Bacteriological and Physicochemical Evaluation of Drinking Water Quality and Related Health Risks in Khyber Teaching Hospital, Peshawar, Pakistan

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Abstract

In Pakistan, the fast development of community and globalization has remarkably deteriorated the standard of drinking water, causing serious risks related to public health. This research work investigates the bacteriological and physicochemical standard of drinking water in different sections of Khyber Teaching Hospital (KTH), Peshawar, and evaluates the related health risks. A cross-sectional expressive approach is accepted, with water samples collected from all major hospital units and analyzed at the laboratory of Khyber Medical College (KMC). Physicochemical variables assessed consisted odor, taste, color, turbidity, nitrate, chloride, Total Dissolved Solids (TDS), sulfate, and. Calcium. Results obtained presented that all samples are as per requirements of World Health Organization (WHO) standards for physicochemical standard. Moreover, bacteriological analysis showed that only 26% of the samples are free from coliform bacteria, while 74% revealed pollution ranging from mild to moderate levels. These results present the remarkable risk caused by microbial pollution instead of acceptable physicochemical properties. The research work presents the urgent need for improved water treatment, regular checking, and infrastructure upgrades to secure the supply of safe drinking water in healthcare environments, finally protecting staff, patients, and visitors from infections produced from water.

Keywords: Drinking Water Quality, Bacteriological Analysis, Physiochemical Parameters, Waterborne Diseases, Coliform Contamination, Public Health, Water Management, WHO Standards.

Introduction

Water is one of the most crucial requirements for the survival of all living organisms on Earth. All daily activities of living beings are dependent on water in some capacity. It is utilized efficiently by humans, plants, animals, and microorganisms. Notably, no microorganism has been found to survive in the complete absence of water (Ahmad et al., 2013). The necessity of water is undeniable; no one can live or even dream of living without it. Access to an adequate, safe, and accessible water supply is crucial for all. Improving access to safe drinking water leads to

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significant health benefits (Edition, 2011). Water quality, defined by its physical, chemical, and biological characteristics, determines its usability for various purposes including drinking, industrial, and agricultural activities. Clean drinking water is a basic human right, not depend on religion, color, wealth, nationality, or belief (Aghlmand et al., 2021). Beyond its biological necessity, water plays a crucial role in economic development. The accessibility of safe drinking water is a growing worldwide issue, motivating governments and organizations to address this challenge. An estimated ten million people need approach to safe and clean drinking water. As per the WHO, poor sanitation and unsafe water result in 17 lakh deaths and 542.0 lakh disability-regulating life years (DALYs) annually. Furthermore, around death of 80% child are caused by diarrhea linked to contaminated water (Murtaza et al., 2020). Water serves as a foundational component of life-support systems. However, many water bodies are increasingly polluted due to industrialization and urban expansion. Both human and natural activities contribute to poor sanitation and unsafe drinking water, leading to serious public health issues. Major sources of water pollution include household sewage, industrial pollutant, agricultural runoff, and waste from chemical industries, fossil fuel-based power plants, and nuclear facilities. These polluted compromise quality of water, supplying it inappropriate for agriculture, drinking, and aquatic ecosystems (Irda Sari et al., 2018). Fecal pollution, a crucial measure of water quality and levels of sanitation, is prevalent world widely, basically in inner-city slum areas of middle-order countries. Gastroenteritis and Diarrhea continue to be major health loads, with 150, 000, 0 deaths because of diarrhea noted in 2012, of which 280,000 are associated to poor sanitation. In some countries just like Indonesia, diarrhea remains ordinary among babies and children because of unsafe water, limited access to pure water, and insufficient hygiene practices (Bigoni et al., 2014). Above 26 million people, almost 40.0% of the world population have no fundamental sanitation services, and roughly more than ten million people depend on sources of unsafe water. Due to which, thousands of children die every day from diarrhea and other diseases produced due to water, linked with polluted water, sanitation, and hygiene (WASH) practices (Irda Sari et al., 2018).

The standard of drinking water in medical management settings is especially crucial, as it directly effects the health and safety of patient. A research in Peru showed that hospital water supplies usually failed to encounter WHO guidelines, disclosing patients to increased health diseases (Anaissie et al., 2002). In the United States of America, about two million nosocomial infections per annum are assigned to germs produced due to polluted water, showing the need for robust management of water in hospitals (Chawla et al., 2016). These issues are amplified in low- and middle-order countries, where insufficient infrastructure of water hampers safe medical policies and increases the problems of disease. In Pakistan, where only 79% of the peoples has available supply of water, problems related to poor quality of water are widespread because of poor management systems. Research done in both rural and urban regions report extensive fecal pollution and contamination groundwater quality, which contribute remarkably to the spread of diseases produced due to water (Daud et al., 2017).

In the healthcare workplaces, such as those in Abbottabad, hospital sources of water usually fail to comply with the standard of WHO, showing systemic shortage in resource management and infrastructure (Zeb et al., 2012). Especially, in Khyber Pakhtunkhwa, reports have documented both chemical contamination and bacteriological in drinking water, showing an urgent need for corrective measures (Awan et al., 2022). Internationally, different countries have different challenges concerning the quality of water. In Iran, evaluation using the Water Quality Index have present more concentrations of toxic elements like arsenic and nickel, involving important interventions (Aghlmand et al., 2021). On the other hand, research in Thailand and Nepal present the prevalence of microbial and turbidity pollution in mountain water sources, recommending the use of latest treatment technologies to stop disease outbreaks (Sudsandee et al., 2020). Even in developed countries such as the European Union, high levels of fecal pollution persist, usually due to aging infrastructure of water, which reduces the reliability of advanced detection technologies (Gunnarsdottir et al., 2020).

Disease produces due to water such as typhoid fever and cholera continue to show big public health issues, specifically in the countries lacking safe water and suitable sanitation. Numerous work have investigated the role of polluted water in spreading these diseases across Africa and Asia (Bwire et al., 2020). Recent cholera outbreaks in Uganda and China further show the need for severe pathogen monitoring and quick-response water management systems (Hu et al., 2022). In inclusion to microbial dangers, chemical pollution of water sources is increasingly being studied. For example, research work in India and Massachusetts has associated the exposure to wastewater pollutants with increased the risk of breast cancer, showing to the wider implications of environmental exposures (Kumar Karn & Harada, 2002). In Pakistan, connections have been pointed out between gastroenteritis incidence and water quality parameters, showing the complex socio-environmental dynamics causing public health (Farooqui et al., 2009). Numerous systematic studies and community-based research have broadened the understanding of worldwide water quality problems. Bain et al. presented data on fecal pollution in improved sources of drinking water across low- and middle-order countries and found persistent pollution instead of infrastructural improvements (Bain et al., 2014). Field studies in Ethiopia, Peru, Lesotho, and Cameroon confirmed high levels of coliform bacteria in both rural and urban water sources, emphasizing that sanitation and hygiene are essential to effective water quality management (Nsoh et al., 2016). Similar patterns are observed in Kenya, Mexico, and Nepal, where bacterial and chemical contamination levels frequently exceeded WHO standards (Sarkar et al., 2022).

In Ethiopia, a comparison of bottled and municipal tap water revealed that even safe water sources become contaminated during household storage, indicating the need for point-of-use interventions (Keleb et al., 2022). Studies in China found dangerously high levels of nitrate and fluoride in groundwater, raising alarms about chronic health effects (Chen et al., 2017). Monitoring data from rivers in South Africa indicated high levels of E. coli and enterococci, further supporting the need for continuous surveillance (Edokpayi et al., 2018). In Southeast Asia, localized water quality concerns have also been documented. Malaysian and Indian studies reported acceptable physicochemical parameters but revealed microbial pollution in street-vended water (Rahmanian et al., 2015).

In Pakistan, groundwater analyses have shown variable levels of pH, suspended solids, and trace metals, reflecting the diverse and localized nature of contamination sources (Khuhawar et al., 2019). From the comprehensive review of literature, it is evident that addressing water quality challenges requires integrated strategies at the local, national, and international levels. While worldwide and regional researches have provided important insights into water pollution sources and their impacts on health, limited data available especially on quality of water in healthcare settings in Pakistan, especially in tertiary care hospitals just like KTH in Peshawar. This work aims to fill the gap by studying a physicochemical and bacteriological judgment of drinking water in the various units of the hospital, with the aim of informing targeted interventions for enhancing standard of water in clinical environments (Sharma & Bhattacharya, 2017).

Different studies have presented water pollution in Pakistan, there remains a remarkable gap in understanding the specific water quality problems within healthcare facilities and public/government organizations. Especially at the Khyber Pakhtunkhwa, limited data available regarding quality drinking water in hospitals. To Address this gap is critical for informed decision-making and policy formulation mean at ensuring safe quality of drinking water provision in healthcare regions. The current study aims to bridge this gap by assessing pollutants, coarse particles, total coliform bacteria, toxicants, and other physicochemical characteristics of water at KTH, Peshawar. By recognizing and quantifying potential risks, this work aim to provide necessary information to healthcare authorities and policymakers. The current research endeavor seeks to strengthen the understanding of water quality within the environment of hospital and facilitate targeted interventions to enhance quality of water and ensure the health and safety of staff and patients.

Methodology

Testing

Samples of water obtained from different units of KTH are analyzed for both physicochemical and bacteriological parameters following standardized protocols. Analysis of bacteriological focused initially on the detection of total coliforms using the method of membrane filtration, presenting to the procedures outlined in the WHO recommendations for the standard of drinking-water. Physicochemical parameters measured included odor, color, taste, chloride, nitrate, turbidity, TDS, calcium, and sulfate. These tests are performed using standard techniques as recommended by the WHO and European Union drinking water standards to guarantee comparability and accuracy. For turbidity test, a cephalometric turbidity meter is used, while ion concentrations are founded through the methods of titration and spectrophotometric. All steps are conducted under strict quality control measures to maintain validity and reliability of the results.

Study Site

This research work is performed at KTH, the principal tertiary care facility affiliated with KMC in Peshawar, Pakistan. Situated along the historic route leading to the Khyber Pass, KTH is one of the largest hospitals in KPK, encompassing 1800 beds across 35 units. As a great referral center, KTH serves a diverse population, consisting of both international and domestic patients from the Afghanistan and Northwest of Pakistan.

Study Duration

The research study completed in 6 months, with collection of sample conducted during two visits. Each visit involved the assembling and analysis of 50 samples of water at the laboratory of KMC, focusing on coliforms, chemical and physical properties. The samples of water are collected over a one-month duration. Samples are collected from all active water dispensers and drinking water taps across different units of KTH to ensure broad and representative coverage of the facility. The collection and analysis of samples are conducted in accordance with the WHO recommendations for standard of drinking-water. This includes procedures for sterile collection, transportation, and bacteriological and physicochemical testing. Initially, the size of sample is calculated using the WHO formula, yielding a requirement of 245 samples. Due to logistical constraints within KTH's numerous units, a total of 50 samples of water are collected, comprising one sample per unit alongside additional random selections. A non-probability convenient sampling technique is employed for sample collection. The study included water sources from all departments of KTH, while open water sources are excluded. Data are gathered using a pre-designed proforma aimed at assessing drinking water quality at KTH. Samples are collected with consent from hospital administration, permission from the Department of Community Medicine at KMC, and approval from KMC administration. Each unit contributed one water sample, with additional random samples of 500ml for testing at KMC's laboratory. Water samples are collected from each unit by gently opening taps and allowing water to flow for 30 seconds. Samples are then placed in sterilized plastic bottles, labeled, and shifted to the laboratory for bacteriological and physiochemical analysis.

Results and Discussion

Actual Bacteriological Quality

In this study, 50 samples are analyzed. Thirteen samples (26%) are free from coliforms, indicating excellent water quality according to WHO standards. Twenty samples (40%) had coliform counts ranging from 1 MPN/100ml to 10 MPN/100ml, categorizing them as acceptable but requiring regular filtration checks. Seventeen samples (34%) exhibited coliform counts ranging from 11 MPN/100ml to 35 MPN/100ml, which is considered unacceptable for drinking water. Table 1 presents the bacteriological (coliform) results for all collected drinking water samples, highlighting contamination levels ranging from 0 MPN/100ml to 35 MPN/100ml at KTH. Table 2 depicts the frequency distribution of coliform counts across the samples. Table 3 presents the interpretation of results according to WHO Standards.

Figure 1 displaying the distribution of residuals from the coliform contamination analysis reveals a left-skewed pattern, with most residuals concentrated between -10 and -4, indicating that many observed values are lower than predicted by the model. This suggests the prediction model tended to overestimate coliform counts in numerous samples. The peak frequency in this negative range implies a systemic bias toward overestimation, while a few outliers on the far right (residuals from 18 to 30) point to isolated instances of unusually high contamination that warrant further investigation, potentially linked to specific departments or problematic water sources. The wide spread of residuals, ranging approximately from -14 to +30, reflects significant variability in contamination levels across the sampled healthcare units. Overall, the distribution highlights the need for targeted interventions tailored to high-risk areas rather than a uniform approach, and indicates that recalibrating the prediction model could improve its accuracy in reflecting the observed data.

Table 1: Bacteriological (Coliform) Contamination in Drinking Water Samples.

S. No.	Unit	Coliform (MPN/100ml)	S. No.	Unit	Coliform (MPN/100ml)
1	Medical A (samp1e 2)	13	26	Eye A sample 1	35
2	Medical A (samp1e 2)	13	27	Eye A sample 2	2
3	Medical A (sample 2)	8	28	Eye B sample 1	2
4	Medical B (sample 1)	0	29	Eye B sample 2	2
5	Medical B (sample 2)	0	30	Urology sample 1	17
6	Medical C (sample 1)	25	31	Surgical A sample 1	0
7	Medical C (sample 2)	2	32	Surgical B sample 1	0
8	Medical D (sample 1)	0	33	Surgical C sample 1	13
9	Medical D (sample 2)	0	34	Surgical D sample 1	35
10	ENT A (sample 1)	13	35	Neurosurgery sample 1	13
11	ENT B (sample 2)	13	36	Neurosurgery sample 1	0
12	Nephro (sample 1)	2	37	Paeds A sample 1	20
13	Nephro (sample 2)	2	38	Paeds B sample 1	8
14	Gynae A sample 1	0	39	Orthopedic A sample 1	5
15	Gynae B sample 1	25	40	Orthopedic B sample 1	0
16	Gynae C sample 1	2	41	Dermatology sample 1	0
17	Labour room A sample 1	5	42	Dermatology sample 1	8
18	Labour room B sample 1	13	43	Psychiatry sample 1	5
19	COVID sample 1	2	44	Psychiatry sample 2	9
20	COVID sample 2	2	45	Pulmonology sample 1	20
20	Med.ICU sample 1	5	46	Pulmonology sample 2	25
20	Med.ICU sample 2	0	47	Emergency sample 1	13
23	Plastic Surgery sample 1	0	48	Emergency sample 2	5
24	Plastic Surgery sample 2	2	49	Cardiology sample 1	14
25	Paeds Surgery sample 1	5	50	Cardiology sample 2	0

Physical Characteristics

All physical parameters, including color, odor, taste, and turbidity, are within normal ranges according to WHO standards. These parameters can be influenced by organic matter, industrial, agricultural, household waste, and biological contaminants present in water sources. In current study, no abnormalities are detected in any of the samples, consistent with findings reported in a study performed in various regions of Punjab and Sindh (Deeba et al., 2019). Table 4 presents the physical properties of drinking water in 32 different hospital units, including surgical, medical, pediatric, and specialty departments. For all units listed, ranging from Medical A to Eye B, the quality of water parameters of odor, color, and taste are constantly reported as normal. This shows that, based on sensory evaluation, the drinking water in all sampled units showed no noticeable abnormalities in smell, appearance, or flavor.

Table 2: Frequency distribution table.

Coliform (MPN/100ml)	Frequency
0	13
1----10	20
11---50	17

Table 3: Interpretation of Results According to WHO Standards.

Coliform MPN/ml	Category
Zero/ml	Excellent
1--10/100ml	Acceptable
11---50/ml	Unacceptable
More than 50/ml	grossly polluted

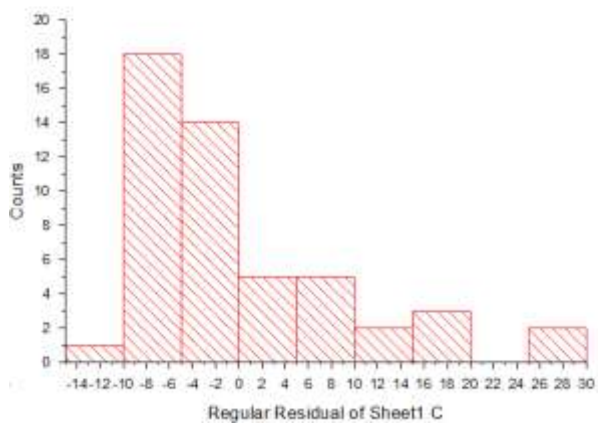

Figure 1: Data analysis of Table 1.

Table 4: Physical Characteristics of Drinking Water (Note: N used for Normal).

S. No	Unit	Color	Odor	Taste
1	Medical A	N	N	N
2	Medical B	N	N	N
3	Medical C	N	N	N
4	Medical D	N	N	N
5	Plastic surgery	N	N	N
6	Urology	N	N	N
7	Dermatology	N	N	N
8	Med. ICU	N	N	N
9	Paeds A	N	N	N
10	Paeds B	N	N	N
11	Paeds C	N	N	N

12	Paeds surgery	N	N	N
13	Psychiatry	N	N	N
14	COVID A	N	N	N
15	COVID B	N	N	N
16	Pulmo	N	N	N
17	ENT A	N	N	N
18	ENT B	N	N	N
19	Ortho A	N	N	N
20	Ortho B	N	N	N
21	Gynae A	N	N	N
22	Gynae B	N	N	N
23	Gynae C	N	N	N
24	Emergency	N	N	N
25	Cardiology	N	N	N
26	Labour Room	N	N	N
27	Surgical A	N	N	N
28	Surgical B	N	N	N
29	Surgical C	N	N	N
30	Nephrology	N	N	N
31	Eye A	N	N	N
32	Eye B	N	N	N

Chemical Properties of Drinking Water in KTH

The chemical properties of drinking water, including pH, Nitrate, Chloride, TDS, Sulfate, and Calcium, as observed in the study performed at KTH, are shown in Table 5. Further discussion on these parameters pH, Nitrate, Chloride, TDS, Sulfate, and Calcium is detailed in the subsequent sections.

Table 5: Chemical Properties of Drinking Water.

S. No.	Unit	Ph	Chloride	Nitrate	T.solid	Calcium	Sulphate
1	Medical A	7.8	114	Nill	428	54	71
2	Medical B	7.4	120	Nill	410	60	84
3	Medical C	7.4	124	Nill	43O	35	144
4	Medical D	7.1	124	Nill	396	45	186
5	Plastic surgery	7.4	118	Nill	455	55	114
6	Urology	7.6	136	Nill	424	52	93
7	Dermatology	7.2	110	Nill	418	48	110
8	Med. ICU	7.2	114	Nill	425	52	124
9	Paeds A	7.3	126	Nill	384	49	171
10	Paeds B	7.4	128	Nill	435	52	82
11	Paeds C	7.8	144	Nill	393	54	90
12	Paeds surgery	7.5	132	Nill	466	56	113
13	Psychiatry	7.3	112	Nill	470	46	149
14	COVID A	7.1	116	Nill	426	61	128
15	COVID B	7.6	151	Nill	380	55	96
16	Pulmo	7.5	154	Nill	424	58	106
17	ENT A	7.4	106	Nill	465	43	98
18	ENT B	7.2	124	Nill	402	40	172
19	Ortho A	7.6	152	Nill	440	54	81
20	Ortho B	7.4	136	Nill	426	48	109
21	GynaeA	7.4	119	Nill	396	46	128

22	Gynae B	7.5	148	Nill	456	55	135
23	Gynae C	7.5	118	Nill	404	42	146
24	Emergency	7.2	114	Nill	410	66	78
25	Cardiology	7.5	128	Nill	440	40	93
26	Labour Room	7.5	142	Nill	394	52	146
27	Surgical A	7.2	130	Nill	451	49	112
28	Surgical B	7.2	156	Nill	388	58	164
29	Surgical C	7.4	122	Nill	406	66	84
30	Nephrology	7.3	121	Nill	390	65	99
31	Eye A	7.6	116	Nill	462	64	86
32	Eye B	7.2	110	Nill	395	52	148

PH

The PH range of the samples of water is from 7.1 to 7.8, falling within the range of WHO-standard of 6.5 to 8.5. PH is a critical parameter that indirectly affects the quality of water. These results align with those revealed by Memon et al. (2011) in southern region of Sindh but differ from a research conducted in Ethiopia (Abegaz & Midekssa, 2021).

Chloride

The range of concentrations of chloride is from 110 mg/L to 156 mg/L, well below the WHO-standard of 200 mg/L. Chloride is relatively benign as compared to other water pollutants and acts as a disinfectant. These results are matching with a research conducted in Peshawar (Iftikhar et al., 2016), but contrast with results from a study in Palestine (Daghara et al., 2019).

Nitrate

Nitrate is not detected in any one of the samples, maintaining levels below the WHO-standard of 0.1 mg/L. This result is consistent to the findings from a study in Rawalpindi (Sehar et al., 2011) but differs from results showing higher nitrate levels in Palestine (Daghara et al., 2019).

Total Dissolved Solids (TDS)

The range concentrations of TDS is from 390 mg/L to 470 mg/L, below the WHO-standard of 500 mg/L. TDS shows the concentration of dissolved substances in water and causes no risk at these levels. The current results align with studies performed in Kenya (Ondieki et al., 2021) and Peshawar (Iftikhar et al., 2016).

Calcium

The range of concentrations of calcium is from 35 mg/L to 66 mg/L, within the WHO-standard of <75 mg/L. Research from China (Edokpayi et al., 2018) and Sindh (56)reported higher concentrations of calcium in some samples, highlighting variability in regional quality of water.

Sulphate

The concentrations of Sulphate ranged from 71 mg/L to 186 mg/L, below the WHO-standard of 200 mg/L. Optimum levels of sulphate in drinking water are also noted in studies conducted in Africa (Khuhawar et al., 2019).

Discussion

The Table 6 investigates that the results of the current research work are strongly aligned with previous research work. Coliform contamination in hospital water supplies is a recurrent theme across different countries, indicating a global public health challenge. While the chemical properties of water in many research studies (including the current one) meet WHO standards, microbial quality is often compromised. The worldwide similarity in results (as reported by Bain, Murtaza, Nsoh, Sarkar, and others) suggests that microbial safety is a more urgent issue than chemical safety in water, especially in healthcare environments where patients are more susceptible to waterborne infections. This consistent trend across countries underlines the importance of targeted disinfection, monitoring, and water treatment practices.

Table 6: Comparison of Microbiological and Physicochemical Water Quality Results with Previous Studies.

Aspects	Current Study	Comparable Study	Results
Microbiological Contamination	74% of hospital drinking water samples contaminated with coliform bacteria	- District Vehari hospitals (Murtaza et al., 2020b) - Low- and middle-income countries (Bain et al., 2014b) - Cameroon (Nsoh et al., 2016b) - Nepal (Sarkar et al., 2022b)	All reported high coliform levels, showing global prevalence in health and community water sources
Physicochemical Quality	Within WHO standards	- Punjab and Sindh, Pakistan (Deeba et al., 2019b) - Kenya (Ondieki et al., 2021b)	Physicochemical parameters met standards
Chemical vs Microbial Trend	Microbial contamination more frequent despite acceptable chemical parameters	Malaysia and India (Rahmanian et al., 2015b)	Emphasizes microbiological contamination as a more critical issue

Overall Implication	Urgent need for microbial safety interventions, especially in healthcare settings	- Supported by global findings	Highlights threat to vulnerable populations

Conclusion

This research work comprehensively investigated the bacteriological, physical, and chemical assigns of drinking water sourced from various wards at KTH. The results investigated that a significant percentage (34%) of the samples is more than the WHO-standard for coliform contamination in drinking water. Despite this, all physical parameters, consisting odor, color, taste, and turbidity are within WHO-standards. Continued investigation is advisable to certify sustained adherence and detect any seasonal changes. Chemical analysis investigated that PH, nitrate, chloride, and TDS, sulfate, and calcium levels met WHO-standards for safe drinking water. Moreover, it is obtained that the majority of drinking water units at KTH are not suitable for consumption because of mild to moderate presence of coliform. Conversely, the physiochemical characteristics of the hospital's water remain suitable for consumption. To strengthen the practical importance of the results, the bacteriological contamination detected in the drinking water of hospital supply, especially the presence of coliforms in 74% of samples is investigated in relation to the disease prevalence data from KTH during the study period. Hospital records showed a significant incidence of illnesses produced due to polluted water, including acute diarrhea and gastroenteritis, especially among pediatric and immunocompromised patients. This correlation presents the potential health risks caused by polluted water within the healthcare setting and highlights the urgent need for improved water quality management. The integration of microbiological data with local health outcomes supplies important insight for hospital administrators and regional health authorities in developing evidence-based strategies and preventive measures.

Coliform bacteria are usually used as indicators of water pollution because their presence suggests that harmful germs, including viruses, bacteria, and parasites, may also be present. High levels of coliforms in drinking water can lead to remarkable health hazards, specifically for unsafe populations such as children, the elderly, and immunocompromised individuals. Exposure to polluted water can lead to gastrointestinal illnesses, such as nausea, diarrhea, and vomiting, and in crucial cases, contamination such as cholera and dysentery. Therefore, the detection of higher coliform levels in 17 samples presents a potential public health concern, emphasizing the need for prompt water quality interventions to prevent diseases produced due to water and protect patient safety within healthcare settings. This research work presents the significance of ongoing surveillance and maintenance of water quality standards to safe the public health within healthcare settings.

Author Contribution

Muhammad Ilyas: Writing of the original Draft
Abdullah Abdullah: Collection of samples, Testing of Samples
Abid Hussain: Review and Editing of the Manuscript, Health and safety standards, Selection and integration of appropriate treatment systems, Statistical Analysis
Farman Ullah: Analysis of the Tests

Recommendation

Based on the results, it is recommended that KTH execute regular bacteriological testing of drinking water, install point-of-use purification systems in crucial areas, and perform routine checking and maintenance of water pipelines to prevent pollution. Staff should be properly trained in water hygiene practices, and the hospital should cooperate with relevant authorities to ensure compliance with WHO-standards. These measures will help reduce the identified coliform pollution and ensure a safer water supply for patients and healthcare workers.

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