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# A Study on Total Dissolved Solids and Hardness Level of Drinking Mineral Water in Bangladesh

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**Abstract:** Natural water is being processed by the Reverse Osmosis purification system in the different area of Bangladesh for drinking purposes. Most of the water processing companies fill the 500 mL, 1000 mL, 2000 mL and 5000 mL bottles with this processed water and sell widely in the different parts of Bangladesh. However, the dissolved minerals in their purified drinking water are not sufficient for human health. Total Dissolve Solids (TDS) is a parameter that counts all dissolved minerals in the water. Calcium, magnesium and potassium are minerals that are introduce as a "Beneficial Minerals" for human health. Calcium is an important mineral for bone development, potassium is needed for muscles and nervous system and magnesium is helpful protect cardiovascular disease. The objective of the study is to examine the Total Dissolved Solids (minerals) and the Total Hardness (TH) in selected bottled water samples. The selected samples have been marketed by the local branded companies in Bangladesh. TDS and TH are measured in total eight of bottled water samples collected from the local confectionery shops in Dhaka city. The obtained results show that the levels of dissolved minerals in the drinking water samples are very low, which is quite alarming. Particularly, calcium and magnesium are found in very low amount in water samples of three companies. It can be assumed that those bottled water do not bring additional benefits to human health. The TDS of sample of one company was alarming low (9.44 mg/L. It may pose negative effects on human health especially malnourished people's health.

**Keywords:** Drinking Water, Mineral, Dissolved Solid, TDS, BDS, BSTI, WHO

## 1. Introduction

Dhaka, the capital of Bangladesh is one of the mega cities in the world with the population of over fifteen million [Figure 1]. [1]. It is one of the rising cities in Bangladesh. The demand of drinking water is increasing in all cities of Bangladesh. One cannot think about life without water. Everyone use water in their daily life for drinking, washing, flashing, bathing and cooking. In addition, water is widely used in irrigation, building construction, electricity and steam generating etc. Different properties of water are important for users though it is depend on the purposes for which water is used. The properties of drinking water must suitable for health. The safe drinking water is also considered to be a pre-requisite for developing public health and economic growth. Always, every thirsty people seek the safe and pure mineral containing drinking water for filling their body demand. In Bangladesh,

most of peoples are very blessed regarding availability of one of the most important natural resource, water. But they cannot use it properly due to contamination of natural resources. Population growth, global warming, rapid industrialization, water, lack of adequate and improved management of natural resources are leading to increased water pollution in an alarming rate. The standard specification (Table-1) of purified drinking water has been set by Bangladesh Standard &Testing Institution (BSTI). The specification's for natural mineral water and natural drinking water are respectively BDS-1414:2000 and BDS-1240:2001 [2].

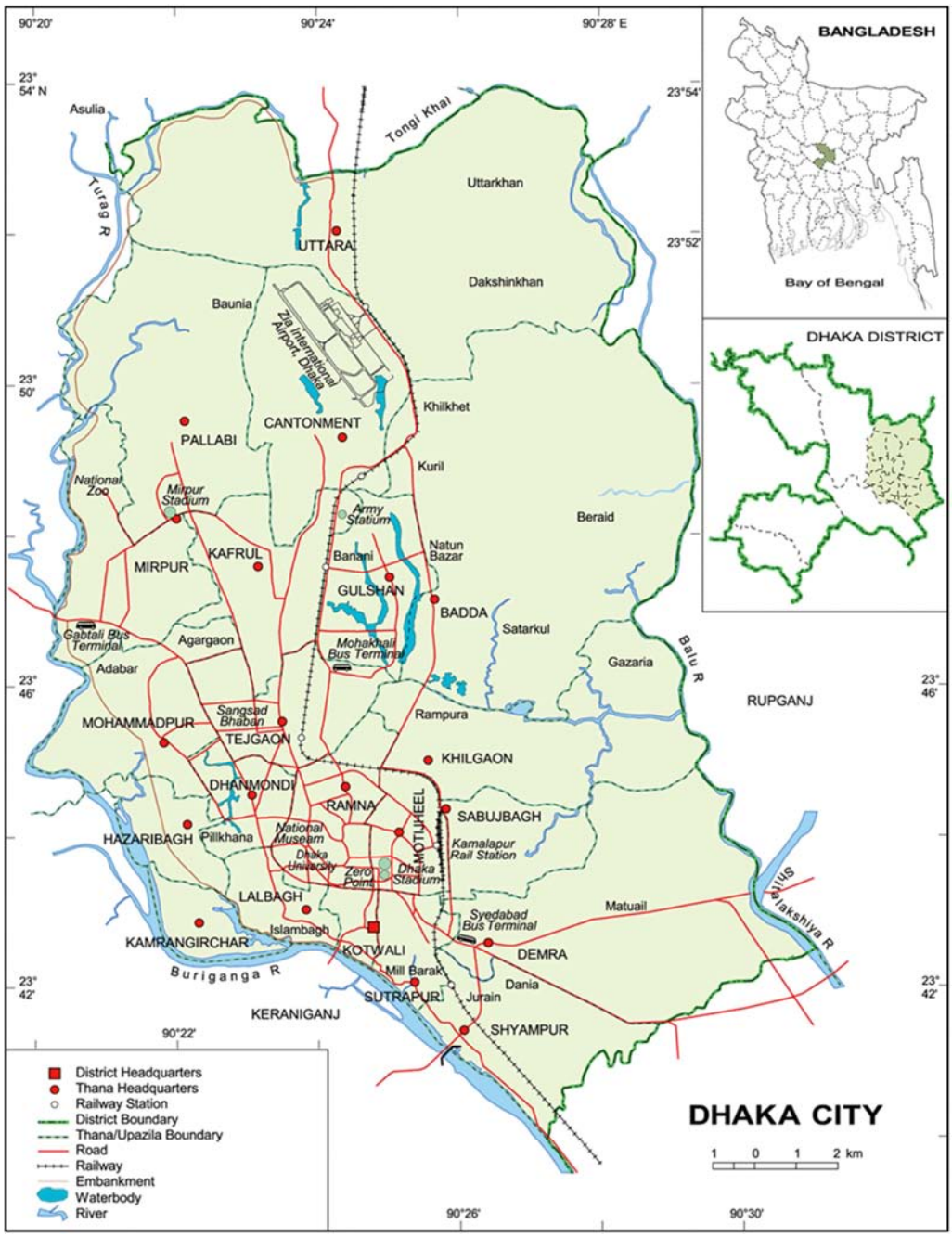


***Figure 1.*** *Map of Dhaka City, Bangladesh.*

Total Dissolve Solids (TDS) are measure of the combined content of all inorganic and organic matters or salts which are found in water. The main ingredients are usually the cat ions such as calcium, magnesium and potassium and the anions such as carbonate bicarbonate, nitrate, chloride sulfate etc. Among the contents of TDS, dissolved calcium and magnesium in the water is called "Hardness". Some ions of the above mentioned are essential where as some ions are toxic to human health. Low TDS and TH in water are defined in this paper as that containing 1-100 mg/L [3]. This is typical of the water quality obtained from distillation, reverse osmosis and deionization system of use water treatment. As per the BDS-1414:2000 and BDS-1240:2001 standards of BSTI, the maximum TDS level are 1000.00 mg/L and 500.00 mg/L

respectively [2]. Along this, the maximum range for hardness level in drinking water is 300.00 mg/L. Although; a minimum level of TDS and TH for drinking water are not specifically mentioned for drinking water is not specifically mentioned in their standard.

According to the medical science, the lower level of minerals in water never benefits for thirsty and malnourished peoples. In Bangladesh, most of the people don't know the benefits of dissolved minerals for maintaining their good health. After 1988 flood when hepatitis broke out widely, drinking bottled water entered into the local market of Bangladesh as safe. Since then, the private companies are producing bottled drinking water (arsenic & cyanide free) by reverse osmosis purification system. BSTI also have been issued the license to around 275 manufacturers of which 100 are filling only jar with their purified drinking water [4, 10]. However, they do not maintain the level of beneficial dissolved minerals properly in their processed water.

***Figure 2.*** *Packaging Unit of Mineral Drinking Water.*

Most of the bottled drinking water manufacturers are producing the desalinated, de-mineralized water and selling to the local market by labeling "Pure Mineral Water".

The World Health Organization conducted a study that revealed some health risks associated with drinking water without dissolved minerals especially hardness (calcium and magnesium) level. Few of the risk include kidney problems, gastrointestinal problems, heart disease, pregnancy complications, bone density issues, joint conditions, cardiovascular diseases anemia fracture, growth disorders etc. It has been also reported that the low mineral drinking water increase the dieresis and the elimination of calcium, magnesium, sodium, potassium, nitrate and chloride ions from the body [5].

According to WHO, the range for hardness (calcium & magnesium) in drinking water is 100-500 mg/L. Two important components of total hardness are calcium & magnesium is needed for dietary. They also result in beneficial effects on bone structure [6]. In addition, mineral shall do the balance of body ions and energy. The presence of dissolved solids in water may affect its taste. Generally, the taste of water containing low mineral is sour or flat .On the other hand, water containing excess minerals tastes metallic, salty, earthy etc [3, 7, and 17]. So, significant deviation of TDS level in water from the standard values is unacceptable to consumers not only because of taste but also due to other effects.It is remarked that the possible bacterial contamination in the lower TDS water which is also very harmful to human health. All coliform bacteria do not cause for diseases. However, some rare strains of E. coli, particularly the strain 0157:H7 can cause serious illness [5, 8, 23]. According to the medical science, calcium, magnesium, potassium are the beneficial components for bone, teethes and plays an important role a co-factor than 300 enzymatic reactions in the body including glycolsis, ATP metabolism, transport of minerals through membranes, synthesis of proteins and nucleic acids, neuromuscular excitability and muscle contraction [3, 5, 6].

The World Health Organization conducted a study that exposed some health risks associated with drinking water without minerals. Few of the risks include kidney problems, gastrointestinal problems, bone density issues and cardiovascular diseases etc. [3, 5]. The kidneys are most important constant mineral's concentration through elimination and re-absorption. In homeostasis, three body fluid are involved: Plasma (3/5 of the blood Volume), Interstitial (fluid between cells), intracellular (fluid inside the cells) [3]. The concentration of sodium ions is the highest outside the cell and that of potassium ions is the highest inside the cells. When the osmotic pressure is high on one side of the cell membrane (higher concentration of ions/minerals) and lower on the another side (low concentration of ions/minerals), water moves across the cell membrane from the dilute side toward another side to equalize the osmotic pressure. This phenomenon is known Reverse Osmosis process. The concentration of normal ions or minerals of all these fluid is about 300 mM/L [3]. Any changes from normal in ions or minerals concentration across the cell membrane are corrected in one minute or less because water moves quickly through cell membranes. Therefore, small changes in os-molality from drinking water are quickly brought to equilibrium. The kidneys control the overall concentration of the constituents of body fluid.

The typical kidneys filter approximately 180 liters of plasma/day and each of the 3.0 liters of plasma gets filtered about 60 times [9, 22]. To replace this much water have to drink a 12- ounce soft drink every 3 minutes of the day fortunately 99% of the filtrate gets reabsorbed, leaving 1.5-2.0 liters of urine per day [11, 12]. If the os-molality of the fluid to be filtered by the kidney is lower than normal, nervous and hormonal feedback mechanisms cause the kidney to excrete more water than normal. Thus, the mineral's concentration in the blood and body fluids are quickly maintained by the kidney through homeostasis. If homeostasis is not maintained because of major diet mineral deficiencies, diseases, consuming lower minerals in drinking water would be minor causes. (If any) factor in any observed symptoms, It is apparent that disease, physiological dysfunction, or major nutritional deficiencies many causes a "leaching" problems, but not consuming one to two liters of low level of TDS water on a daily basis.

## 2. Manufacturing Process

Most of the mineral water industries are manufacturing the mineral water by using the Reverse Osmosis (RO) system [Figure 3 & Figure 2] which is a purification technology that

uses a permeable membrane to remove large healthy and unhealthy minerals, organic & inorganic molecules, mono & multivalent ions and some bacteria & viruses from the untreated water. It is noted that the semi permeable membrane technology of RO was first observed in1748 by Jean-Antoine Nollet. By the end of 2001, about 15200 desalination RO plants were in operation or in the planning stage or worldwide [13]. The pore size of membrane filter is 0.0001 microns [13, 14] which does not allow the minerals to pass through. After passing through the RO membrane, the water goes to a post final filter like as Activated Carbon Filter (ACF). After removing the remaining odors, tastes, organic chemicals, chlorine and other suspended solids by the ACF, water goes to storage tank and fills the bottles with this water. In this manufacturing system, there is no opportunity to add the necessary minerals in produced drinking water.

***Figure 3.*** *Reverse Osmosis Unite of Mineral Drinking Water.*

Due to the lack of accurate monitoring, manufacturers are producing the desalinated /de-mineralized water and selling to the market of Bangladesh randomly.

# 3. Materials and Method

### *3.1. Sample Collection*

Total eight bottles of mineral water (Size: 500 mL) of different brand were collected from different confectionery shops in Dhaka city and storage at below 10°C in the laboratory refrigerator. TDS & TH of the samples were measured according to the standard methods EPA Method #160.1, Gravimetric and Dried at 180°C [15] and EPA Method 130.2, Titrimetric, EDTA [16] respectively.

### *3.2. Apparatus*

For the analysis of total solids in different collected drinking water sample, the following apparatus were used in the laboratory-

- Filtration Unit, Glassco, UK (Glass Fiber Filter Disk, 2.1 cm, Air Suction Pump (Model Rocker-300),Suction Flask 500 mL)
- Evaporating dish, 100 ml
- Hot Plate (Model: AREC, Velp, Italy)
- Water Bath (Model:HH.$S_{21.4}$)
- Drying Oven (Model:3606,Branstead)
- Desiccators
- Graduated cylinder, 100 ml
- Analytical Balance (Model: EW 220-3NM, Kern, Germany)
- Refrigerator (Model: RR-618MW, Rangs).

### *3.3. Analytical Procedure*

200 mL of each sample was filtered through a standard filtration unit using glass fiber filter disk, glass beaker, membrane filter paper, vacuum pump. 100 mL of each filtrate sample was transferred into evaporating dishes using 100 ml graduated cylinders. The evaporating dishes were heated at 550°C for an hour in hot plate. The evaporating dishes were cooled in desiccators and the weight of each dish was measured immediately.Each filtrate samples which were transferred is evaporated and dried to constant weight at 180°C in Oven and cooled in desiccators before taking the weights [15].

The total hardness of water was determined by complexometric method where $Na_2$.EDTA was used as complexion agent and Eriochrom Black T was used as an indicator [16]

### *3.4. Calculation*

To calculate the TDS of each sample the following equation was used:

$$\text{TDS (mg/L)} = \{(A - B) \times 1000\} \div \text{Volume of sample}$$

Where, A = Weight of evaporating dish and dried residue
B = Weight of evaporating dish

# 4. Results and Discussions

Different government has different regulations for the TDS level for drinking water. According to the BSTI guidelines, the maximum level of TDS for mineral bottled water and natural drinking water are 1000.00mg/L and 500.00 mg/L respectively [2]. A review was performed of the Bureau of Indian Standards, United States, Canadian, World Health Organization (WHO) and European Community (EC) for drinking water standards. The Bureau of Indian Standards (IS10500), United States recommended the maximum level of TDS is 500.00mg/L for drinking water, the Canadian guidelines suggest less than 1000mg/L, and the EC Maximum Admissible Concentration (MAC) is 1500.00 mg/L. None of them has minimum limits or optimum levels of TDS [12, 17, 18, 19]. It can be assumed that according to these guidelines, TDS level can be even 0.00 mg/L in the drinking water which does not have any minerals. Water could be transparent, clear, and drinkable without the presence of minerals. However, absence of minerals in drinking water will not fulfill the body demand and there will be no taste. Therefore, necessary minerals required for having suitable taste and for fulfilling the lack of minerals for public health. An isolated report, a summary of Russian studies available through the WHO, has recommended that human body fluid and electrolytes are better replaced with water containing a minimum of 100.00 mg/L of TDS [20]. WHO's team (1980) recommended that an optimum level of TDS should be about 200.00-500.00 mg/L for chloride–sulfate drinking water and 250.00-500.00 mg/L for bicarbonate drinking waters .On the other hand, It is also

reported that in drinking water, the maximum level of alkalinity, sodium, boron, and bromine are 6.5 mg/l, 200.00 mg/L, 0.50 mg/L and 0.01 mg/L respectively [12].

According to WHO, the range for hardness (calcium and magnesium) in drinking water is 100.00-500.00 mg/L. The EC standards also list numbers for calcium (guide level of 100 .00 mg/L) and magnesium (guide level of 30.00 mg/L) [21].

The best tasting drinking water for most consumers contain about 10.00-100.00 mg/L total hardness as $CaCO_3$ and a TDS of about 150.00-250.00 mg/L [7]. As per summary of the TDS or TH or minerals level in safe drinking water, the quality can be categorized in several groups as given below; [7, 12, 17]

| | |
|---|---|
| Poor | : less 100.00 mg/L |
| Excellent | : 100.00 to 300.00 mg/L |
| Excellent | : 300.00 to 600.00 mg/L |
| Fair | : 600.00 to 900.00 mg/L |
| Poor | : 900.00 to 1200.00 mg/L |
| Unacceptable | : Greater than 1200.00 mg/L |

The obtained results for TDS in the present work range is from 9.44 -335.00 mg/L (Table-2). It is clear that the TDS level (335.00 mg/L) of only one company (company 2) is satisfactory whereas that of other companies are much lower than the standard. It is to be noted that the level of TDS (9.44mg/L) of one company (company 6) is abnormally low. Similarly , the result of TH (Table -2) obtained in the range of 4.35-150.38 mg/L as $CaCO_3$. It is also observed that the level of TH of water is not agreeable whereas that of other company are lower than the standard. In this studied company's water samples, company 6 is strangely low.

It has been seen a scenario in their water processing unit, they release healthy ($Ca^{2+}$, $Mg^{2+}$, $Na^{+}$,$CO_3^{2-}$,$HCO_3^{-}$,$Cl^{-}$,& $SO_4^{2-}$) and unhealthy toxic ($Pb^{2+}$, $Zn^{2+}$, $As^{3+}$, $CN^{-}$, $Cd^{2+}$, $Cu^{2+}$, & $NO_2^{2-}$) minerals from the raw water by using the Reverse Osmosis system. They never balance necessary minerals level in drinking water according to the demand of human body.

***Table 1.*** *BSTI Guideline for Mineral Drinking water (Physical, Chemical & Microbiological)*

| Sl/No. | Parameters | Unit | Bangladesh Standard Value (BDS-1240,2001 BSTI) |
|---|---|---|---|
| **Physical Test** | | | |
| 1 | Colour | Hz | < 5.00 (Max.) |
| 2 | Taste | - | Agreeable |
| 3 | Odour (Cool & Hot) | - | Unobjectionable |
| **Chemical Test** | | | |
| 1 | pH | - | 6.40~7.40 |
| 2 | Total Dissolve Solids(TDS) | mg/L | <500 (Max.) |
| 3 | Total Conductivity | µS/cm | <800 (Max.) |
| 4 | Salinity | mg/L | <450 (Max.) |
| 5 | Total Hardness as $CaCO_3$ | mg/L | <300 (Max.) |
| 6 | Chloride ($Cl^{-}$) | mg/L | <250 (Max.) |
| 7 | Arsenic (As) | mg/L | <0.01 (Max.) |
| 8 | Total Iron (Fe) | mg/L | <0.30 (Max.) |
| 9 | Nitrate ($NO_3^{-}$) | mg/L | <4.50 (Max.) |
| 10 | Free Carbon dioxide | mg/L | <0.05 (Max.) |
| **Biological Test** | | | |
| 1 | Total Coliform in 100 ml | cfu | Absent |
| 2 | Fecal Coliform in 100 ml | cfu | Absent |
| 3 | Plate Count in 1 ml | cfu | <1000 (Max.) |

Few experts' responses about low mineral drinking water are as follow;

WHO's Dr. Gala-Gorchev states that WHO has "no information that low minerals water would have an adverse effect on minerals balance" [12, 21]

US EPA' Dr. Edward V. Ohanian, Chief of Human Risk Assessment Branch Wrote:

"Drinking water supplies a number of minerals that are important to human health. However, drinking water is normally a minor source of these minerals. Typically, the diet is the major source of these beneficial minerals. I am not aware of any data adequate to support the conclusion that Water with lower levels of mineral is unsafe". Beside this, U.S Army does not consider lower mineral (less than 100 mg/L) to be a problem and have no minimum [12].

# 5. Conclusion

More than one hundred drinking mineral water (pet bottle) plants are established in Bangladesh in short time. They are selling drinking water to the public through confectionery shops and other retailers in different places including bus & railway stations. In hot seasons, most of the peoples become thirsty and they need water containing minerals to drink especially when they work hard and walk. But they do not get the sufficient minerals to drink it from the bottled water sold in. As a result, they are depriving of the natural mineral. The drinking water quality of most of the companies under the present study does not meet the requirements regarding TDS and TH. Drinking water manufacturer and user might pay attention to improve the quality of drinking water based on the finding from the study.

Finally, the followings can be quoted from the study especially for the manufacturers and users;

A. Read the label before buying to see its content. Generally, most brands have reasonable amounts of minerals that will not give any undue disadvantages
B. Buy only new production bottled mineral water and not old stock to reduce any chances of leached chemicals.
C. Do not leave bottled mineral water in an area exposed to direct sunlight or heat, such as in parked cars on a hot sunny day.

However, it should be remember that not all brands are the same. Mineral water comes from many sources and will not taste the same or have the same mineral content.

***Table 2.*** *Analysis results in mg/L of TDS and TH in Drinking Mineral Water (PET Bottles).*

| Company→ | Company-1 | Company-2 | Compnay-3 | Company-4 | Company-5 | Compnay-6 | Compnay-7 | Compnay-8 |
|---|---|---|---|---|---|---|---|---|
| **Total Dissolve Solids (TDS) as mg/L** | 140 | 335 | *80.50 | 119.1 | 101 | **9.44 | *82.00 | *90.00 |
| **Total Hardness as $CaCO_3$ mg/L** | 72.78 | 150.38 | *38.48 | 56.5 | 35.75 | **4.35 | *40.00 | *45.85 |

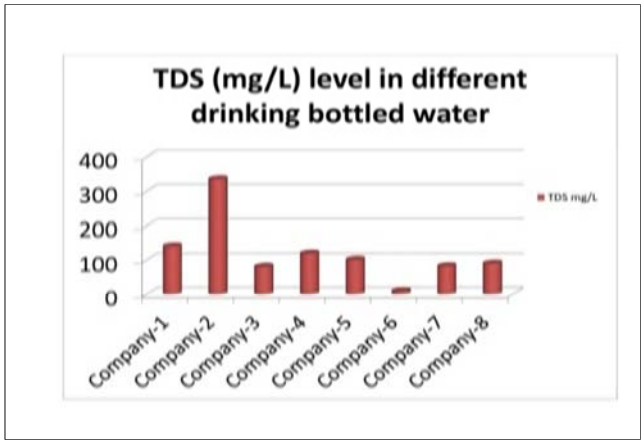


***Figure 4.*** *TDS level at the different drinking bottled water in Dhaka City.*

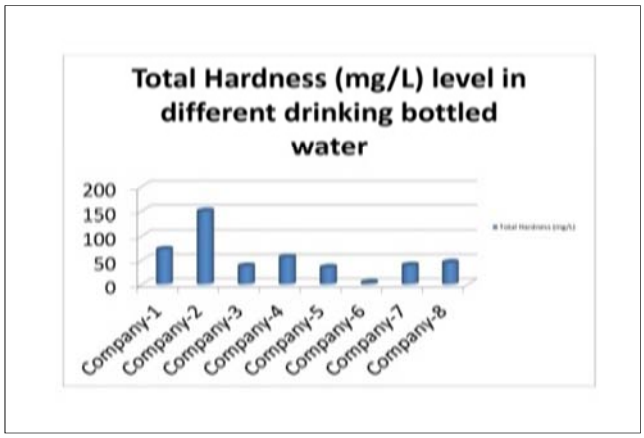


***Figure 5.*** *TH level at the different drinking mineral water bottle in Dhaka City.*

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