DOI: https://doi.org/10.70749/ijbr.v3i2.673

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://induspublishers.com/IJBR
ISSN: 2960-2793/ 2960-2807

Exploring the Status and Health Risks of Microbial Contamination in Sarband's Drinking Water, Peshawar

Furqan Khan[1], Mohammad Nafees[1], Syed Asimullah[1], Sikandar Hayat[1], Junaid Afridi[1]

[1]Department of Environmental Sciences, University of Peshawar, KP, Pakistan.

ARTICLE INFO

Keywords
Microbial Contamination, Drinking Water, E. Coli, Health Risks, Sarband, Peshawar, Waterborne Diseases.

Corresponding Author: Mohammad Nafees,
Department of Environmental Sciences, University of Peshawar, KP, Pakistan.
Email: nafees@uop.edu.pk

Declaration
Authors' Contribution: All authors equally contributed to the study and approved the final manuscript.
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History
Received: 17-10-2024
Revised: 12-01-2025
Accepted: 08-02-2025

ABSTRACT

To sustain life, we need drinking water that is free of contamination by impurities or microorganisms that could be harmful. This study aimed to assess water accessibility in Union Council Sarband Peshawar, testing samples from a tube well and borehole at source, tap, and storage tanks. The physical, chemical, and biological parameters of these materials were investigated after they were collected. Procedures approved by the American Public Health Association (APHA) were utilized in the analysis of the water samples. The results indicated that the physical and chemical parameters were within the permissible range specified by the limits established by the National Environmental Quality Standards (NEQS) for drinking water. pH ranges from 6.8 to 7.5, EC ranges from712 uS/cm to 863uS/cm, TDS ranges from 353 mg/L to 434 mg/l, Total hardness ranges from 200 mg/L to 390 mg/L, Alkalinity ranges from 170 mg/L to 310 mg/L, Turbidity ranges from1.2 NTU to 2.9 NTU, Chloride ranges from 32 mg/L to 61 mg/L, Nitrate ranges from7 mg/L while lowest is 2 mg/L. The measured values of the biological parameters were found to be excessively high. The range for total coliform is between 1 and 52 CFU per 100 ml, and the range for fecal coliform is between 1 and 25 CFU per 100 ml. The levels of microbial contamination were found to be higher at the end user and the storage tanks. The prevalence of coliform bacteria in the collected samples, including fecal coliforms, serves as a definitive indication of the presence of contamination originating from human and animal excrement. Urgent action is needed to improve distribution efficiency, maintain storage cleanliness, fix leaks, prevent pollution, and ensure safe drinking water for human health within the Union Council Sarband Peshawar.

INTRODUCTION

Water occurs on earth in three forms viz solid, liquid, and gaseous. Water is vital for humans, animals, and plant life. It is a part of all organisms, some of which contain more than 92 percent [1].Water is an essential part of protoplasm. It is an important ingredient in photosynthesis. In India, 163 Million Indians lack access to safe drinking water, 21% of communicable diseases are linked to unsafe water, and 500 children under the age of five die from diarrhea each day in India [2]. The water right has several dimensions. The quantity of water must be, at a minimum, sufficient to meet basic needs, in terms of drinking, bathing, cleaning, cooking, and sanitation [3]. The quality of the water must be safe and free from contamination. Though the quality of water can vary with its use, water should never contain anything that could pose a health threat. In world scenario is more or less same, more than one out of six people lack access to safe drinking water; 3900 children die every day from waterborne diseases [4]. An adequate supply of fresh and clean drinking water is a basic need for all human beings on the earth, yet it has been observed that millions of people worldwide are deprived of this. Freshwater resources all over the world are threatened not only by overexploitation and poor management but also by ecological degradation [5].The daily drinking water requirement per person is 2-4 liters, but it takes 2000 to 5000 liters of water to produce one person's daily food [6]. Water is essential for human life, yet only 0.3% of global water resources are suitable for human use, while 97% of the water is saline, and glaciers account for the remaining 2.97%. Access to clean drinking water is a fundamental human right and is integral to the Sustainable Development Goals (SDGs) [7]. However, in Pakistan, water quality issues persist due to bacterial and chemical contamination, leading to significant health concerns [8]. Poor sanitation and industrialization contribute to this problem, exacerbating the spread of waterborne diseases [9]. Microbiological contamination, particularly from fecal matter, is a critical issue affecting human health. Contaminated water has been linked to illnesses such as diarrhea, typhoid, and gastroenteritis, particularly in vulnerable populations [10]. The presence of bacterial pathogens in drinking water underscores the need for improved sanitation, better waste management, and awareness campaigns to combat the spread of waterborne diseases [11].The global burden of waterborne diseases is significant, with an estimated 250 million cases annually, resulting in over 25 million deaths [12,13]. Pathogenic contamination of drinking water by viruses, bacteria, and protozoa poses severe health risks. Pakistan faces severe drinking water challenges, with a significant portion of the population lacking access to safe water. Contamination from sewage, industrial effluents, and agricultural runoff is widespread, leading to increased disease prevalence [14, 15].Waterborne diseases, including cholera, typhoid, and dysentery, contribute to high morbidity and mortality rates globally. In Pakistan, the situation is particularly alarming, with inadequate water treatment infrastructure exacerbating health risks [16].Poor hygiene practices and insufficient water quality monitoring further worsen the situation. In Khyber Pakhtunkhwa and Peshawar, water sources are heavily contaminated with microbial pathogens, including total coliform and fecal coliform bacteria [17]. This contamination arises due to poor sanitation infrastructure, leaking pipelines, and improper waste disposal practices. Several studies indicate that microbiological contamination in Peshawar's drinking water exceeds safe limits, necessitating urgent intervention [18]. The research aims to address the critical issue of microbial contamination in the drinking water of Union Council Sarband, Peshawar. The presence of harmful bacteria in drinking water sources poses a severe health threat to residents. The study aims to assess microbial contamination in drinking water sources, identify sources of contamination and contributing factors, evaluate the effectiveness of current water treatment and supply systems, and recommend measures to improve water quality. The research focuses on Union Council Sarband in Peshawar, an area facing significant water quality challenges. Drinking water in Union Council Sarband is primarily sourced from bore wells, tube wells, and surface water bodies. Recharge sources include precipitation and the Sarband Canal, which also supports irrigation. However, contamination from agricultural runoff and improper waste disposal significantly degrades water quality. Existing studies on water contamination in Pakistan lack specific data on Union Council Sarband, Peshawar. Most research provides general assessments without analyzing local contamination sources, infrastructure deficiencies, or seasonal variations. There is limited focus on the impact of storage, distribution systems, and public awareness. Additionally, the effectiveness of water quality regulations in small communities remains underexplored. This study aims to fill these gaps by assessing microbial contamination, identifying sources, and evaluating health risks. It will provide practical recommendations for improving water quality and management in the area.

MATERIALS AND METHODS

Water Sample Collection and Preservation

Water samples were collected from Union Council Sarband, Peshawar, using a simple random sampling technique. A total of 36 samples were taken from different points, including the source (tube well and borehole), end users (tap water), and storage tanks. GPS coordinates were used to record sample locations precisely. The samples were collected in sterilized 100 ml bottles following WHO guidelines. Before collection, taps were flamed and allowed to run for several minutes to remove contaminants. Samples were then transported to the laboratory in a cooler at 10°C and analyzed on the same day.

Laboratory Analysis

The collected water samples were analyzed at the Department of Environmental Sciences, University of Peshawar. Various physical, chemical, and biological parameters were tested using standard APHA (2012) methods. Physical parameters included pH, electrical conductivity (EC), and total dissolved solids (TDS). Chemical parameters such as turbidity, chloride, nitrate, alkalinity, and total hardness were evaluated, while biological tests focused on detecting fecal coliform and total coliform bacteria.

Table 1

Water Quality Parameters and their method for analysis

S.No.	Parameters	Analysis Method	Method No
1	pH	pH meter	Model E-1 portable
2	Total dissolved solids	Gravimetric Methods	Method No. 2540.C
3	Electrical Conductivity (EC)	Conductivity Meter	Method No.2510.B
4	Turbidity	Nephelometric	Method No. 2130. B
5	Chloride (Cl^{-})	Argentometric	Method No.4500. Cl^{-} (APHA 2012)
6	Nitrate (NO_3)	Phenol Disulfonic Method	Hora, & Webber, (1960).
7	Alkalinity (as M & P)	Titration Method	Method No.2320.B
8	Total Hardness	EDTA Titrimetric	Method No.2340.C

			(APHA 2012)
9	Total coliform	Membrane Filtration	Method No. 9222B (APHA 2012)
10	Fecal coliform	Membrane Filtration	Method No. 9222D (APHA 2012)

Reference: APHA 2012

Microbiological Analysis Using Membrane Filtration Method

Total coliform and fecal coliform bacteria were assessed using the Membrane Filtration Method (APHA 2012, Methods No. 9222B and 9222D). A 0.45-micron membrane filter was used to trap bacteria from a known volume of water. The filter was then placed onto selective agar media and incubated at 37°C for 24 hours. Lauryl Sulfate Broth was used as a selective enrichment medium to restrict the growth of non-coliform bacteria.

Chemical Analysis

- ***pH Measurement***: A digital pH meter (model PHH222) was used to measure pH. Calibration was performed with standard buffer solutions of pH 4, 7, and 10 before testing.
- ***Electrical Conductivity (EC)***: Measured using an AZ8301 conductivity meter, calibrated with 0.01M KCl solution (1412 µS/cm). An AZ8301 conductivity meter was used to measure the conductivity of water samples in the laboratory. The instruments were rinsed with distilled water before use. Samples were collected in 100 ml beakers, ensuring full submersion of the electrode. The meter was set to conductivity mode, and readings were recorded. The electrode was washed with distilled water before each measurement, following a uniform procedure for all samples.
- ***Turbidity***: Determined using a Nephelometric Turbidity Meter (AQUA Fast-II) by comparing samples to known standards. Total hardness was determined using the EDTA Titrimetric Method (APHA, 2012). EDTA solution (0.01 M) was prepared by dissolving 3.7224g EDTA in 1000 ml distilled water. A buffer inhibitor was made by mixing HCl, 2-aminoethanol, and magnesium salt of EDTA. Eriochrome Black T indicator was prepared by dissolving 0.5g dye in triethanolamine. Hardness solutions (100 mg/L & 250 mg/L) were prepared by diluting 1000 mg/L Ca and Mg CRM solutions with distilled water.
- ***Total Hardness***: Measured by the EDTA Titrimetric Method (APHA 2012, Method No. 2340.C).
- ***Chloride Content***: Determined using the Argentometric Method (APHA 2012, Method No. 4500 Cl-).A 0.0141 N silver nitrate solution was prepared by dissolving 2.3987g $AgNO_3$ in 1000ml distilled water and standardized with 0.0141N sodium chloride. The 0.0141N sodium chloride solution was prepared by dissolving 0.8281g NaCl (dried at 140°C) in 1000ml distilled water.
- ***Nitrate Concentration***: Measured using the Phenol Disulfonic Acid Method. Samples were treated with phenol sulfonic acid and NaOH and compared against standard nitrate solutions. A 1:1 NaOH solution was prepared by dissolving 50g of NaOH in 50ml distilled water. A 1000 mg/L sodium nitrate ($NaNO_3$) stock solution was made by dissolving 1370 mg $NaNO_3$ in 1000 ml distilled water, with further processing using phenol disulphonic acid and NaOH until a yellow color appeared. Other standard $NaNO_3$ solutions were prepared via dilution. In the analysis, 50ml of the sample was evaporated, dissolved with phenol disulphonic acid, neutralized with NaOH, diluted to 50ml, and compared with standards for measurement.

Sterilization and Quality Control

Membrane filtration sterilization involved autoclaving membrane filtering components at 121°C after wrapping them in aluminum foil. Membrane filters were UV-sterilized in a laminar flow hood for 15–20 minutes. Before and after each sample, 70% ethanol, 90% ethanol, and distilled water were used for cleaning. Sterile forceps were used to place sterile filter paper on the porous plate of the filtration unit. The funnel unit was carefully locked in place, and filtration was performed under partial vacuum. Filtration units were sterilized at the start of each series, and plates were incubated inverted at 37°C for 24 hours.

Questionnaire Survey

A survey was conducted among residents of Union Council Sarband to assess the prevalence of waterborne diseases. A structured questionnaire with 20 standardized questions was used to collect data on water usage, treatment methods, and disease incidence. A total of 68 respondents participated in the survey. This methodology ensures a comprehensive assessment of water quality by integrating microbiological, chemical, and physical analyses, along with community feedback through surveys.

Sample Size

The questionnaire sample size will be based on a 90% confidence level, a margin of error of 10%, and a population proportion of 50%. The sample size of the questionnaire was 68. The formula was applied to calculate the sample size.

$$N = \frac{Z^2 * (S.D) * (1 - S.D)}{C^2}$$

Where N is sample size, Z is confidence level, S.D is standard deviation and C is margin error (Olowe, B. et al, 2016).

RESULTS AND DISCUSSION

PH

The pH is defined as the negative logarithm of the hydrogen ion concentration. It is used to indicate whether the solution is acidic or basic. The pH scale ranges from 0 to 14, representing a continuum from highly acidic to highly basic. Water that has a greater abundance of free hydrogen ions is characterized as acidic, whereas water that contains a higher quantity of free hydroxyl ions is considered basic. (Islam et al 2017). The pH range of the tested sample was observed to be between 6.8 and 7.5, as shown in Table (4.1). As per the Drinking Water quality guideline, the acceptable pH range is determined to be between 6.5 and 8.5. The pH levels of all the samples that were analyzed fall within the acceptable range set by the Pakistan Environmental Protection Agency (Pak- EPA). The pH values at the source, end user, and storage locations are shown in Figure (3.1) showing the lowest and highest values.

Figure 3.1

pH results of measured samples

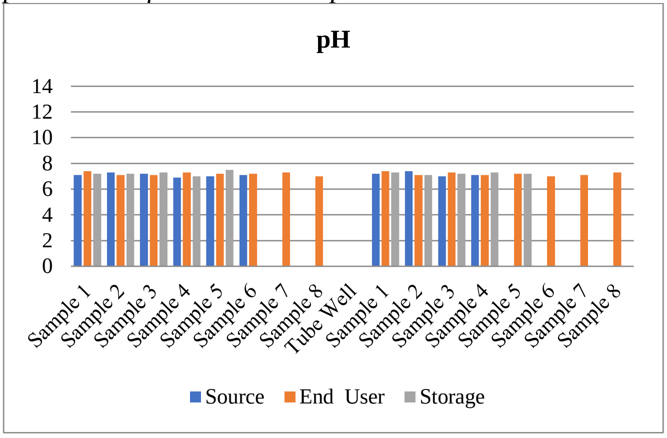


Diagram 3.1 illustrates the **pH values** of the measured water samples at different stages, including the **source, end user, and storage locations**. The pH range observed in the study varied between **6.8 and 7.5**, which falls within the **acceptable limit of 6.5 to 8.5** set by the **Pakistan Environmental Protection Agency (Pak-EPA)**. This highlights the lowest and highest pH values recorded at various points in the water distribution system. The results indicate that the water remains **neutral to slightly basic**, ensuring its suitability for consumption. However, minor fluctuations in pH across different locations suggest potential influences from **water storage conditions, pipeline materials, and external environmental factors**. This serves as an important visual representation of water quality stability and helps in assessing potential risks associated with **pH imbalances** in the region

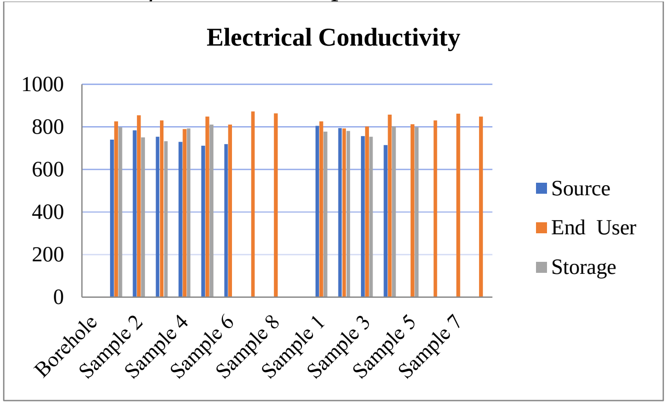
In a study conducted by Bacha et al. (2010), an investigation was carried out in the region of Peshawar to analyze the physical and biological properties of samples obtained from this area. The pH values of the collected samples ranged from 7.0 to 7.85, which fell within the acceptable range which is from 6.5 to 8.5 as recommended by the World Health Organization (WHO) (Bacha et al., 2010). Yousaf et al. (2019) conducted a study in Peshawar. Samples were collected from both the source and consuming sites. The collected pH values of the samples were within the range of 6.9 to 7.6, which is within the acceptable limit of 6.5 to 8.5 specified by the World Health Organization (WHO) (Yousaf et al., 2019). Khan et al. (2020) conducted a study in Peshawar. The result of the study shows that pH ranges from 6 to 8.2. The results of the study were found in a permissible limit of 6.5 to 8.5 according to the World Health Organization (WHO) (Khan et al., 2020). The pH values found during these studies show the stability and safety of the drinking water supply in the Peshawar region. In summary, the result of my study compared with past research, indicates that the pH levels observed in the study area, as well as those reported in earlier studies, always fall into the acceptable range as established by the World Health Organization (WHO) guidelines.

Electrical Conductivity (EC)

Electrical conductivity measures water's ability to transmit electrical current and is expressed in micro-Siemens per centimeter (µS/cm). It is directly related to ion concentration in a solution. The analyzed samples had a conductivity range of 712–863 µS/cm, all within the permissible limit of <1000 µS/cm. Figure 4.2 presents EC values at the source, end user, and storage locations, highlighting minimum and maximum readings.

Figure 3. 1

EC results of measured samples



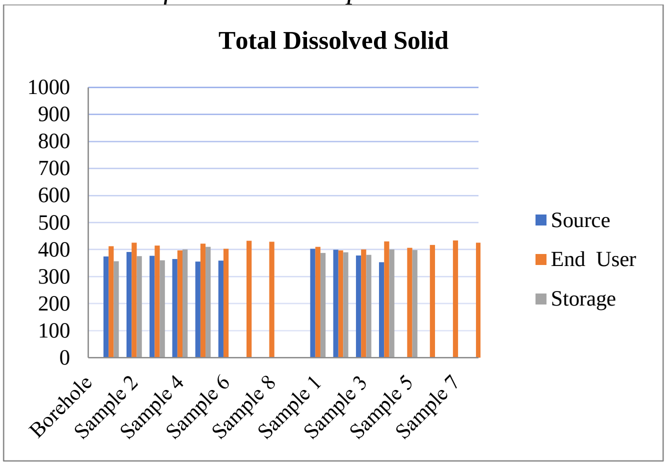
Yousaf et al. (2019) conducted a study in Peshawar. Samples were collected from both the source and consuming sites. The electrical conductivity (EC) value ranges from 630 to 920 µS/cm. The results of the tested samples were within acceptable parameters of 1400 µS/cm as recommended by World Health Organization (WHO). There is an absence of data showing any detrimental impact on the residents of Peshawar (Yousaf et al., 2019). In Peshawar, a study was carried out by Khan et al. (2020). The results indicate that the electrical Conductivity (EC) fall within the acceptable limits of 1400 µS/cm established by the World Health Organization (WHO). The electrical conductivity (EC) values observed in the drinking water samples ranged from 387 to 1320 µS/Cm. A higher electrical conductivity (EC) value is indicative of the presence of a significant concentration of dissolved inorganic compounds (Khan et al., 2020). While conducting a comparative analysis between the results of my research and the studies conducted by Yousaf et al. (2019) and Khan et al. (2020), The electrical conductivity (EC) values observed in all of these studies are although showing minor variations did not exceed the established limit of 1400 µS/cm as defined by the World Health Organization (WHO). In summary, the present study examined the electrical conductivity (EC) of water within the area of study and determined that the EC measurements fell within the acceptable range established by the World Health Organization (WHO).

Total Dissolved Solid (TDS)

Total dissolved solids (TDS) measure the concentration of dissolved salts in water, primarily composed of inorganic salts with some organic molecules. Key contributing ions include sodium, potassium, calcium, and magnesium compounds. The tested samples showed TDS values ranging from 353–434 mg/L, all within the permissible limit of <1000 mg/L set by Pak-EPA. Figure 3.3 presents TDS values at the source, end user, and storage locations, highlighting minimum and maximum readings.

Figure 3. 2

TDS results of measured samples



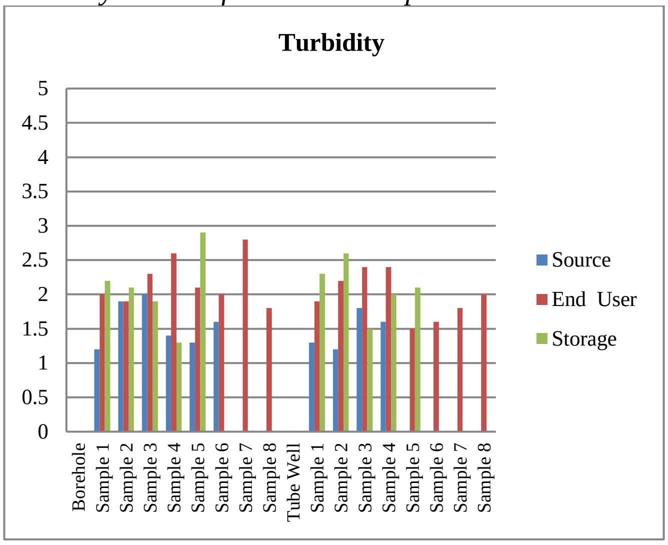
A study assessed the chemical composition of drinking water in urban Peshawar, Pakistan, revealing that all tested parameters were within WHO's permissible limits (<100 mg/L). TDS concentrations ranged from 450–480 mg/L (Iftikhar et al., 2016), 371–680 mg/L (Yousaf et al., 2019), and 232–688 mg/L (Khan et al., 2020), all below WHO's safe limit of <1000 mg/L. Comparisons with these studies indicate a consistent pattern of TDS levels remaining within the recommended standards set by WHO and Pak-EPA.

Turbidity

Turbidity measures water clarity by assessing light dispersion caused by suspended particles. It results from clay, silt, organic and inorganic particles, algae, and microorganisms (Bhardwaj et al., 2023). The tested samples showed turbidity levels ranging from 1.2 to 2.9 NTU, all within the Pak-EPA limit of <5 NTU. Figure 3.4 presents turbidity values at the source, end user, and storage locations, highlighting minimum and maximum readings.

Figure 3.4

Turbidity results of measured samples



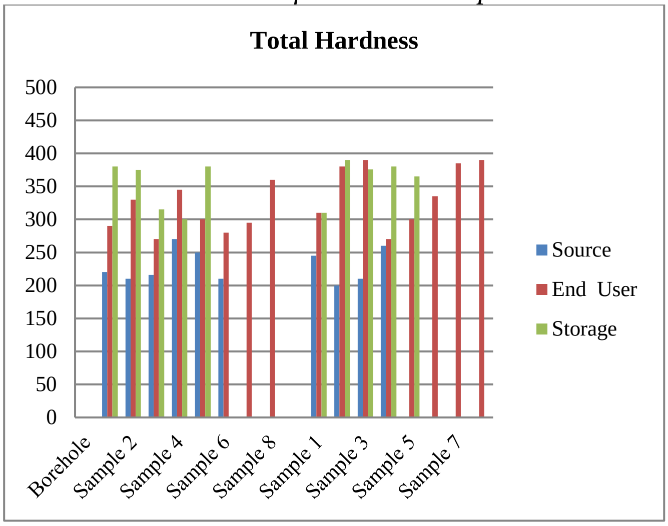
In Peshawar, a study was conducted by Khan et al. (2020). The results show that the physiochemical parameters were within the acceptable range as defined by the World Health Organization (WHO). The turbidity value was less than 5 NTU (Khan et al., 2020). A study was conducted by Khan et al. (2018) in Peshawar. The results of the study reveal that the observed Turbidity levels varied between 0.3 to 2.57 NTU, a range that is within the safe threshold of <5NTU set by the World Health Organization (WHO) (Khan et al., 2018). The present study's examination of turbidity results, when in comparison with the results of Khan et al. (2020) and Khan et al. (2018), provides a conclusion that the water quality in Peshawar frequently meets international criteria in regard to turbidity levels. In each of the previous studies, the measured turbidity levels were found to be significantly lower than the required threshold of <5 NTU as established by the World Health Organization (WHO) and the Pakistan Environmental Protection Agency (Pak- EPA).

Total Hardness

Water hardness is caused by multivalent metallic cations, primarily calcium and magnesium. It is classified into carbonate and noncarbonate hardness and measured by the concentration of these cations. Water is considered mild below 50 mg/L, moderately hard between 50–150 mg/L, and very hard above 300 mg/L (Akram & Rehman, 2018). The tested samples showed hardness levels ranging from 200–390 mg/L, all within Pak-EPA's acceptable limits. Figure 3.5 presents hardness values at the source, end user, and storage locations, highlighting minimum and maximum readings.

Figure 3. 5

Total Hardness results of measured samples



Khan et al. (2018) conducted a study in Peshawar. The study results indicate that the Total Hardness levels recorded ranged from 246 to 278 mg/L, a range that is within the safe limit <500 established by Pakistan Standard Quality Control Authority (PSQCA) (Khan et al., 2018). REHMAN & Khan (2011) carried out study in Peshawar. The results of Total hardness were range from 126 mg/L to 458 mg/L which is within the permissible limit of <500 mg/L as established by World Health Organization (WHO) (REHMAN & Khan, 2011). In conclusion results of total hardness when compared to previous studies by Khan et al. (2018) and REHMAN & Khan (2011), shows that the Total Hardness levels in my study and those of the previous studies all fall within the permissible limits recommended by the WHO and Pakistan Standard Quality Control Authority (PSQCA).

Alkalinity

Water alkalinity refers to its ability to neutralize acids, mainly due to carbonates, bicarbonates, and hydroxide ions (Addy et al., 2004). High alkalinity can result in an intense, unpleasant taste. The tested samples showed alkalinity levels ranging from 170–310 mg/L, with no specific limit set by Pak-EPA. Figure 3.6 presents alkalinity values at the source, end user, and storage locations, highlighting minimum and maximum readings.

Figure 3. 3

Alkalinity results of measured samples

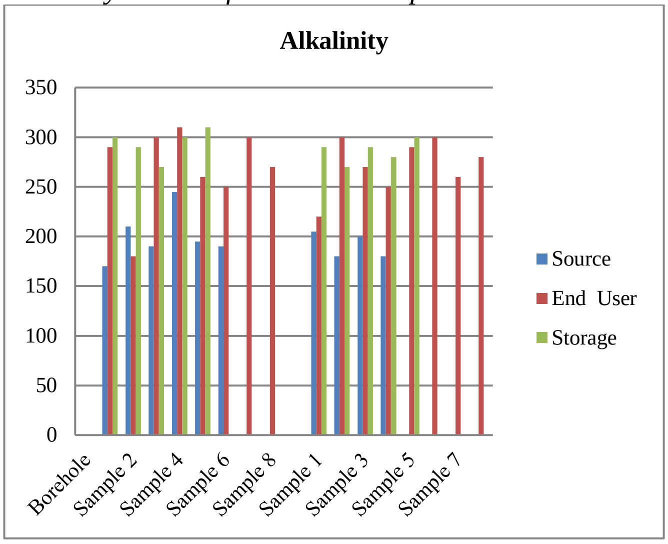


Figure 3.6 presents the alkalinity values of water samples collected from different locations, including the source (boreholes and tube wells), end users (tap water), and storage points. Alkalinity, which represents water's ability to neutralize acids, is primarily influenced by the presence of carbonates, bicarbonates, and hydroxides. The results indicate that the alkalinity levels in the tested samples ranged from 170 mg/L to 310 mg/L.The figure highlights variations in alkalinity across different sampling points, with storage tanks generally showing slightly higher values, possibly due to prolonged contact with container materials or sedimentation effects. There is no specific limit for alkalinity set by the Pakistan Environmental Protection Agency (Pak-EPA); however, all recorded values fall well below the World Health Organization (WHO) guideline of 500 mg/L, indicating that the water is safe from excessive alkalinity concerns. Comparative analysis with previous studies, such as those conducted by Khan et al. (2018) and Yousaf et al. (2019), reveals that the alkalinity values in this study are consistent with historical findings in the Peshawar region. These studies reported alkalinity ranges of 75–280 mg/L and 160–380 mg/L, respectively, further confirming that the measured values remain within acceptable limits. The findings suggest that the water quality in Union Council Sarband, concerning alkalinity, does not pose a significant health risk but should still be monitored for any fluctuations over time.

Chloride

Chloride is present in natural water in the form of salts of sodium, calcium, and magnesium. Chlorides are chemical compounds composed of chlorine and another element. Chloride is produced through a chemical reaction between chlorine and a metal. Chlorides are present in groundwater as a result of infiltration from both naturally occurring and caused by humans' sources.

Figure 3.4

Chloride results of measured samples

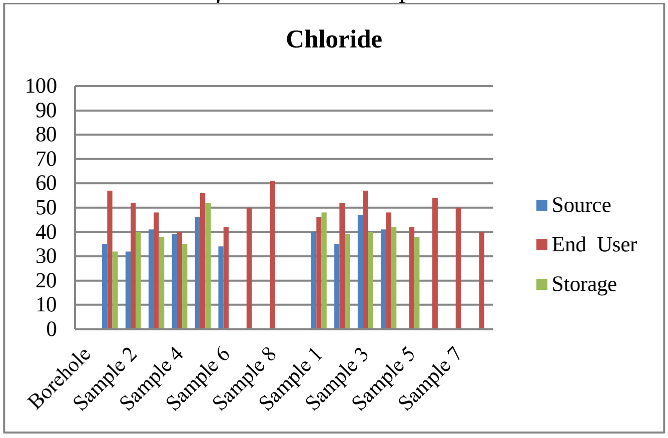


Figure 3.7 illustrates the chloride concentrations measured in water samples from various locations, including source water (boreholes and tube wells), end-user points (tap water), and storage tanks. The chloride levels in the tested samples ranged from 32 mg/L to 61 mg/L, all within the permissible limit of <250 mg/L set by the Pakistan Environmental Protection Agency (Pak-EPA).Chloride is an essential component of water, often originating from natural sources such as the dissolution of chloride-bearing minerals and human activities like sewage infiltration, industrial discharge, and agricultural runoff. The figure highlights minor variations in chloride levels across different sampling points, with slightly elevated concentrations in storage tanks, possibly due to evaporation and accumulation of dissolved salts.Comparative analysis with previous studies conducted in Peshawar, such as those by Khan et al. (2018) and Rehman & Khan (2011), indicates that the observed chloride levels align with earlier findings, which reported chloride concentrations between 21 mg/L and 98 mg/L. These results confirm that the drinking water in Union Council Sarband is safe regarding chloride contamination. However, continued monitoring is essential to prevent potential increases in chloride levels due to anthropogenic activities.

Nitrate

Nitrate (NO_3), a natural element of water, serves as the primary reservoir of nitrogen (N). It constitutes an essential component of all biological entities. Nitrate poses no significant concern at typical concentrations; nevertheless, elevated quantities of nitrate in water can potentially pose a health hazard to human beings. Human activities contribute to the presence of excessive nitrate in water through various sources, including the application of fertilizers, the utilization of on-site sewage systems such as septic tanks and lagoons, the discharge of treated wastewater, the release of animal wastes, the disposal of industrial wastes, and the production of food processing byproducts (Daniels & Mesner 2010).

Figure 3. 5

Nitrate results of measured samples

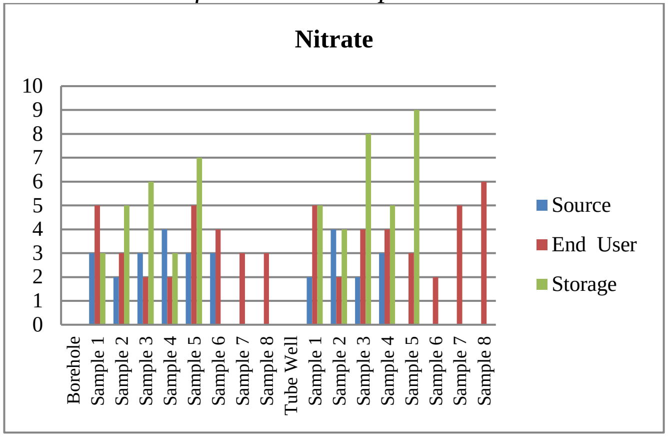


Figure 3.8 represents the nitrate concentration levels measured in water samples collected from different locations, including the source, end user, and storage points. The results indicate that nitrate levels ranged from **2 mg/L to 7 mg/L**, which falls well within the safe drinking water limit of **50 mg/L** set by the Pakistan Environmental Protection Agency (Pak-EPA). Nitrate is an essential nitrogen reservoir in water; however, excessive concentrations can pose health risks, particularly for infants, leading to methemoglobinemia (blue baby syndrome). Compared to previous studies conducted in Peshawar by Khan et al. (2018) and Khan et al. (2016), where nitrate levels ranged from **5.7 to 9.8 mg/L** and **8.38 to 22.49 mg/L**, respectively, the findings from this study indicate that nitrate contamination in Union Council Sarband remains minimal and does not pose an immediate health hazard. The variation in nitrate levels among different sampling points suggests possible influences from local environmental factors such as agricultural runoff, sewage infiltration, or groundwater composition.

Fecal Coliform

Fecal coliform bacteria represent a specific subset of coliform bacteria. They are present in high quantities within the gastrointestinal tract and excrement of both humans and animals.

Figure 3.9

FC results of measured samples

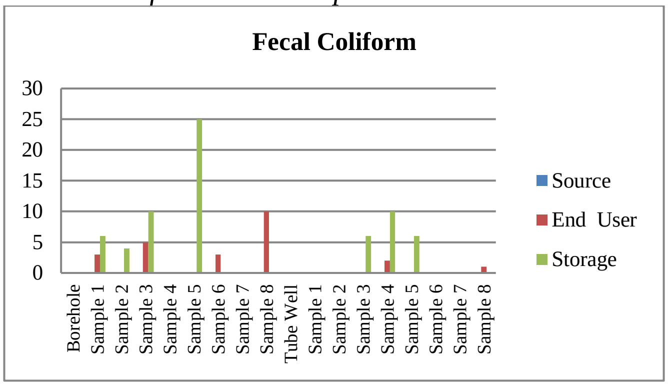


Figure 3.9 illustrates the fecal coliform (FC) contamination levels in the measured water samples from various locations, including the source, end user, and storage points. Fecal coliforms are a subset of coliform bacteria found in human and animal intestines, serving as key indicators of fecal contamination in drinking water. The results indicate that all analyzed samples exceeded the **Pak-EPA permissible limit** of **"must not be detected in 100ml"**, confirming contamination. The fecal coliform concentration ranged from **1 CFU/100ml to 25 CFU/100ml**, signaling potential health hazards. Comparative studies in Peshawar have also highlighted frequent fecal coliform contamination. Ahmad et al. (2013) found that **70% of water samples** in rural Peshawar exceeded WHO's safe limits for total fecal coliform bacteria (TFCB). Similarly, Khan et al. (2013) reported that **20% of tested samples** contained fecal coliforms, while a later study (Khan et al., 2020) identified **34% contamination** in urban Peshawar. Consistent fecal coliform detection in drinking water indicates significant sewage infiltration, posing serious public health concerns. The study underscores the urgent need for improved water treatment, regular monitoring, and source protection measures to ensure water safety.

Table 3. 1

Results of Physical Parameters

Bore hole Source				Tube Well Source			
Sample Code	pH	EC	TDS	Sample Code	pH	EC	TDS
Sample 1 Source	7.1	740	374	Sample 1 Source	7.2	804	403
Sample 2 Source	7.3	783	391	Sample 2 Source	7.4	794	399
Sample 3 Source	7.2	754	377	Sample 3 Source	7.0	756	378
Sample 4 Source	6.9	729	365	Sample 4 Source	7.1	714	353
Sample 5 Source	7.0	712	356				
Sample 6 Source	7.1	719	359				
Borehole End User (Tap)				**Tube well (Tap)**			
Sample 1 End user	7.4	826	412	Sample 1 End user	7.4	825	410
Sample 2 End user	7.1	854	425	Sample 2 End user	7.1	793	397
Sample 3 End user	7.1	830	415	Sample 3 End user	7.3	801	400
Sample 4 End user	7.3	790	397	Sample 4 End user	7.1	858	430
Sample 5 End user	7.2	849	422	Sample 5 End user	7.2	812	406
Sample 6 End user	7.2	810	403	Sample 6 End user	7.0	831	417
Sample 7 End user	7.3	872	433	Sample 7 End user	7.1	862	434
Sample 8 End user	7.0	863	429	Sample 8 End user	7.3	848	425
Borehole Storage				**Tube Well Storage**			
Sample 1 Storage	7.2	798	357	Sample 1 Storage	7.3	777	388
Sample 2 Storage	7.2	750	376	Sample 2 Storage	7.1	780	390
Sample 3 Storage	7.3	733	360	Sample 3 Storage	7.2	754	380
Sample 4 Storage	7.0	792	401	Sample 4 Storage	7.3	802	401
Sample 5 Storage	7.5	811	410	Sample 5 Storage	7.2	798	398

Table 3.1 presents the results of the physical parameters of the collected water samples, including **pH, electrical conductivity (EC), and total dissolved solids (TDS)**. The pH values ranged from **6.9 to 7.5**, which falls within the **acceptable range of 6.5 to 8.5** set by the **Pakistan Environmental Protection Agency (Pak-EPA)**, indicating that the water is neutral to slightly basic and suitable for consumption. Electrical conductivity (EC) values varied between **712 µS/cm and 872 µS/cm**, suggesting the presence of dissolved ions but remaining within the permissible limit of **<1000 µS/cm**, which signifies moderate mineral content in the water. Additionally, the total dissolved solids (TDS) concentrations ranged from **353 mg/L to 434 mg/L**, staying well below the **1000 mg/L** threshold, ensuring the water's palatability and suitability for use. The findings indicate that the physical characteristics of the water samples meet the required standards, though variations in these parameters across different sampling points suggest potential influences from geological formations and human activities.

Table 3. 2

Results of Biological Parameters

Borehole Source			Tube Well Source		
Sample Code	Total Coliform	Fecal Coliform	Sample Code	Total Coliform	Fecal Coliform
Sample 1	0	0	Sample 1	0	0
Sample 2	0	0	Sample 2	0	0
Sample 3	0	0	Sample 3	0	0
Sample 4	0	0	Sample 4	0	0
Sample 5	0	0			
Sample 6	0	0			
Borehole End User			**Tube Well End User**		

Sample Code	Total Coliform	Fecal Coliform	Sample Code	Total Coliform	Fecal Coliform
Sample 1	03	03	Sample 1	00	00
Sample 2	01	0	Sample 2	07	00
Sample 3	11	5	Sample 3	25	00
Sample 4	7	0	Sample 4	18	02
Sample 5	6	0	Sample 5	22	00
Sample 6	04	03	Sample 6	09	00
Sample 7	01	0	Sample 7	00	00
Sample 8	02	10	Sample 8	03	01
Bore hole Storage			**Tube Well Storage**		
Sample Code	Total Coliform	Fecal Coliform	Sample Code	Total Coliform	Fecal Coliform
Sample 1	09	06	Sample 1	00	00
Sample 2	07	04	Sample 2	1	0
Sample 3	04	10	Sample 3	09	06
Sample 4	23	00	Sample 4	02	10
Sample 5	52	25	Sample 5	18	06

Table 3.2 presents the results of the biological parameters of the collected water samples, focusing on the presence of **total coliform (TC) and fecal coliform (FC)**. The analysis was conducted across different sampling points, including **borehole and tube well sources, end-user taps, and storage locations**. The results indicate that while **no coliform contamination** was detected at the **borehole and tube well sources**, significant contamination was observed at **end-user and storage points**. At the **borehole and tube well end-user taps, total coliform levels ranged from 1 to 25 CFU/100ml**, while fecal coliform levels reached a maximum of **5 CFU/100ml** in borehole samples and **2 CFU/100ml** in tube well samples. Contamination levels were even higher in **storage tanks**, with total coliform counts peaking at **52 CFU/100ml**, and fecal coliform reaching **25 CFU/100ml**. These values **exceed the Pak-EPA standard**, which states that **coliform bacteria should not be detectable in any 100ml sample**. The findings highlight the likelihood of bacterial regrowth and secondary contamination occurring within the **distribution system and storage facilities**, possibly due to **poor hygiene practices, cross-contamination from sewage sources, or improper water storage conditions**. The study underscores the need for **regular disinfection, improved water treatment methods, and better sanitation practices** to prevent microbial contamination and ensure safe drinking water.

Table 3.3

Standard for Drinking Water Quality

S.No	Parameter	Pak EPA	WHO
1	pH	6.5-8.5	6.5-8.5
2	EC		
3	TDS	1000	1000
4	Turbidity	<5NTU	<5NTU
5	Alkalinity	__	---
6	Total Hardness	<500 mg/L	<500 mg/L
7	Chloride	<250mg/L	<250 mg/L
8	Nitrate	<50 mg/L	<50 mg/L
9	Total Coliform	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample
10	Fecal Coliform	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample

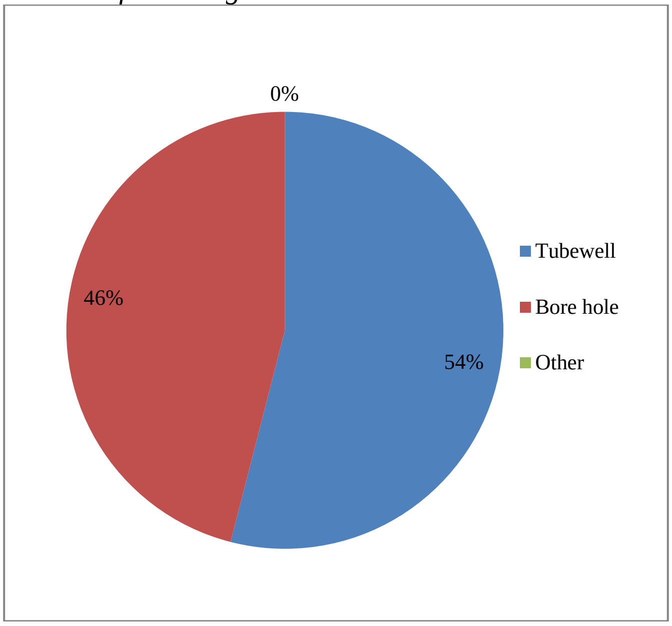
Table 3.3 outlines the **standards for drinking water quality**, comparing the permissible limits set by the **Pakistan Environmental Protection Agency (Pak-EPA)** and the **World Health Organization (WHO)**. The table includes key parameters essential for assessing water quality, such as **pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, alkalinity, total hardness, chloride, nitrate, total coliform, and fecal coliform**. The **pH range** recommended by both Pak-EPA and WHO is **6.5–8.5**, ensuring the water remains within safe acidity and alkalinity levels. **TDS levels** are limited to **1000 mg/L**, while **turbidity** should be **less than 5 NTU**, maintaining water clarity. The **maximum allowable total hardness** is **500 mg/L**, ensuring that the water does not cause scaling in pipes and appliances. The **chloride limit** is **250 mg/L**, and **nitrate concentrations** should remain **below 50 mg/L** to prevent health risks such as methemoglobinemia. From a microbiological perspective, both Pak-EPA and WHO emphasize that **total coliform and fecal coliform must not be detectable in any 100 ml sample**, indicating that drinking water should be free of bacterial contamination. The presence of these bacteria would signal fecal contamination, posing serious health risks. The standards outlined in Table 4.4 serve as critical benchmarks for evaluating drinking water safety, ensuring compliance with national and international guidelines.

Sources of Drinking Water in Sarband

There are two main sources of drinking water, tube-well and borehole. 54% of households obtained drinking water borehole. The remaining 46% of households obtain their drinking water supply from a tube wells. (Fig.4.10) shows sources of water in Union Council Sarband Peshawar. In the Union Council Sarband, bore holes and tube wells are the predominant sources of drinking water, as no households have reported utilizing alternative sources.

Figure 3.10

Sources of Drinking Water in Union Council



Daily Water Availability

According to the data, 30% of families said that water available for duration of 2 hours on a daily basis. According to the data, a 25% of households said that water is available for duration of 5 hours on a daily basis. According to the data, 29% of households said that they have access to water 12 hrs. a day. In 16% of households, water is accessible 24 hours. The water availability in residential dwellings is significant, with a substantial proportion of households having access to water for either 12 or 24 hours on a daily basis. (Figure 3.11) shows the result of respondent answers about daily availability of drinking water in Union Council Sarband Peshawar.

Figure 3.11

Water Availability in Union Council Sarband

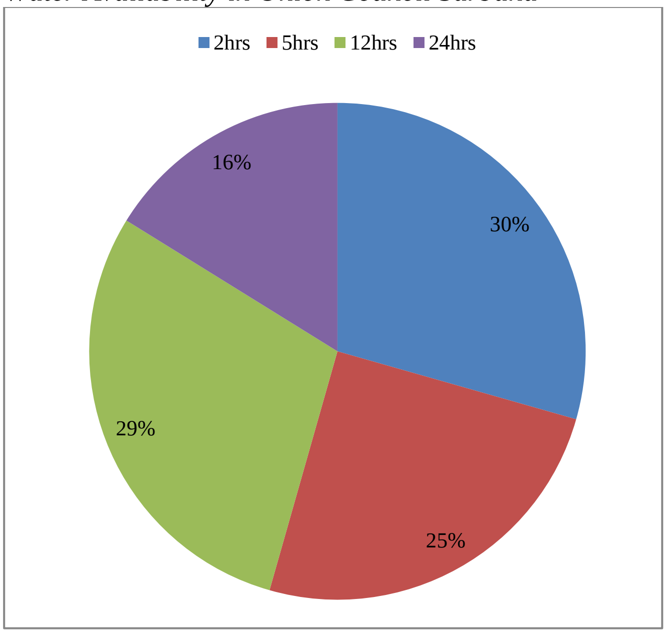


Figure (3.12) Distance from the water sources, **Figure (3.13)** Storage tank Cleaning Frequency, **Figure (3.14)** Water Quality Assessment in Union Council Sarband, **Figure (3.15)** Waterborne Disease Annual Report.

The above diagrams include three visual representations that provide insights into water accessibility, storage habits, and quality perception in Union Council Sarband. Figure 3.12 depicts the varying distances residents travel to obtain drinking water, emphasizing the challenges related to accessibility from sources like boreholes and tube wells. Figure 3.13 illustrates how frequently households clean their storage tanks, categorizing responses based on maintenance intervals such as daily, weekly, or monthly, which directly impacts hygiene and water safety. Figure 3.14 presents an assessment of drinking water quality based on both community perceptions and laboratory findings, addressing factors such as color, taste, and turbidity. These graphical analyses collectively highlight key aspects of water management, public awareness, and the need for improved sanitation measures in the region. Figure 3.15 presents the annual report of waterborne diseases in Union Council Sarband, Peshawar, based on clinical data collected from the Basic Health Unit (BHU) Sarband. The data highlights the prevalence of waterborne illnesses such as diarrhea, typhoid, gastroenteritis, and hepatitis, showing a significant correlation between microbiological contamination in drinking water and public health risks. Cases of diarrhea were the most frequently reported, followed by typhoid and gastroenteritis, with infants and young children being the most vulnerable.The medical professionals at BHU Sarband suspect additional cases of hepatitis and gastroenteritis, but due to the lack of laboratory facilities, definitive diagnoses could not be made. Many patients required referral to general hospitals for further testing and treatment. This clinical data underscores the urgent need for improved water treatment, proper sanitation measures, and increased public awareness to reduce the burden of waterborne diseases in the region

Future Perspective

The future perspective of this study emphasizes the need for sustainable solutions to ensure safe drinking water in Union Council Sarband and similar communities. Future research should focus on developing cost-effective and eco-friendly water purification techniques, such as nanotechnology-based filtration systems and bio-sand filters, which can be easily implemented at the household level. Additionally, long-term monitoring programs should be established to assess seasonal variations in water quality and their impact on public health. Advancements in remote sensing and GIS technology can be utilized to map contamination hotspots, helping authorities take proactive measures. The integration of smart water quality monitoring systems with real-time data collection will allow early detection of microbial and chemical contamination, enabling quick interventions. To improve public health outcomes, collaborative initiatives between government agencies, health organizations, and academic institutions should be encouraged to promote research on waterborne diseases and develop effective mitigation strategies. Future policies should focus on strict water safety regulations, improved sanitation infrastructure, and investment in modern water treatment plants to minimize contamination risks. Moreover, community-driven approaches should be encouraged, where residents participate in water conservation, sanitation improvement, and awareness campaigns. Empowering people through education and training in water management and hygiene practices will ensure long-term sustainability. By incorporating these advancements and policy changes, future efforts can significantly reduce waterborne diseases, improve drinking water quality, and enhance overall public health, making Union Council Sarband a model for safe and sustainable water management.

CONCLUSION

The study aimed to assess the physical, chemical, and microbiological quality of drinking water at different stages—from source to storage—in Union Council Sarband, Peshawar. A total of 36 water samples were analyzed, revealing that while physical and chemical parameters met the Pakistan National Environmental Quality Standards (Pak-NEQS), biological contamination was prevalent. The presence of total and fecal coliforms in 60% of the samples indicated significant microbial pollution, with contamination levels rising in storage tanks compared to the source and end-user points. The primary sources of contamination were identified as leaky pipelines and inadequate storage management, exacerbating health risks. Questionnaire surveys and clinical data from the Basic Health Unit (BHU) Sarband further confirmed that biological contamination was the leading cause of waterborne diseases, with diarrhea being the most frequently reported illness. The findings highlight an urgent need for intervention to improve water safety and prevent health risks. To mitigate microbial contamination and ensure access to clean drinking water, the following measures are recommended. Infrastructure improvements should focus on replacing leaking and outdated pipelines to prevent cross-contamination, installing above-ground water lines in areas where pipes are currently buried, and ensuring proper separation between water supply and sewage pipelines to minimize exposure to pollutants. Water storage and maintenance practices need to be enhanced by securing storage tanks to prevent external contamination and implementing regular cleaning and disinfection of water tanks and storage facilities. Water treatment and monitoring should be strengthened through monthly water quality testing to detect contamination early, encouraging households to boil water before consumption, and reinforcing government-led water treatment programs. Public awareness and community engagement can be improved by launching campaigns to educate residents on waterborne diseases, promoting household-level water treatment techniques, and involving religious scholars and community leaders in spreading awareness about water hygiene. Government and policy interventions are also necessary to enforce strict regulations for water safety, organize monthly community awareness sessions on drinking water management, and enhance coordination between municipal authorities and water suppliers to address contamination sources efficiently. By implementing these recommendations, waterborne diseases can be significantly reduced, ensuring a safer and healthier drinking water supply for the residents of Union Council Sarband.

REFERENCES

[1] Abu Amr, S. S., & Yassin, M. M. (2008). Microbial contamination of the drinking water distribution system and its impact on human health in Khan Yunis Governorate, Gaza Strip: Seven years of monitoring (2000–2006). *Public Health*, *122*(11), 1275–1283. https://doi.org/10.1016/j.puhe.2008.02.009

[2] Hawthorne, J. (2019). The Water Crisis In India: Everything You Need To Know. *11th January, 2018* *https://businessconnectworld.com/2018/01/11/water-crisis-in-india*

[3] Annapoorna, H., & Janardhana, M. (2015). Assessment of groundwater quality for drinking purpose in rural areas surrounding a defunct copper mine. *Aquatic Procedia*, *4*, 685-692. https://doi.org/10.1016/j.aqpro.2015.02.088

[4] Daniels, B., & Mesner, N. (2010). Nitrate. *Utah State University: Water Quality Extension. Utah State University, Logan, Utah*.

[5] Fatima, A., Urooj, S., Mirani, Z. A., Abbas, T., & Khan, M. N. (2021). Fecal coliform contamination of drinking water in Karachi, Pakistan. *PSM Microbiology*, *6*(2), 42-48. https://psmjournals.org/index.php/microbiol/article/view/556

[6] Anonymous. FAO. Cited in Water and Related Statistics Water Published by Resources Information System Directorate Information System Organisation, Water Planning & Project Wing, Central Water Commission, 2015.

[7] Ahmad, N., Waqas, M., Zareen, K., Rehman, H. U., Din, J. U., Bayan, R., ... & Afridi, S. (2017). Bacteriological analysis of well water in distract Swat KPK Pakistan. *Journal of entomology and zoology studies*, *5*(1), 403-406.

[8] Azizullah, A., Khattak, M. N., Richter, P., & Häder, D. (2011). Water pollution in Pakistan and its impact on public health — A review. *Environment International*, *37*(2), 479-497. https://doi.org/10.1016/j.envint.2010.10.007

[9] Singh, R. K., Sinha, V. S., Joshi, P. K., & Kumar, M. (2020). Modelling agriculture, forestry and other land use (AFOLU) in response to climate change scenarios for the SAARC nations. *Environmental Monitoring and Assessment*, *192*(4). https://doi.org/10.1007/s10661-020-8144-2

[10] Bain, R., Cronk, R., Wright, J., Yang, H., Slaymaker, T., & Bartram, J. (2014). Fecal contamination of drinking-water in low- and middle-income countries: A systematic review and meta-analysis. *PLoS Medicine*, *11*(5), e1001644. https://doi.org/10.1371/journal.pmed.1001644

[11] Dufour, A., Snozzi, M., Koster, W., Bartram, J., Ronchi, E., & Fewtrell, L. (Eds.). (2003). *Assessing microbial safety of drinking water: Improving approaches and methods*. IWA Publishing.

[12] Ali, S. S., Anwar, Z., & Khattak, J. Z. K. (2012). Microbial analysis of drinking water and water distribution system in new urban Peshawar. *Current Research Journal of Biological Sciences*, *4*(6), 731-737. https://www.airitilibrary.com/Article/Detail/20410778-201211-201508180050-201508180050-731-737

[13] Wittler, R. R. (2023). Foodborne and Waterborne illness. *Pediatrics In Review*, *44*(2), 81-91. https://doi.org/10.1542/pir.2022-005621

[14] Fida, M., Li, P., Wang, Y., Alam, S. M., & Nsabimana, A. (2022). Water contamination and human health risks in Pakistan: A review. *Exposure and Health*, *15*(3), 619-639. https://doi.org/10.1007/s12403-022-00512-1

[15] Fida, M., Li, P., Wang, Y., Alam, S. M., & Nsabimana, A. (2022). Water contamination and human health risks in Pakistan: A review. *Exposure and Health*, *15*(3), 619-639. https://doi.org/10.1007/s12403-022-00512-1

[16] Greenberg, a. W., w. I. A., clesceri, l., & eaton, a. (2012). Standard methods for the examination of water and wastewater. American public health association wasghington dc.

[17] Iftikhar, B., Bashirullah, N., Ishtiaq, M., Khan, S. A., Siddique, S., & Ayaz, T. (2016). Chemical quality assessment of drinking water in district Peshawar, Pakistan. *Khyber Med Univ J*, *8*(4), 171.

[18] Musa, J. J., Adewumi, J. K., ADEOYE, P. A., Mustapha, H. I., & Adebayo, S. E. (2011). Physicochemical assessment of groundwater as a source of domestic water use in some selected settlements in Minna, Niger State. http://ir.futminna.edu.ng:8080/jspui/handle/123456789/2513