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WATER, SANITATION AND HYGIENE: CHALLENGES OF THE MILLENNIUM

Rainwater harvesting for application in rural Bangladesh

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RAINWATER HARVESTING AND storage do not constitute a new technology. It has been used for domestic, agricultural, runoff control, air-conditioning etc. for a long time in different parts of the world. However, rainwater harvesting is not a common practice in Bangladesh. Only 35.5 percent households have been found to use the rainwater as drinking water source during the raining seasons in coastal areas having high salinity problems (Hussain & Ziauddin, 1989). In the backdrop of arsenic contamination in groundwater of Bangladesh, rainwater has been considered as a potential source of arsenic free water.

Rainfall patterns in Bangladesh

Bangladesh is a tropical country and receives heavy rainfall due to north-easterly winds during in the rainy season. The monthly rainfall distribution of Dhaka City based on rainfall data from 1975 to 1995 is shown in Figure A.

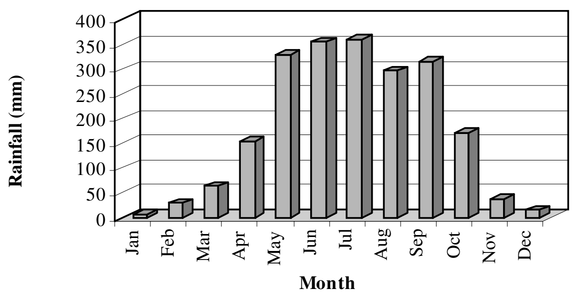

Figure A: Average Monthly rainfall distribution of Dhaka City

The figure shows that the heavy rainfall only concentrated from April to October. The rainfall from November to March is not adequate to meet the demand during the periods. Therefore, rainwater has to be stored during rainy seasons for the rest of the year. Rainwater harvesting for long-term use was not considered as a potential source in past due to unavailability of suitable catchment area and inconvenience of storing water over 5 months when it is compared with the hand tubewells.

Household size in Bangladesh

Household size is one of the important parameter in designing a rainwater harvesting system specifically by using the mass curve analysis method. It is related to the total water demand, storage volume and catchment area. According to the Bangladesh Bureau of Statistics (1995), the average size of household is 5.48 persons and 57% population having household size between 4 to 7. The average household size is taken as 6 for the calculation of design storage capacity.

Roofing materials in Bangladesh

Different types of roofing materials are used in Bangladesh. These include cement concrete, tiles, C.I./metal sheet, straw with or without polythene covering, bamboo with polythene covering. According to the Bangladesh Bureau of Statistics (1995), about 48% households in the rural area have tiles, C.I./metal sheet as roofing materials. These roofing materials are suitable for rainwater catchment. However, others can be used with some modifications such as use of polythene covering for straw roofing.

Roofing size in Bangladesh

There is no data is available on the average roof size in Bangladesh. However, a limited field survey was carried out by Ferdausi (1999) in Chuadanga, one of the arsenic affected districts. Only the household having metal sheet as roof materials were considered and the data is given in Table A.

Table A: Roofing size in a typical rural area.

< 20 m^2	20 - 40 m^2	40 - 60 m^2	60 - 80 m^2	> 100 m^2
6	5	10	4	3

The data was collected on from the 28 households by random selection. This data may not be applicable in all rural conditions in Bangladesh. However, it provides an idea about the available catchment area.

Storage volume calculation

Storage volumes of rainwater for the yearlong use are calculated by using mass curve method and optimal A_c-V_c curve (statistical) method. The daily water consumption is assumed for drinking and cooking purposes is 5 lpcd. The calculations are made for five different locations by using the 20 years rainfall data (from 1975-76 to 1994-95). The rainfall data were collected from the Bangladesh Meteorological Department.

Table B: Storage volume requirement			
Location	Required storage volume (liter) for catchment area		
	20 m^2	40 m^2	60 m^2
Rajshahi	5676	5052	4428
Comilla	4936	4472	4164
Sylhet	3360	3120	2880
Barisal	4164	3828	3492
Satkhira	4488	3828	3492

Table C: Storage volume requirement			
Location	Required storage volume (liter) for catchment area		
	20 m^2	40 m^2	60 m^2
Rajshahi	6236	5484	5087
Comilla	5400	4635	4239
Sylhet	3978	3345	3008
Barisal	4905	4206	3845
Satkhira	4991	4277	3907

Mass Curve Analysis Method

The storage volume is calculated for 6 persons in a family with different roof catchment area i.e., 20, 40 and 60 m^2. The storage volume for different catchment size and location is tabulated in Table B.

Optimal A_c-V_c relation method

The optimal A_c-V_c curves were plotted for the five locations using the relevant equations (for details IWACO BV, 1981). The optimal A_c-V_c curve for Sylhet is shown in Figure B.

Using the figures and related equations, storage volumes are calculated f or 6 persons with catchment sizes 20 m^2, 40 m^2 and 60 m^2 and presented in the Table C.

Comparison of two methods

The design capacity calculated by A_c-V_c method requires a higher design capacity than calculated by mass curve analysis method. The differences vary between 3.65% to 18.39%. The reasons for these differences may be due to consideration of loss factor for stored water in the case of A_c-V_c method. It is also fact that A_c-V_c method does not consider the distribution of rainfall during the dry period and only considers the number of dry periods and the total rainfall during these periods.

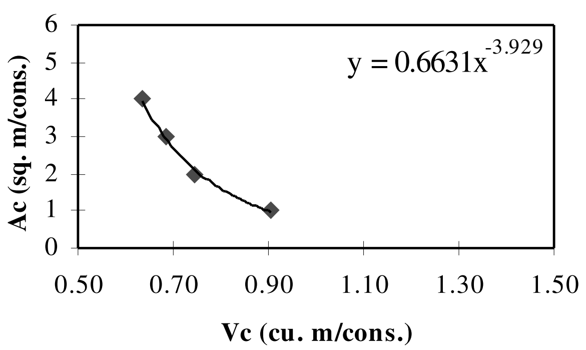

Fig B: Optimal A_c-V_c curve for Sylhet

The major advantage of the mass curve analysis is the simplicity in the calculation. However, the calculation is very much situation specific i.e., separate calculation is needed for the each household having different catchment area and family size.

On the other hand, the major advantage of A_c-V_c method is that this curve can be applied to each household in a specific area regardless of catchment area and household size. However, this method requires expertise for a series of calculation using 7 mathematical equations. This method gives a higher value for storage volume, which increases the reliability of the system over a long period. But, it also increases the cost involvement.

Materials and costing of gutters and down-pipes

Different materials can be used as gutters and down-pipes and material requirements depend on the roof size. The Table D gives the costing of gutters and down-pipes. The cost includes about 8 meter guttering and down-pipe with accessories and labor cost.

The bamboo made gutters and down-pipes have short life span. It normally works properly only one rainy season. Again, leakage is a major concern in case of bamboo and wood made gutters and down pipes. The cost of G.I. pipes is very high comparing to other materials. PVC pipes are low-cost and readily available at the rural areas of Bangladesh. The PVC pipes are suitable materials for gutters and down-pipes.

Table D: Costing of gutters and down-pipes	
Materials	Total cost (Tk.*)
Bamboo made	220
Wood made	640
PVC pipes	740
G.I. pipes	2240
52.5 Tk = 1 US$	

Materials and costing of storage tanks

A storage tank is the most expensive component of a rainwater harvesting system. The storage tanks are constructed from different materials depending on local situation. Some potential materials for storage tank have been selected after reviewing the different documents. These can be applied in different sizes in the rural Bangladesh. No fixed design or materials are selected on the basis on literature review, as these technologies require field-testing at the rural context of Bangladesh.

Table E: Costing of storage tank.

Materials	Capacity (m^3)	Total cost (Tk.*)	Per m^3 Cost (Tk.*)
Ferrocement-molded tank	3.2	7170	2240
Ferrocement-wire framed tank	10	14040	1404
Ferrocement-bamboo reinforced tank	4.5	6660	1480
Cement jars	2.0	2800	1400
Cement ring tank	5.0	6330	1266
Brick reinforcement tank	5.0	16500	3300
* 52.5 Tk = 1 US$			

Though the cost of the tanks decreases with the size of the tank, the cement ring tank are low-cost for rural Bangladesh. The main advantage of this type of tank is that familiarity of the construction process. Cement rings are used and constructed widely in the rural Bangladesh for sanitary latrine construction. The ferrocement is not a common technology in Bangladesh and it requires an extensive training before construction.

The cost of earthen jars was not compared with the costing of other materials due to uncertainties regarding its applicability. However, several jars could be used together for long-term water storage. Adequate measure should be taken in water storage and especially water collection. The average cost of 0.3 m^3 earthen jars varies Tk. 250 to 350, i.e., approximately Tk. 1000/m^3.

Considerations for RWH in rural Bangladesh

The rainwater harvesting in rural Bangladesh seems as a viable alternative water source particularly in the arsenic contaminated area of rural Bangladesh. The required size for a typical family would vary between 2.9 and 4.4 m^3. There is a regional variation of rainfall. Lesser storage volume is required in the western part, and a higher storage volume is required for north-western part (Ferdausi, 1999).

The quality of rainwater is high and the stored water is also safe when proper attention is taken. This water is free from two extreme contaminants i.e., arsenic and fecal coliform (with due care). The major advantage of the rooftop rainwater harvesting system is that the system is independent and suitable for scattered settlements.

The operation of the rainwater harvesting is easier than other water supply system. No specialized skill is necessary to operate the system. It does not require any pumping device to abstract the water. The system also requires little maintenance work.

Economic considerations

Economic issue is crucial for the introduction of water harvesting systems to the rural Bangladesh. It is reported by Ferdausi (1999) that the capital cost of rainwater harvesting system per family is high compared to other water supply systems. The financial base in rural area of Bangladesh is very weak and rainwater harvesting system would not be easily affordable. Clearly, up-front payment in cash for storage tank would create a major problem for lower income groups.

Although the capital cost of rainwater harvesting is high, this cost in some extent is offset by their negligible recurrent costs. The average life expectancy of a storage tank is considered about 10-15 years. The cost of the system is also reduces when the free labor is available from the user.

Implementation of rainwater harvesting in rural Bangladesh requires the external support. Government or other supporting organization can provide promotion through subsidy and establish revolving funds for the capital cost of the system. The government has done it successfully in Thailand (Gould, 1992). Lee and Visscher (1990) pointed out that the community contribution was 10 to 40% in the five African countries.

Another promising option for financing is micro-credit scheme. Rainwater harvesting can be coupled with other income generating activities and the cost can be recovered with a low interest rate.

Technical considerations

The rainwater harvesting system for long term use is a new technology in Bangladesh. The system requires to incorporate materials, skill and construction procedures that are compatible with the local conditions. Extensive training and demonstration program is essential for the construction procedure and operation and maintenance of the system.

Social considerations

The success of rainwater harvesting system program depends on the interest, enthusiasm and active support of the users. Groundwater is the major source of water supply for more than two decades in Bangladesh. People may have negative attitude about the rainwater. The rainwater harvesting program can be implemented only when people have the willingness to use the system. Failure to involve the community in the planning, design, siting and construction of the rainwater harvesting is commonly a cause of failure of the system in many countries.

Combination with other system

Rainwater can be harvested for only rainy season. In this case, no special storage tank is required. Earthen and other types of jars can be used for this purpose. Rainwater can also be used for about 8 months of a year. In this case, the size of the storage tank reduces about 50%. In both two cases, rainwater harvesting has to be combined with the other safe water supply options.

Conclusion

Rainwater harvesting is found technically feasible on the basis of the prevailing rainfall pattern. About 50% of household has a roof constructed from technically appropriate materials. Mass curve analysis and A_c-V_c method are both feasible for estimating the capacity. However, A_c-V_c curve can be developed for different regions and non-professionals can easily calculate the required size for different household at the field level by using it. The estimated cost for cement ring storage tank (Tk. 1266/m^3) is found relatively cheaper than other materials tank. However, this capital cost of the system is still high compare to other system. Field study is required to reduce the cost of the materials using local materials. On the other hand, the recurrent cost of the system is very negligible. The system is only feasible for the low-income group if high subsidy or other financial arrangement is provided. Micro-credit system is one the attractive option for financing the storage tank. Rainwater harvesting can also be considered in combination with other systems.

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