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# COMPARATIVE STUDY OF RAINWATER QUALITY AT CUET CAMPUS AREA, HARVESTED FROM ROOFTOP AND OPEN SPACE

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## ABSTRACT

Currently, Rainwater Harvesting System (RWS) is considered as one of the most important sustainable drinking water source. But there are so many factors that affect the rainwater quality, roof surface is one of them. This study is focused to compare the rainwater quality in between harvested from Rooftop and Open Space. Rainwater samples were collected from July 2018 to January 2019 by 500 ml polypropylene bottle. In almost every sample, the concentration of different physiochemical (pH, Temperature, Conductivity, Total Dissolved Solids, Turbidity, Alkalinity, Hardness, Carbon dioxide, Sulfate ($SO_4^{2-}$) and Nitrate ($NO_3^-$)) and trace metals (Fe, Pb, Zn, Mn, Cd, Cr, Cu) parameters were found higher in rooftop harvested rain water than the open space harvesting. For evaluating the water quality of harvested rainwater with time, both water (one collected from rooftop another directly from open space) is stored for long time (July 2018 to January 2019) and tested that water at regular interval. From the tested result it is revealed that for both conditions the physico-chemical parameters are not changed but the bacteriological parameters changed with time.

***Keywords:*** *Rainwater quality, Rooftop, Open space, Physico-chemical parameters; Bacteriological parameters.*

## 1. INTRODUCTION

Water is a key commodity which is necessary for all living beings to grow and reproduce (Ahmed, 2010; Al-Khatib, Daoud, Rasmawi, Wa'rra & Kassabry, 2005). Sustainable development is based on clean water (Ezbakhe, 2018). The Sustainable Development Goals tackle this problem in Objective 6, which seeks to: "Ensure accessibility and sustainable water and sanitation management for all." Target 6.1 sets out: "Achieving universal and equitable access for all to secure and affordable drinking water by 2030" and significantly improving global recycling and secure reuse. But, now-a-days drinking water scarcity is one of the most significant environmental issues in developing countries (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). Whereas, Water scarcity impacts all industries of society and the economy and threats the sustainability of natural resources (Mancosu, Snyder, Kyriakakis, & Spano, 2015). Most developing countries go through industrialization and population growth so fast that the drinking water supply cannot keep up with the demand. The rapid development of cities and consequent population explosion in urban areas has led to depletion of surface water resources as well as ground water resources (Perilla, Gomez, Diaz, & Cortezon, 2012). In this condition Rainwater Harvesting System (RWS) is considered as one of the most important sustainable drinking water source. But rainwater may pollute by several things. Factors that influence the quality of harvested rainwater include: roof geometry (size, exposure, and inclination), roof material (chemical characteristics, roughness, surface coating, age, and weather ability), location of the roof (proximity of pollution sources), maintenance history of the roof, rainfall events (wind speed, intensity, and pollutant concentration), other meteorological factors (seasons, weather characteristics, and antecedent dry period), and concentration of substances in the atmosphere (transport, emission, half-life, and phase distribution) (Abbasi & Abbasi, 2011).

Several research were done in Bangladesh about the potentiality of harvested rainwater(Akter & Ahmed 2015; Ashraful & Islam 2015; Rahman, Khan, Akib, Din, Biswas, & Shirazi, 2014; Dakua, Akhter, Biswas, Siddique, & Shihab, 2014; Islam, Chou, Kabir, & Liaw, 2010). Islam et al., 2011, studied about the feasibility and acceptability of rainwater for Dhaka city, Akter & Ahmed 2015, studied about the potentiality of rainwater harvesting in chittagong city and Alam et al., 2012, caried out a study about the feasibility of rainwaterv harvesting for Sylhet city. This paper is mainly focused on the comparison between rooftop and open space harvested rainwater-quality parameters and also evaluate the stored water quality of harvested rainwater with time.

## 2. METHODOLOGY

### 2.1 Instrument- Setup

The roof size for rooftop rainwater collection is (20′ × 10′) with 15° inclination and 12′ height. A 500-liter storage tank is used for storing the rainwater. For collecting rainwater from open space, a frame like Figure 1 is used. The frame is placed in the top of the civil engineering building at CUET campus. The frame is consist of two step, in upper step a 50 litre water bucket is placed for collecting rainwater directly from space and in lower step there are two 5 litre container, the left side one is for first flash rainwater collecting and the right side one is for after first flash rainwater collecting.


Rooftop Harvesting

Open Space Harvesting

Figure 1: Instrument setup for rainwater collection.

### 2.2 Rainwater Sampling

The sampling of rainwater from rooftop and open space were performed 16 times with 500 mL polypropylene bottles for a period July 2018 to December 2018. At the time of collection of sampling, always tried to take samples as per sampling guideline. Rainwater from Open space harvested and Rooftop harvested is stored separately in 50-litre tank for evaluating the water quality of harvested rainwater with time.

### 2.3 Laboratory Analysis

It has assembled around 60 different samples and tested for different physiochemical (pH, Temperature, Conductivity, Total Dissolved Solids, Turbidity, Alkalinity, Hardness, Carbon dioxide, Sulfate ($SO_4^{2-}$) and Nitrate ($NO_3^-$)), trace metals (Fe, Pb, Zn, Mn, Cd, Cr, Cu) and microbiological (TC) characteristics. The testing methods and standard of WHO & Bangladesh is shown in Table 1.

Table 1: Testing methods and standards (WHO & Bangladesh) of different water quality parameters

| **Water Quality Parameters** | **Bangladesh Standards (mg/L)** | **WHO Guide Line** | **Methods/ Equipment** |
|---|---|---|---|
| pH | 6.5-8.5 | 6.5-8.5 | pH Meter |
| Electrical Conductivity | -µs/cm | - | Multi-meter |
| Total Dissolved Solid | 1000 | - | Multi-meter |
| Turbidity | 10 NTU | - | Turbidity meter |
| Alkalinity as CaCO3 | - | - | Titrimetric |
| Hardness as CaCO3 | 200-500 | - | Titrimetric |
| Carbon dioxide ($CO_2$) | - | - | Titrimetric |
| Nitrate | 10 | 50.0 as N | UV-VIS |
| Sulfate ($SO_4^{2-}$) | | | UV-VIS |
| Iron | 0.3-1.0 | - | UV-VIS |
| Copper | 1 | 2 | UV-VIS |
| Lead | 0.05 | 0.01 | AAS |
| Zinc | 5 | - | UV-VIS |
| Manganese | 0.1 | - | UV-VIS |
| Chromium | 0.05 | 0.05(P) | UV-VIS |
| Cadmium | 0.005 | 0.003 | AAS |
| TC | 0 CFU (N/100mL) | 0 | Membrane Filtration Method |

## 3. RESULT & DISCUSSION

### 3.1 Open Space Harvesting

Descriptive statistics for selected parameters of open space harvested rainwater were presented in Table 2 both for first flash and after first flash rainwater. The statistical analysis showed no statistically significant difference in the concentration of pH of the first flush and the corresponding the rainwater of after first flash (Table 2). The mean concentration of pH in first flash tank is slightly higher than the tank of after first flash. The mean value of pH at all sampling points was in the acidic range and fluctuated between 4.52 and 7.01. Mean EC values of first flash and after first were 14.97 µS/cm and 12 µS/cm respectively which is very much lower than the threshold set by Bangladesh Standard for drinking water. The statistical difference in between first flash and after first flash for TDS concentration were found same as EC. The mean concentration of alkalinity values for first flash and after first flash rainwater were found 5.79 mg/l and 5.46 mg/l respectively. Mean hardness values of first flash and after first flash rainwater were 51.79 and 38.4 (mg $CaCO_3$/L), respectively (Table 2), i.e., hardness exhibited higher mean values in waters (first-flush) and was around 26 times greater than the concentrations in after first flash water tanks. The concentration of sulfate and nitrate were found higher in the first flash tank than the after first flash tank. The reasons behind the higher concentration of sulfate and nitrate in first flash tank is, generally the pollutants $SO_x$ and $NO_x$ present in air accumulates in initial rainfall. There is no statistically significant difference in the concentration of all trace metals (Fe, Cu, Zn, Mn, and Cr) of the first flush and the corresponding the rainwater of after first flash (Table 2). The concentration of lead and cadmium were not found within the minimum detection limit.

Table 2: Descriptive Statistics of Open Space Harvested Rainwater

| Parameters | First Flash | After First Flash |
|---|---|---|
| pH | 5.85 ± 0.80 | 5.7 ± 0.78 |
| Conductivity (µS) | 14.97 ± 5.62 | 12 ± 6.04 |
| TDS (mg/l) | 9.94 ± 3.16 | 8.2 ± 3.35 |
| Turbidity (NTU) | 1.5 ± 0.78 | 1.4 ± 0.38 |
| Alkalinity as CaCO3 (mg/l) | 5.79 ± 1.08 | 5.46 ± 0.95 |
| Hardness as CaCO3 (mg/l) | 51.79 ± 18.36 | 38.4 ± 14.2 |
| Sulfate ($SO_4^{2-}$) (mg/l) | 0.43 ± 0.65 | 0.23 ± 0.18 |
| Nitrate ($NO_3^-$) (mg/l) | 0.22 ± 0.27 | 0.13 ± 0.16 |
| Iron | 0.07 ± 0.11 | 0.06 ± 0.09 |
| Copper | 0.018 ± 0.01 | 0.02 ± 0.012 |
| Zinc | 0.19 ± 0.019 | 0.14 ± 0.023 |
| lead | 0 | 0 |
| Manganese | .0013 ± .0006 | .0003 ± .0005 |
| Chromium | 0.0074 ± 0.0086 | 0.002 ± 0.001 |
| Cadmium | 0 | 0 |

### 3.2 Comparisons in Between Open Space and Rooftop Harvested Rainwater

In almost every sample, the concentration of selected parameters found higher in rooftop harvested rain water than the open space harvesting (Table 3). Especially for the concentration of pH, Iron and Zn, the variation was considerable. The concentration of pH value for open space harvesting found in between 4.52 to 7.68, whereas for rooftop harvesting it is found 6.85 to 8.66. Same for Iron concentration, for open space harvesting found in between 0.01 - 0.11 mg/l, whereas for rooftop harvesting it is found 0.03 - 0.32 mg/l. Zinc concentration for rooftop harvested rainwater was found 0.18 - 0.37 mg/l but for open space harvesting it was in the range of 0.06 -0.23 mg/l.

Table 3: Comparison of CUET Campus Rainwater Quality between Open space harvesting and Roof top harvesting

| Parameters | Open Space Harvesting | | Rooftop Harvesting | |
|---|---|---|---|---|
| | Median | Range | Median | Range |
| pH | 5.76 | 4.52 - 7.68 | 7.2 | 6.85 - 8.66 |
| Conductivity (µS) | 13.89 | 8.39 -26.6 | 54.9 | 27.1 - 63 |
| TDS (mg/l) | 9.51 | 5.95 -16.6 | 38.2 | 19.7 - 41.8 |
| Turbidity (NTU) | 1.16 | 0.6 - 3.48 | 1.3 | 0.41 - 2.19 |
| Alkalinity as CaCO3 (mg/l) | 6 | 4.0 - 8.0 | 23 | 20 - 25 |
| Hardness as CaCO3 (mg/l) | 50 | 15 - 80 | 60 | 35 - 90 |
| Sulfate ($SO_4^{2-}$) (mg/l) | 0.5 | 0 - 2 | 1 | 0 -11 |
| Nitrate ($NO_3^-$) (mg/l) | 0.22 | 0 – 0.89 | 0.47 | 0 – 0.88 |
| Nitrite ($NO_2^-$) | 0.14 | 0 - 2 | 0.5 | 0 -2 |
| Iron (mg/l) | 0.03 | 0.01 - 0.11 | 0.06 | 0.03 - 0.32 |
| Copper (mg/l) | 0.02 | 0.01 - 0.04 | 0.03 | 0.01 - 0.08 |
| Zinc (mg/l) | 0.19 | 0.06 -0.23 | 0.23 | 0.18 - 0.37 |
| lead (mg/l) | 0 | 0 | 0 | 0 |
| Manganese (mg/l) | 0.001 | 0.001 - 0.003 | 0.004 | 0.001 - 0.007 |

| Parameters | Open Space Harvesting | | Rooftop Harvesting | |
|---|---|---|---|---|
| | Median | Range | Median | Range |
| Chromium (mg/l) | 0.004 | 0.001 - 0.022 | 0.007 | 0.002 - 0.011 |
| Cadmium (mg/l) | 0 | 0 | 0 | 0 |
| Total Coliform (TC) (N/100mL) | 4 | 0 - 12 | 1 | 0 - 4 |

### 3.3 Stored Rainwater Quality

For comparison both water (one collected from rooftop another directly from open space) was stored for several months and tested that water frequently. From the tested result it is revealed that for both conditions the physicochemical parameters are not changed but the bacteriological parameters changed. The variation of physicochemical parameters with storage period for open space harvested and rooftop harvested rainwater are shown in Figure 2 and Figure 3. For both cases the concentration of Hardness varies more than other parameters. Initially the concentration of Hardness for rooftop harvested rainwater was 60 mg/l. After reaching the concentration to 40 mg/l, the curve for Hardness was being flat till the final sampling date. For the case of open space harvested rainwater, the concentration of Hardness initially was 55 mg/l, after reaching to 70 mg/l for some sampling dates the concentration falls to 40 mg/l finally.

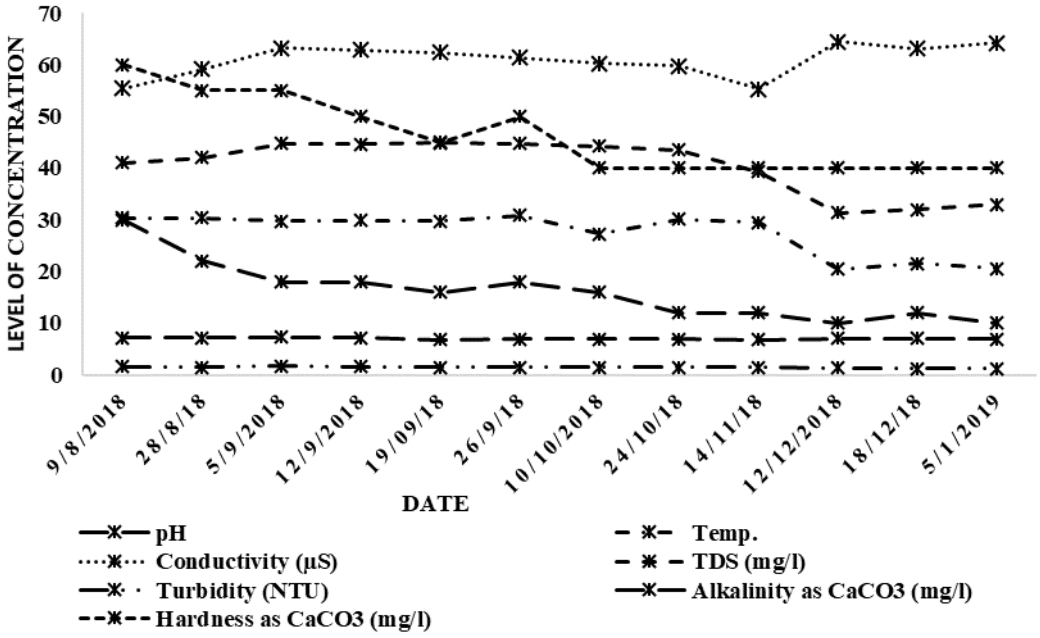


Figure 2: Variation of Physicochemical- Parameters due long-time storage (Roof Top Harvested)

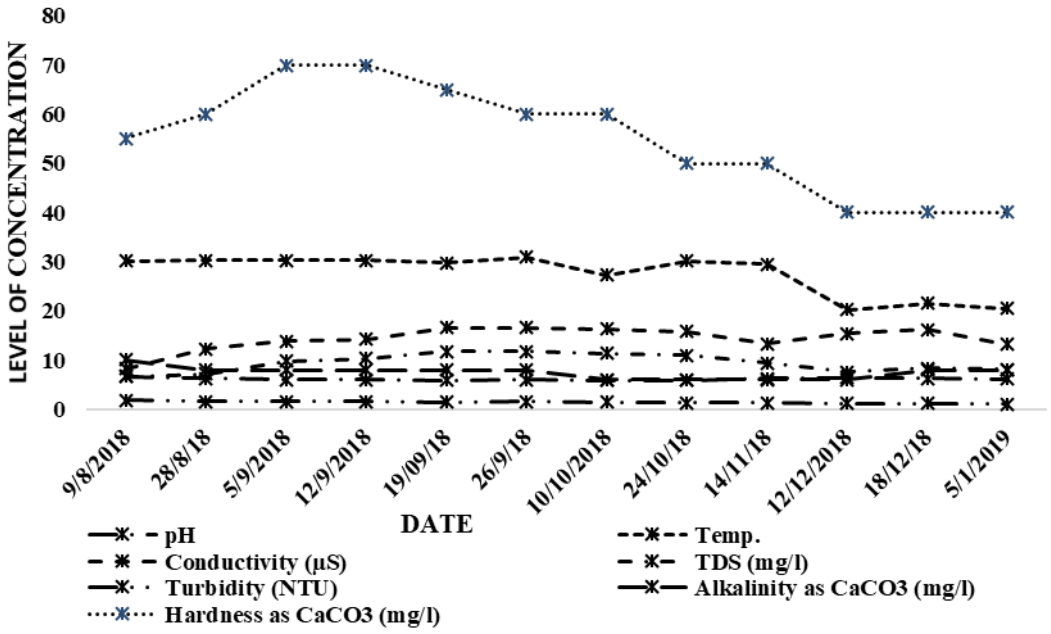


Figure 3: Variation of Physicochemical- Parameters due long-time storage (Open Space Harvested)

For rooftop harvested rainwater, initially the amount of total coliform was found per 100 ml water around 25 which is reduced to 4 (Figure 4). And for open space harvested rainwater, initially the amount of total coliform was found per 100 ml water around 140 which was reduced to 10 (Figure 5).

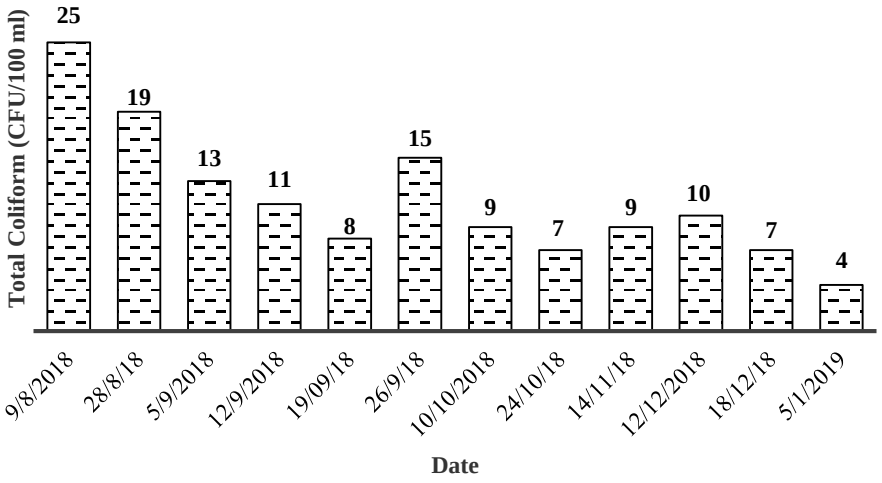


Figure 4: Trend of Coliform in Stored Rainwater collected from rooftop

The materials of storage tank were same throughout the storage period, moreover the temperature difference from the first date of storage period to last date was not high. So, the variation of number of coliforms may be due to lack of food for the survival.

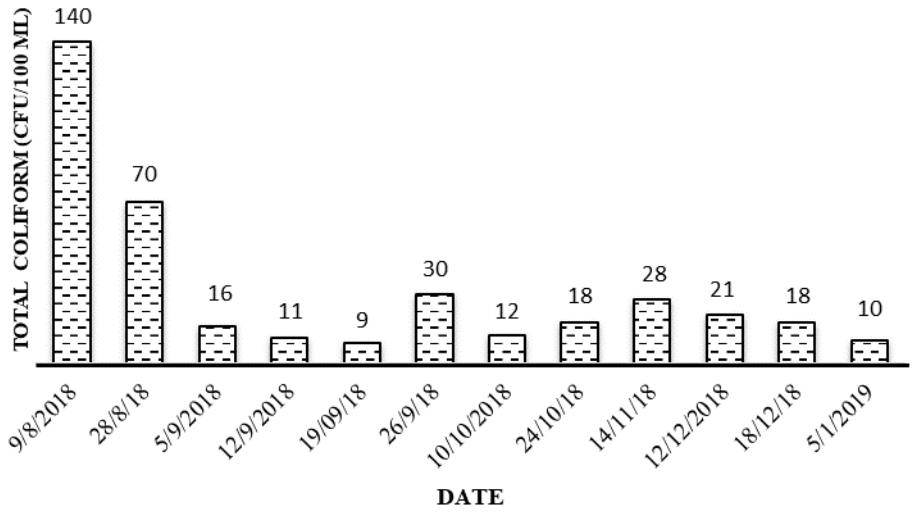


Figure 5: Trend of Coliform in Stored Rainwater collected from Open Space

## 4. CONCLUSIONS

In this study, the quality of harvested rainwater was assessed for different catchment type from July 2018 to January 2018. The difference between the quality of first flash and the after first flash rainwater was also exmined. The rainwaters were also stored from August 2018 to January 2019 and tested them at regular interval. Analysis of rainwater samples revealed that the concentrations of all measured parameters were within the permissible limit for drinking purpose according to Bangladesh Standard. But, the concentrations of all parameters were found higher for first flash rainwater than the rainwater after first flash. In almost every sample, the concentration of selected parameters found higher in rooftop harvested rain water than the open space harvesting. Especially for the concentration of pH, Iron and Zn, the variation was considerable. For stored rainwater, it is revealed that for both conditions (open space and rooftop harvested) the physico-chemical parameters are not changed but the bacteriological parameters changed with time. The reason behind the change of bacteriological parameters may be due to lack of food for the survival of coliform.

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