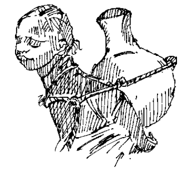
25th WEDC Conference Addis Ababa, Ethiopia, 1999

INTEGRATED DEVELOPMENT FOR WATER SUPPLY AND SANITATION



Rainwater harvesting potentials in Bangladesh

Dr M. Feroze Ahmed, Bangladesh

RURAL WATER SUPPLY in Bangladesh is based on groundwater, as it is free from pathogenic microorganisms and available in adequate quantity in shallow aquifers. In Bangladesh, except in coastal and hilly areas, a remarkable success has been achieved by providing 97 per cent of rural population with tubewell water. In the coastal belt, high salinity in surface and ground waters and in the hilly areas, absence of good ground water aquifers as well as difficulties in tubewell construction in stony layers are the main constraints for the development of a dependable water supply system. At present, the success achieved in hand tubewell based rural water supply is on the verge of collapse due to presence of arsenic in groundwater in excess of acceptable levels in the shallow aquifers. Provision of arsenic contamination free water is urgently needed to mitigate arsenic toxicity and protection of health and well being of the rural population living in acute arsenic problems areas. The people, particularly the women living in the problem areas have to walk long distances to fetch water from a available source (Ahmed, A., 1993).

Bangladesh is a tropical country and receives heavy rainfall during the rainy season. In the coastal districts, particularly in the offshore islands of Bangladesh, rainwater harvesting for drinking purposes is a common practice in a limited scale for long time. In some areas with high salinity problem, about 36 percent households have been found to practice rainwater harvesting in the rainy season for drinking purpose (Hussain and Ziauddin, 1989). The protected ponds replenished by rainwater each year are main sources of water supply in the coastal area. Since various uses and unhygienic practices are increasingly polluting the pond water, an alternative source of good quality water supply is needed to maintain the service coverage. In the present context, rainwater harvesting is being seriously considered as an alternative option for water supply in Bangladesh.

A rainwater based water supply system requires determination of the capacity of storage tank and catchment area for rainwater collection in relation to water requirement, rainfall intensity and distribution. The main advantages of a rainwater system are that the quality of rainwater is comparatively good, it is independent and therefore suitable for scattered settlement and the owners/users can construct and maintain the system. On the other hand, the availability of rainwater is limited by the rainfall intensity and availability of suitable catchment area. The mineral free rainwater may not be liked by many and the poorer section of the people may not have a roof/ catchment area suitable for rainwater harvesting.

Rainwater availability

Rainwater is available in adequate quantity in Bangladesh. The spatial distribution of normal rainfall in Bangladesh has been shown in Figure 1. The distribution of rainfall in Figure 1 shows that relatively higher rainfalls occur in the eastern part of the country and highest rainfalls occur in north-eastern region and eastern part of the coastal area. The low rainfall, less than 1500 mm per year, occurs in the western part of Bangladesh. In the coastal and hilly areas with greater intensity of fresh water source problem have higher rainfall, which is favourable for rainwater harvesting.

A 10-year rainfall pattern based on the mean rainfall intensity recorded in 28 stations for the period from 1987 to 1996 is shown in Figure 2 (BBS, 1997). It appears that the average yearly rainfall in the country during 1987-96 varied from 1950 to 2800 mm i.e. 1.95 to 2.80 m^3 of

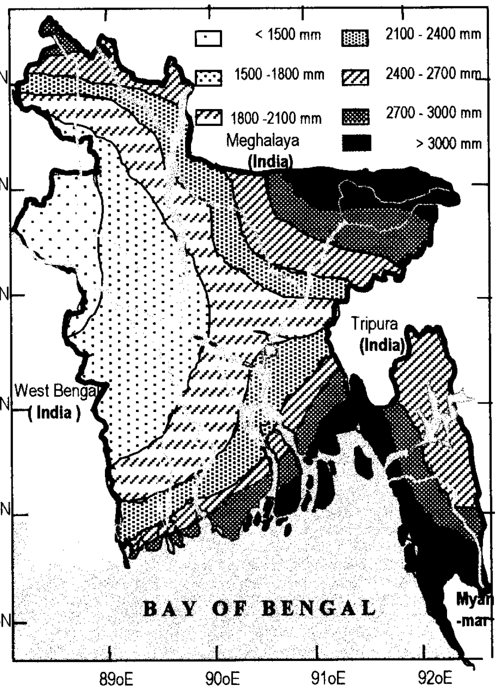


Figure 1. Distribution of rainfall in Bangladesh

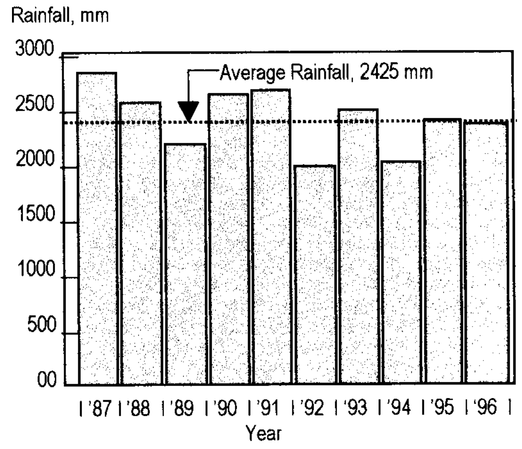


Figure 2. Variations of annual rainfall in Bangladesh

rainwater was available per m^2 of catchment area each year for development of a rainwater based water supply system. However, there are some losses in the collection system. The available rainwater can be estimated by the equation:

$$Q = C\,I\,A \qquad \ldots \qquad (1)$$

Where Q is the total quantity of rainwater available in m^3/year, C is coefficient of available runoff, I is the rainfall intensity in m/year and A is the catchment area in m^2.

Rainwater catchment

The catchment area for rainwater collection is usually the roof, which is connected with a gutter system to lead rainwater to the storage tank. Rainwater can be collected from any types of roof but concrete, tiles and metal roofs give cleanest water. The C.I. sheet roofs commonly used in Bangladesh perform well as catchment areas. A study shows that 26 per cent of the rural household having family size 4 – 8 persons have suitable permanent roofs for rainwater collection (Chowdhury, et. al., 1987). A thatched roof can also be used as catchment area by covering it with polyethylene but it requires good skills to guide water to the storage tank. In coastal areas of Bangladesh, cloths fixed at four corners with a pitcher underneath is used during rainfall for rainwater collection. The minimum catchment area A, required for the collection of rainwater for N number of people supplied with q litres per capita per day (lpcd) of water can derived from Equation (1) as:

$$A = 0.365\,q\,N / C\,I \qquad \ldots \qquad (2)$$

About 25 per cent of the rainwater may be assumed to be lost by evaporation and for wahing the catchment area using first rain that produces inferior quality rainwater. The Equation (2) can be written for an average annual rainfall of 2.4 m/yr., as indicated in Figure 2 and a coefficient of runoff of 0.75 in the following form:

$$A = 0.203\,q\,N \qquad \ldots \qquad (3)$$

The poorer section of the people is in disadvantageous position in respect of utilization of rainwater as a source of water supply. This section of people have smaller size thatched roof or no roof at all, which can be used as catchment for rainwater collection. The use of land surface as catchment area and underground gravel/sand packed reservoir as storage tank can be an alternative system of rainwater collection and storage. In this case, the water has to be channeled towards the reservoir and allowed to pass through a sand bed before entering into underground reservoirs. This process is analogous to recharge of underground aquifer by rainwater during rainy season for utilization in the dry season.

Storage tank

The unequal distribution of rainfall over the year requires storage of rainwater during rainy season for use in the dry season. The minimum volume of the storage rainwater tank V, required for rainwater can be computed by the equation:

$$V = 0.365\,f\,q\,N \qquad \ldots \qquad (4)$$

Where f is the fraction of water required to be stored for consumption of total available rainwater at a constant rate throughout the year. The total annual rainfall in 1996 as shown in Figure 2 is approximately equal to the average annual rainfall of the last 10 years. The monthly distribution of average rainfall in 1996 shown in Figure 3 is assumed to represent the average condition. The rainwater availability mass curve assuming and cumulative consumption/demand of total available rainwater at constant rate are also shown in Figure 3.

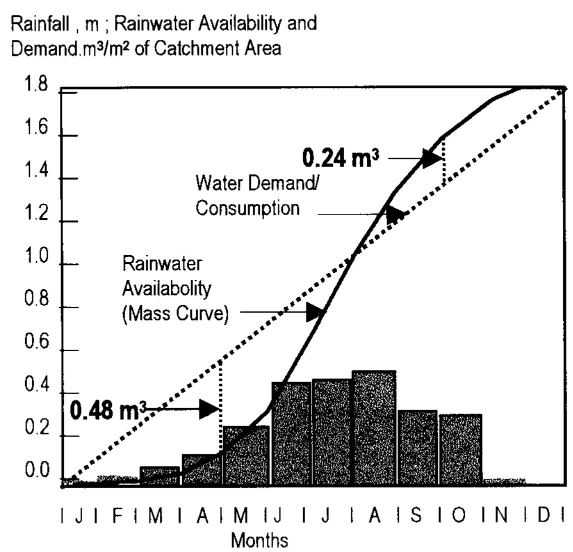


Figure 3. Rainfall intensity, cumulative rainfall availability and demand

The mass curve has been prepared considering the fact that 75 per cent of the rainwater would be available. It may be observed that there is a shortfall of 0.48 m^3 in the dry periods and an excess of 0.24 m^3 during rainy season. For full utilization of rainwater potential, a storage tank of capacity 0.72 m^3 that is 40 per cent of the available rainwater is required for uninterrupted water supply at a constant rate throughout the year. However, if only drinking and cooking water is harvested, the sizes of the storage tank and catchment area would be smaller and within affordable range a family. Substituting f = 0.4 in Equation 4 for representative rainfall distribution of 1996, the minimum volume of the storage tank required for rainwater becomes:

$$V = 0.146\ q\ N \quad \ldots \qquad (5)$$

Rainwater quality

The quality of rainwater is relatively good but it is nor free from all impurities. Analysis of stored rainwater has shown some bacteriological contamination. Cleanliness of roof and storage tank is critical in maintaining good quality of rainwater. The first run off from the roof should be discarded to prevent entry of impurities from the roof. If the storage tank is clean, the bacteria or parasites carried with the flowing rainwater will tend to die off. Some devices and good practices have been suggested to store or divert the first foul flush away from the storage tank. In case of difficulties in the rejection of first flow, cleaning of the roof and gutter at the beginning of the rainy season and their regular maintenance are very important to ensure better quality of rainwater. The storage tank requires cleaning and disinfection when the tank is empty or at least once in a year. The rainwater is essentially lacking in minerals, the presence of which is considered essential in appropriate proportions. The mineral salts in natural ground and surface waters sometimes impart pleasing taste to water.

Conclusions

In Bangladesh, rainwater can be good source of water supply in coastal, hilly and acute arsenic affected areas. A rainwater tank having minimum storage capacity of about 40 per cent of the available rainwater for a catchment area is required for uninterrupted water supply throughout the year at a constant rate due to unequal distribution of rainfall. The capacity of storage tank and the catchment area required for all purpose water supply system based on rainwater only are quite large but these can be reduced to affordable sizes, if only drinking and cooking water is collected and stored.

References

AHMED, A. (1993), Prospects for rainwater Catchment in Bangladesh and Its Utilization, Proc. 6th Int. Conf. nn Rainwater Catchment System, Nairobi, 1-6 August;

BANGLADESH BUREAU OF STATISTICS (1997), Statistical Year Book of Bangladesh, Ministry of Planning, Govt. of People's Republic of Bangladesh

CHOWDHURY, N.I., AHMED, M.F. and CHOUDHURY, J.R. (1987), Use of Rain Water for Water Supply in the Coastal Areas of Bangladesh, Proc. International Conference on Rainwater Cistern System, Thailand, 14-17 January;

HUSSAIN, M.D., and ZIAUDDIN, A.T.M. (1989), Rainwater Use in Bangladesh – A Case Study in Dacope Upozilla, Proc. Int. Conf. on Rainwater Cistern System, Manila, 2-4 August;

DR. M. FEROZE AHMED is a professor of Civil/ Environmental Engineering at Bangladesh University of Engineering and Technology (BUET), Dhaka and Director, International Training Network (ITN) Center for Water Supply and Waste Management, Bangladesh.