Global Scholars Journal of Multidisciplinary Studies
ISSN xxx-xxxx (Print) & ISSN xxxx-xxxx (Online)
Frequency: Bi-Annual
DOI: xxxxxxxxxxxxxxxxxxxxxxxx

GLOBAL SCHOLAR Publishers
Website: www.gspublisher.org
Email: editor@gspublisher.org
Volume-1 | Issue-1 | Sep-Oct 2025

Assessment of Tube-Well Water Quality for Drinking Purpose at Mirpur Upazila, Kushtia District, Khulna, Bangladesh

Shahria Imam Zahid, Md. Abdul Khaleq Sarker Rabbeny, Md. Saikat Hossain, Ridita Bairagi, Dr. Khandoker Qudrata Kibria

Soil, Water and Environment Discipline, Khulna University, Khulna, Bangladesh

Abstract: ***Background:*** *Access to safe drinking water is essential for human health. However, in many rural areas of Bangladesh, tube well water quality is compromised by physical and chemical contaminants, notably elevated iron levels.*
Aim of the study: *This study aims to evaluate the drinking water quality of tube wells in Chalk village, Mirpur upazila of Kushtia district by comparing the results with World Health Organization (WHO) and Bangladesh drinking water standards.*
Methods: *A total of 35 tube well water samples were collected and analyzed for key physical parameters (color, odor, taste, temperature, total dissolved solids) and chemical parameters (pH, electrical conductivity, sodium, potassium, chloride, bicarbonate, and iron). Standard analytical methods were used, and findings were compared to WHO (2011) and Bangladesh (ECR'97) guidelines.*
Result: *The analysis revealed that 13% of the samples were of very poor quality, 19% were poor, 45% were good, and 23% were excellent for drinking. Physical parameters like taste and temperature were mostly within acceptable ranges, whereas color and odor were often unfavorable. Chemical parameters such as pH, EC, sodium, potassium, chloride, and bicarbonate were generally within standard limits, while iron levels exceeded recommended thresholds in several samples. The study highlighted that tube well depth between 180–210 feet can help maintain acceptable iron concentrations.*
Conclusion: *Although the majority of tube well water samples were of good to excellent quality, concerns regarding iron concentration, color, and odor remain. Proper management of tube well depth and regular monitoring are recommended to ensure safe drinking water in the study area.*
Keywords: *Water quality, Tube well, Physical parameters, Chemical parameters, Iron contamination*
Corresponding author: *Shahria Imam Zahid, Soil, Water and Environment Discipline, Khulna University, Khulna, Bangladesh, Email:* shahriaimamzahid@gmail.com

Original Research Article

****Correspondence:***
Shahria Imam Zahid,
Soil, Water and Environment Discipline, Khulna University, Khulna, Bangladesh,
Email: shahriaimamzahid@gmail.com

How to cite this article:
Shahria Imam Zahid, Md. Abdul Khaleq Sarker Rabbeny, Md. Saikat Hossain, Ridita Bairagi, Dr. Khandoker Qudrata Kibria Assessment of Tube-Well Water Quality for Drinking Purpose at Mirpur Upazila, Kushtia District, Khulna, Bangladesh Global Scholars Journal of Multidisciplinary Studies 2025; 1(1): 35-46.

Publication history:
Received: August 10, 2025
Revised: August 25, 2025
Accepted: September 09, 2025
Published: September 15, 2025

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) is a global health burden and a leading cause of chronic liver disease, closely linked to the rising prevalence of obesity and type 2 diabetes mellitus (T2DM) [1]. It encompasses a spectrum of liver conditions, from simple steatosis (fat accumulation in more than 5% of hepatocytes) to non-alcoholic steatohepatitis (NASH), which can advance to fibrosis, cirrhosis, and hepatocellular carcinoma [1]. NAFLD is recognized as the hepatic manifestation of metabolic syndrome, often characterized by insulin resistance, dyslipidemia, and a proinflammatory state [2]. Its prevalence is approximately 30% in Asian populations and affects nearly one-third of the global population, with a higher incidence (70-80%) among individuals with Type 2 Diabetes Mellitus (T2DM) and obesity [2,3]. The pathogenesis of NAFLD involves lipid accumulation, insulin resistance, oxidative stress, and inflammation [4]. Lifestyle modifications, including exercise and weight loss, remain the cornerstone of NAFLD management, but these interventions are challenging to maintain long-term [5]. Furthermore, lifestyle changes alone are inadequate for advanced disease stages, highlighting the need for effective pharmacological treatments [6]. Despite significant progress in understanding NAFLD pathophysiology, the development of reliable therapies targeting key metabolic pathways has been limited [7]. Numerous drugs have been tested in the past decade, but none have achieved definitive therapeutic endpoints [7]. Peroxisome proliferator-activated receptors (PPARs) are nuclear receptors critical for regulating metabolic homeostasis, inflammation, cellular growth, and differentiation. PPARs exist in three main isoforms: alpha (α) in the liver, beta (β)/delta (δ) in skeletal muscle, and gamma (γ) in adipose tissue. Drugs targeting both PPARα and PPARγ, such as glitazars, have been explored for addressing dyslipidemia and insulin resistance (IR) in non-alcoholic fatty liver disease (NAFLD). However, the development of early glitazars (Tesaglitazar, Muraglitazar, Aleglitazar) was discontinued due to adverse effects linked to their significant PPARγ activity. Saroglitazar, a novel dual PPARα/γ agonist with predominant PPARα and moderate PPARγ activity, demonstrates a favorable safety profile, overcoming the limitations of earlier agents [8]. In South Asian countries like India, saroglitazar magnesium (Lipaglyn) is approved for type 2 diabetes (T2D) and dyslipidemia. It has shown promise in clinical trials for treating non-alcoholic steatohepatitis (NASH), highlighting its potential in managing metabolic syndrome-related disorders [9]. Unlike thiazolidinediones and fibric acid derivatives, saroglitazar is a unique compound that regulates lipid and glucose metabolism by activating PPARα and PPARγ. Its insulin-sensitizing properties stem from PPARγ activation, leading to a reduction in blood glucose levels. Concurrently, PPARα activation enhances hepatic fatty acid oxidation while suppressing triglyceride synthesis and secretion. This dual action promotes increased lipolysis and facilitates the clearance of triglyceride-rich lipoproteins from plasma by upregulating lipoprotein lipase (LPL) activity and downregulating Apo C-III, an endogenous inhibitor of LPL [10]. Additionally, saroglitazar lowers low-density lipoprotein (LDL) cholesterol levels, boosts the synthesis of apolipoproteins A-I and A-II, and elevates high-density lipoprotein (HDL) cholesterol. Currently approved for managing diabetic dyslipidemia in patients with inadequate response to statin therapy, saroglitazar holds promise for broader metabolic applications [10,11]. Despite these encouraging findings, there remains a need for further clinical evidence regarding the long-term safety and efficacy of saroglitazar, especially in comparison to other emerging pharmacologic agents. The study aims is to evaluate the efficacy and safety of saroglitazar in the management of NAFLD. Water is fundamental to the survival of all life forms and is intricately linked to human health, wellbeing, and economic development [1]. Globally, about 2.2 billion people still lack access to safely managed drinking water services [2], making water quality a pressing public health concern. In addition to sustaining ecosystems, clean water is essential for food security, livelihoods, and social development [3]. Freshwater resources are, however, increasingly under threat from both natural and anthropogenic factors. Natural processes such as floods, weathering of parent materials, climatic variations, and geographic influences, combined with human activities like industrial discharge, agricultural runoff, urbanization, and improper waste disposal, contribute to widespread groundwater contamination [4, 5]. Groundwater, which serves as a major drinking water source, particularly in developing nations like Bangladesh, is increasingly affected by these contaminants [6,7]. Bangladesh, a densely populated South Asian country, relies heavily on groundwater for its domestic, agricultural, and industrial needs [8]. Around 97% of rural drinking water needs are met by groundwater, primarily accessed through hand-pumped tube wells [9]. However, groundwater quality varies significantly depending on regional hydrogeology, recharge conditions, aquifer depth, and human activity [10]. Factors such as unregulated groundwater abstraction, agrochemical usage, and lack of wastewater management exacerbate contamination risks [11]. Metal ions, notably iron and arsenic, often dissolve into groundwater during its passage through geologic strata, leading to elevated concentrations in drinking water sources [12]. Chronic exposure to contaminated water is associated with severe health outcomes including gastrointestinal diseases, liver damage, cardiovascular diseases, and increased mortality from waterborne illnesses such as diarrhea, cholera, dysentery, and typhoid. According to WHO (2019), unsafe drinking water accounts for an estimated 485,000 diarrheal deaths annually [13]. In rural Bangladesh, shallow tube wells are extensively used without proper water quality monitoring. Although the installation of tube wells significantly reduced waterborne diseases in the past, iron contamination has become a pervasive issue, especially in shallow aquifers. Physical characteristics such as color, odor, and taste, alongside the concentration of organic and inorganic constituents, serve as preliminary indicators of drinking water quality [14]. The present study focuses on Chalk village, located in Sadarpur Union of Mirpur Upazila, Kushtia District, Khulna Division, Bangladesh, covering an area of approximately 3.06 square kilometers. The village population predominantly relies on shallow tube wells for drinking water. Severe iron contamination is evident, as freshly drawn water gradually turns yellowish or reddish and emits a strong iron odor after exposure to air. Preliminary observations suggest a high prevalence of liver, heart, and pancreas-related diseases among the villagers, likely linked to poor water quality. Despite the evident health risks, no prior studies have been conducted to evaluate the drinking water quality in this area. This study aims to assess the groundwater quality of Chalk village by analyzing physical and chemical parameters, comparing them with Bangladesh and WHO standards using the Water Quality Index (WQI), and recommending optimal tube-well depths, while noting limitations such as lack of heavy metal analysis and restricted sampling within Mirpur Upazila.

MATERIAL AND METHODS

This was a cross-sectional, observational study conducted based on primary data collected through field sampling. The primary data involved the physical and chemical analysis of groundwater samples from tube wells.

Inclusion Criteria

- Tube wells located within Chalk Village of Sadarpur Union, Mirpur Upazila, Kushtia District.
- Tube wells used regularly for domestic drinking purposes.
- Tube wells accessible for water sample collection.

Exclusion Criteria

- Tube wells showing mechanical defects or non-functionality at the time of sampling.
- Wells located in industrial or non-residential zones.

Ethical Considerations

Prior verbal consent was obtained from all tube-well owners before sample collection. No personal identifiers were used in data presentation. As the study involved environmental sampling without human intervention, formal ethical approval was not required.

Data Collection Procedure

Water samples were collected from various paras (local neighborhoods) within Chalk Village, Sadarpur Union, Mirpur Upazila, Kushtia District, Khulna Division, Bangladesh. The village is geographically bounded between latitudes 23°85′18″ to 23°85′84″ North and longitudes 88°93′45″ to 88°94′21″ East, covering an area of approximately 3.06 km². Neighboring villages include Mehernagar (south), Titutala (north), Kakiladha (west), and Basbaria (east). A canal flows to the north of the village. Figure 3.1 shows the sampling location map.

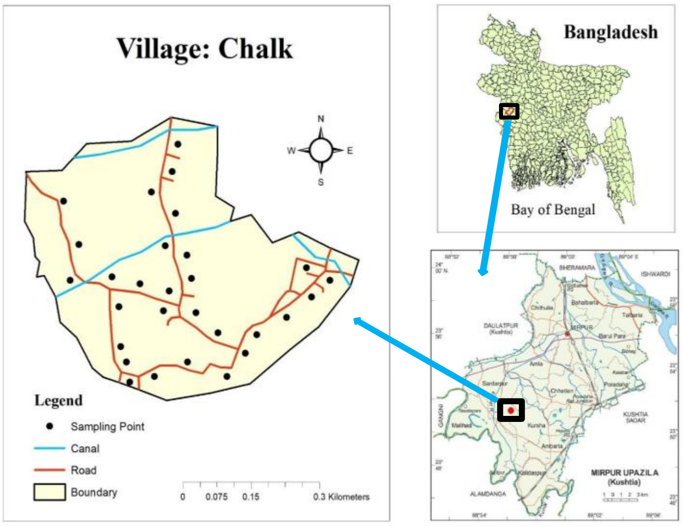


Figure 1: Sampling location map of the study area

Water Sampling and Preservation

Thirty groundwater samples were randomly collected from 30 tube wells across different paras on March 5, 2022. Before sample collection, each tube well was pumped for 1–2 minutes to ensure representative sampling. Water was collected in new plastic bottles pre-rinsed with the sample water two to three times. Bottles were completely filled to avoid air entrapment, sealed airtight to prevent oxidation, and labeled with sample IDs. GPS coordinates, approximate tube-well depth, installation year, and additional contextual information (such as reported water quality issues) were recorded individually for each sampling point using Google Maps via mobile devices. Samples were transported to the laboratory in an icebox and preserved at 4 °C until analysis.

Physical and Chemical Parameter Analysis

Physical and chemical parameters of the collected water samples were measured based on standard laboratory methods following the Environmental Conservation Rules (1997) and WHO guidelines (2011) [2,15]. Temperature was measured using a mercury thermometer immersed two-thirds into the water, while color was visually inspected by comparing the samples against color standards. Odor and taste were assessed manually by direct perception. Total dissolved solids (TDS) were measured electrometrically using a Hanna HI9813-5 portable meter, and pH was determined using an Ezdo pH 5011 portable pH meter after calibration. Electrical conductivity (EC) was measured using a Hanna EC214 conductivity meter. Sodium (Na^+) and potassium (K^+) concentrations were determined using a JENWAY PFP7 flame photometer. Chloride (Cl^-) was analyzed through titration with a 0.034N $AgNO_3$ solution, while carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) were evaluated by titration using 0.0625N H_2SO_4. Iron (Fe) concentration was determined by spectrophotometry with a Yoke V1000 VIS spectrophotometer at 510 nm using the colorimetric method. Table 3.3 summarizes the methods and units used for the analysis.

Water Quality Index (WQI) Calculation

The Water Quality Index (WQI) was computed using Horton's method (1965) and the weighted arithmetic index approach modified by Brown et al. (1972). Eight parameters (pH, EC, TDS, Na+, K+, Fe, Cl-, HCO_3^-) were considered for WQI calculation.

Statistical Analysis

All data analyses were conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics such as mean, standard deviation, and range were computed. Differences between groups were tested using one-way ANOVA or independent sample t-tests where applicable. A p-value < 0.05 was considered statistically significant. Microsoft Excel 19.0 was used for preliminary calculations and graphical representations.

RESULTS

A total of 162 participants were included in this study. The mean age was 42.8±8.6 years, and the average BMI was 29.5±3.2 kg/m². Males comprised 57.41% of the study population, while females accounted for 42.59%. Diabetes was the most common comorbidity, affecting 30.25% of participants, followed by hypertension in 25.31%, hypothyroidism in 19.75%, and coronary artery disease in 14.81% (Table 1). During the follow-up period, significant improvements were observed across all measured parameters. ALT levels showed a progressive decline from a baseline value of 67.8±10.1 U/L to 45.2±8.7 U/L at 12 weeks and further decreased to 34.6±7.9 U/L at 24 weeks. AST levels followed a similar trend, reducing from 56.4±8.5 U/L at baseline to 39.1±7.4 U/L at 12 weeks and 29.8±6.8 U/L at 24 weeks. Lipid profile parameters also demonstrated notable changes, with LDL levels decreasing from 152.5±18.4 mg/dL at baseline to 134.2±15.8 mg/dL at 12 weeks and 118.6±14.7 mg/dL at 24 weeks. Conversely, HDL levels improved over time, rising from 38.5±4.2 mg/dL at baseline to 42.3±4.7 mg/dL at 12 weeks and reaching 45.1±4.5 mg/dL at 24 weeks. Triglyceride levels showed a substantial reduction from 245.3±27.9 mg/dL at baseline to 196.4±24.6 mg/dL at 12 weeks and further declined to 155.7±21.3 mg/dL at 24 weeks. Liver stiffness measurements also indicated significant improvement, with values decreasing from 11.2±1.8 kPa at baseline to 9.7±1.5 kPa at 12 weeks and 8.5±1.3 kPa at 24 weeks. All observed changes were statistically significant ($p<0.001$) (Table 2). Table 3 showed the study outcome and adverse events. A majority of participants (90.12%) showed improvement in ALT and AST levels, while 85.19% exhibited enhancements in their lipid profiles. Additionally, liver stiffness was reduced in 80.25% of the study population, indicating positive treatment effects. Adverse events were reported in a small proportion of participants, with nausea and fatigue each affecting 4.94% of individuals, while diarrhea was observed in 2.47% of cases.

Table 1: Baseline characteristics of the study population (N=162)

Variable	Frequency (n)	Percentage (%)
	Mean ± SD	
Age (years)	42.8 ± 8.6	
BMI (kg/m²)	29.5 ± 3.2	
Gender		
Male	93	57.41
Female	69	42.59
Comorbidities		
Diabetics	49	30.25
Hypertension	41	25.31
Coronary Artery Disease	24	14.81
Hypothyroidism	32	19.75

Table 2: Comparison of parameter during follow up

Parameter	Baseline	Week 12	Week 24	p-value
ALT (U/L)	67.8 ± 10.1	45.2 ± 8.7	34.6 ± 7.9	<0.001
AST (U/L)	56.4 ± 8.5	39.1 ± 7.4	29.8 ± 6.8	<0.001
LDL (mg/dL)	152.5 ± 18.4	134.2 ± 15.8	118.6 ± 14.7	<0.001
HDL (mg/dL)	38.5 ± 4.2	42.3 ± 4.7	45.1 ± 4.5	<0.001
Triglycerides (mg/dL)	245.3 ± 27.9	196.4 ± 24.6	155.7 ± 21.3	<0.001
Liver Stiffness (kPa)	11.2 ± 1.8	9.7 ± 1.5	8.5 ± 1.3	<0.001

Table 3: Study outcome and adverse events.

Outcome	Frequency (n)	Percentage (%)
Improvement in ALT/AST	146	90.12
Improvement in Lipid Profile	138	85.19
Reduction in Liver Stiffness	130	80.25
Adverse Events Reported		
Nausea	8	4.94
Diarrhea	4	2.47
Fatigue	8	4.94

The majority of the tube-well water samples were yellowish in color, likely associated with high iron content, while the remaining samples were colorless. Odor was present in most samples, with nine samples odorless. Similarly, most samples had a slightly metallic taste, while nine were tasteless. Water temperatures ranged between 24°C and 26°C, all within the acceptable range (Table 1). The TDS values of the collected samples varied from 273 to 564 mg/L, remaining below the Bangladesh standard of 1000 mg/L, illustrated in Figure 2. The pH values of the samples ranged from 7.1 to 7.6, within the acceptable range of 6.5 to 8.5 as per WHO and Bangladesh standards (Figure 3). The electrical conductivity values ranged from 545 to 896 µS/cm (Figure 4). Four samples matched the standard value of 700 µS/cm, eighteen samples recorded lower values, and eight samples showed higher values. Sodium content ranged from 50 to 175 mg/L, all within the Bangladesh standard of 200 mg/L, presented in Figure 5. Potassium content ranged from 0.98 to 1.97 mg/L, much lower than the permissible limit of 12 mg/L, demonstrated in Figure 6. Chloride concentration ranged between 12.07 and 72.42 mg/L, significantly below the acceptable range of 150 to 600 mg/L (Figure 7). Bicarbonate concentrations varied from 381.3 to 762.5 mg/L, shown in Figure 8; among them, nine samples exceeded the standard limit of 600 mg/L. Iron content ranged from 0.13 to 2.54 mg/L (Figure 9). Seventeen samples exceeded the standard range of 0.3 to 1.0 mg/L, eight samples were within the range, and five samples were below it. Iron concentration decreased with increasing depth (Figure 10). Average iron concentrations were 1.78 mg/L at 80–100 feet (n=4), 1.75 mg/L at 110–130 feet (n=7), 1.52 mg/L at 140–160 feet (n=9), 0.80 mg/L at 170–200 feet (n=4), and 0.19 mg/L at 210–240 feet (n=6). The water quality index of analyzed parameters showed TDS, pH, EC, Na^+, K^+, and Cl^- ranged from excellent to good status, whereas HCO_3^- was poor and Fe was very poor, outlined in Table 2. According to the overall water quality evaluation (Figure 11), 23% samples were excellent, 45% good, 19% poor, and 13% very poor.

Table 4.1. Summary of measured physical properties of water samples

<table>
<tr><th>Sample ID</th><th>Color</th><th>Odor</th><th>Taste</th><th>Temperature (°C)</th></tr>
<tr><td>ZS-1</td><td rowspan="3">Colorless</td><td rowspan="3">Odorless</td><td rowspan="3">Tasteless</td><td>26</td></tr>
<tr><td>ZS-2</td><td>25</td></tr>
<tr><td>ZS-3</td><td>24.5</td></tr>
<tr><td>ZS-4</td><td rowspan="7">Yellowish</td><td rowspan="7">Odorous</td><td rowspan="7">Slightly metallic</td><td>24.5</td></tr>
<tr><td>ZS-5</td><td>24</td></tr>
<tr><td>ZS-13</td><td>25.5</td></tr>
<tr><td>ZS-14</td><td>26</td></tr>
<tr><td>ZS-30</td><td>25</td></tr>
<tr><td>ZS-6</td><td>26</td></tr>
<tr><td>ZS-7</td><td>24</td></tr>
<tr><td>ZS-8</td><td>Colorless</td><td>Odorless</td><td>Tasteless</td><td>24.5</td></tr>
<tr><td>ZS-9</td><td rowspan="4">Yellowish</td><td rowspan="4">Odorous</td><td rowspan="4">Slightly metallic</td><td>25.5</td></tr>
<tr><td>ZS-10</td><td>25</td></tr>
<tr><td>ZS-11</td><td>24.5</td></tr>
<tr><td>ZS-12</td><td>24</td></tr>
<tr><td>ZS-15</td><td rowspan="3">Colorless</td><td rowspan="3">Odorless</td><td rowspan="3">Tasteless</td><td>26</td></tr>
<tr><td>ZS-16</td><td>25.5</td></tr>
<tr><td>ZS-17</td><td>26</td></tr>
<tr><td>ZS-22</td><td rowspan="3">Yellowish</td><td rowspan="3">Odorous</td><td rowspan="3">Slightly metallic</td><td>25.5</td></tr>
<tr><td>ZS-18</td><td>26</td></tr>
<tr><td>ZS-19</td><td>24.5</td></tr>
<tr><td>ZS-20</td><td>Colorless</td><td>Odorless</td><td>Tasteless</td><td>24.5</td></tr>
<tr><td>ZS-21</td><td rowspan="4">Yellowish</td><td rowspan="4">Odorous</td><td rowspan="4">Slightly metallic</td><td>25</td></tr>
<tr><td>ZS-23</td><td>24.5</td></tr>
<tr><td>ZS-24</td><td>25</td></tr>
<tr><td>ZS-25</td><td>25.5</td></tr>
<tr><td>ZS-26</td><td>Colorless</td><td>Odorless</td><td>Tasteless</td><td>24.5</td></tr>
<tr><td>ZS-27</td><td rowspan="3">Yellowish</td><td rowspan="3">Odorous</td><td rowspan="3">Slightly metallic</td><td>24.5</td></tr>
<tr><td>ZS-28</td><td>25</td></tr>
<tr><td>ZS-29</td><td>25</td></tr>
</table>

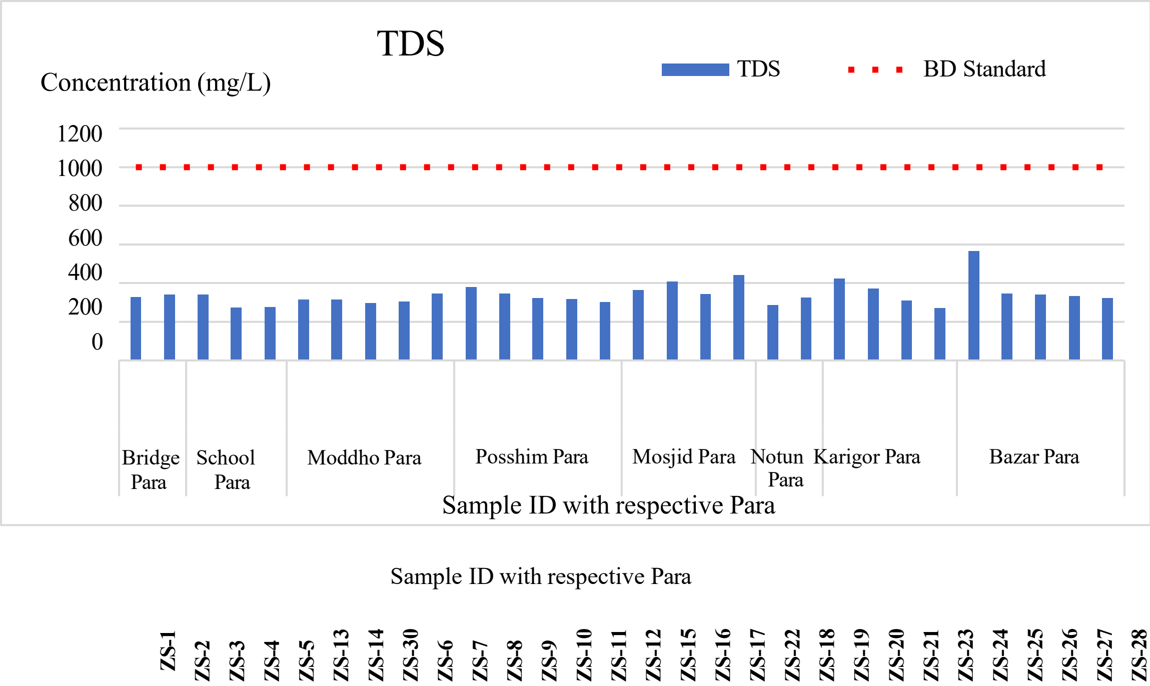


Figure 2: Measured TDS values of the water samples

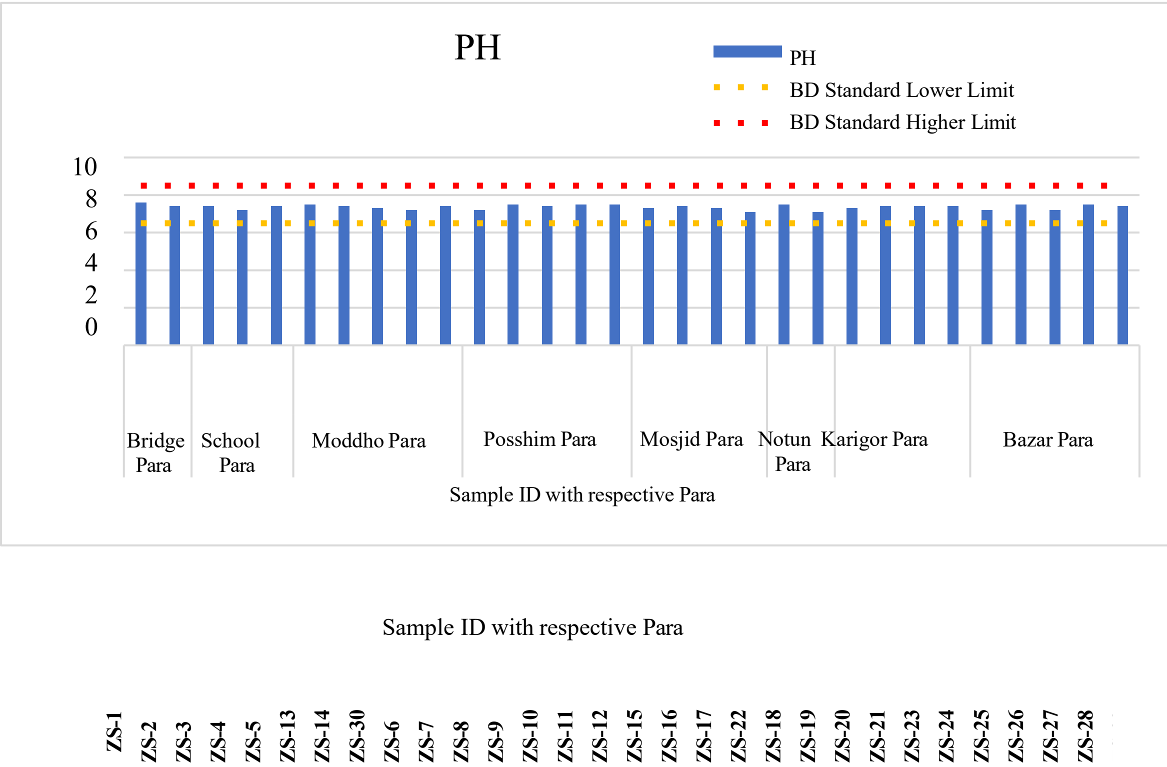


Figure 3: Measured pH values of the water samples

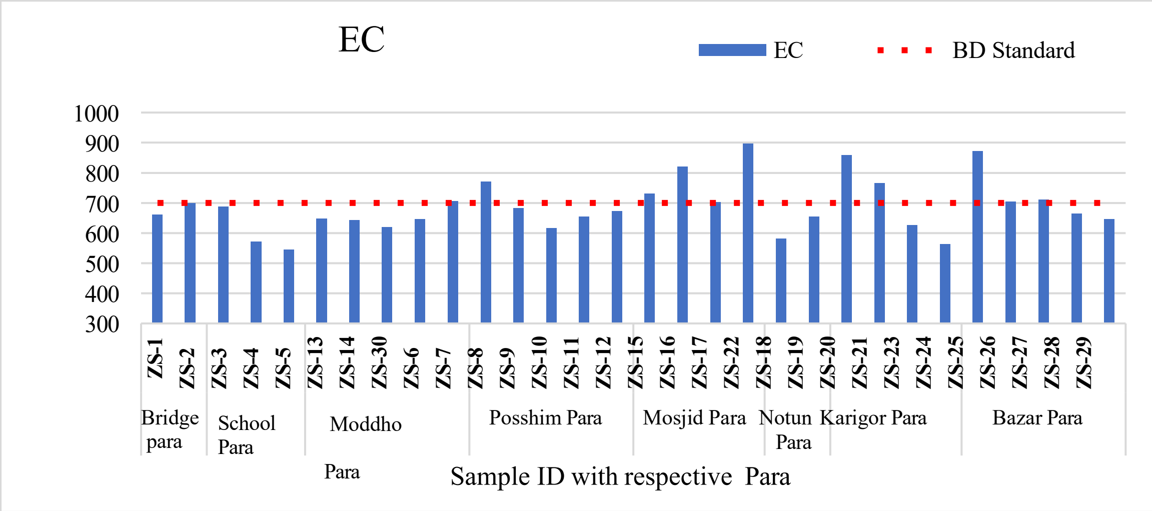


Figure 4: Measured EC values of the water sample

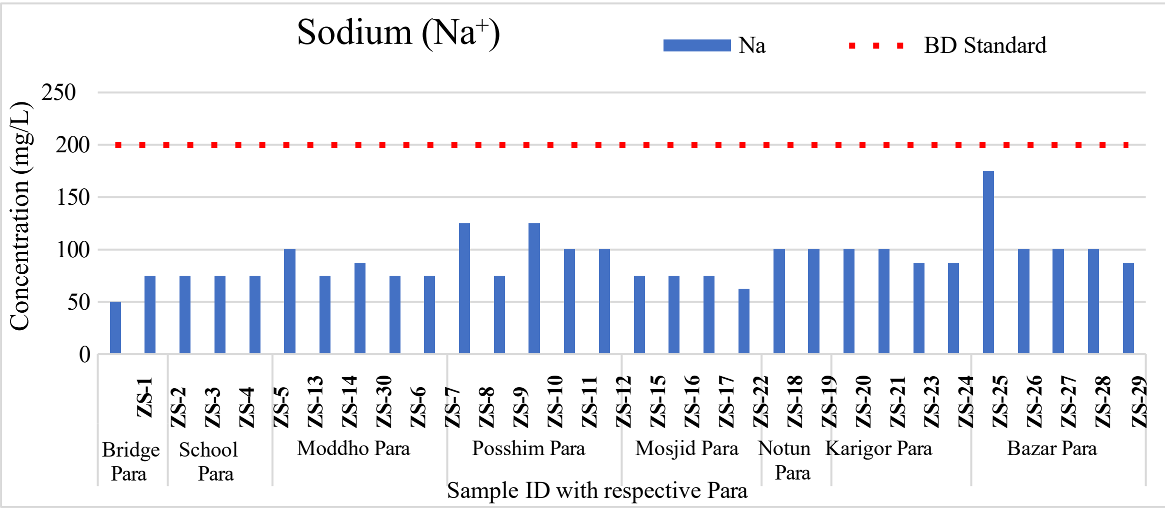


Figure 5: Measured sodium (Na^+) content of the water samples

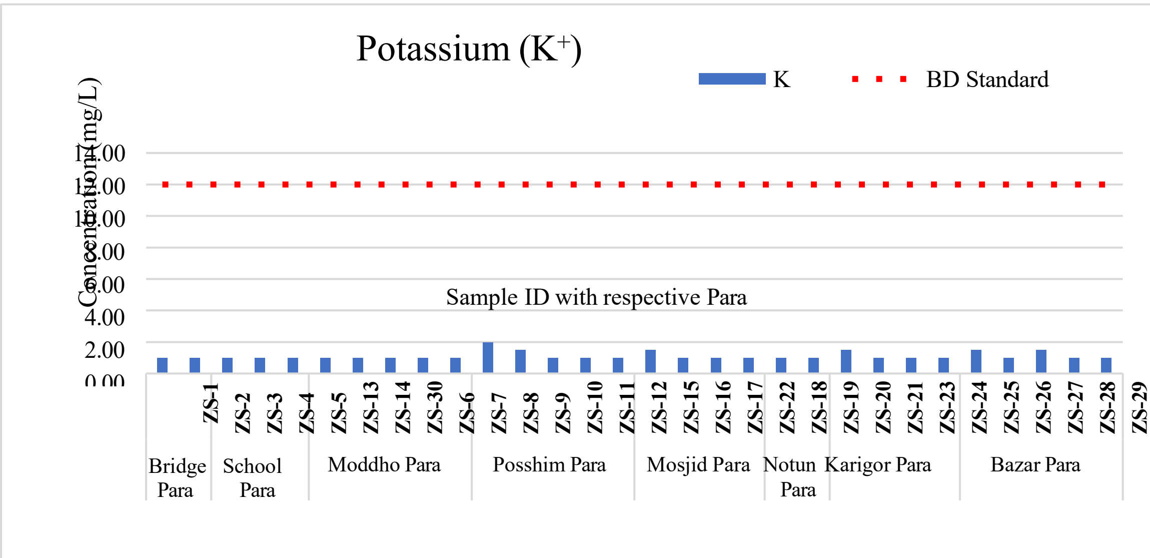


Figure 6: Measured potassium (K+) content of the water samples

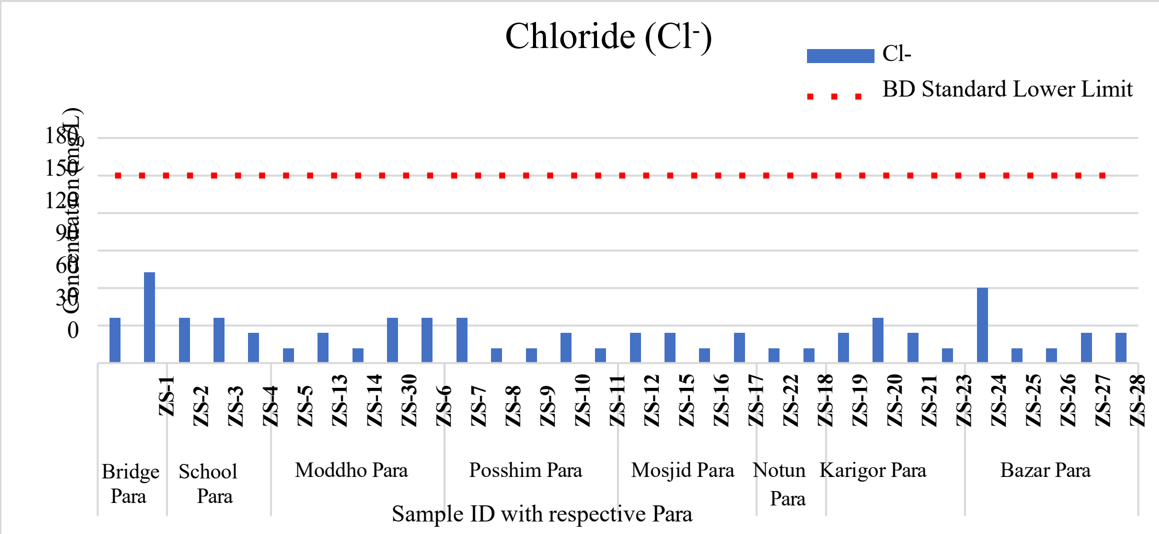


Figure 7: Measured chloride (Cl^-) content of the water samples

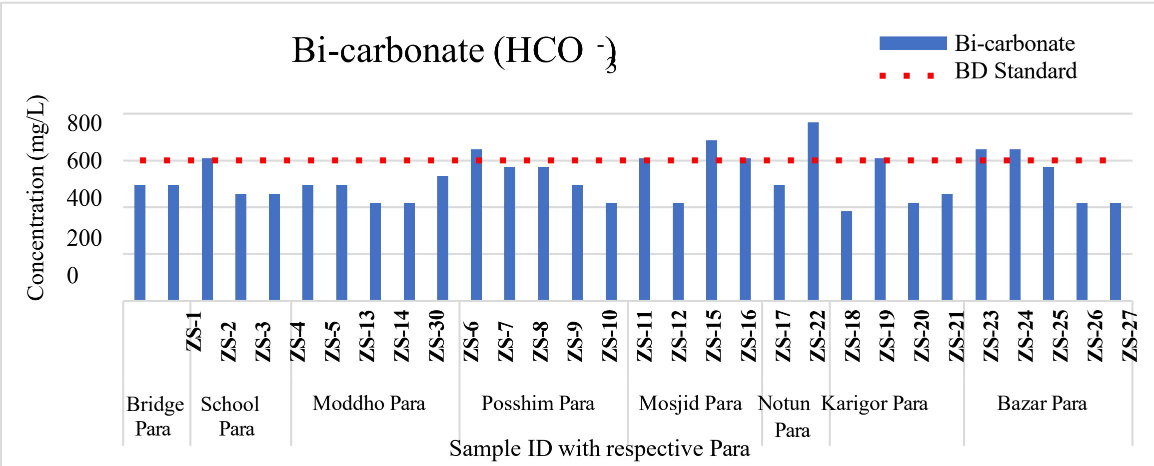


Figure 8: Measured bicarbonate (HCO3-) content of the water samples

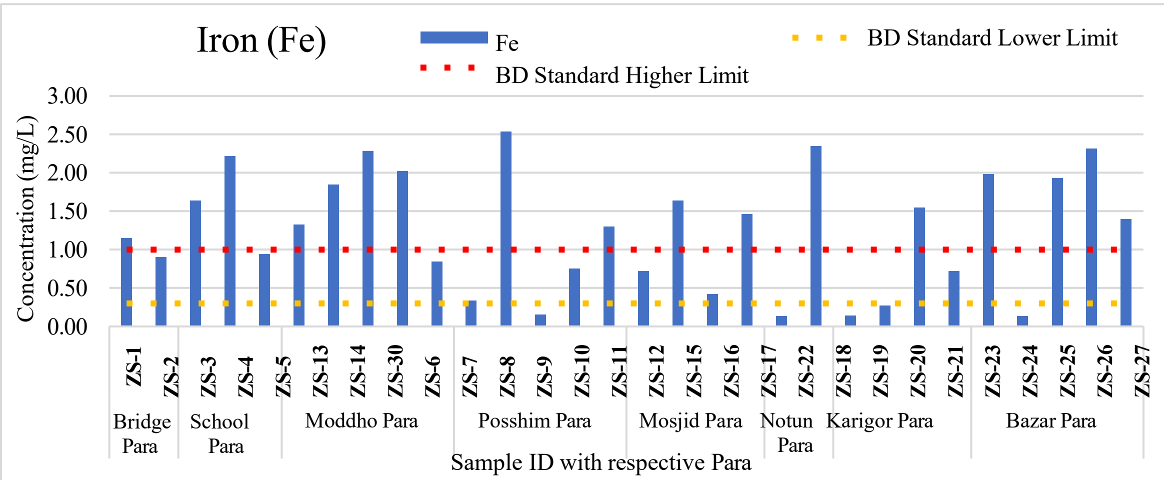


Figure 9: Measured iron (Fe) content of the water samples

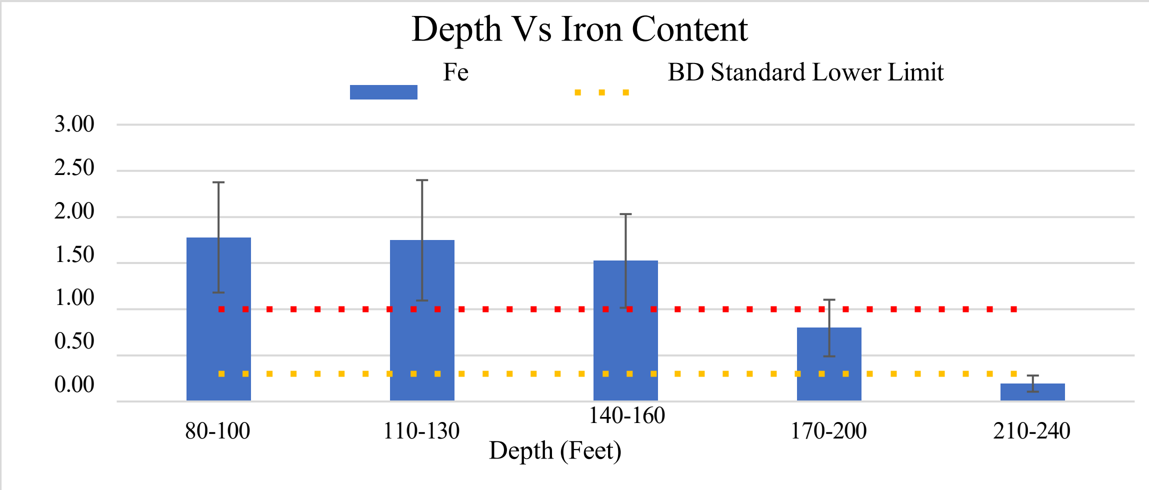
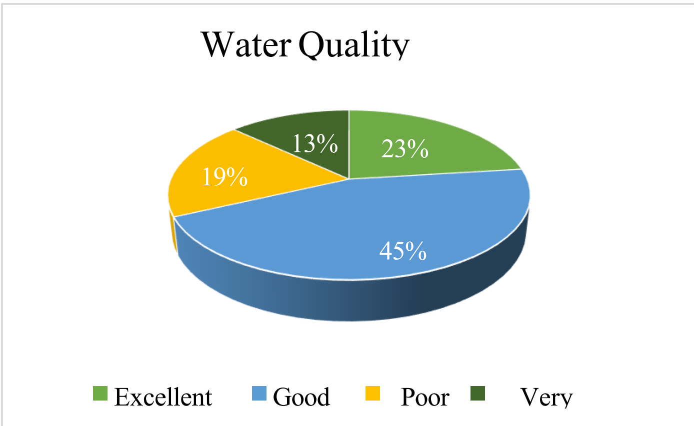


Figure 10: Depth vs iron content of the water samples

Table 2: Summary of water quality index of the analyzed parameters

Parameters	WQI Index	WQI Status
TDS	34.12	Good
pH	24.22	Excellent
EC	48.18	Good
Na^+	40.42	Good
K+	9.16	Excellent
Cl^-	36.63	Good
Fe	98.65	Very Poor
HCO3	67.48	Poor

Figure 11: Drinkable water quality status in the area under study



DISCUSSION

The present study evaluated the physicochemical characteristics of tube-well water samples from the study area, particularly focusing on parameters essential for drinking water quality according to Bangladesh (ECR'97) and WHO guidelines [2, 15]]. The findings provide critical insights into the aesthetic and chemical aspects of the water and their potential health implications. The color of drinking water is a vital aesthetic parameter influencing public acceptability. Although pure drinking water is ideally colorless, a majority of the samples analyzed exhibited a yellowish tint. This discoloration can be attributed to a high concentration of iron (Fe) in the water samples [16]. According to WHO (2011), iron in water exists predominantly in two forms: soluble ferrous iron and insoluble ferric iron. Soluble ferrous iron renders the water clear and colorless, while upon exposure to atmospheric oxygen, it oxidizes to ferric iron, leading to the formation of yellowish to reddish-brown precipitates [17]. Thus, the presence of colorless samples likely indicates that iron remains in the ferrous state, fully dissolved, whereas yellowish water samples have undergone oxidation, suggesting elevated iron levels and possible aesthetic concerns. Odor is another crucial quality parameter for potable water. Ideally, drinking water should be free from any discernible smell, as emphasized by both WHO (2011) and ECR (1997) standards [2 15]. However, the majority of the tested samples emitted detectable odors, likely linked to elevated iron concentrations [18]. Such odors may arise from the chemical reactions involving iron oxidation, microbial activity, or the presence of other organic and inorganic substances, undermining the aesthetic quality and potentially indicating secondary contamination risks [19]. Taste plays a critical role in determining water acceptability. A slightly metallic taste was reported in most tube-well water samples, a typical manifestation of high iron content [20]. Besides taste issues, iron-laden water can discolor plumbing fixtures and stain laundry, adding economic burdens to communities relying on such water sources. These findings highlight the pressing need for iron removal or management techniques, such as aeration or filtration, in the study area to enhance water acceptability and usability. Temperature is another important physicochemical property, influencing microbial activity and chemical equilibria in water. All water samples recorded temperatures between 24°C and 26°C, falling well within Bangladesh's standard acceptable range of 20°C–30°C (ECR, 1997). While temperature within this range does not directly impact health, elevated temperatures can foster microbial growth, accelerating corrosion and worsening taste, odor, and color issues [2, 21]. Hence, regular monitoring is crucial, particularly in tropical regions where temperatures can fluctuate seasonally. Total Dissolved Solids (TDS) offer an indirect measure of water salinity and the presence of various dissolved substances. All samples exhibited TDS levels below the maximum permissible limit of 1000 mg/L [15]. According to Uddin et al. (2021), TDS levels below 600 mg/L, as observed in this study, are associated with "good" tasting water. Although lower TDS levels are generally desirable, it is noteworthy that very low TDS can render water corrosive and reduce its buffering capacity, thus affecting plumbing and infrastructure longevity [22]. The pH values of all samples ranged between 6.5 and 8.5, aligning with both WHO and ECR guidelines. The slightly alkaline nature of the water samples (pH > 7) could be attributed to the proximity of the Padma River and associated geochemical interactions, as noted by Islam et al. (2014). While pH itself does not pose direct health risks [23], it governs the solubility and speciation of metals and other contaminants, thereby indirectly influencing water quality. Electrical conductivity (EC) measurements, a proxy for the ionic content of water, revealed that most samples were within the acceptable threshold of 700 µS/cm. However, a few samples exceeded this limit, indicating localized zones of higher salinity or ionic concentration. EC values correlate positively with TDS levels, impacting both water taste and potential corrosivity [24]. The occasional elevation of EC necessitates further investigation into possible sources, such as mineral dissolution, agricultural runoff, or anthropogenic activities. Sodium levels in all samples were below the Bangladesh drinking water guideline value of 200 mg/L [2,15]. Maintaining low sodium concentrations in drinking water is vital as excessive sodium intake is linked to hypertension, cardiovascular diseases, and kidney disorders [25]. Similarly, potassium levels in all samples were significantly lower than the 12 mg/L guideline value [15], posing minimal risk to public health. While potassium intake from water is generally negligible compared to dietary sources [26], its monitoring remains essential for individuals with pre-existing conditions like hyperkalemia. Chloride, another essential inorganic ion, was well below the guideline range of 150–600 mg/L in all samples [15]. Chloride is crucial for maintaining fluid balance and nerve function [27]; however, excessive chloride levels can impart a salty taste and corrode pipes. The low chloride content observed in this study suggests minimal salinity intrusion, which is a positive indication regarding the area's aquifer health. Bicarbonate levels showed variation among samples, with most below the 600 mg/L standard, although a few exceeded this threshold. Bicarbonates play an important role in buffering pH and neutralizing acids [28]. Elevated bicarbonate concentrations, while not generally harmful, can contribute to water hardness and affect aesthetic quality. Furthermore, bicarbonate-rich water may have a mild alkaline taste, which some consumers may find undesirable. Iron concentrations emerged as a significant concern. According to the ECR (1997) standard (0.3–1.0 mg/L), a majority of samples had iron levels exceeding permissible limits [15]. Specifically, seventeen samples showed iron concentrations above the standard, eight samples fell within the acceptable range, and five samples were below the threshold. Elevated iron content, while essential for human nutrition, can lead to aesthetic and technical issues such as staining, clogging, and metallic taste [29, 30]. Health risks associated with excessive iron intake include hemochromatosis, a condition leading to iron overload and damage to vital organs [31]. Moreover, high iron concentrations, as indicated by Tonmoy et al. (2009), were not strongly correlated with tube-well depth [32]. However, wells between 180 and 210 feet appeared to maintain iron concentrations within acceptable limits, suggesting an optimal drilling depth for future tube-well installations.

Limitations of the study:

- The study area was limited to Chalk village in Mirpur upazila, which may not represent broader regional or national conditions.
- Seasonal variations in water quality were not assessed, though parameters like iron and TDS can change over time.
- Only selected physical and chemical parameters were analyzed; important microbiological contaminants were not included.
- Tube well depth variations were mentioned but not extensively studied across a large range of wells.
- Resource and time constraints prevented repeated sampling and long-term water quality monitoring.
- Potential influences from agricultural, industrial, or household pollution sources were not separately evaluated.
-

CONCLUSION AND RECOMMENDATIONS

The drinking water quality of tube wells in Chalk village, Mirpur upazila, Kushtia district shows a mixed status, with a notable proportion falling into poor to very poor categories, primarily due to issues with color, odor, and elevated iron content. However, most physical and chemical parameters, including TDS, pH, EC, sodium, potassium, chloride, and bicarbonate, remain within acceptable limits. Ensuring tube well depths between 180 and 210 feet could help control iron levels and improve overall water quality. Regular monitoring and appropriate management strategies are essential to ensure safe and palatable drinking water for the local community.

Funding: *No funding sources*
Conflict of interest: *None declared*
Ethical approval: *The study was approved by the Institutional Ethics Committee.*

.

REFERENCES

1. Bunch MJ, Morrison KE, Parkes MW, Venema HD. Promoting health and well-being by managing for social–ecological resilience: the potential of integrating ecohealth and water resources management approaches. Ecology and society. 2011 Mar 1;16(1).
2. Edition F. Guidelines for drinking-water quality. WHO chronicle. 2011;38(4):104-8.
3. Munang RT, Thiaw I, Rivington M. Ecosystem management: Tomorrow's approach to enhancing food security under a changing climate. Sustainability. 2011 Jun 28;3(7):937-54.
4. Vadde KK, Wang J, Cao L, Yuan T, McCarthy AJ, Sekar R. Assessment of water quality and identification of pollution risk locations in Tiaoxi River (Taihu Watershed), China. Water. 2018 Feb 10;10(2):183.
5. Schwarzenbach RP, Egli T, Hofstetter TB, Von Gunten U, Wehrli B. Global water pollution and human health. Annual review of environment and resources. 2010 Nov 21;35(1):109-36.
6. Moe CL, Rheingans RD. Global challenges in water, sanitation and health. Journal of water and health. 2006 Jul 1;4(S1):41-57.
7. Chowdhury MM, Kubra K, Amin MR. Microbiological water pollution in Chittagong hill tracts in Bangladesh. J. of Medi. Sci. and Pub. Heal. 2014;2(2):37-42.
8. Mukherjee A. Overview of the groundwater of South Asia. Springer Singapore; 2018.
9. Emch M, Yunus M, Escamilla V, Feldacker C, Ali M. Local population and regional environmental drivers of cholera in Bangladesh. Environmental Health. 2010 Dec;9:1-8.
10. Haque SE. An overview of groundwater quality in Bangladesh. Groundwater of south Asia. 2018 Jun 2:205-32.
11. Govindarajan M, Senthilnathan T. Groundwater quality and its health impact analysis in an industrial area. Int. J. Curr. Microbiol. App. Sci. 2014 Jul;3(7):1028-34.
12. Moyo NA. An analysis of the chemical and microbiological quality of ground water from boreholes and shallow wells in Zimbabwe. Physics and Chemistry of the Earth, Parts A/b/c. 2013 Jan 1;66:27-32.
13. GLOBAL UW. NATIONAL SYSTEMS TO SUPPORT DRINKING-WATER, SANITATION AND HYGIENE: GLOBAL STATUS REPORT 2019.
14. Rahmanian N, Ali SH, Homayoonfard M, Ali NJ, Rehan M, Sadef Y, Nizami AS. Analysis of physiochemical parameters to evaluate the drinking water quality in the State of Perak, Malaysia. Journal of chemistry. 2015;2015(1):716125.
15. Environment Conservation Rules. Bangladesh Government; 1997. p. 179–227.
16. Haile MZ, Biru NB. Physicochemical Characteristics of Drinking Water Sources and Household Tape Water in Yabelo Town.
17. Sain AE, Dietrich AM. Rethinking aesthetic guidelines for manganese and iron in drinking water. Journal of Water Supply: Research and Technology—AQUA. 2015 Nov 11;64(7):775-82.
18. Dietrich AM, Burlingame GA. A review: the challenge, consensus, and confusion of describing odors and tastes in drinking water. Science of the Total Environment. 2020 Apr 15;713:135061.
19. Suffet IH, Mallevialle J, Kawczynski E, editors. Advances in taste-and-odor treatment and control. American Water Works Association; 1995.
20. Colter A, Mahler RL. Iron in drinking water. Moscow: University of Idaho; 2006 Jun.
21. Otieno FA, Olumuyiwa IO, Ochieng GM. Groundwater: Characteristics, qualities, pollutions and treatments: An overview. African journal of agricultural research. 2012 Feb 22.
22. Uddin MR, Khandaker MU, Abedin MJ, Akter N, Molla Jamal AS, Sultana R, Sultana S, Hasan M, Osman H, Elesawy BH, Sayyed MI. Quality assessment of bottled and unbottled drinking water in Bangladesh. Water. 2021 Jul 24;13(15):2026.
23. Remucal CK, Manley D. Emerging investigators series: the efficacy of chlorine photolysis as an advanced oxidation process for drinking water treatment. Environmental Science: Water Research & Technology. 2016;2(4):565-79.
24. Rahmanian N, Ali SH, Homayoonfard M, Ali NJ, Rehan M, Sadef Y, Nizami AS. Analysis of physiochemical parameters to evaluate the drinking water quality in the State of Perak, Malaysia. Journal of chemistry. 2015;2015(1):716125.

25. Meride Y, Ayenew B. Drinking water quality assessment and its effects on residents health in Wondo genet campus, Ethiopia. Environmental Systems Research. 2016 Dec;5(1):1-7.
26. Preuss HG. Sodium, chloride, and potassium. InPresent knowledge in nutrition 2020 Jan 1 (pp. 467-484). Academic Press.
27. Lutsenko S, Barnes NL, Bartee MY, Dmitriev OY. Function and regulation of human copper-transporting ATPases. Physiological reviews. 2007 Jul;87(3):1011-46.
28. Rudra K. Changing river courses in the western part of the Ganga–Brahmaputra delta. Geomorphology. 2014 Dec 15;227:87-100.
29. Bhattacharya PT, Misra SR, Hussain M. Nutritional aspects of essential trace elements in oral health and disease: an extensive review. Scientifica. 2016;2016(1):5464373.
30. Colter A, Mahler RL. Iron in drinking water. Moscow: University of Idaho; 2006 Jun.
31. Walker PL, Bathurst RR, Richman R, Gjerdrum T, Andrushko VA. The causes of porotic hyperostosis and cribra orbitalia: A reappraisal of the iron-deficiency-anemia hypothesis. American Journal of Physical Anthropology: The Official Publication of the American Association of Physical Anthropologists. 2009 Jun;139(2):109-25.
32. Tonmoy FN, Rahman MM, Kitawaki H. Impact of ground water depth on arsenic and iron correlation in Bangladesh: GIS approach. International Journal of Applied Environmental Sciences. 2009 Dec 1;4(4):437-58.