

CASE REPORT

Evaluating groundwater and supply water quality in Rajshahi City: Challenges in water resource management and public perception

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ABSTRACT

Urban water governance is a problem in many developing nations. Rajshahi is located on the bank of the Padma River in the northwest of Bangladesh and is a growing city in Bangladesh's northwest region. The goal of this research was to evaluate the state of the water resources in the Rajshahi City Corporation (RCC) region. The main methods for gathering data were open-ended interview scheduling and water parameter testing. Approximately, 300 families volunteered to take part in the full process of giving data. According to the statistics, 80% of the RCC's population gets its drinking water from subterranean sources, and around 45% of participants, experienced elevated iron. The water in the older town region in particular has serious issues with iron, odor, and color. According to the laboratory test, the maximum levels of Fe and Mn found in groundwater were 12 and 37 times higher than what is considered safe for human consumption. However, the other water quality parameters of groundwater look satisfying although based on the perception people are more or less happy with the amount and quality of water that the Rajshahi Water Supply and Sewerage Authority (RWASA) offers though it is capable of fulfilling only 52.64% of the demand. The findings of this research suggest that, in order to safeguard the public's interest in water supply, groundwater dependency has to be normalized and appropriate policy measures put in place. In order to fulfill Sustainable Development Goals (SDG 6), the government should take the necessary steps. This would eventually improve the socio-economic and living conditions of individuals who live in the study area.

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INTRODUCTION

It is impossible to exaggerate how vitally important clean water is for ecosystems, public health, and many other facets of human existence. The main issue over the last several decades has been ensuring the public has access to enough clean drinking water [1]. Water is essential for life, and development along with the environment, but poor water quality is a significant issue in developing countries like Bangladesh. Unadulterated water is necessary for the sustenance of human beings, but contaminated water is detrimental. Water is a crucial natural resource, important to maintain life, for economic and social growth, and for environmental conservation. Based on a study from the World Bank, the proportion of the population with access to enhanced water sources is just 62%. In 2012, the World Health Organization (WHO) and the United Nations

Children's Fund (UNICEF) together undertook a collaborative monitoring campaign for water supply and sanitation and revealed that over 783 million people in the globe do not have access to clean drinking water and 84% of them are living in remote regions [2, 3]. Drinking water quality is deteriorating owing to population increase, growing cities, economic growth, climate change, woodland loss, soil degradation, and inadequate wastewater treatment. Climate change disrupts the availability of water; deforestation and soil degradation reduce natural filtration. Additionally, the poor treatment of wastewater allows contaminants to enter water sources, further compounding the problem and excess implementation of fertilizer and pesticides in agro fields also increases groundwater pollution [4-6].

Groundwater is the hidden, underground component of the hydrological cycle and plays a vital role in sustaining wetlands and the continuous flow of water bodies [7].

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Groundwater is the fundament of millions of municipal and pastoral people around the globe. Due to the intensive pumping of groundwater, the depletion of the water table increases rapidly. The over-pumping depletion of groundwater can cause salinity intrusion which makes the aquifer useless for drinking and other purposes. Over-pumping also causes the contamination of heavy metals like arsenic intensively which is shown in Bangladesh, West Bengal, Torreon, and Mexico on Irapuato aquifers. Incessant pumping lowers the water level which leads to the release of arsenic and other toxicants from subsurface sediments to the water supply, posing serious health hazards [8]. Rapid urbanization, particularly in developing countries, is placing significant strain on natural resources due to demographic changes. This growth negatively impacts surface water bodies and overall environmental sustainability. Urbanization contributes to the decline of water bodies by increasing impervious surfaces and built-up areas [9]. Furthermore, Bangladesh has seen acute poverty and inequalities in access to water services as a result of unanticipated industrialization [10]. The availability of surface water exhibits inconsistency due to seasonal variation. Groundwater serves as the primary resource for agriculture, industrial applications, and domestic use due to shortages and inconsistencies in surface water supplies [11]. In Bangladesh, the majority of the population considers groundwater or water from tube wells to be free from pollution. For this reason, hand-pumped tube-well water is utilized as the main source of clean potable water in Bangladesh. Roughly 90% of the families employ this hand-pumped tube-well system in Bangladesh [12]. However, most of the population, especially the poor and very poor component, suffers from water quality and health issues associated with unsafe drinking water [13]. By 2030, the present 3 meters per year annual groundwater level decrease is expected to deteriorate to 5.1 meters per year (about 70% more than the current pace). In the next ten to twelve years, the groundwater table may descend to a depth of 132 meters from its current average depth of 78 meters below ground level. This will probably have a significant effect on industry access to groundwater. It is anticipated that this will have permanent effects on the ecosystem [14].

Bangladesh, a constituent of the enormous Ganges-Brahmaputra-Meghna (GBM) Delta basin, faces major potable water supply challenges [15, 16]. Despite being a developing nation, Bangladesh demonstrated significant progress in broad access to a superior supply of water, exceeding 97% of the population in 2013; yet, access to safe drinking water remained inadequate at 34.6%. Almost two-fifths of families (38.3% of the total population) utilize drinking water from sources contaminated with pathogenic bacteria and viruses. Approximately 90% of families in Bangladesh rely on hand-pumped tube-well tech as their primary supply of potable water, as it is popularly perceived that tube wells reliably provide uncontaminated drinking water [4, 12, 17, 18]. The growing competition and need among various water users have prompted the pursuit of novel and inventive strategies for managing water supplies [19, 20]. Some have proposed establishing a "right to the city" as a way to ensure access to water in urban areas. Citizens' freedom to obtain land, employment, and basic necessities should be woven into the civic fabric. There has been the latest endorsement of the New Urban Agenda, which centers on the right to the city and integrates the Sustainable Development Goals (SDGs) [21]. In addition to providing a supply of water, the right to water encompasses the infrastructure and technology required for water transportation, water source site determination, and

the establishment of the right to water as an asset [22]. As one of the strategies, the Rajshahi Water Supply and Sewerage Authority (RWASA) was founded in 2012 to address the water scarcity resulting from the growing population in the Rajshahi City Corporation (RCC) [1]. Several studies were also conducted to determine the quality of supplied water and groundwater, but those studies lack the total comparison and at the same time the city dweller's perception of the quality, quantity, and service of RWASA. The main objective of this study is to evaluate the current water scenario of Rajshahi City Corporation and to warn governmental agencies to look on this major problem. Hence, the current study set out to evaluate the reliability of drinking water pumped up from the ground in the Rajshahi City Corporation area, as well as the quantity and quality of water supplied from RWASA, as a potential long-term solution to the water shortage that already exists there.

MATERIALS AND METHODOLOGY

Study Site

The location of this research is the Rajshahi City Corporation region, which is located 246.9 Km from the capital city of Bangladesh. It has a total population of 388811 within the area of 95.56 km². The city is located between 24°21' and 24°26' north latitudes and 88°28' and 88°37' east longitudes. It is shaped like an inverted "T" and Paba Thana bordered the city on the east, north, and west and Padma River on the south. Figure 1 shows the RCC area with 30 wards.

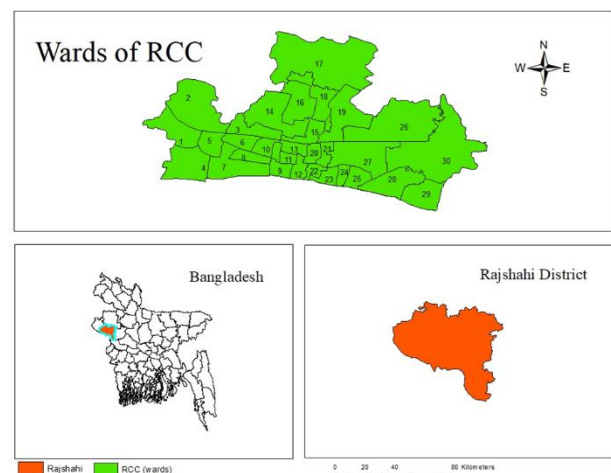


Figure 1. Map of the study area

Questionaries

Residential areas and local communities were the main targets for collecting relevant data from water resource management perspectives. A mixed methods approach was used to design a questionnaire containing the following topics in mind:

- Different sources of drinking water and purifying technology used.
- Quality of water based on various uses.
- Existing water supply scenario of RWASA (cost, availability, service).
- Long-term forethought (existing reserve tank quality & quantity, maintenance period).
- Encountered waterborne diseases if any.

Initially, a total of 300 individuals covering households are made part of the sampling frame with 10 households from each ward. The survey was done based on 1 vs 1 interviews and the authors personally visited each ward and collected data by questioning 12 individual questions, besides this data for the current situation of RWASA was managed from RWASA office by a simple application to provide this data. The main focus was on the residential consumers who do not use bottled water for consumption and other uses. All our collected information was from house owners and tenants for deep, details and actual information. Approximately 300 households (large, medium, and small) were visited and requested to participate in the survey.

Sample Collection

A total of 10 samples were collected from different locations of RCC. The samples were collected in a polypropylene transparent 50 mL centrifuge tube (Sigma Aldrich). The samples were then acidified using ultrapure HNO₃ (65%; MW 63.01 g/mol) to compensate for the 1.75% acidification of the solutions that were needed to preserve the samples for elemental quantification (such as Fe, Mn, etc.). The gathered samples were securely delivered to RUET's public health lab. The authors instantly evaluated the obtained water samples on numerous physical properties, such as EC, pH, turbidity, temperature, etc and the methods are mentioned in Table 2 [23]. The idea of spatial dynamics in water quality and suitability of water is also analysed [24].

Data Analysis

The gathered information was analyzed using standard statistical methods, and results were presented visually or tabulated using computer software such as MS Word and MS Excel to assess water quality.

RESULTS AND DISCUSSION

Current Situation of RWASA

The current situation of RWASA has improved from the past and the service of RWASA has to be quite outstanding day by day. The following Table 1 demonstrates the current capacity and situation of RWASA which has been collected by the authors by physically visiting the office of RWASA.

According to the data collected from RWASA, the two overhead tanks are the Rani Hemanta Kumari overhead water tank and the Ramchandrapur overhead water tank, however, neither of these overhead water tanks is currently in service. Rani Hemanta Kumari water treatment plant and Shahid A. H.M. Kamruzzaman water treatment plant are two water treatment plants for RWASA. Currently, only the Shahid A. H.M. Kamruzzaman water treatment plant is in service. The collected data shows that RWASA now only fulfilled 52.64% of the demanded water.

Table 1. Current condition of RWASA

Water Demand	15939.4 million gallons/year
Supply water	8389.8 million gallons/year
No. of production well	118 nos.
No. of service connection	48645
Total pipeline	859 Km
No. of overhead tank	2 nos.
Capacity of treatment plant	27 MLD
Daily production	1040 MLD
Water availability	12 hours
Pumping time	6 am to 6 pm
Person per house connection	4

Condition of Supply Water

According to the survey, only 20% of the population of RCC (Rajshahi City Corporation) uses supply water, the rest of the population mostly depends on private submersible pumps or community deep tubewells for drinking purposes. This chart indicates that a significant portion of the water comes from submersible pumps, followed by deep tube wells, while supply water makes up the smallest proportion of the water sources (Figure 2). In most cases the community deep tubewell is not at a close distance from the house, as a result, people need to carry water once or twice a day for drinking purposes. The establishment of a submersible pump is also quite expensive.

Inside the area of RCC, about 42% of respondents depend on energy (electricity) to withdraw water from the groundwater aquifer from the underground reservoir to the overhead tank. This also indicates that the water user may face critical issues

when the power is cut off. According to this graphic, most individuals or entities are either entirely or somewhat reliant on energy, with the majority having at least some degree of dependency. Just 18% of people are completely independent of energy. About 40% of people have access to both as they have a community or private tubewell from which they can collect their minimum required water when any electric or supply problem is encountered. Only 18% of people do not face any problems during the disruption of the supply system. This indicates that electricity plays a significant role in such a supply system because if the electricity is not present for more than 24 hours the population of the city may face extreme situations (Figure 3).

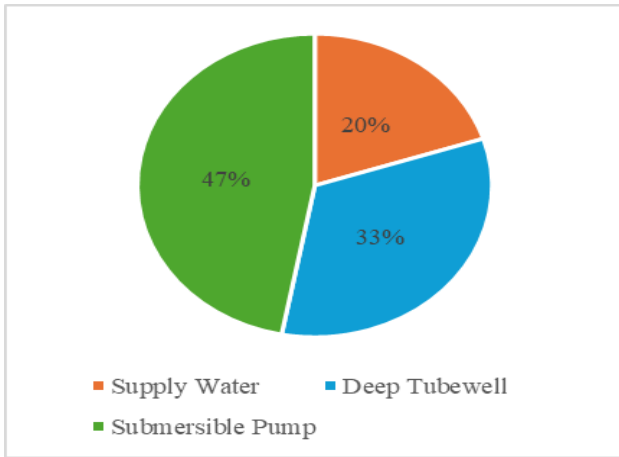


Figure 2. Perception of drinking water source

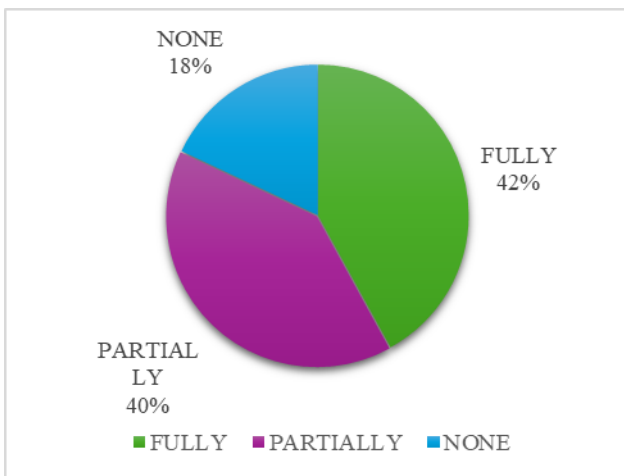


Figure 3. Dependency of people on energy

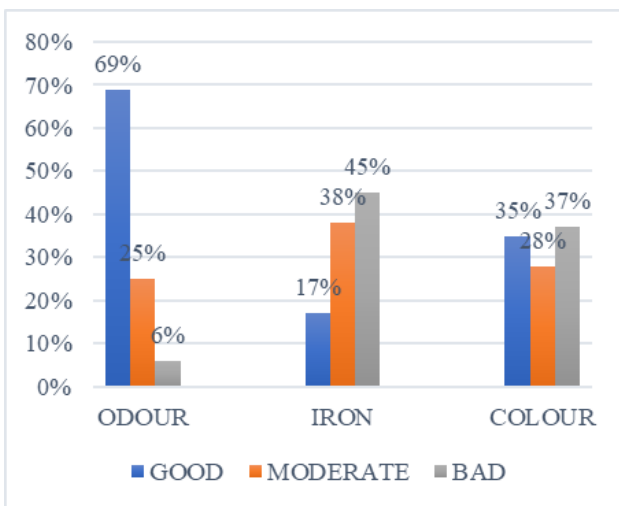


Figure 4. Quality of supply water

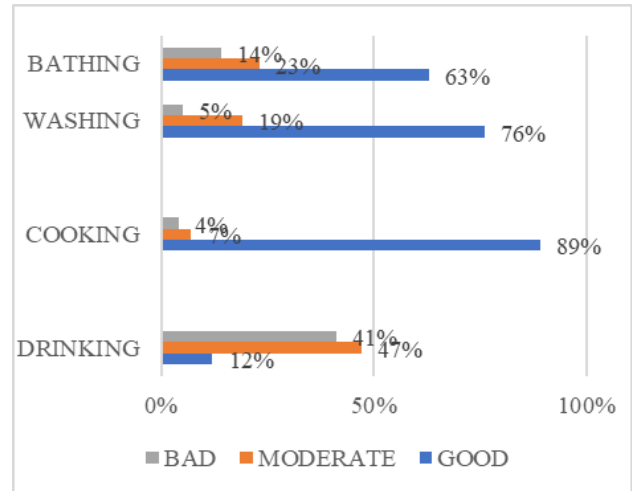


Figure 5. Suitability of supply water

According to the survey, among the 52.64% of consumers who have a supply water connection, 69% of consumers confirmed that the odor of the water supplied was good, 25% said it was moderate, and 6% said it was bad. In Rajshahi District, most water contains excess iron, with 45% of consumers claiming their supplied water has high iron levels and 38% saying the iron problem is moderate based on their hypothesis. Additionally, 37% of respondents reported bad color in the supplied water, while 35% said the color was good. The water samples examined had generally acceptable odor quality. Iron and color levels, however, have serious quality problems, with a large proportion of samples falling into the poor range for the two. Priority should be paid to water purification or source enhancement since the high iron level and poor color quality suggest possible difficulties in reaching safe drinking water requirements (Figure 4). The issues with iron, odor, and color are mainly experienced in the morning. The survey suggests that the problem might be due to the chlorination of the supplied water. Consumers often assume that tap water is appropriate for purposes other than drinking when questioned about its suitability. Merely 12% of the participants think that drinking tap water is safe. Of the respondents, 89% verified that tap water is OK for cooking, 63% said there were no problems using it for bathing, and 76% said it's good for washing clothes. On the other hand, 5% of respondents reported issues like stains after using tap water to wash their clothing (Figure 5).

Figure 6 depicts the number of reserve tanks currently present inside the households of the participants. The data shows that 69% of users had just one reserve tank, while only 7% possessed more than two tanks for saving water for future use. According to the statistics, consumers' water storage habits show a trend, with 69% of them depending on a single reserve tank to meet their demands. This implies that most users may not have much water storage capacity, whether as a result of financial concerns, lack of perceived need for extra reserves, or space limitations. Because they only have a single tank, these consumers may be more susceptible to water shortages in the event that the supply is interrupted because they have less water stockpiled for emergencies. On the other hand, just 7% of customers have more than two tanks. Due to concerns about water availability, a desire for greater resilience against supply disruptions, or the necessity for larger amounts of stored water (possibly as a result of larger households, higher water usage, or areas with more frequent supply interruptions), this

minority probably represents those who place a higher priority on having a larger buffer for future water use. All things considered, this distribution shows that although the majority of users maintain minimal storage with just one tank, a small but noteworthy group purchases additional tanks, illustrating variations in water storage tactics depending on variables such as household requirements, financial means, and the dependability of the local water supply. According to Figure 7, most people clean, verify, and wash their reserve tanks yearly. Yearly maintenance demonstrates a widespread knowledge of the necessity of clean water storage, but the frequency may be driven by convenience or a belief that annual maintenance is enough to assure water quality. In cases of excessive iron concentration or discoloration in their water supply, people are more proactive. More often, these people maintain their reserve tanks and home plumbing system every six months. This more rigorous maintenance program helps prevent possible difficulties caused by iron deposits or discoloration, which may collect in both tanks and pipes, compromising water quality, flavor, and potentially even the longevity of the plumbing system. This conduct suggests a heightened degree of alertness among persons who know the hazards connected with water quality concerns. Increased maintenance frequency reduces these concerns, delivering safer and cleaner home water. This proactive approach underlines the importance of water quality knowledge on maintenance behaviors and proposes that focused education might induce more regular maintenance among users experiencing water quality concerns.

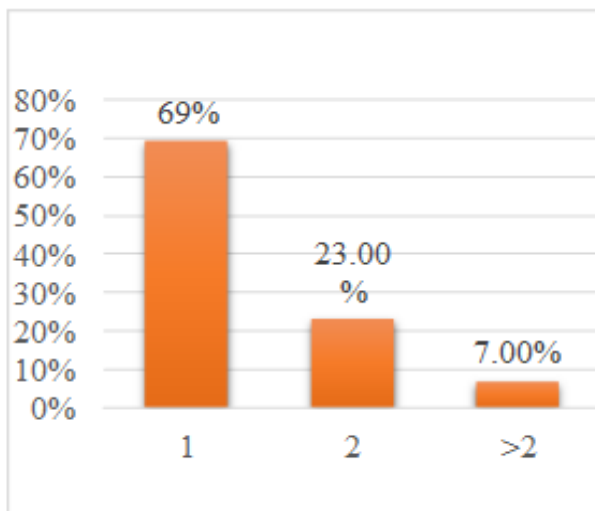


Figure 6. No. of reservoir tank

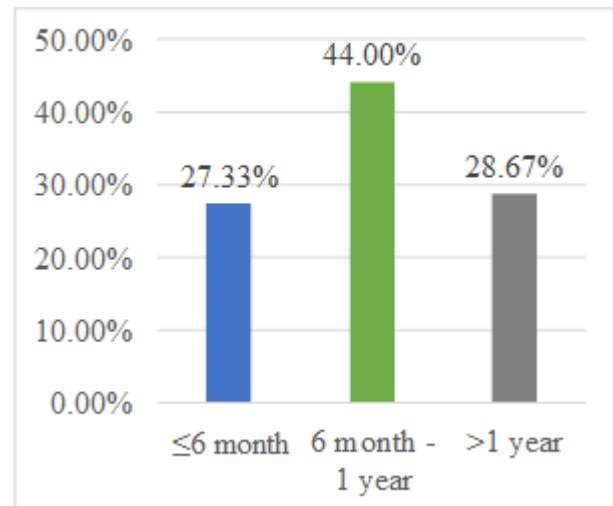


Figure 7. Maintenance period of reserve tank

The distribution of people using various purifying techniques to make drinking water safe is shown in Figure 8. The boiling approach, one of the easiest and most economical ways to eradicate microorganisms, is used by the majority of recipients (51.67%) who treat their water. Boiling is particularly well-liked in low-resource areas since it is a commonly available technique that doesn't require extra equipment. Another 36.67% of people use filters that are sold commercially. Sediment, germs, and certain chemicals are among the impurities that these filters are usually better at eliminating. They may need frequent maintenance or replacement components, though, and their greater initial cost might be a deterrent for lower-income homes. According to the data, the majority of this water supply's users live in impoverished regions with a restricted budget. As a result, they choose the boiling approach since it is inexpensive and accessible, whereas a smaller percentage can purchase or use commercial filtering devices. This distribution emphasizes the necessity for sustainable, reasonably priced solutions in disadvantaged areas as well as the impact of socio-economic considerations on the selection of water purification techniques. Figure 9 shows that the majority of the respondents used the supplied water for less than 30 years which is quite a long period. In particular, the older houses have supplied water systems for a long period.

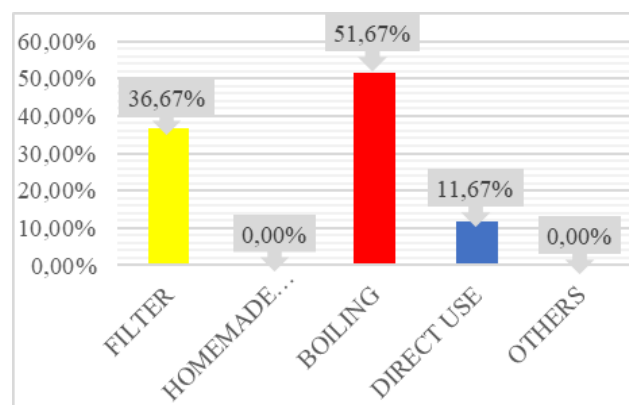


Figure 8. Purifying process of supply water

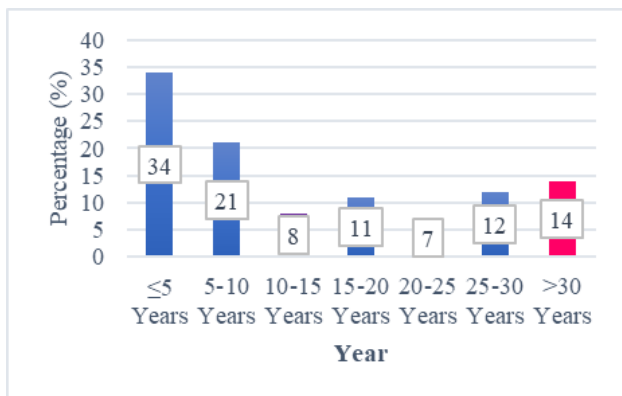


Figure 9. Years of service taken

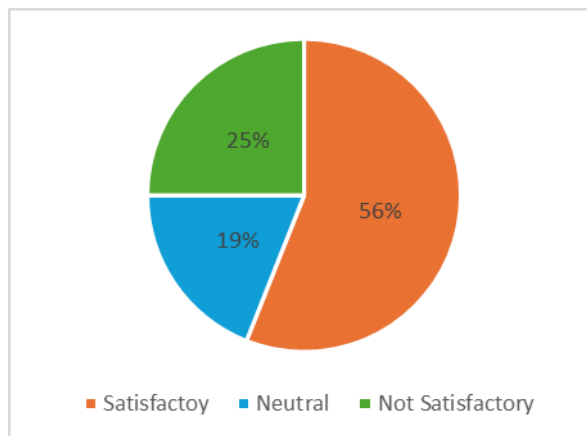


Figure 10. Service of RWASA water

Figure 10 shows the levels of user satisfaction with RWASA's (Rajshahi Water Supply and Sewerage Authority) services. The results indicate that 56% of respondents are satisfied with the service, representing more than half of the total responses. This majority who have the supply water connection and use this water for various purposes suggests that RWASA's service meets the expectations or needs of a significant portion of users, which could be attributed to factors like water availability, quality, and reliability of service. On the other hand, 25% of respondents express dissatisfaction with RWASA's service. This notable portion points to areas where users feel that RWASA's service does not meet their needs, which may involve issues such as service interruptions, water quality concerns, or customer service. Additionally, 19% of respondents remain neutral, indicating a moderate level of satisfaction where users may neither feel strongly positive nor negative about the service. This neutral group may represent individuals who have infrequent interactions with the service or whose needs are minimally impacted by RWASA's performance. Overall, the data suggests that while the majority of users are satisfied with RWASA's services, a considerable portion remains dissatisfied, pointing to potential areas for improvement. Figure 11 depicts respondents' perceptions of the cost of water delivered by the service provider. A considerable number of respondents say that the cost of water supply is high, showing a general attitude that the pricing may be burdensome or surpass what they consider fair or reasonable. Additionally, approximately one-fourth of respondents are unsatisfied with the cost of given water, further underlining widespread unhappiness connected to pricing. This discontent might originate from perceived mismatches between the expense and the quality or reliability of the service. The data also reveals that people perceive a pattern of escalating expenses over time. This steady increase might create a further financial burden on households, especially in low-income neighborhoods, and may contribute to the general discontent found among respondents. These findings indicate an opportunity for the service provider to assess the price structure and propose methods to promote affordability, as well as to communicate honestly about the elements that drive pricing. Addressing these problems might increase customer satisfaction and make the water supply more accessible to a larger audience.

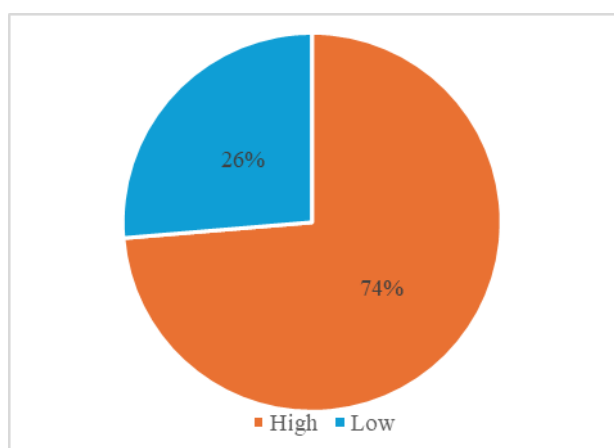


Figure 11. Fare of supply water

The analysis of waterborne disease occurrences among users of this water source reveals a low overall rate of disease, with only 5% of respondents reporting illness within the past month (Figure 12). However, those affected primarily suffered from common waterborne illnesses such as diarrhea, cholera, jaundice, and skin diseases. Among these, jaundice (specifically Hyperbilirubinemia) was the most frequently reported, accounting for about 40% of the cases (Figure 13). The data highlights that certain areas are more prone to these health issues, including older sections of the city, the Rajshahi University of Engineering & Technology (RUET), Rajshahi University, and the student halls of Rajshahi Medical College. Students and residents in these areas appear to be at a higher risk, possibly due to environmental or infrastructural factors that contribute to contamination.

The potential causes for these health issues, as identified by the respondents, include leakages in the water supply lines and poor water conservation practices in homes. These defects can allow contaminants to enter the water supply, increasing the risk of waterborne diseases. The findings suggest a need for improved infrastructure maintenance, particularly addressing pipeline integrity and water storage practices, to prevent contamination and reduce disease occurrences.

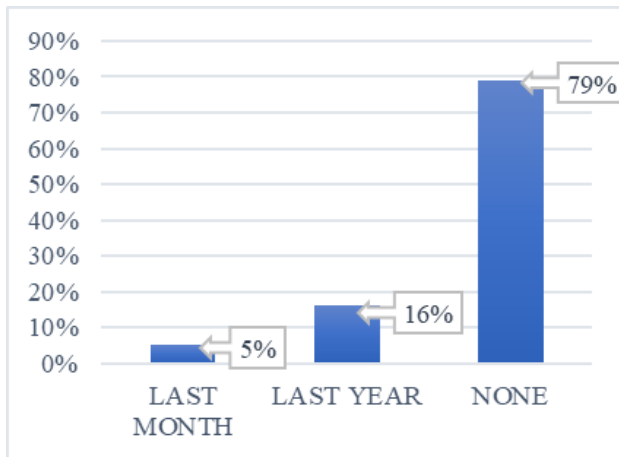


Figure 12. Occurrence of waterborne diseases

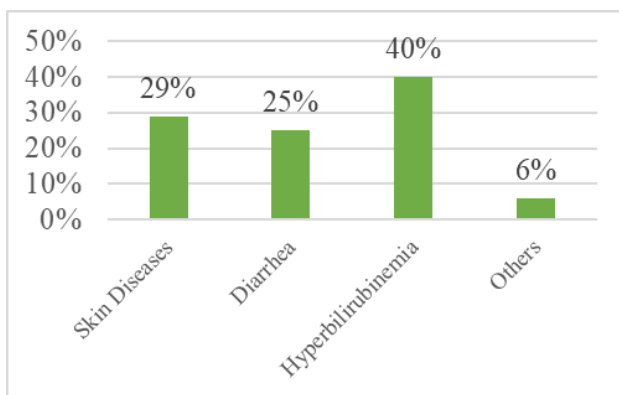


Figure 13. Types of waterborne diseases

Water Parameters of Groundwater

Some of the major water quality parameters, such as pH, concentration of Fe & Mn, conductivity, temperature,

turbidity, TDS, DO, etc., have been tested from different locations of RCC. Water quality is a major problem for the acceptance of RWASA supply water, and most people of RCC still consume groundwater. The drinking water quality standards are shown in Table 2.

Five locations were selected based on the user's perception of those areas and the groundwater quality was determined using standard methods and instruments. The tested sample data is given below in Table 3.

Table 3 indicates that most water quality data are within the WHO and BD standards but iron and manganese problems are severe. The pH value of five sample data was within the range of 7.0-7.4 which is good for human consumption. The maximum temperature observed was 19.1°C. This temperature might look low, but the water sample was collected during the winter season. High turbidity blocks sunlight from entering and disrupts the photosynthetic processes of plants submerged in water. Turbidity can be caused by suspended particles such as algae, decomposing plant leaves, organic debris, and eroding soil. Turbidity in water can occur as a result of the presence of suspended particles such as degraded soil, algae, decomposed plant leaves, organic materials, etc. High turbidity disrupts photosynthesis in aquatic plants. This affects the food chain of live water bodies and unbalances the aquatic ecology [27]. Electric conductivity (EC) readings are conventionally implemented as a proxy for the amounts of salts in water. Salinity levels vary due to the aquifer conditions and the flow and origin of water. The electric conductivity of most of the samples is within the limit of both WHO and Bangladesh Standards. The maximum EC encountered was 1652 µS/cm which exceeds both the standards for drinking water. TDS, DO, and Coliform all these three parameters are okay for drinking. However, the main problem and dissatisfaction arise with the iron and manganese content of the groundwater, according to the laboratory test the amount of Fe and Mn is much higher than the permissible limit. The maximum value of Fe & Mn was 1.23 and 3.70 mg/l respectively, about 12 and 37 times the Bangladesh standard.

Table 2. Drinking water quality standards [25, 26]

Parameters	Bangladesh standards (BS)	World Health Organization (WHO) guidelines	Determination Methods
pH	6.5-8.5	6.5-8.5	Multi-parameter analyzer (Pocket Tester)
Temperature	20-30°C	--	Multi-parameter analyzer (Pocket Tester)
Turbidity	10 NTU	5 NTU	Turbidity meter
Manganese	0.1 mg/l	0.4 mg/l	AAS
Iron	0.3-0.1 mg/l	0.1 mg/l	AAS
Electric Conductivity	600-1200 µS/cm	1200 µS/cm	Multi-parameter analyzer (Pocket Tester)
TDS	1000 mg/l	--	Multi-parameter analyzer (Pocket)
DO	6 mg/l	--	
Coliform (Total)	0 N/100ml	0 N/100 ml	MPN method
Residual Chlorine	0.2 mg/l	--	Titration method

Table 3. Different parameters of five water samples

Parameters	S1	S2	S3	S4	S5
pH	7.2	7.1	7.4	7.1	7.0
Temperature (°C)	17.4	18.6	19.1	18.1	18.4
Turbidity (NTU)	2.0	0.75	1.5	4.0	1.0
Manganese (mg/L)	3.70	0.82	1.62	0.1	1.60
Iron (mg/L)	1.23	0.23	0.1	0.55	0.1
Electric Conductivity (µS/cm)	964	724	1652	805	1100
TDS (mg/L)	395	548	721	400	439
DO (mg/L)	4.2	4.8	3.6	5.1	3.9
Coliform (Total)	0	0	0	0	0

Water Parameters of Supply Water

Similar to the process of testing the groundwater quality of RCC five locations are selected for collecting supply water samples and testing. The results of tested samples for different locations are given below in Table 4.

The pH of the groundwater samples analyzed was found to be neutral to slightly acidic. These values were well within the safe limits prescribed by both WHO and the Bangladesh Drinking Water Standards (BDS). The pH of drinking water must be carefully controlled at neutral levels because if water is too acidic or basic, it poses a risk of corrosion to the pipes and may also cause health complications. Majority of the samples obtained of constant temperature in broad agreement with the average groundwater temperature recorded in Bangladesh. While temperature was not considered a health concern, it is a factor that affects other parameters like dissolved oxygen content, microbial activity, and water quality in general. All samples showed great turbidity higher than WHO guidelines of ≤ 1 NTU and most were also above BS. High turbidity stands for high concentration of suspended solids which may promote the presence of pathogens and lowers the effectiveness of treatment options available for the water. Concentrations of manganese and iron were both very concerning in measurement and were well above the EPA guideline for safe concentrations in drinking water. Manganese, in excess, has the possibility of turning the water unappealing in color and taste with its higher degrees posing serious health hazards, especially on the nervous system. Iron too is a real trouble poison, especially at high levels for functional and even

aesthetic reasons; its excessive concentrations in water are staining and blocking related operations water systems such as pipes, tanks, and warmers. These results call for the introduction of new water treatment systems that will help in removing these metals. The EC of the supply water mostly exceeded standards and TDS levels were within the permissible limits, but the values were nearly at the upper tolerable levels. This indicates high dissolving of less salts and a moderate degree of particulate solids in the water which though not harmful now, places a risk of higher levels of salinity or mineralization in the near future. There should be a proactive approach including monitoring to ensure that these values do not go beyond the limits. All the groundwater samples examined were found to contain a dissolved oxygen concentration lower than the required concentration of ≥ 6 mg/L. Extended periods of low DO concentrations are responsible for the development of oxygen depletion conditions and consequential growth of anaerobic microorganisms which in return leads to the production of toxic substances such as hydrogen sulfide. This is troubling for the groundwater organisms and potentially, the water's edible aspect. Total coliform was detected in every sample taken, violating the WHO advice of 0 CFU/100mL for drinking water. Such presence tells that there is human waste in the water because it contains bacteria which leads to great health risks associated with the consumption of water with bacteria, leading to diseases such as diarrhea, cholera, and typhoid. This issue raises the importance of ensuring disinfection barriers and containment of potential external sources of pollution.

Table 4. Different parameters of five supply water samples

Parameters	S1	S2	S3	S4	S5
pH	6.8	7.1	6.5	7.1	6.9
Temperature (°C)	25.2	26.1	24.8	25.5	25.3
Turbidity (NTU)	5.4	6.0	4.5	5.2	5.7
Manganese (mg/L)	2.9	2.1	1.7	1.0	0.8
Iron (mg/L)	1.4	1.6	1.2	1.5	1.3
Electric Conductivity (µS/cm)	1250	1400	1100	1300	1200
TDS (mg/L)	850	720	800	890	670
DO (mg/L)	2.6	0.27	4.7	3.5	3.44
Coliform (Total) (CPU)	22	18	25	21	20
Residual Chlorine (mg/L)	0.02	0.1	0.0	0.02	0.16

CONCLUSIONS

In this research paper, the author presents and discusses the main challenges regarding water governance and quality in Rajshahi City Corporation (RCC), Bangladesh, whose population depends largely (80%) on groundwater that is highly contaminated with iron as much as 12 times and manganese as much as 37 times above the safe limits. The provision of water services in Rajshahi is the responsibility of the Rajshahi Water Supply and Sewerage Authority (RWASA) which covers only 52.64% of the water demand where only 20% of the residents use the supply water for drinking due to the poor quality and the high cost of the water. However, customers have been dissatisfied with the cost of services for a few years, which is why the majority of them employ deep tube wells and submersible pumps. Users raise concerns that the water supplied to them has a high concentration of iron, has a bad smell, and is discolored whereby they default to using private deep tube wells and submersible pumps which are expensive and not sustainable. Water quality has also been associated with diseases such as jaundice and diarrhea. But further investigations can be done because the water quality data were collected during a single season (winter), ignoring seasonal fluctuations (e.g., monsoon vs. dry season) that significantly affect groundwater levels, contamination risks (e.g., bacterial load), and supply water quality. Despite many of the water quality indicators being measured falling within the acceptable range, iron and manganese levels posed significant problems, and therefore, action should be taken immediately. Refraining from excessive groundwater use and enhancing RWASA's performance to provide an affordable and sufficient water supply is recommended in this study as a key point to establish SDG 6. To make the provided water more accessible for locals, particularly those living in low-income regions, the pricing system should be reviewed and modified. Authorities need to implement the required actions to make use of surface water, including rainwater and river water. Projects involving groundwater and surface water purification facilities have to be carried out by the government. NGOs along with government entities should promote the use of water-saving methods such as effective rainfall collection and wastewater reuse.

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DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest with any individual, institution, or organization in the preparation, evaluation, or publication of this study.

USE OF AI FOR WRITING ASSISTANCE

Authors declare no use of AI for writing assistance.

ETHICS

There are no ethical issues with the publication of this manuscript.

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