

Research Article

# Assessment of Water Quality and Sanitation Systems in Urban Slums: A Case Study of Rajshahi City Corporation, Bangladesh

Shuvonkor Shuvo Dey Pijon<sup>\*</sup> , Shakib Al Hasan , Muhammad F Mubin ,  
Tanjina Akther 

Department of Civil Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh

## Abstract

Over the past few decades, Rajshahi City slum population has grown as a result of the city's promise to provide jobs for the underprivileged in the surrounding area. Thousands upon thousands of poor, helpless people are pouring into cities in search of work. Due to the involvements of the government, RCC, and other national and international non-governmental organizations (NGOs), the slums are getting access to pure drinking water supply, although these are still insufficient. The study's objectives are to evaluate the drinking water quality in a few chosen Rajshahi city slums, as well as to examine the current water distribution and sanitation systems. Every slum home (8 slums) completed a questionnaire survey to provide data for the study. In this cross-sectional study conducted in randomly selected slums, color, pH, TS, TDS, turbidity, and electric conductivity were measured in drinking water in the laboratory. Twenty water samples (randomly chosen based on ownership, such as singly, jointly, or City Corporation provided) have been taken from the research area in all, with tubewells providing the majority of them. The survey found that most slum dwellings employ water seal latrines for waste disposal and tube-well water for drinking. There are somewhat hygienic pit and water seal latrines. These could contaminate groundwater, depending on the characteristics of the soil and the distance between the latrines and water sources. Drinking water at sample sites was slightly acidic (pH 5.7-6.8). Turbidity varies from 0.28 to 21.7 NTU, conductivity varies from 300 to 1300  $\mu\text{S}/\text{cm}$ , TDS varies from 200 to 700 ppm, and TS varies from 200 to 2200 ppm. This paper concludes that awareness raising on physical contents in drinking water at the household level is required to improve public health.

## Keywords

Slum, Water Quality, Water Supply, Sanitation

## 1. Introduction

Rapid urban growth in Bangladesh has created adverse effects on different sectors. Some adverse effects include mass poverty, the increase of slums and squatters, and the inadequate supply of urban facilities such as water, electricity, solid

waste disposal, sanitation, sewerage, and fuel for cooking. Additionally, the degradation of social, neighborhood, and physical environments remains a significant concern [1]. Access to safe drinking water and adequate sanitation are

<sup>\*</sup>Corresponding author: shuvonkarshuvo00@gmail.com (Shuvonkor Shuvo Dey Pijon)

**Received:** 23 December 2024; **Accepted:** 13 January 2025; **Published:** 7 February 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

fundamental human rights, serving as the bedrock of public health and well-being. Yet, in many developing countries, particularly within the densely populated slums of major cities, securing these necessities remains a constant struggle. Rajshahi City, Bangladesh, with its burgeoning slum population, exemplifies this challenge. Driven by the allure of economic opportunities, a steady influx of migrants from rural areas has led to a significant increase in slum settlements in recent decades. Water is a prime natural resource. Acknowledging its importance and addressing the limited availability for biological needs and economic growth activities is of utmost concern [2]. Water is the most abundant substance on Earth, covering roughly three-quarters of the planet's surface, and it plays a vital role in maintaining life. In its pure state, water is considered key to health, and many believe it is more fundamental than all other essentials of life [3]. The World Health Organization (WHO) estimates that up to 80% of all sickness and disease worldwide are caused by inadequate sanitation, polluted water, or the unavailability of potable water [4]. While commendable efforts by the government, Non-Governmental Organizations (NGOs), and the Rajshahi City Corporation (RCC) have improved access to water supplies within these communities, concerns persist regarding water quality and the adequacy of sanitation systems.

This research explores the critical issues surrounding water quality, distribution, and sanitation systems within selected slums of Rajshahi City. Furthermore, it seeks to pinpoint areas for improvement, paving the way for targeted interventions to ensure the well-being of slum residents.

Understanding existing water quality is paramount. This research employs laboratory analysis to assess various parameters, including color, pH, Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), turbidity, and electrical conductivity in drinking water samples collected from the chosen slums. The primary source of drinking water in these communities, tube wells, will be the focus of this analysis.

The study also explores the current water distribution systems within the slums. Problems with water quality in the

distribution system are especially severe in middle-income and developing countries where resources to maintain infrastructure and disinfectant residuals are inadequate [5]. Drinking water supply initiatives play a critical role in securing access [6]. Examining the infrastructure, frequency of supply, and potential issues like waterlogging or contamination will be crucial in understanding the overall accessibility and efficiency of water distribution.

Finally, the research investigates the existing sanitation systems in the selected slums. In 2015, the World Health Organization (WHO) estimated that 2.5 billion people—more than one-third of the global population—lived without basic sanitation facilities [7]. The sanitation situation is worse than water supply in low-cost areas [8]. One of the major factors influencing deprivation or vulnerabilities is the lack of drinking water and sanitation [9]. Poor sanitation and wastewater management are attributed to 280,000 deaths from diarrhoea every year [10].

Through a comprehensive evaluation of water quality, water distribution, and sanitation systems, this research aims to provide valuable insights for policymakers, NGOs, and the RCC. The findings can inform targeted interventions to improve access to safe drinking water, enhance water distribution efficiency, and promote the adoption of hygienic sanitation practices within Rajshahi City's slums. Ultimately, this research aspires to contribute to improved public health outcomes and a better quality of life for the city's most vulnerable residents.

## 2. Methodology

### 2.1. Study Area and Selection

The study was conducted in Rajshahi City, Bangladesh, focusing on eight randomly selected slums. Selection aimed for a representative sample across the city's slum areas.

**Table 1.** Location of sample area.

SL. No	Name of the Slums	Location (Ward no)	SL. No	Name of the Slums	Location (Ward no)	SL. No	Name of the slums	Location (Ward no)
1	Badurtola	25	4	Char Kazla	28	7	Sekherchalk Panchoboti	23
2	Ramchandrapur Baze Kazla East	24	5	Baze Kazla	28	8	Dharampur	28
3	Balurghat	29	6	Powerhouse Para	25			

## 2.2. Data Collection

### Questionnaire Survey:

A standardized questionnaire was developed after a comprehensive review of relevant research to assess water distribution, sanitation practices, and socio-demographic information within the selected slums. The questionnaire was administered to the head of each household in all eight slums, resulting in data collection from approximately 1,000 families. To ensure reliability and validity, the questionnaire was pilot-tested on a small sample of households from non-study areas, and necessary adjustments were made based on feedback. This approach minimized ambiguities and ensured comprehensiveness.

### Water Quality Analysis:

Quality of drinking water indicates water acceptability for human consumption. Water quality depends on water composition influenced by natural process and human activities [11].

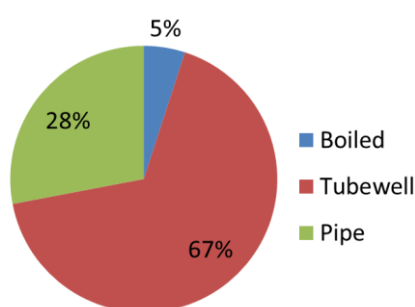
The collected water samples underwent laboratory testing to assess physical parameters including:

1. Color
2. pH
3. Total Solids (TS)
4. Total Dissolved Solids (TDS)
5. Turbidity
6. Electrical Conductivity (EC)

## 3. Results and Discussions

### 3.1. Water Distribution System

#### 3.1.1. Perception of Safe Drinking Water



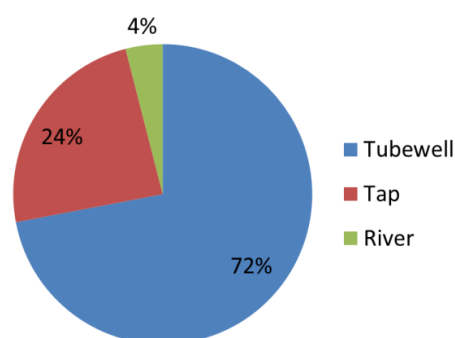
**Figure 1.** The average percentages of perception of drinking water.

Most impoverished homes don't boil their water before using it. They would rather drink them unfiltered, without adding any alum or filter. This practice reflects a combination of financial constraints, lack of awareness about the risks of untreated water, and accessibility issues related to safer water

sources. In this case, the proportion of unique households is 10% in Badurtola and 25% in Ramchandrapur Baze Kazla East. In this instance, the average proportion of slum dwellers on their perception of safe drinking water is 28% pipe, 67% tubewell, and 5% boiled. This limited adoption of boiling or filtering practices may significantly increase the risk of waterborne diseases, particularly in areas where water sources are prone to contamination.

#### 3.1.2. Water Source for Drinking

The majority of slum dwellings get their drinking water directly from tubewells. Tubewell water is used for drinking by 59%, 63%, and 86% of slum inhabitants in Badurtola, Ramchandrapur Baze Kazla East, and Powerhouse Para, respectively. In Sekherchalk Panchoboti, 90% of the slum dwellings use tap water, which is unusual since relatively few dwellings in other slums use tap water as their drinking water source. Additionally, some slum people drink river water. The average percentages are 4% river, 24% tap and 72% tubewell as drinking water source.



**Figure 2.** The average percentages of water sources for drinking.



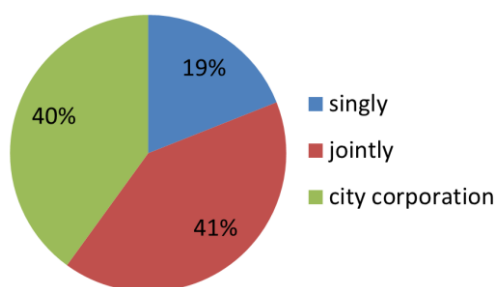
**Figure 3.** Tubewell at Badurtola (City corporation provided).



**Figure 4.** Tap at Sekherchalk Panchoboti.

### 3.1.3. Ownership of Water Sources

In Ramchandrapur Baze Kazla East, every slum dweller uses water sources that are provided by the city corporation. In Sekherchalk Panchoboti, 86% of slum inhabitants use water sources that are provided by the city corporation. Water supplies are shared by 78% of inhabitants in Dharampur and 86% in Powerhouse Para. In Char Kazla, around half of the slum dwellers have access to their own water source. The average percentage is 19% singly, 41% jointly and 40% city corporation provided. Numerous drinking water sources were made available to these slums by the Rajshahi City Corporation authorities.

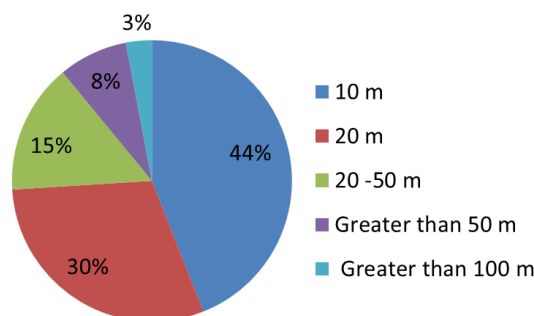


**Figure 5.** The average percentages of ownership of water sources.

### 3.1.4. Distance from Household to Water Sources

Most of the homes have their water sources within a 20-meter range in Powerhouse Para, Char Kazla, Baze Kazla, and Dharampur. Furthermore, 15% of Char Kazla households have water sources that are 50 meters away. To obtain water for drinking and other uses, a sizable portion of the slum population in Ramchandrapur Baze Kazla East and Badurtola

must cross distances greater than 50 and 100 meters. The average percentages of distances are 44% (10m), 30% (20m), 15% (20-50m), 8% (more than 50m), and 3% (more than 100m). Increased distance can lead to reduced water availability for household use, affecting sanitation practices and overall cleanliness. Fetching water, especially over long distances, can be time-consuming and physically demanding, particularly for women and children. Therefore, living more than 50 meters away from a water source can pose significant challenges.

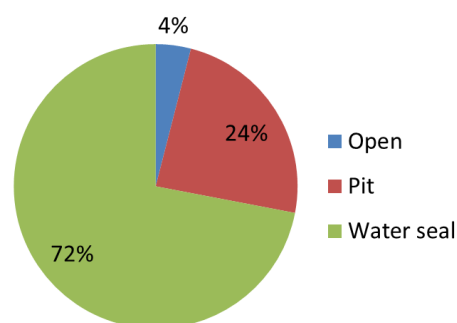


**Figure 6.** The averages percentages of distance from household to water sources.

## 3.2. Sanitation Facilities and Water-borne Diseases

### 3.2.1. Types of Latrine

In most slums, there is a water seal latrine. However, some slum dwellings also have pit latrines. The percentages of people who use pit latrines for defecation in Powehouse Para, Dharampur, Badurtola, Ramchandrapur Baze Kazla East and Balurghat are 29%, 25%, 10%, 25%, and 40%, respectively. 3% people in Badurtola defecates in the open. The mean percentages are 4% open, 24% pit, and 72% water seal. Proper use of water seal latrines can significantly improve sanitation and reduce the spread of diseases, whereas improperly managed pit latrines can contaminate ground-water and soil.



**Figure 7.** The average percentages of latrine types.

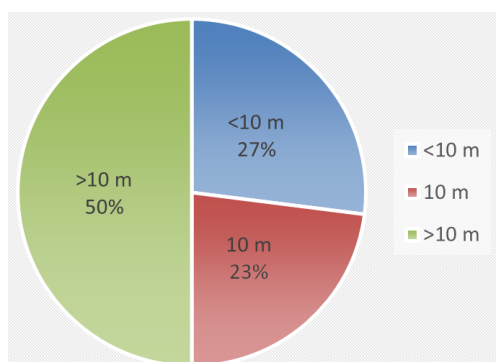




**Figure 8.** Community latrine (City corporation provided).

### 3.2.2. Distance of Latrine and Water Sources

It is discovered that in most slum dwellings, the distance between the water source and the latrine is 10 meters or less. The situation is entirely different in Badurtola, where the latrine is located more than 10 meters from the water source in 80% of the slum dwellings. 63%, 60%, and 58% of households in Ramchandrapur Baze Kazla East, Char Kazla, and Sekherchalk Panchoboti, respectively, have their latrines 10 meters from the water source. The average percentages are 27% (<10m), 23% (10m), and 50% (>10m). When water sources and latrines are close together, there's a higher risk of faecal contamination of the water source. While specific recommendations may vary depending on local conditions, a general guideline is to maintain a minimum distance of 30 meters between water sources and latrines. Households that use pit latrines and have a distance of less than 30 meters between them and a water source are more vulnerable to waterborne illnesses.

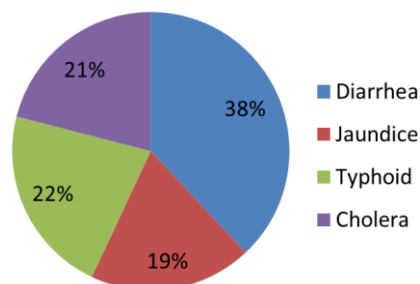


**Figure 9.** The average percentages of distance between latrine and water sources.

### 3.2.3. Previous History of Waterborne Diseases

Due to drinking unclean water, one can easily be diagnosed with a waterborne diseases. It is found that, at least one family member has been affected by any waterborne disease in the last 5-6 months. The average percentage of the slum home having previous history of waterborne diseases are 38%, 21%, 22% and 19% which are Diarrhoea, cholera, typhoid and

jaundice respectively.



**Figure 10.** The average percentage of previous history of waterborne diseases.

### 3.3. Water Quality Assessment

#### *pH and Color:*

pH is an indicator of the acidic or alkaline nature of water, measured on a scale ranging from 0 to 14, where a pH of 7 represents a neutral state. Groundwater is often slightly acidic, primarily due to the dissolution of excess carbon dioxide. In this study, the pH values of the collected water samples ranged from 5.7 to 6.8, indicating an acidic condition. Comparing these findings to the WHO-recommended pH range for drinking water (6.5–8.5) underscores the need for treatment measures to neutralize acidity in slum water supplies.

In its pure state, water is colorless. However, most naturally available water exhibits some degree of coloration due to the presence of impurities. According to the Bangladesh Environmental Conservation Rules (BECR) of 1997, the permissible standard for drinking water color is 15 True Color Units (TCU). The analysis revealed that the color of all collected samples was within the acceptable limit, measuring below 15 TCU.

#### *Turbidity and Electrical Conductivity:*

Turbidity measures the clarity of water by evaluating the extent to which light passes through a sample. It is influenced by the presence of suspended particles, ranging from fine colloidal matter to coarse sediments, depending on the level of turbulence in the water. The sources of turbidity are diverse, and many of the constituent particles (e.g. clays, soils and natural organic matter) are harmless. However, turbidity can also indicate the presence of hazardous chemical and microbial contaminants, and have significant implications for water quality [12]. According to the Bangladesh Environmental Conservation Rules (BECR) of 1997, the permissible limit for turbidity in drinking water is 10 Nephelometric Turbidity Units (NTU). According to the World Health Organization (WHO) guidelines, the permissible limit for turbidity in drinking water is 5 Nephelometric Turbidity Units (NTU), with a maximum allowable limit of 10 NTU for exceptional cases. The analysis revealed that the turbidity levels in all samples were within the acceptable limit, except for the tube well in Ramchandrapur Baze Kazla (provided by

the city corporation), which exceeded the standard value.

Electrical conductivity, on the other hand, measures the ability of water to conduct electrical current, which is primarily influenced by the concentration of dissolved ions. In most natural waters, electrical conductivity is relatively low. In contrast, the conductivity of distilled water is less than 1  $\mu\text{S}/\text{cm}$  [13]. The WHO does not specify a guideline value for electrical conductivity but notes that values above 1,500

$\mu\text{S}/\text{cm}$  may affect the taste and acceptability of water. A generally considered "safe" value for the electrical conductivity of drinking water is less than 1,000 microsiemens per centimeter ( $\mu\text{S}/\text{cm}$ ), as recommended by the Environmental Protection Agency (EPA). In this study, the electrical conductivity of the collected samples varied between 300 and 1300  $\mu\text{S}/\text{cm}$ , reflecting differences in ion concentrations across the selected slums.

**Table 2.** Physical properties of samples.

Slum name	Water source	pH	Turbidity (NTU)	Electrical Conductivity ( $\mu\text{S}/\text{cm}$ )	Color (TCU)
Badurtola	Tubewell*	6.3	1.83	600	5
	Tubewell***	5.7	1.94	400	5
	Tubewell**	6.6	2.56	400	5
	Tap***	6.7	0.28	400	5
Ramchandrapur Baze Kazla East	Tubewell ***	6.4	21.7	1300	5
	Tap	6.4	0.59	450	5
	Tubewell***	6.4	1.63	300	5
Balurghat	Tubewell*	6.5	1.42	280	5
	River	6.8	3.75	280	10
Sekherchalk Panchoboti	Tubewell*	6.4	1.49	600	5
	Tap***	6.3	0.73	500	5
	Tubewell***	6.0	12.22	500	5
Char Kazla	Tubewell*	6.8	4.75	600	5
	Tap***	6.2	3.39	625	5
Baze Kazla	Tap*	6.5	2.04	400	5
	Tap**	6.3	1.65	800	10
Powerhouse Para	Tubewell**	6.3	0.78	600	5
	Tap***	6.6	0.78	400	10
Dharampur	Tubewell*	6.7	1.06	450	10
	Tubewell**	6.5	0.55	400	5

\*= single owner, \*\*= joint owner, \*\*\*= city corporation provided  
Red color indicates value above the safe limit

#### TS & TDS:

Solids are found in streams in three forms, suspended, volatile and dissolved. Suspended solids include silt, stirred-up bottom sediment, decaying plant matter, or sewage treatment effluent. Suspended solids will not pass through a filter, whereas dissolved solids will [14]. Total Solids (TS) and Total Dissolved Solids (TDS) represent the overall concentration of suspended and dissolved substances in water, respectively. This study focused on analyzing major sources of drinking water commonly utilized by slum dwellers in the

selected areas.

The analysis revealed that TS levels in the collected water samples ranged from 200 to 2200 ppm. Although no specific WHO guideline exists for TS, elevated TS levels above 1,000 ppm may indicate contamination, reducing water quality. TDS levels varied between 200 and 700 ppm. According to the World Health Organization (WHO), the recommended limit for TDS in drinking water is 500 mg/L, with an allowable maximum limit of 1,000 mg/L for exceptional cases. Additionally, the Bangladesh Environmental Conservation

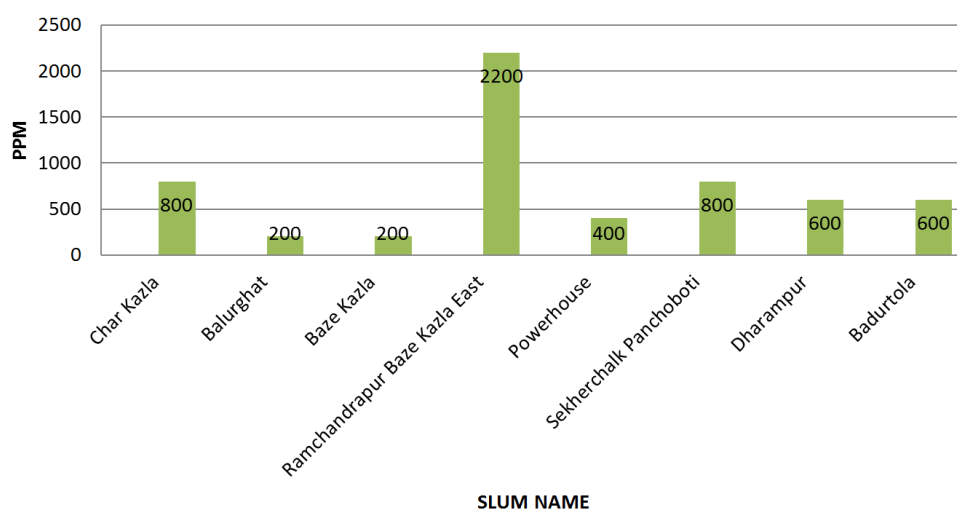
Rules (BECR) of 1997, the permissible limit for TDS in drinking water is 1000 mg/L. The TDS values of all analyzed samples were within the acceptable range. However, elevated TS levels at certain sites highlight possible contamination

sources, warranting further investigation. Figures 11 and 12 illustrate the respective TS and TDS values across the samples.

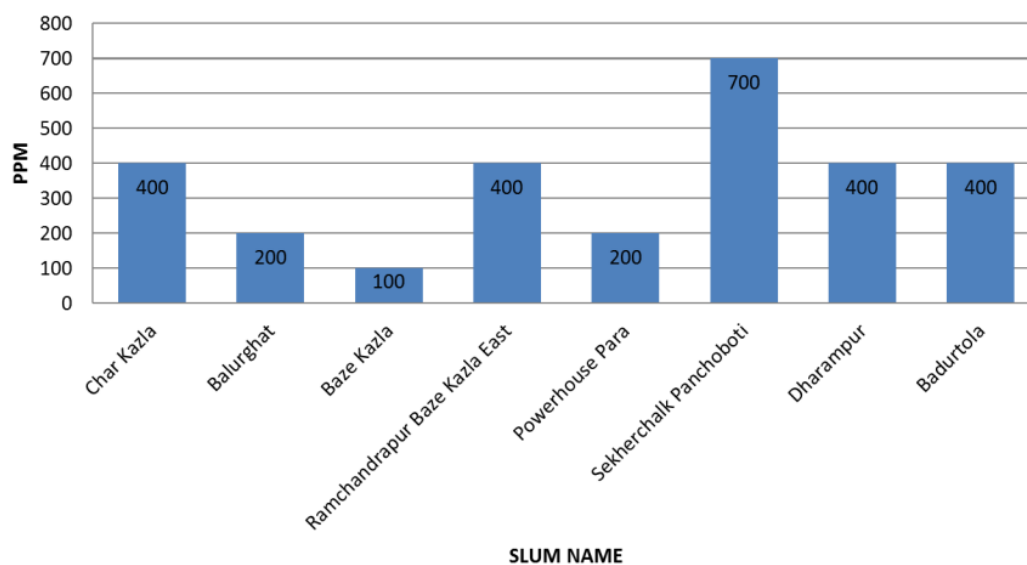
**Table 3.** Major water sources.

Slum name	Major source of water	Slum name	Major source of water
Char Kazla	Tubewell***	Powerhouse Para	Tubewell**
Balurghat	Tubewell***	Sekherchalk Panchoboti	Tap***
Baze kazla	Tap**	Dharampur	Tubewell**
Ramchandrapur Baze Kazla East	Tubewell***	Badurtola	Tap***

\*\*= joint owner, \*\*\*= city corporation provided



**Figure 11.** TS value of samples.



**Figure 12.** TDS value of samples.

## 4. Conclusion

The United Nations projected a rapid population growth in urban areas between 2000 and 2030, suggesting that 6 out of 10 people will live in cities. Therefore, accessible and adequate safe drinking water and sanitation in urban areas, particularly for urban-slum dwellers, should be a priority of policy makers to decrease the risk of water-related diseases [15]. While efforts by the government, Rajshahi City Corporation (RCC), and Non-Governmental Organizations (NGOs) have improved access to water supplies in slum communities, significant challenges persist. To address these, multi-stakeholder approaches focusing on seasonal monitoring of water quality and community-driven initiatives for sanitation improvements are essential. Integrating findings from international case studies could further inform locally appropriate strategies. The analysis in this study revealed that drinking water samples exhibited slightly acidic pH values and varying levels of turbidity, electrical conductivity, Total Dissolved Solids (TDS), and Total Solids (TS). It is important to note that these samples were collected during the spring season, and water quality may vary across different seasons. Contamination risks are likely to increase during the winter and rainy seasons, necessitating further research to understand seasonal variations comprehensively.

The study also highlighted a notable lack of awareness among slum residents regarding the optimal utilization of available services. This knowledge gap underscores the need for targeted educational initiatives led by the RCC, government bodies, and private NGOs to empower communities and encourage hygienic practices.

Additionally, infrastructural vulnerabilities were identified, particularly in the Powerhouse slum, where the low-lying location of households relative to the road results in water accumulation during the rainy season. This exacerbates risks to sanitation and public health. Addressing drainage and flooding issues in such areas is crucial.

Another pressing concern is the disposal of children's excreta directly into the river, which poses significant public health and environmental risks. Drawing lessons from successful urban sanitation projects in comparable low-resource settings, eco-friendly and culturally sensitive solutions can be adopted to mitigate these risks. Interventions to promote eco-friendly sanitation practices, alongside the development of appropriate sanitation infrastructure, are urgently needed. Educational campaigns focusing on the benefits of hygienic practices and the provision of accessible sanitation facilities are essential steps toward mitigating these risks.

By addressing these limitations and challenges, stakeholders can collaboratively improve water quality, enhance the efficiency of water distribution systems, and foster sustainable sanitation practices within Rajshahi City's slums. These

efforts will contribute to better public health outcomes and create a healthier, more sustainable living environment for all residents.

## Abbreviations

WHO	World Health Organization
RCC	Rajshahi City Corporation
TS	Total Solids
TDS	Total Dissolved Solids
NGO	Non-Governmental Organizations
BECR	Bangladesh Environmental Conservation Rules
NTU	Nephelometric Turbidity Unit
TCU	True Color Unit
PPM	Parts per Million
µS/cm	Microsiemens per Centimeter

## Conflicts of Interest

The authors declare no conflicts of interest.

## References

- [1] S. Chowdhury, 'DRINKING WATER QUALITY IN SOME SELECTED SLUMS OF DHAKA CITY, BANGLADESH', 2021. [Online]. Available: <http://www.ijeast.com>
- [2] P. Tirkey, T. Bhattacharya, S. Chakraborty, T. Poonam, B. Tanushree, and C. Sukalyan, 'Water quality indices-important tools for water quality assessment: a review', 2013. [Online]. Available: <https://www.researchgate.net/publication/262730848>
- [3] L. D. Edungbola and S. O. Asaolu, 'Parasitologic Survey of Onchocerciasis (River Blindness) in Babana District, Kwara State, Nigeria', *Am J Trop Med Hyg*, vol. 33, no. 6, pp. 1147–1154, Nov. 1984, <https://doi.org/10.4269/ajtmh.1984.33.1147>
- [4] M. Atiqul Haque, M. Shamim Ahasan, and M. Rahman, 'SANITARY QUALITY AND PUBLIC HEALTH SIGNIFICANCE OF DRINKING WATER OBTAINED FROM DIFFERENT COMMUNITIES'. [Online]. Available: <http://www.bdresearchpublications.com/admin/journal/upload/09172/09172.pdf>
- [5] Richard D. Rheingans & Christine L. Moe, 'Global Challenges in Water, Sanitation and Health', *Journal of Infectious Disease*, vol. 4, no. s, pp. 41–57, 2006.
- [6] 'INDIA INFRASTRUCTURE REPORT 2011 Water: Policy and Performance for Sustainable Development'.
- [7] A. Adeniran, 'Assessment of Water Quality in Slum Area Ibadan', *Hydrology: Current Research*, vol. 09, no. 01, 2018, <https://doi.org/10.4172/2157-7587.1000296>
- [8] P. Biplob, D. Chandra Sarker, and R. Chandra Sarker, 'Assessment of Water Supply and Sanitation Facilities for Korail Slum in Dhaka City', 2011.



- [9] A. Vidhyadharan, 'Disparities in Drinking Water and Sanitation in the Urban Slums of Kerala, India', *Sustainability (Switzerland)*, vol. 15, no. 9, May 2023, <https://doi.org/10.3390/su15097559>
- [10] 'WHO WATER, SANITATION AND HYGIENE STRATEGY 2018-2025', 2018. [Online]. Available: <http://apps.who.int/bookorders>
- [11] T. Akter *et al.*, 'Water Quality Index for measuring drinking water quality in rural Bangladesh: A crosssectional study', *J Health Popul Nutr*, vol. 35, no. 1, Feb. 2016, <https://doi.org/10.1186/s41043-016-0041-5>
- [12] 'WATER QUALITY AND HEALTH-REVIEW OF TURBIDITY: Information for regulators and water suppliers'.
- [13] M. Abdul Halim *et al.*, 'of the People's Republic of Bangladesh Assessment of water quality parameters in baor environment, Bangladesh: A review', *Int J Fish Aquat Stud*, vol. 6, no. 2, pp. 269–263, 2018, [Online]. Available: <https://www.researchgate.net/publication/353514584>
- [14] R. Bhateria and D. Jain, 'Water quality assessment of lake water: a review', *Sustain Water Resour Manag*, vol. 2, no. 2, pp. 161–173, Jun. 2016, <https://doi.org/10.1007/s40899-015-0014-7>
- [15] U.-W. Decade Programme on Advocacy, 'UN-Water Decade Programme on Advocacy and Communication (UNW-DPAC). Biennial report 2010-2011', 2010.