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# Assessment of Household and Industrial Suitability of Water of Dhaka WASA

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***ABSTRACT: Understanding the hardness levels in the water supply framework is one of the prerequisites for assessing its appropriateness for drinking, agricultural, and industrial purposes. This study aimed at evaluating the water hardness levels in tap water and supply water inside different regions of Mirpur area, Dhaka. Complexometric titration was applied to determine the hardness level of water between March 2023 to April 2023. The maximum level of hardness is found in Agargaon at 220 ppm, whereas the minimum level (105 ppm) of hardness is found in Mirpur 1, 2 and 10. The permanent hardness values ranged from 95 ppm (Mirpur1, 2) to 145 ppm (Agargaon), while the temporary hardness ranged from 5 ppm to 50 ppm. These findings indicate that the water supplied by Water Supply and Sewerage Authority (WASA), Dhaka in Mirpur area contains notable concentrations of divalent cations, primarily calcium, and magnesium, contributing to water hardness which will not be removed by boiling only. Therefore, this study can be a guideline to provide insight into the water conditions in the Mirpur area and understand the quality of water provided by WASA. Furthermore, the outcomes of this research can contribute to water quality management in urban areas to improve the water supply system.***

***Keywords: Dhaka WASA; Hardness; Water Suitability; Public Health***

## 1. INTRODUCTION

Drinking water is a fundamental human right governed by WHO [1–3]. Besides, water plays important roles both in domestic and industrial purposes [4]. Therefore, the investigation of the water quality in different regions of the world has been popular and prevalent till now [5–7]. Surface water quality is mainly evaluated for both domestic and industrial purposes [8–10]. On the other hand, groundwater is primarily assessed for the purpose of drinking [2,11,12].

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In different studies, physical (colour, odour, tastes, etc.), chemical (pH, dissolved oxygen, biological oxygen demand, chemical oxygen demand, alkalinity, conductivity, hardness, etc.) and biological (coliform, salmonella, etc.) parameters were investigated to determine the overall water quality using different kind of indices [5,6,8–12]. Among them, the hardness of water is one of the most critical parameters considering health in both domestic and industrial issues.

Hard water is characterized by elevated levels of divalent cations, primarily calcium ($Ca^{2+}$) and magnesium ($Mg^{2+}$). Hence, hard water can have a metallic or chalky taste which can bring offensive feelings [13]. When detergents and soaps are used with hard water, their effectiveness are reduced [14]. During domestic use of washing machines, dishwashers, and water heaters can be damaged by hard water [15]. Moreover, mineral deposits on plumbing appliance which can form scale and subsequently lead to damage of these instruments [16]. Hard water can cause different health problems like skin irritation, cardiovascular problems, diabetes, reproductive failure, neural diseases, and renal dysfunction [17,18]. Therefore, study on hardness of water has drawn attraction towards the researchers [19–23].

This investigation holds significant importance for several reasons. Firstly, understanding the significance of water hardness in various industrial, environmental, and household contexts is crucial for ensuring optimal performance and efficiency [24]. Secondly, focusing specifically on the Mirpur area in Dhaka city, the research addresses the pressing need to assess the suitability and quality of surface and groundwater for drinking purposes. With the reliance of the local population on water supplied by Dhaka WASA (Water Supply and Sewerage Authority), it is essential to gain insight into the water conditions in the area and understand the quality of water provided. The findings of this research can serve as a foundation for improving water resource management, ensuring the provision of safe drinking water, and identifying potential areas for improvement in water treatment processes.

This study focused on the Mirpur area, a developed urban region located in the western part of Dhaka city. Though Mirpur is known for its reliance on groundwater as a primary water source for drinking, domestic, and other purposes, Dhaka WASA has also provided water supply to the habitants to ensure safe drinking water. But, the supply system has been criticized in recent years as many habitants found the water with stinky odour and offensive taste [25]. In 2019, WASA itself admitted that water of Dhaka city is polluted in 57 areas [26].

Thus, continuous monitoring of the water supplied by WASA is a crying need to ensure safe drinking water to the habitants of Mirpur area. By addressing the issue of water hardness in Mirpur, the safe and sustainable use of water resources can be ensured, which is vital for the well-being and development of the local population. Furthermore, the outcomes of this research can contribute to broader efforts aimed at managing water quality in that area and promoting effective water resource management practices.

## 2. METHODOLOGY

### *2.1. Study area*

Mirpur is an outlying town and a neighborhood in the north of Dhaka. It is surrounded by Pallabi to the north and situated directly between the city's zoo and Hazrat Shahjalal International Airport in Dhaka.

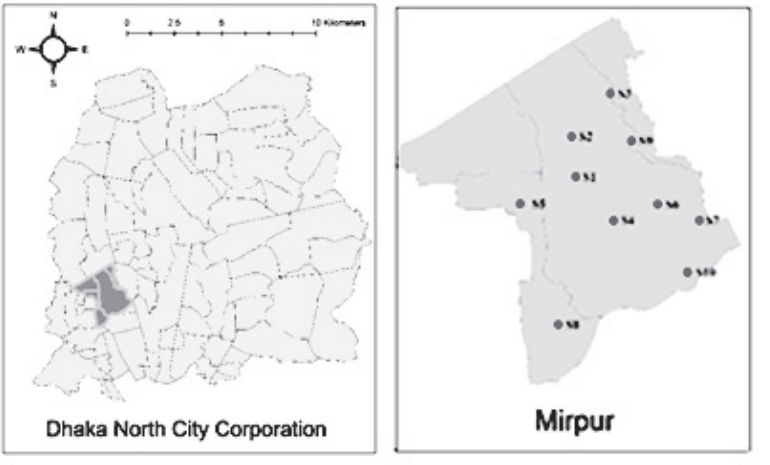


**Figure 01:** Sample locations of the Mirpur area for this study.

The total population of the region is over 456,200 as of 2017. The Latitude and longitude coordinates of this area are 23.822350 and 90.365417, respectively [Figure 01].

### *2.2. Collection of Samples*

To conduct this study, the samples were collected from different areas of Mirpur during March 2023 to April 2024 [Table 01]. Before collecting the water sample, the container was washed, cleaned and rinsed with distilled water. During the collection, all possible contamination was avoided. The containers were labeled instantly with date, location and other physical properties. 1 mL of $HNO_3$ was added for preserving the water for further use.

**Table 01:** Samples stations of the collected water from Mirpur area.

| Sample ID | Area |
|---|---|
| S1 | Mirpur-1 |
| S2 | Mirpur-2 |
| S3 | Mirpur-10 |
| S4 | West Shewrapara |
| S5 | Diabari |
| S6 | East Shewrapara |
| S7 | Ibrahimpur |
| S8 | Kallyanpur |
| S9 | Kazipara |
| S10 | Agargaon |

### *2.3. Determination of the Total Hardness*

Hardness of water has been analyzed by Titrimetric Method using Ethylenediaminetetraacetic acid (EDTA), following established protocol by American Public Health Association (APHA) [27]. To a 50 mL sample of the water to be tested, 1 mL buffer solution (ammonium hydroxide/ammonium chloride, pH 10) and 30-40 mg Eriochrome Black T (EBT) indicator mixture was added.

Then the mixture was titrated with standard EDTA solution (0.01 M) until the colour changed from red to blue. However, it was confirmed that there was no magnesium present in the sample of water. Therefore, it was necessary to add 0.1 mL magnesium-EDTA solution (0.1 M) before adding the indicator. The total hardness is expressed in parts of $CaCO_3$ per million (ppm) of water.

### *2.4. Determination of the Permanent Hardness*

A 250 mL of the sample of water was placed in a 600 mL beaker and boiled gently for 20-30 minutes. Then it was cooled and filtered directly into a 250 mL graduated flask. The filtrate was diluted to volume with deionized water and mixed well. Then, 50.0 mL of the filtrate was titrated by the same procedure as was used for the total hardness. This titration measured the permanent hardness of the water.

### *2.5. Determination of the Temporary Hardness*

Calculation of the temporary hardness of the water was done by subtracting the permanent hardness from total hardness.

### *2.6. Reagents and Chemicals*

All the chemicals and reagents used during the analysis were analytical grade and were obtained from Merck, Germany.

### *2.7. Method Validation*

Before starting the analysis, the method was validated by analyzing standard $Ca^{2+}$ solutions and therefore, all the samples were analyzed in triplicate and average values with standard error of hardness were presented in this study.

## 3. RESULTS & DISCUSSION

The analysis of water hardness of various areas of Mirpur revealed significant variations of the hardness levels of supplied water. Total hardness of water in Mirpur area ranged from 105-220 ppm with a mean of 153.6±43.1 ppm [Table 02].

The median value of total hardness was 151.5 ppm. When the permanent hardness was calculated, the value ranged from 95 to 145 ppm with a mean of 121.5±19.5 ppm where the median was 125.8 ppm.

**Table 02:** Descriptive statistics of the Hardness in Mirpur area.

| | TH | Permanent Hardness | Temporary Hardness |
|---|---|---|---|
| Mean | 153.6 | 121.5 | 32.1 |
| Standard Deviation | 43.1 | 19.5 | 28.2 |
| Minimum | 105.0 | 95.0 | 5.0 |
| Median | 151.5 | 125.5 | 22.3 |
| Maximum | 220.0 | 145.0 | 81.5 |

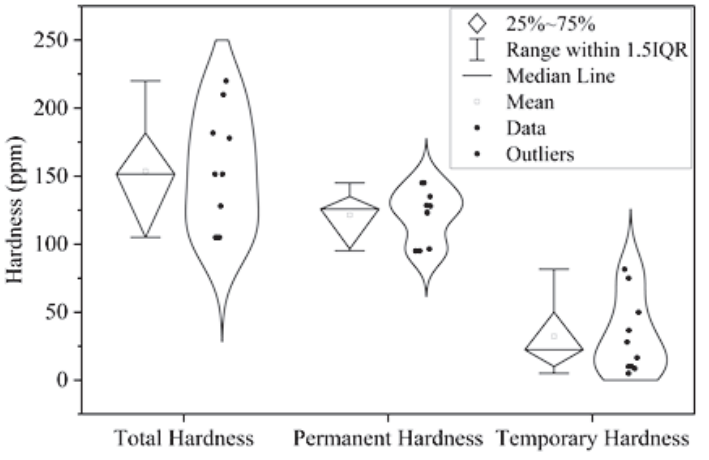


**Figure 02:** Violine plot to determine the 1.51QR percentile and data distribution of the hardness, temporary and permanent hardness of water in different sample stations of Mirpur Area.

Temporary hardness was obtained from the difference between total hardness and permanent hardness. It was ranged from 5-81.5 ppm. The mean value of temporary hardness in Mirpur area was 32.1±28.2 ppm with 22.2 ppm as median value [Figure 02].

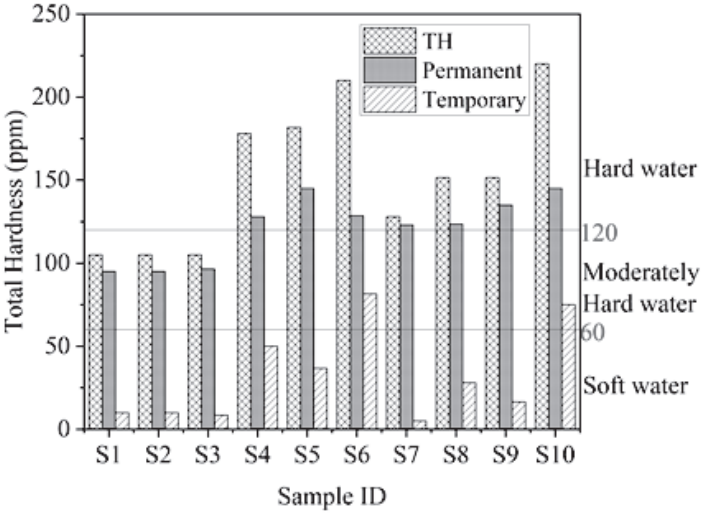


**Figure 03:** Comparative level of total hardness, temporary and permanent hardness of water in different sample stations of Mirpur Area.

Lowest total hardness was obtained in Mirpur 1 (S1), Mirpur 2 (S2) and Mirpur 10 (S3) (105 ppm) area where Agargaon (S10) (220 ppm) area came up with the highest total hardness followed by East Shewrapara (S6) (210 ppm) area [Figure 03]. Permanent hardness usually correlated with total hardness which was also indicated in this study. We found Mirpur 1 (S1) and Mirpur 2 (S2) area were found with lowest permanent hardness (95 ppm). Interestingly, Diabari (S5) and Agargaon (S10) areas had highest permanent hardness (145 ppm). Temporary hardness was not the lowest in Mirpur 1 (S1) and Mirpur 2 (S2) area though total hardness was highest in these areas. However, the lowest temporary hardness was found in Ibrahimpur (S7) area (5 ppm). Likewise total hardness, temporary hardness was also higher in East Shewrapara (S6) (81.5 ppm) and Agargaon (S10) (75 ppm) areas.

However, the decreasing order of total hardness was: S10>S6>S5>S4>S8, S9>S7>S1,S2,S3 where decreasing order of permanent hardness was S10,S5>S9>S6>S4>S8>S7>S3>S1,S2 and the temporary hardness order showed S6>S10>S4>S5>S8>S9>S1,S2>S3>S7 [Figure 03].

It is well-known that if the total hardness of water is below 60 ppm, the water is regarded as soft water. Moderately hard water ranged between 60-120 ppm whether if total hardness exceeds 120 ppm, the water is regarded hard water.

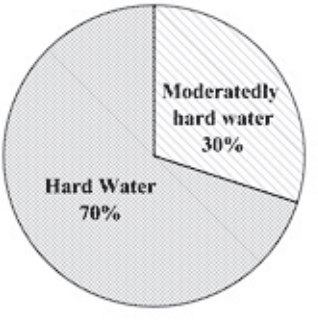


**Figure 04:** Pie diagram showing percentage of hard, soft and moderately soft water in different sample stations of Mirpur Area.

According to study, 70% of water samples were found as hard water where moderately hard water was found in 30% of water samples [Figure 04]. However, recommended hardness for safe drinking water by WHO is below 500 ppm. On the other hand, for industrial uses, soft water is recommended to avoid scale formation and deterioration of equipment. According to this investigation, the water of the 70% of Mirpur area can be vulnerable for various household and industrial equipment.

According to the annual report of Dhaka WASA, the authority claimed that they strictly followed the national standard of hardness (200-500 ppm) in their supply chain management [27]. However, this investigation found mean hardness of 153.6 ppm with a maximum value of 220 ppm. Therefore, reduction of hardness was observed from the Dhaka WASA to the different collection points of Mirpur area. Thus, disparity between the claimed hardness of water with investigated sample points indicated the alteration of pipeline for water supply which reduces the hardness of water.

Variations in water hardness within a territory served by the same authority can occur for a variety of reasons, even in cases when the water source and treatment methods are the same [28]. Hardness may be influenced by the distance from the treatment plant to the distribution system. Therefore, Extended distances could give minerals more time to dissolve and harden the water [29]. Water hardness can be altered by the components of the distribution system, including pipelines and storage tanks. With time, corrosion from old pipes made of iron or galvanized steel may increase the amount of minerals in the water [30]. In addition, concrete pipes can be corroded by bacteria, chlorides, nitrates, fluorides, and other substances that affect water hardness, such as salty or acidic water [31]. The hardness of the water could sometimes be affected by the local water storage system. Long-term storage of water may cause scale formation, which lowers hardness levels [32]. The water hardness, however, could be impacted by improper storage cleaning. Even, water hardness can vary with the seasons due to variations in temperature and precipitation [33]. More minerals may enter the water supply, for instance, due to increased runoff during rainy seasons. Water hardness may also vary depending on the plumbing configurations of individual homes or structures. For example, regardless of the water supply authority's hardness, residences equipped with water softeners will always have softened water [34]. However, to identify the exact reason for variation of the water supplied by Dhaka WASA, further investigation is required.

## 4. CONCLUSIONS

This study revealed that the highest level of hardness, 220 ppm, is found in Agargaon, while the lowest level, 105 ppm, is found in Mirpur 1, 2, and 10. Permanent hardness ranged from 95 ppm (Mirpur1, 2) to 145 ppm (Agargaon). Most of the samples came out with the indication of hard water which can be vulnerable to different equipment. Precautions should be taken to reduce the hardness of water for industrial uses.

However, for the drinking purpose, the water could maintain WHO standards which indicated safety for human health. Due to the disparity of the hardness of supply and sample stations, continuous monitoring of pipelines is recommended.

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## 6. CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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