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Comparative Microbial Examination of Household Drinking Water and Water Filtration

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ABSTRACT

Water is an essential element for survival on earth. Poor water quality is one of Pakistan's biggest health concerns and environmental issues. Drinking water quality has become worse due to microbial and chemical contamination in water supplies and groundwater. To evaluate contamination, the standard plate count method, spread plate method, most portable number (MPN), and kit method were used. In the spread plate method, a specific amount of sample was poured and spread by the sterilized spreader evenly on the agar medium. The petri plates were incubated at 37° Celsius for 24 hours. After 24 hours, colonies were enumerated with the help of the colony counter. In the kit method, the sample water inoculated in the reagent vile showed characteristics of color if it was contaminated with coliforms. 70.36% of the household samples and 28.35% of filtered water samples were found with total coliform bacterial contaminated ions when compared with National Standards for Drinking Water Quality. In contrast to the Nestle mineral water, boiling water did not uncover any coliform bacterial colonies or other microorganisms. Hard and cloudy drinking water was encountered. Regulatory agencies must carefully examine drinking water sources for microbial contamination to prevent dangers to the public's health.

Keywords: Coliforms, drinking water, *Escherichia coli*, filtered water, Microbiological contamination, spread plate method, bacterial contaminants

INTRODUCTION

Water is necessary for the maintenance of life (Irfan et al., 2020). Nature has blessed Pakistan with all water resources, ground, and surfactant water. Although less than 3% of the water on Earth's surface is freshwater, about 70% of its surface is covered by water (Papa et al., 2023). Around 0.01 percent of the world's freshwater is available for human consumption; the remainder is locked in ice caps (Rodríguez et al., 2021). Pakistan has enough water resources, but regrettably, human activities like population increase, industrialization, and improper use decrease the quantity and impair the quality of resources (Khan et al., 2020). If the present trend continues, Pakistan's water supply will drastically decrease, reaching a terrifying 575 cubic feet by the year

2050 (Nazam Maqbool, 2022). Water for drinking is obtained by Pakistanis from several sources, such as surface water (open wells or ponds), subterranean water (hand pumps), government-provided water (taps), etc (Bashir et al., 2020). Contamination of water by chemicals and microbes is a serious issue in Pakistan based on the availability of clean water (Arif and Bannian, 2022; Nazam Maqbool, 2022). Pakistan is number eight (Rasheed et al., 2022). People of Pakistan are left with no option but to consume water is available for drinking which is salty or contains other contaminants (Ahmed et al., 2022). Most rural areas of Pakistan use surface water for drinking after gradual sand filtering; filtration facilities do not chlorinate the water. The majority of rural areas lack pre-treatment water purification facilities. These inadequacies are all the result of contaminated water and microbial growth. Wells and hand pumps are at risk from surface runoff and flooding. Water quality has been disturbed due to manmade processes and natural disasters. One-third of Pakistan's nation suffering from waterborne diseases. People can survive days without food but can't move without water. Water is a crucial element for the survival and maintenance of life. Sewage (faecal), which is frequently dumped into drinking water system sources, is the main cause of pollution. The release of harmful compounds from industrial effluents, pesticides, and fertilizers from agricultural sources into water bodies is a secondary source of pollution. Water in Pakistan is severely contaminated with coliforms and faecal coliforms at the source, throughout the distribution system, and at the consumer tap. In Pakistan, only 20% of people have the opportunity to get safe drinking water. According to estimates, polluted water contributes to 20–40% of illnesses and 33% of deaths in Pakistan, costing the country 5800-25000 million lost tax income (Daud et al., 2017; Nabi et al., 2019). When faeces contaminate water, the risk of water-borne illness increases. Water that has been contaminated may have pathogenic (disease-causing) faecal bacteria, viruses, or other microbes (Daly and Harris, 2022). To attempt to routinely identify any of them would be far too difficult, and many of the pathogens might only be present in very minute amounts or not at all. Thus, it is common practice to search for "indicator bacteria.". Runoff from informal settlements and sewage plant discharges are two major variables impacting the microbiological quality of surface waterways (Reitter et al., 2021). Faecal coliforms (FC), the most prevalent bacterial indicator of faecal contamination, are utilized to assess the microbiological quality of surface water. The presence of coliforms indicates how hygienic the water is generally and whether there is a chance that it contains infectious illnesses. High FC and TC concentrations in water often cause diarrhea, but they can also cause fever and other problems (Laolang et al.). Bathing and swimming in streams and rivers are also common among children and adults in the local community (Utami et al., 2024). The probability of ingesting an infectious dose of diseases causing microorganisms is very high considering the fact that waterborne pathogens generally have low infective doses (Barielnu et al., 2022; Daher et al., 2022). The microbiological safety of drinking water is becoming a worldwide concern. Similar worries have been raised as a result of the development of germs like Cryptosporidium which are resistant to chlorine and antibiotics (Shah et al., 2020). The most serious effects of contaminated drinking water on human health are seen in poor nations, where the emergence of drug resistance threatens the effectiveness of medicines and contributes to the spread of waterborne infections (Teo et al., 2022). The quantity of organic matter present, the presence of poisonous compounds, the salinity of the water, and environmental conditions like pH, temperature, and aeration all affect the types and numbers of bacteria present (Tahir Maqbool et al., 2020). Other pathogens that may present in drinking water are bacteria, viruses, and some intestinal pathogens like bacteria, *vibrio cholerae, Shigella, dysenteries enterotoxigenic Escherichia coli, Salmonella spp.* (e.g. *Salmonella typhi*), *Campylobacter jejune Aeromonas, hydrophile, Pseudomonas aeruginosa, Legionella, Yersinia, enterocolitica* etc.

l was discovered in water samples from drilled wells. The majority of the samples' chemical contamination levels were found to be within World

Health Organization (WHO) and U.S. Environmental Protection Agency permissible limits (USEPA). The presence of coliform bacteria is not always proof of faecal contamination. The presence in drinking water typically indicates a problem with water pipelines or treatment systems and suggests that the water may be polluted with pathogenic bacteria (Abdelnabi et al., 2022; Gunter et al., 2023; Sattar et al., 2022; Zhang et al., 2022).

Aims and Objectives

- To analyse the quality of water from water filtration plants.
- To improve the microbiological quality of water
- To identify the level of microbial contamination in drinking water.
- To analyse the different pathogens in the filtered drinking water

MATERIALS AND METHODS

Study Area

The study area was Depalpur, the largest Tehsil in Pakistan, which had its administrative center in this city, which is located in the Okara District of the country's Punjab region. It is in Bari Doab on the Satluj Riverbank, 25 kilometers from the district center of Okara. It is situated in Kasur District's western region.

Sample Collection and Transportation:

Samples from different sources like household and filtration plants were taken in sterile conditions. These samples were transported in sterile within 2-6 hrs in university lab and then subjected towards different testing. These samples were stored in the refrigerator at 4ºC.

Methodology:

Different parameters were used to analyze water samples, they are described below.

Physiochemical Parameters: The physical parameters such as temperature was measured with a thermometer. Other physical parameters such as color, odour, turbidity, and taste were also observed at the time of sampling. The chemical parameters such as pH measured with a pH (Hanna) meter were measured. TDS was measured with TDS (Hanna), while turbidity was measured with the Turbidity (Milwaukee) meter. The majority of the samples were also tested for electrical conductivity with a conductivity meter, magnesium ions, Calcium ions, HCO3, total hardness, and chloride were measured with titration method.

Microbiological analysis

Total coliform count, most portable number, direct plate method and Kit method was performed using standard methods for the water examination. Kit method was performed by using HiWater™ test kit. This Kit has reagent such as Bromo Cresol Purple, Ferric ammonium sulphate, peptone, and Lactose. When lactose used by bacterial enzymes in contaminated water, it produces acid and pH of sample decreases. The lowering of pH changes the color of Bromo Cresol Purple from purple to yellow if sample is contaminated. 2 samples were tested with this method.

RESULTS

All samples included filtered water which is implanted by government of Pakistan and household drinking water were collected from different areas of Depalpur city as shown in (Table 1). **Physical parameters of drinking water samples**

Physical analysis of household and WFP showed that it is safe for drinking purpose as shown in (Table 2). The samples collected from different regions of Depalpur city were given the sample ID for identification. Firstly, the physical parameters were analysed. The mean temperature of all household samples was found 16.928±0.47 ºC. The taste and odour of all motor pump source water samples were found sweet, and turbidity was 1.46±0.79. The Turbidity value of all motor pump sources was within the permissible limit. The highest turbidity 1.3 NTU was found in water from as mentioned in (Table 2). **Chemical Analysis**

All values were in reasonable range. the chemical parameters from filtration plants water found in permissible limit. The mean value of pH from all filtered water was 7.75±0.03. The results of other parameters such as total hardness, total dissolved solids and chloride were satisfactory. The average value of total hardness, total dissolved solids and chloride was 369.56±16.53 mg/l, 07.7±39.02 mg/l,

Table 1: Sample collection from Household drinking water.

Sample	Sample Id	Location
1	H-1	Khalilabad colony Depalpur
2	H-2	Fakhar Shah colony Depalpur
3	H-3	Abdullah Town Depalpur
4	H-4	Basti Noor Muhammad
5	H-5	Quid e Azam chowk Depalpur
6	H-6	Gala Mandi Depalpur
7	H-7	Fareed Town Depalpur
8	F-1	Khalilabad UF Plant Depalpur
9	F-2	Abdullah Basti UF Plant Depalpur
10	F-3	Basirpur Gate UF plant Depalpur
11	F-4	Fatima Jinnah Park UF Plant Depalpur
12	F-5	Gov. Colony Filtration Plant Depalpur
13	F-6	Naveed
14	F-7	Fareed Town Depalpur
15	F-8	Faridia Colony Depalpur

110.68±17.95 mg/l respectively. Whereas the mean value of Ca2+, Mg2+, HCO3-, and electrical conductivity for all samples was found 54.81±5.12 mg/l, 19.49±1.17 mg/l, 250.4±13.87 mg/l, 323.717±65.99 us/cm respectively (Table 3).

Table 2: Physical characteristics of Household drinking water

Sr. No	Sample ID	Sample source	physical parameters				
			color	Temp.	odour	taste	turbidity
1	H-1	M/P	Colorless	15	Unobjectionable	Unobjectionable	0.79
2	H-2	M/P	Colorless	16	Unobjectionable	Unobjectionable	0.79
3	H-3	M/P	Colorless	17	Unobjectionable	Unobjectionable	0.67
4	H-4	M/P	Colorless	15	Unobjectionable	Unobjectionable	0.37
5	H-5	M/P	Colorless	15	Unobjectionable	Unobjectionable	0.93
6	H-6	M/P	Colorless	16	Unobjectionable	Unobjectionable	1.3
7	H-7	M/P	Colorless	18	Unobjectionable	Unobjectionable	0.91
8	F-1	F/P	Colorless	20	Unobjectionable	Unobjectionable	0.29
9	F-2	F/P	Colorless	16	Unobjectionable	Unobjectionable	0.87
10	F-3	F/P	Colorless	18	Unobjectionable	Unobjectionable	0.99
11	F-4	F/P	Colorless	18	Unobjectionable	Unobjectionable	0.18
12	F-5	F/P	Colorless	17	Unobjectionable	Unobjectionable	0.99
13	F-6	F/P	Colorless	16	Unobjectionable	Unobjectionable	0.57
14	F-7	F/p	Colorless	20	Unobjectionable	Unobjectionable	0.81

Microbiological Analysis:

Different methods were used for microbial analysis. Total coliform count, MPN, Direct platting and kit method was used. Detailed results are described below in tables and description.

Total coliform count

28.6% of the filtered water samples were contaminated with coliform as described in

Table 3: Chemical characteristics of household drinking water and water filtration plants

Sample no.	pH	TDS	Ca	HCO3	Mg	T.H	Cl2	Electroconductivity
	6.5-9.5	1000 mg/l	200 mg/l	-	150 mg/l	500 mg/l	600 mg/l	um/cm
F-1	7.7	230.4	55.95	235.2	17.9881	213.9	95	360
F-2	7.8	364.8	67	274.4	20.2298	251.5	115	570
F-3	7.5	390.4	78	284.2	15.6917	2660.4	115	570

F-4	7.7	460.8	78	303.8	20.2115	279	125	610
F-5	7.6	435.2	82	313.6	20.2055	288.3	120	720
F-6	7.8	288.4	67	235.2	15.71	232.5	95	680
F-7	7.4	230.4	52	225.4	17.9942	204.6	85	450
H-1	7.6	377.6	67.14	67.14	17.982	232.5	105	590
H-2	7.7	262.4	59.68	59.68	17.9638	232.5	105	410
H-3	7.6	332.8	70.87	70.87	13.4501	213.9	130	520
H-4	7.1	268.8	67.14	67.14	20.2176	195.3	115	420
H-5	7.2	339.2	339.2	63	13.4561	381.3	95	530
H-6	7.4	1113.6	1113.6	101	31.4746	213.9	155	1740
H-7	7.6	262.4	262.4	56	20.2541	251.5	105	410
H-8	7.8	268.8	268.8	52	20.2419	233.3	100	420
H-9	7.4	288	288	60	20.2298	232.5		450

(Table 4), whereas, 72.5% of the filtered water samples were contaminated with coliform bacteria. Highest number of coliform counts were obtained in sample ID H-7 was 6.as shown in (Table 4).

Table 4: Results of Total coliform count of household drinking water

Sr. No	Sample ID	Total coliform count
1	H-1	4 colonies
2	H-2	4 colonies
3	H-3	No colony
4	H-4	No colony
5	H-5	5 colonies
6	H-6	3 colonies
7	H-7	6 colonies

Table 5: Results of Total coliform count of filtered drinking water

Sr. No	Sample ID	Total coliform
1	F-1	No colony
2	F-2	No colony
3	F-3	No colony
4	F-4	No colony
5	F-5	1 colony
6	F-6	No colonies
7	F-7	1 colony

Most portable number counts

MPN was examined. F1, F2, H1 and H2 samples were subjected to this test. Maximum number of colonies were detected on 10-1 which was uncountable. In the last dilution there was no colony of any microorganism.

Table 6: MPN of filtered and household drinking water

Sample No	10^{-1} MPN no.	10^{-2} MPN no.	$10^{-3.}$ MPN.no	10^{-4} MPN.no	10^{-1} MPN.no
F1	15	6	3	2	0
F2	13	8	5	3	0
H1	TNTC	5	3	1	0
H2	9	4	3	2	1

3.4.3 Direct Plate count

In this method maximum colonies were observed in bottled water (Nestle) and least were in F2 samples. Boiling water was free of contamination as shown in (Table 7).

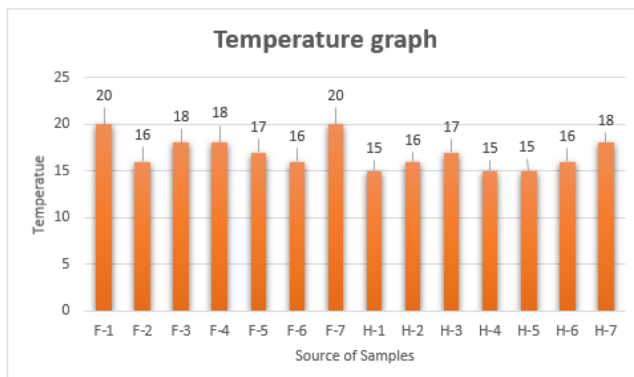

Figure 1: Temperature comparison of both sources**.**

3.5 kit method:

Two samples were subjected to this method for microbial quality testing. In which one turns yellow and one turns purple. This shows that the yellow colour is the indication of microbial contamination and purple colour means that water was free of bacteria as it is shown in Figure 1.

Table 7: Results of bottled household boiled and filtered water

Sample No.	50*u*	100*u*
H1	6	8
H2	10	15
F1	8	6
F2	3	5
B1(boiled water)	0	0
B2(Bottled water)	21	34

DISCUSSION

This study was carried out to determine the microbial quality of household and filtered water implanted by the municipal committee of Depalpur City. Boiling water and bottled water were also added to microbial analysis. For bottled water quality analysis, Nestle mineral water was used.

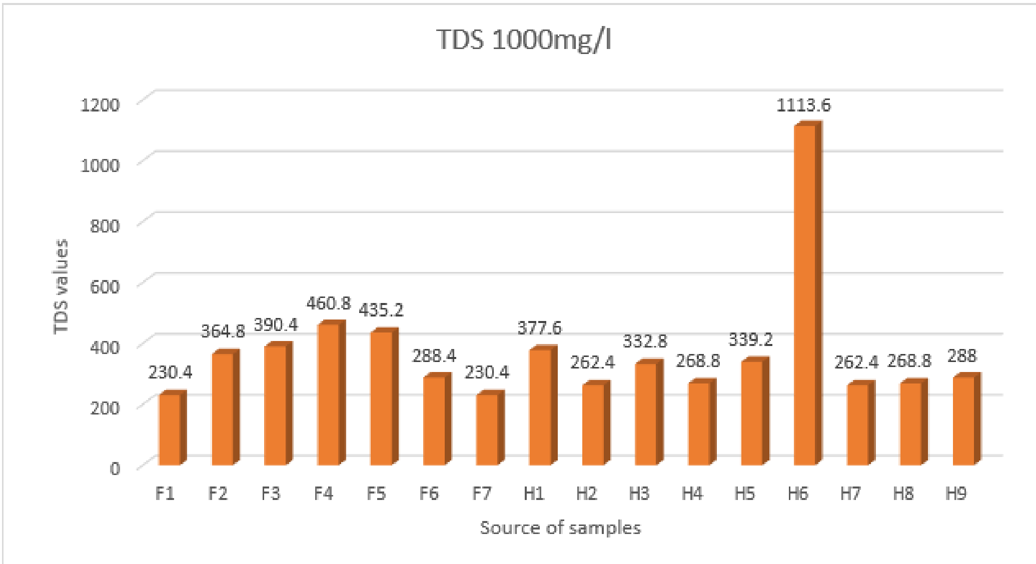

Figure 2: TDS comparison of household drinking water and filtered water

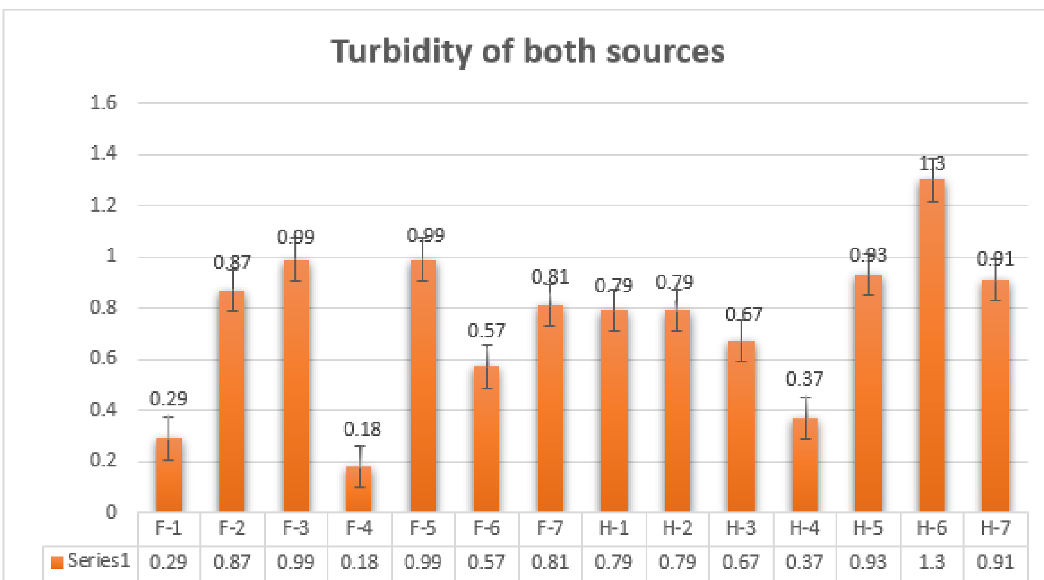

Figure 3: Turbidity comparison of household drinking water and filtered water

An estimated 30,000 people a day perished, many of them from illnesses brought on by a lack of hygienic conditions and clean water (Mokdad et al., 2018).

In this study, all the samples from filtration sources of water and household water were found acceptable taste, colourless water, and unobjectionable odour. Temperature of all water samples was normal as according to this study (REHMAN et al.) temperature generally varied from 16.8-22.1 with no discernible variations between the places (Figure 1).

In comparison pH was almost lower and equal to filtered water samples. Lowest pH observed in household H-4 sample was 7.1. All the samples were in reasonable range of pH. As organic matter decomposes in a body of water, carbon dioxide is created. When carbon dioxide and water interact, carbonic acid is the result. Additionally, when water flows over certain metals in the ground, such as calcium oxide and sodium carbonates, it lowers the pH of the surrounding water. These metals include aluminium, copper, and zinc. Although being a weak acid, carbonic acid lowers pH when applied in large amounts. Photoelectric activities result in the production of acidic oxides like SO2 and NOx, which readily dissolve in water to make it acidic. Moreover, chemical pollution reduces water's pH (Dirisu et al., 2016).

In this study comparative analysis showed minor differences in both sources. But household sample H-6 showed entire change value which is 1113.6. Moreover, filtration plants are somehow safe of chemical contamination (Figure 2). Results revealed that while most residential water samples were judged to be acceptable and within WHO's (1993) authorised limit, several had TDS and total hardness readings that were higher. The physicochemical quality of the water was determined using a number of parameters, and the majority of the samples were found to be suitable for drinking according to WHO standards. The aesthetic quality of drinking water may be influenced by temperature, PH, total hardness, magnesium ions, calcium ions, HCO3-, and chloride, among other variables. In similar fashion, chloride and general hardness in filter samples were discovered to be within WHO permitted levels (Kay et al., 2004).

Turbidity is a key indicator of a water's suitability for human consumption. The particles floating in murky water may contain a number of diseases. Moreover, excessive turbidity might harm various water treatment and utilization procedures in a number of ways. In this investigation, it was discovered that home samples had higher levels of turbidity than the WHO-acceptable norm, which is what causes neurological illness and other negative health effects in consumers. In both sources, the turbidity was within acceptable bounds (Figure 3).

In this study the filtered water samples found satisfactory in respect to microbial contamination, but the mostly household samples were contaminated as many colonies observed when sample incubated. Similar study was done and the majority of the water sources were determined to be suitable for drinking, with only 14.5% exceeding the WHO-recommended levels. The least contaminated water came from filtration facilities out of all the sources (Platts-Mills et al., 2015).

Conclusion:

Further research and development of water treatment technologies are needed to address the microbiological contamination of household drinking water and give access to safe and clean water for all populations. Ultimately, improving public health and reducing the risk of developing waterborne illnesses require ensuring that everyone has access to clean water. The local community and government should pay more attention to the presentation and maintenance of water supplies in rural regions. The public should be informed about sanitary procedures and the preservation of a clean environment in rural regions by the government and pertinent organizations. The improvement of municipal water supply and community health activities should have a political commitment at the federal level.

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Conflict of Interest

Authors declare no conflict of interests.

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