Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 2 No. 3 (October) (2024)

Comparative Assessment of Bacteriological Drinking Water Quality in Urban and Rural Areas of Peshawar, Pakistan

Muhammad Essa
Bs Department of Environmental Science University of Peshawar.
Email: std105227@uop.edu.pk

Shahid Nawaz
Bs Department of Environmental Science University of Peshawar.
Email: std105231@uop.edu.pk

Abstract:
Access to safe drinking water is essential for life, yet Pakistan struggles with waterborne pathogens affecting its supply. This study compares drinking water quality in urban (Hayatabad) and rural (Larama) areas of Peshawar, Khyber Pakhtunkhwa. Randomly collected water samples from sources and user points were tested for bacteriological parameters, including total and fecal coliforms, and physicochemical parameters like pH, turbidity, hardness, TDS, EC, and chloride. Results showed 90% of urban samples were free from fecal contamination, while 80% of rural samples were contaminated. Urban water mostly met national standards, whereas rural water often exceeded limits for coliforms and TDS, posing health risks. Recommendations include enhanced sanitation, reliable water systems, and regular quality monitoring, especially in rural areas.
Key Words: Drinking Water Quality, Pathogen Contamination, Urban-Rural Comparison, Water Treatment.

Introduction

Access to safe drinking water is universally recognized as a fundamental human right and an indispensable necessity for sustaining life. Water is vital for numerous physiological functions, including waste elimination, temperature regulation, digestion, and nutrient transport. It constitutes approximately 60% of the human body, and survival without adequate water is limited to only a few days. However, the availability of safe drinking water remains a significant challenge worldwide. Water contamination, particularly by microorganisms, is a primary factor contributing to the prevalence of waterborne diseases. Deep groundwater, often considered a secure source of drinking water globally, is not immune to contamination, as numerous studies have documented cases of microbial pollutants infiltrating groundwater supplies. In Pakistan, water quality issues are a pressing environmental and public health concern. Both surface and groundwater resources are increasingly polluted with harmful substances and microbial contaminants, resulting in widespread health risks. Poor sanitation, inadequate waste management, and the intermixing of sewage and drinking water systems exacerbate the problem. Despite groundwater being a critical resource, accounting for nearly one-third of Pakistan's total water supply, only about 20% of the population has access to safe drinking water. The remaining 80% rely on unsafe water sources, with a pronounced disparity between urban and rural areas. Statistics reveal that 70% of the rural population lacks access to potable water, while urban access ranges between 40% and 60%, underscoring significant inequities in water resource distribution. Urban water quality in Pakistan is often compromised due to aging infrastructure and leakage in water distribution systems, leading to cross-contamination with sewage lines. In rural areas, the absence of centralized water supply systems leaves communities dependent on untreated sources such as wells and springs, which are frequently contaminated with pathogens. Studies have identified a range of harmful microorganisms in Pakistan's water sources, including *E. coli*, *Salmonella spp*., *Vibrio cholerae*, *Pseudomonas aeruginosa*, and others, often at concentrations exceeding World Health Organization (WHO) standards. These contaminants pose severe risks of waterborne diseases, which are a leading cause of morbidity and mortality in the country. In Peshawar, the capital of Khyber Pakhtunkhwa, the challenges of ensuring safe drinking water are particularly acute. Urban areas, characterized by high population densities and rapid economic growth, face significant strain on water treatment and distribution systems. Leakages in pipelines, inadequate treatment facilities, and improper disposal of industrial and municipal waste contribute to microbial contamination of water supplies. As a result, a substantial proportion of water samples collected from urban households in Peshawar have been found to contain total coliforms and fecal coliforms, exceeding permissible limits. Such contamination indicates sewage pollution and raises concerns about public health in urban settings. Conversely, rural areas of Peshawar often lack access to any formalized water supply systems, relying instead on untreated surface and groundwater sources. The absence of filtration or disinfection processes in these areas further compounds the risks associated with waterborne pathogens. Research has revealed alarming levels of microbial contaminants, including *E. coli*, in rural drinking water sources. This disparity between urban and rural water quality in Peshawar reflects broader national trends and highlights the need for targeted interventions to address water safety and access issues in both settings. The root causes of water quality challenges in Peshawar are multifaceted. They include poor waste management practices, inadequate regulatory enforcement, lack of public awareness about water safety, and insufficient investment in water infrastructure. Moreover, rapid urbanization and population growth have placed additional pressure on existing water resources, further deteriorating their quality. In rural areas, the lack of basic water treatment facilities means that communities remain vulnerable to diseases caused by microbial contaminants. If these issues are not addressed promptly, the health and economic impacts could be catastrophic, with increased disease prevalence and reduced productivity exacerbating poverty and inequality in the region. This research seeks to provide a comprehensive understanding of the biological drinking water quality in Peshawar by conducting a comparative assessment of urban and rural areas. The study focuses on the prevalence of microbial contaminants, including total coliforms and fecal coliforms, in drinking water samples from selected locations. By quantifying these contaminants and evaluating compliance with national water quality standards, the research aims to identify disparities between urban and rural water supplies. The

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 2 No. 3 (October) (2024)

findings will help to elucidate the underlying factors contributing to contamination and inform the development of strategies to improve water quality in both settings. Through this comparative assessment, the study also aims to address the broader implications of water quality disparities in Peshawar. Understanding the differences in contamination levels between urban and rural areas can provide valuable insights into the effectiveness of existing water management practices and highlight areas requiring urgent intervention. Recommendations based on the research findings will focus on enhancing water treatment and distribution infrastructure, promoting public awareness about water safety, and strengthening regulatory frameworks to ensure compliance with quality standards. By addressing these critical issues, the study seeks to contribute to the broader goal of safeguarding public health and improving water resource management in Peshawar.

Literature Review

Access to safe and clean drinking water is essential for the health and well-being of individuals, and is recognized as a fundamental human right. Yet, in many developing countries, including Pakistan, significant challenges persist in ensuring equitable access to safe drinking water. These challenges are compounded by issues such as water scarcity, inadequate infrastructure, poor water quality, and socio-economic inequalities, which together contribute to a high burden of waterborne diseases. Water scarcity, in particular, is a prominent issue in arid and semi-arid regions, where water resources are limited, and inadequate storage facilities further restrict access to water. The disparity between urban and rural areas regarding water availability is also significant, with urban centers typically receiving better water services, while rural areas remain underserved and often rely on contaminated water sources (World Health Organization [WHO], 2019).

Poor sanitation practices, the lack of waste disposal systems, and untreated sewage discharge contribute significantly to the contamination of water sources in developing countries. Pathogenic microorganisms such as bacteria, viruses, and parasites are commonly found in drinking water sources, leading to a range of diseases including diarrhea, cholera, typhoid, and hepatitis. These diseases disproportionately affect vulnerable populations, such as children and the elderly, causing significant morbidity and mortality (WHO, 2019). In addition, many areas suffer from aging water infrastructure, including leaking pipelines, outdated treatment facilities, and inefficient water distribution systems. These issues contribute to water losses and diminished water quality, further exacerbating the challenges in providing safe drinking water to communities (UN-Water, 2017).

Socio-economic factors play a pivotal role in shaping access to safe drinking water. Poverty, limited resources, and political challenges often hinder investments in necessary infrastructure and sanitation programs. As a result, marginalized communities continue to face water insecurity, and the cycle of poverty is further perpetuated by the adverse health impacts of waterborne diseases. The economic

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 2 No. 3 (October) (2024)

burden of these illnesses is substantial, including high healthcare costs, reduced productivity, and the diversion of resources from other critical needs, ultimately exacerbating the poverty cycle (UNICEF, 2018). The lack of access to clean water and sanitation not only impacts public health but also stifles socio-economic development by limiting educational and economic opportunities, and contributing to environmental degradation.

Waterborne diseases remain a significant public health threat in Pakistan, with contaminated water being a major source of morbidity and mortality. According to WHO, waterborne diseases such as diarrhea, cholera, and typhoid are widespread in both urban and rural areas, where water contamination is often a result of inadequate water treatment, poor sanitation, and the discharge of untreated sewage. The quality of water in many areas is compromised by industrial discharges, agricultural runoff, and open defecation, which pollute water sources. Heavy metals, chemicals, and pathogens from these sources pose serious health risks to the population. Additionally, poor water treatment infrastructure and the lack of regular maintenance of water facilities contribute to the persistence of waterborne diseases (Muzammil et al., 2020; Kumar et al., 2023).

Agricultural practices also contribute significantly to water contamination in Pakistan. The excessive use of pesticides, fertilizers, and other chemicals in agriculture leads to the contamination of both surface and groundwater sources. These chemicals can leach into water bodies, causing long-term environmental damage and posing a threat to public health. The lack of proper sanitation infrastructure further exacerbates water pollution, particularly in rural areas where open defecation remains prevalent, leading to contamination of water sources with fecal matter. The release of untreated sewage into water bodies is a common practice, especially in urban centers, significantly impacting water quality and increasing the risk of waterborne diseases (Ejaz et al., 2020; Iqbal et al., 2023).

The inadequacy of existing water treatment facilities in Pakistan is another critical issue that undermines the safety of drinking water. Many water treatment plants are outdated, lack the necessary capacity, and are poorly maintained. As a result, they fail to effectively remove harmful contaminants from water, leaving the population exposed to waterborne diseases. Microbial contamination, such as the presence of coliform bacteria and E. coli, is widespread in water samples across the country, further highlighting the insufficient treatment infrastructure. The challenges of inadequate water treatment are further compounded by the lack of access to modern treatment technologies, which can remove chemical and microbial contaminants more effectively (Parveen et al., 2023; Mohsin et al., 2017).

The effects of climate change also pose significant challenges to water quality in Pakistan. Erratic rainfall patterns, prolonged droughts, and rising temperatures contribute to changes in the availability of water resources, leading to the concentration of pollutants in limited water sources. For instance, in times of drought, the low volume of water in rivers and lakes increases the concentration of pollutants, making it even more difficult to ensure safe drinking water. Furthermore, extreme weather events such as floods and heatwaves can damage water infrastructure, compounding the existing water quality issues and putting more strain on water systems (Ahmad et al., 2020). Climate change is, therefore, a key driver of water quality deterioration in Pakistan and requires adaptation measures to ensure water security and public health.

Previous studies on the drinking water quality in Peshawar, Pakistan, have highlighted significant concerns regarding water safety, with high levels of microbial contamination and physicochemical issues observed in both urban and rural areas. Ahmad et al. (2013) found alarmingly high levels of total coliforms and E. coli in water sources in rural areas, indicating significant public health risks. Yousaf et al. (2019) conducted a study in which they assessed the physicochemical parameters of drinking water, finding notable variations in water quality between urban and rural locations. The study revealed that while urban areas had relatively better water quality, rural areas suffered from poor water infrastructure and higher contamination levels. In urban Peshawar, Khan et al. (2018) found elevated levels of coliform bacteria, including E. coli, in 65% of water samples, signaling serious contamination and the potential for waterborne diseases. These findings underline the urgent need for water quality monitoring and treatment improvements in the city.

Ahmad et al. (2021) found that water from rural areas, especially from hand pumps and wells, harbored dangerous microorganisms such as Salmonella, Shigella, and E. coli, with 45.7% of samples testing positive for these pathogens. The study emphasized the need for public health interventions to reduce the burden of waterborne diseases in rural communities. Ali et al. (2012) similarly found high contamination levels in rural water sources, with 90% of samples showing total coliform contamination and 60% contaminated with fecal coliform. The presence of these contaminants poses significant health risks, especially in regions with inadequate water treatment systems. These studies provide critical insights into the water quality issues in Peshawar and highlight the need for improvements in water infrastructure, sanitation, and public health awareness to reduce the prevalence of waterborne diseases.

Materials and Methodology

Peshawar, the capital of Khyber Pakhtunkhwa (KP), is a historically significant city and a hub of commercial, industrial, social, and political activities in Pakistan's northwest. It lies near the Hindu Kush mountain range and along the Kabul River, offering a diverse landscape from urbanized areas to rural communities, ideal for studying water quality disparities. Geographically, Peshawar is situated at an altitude of 359 meters (1,178 feet) above sea level, between 33°44′ to 34°15′ North Latitude and 71°22′ to 71°42′ East Longitude. Located near the Pak-Afghan border, it is 160 km from Islamabad and 48 km from the historic Khyber Pass. The city's strategic location, coupled with its road, rail, and air links, underpins its historical, military, economic, and political significance.

Figure (1) Map of the Rural Study Area (Larama)

Dialogue Social Science Review (DSSR)

www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 2 No. 3 (October) (2024)

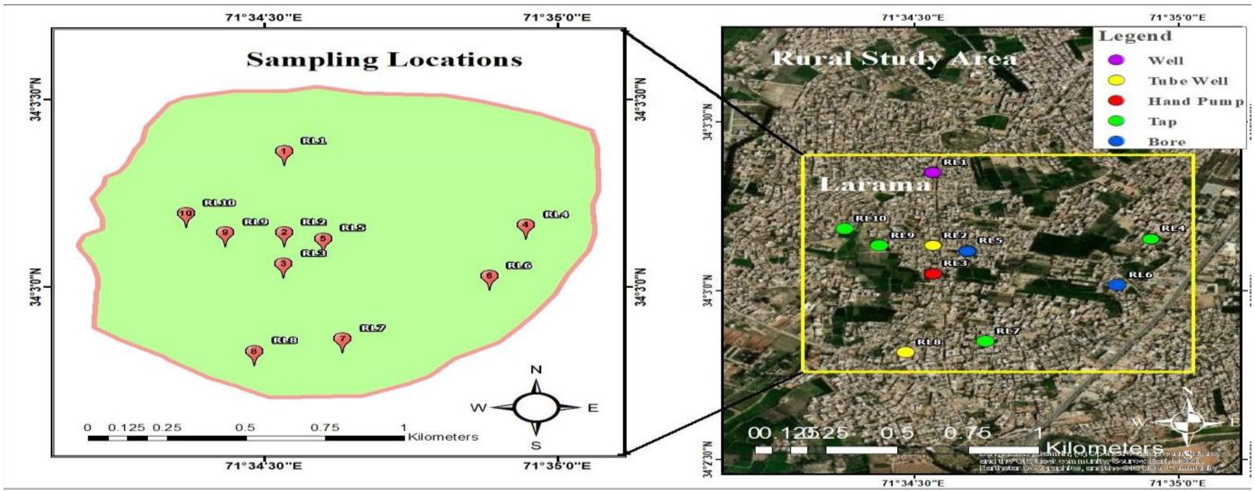
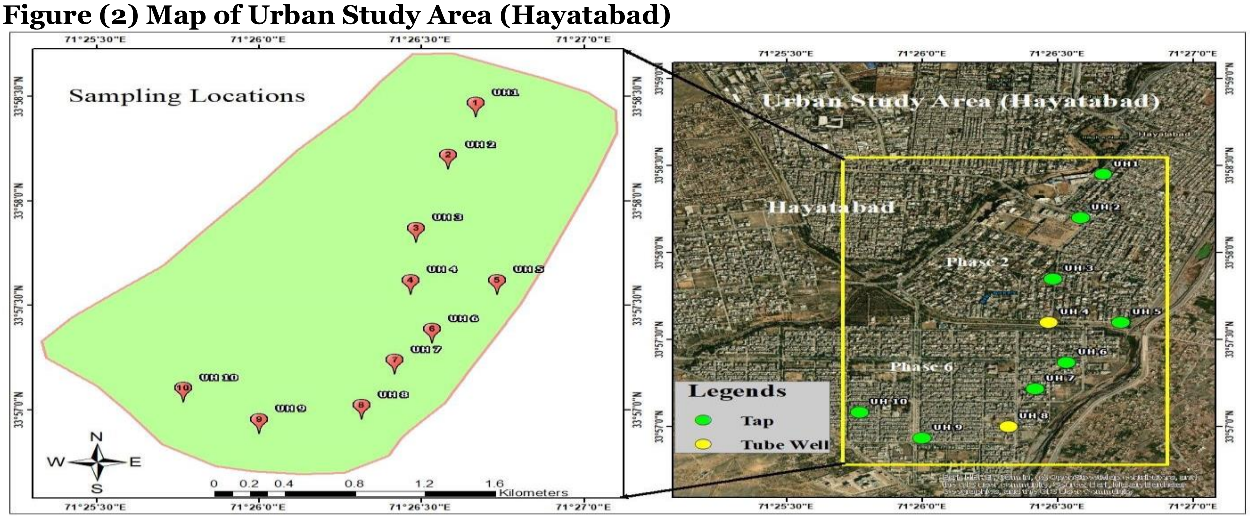


Figure (2) Map of Urban Study Area (Hayatabad)



The study, conducted at the Department of Environmental Sciences, University of Peshawar, assessed drinking and domestic water quality in urban Hayatabad and rural Larama, Peshawar. Random sampling was used to collect 20 representative water samples (10 urban and 10 rural) from sources and user points between November 2022 and April 2023. Samples were tested for parameters such as pH, electrical conductivity, turbidity, alkalinity, hardness, chloride, and total dissolved solids (TDS). Additional data on contamination sources and sanitation facilities were gathered through questionnaires during a field survey.

Following WHO guidelines, bacteriological samples were collected in 100 ml sterilized bottles, ensuring no air bubbles entered, and labeled with details like source, site, and collection time. Samples were delivered to the lab within two hours to preserve microbial integrity. For physicochemical analysis, sterile 1-liter bottles were used to collect water directly from sources or points of use.

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 2 No. 3 (October) (2024)

The data were analyzed to compare water quality in urban and rural areas against NDWQS standards, identifying any deviations from permissible limits. This standardized approach ensured accuracy in assessing microbial contamination and water quality in both regions.

Laboratory Analysis

pH is a measure of the acidity or alkalinity of water, determined by the concentration of hydrogen ions in the water. To measure pH, the pH meter is calibrated using standard buffer solutions with known pH values. A water sample free from contaminants is then collected, and the electrode of the pH meter is immersed in the sample. After stabilization, the pH reading is recorded, and the electrode is rinsed with distilled water to prevent cross-contamination. Alkalinity, the water's capacity to neutralize acids, is determined through titration. A measured volume of water is treated with phenolphthalein indicator and titrated with sulfuric acid until the pink color disappears, followed by the addition of methyl orange for a second endpoint. The total alkalinity is calculated based on the volume of acid used. To measure chloride content, a water sample is titrated with a silver nitrate solution in the presence of a potassium chromate indicator. A reddish-brown color indicates the endpoint. The chloride content is calculated using the volume of silver nitrate used. The total hardness of water, primarily due to calcium and magnesium ions, is determined using an EDTA titration method. A water sample is treated with Eriochrome Black T indicator and titrated with EDTA until a color change from wine-red to blue occurs, indicating the endpoint. Calcium hardness is similarly determined using the Murexide indicator and a NaOH solution to maintain pH-12. Turbidity, a measure of water clarity, is determined using a turbidity meter calibrated with standard solutions. A representative sample is tested, and the turbidity is expressed in Nephelometric Turbidity Units (NTU). Total Dissolved Solids (TDS) are measured gravimetrically by evaporating a known volume of water at 103-105°C and weighing the residue. The TDS concentration is calculated based on the weight difference before and after evaporation. Electrical conductivity, indicating water's ability to conduct electricity, is measured using a conductivity meter calibrated with standard solutions. A water sample is tested, and the reading is expressed in micro Siemens per centimeter (μS/cm). Bacteriological analysis is conducted using the Membrane Filtration Method, where a water sample is filtered through a membrane with a pore size of 0.45 microns. The membrane is then transferred onto selective agar media to grow and identify coliform bacteria. Lauryl Sulfate Broth is used as a selective medium to inhibit non-coliform bacteria. This analysis identifies microbial contamination, including fecal coliforms and E. coli, indicating potential health risks in drinking water.

Figure (3) Laboratory testing of water samples

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 2 No. 3 (October) (2024)

Results and Discussion

The discussion and interpretation of the results provide a comprehensive understanding of the findings obtained from the comparative assessment of water quality in urban and rural areas of Peshawar. The parameters analyzed include pH, turbidity, electrical conductivity, bicarbonate/alkalinity, carbonate, calcium, magnesium, hardness, chloride, total dissolved solids (TDS), fecal coliforms, and total coliforms. These results were compared with the maximum permissible limits defined by the National Drinking Water Quality Standards (NDWQS) to evaluate compliance and potential health risks.

The bacteriological analysis of urban Peshawar's drinking water provides critical insights into microbial contamination, focusing on fecal and total coliforms as key indicators of water quality and associated health risks. Fecal coliforms, bacteria originating from the intestines of warm-blooded animals, are used to indicate fecal contamination in water. An analysis of ten samples revealed that most were within the NDWQS permissible limits, indicating the absence of fecal contamination and confirming the water's safety for consumption.

Total coliforms, which include both fecal and non-fecal bacteria, reflect broader contamination risks. Out of the ten samples analyzed, nine were within the NDWQS limits, indicating minimal microbial contamination. These findings suggest that urban water sources are largely free from significant microbial pollutants, demonstrating acceptable quality in terms of bacteriological parameters.

Figure (4) Determination of urban biological parameters result

The bacteriological analysis reveals that drinking water in the selected urban areas of Peshawar complies with regulatory standards for microbial quality. The absence of fecal and total coliforms in the samples indicates low risks of microbial contamination, reflecting the water's safety for consumption, as shown in the findings (1).

Sr. #	Sample Code	Location	Source	Fecal Coliforms	Total Coliforms
Units			-	(CFU/100 ml)	(CFU/ 100 ml)

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 2 No. 3 (October) (2024)

Maximum Permissible Limits NDWQS			-	*0*	*0*
1	UH-01	House no. 5, Sector J-1, Phase 2.	Tap	0	0
2	UH-02	House no. 6, Sector J-2, Phase 2.	Tap	0	0
3	UH-03	Masjid Turangzai, Sector G-1, Phase 2.	Tap	0	0
4	UH-04	Tube Well no. 11, Sector G-4, Phase 2.	T. Well	0	0
5	UH-05	House no. 134, Sector H-3, Phase 2.	Tape	0	0
6	UH-06	House no. 16, F-2, Phase 6.	Tape	0	0
7	UH-07	House no.177, F-2, Phase 6.	Tap	11	23
8	UH-08	Tube Well, F-3, Phase 6.	T. Well	0	0
9	UH-09	House no. 795, F-6, Phase 6.	Tape	0	0
10	UH-10	House no. 78, Sector F-9, Phase 6.	Tape	0	0

Table 1 Results of bacteriological parameters of urban area

The analysis of physicochemical parameters in urban Peshawar highlights the quality of drinking water, ensuring its suitability for consumption. The pH of the water ranged from 7.20 to 8.40, within the acceptable limits of 6.5-8.5 set by Pakistan's National Drinking Water Quality Standards (NDWQS), indicating balanced acidity and alkalinity. Turbidity levels were below 5.0 NTU, reflecting clear water free from significant suspended particles. Parameters like bicarbonate, carbonate, calcium, magnesium, and overall hardness were within permissible ranges, ensuring appropriate buffering capacity, essential mineral content, and desirable water hardness. Chloride levels were also within acceptable limits, preventing adverse effects on taste, while total dissolved solids (TDS) were found in safe concentrations, indicating no excessive dissolved substances. Collectively, these findings confirm that the drinking water from urban areas of Peshawar complies with NDWQS for physicochemical quality, making it safe for consumption.

Table 2 Results of physiochemical parameters of urban areas (Hayatabad)

Sr. #	**Sample Code**	**Location**	**Source**	**E.C**	**pH**	**Turbidity**	**HCO 3/ Alk**	**Ca**	**Mg**	**Hard**	**Cl**	**TDS**
Units			-	*µS/c m*	-	*NTU*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*
Maximum Permissible Limits NDWQS			-	*NGVS*	6.50-8.50	*5.00*	*NGVS*	*NGVS*	*NGVS*	*500*	*250*	*1000*
1	UH -01	House no. 5, Sector J-1, Phase 2.	Tap	1021	8.10	1.5	275	185	200	485	155	758

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 2 No. 3 (October) (2024)

2	UH-02	House no. 6, Sector J-2, Phase 2.	Tap	925	7.70	1.9	290	135	275	410	117	895
3	UH-03	Masjid Turangzai, Sector G-1, Phase 2.	Tap	890	7.30	2.5	355	270	120	390	95	790
4	UH-04	Tube Well no. 11, Sector G-4, Phase 2.	T. Well	810	7.70	3.1	260	220	100	420	72	513
5	UH-05	House no. 134, Sector H-3, Phase 2.	Tape	1015	8.40	1.1	395	350	125	475	121	754
6	UH-06	House no. 16, F-2, Phase 6.	Tape	1031	7.50	2.3	270	320	170	490	93	656
7	UH-07	House no.177, F-2, Phase 6.	Tap	795	7.20	2.5	390	307	143	450	43	531
8	UH-08	Tube Well, F-3, Phase 6.	T. Well	635	7.80	1.7	210	185	125	310	39	317
9	UH-09	House no. 795, F-6, Phase 6.	Tape	670	7.40	1.8	310	107	198	305	35	435
10	UH-10	House no. 78, Sector F-9, Phase 6.	Tape	530	7.60	2.1	230	150	90	240	28	293

The analysis of drinking water quality in rural Peshawar revealed significant microbial contamination, highlighting concerns over its safety for consumption. Bacteriological assessments showed that 80% of water samples exceeded the permissible limits for fecal and total coliforms as defined by Pakistan's National Drinking Water Quality Standards (NDWQS). Fecal coliforms, indicators of fecal contamination and potential waterborne pathogens, were present in samples RL-01, RL-02, RL-03, RL-04, UH-05, UH-07, UH-09, and UH-10, rendering the water unsafe for drinking. Similarly, total coliform counts in these and additional samples exceeded acceptable limits, further emphasizing widespread microbial contamination in rural water sources.

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 2 No. 3 (October) (2024)

Figure (5) Biological results of rural areas (Larama)

Sr. #	Sample Code	Location	Source	Fecal Coliforms	Total Coliforms
Units			-	(CFU/ 100 ml)	(CFU/ 100 ml)
Maximum Permissible Limits NDWQS			-	*0*	*0*
1	RL-01	Shakeel Khan Bore	Well	13	32
2	RL-02	Ahmad Malik House	T. Well	27	30
3	RL-03	Arshad Khan Hujra	Hand Pump	37	53
4	RL-04	Waqas House	Tap	46	56
5	RL-05	Anwar Afridi Hujra	T. Well	31	43
6	RL-06	Govt Primary and High school larama	Bore	0	0
7	RL-07	Larama Masjid	Tap	8	19
8	RL-08	Village Council Office Larama 1	T. Well	0	0
9	RL-09	Zameer Khan Shop	Tape	15	34
10	RL-10	Madrassa Zainatul Quran	Tape	4	21

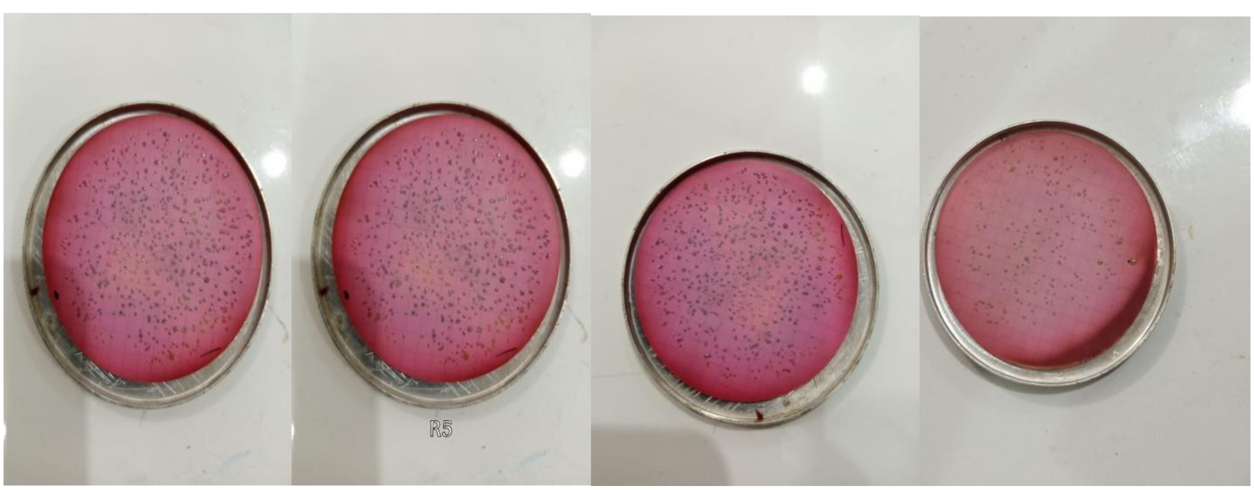


Table 3 Result of rural bacteriological parameters

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 2 No. 3 (October) (2024)

The analysis of water samples from rural Peshawar revealed that most parameters, including pH, turbidity, alkalinity, and chloride levels, were within the permissible limits set by the National Drinking Water Quality Standards (NDWQS). However, one sample (RL-05) had a pH level above 8.5, indicating slight alkalinity, while some samples (RL-04, RL-05, and RL-07) exceeded the NDWQS limit for hardness, which can lead to scale buildup and other issues. Additionally, the Total Dissolved Solids (TDS) levels in samples RL-3, RL-4, and RL-5 surpassed the National Environmental Quality Standards (NEQS), highlighting a higher concentration of dissolved substances that could impact water taste, clarity, and safety over time. These findings emphasize the need to address elevated hardness and TDS levels to ensure the provision of safe drinking water in rural Peshawar.

Sr. #	Sample Code	Location	Source	E.C	pH	Turbidity	HCO_3 Alk	CO_3	Ca	Mg	Hard	Cl	TDS
Units			-	µS/cm		NTU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Maximum Permissible Limits NDWQS			-	NGVS	6.50-8.50	5.00	NGVS	NGVS	NGVS	NGVS	500	250	1000
1	RL-01	Shakeel Khan Bore	Well	945	7.40	3.2	315	0	240	250	490	210	880
2	RL-02	Ahmad Malik House	T. Well	990	6.80	2.5	285	0	275	220	495	154	905
3	RL-03	Arshad Khan Hujra	Hand Pump	1123	7.80	3.8	335	0	330	140	470	170	1005
4	RL-04	Waqas House	Tap	835	7.60	3.4	325	0	280	235	515	220	1023
5	RL-05	Anwar Afridi Hujra	T. Well	1015	8.60	4.7	410	37.5	335	190	525	240	1075
6	RL-06	Govt Primary and High school larama	Bore	1011	7.50	3.2	320	0	165	230	395	198	876

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 2 No. 3 (October) (2024)

7	RL-07	Larama Masjid	Tap	895	8.50	4.5	380	25	320	185	505	234	995
8	RL-08	Village Council Office Larama 1	T. Well	725	7.10	2.9	300	0	125	200	325	187	690
9	RL-09	Zameer Khan Shop	Tape	780	8.10	4.1	370	0	347	145	492	190	785
10	RL-10	Madrassa Zainatul Quran	Tape	675	6.70	2.1	265	0	178	132	310	222	548

Table 4 Results of physiochemical p

The bacteriological analysis of water samples from rural Peshawar revealed significant microbial contamination, with many samples exceeding the permissible limits for fecal and total coliforms as defined by the NDWQS. This underscores potential health risks due to microbial pollution in the tested areas. Table 4.5 provides a detailed comparison of key parameters against the NDWQS standards.

Table 5 The level of major parameters compared with the NDWQS in Rural Areas (Larama)

Sr. #	Water Quality Parameter	Unit	Total No. of Samples Analyzed	Number of Contaminated Samples	%age of Contaminated Samples
1	Chloride (Cl)	mg/l	10	0	0
2	Turbidity	NTU	10	0	0
3	Hardness	mg/l	10	3	30
4	Electrical Conductivity	µS/cm	10	0	0
5	pH	mg/l	10	0	0
6	TDS	mg/l	10	3	30
7	Total Coliforms	CFU/100 ml	10	8	80
8	Fecal Coliform	CFU/100 ml	10	8	80

The comparative analysis of water quality between urban and rural Peshawar revealed significant disparities, particularly in bacteriological parameters. Several rural water samples (RL-01, RL-02, RL-03, RL-04, RL-05, RL-07, RL-09, and RL-10) tested positive for fecal and total coliforms, indicating microbial contamination, while urban

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

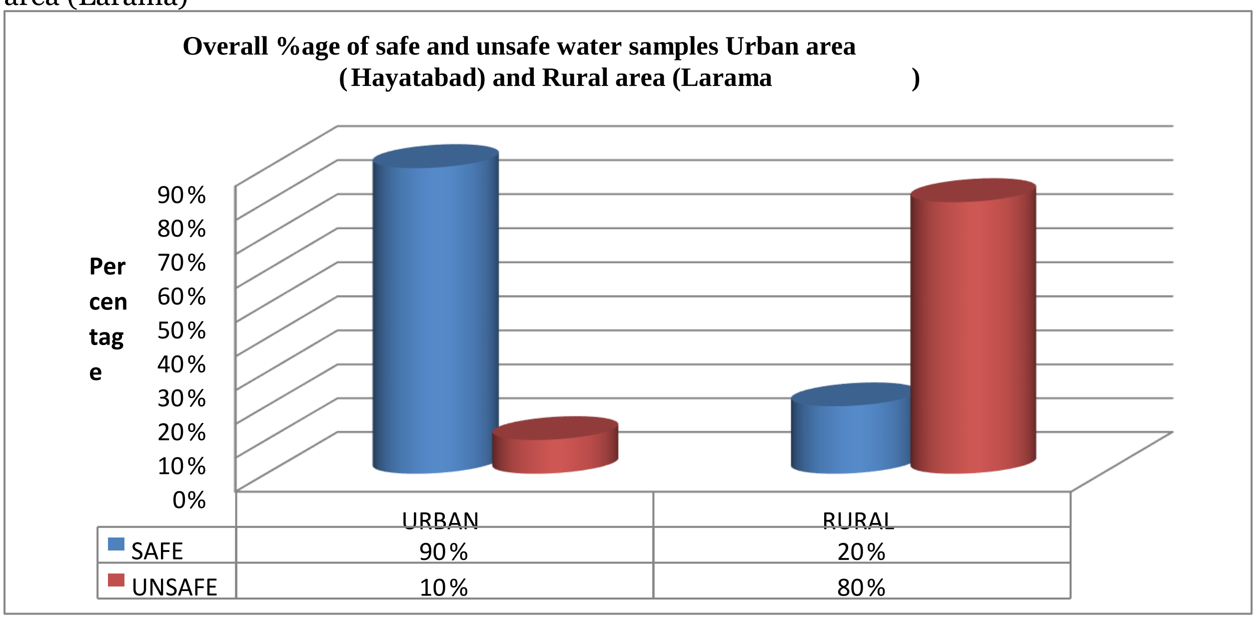
ISSN Online: 3007-3154
ISSN Print: 3007-3146

DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 2 No. 3 (October) (2024)

samples showed no such contamination, reflecting better microbial quality in urban areas. Physicochemical parameters, including turbidity, pH, alkalinity, and chloride, were generally within permissible limits in both regions. However, some rural samples (RL-03, RL-04, and RL-05) exceeded the acceptable TDS levels, suggesting higher contamination with dissolved substances. Overall, urban water sources demonstrated better compliance with water quality standards, particularly in bacteriological safety.

Figure 6 Overall %age of safe and unsafe water samples Urban area (Hayatabad) and Rural area (Larama)



The comparative assessment of water quality in urban and rural Peshawar identified several factors, based on a questionnaire survey, that contribute to the differences in water quality between the two areas. These factors significantly influence the overall water quality and highlight the disparity between urban and rural settings.

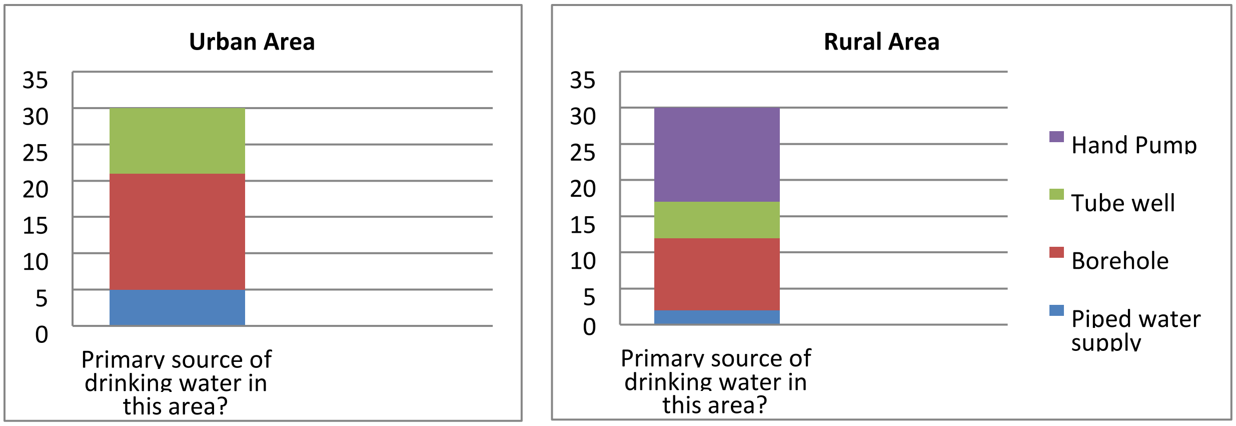
Figure 7: Primary sources of water in urban and rural areas of Peshawar

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

DIALOGUE SOCIAL SCIENCE REVIEW

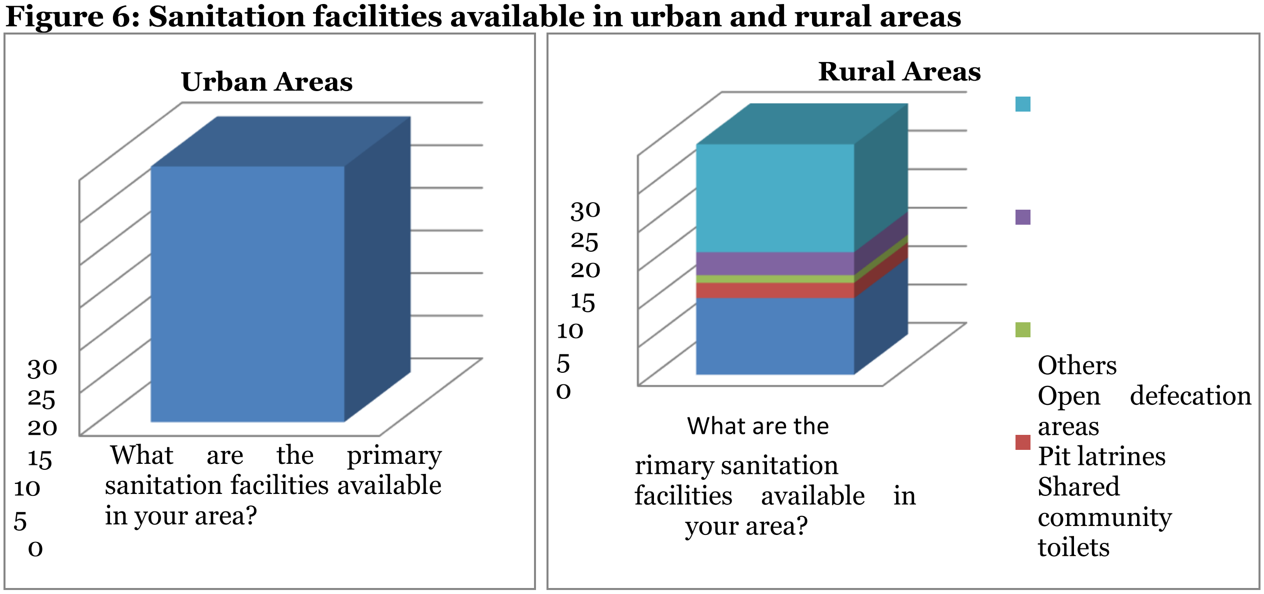
Vol. 2 No. 3 (October) (2024)



Source of Water Supply and Distribution in Urban and Rural Areas.

In Peshawar, urban water supply is managed by the Water and Sanitation Services Peshawar (WSSP) and the Peshawar Development Authority (PDA), utilizing advanced systems like piped networks and filtration plants to ensure better quality control and minimize contamination.

Figure 6: Sanitation facilities available in urban and rural areas



Sanitary Conditions in Urban and Rural Areas.

Urban areas in Peshawar benefit from proper sanitation infrastructure, including sewage systems, well-maintained septic tanks, and organized waste management, which help minimize water contamination risks. In contrast, rural areas face significant challenges due to inadequate sanitation facilities, open defecation, and improper waste disposal, leading to higher risks of water contamination with fecal matter. Figure 4.6 reflects the perspectives of residents in these areas.

Table 6 Health effects, sources and possible treatment of potential contaminants

Contaminants	Hot spots identified	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water	Possible treatment
Microbiological contamination	RL-01 RL-02 RL-03 RL-04 RL-05 RL-07 RL-09 RL-10 UH-07	Cholera Diarrhea Typhoid Dysentery Gastroenteritis Hepatitis A & E	Coliforms are naturally present in the environment; as well as feces; Fecal coliforms and *E- coli* only come from human and animal fecal waste	Chemical disinfectants (chlorine, chlorine dioxide, and ozone), Physical disinfectants (ultraviolet light, and boiling), Filtration.
Hardness	RL-04 RL-05 RL-07	Hardness is not a health concern, but it can cause mineral buildup in plumbing, fixtures, and water heaters, and poor performance of soaps and detergents.	Calcium and magnesium present in many sedimentary rocks (i.e. limestone and chalk)	Water Softeners, Reverse Osmosis.
TDS	RL-03 RL-04 RL-05	High TDS level alters the taste of water and makes it salty, bitter, or metallic High TDS levels also indicate the presence of health hazardous toxic minerals	TDS is made up of inorganic salts, as well as a small amount of organic matter	Reverse Osmosis, Distillation, Deionization (DI).

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 2 No. 3 (October) (2024)

Infrastructure and Water Treatment Facilities in Urban and Rural Areas
Urban areas have more developed infrastructure with centralized water treatment facilities, ensuring consistent monitoring and better control over water quality. In contrast, rural areas lack such facilities and monitoring mechanisms, resulting in compromised water quality and limited access to safe drinking water.

Concluding Remarks.

The comparative analysis of drinking water quality in urban and rural areas of Peshawar revealed significant disparities. Urban water sources demonstrated better microbial quality, with 90% of samples free from fecal contamination and adherence to the National Drinking Water Quality Standards (NDWQS). In contrast, rural water sources showed alarming levels of microbial contamination, with 80% of samples testing positive for fecal and total coliforms, alongside issues like high hardness and total dissolved solids (TDS). The differences stem from urban areas having superior infrastructure, centralized water treatment, and sanitation systems, while rural areas struggle with inadequate facilities and unregulated water sources. Addressing these challenges in rural areas through improved infrastructure, sanitation, and water treatment is essential to ensure safe drinking water for all.

References

Adnan, S., Iqbal, J., Maltamo, M., Bacha, M. S., Shahab, A., & Valbuena, R. (2019). A simple approach of groundwater quality analysis, classification, and mapping in Peshawar, Pakistan. *Environments*, *6*(12), 123.

Ahmad, I., Hassan, S., & Ahmad, I. (2013). Bacteriological Quality Analysis of Drinking Water of Rural Areas of Peshawar, Pakistan. *hospitals*, *8*, 9.

Ahmad, M., Jamal, A., Tang, X. W., Al-Sughaiyer, M. A., Al-Ahmadi, H. M., & Ahmad, F. (2020). Assessing potable water quality and identifying areas of waterborne diarrheal and fluorosis health risks using spatial interpolation in Peshawar, Pakistan. *Water*, *12*(8), 2163.

Ahmed, T., Zounemat-Kermani, M., & Scholz, M. (2020). Climate change, water quality and water-related challenges: a review with focus on Pakistan. *International Journal of Environmental Research and Public Health*, *17*(22), 8518.

Ahmad, S., Shan, F., Ali, S. B., Ali, N., Khan, M. K., & Ahmad, W. (2021). 40. Health risk attributed to poor microbial quality of drinking water from rural area of Peshawar, Pakistan. *Pure and Applied Biology (PAB)*, *10*(4), 1364-1368.

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.

Ali, J., Ullah, N., Ali, K. F., Rahman, Z., Ahmad, I., Hassan, S., & Ahmad, I. (2013). Bacteriological quality analysis of drinking water of rural areas of Peshawar, Pakistan. *Am Eur J Agric Environ Sci*, *13*(9), 1202-1206.

Amin R, Ali SS, Anwar Z, Khattak JZK (2012) Microbial analysis of drinking water and water distribution system in new urban Peshawar. Curr Res J Bio Sci 4:731–737

Azizullah, A., Khattak, M. N. K., Richter, P., & Häder, D. P. (2011). Water pollution in Pakistan and its impact on public health—a review. *Environment international*, *37*(2), 479-497.

Daud, M. K., Muhammad Nafees, Shafaqat Ali, Muhammad Rizwan, Raees Ahmad Bajwa, Muhammad Bilal Shakoor, & Muhammad Umair Arshad. "Drinking water quality status and contamination in Pakistan." *BioMed research international* 2017 (2017).

Dialogue Social Science Review (DSSR)
www.journalforeducationalresearch.online

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 2 No. 3 (October) (2024)

Ejaz, F., Nawaz, M. F., Dasti, Z. A., Gul, S., Islam, U., & Waqar, M. (2020). Risk assessment of heavy metal and microbial contamination in commercially available salad vegetables of Faisalabad, Pakistan. *Pak. J. Bot*, *52*(4), 1397-1403.

Fida, M., Li, P., Wang, Y., Alam, S. K., & Nsabimana, A. (2022). Water contamination and human health risks in Pakistan: a review. *Exposure and Health*, 1-21.

Hardberger, A. (2005). Life, liberty, and the pursuit of water: evaluating water as a human right and the duties and obligations it creates. *Nw. Univ. J. Int'l Hum. Rts, 4*, 331.

Hendel, B., & Ferreira, P. (2003). *Water: The Essence of Life*. Natural resources Incorporated.

InamUllah, E., & Alam, A. (2014). Assessment of drinking water quality in Peshawar, Pakistan. *Bulgarian Journal of Agricultural Science*, *20*(3), 595-600.

Iqbal, J., Su, C., Wang, M., Abbas, H., Baloch, M. Y. J., Ghani, J., & Huq, M. E. (2023). Groundwater fluoride and nitrate contamination and associated human health risk assessment in South Punjab, Pakistan. *Environmental Science and Pollution Research*, *30*(22), 61606-61625.

Tanzeel, K., Muhammad, A. M., Gohram, M., & Rabia, A. (2022). Comparative analysis of bacterial contamination in tap and groundwater: A case study on water quality of
Quetta City, an arid zone in Pakistan. *Journal of Groundwater Science and Engineering*, *10*(2), 153-165.

Khan, S., Ali, S., Muhammad, S., Khan, B., Ali, A., Hesham, E. L., & Begum, S. (2020). Bacterial contamination in drinking water of urban Peshawar: a comparative study at the sources and user points of tube wells. Desalination and Water Treatment, 181, 221-227.

Ki-moon, B., & General, U. S. (2010). The human right to water and sanitation. *Media Brief at the United Nations General Assembly-28 July*.