Rainwater Harvesting Practices and Its Effectiveness in Kathmandu Metropolitan City

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Abstract

Water scarcity has been a major problem of Kathmandu Metropolitan City (KMC). Different interventions are being attempted to solve this problem including the highly discussed Melamchi Drinking Water supply project. Thus, so rainwater harvesting (RWH) could be a promising approach to satisfy water to some extent.The study has aimedto assess the status of rainwater harvesting practices in KMC and to examine its effectiveness in overcoming the water shortage. A total of 244 households were surveyed covering 32 wards of KMC through random sampling method and semi structured questionnaire forms were laid for the data collection. The annual rainfall data of interval 30 years (1990-2019) of KMC, collected from department of Hydrology and Meteorology for trend analysis. Study revealed 58.2% of households are practicing RWH and among them63.2% installed RWH system more than five years ago. About 63% of households are practicing roof top harvesting which is found to be more convenient in terms of cost and space. Strong positive correlation (R^2=0.876, r=0.942) was observed among amount of water harvested and space occupied by RWH system and was statistically significant ($P<0.05$).Harvested water isfound mainly used for household's chores, flushing toilets and watering the garden. Majority (95.8%) of respondents did not prefer harvested water for drinking due to its poor water quality, high contamination and bad odor and taste.About 73.2% of the respondents decontaminate harvested water before using and filtration (63%) is found to be most common and effective method for decontamination. Despite of challenges like leakages of storages and gutters, about 87.3% of respondents are strongly satisfied with RWH system as it reduced the municipal water supply bill and provides excess water for the sanitation. Furthermore, the trend analysis showed increment of rainfall in the area by 1.21 mm per annum. Study regarding governmental incentives for the installation of RWH system, availability and accessibility of quality products, training on installation and sanitary management of RWH system would help to shed further light in the aspects of RWH.

Keywords: *Hydro-meteorological data, Rainwater, Rainwater harvesting, Sanitation*

Introduction

The availability of safe and reliable source of water is prerequisite for the establishment of stable community(Koju et al. 2014). Demographic factor, economic and cultural factors are major determinants of the availability of water resources. Human's population explosion and environmental degradation in many developing countries leading to the declination of water availability in many countries (Aladenola and Adeboye 2010, Domene and Saurí 2006). Many surface water sources are being degraded by such anthropogenic interferences further exaggeratingthe problems of water scarcity in such areas. Identification of the alternative sources of water would be vital to solve those problems.

Kathmandu valley (KV) is one of the densely populated city of Nepal and is one of the city where the problem of water availability is rampant. The population of KV is expanding with annual growth rate of 4.63%(CBS 2011). Each year the problems related to the water are being escalating rapidly. Rapid population growth along with unplanned population growth, unsustainably water resources consumption, change in land use pattern and poor managerial system have resulted inconvenient supply of water in KV(Udmale et al. 2016).Currently, Water supply system in the KV is managed by the Kathmandu valley Water supply management board and operated by Kathmandu Upatyaka Khanepani Limited (KUKL)(KUKL 2017). KUKL annual report (2020) reported that average demand of drinking water in KV is 470 million litres a day (MLD) whereas supply is about 106 MLD in rainy season and 80MLD in dry season. Recently first phase of Melamchi water supply project has been completed and delivered 170 MLD water in Kathmandu valley. In addition, 340 MLD is proposed to supply through second phase by 2023(Thapa et al. 2018). The devastating flood of June 15, 2021 in Melamchi river has severely damaged the structures of water supply project which interrupted thecurrent water supply and projected water supply has been postponed. Fulfilling the water demand in the KMC has become challenging.Almost all households in Kathmandu depend on groundwater as their major source of water, but with climate change and the modernization in construction of roads and buildings, the land has turned impervious depriving groundwater of its natural recharge.

The demands are being partially fulfilled by collecting the water from nearby sources, extraction of the ground water and other means. The surface water near the valley area are limited while the ground water is declining rapidly. As the mean annual precipitation of the valley range from 1500mm (city area) to 1800 mm (surrounding hills) per annum with average 97 rainy days in a year(Thapa et al. 2016), Rain Water Harvesting (RWH) could be one of the options to partially fulfill the water demand of KV. RWH techniques has made significant contribution to overcoming water shortage issues and are found effective in both urban and rural areas (Dahal et al. 2010).RWH is the process of collecting rainwater from surfaces on which rain falls, filtering it and storing it for multiple uses (Barron 2009). In 1960, first modern RWH system was installed in Nepal at mission hospital Pokhara. Rainwater is usually of high quality and is safe for human consumption (Dahal et al. 2010). So, RWH could be the alternative to reduce overloads to the water treatment plants, recharging water to aquifers, primarily drinking purpose and secondarily ground water recharge and flushing toilets (Gautam 2017).However, when options for the problems are discussed, proper understanding the perception of the end consumer to use technology is vital for promoting such alternatives.

In context of degradation of groundwater and surface water in both quality and quantity, RWH could be the better alternative to meet the need of water to some extent. So, this study has aimed to address the current RWH practices and its effectiveness on overcoming the water shortage issues.

Materials and Methods

Study Area

The study was conducted in Kathmandu metropolitan city (Figure 1), situated north-western part of Kathmandu valley, the oldest metropolitan city of Nepal. The geographical area covered by KMC is 49 sq km and has a population 975,453(CBS 2011). The city lies at an average altitude of 1,350 meters above ground level. The climate is sub-tropical cool temperate. In general, the annual maximum and minimum temperature is between 27.9^{o}C in May and 2^{o}C in January, respectively. Average annual rainfall is1483.15mmin the interval of 30 years (1990-2019) recorded at Kathmandu airport station. Heavy concentration of precipitation occurs in the June to August. Average humidity in the city is 75%.

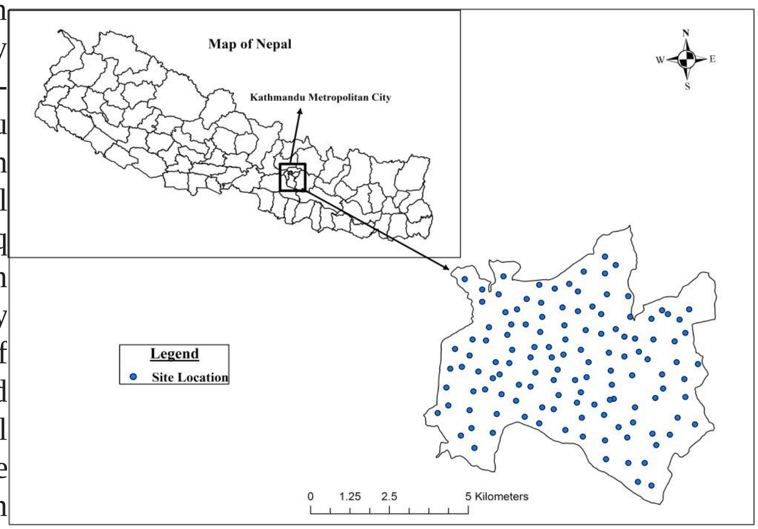

Figure 1 : Map of study area (KMC). Blue dots in the figure are surveyed location.

Data collection

A total of 244 households selected randomly. Prior to the household survey, coordinates were randomly interpolated covering all the 32 wards of KMC using ArcGIS. The real location of the coordinates was then identified and performed survey in the surrounding areas. Verbally consent from the respondents was taken before the survey. A social survey was performed with the use of semi structured questionnaire for the collection of primary data regarding rainwater harvesting practices, harvesting techniques, its management and effectiveness. Age group of the respondents was ranged from 20-60 years old. The rainfall data of Kathmandu Airport Station (1030) of interval 30 years (1990-2019) were collected from DHM.

Data analysis

All the data were statistically analyzed through MS Excel 2010. Data were represented in bar graphs and doughnut. Pearson's correlation was performed to analyze relation between space occupied by RWH system and amount of rainwater harvested. Rainfall data of interval 1990 – 2019 were plotted and trend was determined.

Results and Discussion

Annual rainfall pattern analysis

The data obtained from the DHM reveals an increase in the trend ofrainfall pattern (1.21 mm per year) over the period of 30 years which supports the feasibility of RWH inKathmandu (Figure 2).

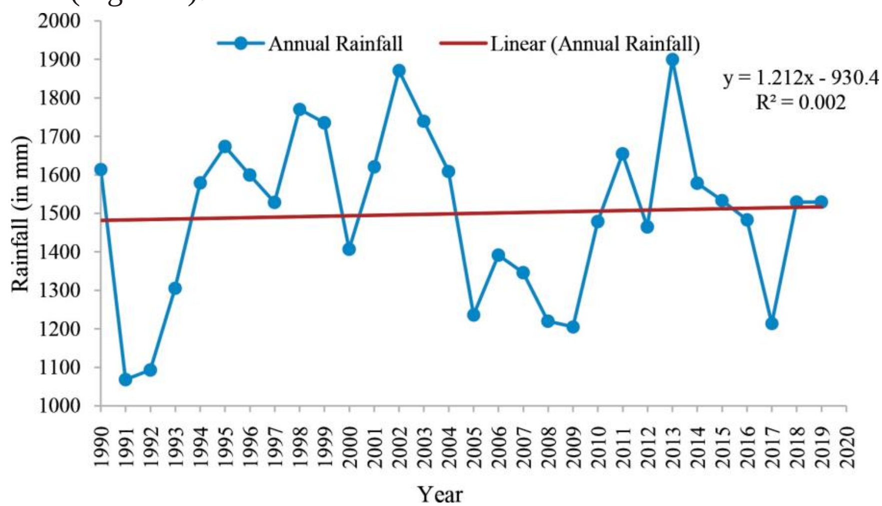

Figure 2: Trend line of annual rainfall recorded at Kathmandu Airport Station

Status of Rainwater Harvesting Practice

The study revealed 63.4% of HHs has installed RWH system survey and practicing more than 5 years ago (Figure 3).

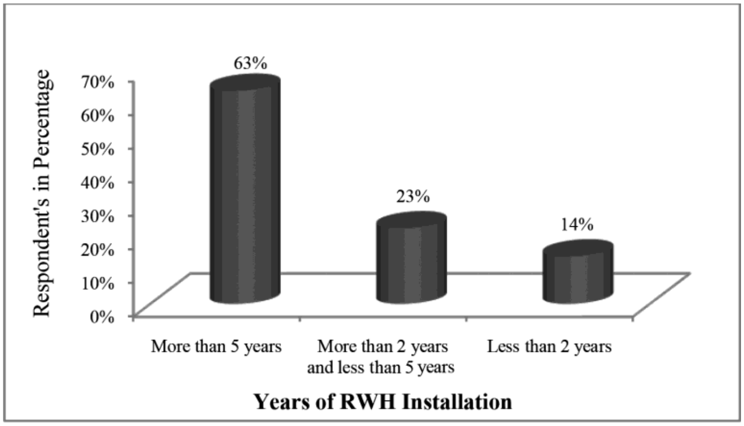

Figure 3:Interval of installation of RWH system

Rainwater Harvesting Techniques

Majority of households (63%) has installed Rooftop harvesting technique followed by direct collection of rainwater (24%), surface runoff harvesting (9%) and only 4% of households practice both rooftop and surface runoff harvesting techniques (Figure 4).The storage of harvesting system was found mainly installed in Terrace (29.5%) followed by Underground storage tank (27.7%), Backyard (21.1%), Front yard (15.5%), nearby field (5.5%) and Balcony (2.8%).

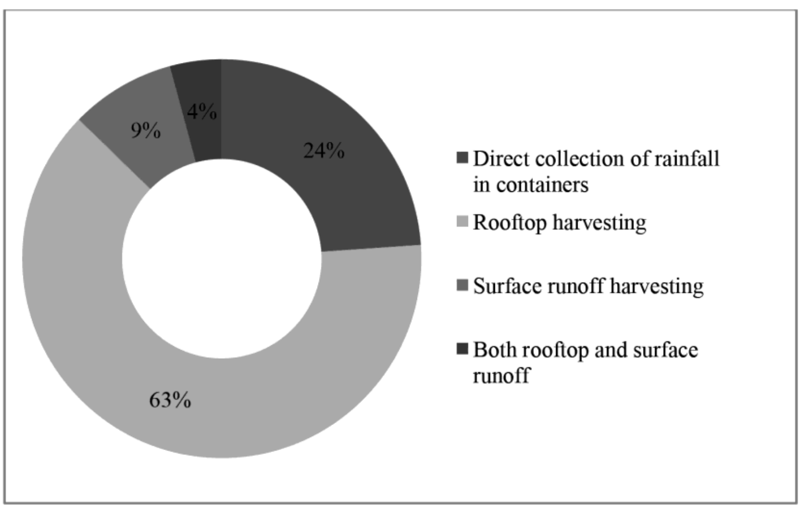

Figure 4: Different techniques used for RWH

RWH supply system

The study revealed mainly five types of harvested water supply system *i.e* water butt, direct-pumped, indirect-gravity, gravity only, indirect-pumped found to be practiced in KMC. These systems have the same purpose but differ in their functioning and the respondents used different types of system based on their convenience. About 59% of the respondents used the water butt technique as it is the most basic form of harvesting rainwater (Figure 5).

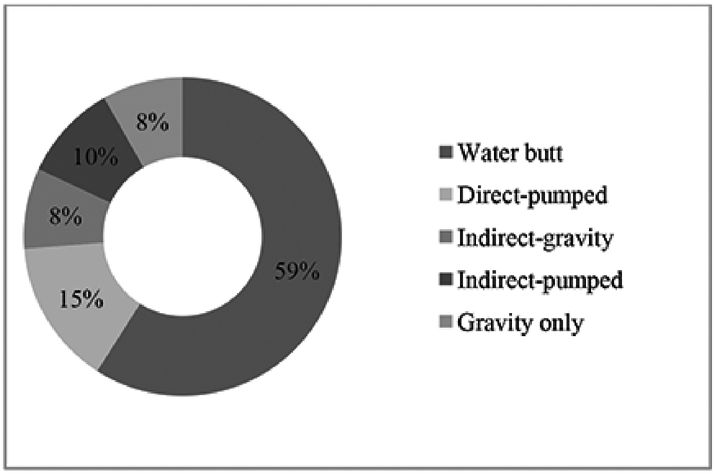

Figure 5: Type of system used for supplying harvested water.

Use of harvested water

Study revealed 74.6% of the households used harvested rainwater for household's chores activities such as cleaning, washing clothes and dishes and mopping the floor (Figure 6). About 59.2% of the households use harvested water for flushing toilets which helps to reduce ground water consumption and promotes sanitation. About 42.3% use harvested water in their gardens for watering the plants and other gardening purposes. Majority (95.8%) of the households don't prefer rainwater for drinking purposes. Poor water quality, bad taste and odour, high contamination are major cause reported for not preferring to drinking purpose. A total of 73.2% of the respondents decontaminated the harvested rainwater before using it. Filtration, chlorination, sedimentation, boiling and solar water disinfection (SODIS) methods are found usually practiced for the decontamination. Among them, media filtration method (63%) is found to be most common decontamination method. Among the households who are using harvested water for drinking purpose, only 5.6% of HH stests the quality of water every season.

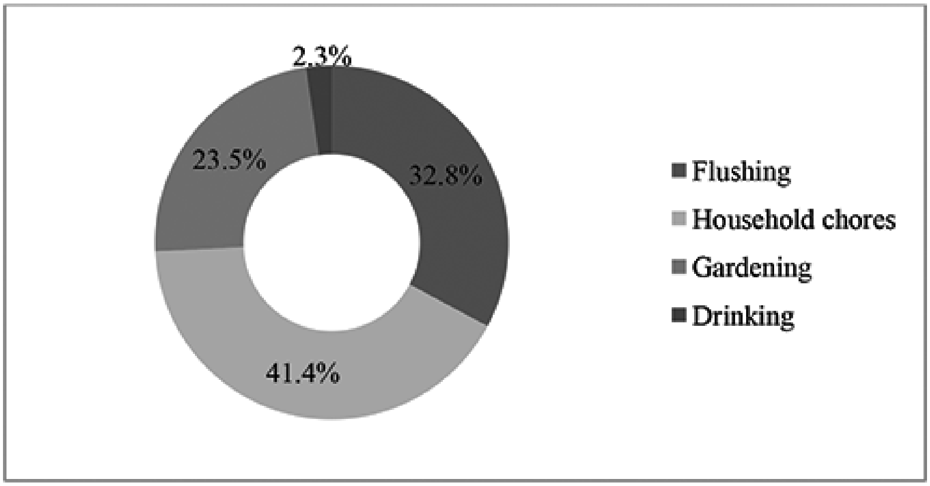

Figure 6: Purpose of use of the harvested water

Space occupied and amount of water harvested

The relation between amount of water harvested and space occupied by the harvesting system was found strongly correlated (R^2=0.876, r=0.942) and is statistical significant ($P<0.05$).Space occupied by harvesting system found ranging from less than 100 sq ft to 600 sq ft. About 27% of the households have installed harvesting system in less than 100 sq ft.

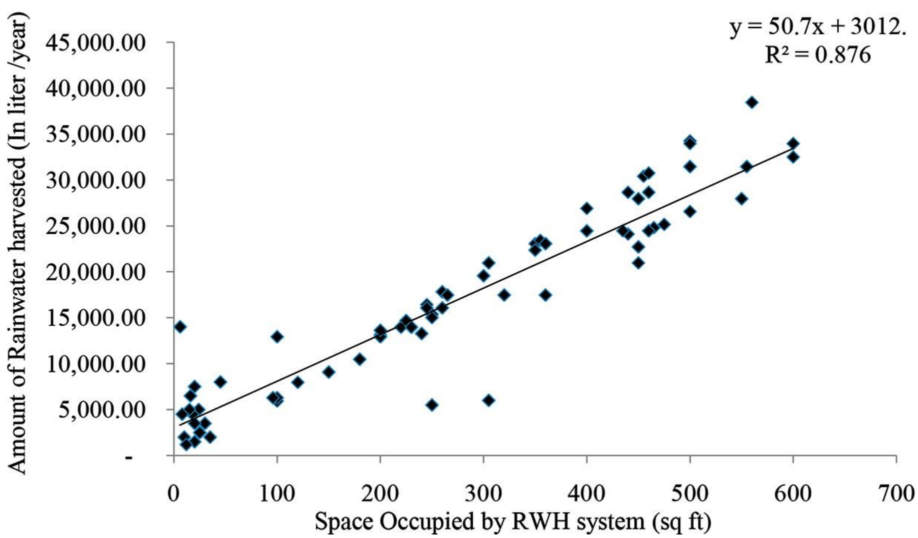

Figure 7: Relation between amount of rainwater harvested and space occupied

Operation and Maintenance

There is no proper timing observed for cleaning of storages and catchment areas in the study area. Four households were found cleaning catchment right before the rainy season. First flush method is not found practicing which is due tonot using harvested water for drinking purpose and no one in the house during the day time to flush the first rain. A total of 22.5% of the respondents reported leakages of storage and gutters are major challenges facing whereas mosquitoes breeding and contamination due to wind and bird faeces are common and simple issues reported.

Benefits and level of satisfaction

Majority of households (87.3%) found to be strongly satisfied and considered RWH as best alternative for fulfilling current water demand. Remaining (12.7%) reported issues like contamination, leakages of gutter and storage and small area for RWH system which makes them not much satisfied but are agreed with fulfilling water demand. About 60% of the respondents agreed with reduction on municipal water supply bill due to RWH system installed.

The results above revealed RWH practices are feasible in terms of its quality and quantity. Low installation and maintenance costand multiple use of harvested water showsits effectiveness towards meeting the water need. High amount of rainwater collected during the monsoon season supports to fulfil current demand of water to some extent (Gautam 2017). The rainfall data (Figure 1) shows increasing trend over the period of 30 years.

Harvested water has multiple uses and varies among the households. During the rainy season people use rainwater for most of their activities in order to save water from other sources. Drinking and cooking require a better water quality, the harvested water needs to be purified and storage should be timely cleaned. Using rainwater for flushing helps to save a lot of groundwater which also promotes sanitation (Pasakhala et al., 2013). Respondents were found to be cleaning and flushing their toilets more often than before after using harvested rainwater as they did not have to pay for rainwater, which shows RWH has also helped in maintaining sanitation. Although the rainwater is of very high quality (Shrestha et al. 2013) fallen leaves, suspended dust particles and rust of the catchment materials are found to be major causes of contamination of harvested water. The study shows that the chances of contamination increase due to presence of leaves, dust particles or microbes or due to rusting of catchment materials.

The capacity of a harvesting system to collect rainwater depends on the area of the roof or catchment area and the amount of precipitation (Udmale et al., 2016), so people also rely on water from other sources during dry seasons. Respondents mainly relied on

KUKL water supply system, Tankers/ Jar water and stone spouts as well.For drinking water, they mostly relied on Jar/bottled water and tap water is mostly used for drinking purpose.

Rainwater harvesting is viewed as a practice that is socially acceptable and environmentally responsible all the while, promoting self-sufficiency (Dahal et al., 2013). The study revealed majorityof the HHs was satisfied with the benefits of access to water for household's chores and support on reducing water bill. Regular cleaning of storage tank and contamination through winds were found RWHpractice hectic and time consuming.RWH is currently practiced all around the world and is suitable alternative for domestic use and irrigation (Liang and Van Dijk 2016) also enhance water security (Christian Amos et al. 2016). Abundance of conventional water sources, climatic conditions, financial and institutional support are some major determinants for the effectiveness of RWH system(Christian Amos et al. 2016). RWH systems are cost effective during installation (Gautam 2017), supports on recharging ground water, irrigation and also reduces urban flooding (Jamali et al. 2020).

Conclusion

RWH techniques being cost effective and requires small area is rapidly adopting by the peoples of KMC. Rainwater, although being purest form, was found mainly usedfor households chores, flushing, gardening and few households found using for drinking. Except drinking purpose, harvested water was not found tested chemically and timely cleaning the storage and gutters.

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