Paper ID: CE 0245

DEVELOPMENT OF RAINWATER HARVESTING SYSTEM FOR RESIDENTIAL BUILDING OF WATER CRISIS AREA OF JURAIN

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Abstract

The possibility for a rainwater harvesting system in Dhaka's East Jurain neighborhood is the main subject of this study. The residents of Jurain and its adjacent areas suffer due to the heavy iron contains of the tap water supplied by DWASA. Additionally, the tap water has an unpleasant odor or an odd hue, making it unsafe to consume even after boiling. To understand the current condition regarding drinking water, a survey was conducted in 100 household of the ward-53. From the survey it was found that, around 50% of the residents have to buy drinking water every day. And around 40% people collect their water from deep tube well. Collecting rainwater can be used as a solution for this problem. At first the monthly rainfall data of past 16 years (2005-2021) has been analyzed which was collected from BMD.This rainfall data was used to compute the monthly catchment yield on the rooftop of an average residential building in the area. This is the monthly water supply through rain water harvesting for each residential building. The monthly water demand for a residential building was found through the survey. After that the reservoir capacity to store the rainwater has been calculated through Mass curve analysis. This strategy provide near about 4% of each person's daily water usage. Some treatment is necessary for this collected water to make it safe and hygienic for drinking purpose.

Keywords: *Drinking water scarcity, Rooftop rain water harvesting, Rainfall calculation, Water treatment, and Economic benefit.*

1 Introduction

Water scarcity is a pressing issue worldwide, particularly in developing countries where approximately half the population lacks access to safe drinking water and sanitation. The contamination of drinking water due to inadequate waste management leads to significant suffering. Environmental hazards caused by water scarcity are worsening and could become major problems if not addressed promptly. Currently, more than 1 billion people lack access to water (Npr.org), resulting in the tragic deaths of over 5,000 children (Yeasmin et al 2013) each day due to water-related illnesses. Predictions indicate a potential 10-30 percent decrease in water availability by 2050 in dry regions (Yeasmin et al 2013). Urban areas face increasing water demand, with cities requiring almost double the water consumption compared to rural areas. In Bangladesh, as well as upstream in India, excessive water extraction contributes to water scarcity in surface water systems. The ineffective functioning of public water facilities in Dhaka City has deprived most residents of safe water access. While Bangladesh has a rapidly growing economy in South Asia, not all parts of the country have equally benefited. According to Water.org, around 41% of Bangladesh's 165 million population lack access to a reliable and well-managed water source (Water.org). Dhaka, the capital city, is particularly affected by a severe water crisis caused by urbanization, population growth, inadequate infrastructure, and climate change (Rabbani et al 2011). This crisis has dire consequences for public health, sanitation, and overall well-being. Limited access to clean drinking water increases the risk of waterborne diseases and burdens the healthcare system, while marginalized communities face exploitative pricing for poor-quality water sources (WHO). Dhaka city, with a population of 10 million people (World population review), is densely populated. However, the water supply system is unable to meet the increasing demand caused by population growth. The city's water supply falls short of the requirements, with Wasa, the water authority, having a production capacity of approximately 270 crore liters per day. Out of this, 91 crore liters are produced from treatment plants, while the remaining 179 crore liters come from deep tube wells (DWASA). The daily demand for water in the capital ranges from 210 to 240 million liters (DWASA). Rainwater harvesting (RWH) offers a potential solution to the severe water crisis in Dhaka, benefiting rural, urban, and industrial areas (Tabassum et al 2013). By collecting and reusing rainwater, it can help alleviate water scarcity and the issue of waterlogging. The United Nations Environment Program (UNEP) recognized the effectiveness of rainwater collection techniques in providing access to safe water. RWH, also known as Rooftop Rainwater Harvesting, has been successfully implemented in countries like Brazil, China, New Zealand, and Thailand (Teston et al 2018). In Bangladesh, rainwater harvesting is commonly practiced in rural areas for a safer water supply without arsenic contamination. The government is also taking steps, such as constructing buildings with RWH facilities in Uttara, and planning to incorporate RWH in upcoming residential projects in Jhilmil and Purbachal (Hasan, Irfanullah 2022).

2 The study problem

The study has been conducted on ward 53 of East Jurain which is a part of the DSCC. Ward 53 of Dhaka South City Corporation (DSCC) covers most parts of East Jurain's Muradpur area. Jurain in Dhaka experiences severe waterlogging during the monsoon season, leading to a persistent water crisis throughout the year. A survey conducted on 100 households in ward 53 revealed that approximately 95% of them receive either polluted or heavily iron-infested water. As a result, residents are compelled to purchase water for drinking and cooking, while relying on contaminated water from the Water Supply and Sewerage Authority (WASA) for other purposes. This leads to skin issues, such as dermatitis and rashes, and causes discoloration of clothes and utensils due to the high iron content in the water. The survey revealed that the water provided by the Dhaka Water Supply and Sewerage Authority (DWASA) is contaminated with high levels of iron and has an unpleasant odor, making it unfit for drinking. Approximately 50% of the population purchases drinking water, while 40% rely on deep tube wells. Unfortunately, 10% of the residents are forced to use the contaminated water for all their activities, despite its unpleasant qualities. This situation is both burdensome and expensive. Consequently, there is a persistent demand for clean drinking and cooking water**.**

Figure 2.1: Study Area - Ward 53 of DNCC
(Source: Google Map)

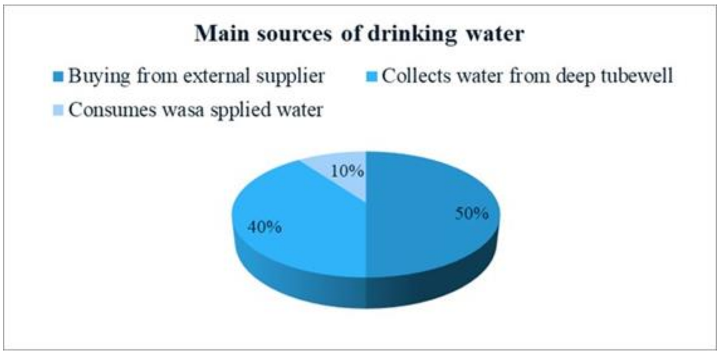

Figure 2.2: Main sources of drinking water

3 Methodology

This study focuses on calculating the rooftop area to determine the potential of rainwater harvesting in each building. In East Jurain, there are approximately 3,000 structures and a population of around 180,000. The size of the rainwater harvesting tank depends on the available catchment area and water demand of each building. Installing a rainwater collection system is challenging due to the size of the catchment area. The average building size in Jurain is 1200 sq. ft. or 112 sq.m, typically 3-4 stories high, accommodating an average of 60 people. A questionnaire survey was conducted to gather information on local people, water consumption, and usage patterns. The survey conducted in Ward-53 revealed that the water provided by DWASA is contaminated with high levels of iron and has an unpleasant odor, rendering it unsuitable for drinking purposes. According to the Center for Science and Environment (CSE), water requirement for drinking is 5 liters/day/capita. Accurate rainfall data is crucial for assessing the potential for rainwater harvesting in specific areas. The Bangladesh Meteorological Department (BMD) operates 35 stations that continuously monitor rainfall. The majority of annual rainfall, approximately 70%, occurs during the monsoon season. Analyzing rainfall da ta from 2005 to 2021 revealed an average annual rainfall of around 2,100 mm in the Dhaka division. For this study Mass Curve method has been used. The mass curve method is a technique used for rainwater harvesting to estimate the storage capacity required for a given catchment area. It involves plotting cumulative rainfall against time to determine the maximum rainfall intensity and the corresponding storage capacity needed. To calculate the potential of rainwater harvesting at Jurain at first each building roof top area has been calculated and surface runoff has been calculated. Then catchment area is multiplied with the average monthly rainfall and runoff coefficient.

The potential of rainwater harvesting would be in each building = A* I* C
So for the month of January rainfall intensity, I= 4.6875 mm
Catchment area, A = 110 sq.m
Runoff coefficient, C = 0.75
Total supply for the month of January = (0.75 *4.6875 *110)/1000 = 0.387 m^3
Water demand = 5 liter/day/capita
Total monthly water demand for a building = (5x60x30)/1000 = 9m^3

Table 3.1 Mass curve calculations for finding reservoir storage capacity

Time	Rainfall (mm)	Monthly Water Demand(m^3)	Monthly Water Supply (m^3)	Cumulative Water Demand (m^3)	Cumulative Water Supply (m^3)
Jan	4.6875	9	0.387	9	0.387
Feb	21.6875	9	1.79	18	2.177
Mar	38.567	9	3.181	27	5.358
Apr	145.1875	9	11.98	36	17.338
May	253.125	9	20.88	45	38.218
Jun	365.625	9	30.164	54	68.382
Jul	454.0625	9	37.46	63	105.842
Aug	342.25	9	28.24	72	134.082
Sep	254.1875	9	20.97	81	155.052
Oct	177.5625	9	14.65	90	169.702
Nov	21.1875	9	1.75	99	171.452
Dec	18.4375	9	1.52	108	172.972

From the table it is apparent that there is a deficit of water for the months of January, February, March, April, November and December. Whereas there is a surplus of water from rainwater harvesting during the months of May, June, July, August, September, October. To meet the water demand during deficit periods, it will be appropriate to construct a storage structure to store water during excess supply and use the stored water during deficit periods. The required storage capacity of the reservoir can be determined using mass curve method. A mass curve is a plot between time (months or years) and cumulative inflow values. After the inflow mass curve has been plotted, the mass curve of demand may also be plotted. Difference between the inflow and demand will be the required storage.

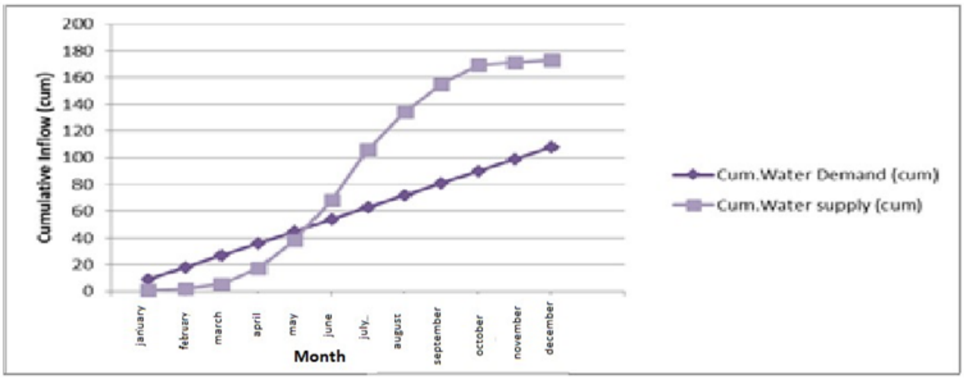

Figure 3. 1: Monthly rainfall intensity, illative rainfall availability (mass curve) and water demand/capita

From the above graph for the demand of 5 liter/day/capita, the required reservoir capacity will be 105 m^3. Assuming a depth of 3 m, the required area for storage reservoir will be 35 sq.m, and with square shape, the dimensions of the reservoir will be 6m x 6m.

3.1.1 Price Calculation

Monthly water demand= 5x60x30= liters=9000 liters.
Price of drinking water for per person per day is= 75 BDT
Price of drinking water for per person per Month is= 75*30*30 = 67500 bdt
The demand for water is completely fulfilled through rainwater harvesting. So monthly Cost savings per building is 67500 bdt. Of Dhaka city.

3.1.2 Result and Discussion

According to the study, rainwater-harvesting systems in residential buildings can meet approximately 4% of each resident's daily water demand, according to the Center for Science and Environment (CSE). This percentage is relatively low due to the small size of the buildings in the area, resulting in a small catchment area. Additionally, the high population density further contributes to the limited potential.

Table 3. 2: Water requirement for different purposes according to the Center for Science and

Use	Consumption(liters/day/person)	Percentage consumption
Drinking	5 liters	3.70%
Cooking	5 liters	3.70%
Bathing (including ablution)	55 liters	40.74%
Washing clothes	20 liters	14.81%
Washing utensils	10 liters	7.41%
Cleaning the house	10 liters	7.41%
Flushing of latrines	30 liters	22.22%
Total for urban areas	135 liters/person/day	100.00%

The results obtained from the flow mass curve analysis indicated that a storage reservoir with a capacity of 105 m^3 would be sufficient for a constant demand of 9 m^3. Considering a depth of 3m, the reservoir would have an area of 6m x 6m, which accounts for approximately 32% of the average building's area. Maintaining a reservoir of this size is cost-effective. To ensure the suitability of harvested water for drinking, its quality needs to be assessed based on various parameters such as pH, fecal coliform, total coliform, total dissolved solids, turbidity, NH3-N, lead, and BOD. This evaluation should be conducted throughout the year to obtain more precise and reliable results. The success of a rainwater harvesting system depends on its capacity to meet the specific requirements and preferences of the site and intended usage.

4 Conclusion

Solving the problem of water scarcity will be crucial to sustainable development. The vast majority of Dhaka City's residents face a year-round crisis of clean drinking water and a severe water deficit. Seven zones make up the DWASA's water supply coverage areas. However, residents of the city's low-lying and underdeveloped neighborhoods continue to lack access to DWASA's water supply but do have access to DPHE's deep tube wells and well coverage. The city residents do not accept the water from DWASA as drinking water for a variety of reasons. For drinking water, they boil and filter the water. For their own safety, people are starting to get used to drinking water from sealed bottles. The greater Dhaka city's underserved and unserved areas should receive priority when it comes to receiving water from the government. It is crucial to regularly evaluate and monitor qualitative and quantitative drinking water issues. In order to preserve sustainable health, environment, and growth for Dhaka city residents, it is imperative that the management of solid and liquid wastes, increased water consumption, and decreased reliance on groundwater be implemented.

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