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POTENTIALS OF ROOFTOP RAINWATER HARVESTING AT BAYERO UNIVERSITY NEW CAMPUS, KANO

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ABSTRACT

Rainwater harvesting is receiving attention world wide as an alternative source of water. The present study was undertaken to assess the potentials of rooftop rain water harvesting technique in the sustainable development of water resources of Bayero University Kano (New Campus).The harvesting potential, yield factor, catchment area were determined and water samples were collected for water quality analysis. The result showed that, 322,645m3 of rooftop rainwater can be harvested annually; the yield factor was computed to be 88% and the catchment area was found to be 293,725m2.The rain water quality was assessed, parameters such as pH, hardness, acidity, turbidity, electrical conductivity, total suspended solids and total dissolved solids were found to be below the maximum values of World Health Organization (WHO) standard. It is was found that the harvested volume can cater for 36% of the water demand within the campus.

Key words: *Rainwater, Rooftop harvesting, Water demand, Yield factor.*

1. INTRODUCTION

The availability of safe drinking water for rural as well as urban habitation has become a major issue and challenge to the Government. Rainwater harvesting is the practice of collecting the water produced during rainfall event before it has a chance of running into rivers, streams or soaks into the ground and become ground water. It is classified into two broad categories namely; land-based and roof-based. Land-based method of harvesting rainwater occurs when rainwater runoff from the land is collected in ponds and small impoundments before reaching into the rivers or streams, where as roof-based rainwater harvesting involves the collection of rainwater that falls on the roof before the water even reaches the ground (Baron and Stenier 2009). Rainwater harvesting through roof top and ground catchments is an ancient technique of providing domestic water supply (Agarwal and Narain, 1997) and it is still widely used, especially in tropical islands and in semi-arid rural areas. Rainwater harvesting has assumed overriding significance all the more in view of the depleting ground water levels during the recent droughts in various parts of India (Ariyabandu, 2001). Although, roof based system of rainwater harvesting generally produced water with lower levels of chemical and biological contaminants, the water produced by both the systems must be properly treated before use. Though, the level of treatment depends to great extent on whether it should be used for potable purpose (such as drinking, food preparation, bathing and dish or hand washing) or for non potable purposes (such as toilet flushing, cloth washing and watering flowers). Obviously, rainwater that is intended for potable purposes must receive higher level of treatment than rainwater that is intended for irrigation purpose. In order to fight water scarcity, many countries started harvesting rain. Some players including Germany. Singapore and Tokyo, etc (Villarreal & Dixon, 2005; Abdulla & Alsharef, 2009).

1.1 Objective

The study was undertaken to:

1. assess the potentials of rooftop rain water harvesting technique in the sustainable development of water resources of Bayero University Kano (New Campus).

2. METHODOLOGY

2.1 Catchment Area

To estimate the potential amount of rainwater that can be harvested from rooftops of all buildings in Bayero University Kano (New Campus), data were collected as follows: The geo-reference satellite image of Bayero University, New campuswas captured using the Google Earth 2014 with maximum resolution for clear identification of the geographic data. The captured image was imported into ArcGIS, 2007, an object oriented, and raster-based Remote Sensing/GIS package. The images were then geo-referenced to a universal transverse Mercator UTM coordinate system, yielding a re-sampled spatialresolution of less than one meter. The process of on-screen digitizing focused on roofs of the largest,individual building in each area. Due to rainwater interception, only the unobstructed roof area wasdigitized where no tree(s) covered the roof surface. In essence, the average roof area foreach roof would thus be marginally under-estimated under this approach. The digitized roof area for each suburb wasthen converted to polygons and areas were calculated using the same GIS program.

2.2 Determination of Yield Factor

In this research work, El-kanemi dormitory was considered as proto-type with a total rooftop catchment area of 720m^2. The amount of runoff was measured using a plastic bucket calibrated in liters per rainfallevent from the roof top catchment area at the sample point. After the volume of runoff was collected andmeasured it was then multiplied by the total numbers of outlets within rooftop catchment which givesthe total estimated volume of runoff within the catchment. This was determined by collecting the totalvolume of runoff from a point outlet of a specific building (El-kanemi) and thenmultiplied by thenumbers of outlets within the building for a given rainfall event and then the yield factor 'C' wascomputed using the equation; $C = \frac{Runoff(mm)}{Rainfall(mm)}$

2.3 Water Demand Andrainfall Data

Rainfall data was collected at Kano State Bureau of Statistics, the demand per capita per day was used in computing the average annual volume of water demand in the campus using the information collected both from the Maintenance Service Department (MSD) and Student's Affairs Division. The demand for water include: Domestic water demand, Fire demand, Losses, Lawn watering and Academic activities

2.3.1 Domestic water Demand

According to Bayero University maintenance service department and students affairs division 150l/c/day was allocated to staff quarters with population of over 4,000 staffs, 125l/c/day was allocated to boarding students with population of almost 9,500 were as for day students 50% of that allocated to boarding students was used as domestic water demand.

2.3.2 Fire Demand

Certain quantity of water was used to cater for fire disaster based on Bustan equation

$Q = 5663 \times \sqrt{P}$

Q = volume of water in liter per minute

P = population in thousand

2.3.3 Lawn watering and losses

As for lawn watering and losses 10% of domestic water demand was allocated to cater for these two demands.

2.3.4 Other academic Demand

Certain quantity of water should also be provided in the academic area for things like sanitary of the area during the working hours and also for other academic activities to cater for this 2% of domestic water demand is also allocated.

2.4 Rooftops Volume Calculation

The rational method is the most popular method for calculating rooftops runoff that generated from the rainfall. This method is unanimously used with all RTRWH studies reviewed in calculating the roof top harvested volume.

$V = CRnA$

V = volume

C = Average yield factor

Rn =Average annual rainfall

A = Rooftop area

2.4.1 Rainwater Sampling: A total of nine samples were collected at El-kanemi student's residential hostel and tested. For each rainfall event, three samples where taken at a certain time intervals. The first sample was taken at theinitial time (during the first runoff event) where as the second and the third were taken after 5minute and 10minute respectively in order to analyse the level of contamination with respect to time.

2.5 Sample Analyses

The collected samples were taken to Public Health laboratory of Civil Engineering Department Bayero University Kano for quality assessment of some physico-chemical parameters.

2.5.1 pH

A pH meter was used after calibrated with a known buffer solution. The electrode was placed in the sample and the meter switched on. The display lock was off and the display showed the actual reading of the pH and the reading was recorded.

2.5.2 Turbidity

Turbid meter was prepared for operation as described in the instrument instruction manual. The appropriate range (meter scale) was selected and the cell riser was installed in the cell holder. A clean sample was filled with water to 25ml mark. The sample was then placed in the instrument and then covered with light shield. The turbidity was then read directly in NTU units.

2.5.3 Electrical conductivity

A conductivity meter was used after calibration with a buffer solution. It was then placed in the collected sample and then the meter was switched on. The display lock was off and the display shows the actual reading of ionic conductivity and the reading was recorded.

2.5.4 Hardness

50ml of the sample was measured into a clean beaker and 0.5ml 0f 0.1NHcl was added into the sample and then heated to boil in order to expel CO_2. The solution was then cooled at 500and then 20ml of the buffer solution was added. Also two drops of erichrome T-indicator was also added and then titratedwith EDTA standard titrant until the colour changes from wine red to blue and the volume of EDTA used was recorded.

The procedure was done for the samples as described above and the value of the titre value recorded. Calculations/ result

$Total\ hardness$ (mg/l$CaCO3$) = $ml\ of\ EDTA\ titrant \times f$ ×1000 ×0.1 ×17.8 $ml\ of\ sample$

2.5.5 Total Suspended Solids

100ml of the sample was measured with a measuring cylinder and poured into a clean beaker; the sample was then filtered into a pre weight filter paper and then dried in an oven for about 24hours. The dried filter paper was then measured with a weighing balance and the recorded. The same procedures repeated for the rest of the samples and the amount of suspended solid was computed using the formular;

$$TS(m/l) = (B-A)\times 1000 ml\ of\ sample$$

Where A = is the initial weigh of filter and B is the weight of dried filter after left for 24hours.

2.5.6 Total dissolved solids

An initial weight of the evaporating dish was measured and recorded with a weighing balance, and then 50ml of the sample was measured and then poured into the evaporating dish. The measured sample was then evaporated to dryness with the help of the hot air oven and then allowed to cool. The evaporating dish was then re-weight and the reading was recorded, the result was computed using the formular; $TDS= \quad (B-A)\times 1000ml \quad of \; sample$

Where A is the initial weigh of the evaporating dish and B is the re- weighted value of the evaporating dish after it has dried.

3. ANALYSIS AND DISCUSSIONS

A total of 547 rooftop areas were calculated using Geographic information system (GIS) software and then grouped into five zones as shown in the table 1 below;

Table 1: Rooftop areas calculated using Geographic information system

Zones	Number of buildings	Rooftop areas (m^2)
Academic Building	325	167.521
Senior staff quarters	115	41.679
Professor's quarters	50	18.307
Student;s hostel	10	9.764
Others	47	56.452
Total	547	293.725

The estimated rooftop catchment area was computed to be 293,725m^2

Table 2: Yield Factor

Rainfall events	Runoff volume(L)	Total volume(L) =runoff×n	Total volume(m^3)	Runoff $=\frac{volume}{area}$ Area=720m^2	Runoff (mm)	Recorded runoff (mm)	Yield factor $=\frac{runoff}{rainfall}$
1st event	189	4536	4.536	6.3×10^{-3}	6.3	7.4	0.8513
2nd event	894	21456	21.456	29.8×10^{-3}	29.8	38.0	0.7842
3rd event	645	15480	15.480	21.5×10^{-3}	21.5	24.0	0.8958
Average yield factor=0.88097							

Where n = total number of outlet drains (24)

Table 3: Results of Qualitative Analysiso Water Samples

Rainfall event	1st event			2nd event			3rd event			Mean	WHO
	A	B	C	D	E	F	G	H	I		
Ph	6.0	6.7	6.7	6.6	6.8	7.0	6.3	6.7	6.9	6.6	6.5-8.5
Acidity(mg/l)	4.9	5.6	5.5	3.2	4.7	5.9	3.9	4.7	5.1	4.8	Ns
Turbidity(NTU)	2.74	1.36	0.96	2.61	2.0	1.55	2.74	2.24	1.34	1.95	5.0
E.conductivity (µs/cm)	231	241	236	301	298	311	365	314	326	291.4	900
Hardness(mg/l)	5.7	5.3	2.0	6.3	5.7	3.7	5.9	6.0	4.3	4.9	100
TSS(mg/l)	23.6	18.6	11.9	12.7	11.9	12.3	24.3	19.3	17.2	16.9	400

TDS(mg/l)	11.4	10.2	9.7	10.9	11.3	8.3	9.4	8.70	8.3	9.8	1000

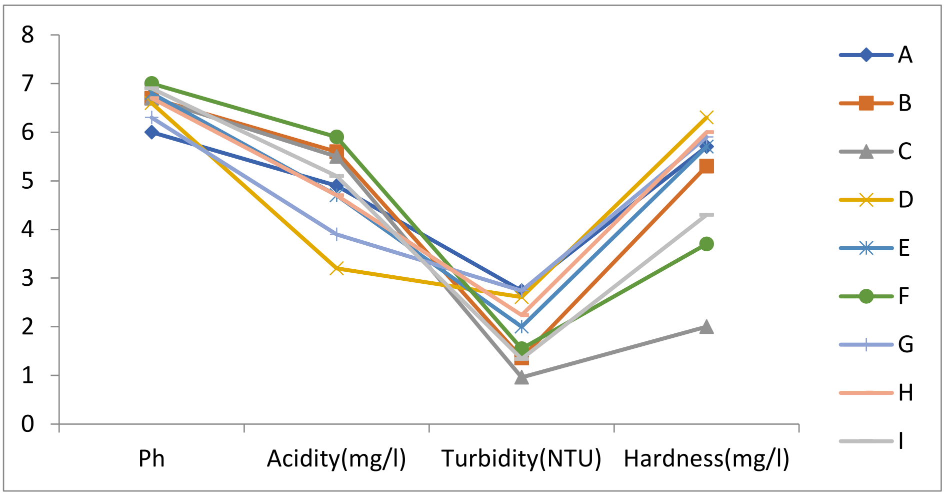

Figure 1: Variation of physiochemical parameters of water samples

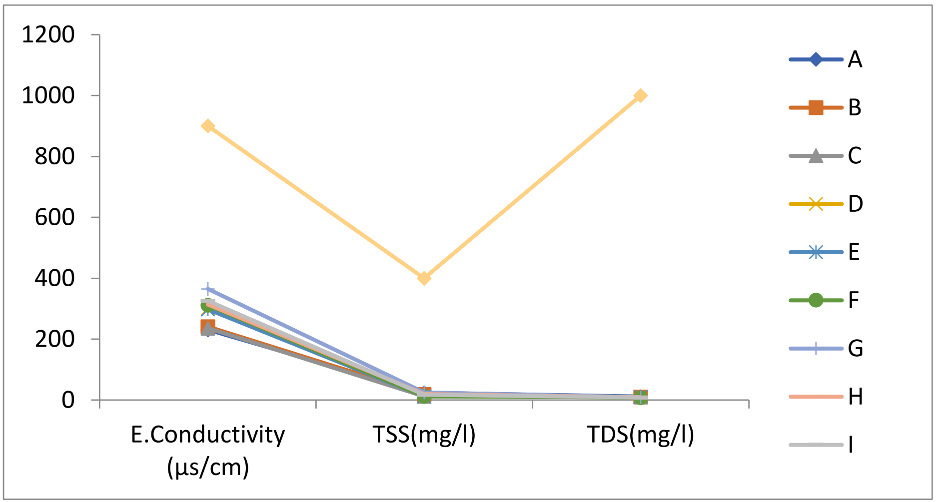

Figure 2: Variation of physiochemical parameters of water samples

It is noteworthy that a pH value of 7.0 is considered as the best and ideal. In the present research, pH values of water sample varied with a narrow range within the permissible limits in all samples. Also, the acidity values for all samples collected where within the maximum permissible limit when compared with World Health Organization standards. Turbidity is the degree to which water losses it transparency due to the presence of suspended particulates. The turbidity levels were found to be below the standards (WHO: 2011). Sample A, D and G as in Table 3 show higher turbidity values than the other samples, and this maybe due to the first flush. Electrical conductivity (EC), also called specific conductance, is a measure of ability of water sample to convey an electric current and its related to the concentration of ionized substances in water. The EC values ranges from 231 – 361µs/cm. These values when compared with the WHO standard were below 900µs/cm limit it therefore poses no salinity problem and there is no restriction on the use of water for consumption. In this study, all samples tested shows a significant result in which they all fall within the maximum permissible limit with respect to WHO standards. For all sample tested in the laboratory total dissolved solids ranges from 8.3-11.4 mg/l where as total suspended solid ranges from (11.9 – 24.3) for either of the samples tasted compared with the guideline (WHO: 2011) standards has no threat either for consumption purpose or for non drinking purpose.

4. CONCLUSION AND RECOMMENDATIONS

It was concluded that, the total catchment area using GIS was found to be 293,725m^2 with an average yield factor of 88%. The result from the physico-chemical analysis of rooftop rainwater samples collected shows that the water is free from high concentration of contaminants. The harvesting potential was computed using the modified rational method and found to be 322,645m^3 which caters for 36% of water demand within the campus. .

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