10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Harnessing of rainwater, the underutilised source in developing countries

Dr A Appan

INTRODUCTION

At the time of the proclamation of the International Hydrological Decade in 1980 for "providing safe water for all by 1990", one third of the world's population did not have drinking water (ref.1). In fact, three quarters of the third world countries in Asia, Africa and Latin America lack a supply of safe water for drinking and washing and 85% of these people still live in rural areas (ref.2). These statistics point towards the pressing need for establishing water supply systems that can be implemented in large tracts of the universe classified as "developing countries" where economic factors largely influence decision-making in any type of development project. One system that is simple, easily adaptable and involves low capital outlay is a Rain Water Cistern System. This is not a new concept but, in fact, has been in existence for more than three thousand years (ref.3). A rising awareness of the potential of Rain Water Cistern System (RWCS) culminated in the first international conference in 1981 (ref. 4) followed by a regional seminar in 1983 (ref.5).

COMPONENTS OF RAIN WATER CISTERN SYSTEMS

The term RWCS is synonymously used with 'rainwater catchment' and is loosely referred from methodologies adapted for the enhancement of runoff capabilities of small catchments to roof water collection systems. In this paper, the emphasis will be essentially on RWCS, as it is deemed that the basic twin collection requirements viz., roof area and rainfall already prevalent in developing countries. The system will involve the collection of roof water from an individual building or group of buildings, storage in cisterns and distribution with or without treatment. In this context, the cistern volume will be determined as a function of rainfall and demand. Mention will be made of methods of computation of cistern sizes, materials for storage, maintenance and distribution. Also, technical issues in relation to water quality, health education, socio-economic factors etc., will be touched upon.

METHODOLOGIES AVAILABLE FOR SIZING OF CISTERNS

In large-scale water supply schemes, the conventional relationship between yield (demand/supply) and storage has been well-defined and analysed by the Rippl method (ref.6) and progressed to more probabilistic methods (ref.7 and 8). All these methods utilise the rainfall or runoff patterns and the resulting large reservoir volumes balance the stochastic inputs and the constant outputs. In RWCS, the catchment area corresponds to available roof area, the input (rainfall) remains unaltered, storage is limited to cistern size and the output is the volume available for collection from the cistern. The factors that influence the sizing of cisterns are the stochastic pattern of rainfall, roof areas that are very often limited and the demand that can be highly variable.

Based on these criteria, a number of methods have been propogated for the sizing of cisterns. The methodologies have varied from stochastic assessments using deterministic models (ref.9, 10 and 11) to probabilistic (ref.12 and 13) and simulation models (ref.14), all having varying degrees of sophistication.

In all these models the four major influencing factors remain unaltered. The relationship between these four parameters, the frequency of failure to meet demands and the volume of alternate source required to meet the total demands are well-represented in a simple flow chart. (ref. 15). Summing up, all design methodologies will be geared towards ultimately producing a matrix of information that can be represented by simple nomograms as shown in Fig. 1 These data will be applicable only for specific catchments as rainfall patterns vary from area to area.

FACTORS AFFECTING IMPLEMENTATION OF RWCS IN DEVELOPING COUNTRIES

Large-scale implementation of RWCS could be influenced by technical, socio-economic and other factors.

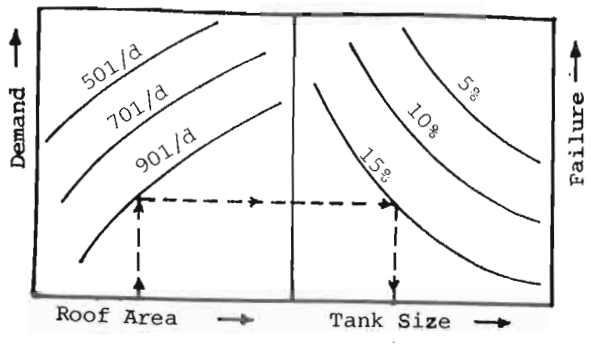

Figure 1 : Typical RWCS Nomogram

Technical Factors

Investigation of the region under consideration should include identification of dry zones, areas having very low groundwater tables or areas having brackish water. Some influencing factors requiring detailed investigation are:

Roofing Material: Roofing material can vary from conventional tiles to corrugated metal sheets and much cheaper dried palm leaves. Runoff quality will be affected according to the type of material and its existing state.

Water Quality: The quality of rain water is generally of a high order. In most locations an equilibrium pH of 5.65 is reached under normal circumstances. But there is evidence that with industrialisation the S and N gases emitted can lead to acid rain having a pH of 2.5 to 3 (ref.16). Such conditions of high pH which normally exist initially (ref. 17) call for diversion systems in RWCS which will remove the potent first flushes. In the case of roofing material affecting the physical characteristics, simple filter (ref.18) may be incorporated. If the bacterial purity of the water is affected by the cistern material, long detention or sludge build up in cisterns (ref.19), simple disinfection can be effected by boiling the collected water or by the use of a solution of chlorine or chlorine tablets (ref.20).

Cistern material and size: The overall cost of RWCS is influenced largely by the cost of the cistern. Hence, emphasis has to be placed on the economic design of size and choice of material for construction. Conventional materials like steel, reinforced concrete, mass concrete and even brick tend to be on the costly side. Extensive investigations have been carried out to utilize much cheaper material like ferro-cement (ref.21) and bamboo reinforcement, (ref.22) that reduce the cost by 2 to 4 times (ref.21). Indegenous materials are much cheaper, readily available and besides, they can be handled by personnel who do not need any special training. The shape of the cistern in terms of minimum surface area should be cylinderical but, in practice, the shape is determined by the number of units being built and the type of material being used.

Operation and maintenance: These twin aspects play an important role in the long term utilization of the system. In this respect, a simple water level indicator should be installed and the users should be made aware of the need to conserve water in relation to the existing water levels and rainfall. Besides, periodic inspection should be made of the inside of the cistern to ensure that sludge levels, if any, are not high and do not affect water quality. Also, a close watch has to kept so that the cistern does not become a breeding ground for mosquitoes.

A proper programme on operation and maintenance is very essential and there is the need to emphasis that these aspects are crucial for ensuring the palatability and safety of the water and its availability during periods of drought.

Socio-Economic Factors

In most developing countries, the cost for implementing a RWCS will be a strain on the already stretched economic resources of the potential user. This is evidenced by the implementation strategies evolved in Thailand where the villagers have had to be subsidised (ref.23) and in Indonesia where they were provided with a means to a source of income so that they could effect repayment (ref.24).

Though the locations that have potential to harness rain water may be identified, the introduction of this new source can pose problems of acceptance, particularly if it has not been used in the past. Some issues that have been encountered are the belief that its use will lead to rheumatic complaints (ref.25) and a weakness of limbs (ref.26). Consequently, before embarking on RWCS, the economic and educational level of the people, their habits and attitudes with regard to the use of water, their present sources of water etc., have to be appraised. Such information can be obtained by a field survey.

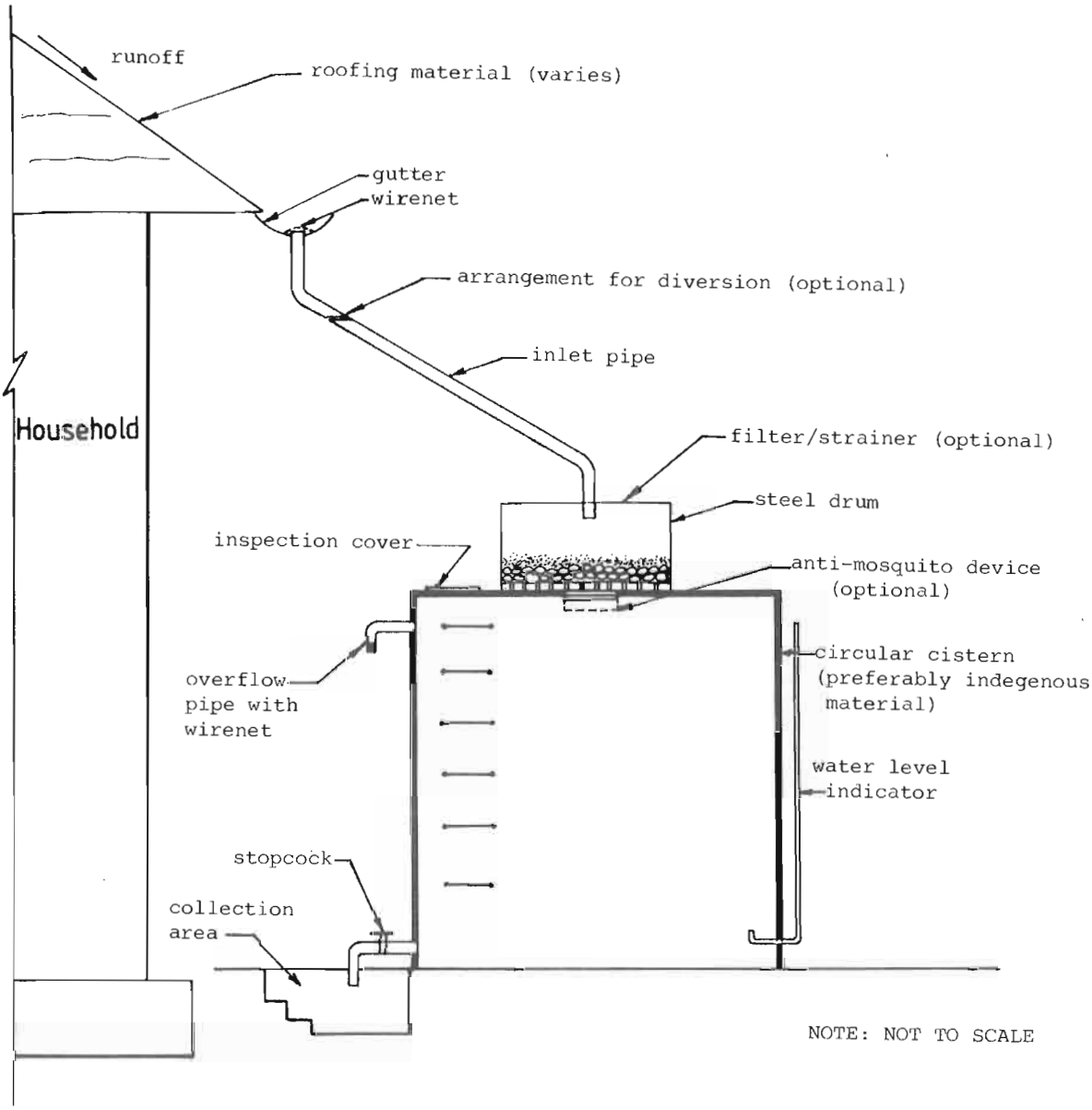

Figure 2 : Schematic Diagram of Typical RWCS

Other Factors

Though the RWCS is basically a simple concept, for it to have an appreciable impact, a large number of units may have to be installed. One important aspect of RWCS is that by having an independent system for an individual household or group of households, the responsibility of operating and maintaining the system supplying safe drinking water will be shifted from the central authority (normally the Government or quasi-Government) as in any large water supply system, to the individual or small group of individuals who, very often, are not sufficiently well-educated. Hence, the health education aspect of the programme has to emphasise the importance of water quality in terms of safety and potability. Another aspect of the implementation of RWCS is to get community involvement and to plan the whole programme such that there is almost total committment by the community. Such participation will not only go a long way towards reducing costs but will bring about an awareness in the users to operate and maintain the system properly. This type of modus operandi is exemplified in the Tungnam Project (ref.23) in Thailand.

TYPICAL RWCS IN A DEVELOPING COUNTRY

In Fig. 2 is shown a simple set-up for a RWCS. The system by itself is very simple and does not call for special skills for design or erection. The overall feasibility of putting up such a system is largely dependent on the cost which is crucial to the user. So, the material for utilization in the system has to be chosen very carefully, a health education programmes embarked upon and, most important of all, an appropriate payment or repayment programme worked out.

CONCLUSIONS

(a) The state of art of choosing a cistern size is at a stage where it can be made with a reasonable degree of certainty.

In any case, when a large number of cisterns are to be built, the economy of scale may call for only one or a few more sizes of cisterns to be built. Then, the size of the cistern becomes constant and the roof area has no bearing on the design.

(b) The identification of the most appropriate areas to establish RWCS will depend on whether the area is classified as a dry zone and whether there is no scope for development of other sources. This identification by itself will be a major motivating factor to induce the potential users to embark on RWCS.

(c) An awareness of the socio-economic level of the area is very helpful. Preferably some field survey has to be undertaken to get a better understanding of the people who are going to benefit by the scheme.

(d) A heath education programme is very necessary and will help to do away with the existing social taboos and, at the same time, implant the the importance of proper operation and maintenance.

(e) For the successful implementation of RWCS on a large scale, a total approach has to be adopted. For such an approach it is necessary to ensure that there is, to a large extent, community involvement. This will not only reduce costs but will help in subsequent operation and maintenance and will go long way towards improving the quality of life of the people.

REFERENCES

1. "World Water". D-day for the Water Decade, World Water, 1981.

2. MORRISON Alan, Civil Engineering., Oct. 1983.

3. OZIS Unal. "Outlook on Ancient Cisterns in Anatolia, Turkey". Proc. Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

4. International Conf. on Rain Water Cistern systems, Honolulu, June 1982.

5. Rainwater Catchment Seminar, Regional Workshop, Khon Kaen, Thailand, 30 Nov. - 2 Dec. 1983.

6. RIPPL W. "The Capacity of Storage Reservoirs for Water Supply", Proc. Inst. of Civil Engineers, London, pp. 270, Vol. 70, 1883.

7. STALL J.B. "Reservoir Mass Analysis by Low-flow Series", ASCE, J. Sanit. Dn., Vol. 88, No. SA5, Paper 3283, Sept. 1962.

8. MORAN P.A.P, "A Probability Theory of Dams and Storage Systems". Aust. J. Appl. Sci., Vol. 5, 1954.

9. APPAN A. "Some Aspects of Roof Water Collection in a Subtropical Region". Proc. Int. Conf. Rainwater Cistern Systems, Honolulu, June 1982.

10. LEUNG P. and FOK Y.S. "Determining the Desirable Storage Volume of Rain-Catchment Cistern System". Proc. Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

11. HOEY P.J. and WEST S.F. "Recent Initiatives in Rain Tank Suppy Systems for South Australia". Proc. Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

12. FOK Y.S., FONG R.H.L., MURABAYASHI E.T. and LO A. "Deterministic and Probabilistic Processes of Weekly Rainfall". Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

13. FOK Y.S., FONG R.H.L., HUNG J., MURABAYASHI E.T. and LO A. "Bayes-Markov Analysis for Rain Catchment Systems", Tech. Rep. 133, Water Resources Res. Center, Uni. of Hawaii, Honolulu, March 1980.

14. PERRENS S.J. "Design Strategy for Domestic Rainwater Systems in Australia". Proc. Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

15. APPAN A. "Design and Development Aspects of Rainwater Cistern Systems in South East Asia". Rainwater Catchment Seminar at Khon Kaen, Thailand, 30 Nov - 2 Dec 1983.

16. LIKENS G.E., BORMAN F.H. and JOHNSON N.M. "Acid Rain", Environment, Vol. 4, pp. 33-40, 1972.

17. SEYMOUR M.D., SCHUBERT S.A., CLAYTON J.W. and FERNANDO Q. "Variations in acid content of rainwater in the course of a single precipitation". Water, Air and Soil Pollution, Vol. 10, pp. 147-161, 1978.

18. CAPTURED RAINFALL. "Small-scale Water Supply System", State of California, Dept. of Water Resources, May 1981.

19. BUNYARATPAN Vanasari and SINSUPAN Suparerk. "Roof Catchment: Water Quality". Rainwater Catchment Seminar, Khon Kaen, Thailand, 30 Nov - 2 Dec 1983.

20. PICKFORD John. "Water Treatment in Developing Countries". Water, Wastes and Health in Hot Climates. John Wiley & Sons, 1977.

21. VADHANAVIKKIT Chayatit. "Ferro-Cement Tank Construction". Rainwater Catchment Seminar, Khon Kaen, Thailand. 29 Nov - 2 Dec 1983.

22. THIENSIRIPIPAT Nipon. "Bamboo Reinforced Concrete Tanks". Rainwater Catchment Seminar, Khon Kaen, Thailand. 29 Nov - 2 Dec 1983.

23. HAYSSEN Jonathan. "Rainwater Collection and Storage Project (Tungnam III)". Rainwater Catchment Seminar, Khon Kaen, Thailand. 30 Nov - 2 Dec 1983.

24. ARISTANTI Christina. "Dian Desa's Rainwater Catchment, its Implementation and Development". Rainwater Catchment Seminar Khon Kaen, Thailand, 30 Nov - 2 Dec 1983.

25. MALIK U.A. "Rainwater Cistern Systems and Policy in Malaysia". Proc. Int. Conf. Rainwater Cistern Systems, Honolulu, June 1982.

26. RAJAPAKSE R.K.C. Discussion following paper "Sri Lanka's Contribution towards Rainwater Catchment Technology". Rainwater Catchment Seminar Khon Kaen, Thailand, 30 Nov - 2 Dec 1983.