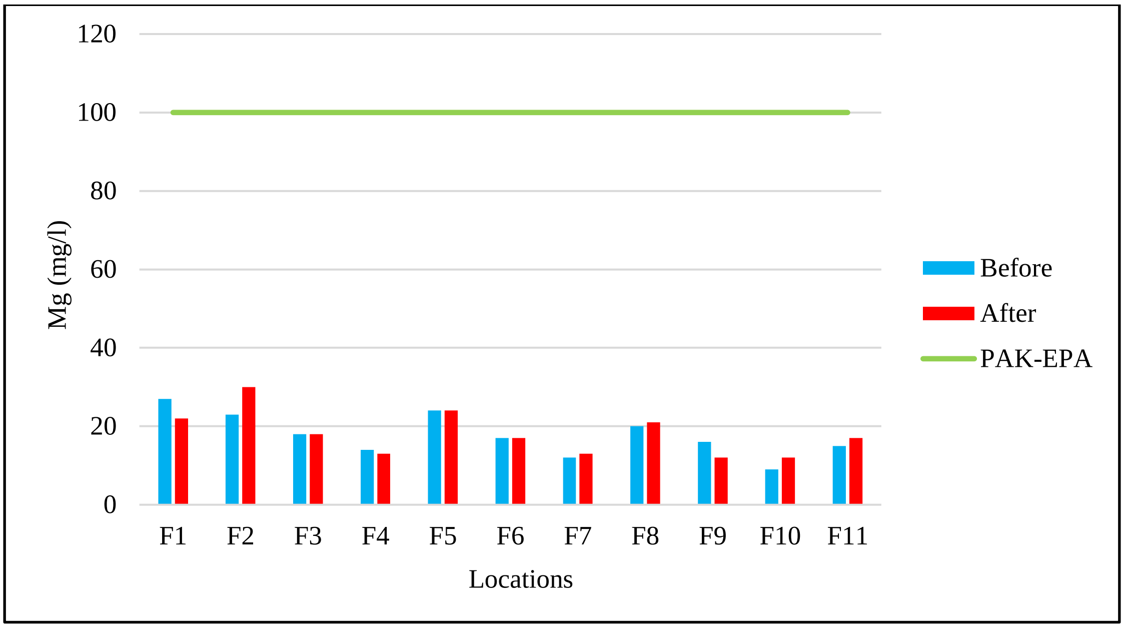


Figure 3.6. Mg concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.2.4 Chloride

The water samples from filtration plants of the various sectors for chloride were analyzed. The concentration of chloride was compared with the standard limit of PAK-EPA is 250 mg/l. Results from the water supply chloride analysis to filtration plants of different sectors showed concentration of 11.74 - 85.26 mg/l with value of 35 mg/l, whereas water samples collected after filtration showed concentration of 11.15-88.52 mg/l, value of 34.86 mg/l. High concentrations of chloride damage metallic pipes and structure, and harmful plants (Soylak, 2001).

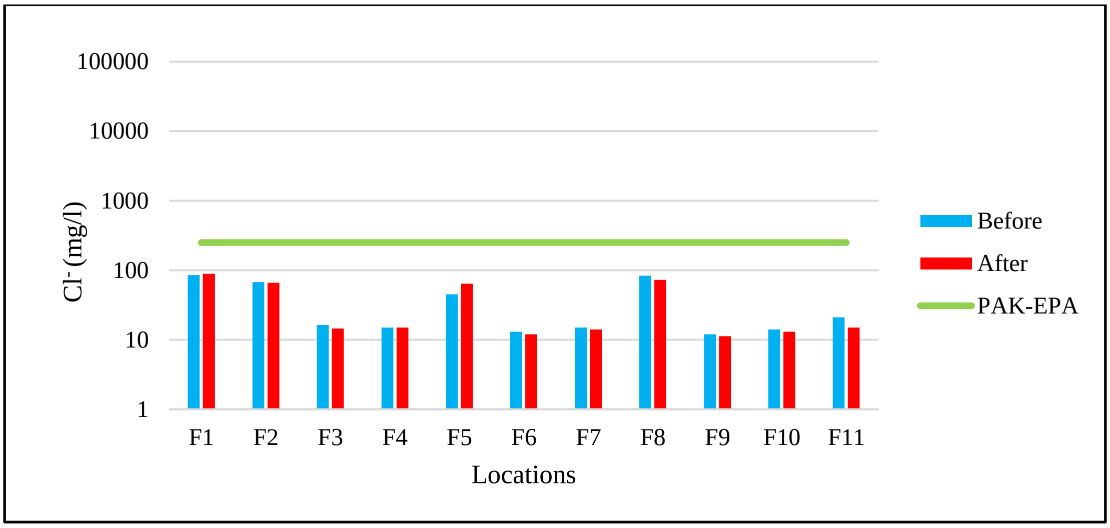


Figure 3.7. Cl^{-} concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.2.5 Sulfate

For Sulfate, water samples from filtration plants of the different sectors were analyzed. The sulfate concentration has been contrasted with the PAK-EPA normal limit of 400 mg/l. Results of the water supply sulfate study for filtration plants in different sectors showed concentration of 7.36 - 16.8 mg/l at value of 12.69 mg/l, while sample of water obtained after filtration showed concentration of 7.99-19.21 mg/l at value of 12.22 mg/l. High sulfate concentrations can be attributed to pyrite oxidation and mine drainage (WHO, 1984).

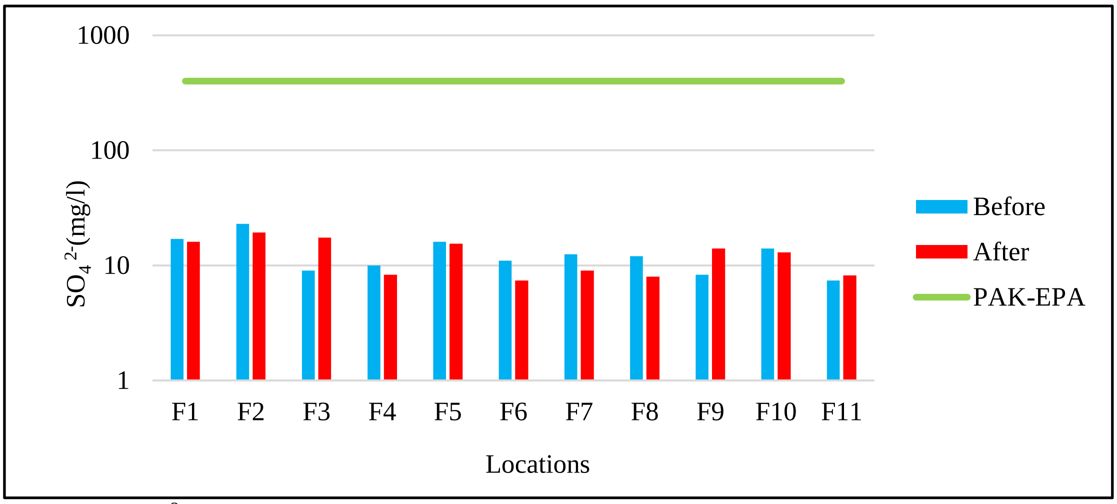


Figure 3.8. SO_4^{2-} concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street.

Table 3.3. Chemical parameters of drinking water samples before and after filtration.

Sectors	Before					After				
	Concentration(mg/l)					Concentration(mg/l)				
	Total Hardness	Ca	Mg	Cl^-	SO_4^{2-}	Total Hardness	Ca	Mg	Cl^-	SO_4^{2-}
F1	287	88	26	85	17	311	96	22	89	16
F2	267	88	23	67	23	298	128	30	65	19
F3	168	63	18	16	9	180	71	18	14	17
F4	125	48	14	15	10	216	55	13	15	8
F5	266	94	24	44	16	270	91	24	64	15
F6	254	56	17	13	11	196	61	16	12	7
F7	242	53	12	15	12	124	44	13	14	9
F8	255	87	20	83	12	232	99	21	72	7
F9	230	77	16	12	8.	210	36	12	11	13
F10	216	47	9	14	14	168	55	12	13	13
F11	200	68	15	20	7	224	56	17	15	8
PAK-EPA	500	200	100	250	400	500	200	100	250	400

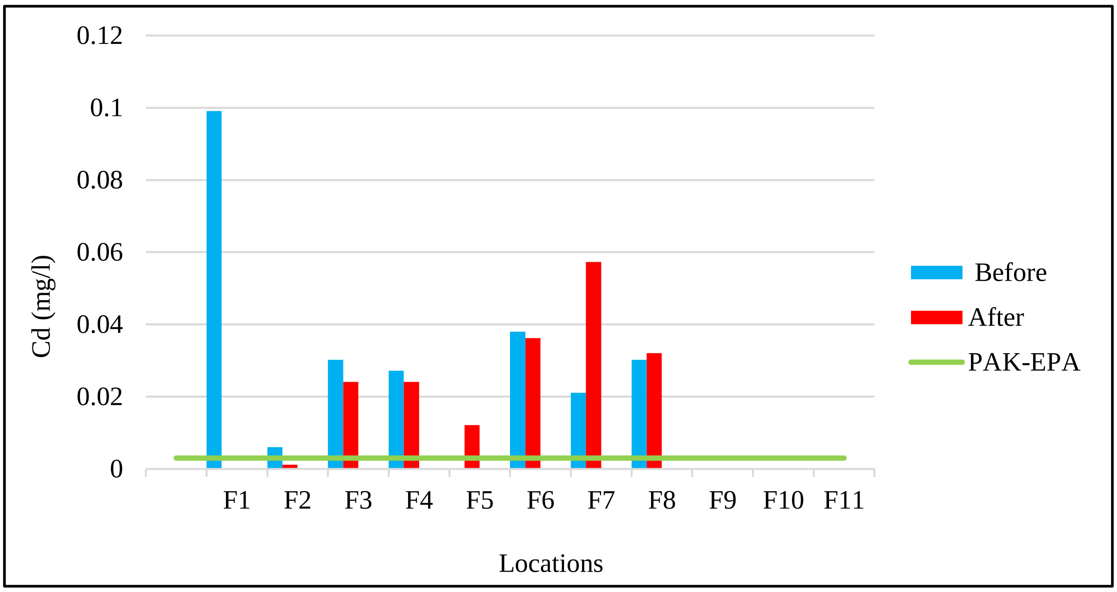
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street.

3.3 Heavy Metals

3.3.1 Cadmium

Cadmium was tested in water samples from separate Defence Housing Authority 2 filtration facilities. In figure 3.10 is shown Islamabad. Water supply samples to filtration plants suggested concentration of Cd in the range of 0 - 0.100 mg/l. The value obtained is 0.023 mg/l. Likewise, water samples obtained after filtration suggested concentration of Cd with a mean value of 0.014 mg / l in the range of 0 - 0.057 mg/l. The concentrations of CD were compared to the PAK-EPA standard limit of 0.003 mg/l. Impurities in galvanized zinc pipes and solders and certain metal fittings may also cause pollution in drinking water (Idiko et al., 2012). Exposure to oral Cd can adversely affect a variety of tissues, liver, kidney and cardiac veins damage (Amiri and Mirhoseiny, 2015).

Figure 3.9. Cd concentrations of water samples of study area.



F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.3.2 Iron

Iron was analyzed from various filtration plants in water samples. Water supply samples to filtration plants revealed a concentration of Fe in the range of 0.005 -0.100 mg/l with value of 0.045 mg/l. Similarly, after filtration samples of water indicated a concentration of Fe in the range of 0.004 – 0.122 mg/l with value of 0.046 mg/l. the standard according to PAK-EPA is 0.3. All the samples were within the permissible limit. Excess iron can cause damage to cells in the heart, liver which can lead to siderosis (Ildiko et al., 2012).

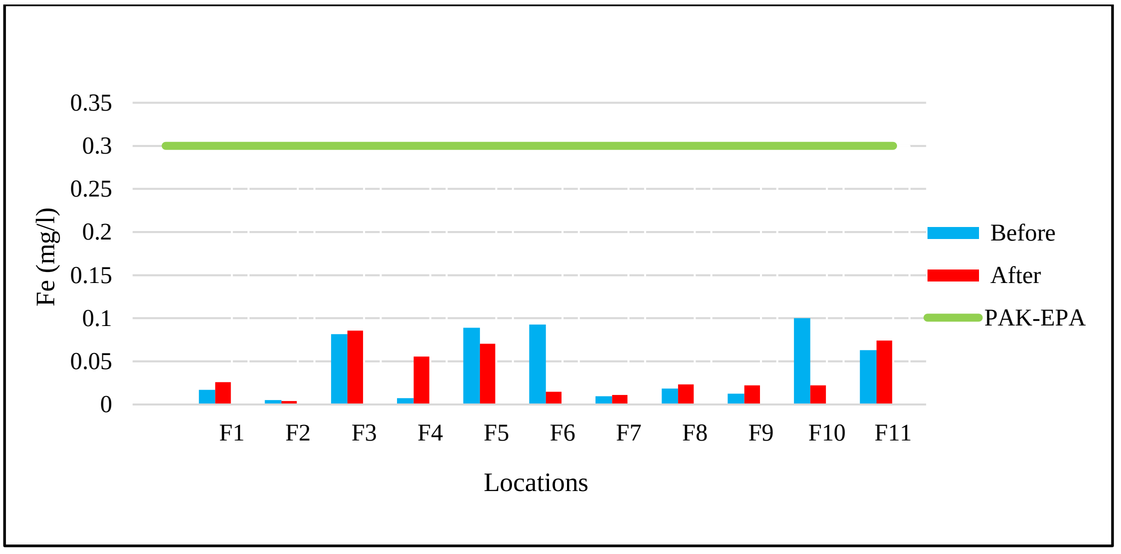


Figure 3.10. Fe concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.3.3 Lead

Lead was analyzed from various filtration plants in water samples. Water supply samples to filtration plants suggested concentration of Pb that is 0.001-0.034 mg/l, value is 0.012 mg/. Similarly, water samples collected after filtration showed concentration of Pb in the 0.001 – 0.037mg/l range with a mean value of 0.013 mg/. Pb concentrations were compared with 0.010 mg/l of standard PAK-EPA limit. The water samples collected from filtration plants prior to and after treatment indicated Pb concentration in F3, F6, F7, F8, F9, F10 and F11 exceeding PAK-EPA limits. Lead, through its many sources of origin, contaminates drinking water, such as industrial waste, automotive exhaust and household paint. Lead has also severe damage to human life (Haq et al., 2009).

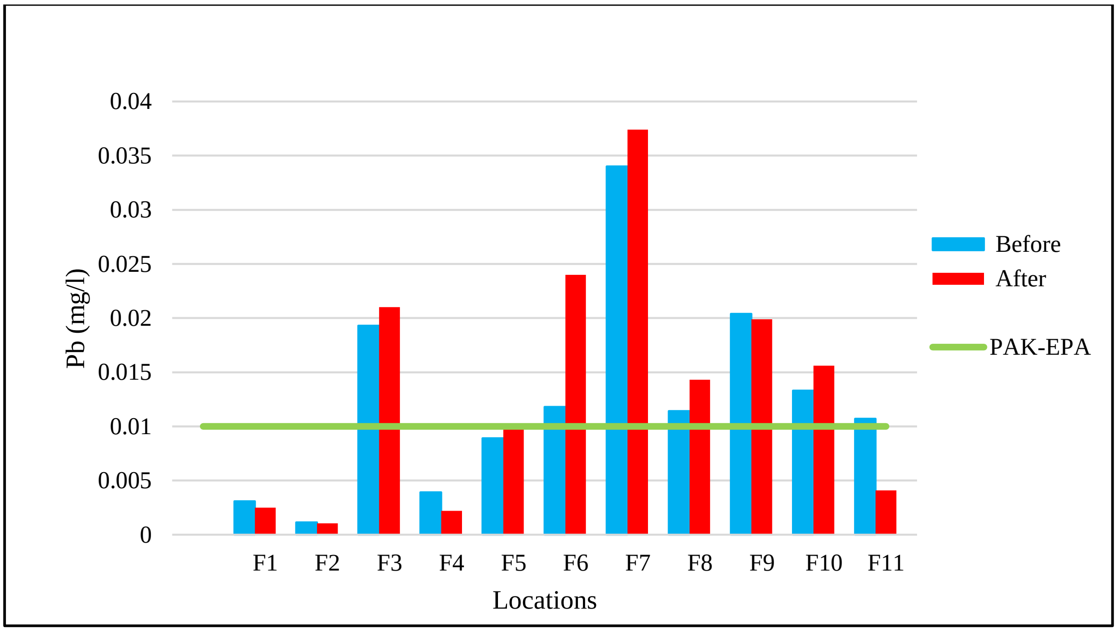


Figure 3.11. Pb concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.3.4 Nickel

In water samples from different filtration facilities, Ni was analyzed. Samples from water supply to filtration plants showed Ni concentration value is 0.012 mg/l that is of 0.003 - 0.081 mg/l range. Likewise, after filtration water samples suggested concentration of Ni in the range of 0.003 - 0.082 mg/l with value of 0.018 mg/l. Neither concentration has been compared with the PAK-EPA standard limit of 0.020 mg/l. Treatment the water samples obtained from filtration plants showed .Ni concentration exceeding the normal PAK-EPA level in F4, F6 and F9. The primary source of nickel in drinking water comes from metal pipes and drinking water-contact fittings. Dermal exposure is the most common cause of skin irritation for those allergic to nickel that occurs at very low exposure levels (Alam et al., 2008).

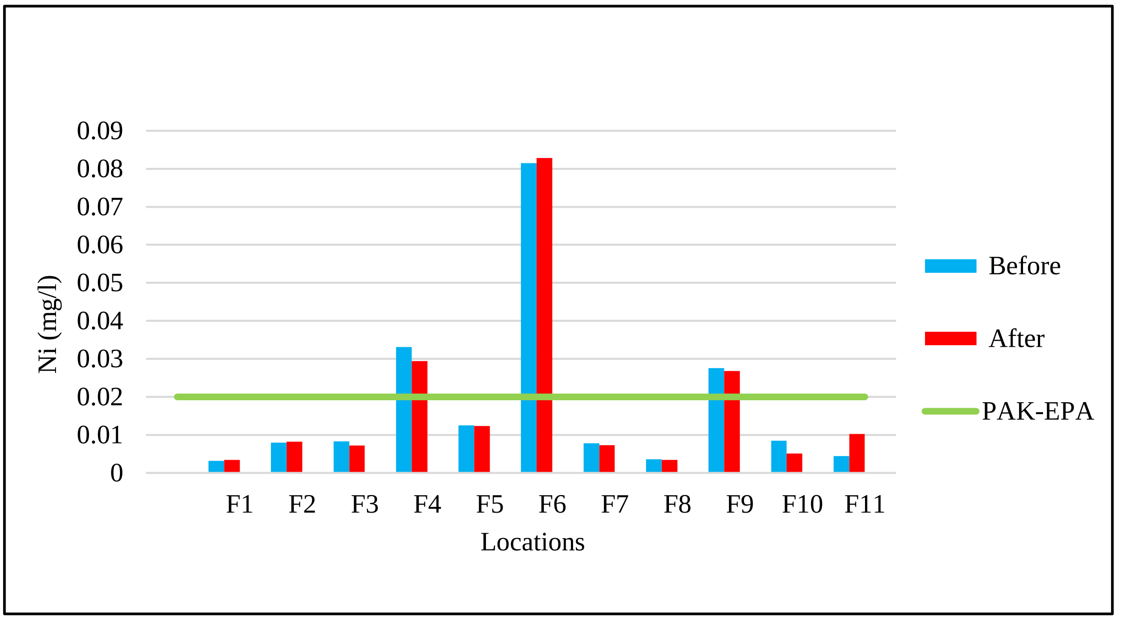


Figure 3.1.2 Ni concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.3.5 Chromium

The water samples for Chromium from filtration plants of the various sectors were analyzed. The Cr concentration was compared to the normal value of PAK-EPA that is 0.050 mg/l, findings of the Cr study of water supply to filtration plants in different sectors showed concentration range 0 - 0.1043 mg/l with value of 0.030 mg/l, while water samples obtained after filtration showed concentration range 0 -0.13 mg/l with value of 0.03 mg/l respectively. The results showed that the Cr in F3, F8, and F9 reaches the allowable PAK-EPA limit. The chromium is injurious to human beings and cause growth depression and kidney damage (Haq et al., 2009).

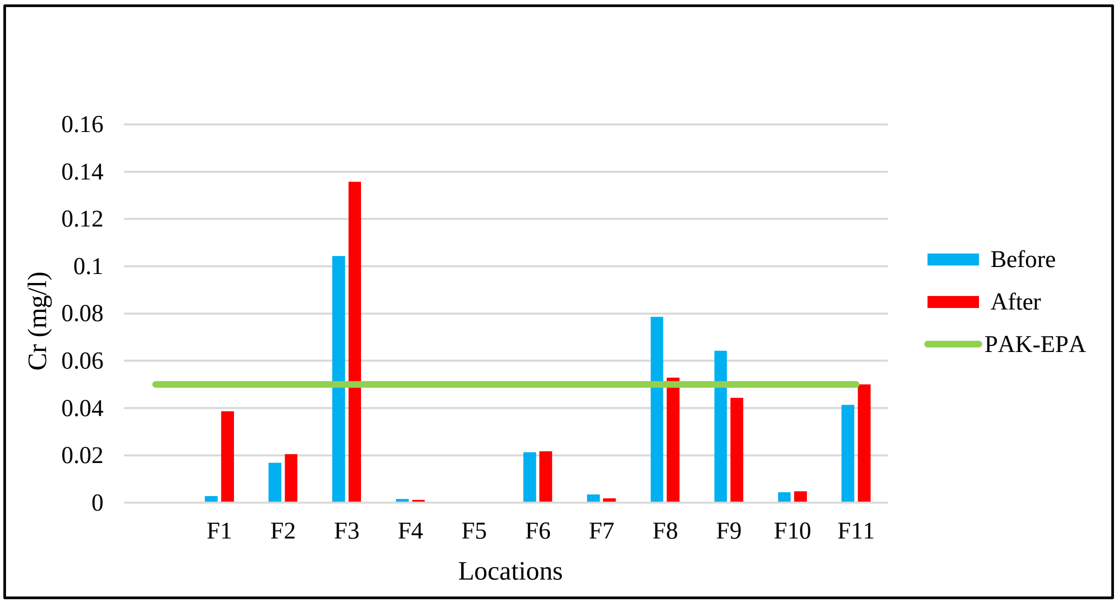


Figure 3.13. Cr concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.3.6 Manganese

For Mn, water samples from filtration plants were analyzed from the various sectors. The Mn concentration was compared to the PAK-EPA norm limit of 0.500 mg/l. The findings of the water supply study of manganese to filtration plants in different sectors showed concentration ranging from 0.001 - 0.105 mg/l with value of 0.022 mg/l while water samples obtained after filtration showed concentration ranging from 0.001 to 0.079 mg/ with value of 0.0098 mg/l. Generally, high concentrations of Mn in drinking water can cause mental diseases such as manganese. Contamination of the metal in water affects the ability and thinking sense of 10-year-old children (Muhammad et al., 2011).

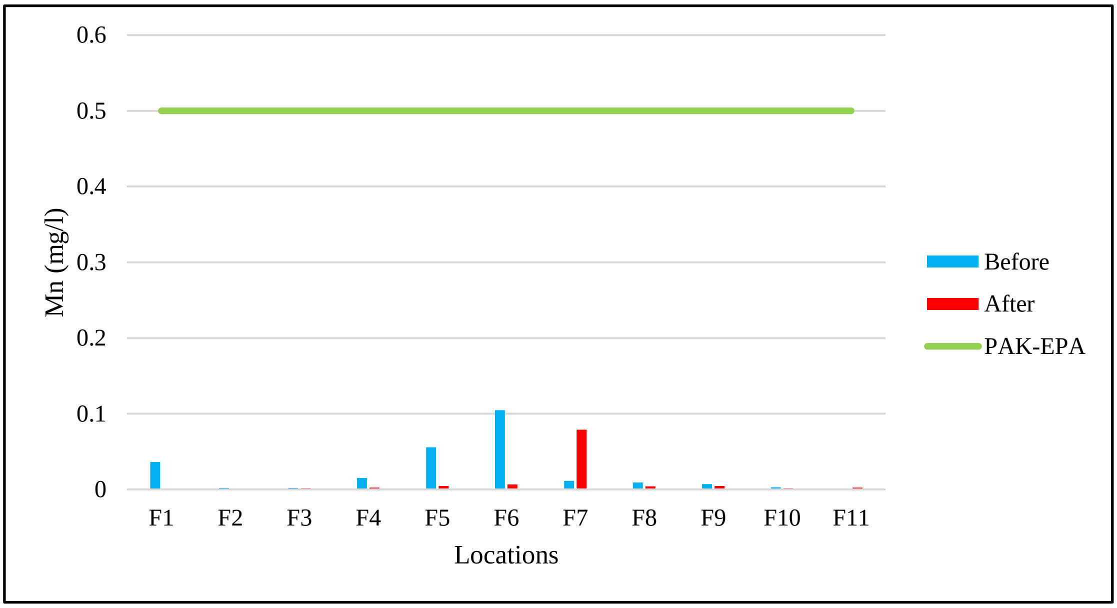


Figure 3.14 Mn concentration of water samples of study area.
F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.3.7 Zinc

The samples of water from filtration plants of the different sectors for Zinc were analyzed. The concentration of Zinc was compared with the PAK-EPA which is 5mg/l. The findings of the water supply zinc study for filtration plants in different sectors showed concentration in the range 0.0078 - 0.277 mg/l with value of 0.039 mg/l , while water samples obtained after filtration showed concentration in the range 0.0479 - 0.0144 mg/l with value of 0.024 mg/l. In humans, zinc is very essential micronutrient and only at very high concentrations; it can cause some toxic effects Zinc compounds are corrosive astringent to skin, hair, and mucous membrane. Zinc also irritates the digestive tract which causes nausea and vomiting (Patil and Ahmad, 2011).

3.3.8 Arsenic

The water samples from the various filtration plants were analyzed through kit method for Arsenic concentration. The results showed were all zero that means that there was no arsenic detected in the water samples. Arsenic's adverse health effects are strongly dependent on the dosage and length of exposure. Inorganic arsenic intake is a known cause of skin, bladder and lung cancer (Mukherjee et al., 2006).

Table 3.4. Heavy metals of drinking water samples.

	Before							After						
Sectors	Concentration (mg/l)							Concentration (mg/l)						
	Cd	Fe	Pb	Ni	Cr	Mn	Zn	Cd	Fe	Pb	Ni	Cr	Mn	Zn
F1	0.099	0.017	0.003	0.003	0.003	0.036	0.012	0	0.026	0.002	0.003	0.037	0.005	0.027
F2	0.006	0.005	0.001	0.008	0.017	0.002	0.008	0.001	0.004	0.001	0.008	0.02	0.001	0.011
F3	0.03	0.082	0.019	0.008	0.104	0.002	0.017	0.0024	0.086	0.021	0.007	0.136	0.002	0.02
F4	0.027	0.007	0.004	0.033	0.002	0.015	0.018	0.0024	0.056	0.002	0.029	0.001	0.003	0.025
F5	0	0.089	0.009	0.012	0	0.056	0.277	0.012	0.07	0.01	0.012	0	0.005	0.039
F6	0.038	0.093	0.012	0.081	0.021	0.105	0.034	0.036	0.015	0.024	0.083	0.022	0.007	0.048
F7	0.021	0.009	0.034	0.008	0.003	0.011	0.017	0.057	0.011	0.037	0.007	0.002	0.079	0.027
F8	0.03	0.019	0.011	0.004	0.079	0.009	0.008	0.032	0.023	0.014	0.003	0.053	0.004	0.016
F9	0	0.012	0.02	0.028	0.064	0.007	0.015	0	0.022	0.02	0.027	0.044	0.005	0.019
F10	0	0.1	0.013	0.008	0.004	0.003	0.019	0	0.122	0.016	0.005	0.005	0.002	0.02
F11	0	0.063	0.011	0.004	0.041	0.001	0.012	0	0.074	0.004	0.01	0.05	0.003	0.016
PAK-EPA	0.003	0.3	0.01	0.02	0.05	1	5	0.003	0.3	0.01	0.02	0.05	1	5

F1= Sector G, F2 = Sector J, F3 = Sector D, F4 = Sector E, F5 = Sector B, F6 = Sector A, F7 = Sector C, F8 = Sector F Street 13, F9 = Sector F Street 1, F10 = Sector H, F11 = Sector H Street 8.

3.4 Biological parameter

3.4.1 E.coli

The study of the E.coli bacteria was performed for the samples collected from different phase II DHA sectors. The presence of E.coli was demonstrated by water samples obtained prior to filtration from sector G, sector J, sector A, sector F st 13, sector H ST 8. Water samples collected from sectors G, E, F ST 13, H POWER AVENUE, H ST 8 after filtration indicated the presence of E.coli. Sector G, Sector F ST 13, Sector H ST 8 filtration plants shows microbial contamination because their filter paper replaces after 6 months and thus they are incapable of filtering E.coli. The higher number of bacterial colonies is present due to percolation of sewage into water

Table 3.5. Microbial contamination in drinking water samples before and after filtration.

Sample ID	Sectors (DHA-II)	E.coli	
		Before	After
F1	G	positive	positive
F2	J	positive	negative
F3	D	negative	negative
F4	E	negative	positive
F5	B	negative	negative
F6	A	positive	negative
F7	C	negative	negative
F8	F, St.13	positive	positive
F9	F, St. 1	positive	negative
F10	H, Power Ave	negative	positive
F11	H, St. 8	positive	positive

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

i. Values of water quality parameter such as pH, TDS,EC, Total Hardness, Ca, Mg, Cl^-, SO_4^{2-} from all filtration plants of various sectors of DHA 2, Islamabad were found to be within the recommended limits of PAK- EPA.

ii. Heavy metals concentration such as Fe, Zn, Mn were also found to be well below the standard limit of PAK- EPA whereas the cadmium concentration in all water samples was found in six filtration plants above the standard PAK- EPA limit (F3, F4, F5, F6, F7, F8). Pb concentrations were also found above the PAK- EPA limit in six filter plants (F3, F6, F7, F8, F9, F10 and F11). Ni concentration were found above the PAK- EPA limit in F4, F6 and F9. Cr concentrations were found above the PAK- EPA limit in F3, F8 and F9.

iii. Biological analysis shows the presence of E.coli in samples collected from filtration plants of DHA 2, Islamabad. The results showed that some of the samples had been infected with E.coli bacteria and were not suitable for drinking.

iv. One of the unexpected conclusion is that the E.coli bacteria was not present in F4 and F10 filtration plants before treatment but after treatment, clearly indicates contamination of water during treatment.

4.2 Recommendations

i. Authorities should keep proper monitoring and maintenance to trace possible means of contamination and improvement.
ii. Good quality of filter paper should be used in filtration plants.
iii. Membranes should be regularly changed in filtration plants.
iv. Pb galvanized pipes and fittings should be replaced timely.
v. UV lamp should be installed for killing microorganisms.
vi. Results should be displayed on front side of filtration plants so that people may be aware of the results.
vii. Further studies should be conduct with focus on treatment of water quality of filtration of plants monthly.

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