Household Scaled Rainwater Tank System

- Concept and Practices -

Sucharit Koontanakulvong¹ and Udorn Jaruratana²

Abstract: Water Supply in rural area is still a crucial issue in many countries. Storage in groundwater aquifer is a promising alternative for water harvesting. Rainwater tank system on a household scale is proposed for storing excessive water both in the tank and in the aquifer during rainy season and recovering the recharged water from the aquifer for use during dry season. The design concept is described with a calculation sample for reference. From the data of water level and water quality, obtained through monitoring 400 constructed tank systems, the system proposed is proved to be workable and effective in both quantitative and qualitative aspects, especially in the area with high rainfall and moderately or low yielded aquifer.

1 Introduction

Water demand has always increased due to economical and social development, while water supply development especially from surface water is limited due to topographical constraints and environmental awareness. The groundwater then becomes critical source for many areas, especially in rural areas. This caused the decrease in groundwater table in many major aquifers, including those in Bangkok and its vicinity, that need proper management to balance natural conditions (Somchai, 1999).

Water supply in the rural area is still crucial for rural development, and therefore many water harvesting methods had been studied and proposed, e.g., tameike (irrigation tank) method (Minami *et al.*, 1986) and qanat (Pouraghniaei, 2000). At the same time, groundwater artificial recharge is becoming an important issue to help balance the groundwater table decline and many studies also had been done to find its technical and economical feasibility (Nippitawasin, 1989; Pyne, 1994; Kelvin, 1998; Sucharit, 1999).

This paper proposes the concept of rainwater tank system to be used as micro water supply and groundwater artificial recharge device on a household scale. The preliminary design of the system is introduced and some results from practices are collected and presented both in quantitative and qualitative aspects.

2 Concept

The average rainfall in Thailand is 1,550 mm, while about 80 % of the rainfall is in rainy season, i.e., from May to October. Water shortage becomes acute from February to April after surface runoff from rain decreases. In the area where groundwater is still abundant, people use groundwater well during this period till next rainy season comes. However, due to the in-

crease in groundwater use, groundwater table also declines and make conditions more suffered.

Furthermore, people in the area with less yielded aquifer suffer more. Thai government, with the policy of clean water supply for rural area, had promoted and helped constructing the small scaled rainwater tank with the capacity of 6-12m³ for each household in order to store excessive rainwater during the rainy season and to be used during dry season. This policy helps lessen the water shortage problems in the dry season, but the groundwater is still in need though its use is confined in the shorter period.

The concept of rainwater tank is then modified to function not only as rainwater storage but also as groundwater artificial gravity storage and recovery device by constructing one more slow sand filtration tank so that excessive rainwater from the roof during rainy season, which is overflowed from the storage tank, is filtered, recharged into and stored in the aquifer through a working well (Nippitawasin, 1989; PWD, 1998). This stored rainwater can then be recovered for use by pumping up from a recharge well again during dry season after rainwater stored in the storage tanks becomes empty.

3 Design

In order to design this rainwater tank system, the data of rainfall, water supply requirement, filtration rate and recharge rate through well should be collected to determine the system's appropriate dimensions. The inflow volume is determined from the roof area multiplied by the amount of rainfall. The storage capacity of a tank and the number of tanks that are required are determined from the per capita water requirement and the number of family member (in Thailand, 50 l/d/person is used for minimum water supply requirement in rural area). The filtration rate is considered from raw water quality and sand size. The recharge rate is determined from the characteristics of aquifer, i.e., sand size and distribution, groundwater table and transmissivity. Water quality is also designed to be under the raw water

¹Associate Professor, Water Resources Engineering Department, Chulalongkorn University, Phayathai Road Patumwan, Bangkok, Thailand 10330

²Assistant Professor, Environmental Engineering Department, King Mongkut Institute of Technology, Thonburi, Bangkok, Thailand

Figure 1: Schematic sketch of rainwater tank system

Photo 1: Rainwater tank system in practice

Table 1: Preliminary water balance calculation

S/N	Month	Rainfall (mm)	Inflow (m ³)	Total Storage (m ³)	Use (m ³)	Carry Over Storage(m ³)	Recharge Volume(m ³)	Recovery Volume(m ³)
1	May	200	27	27	9	12	6	-
2	June	170	22	34	9	12	13	-
3	July	148	20	32	9	12	11	-
4	August	155	20	32	9	12	11	-
5	September	272	36	48	9	12	27	-
6	October	211	28	50	9	12	29	-
7	November	66	9	21	9	12	19	-
8	December	2	0.3	12.3	9	12	-	-
9	January	1	0.4	3.7	3.7	3.3	-	5.3
10	February	14	1.9	1.9	1.9	-	-	7.1
11	March	18	2.4	2.4	2.4	-	-	6.6
12	April	41	5.5	5.5	5.5	-	-	3.5
Total		1,298	172.5	-	85.5	-	116	22.5

Remarks 1) Inflow = $0.9 \times \text{Rainfall} \times 150\text{m}^2$ (roof area)

2) Water requirement = Use + Recovery = 9m^3 (for 6 persons)

quality standards for water supply after filtered by slow sand filter tank.

Table 1 shows a sample of monthly water balance calculation with the rainfall pattern in Kamphaeng Phet Province, with a roof area of 150m^2 , monthly water requirement of 9.0m^3 (6 persons $\times$ 50 ℓ /d/person) and rainwater storage tanks of $2 \times 6\text{m}^3$. These data show that only groundwater of 23m^3 , out of rainwater of 116m^3 recharged during rainy season, is needed for recovery by pumping up during dry season. Figure 1(A) shows the schematic sketch of the rainwater storage tank system with a slow sand filtration tank. Technical dimensions and specifications of the filtration tank are depicted in Figure 1(B).

4 Results

With this design, 100, 200 and 100 rainwater tank systems had been introduced in Kamphaeng Phet Province during the year 1994-1997, 1998 and 1999, respectively, as a newly established practice shown in Photo 1. All rainwater tank systems are still working well with adequate water supply during dry season. The data of groundwater table monitored during these years indicate that there are 18 wells got clogged and groundwater is maintainable or slightly increasing (as interviewed from the officer in charge). For the pilot area in the province, the filtration rate is found to be 0.4 m/h and the recharge rate of 6-inch well in the field to be $4\text{m}^3/\text{h}$ (Sucharit K., 1999). In terms of water quality or filtration effectiveness, this slow sand filter tank was tested in the nearby site by diverting water from irrigation canal to the tank. The effective size of slow sand used is 0.35mm and the uniformity coefficient is 3.1. Tables 2 and 3 show the water quality results of both before and after filtration (PWD, 1998). These data show that the slow sand filter can improve irrigation water quality up to the standard values in physical and chemical aspects

if the turbidity of raw water is in the range of 30-40 NTU, though the filter tank cannot improve biological aspect up to standard and cannot purify poisonous chemical components by itself. These results demonstrate that the quality of water recharged into aquifer is always above allowable water quality standard values owing to the designed device because, in practice, rainwater quality from roof is always better than irrigation water quality and above the required standard.

5 Conclusions and discussions

The concept of rainwater tank system is proposed for both water supply storage and artificial gravity recharge and recovery to the aquifer. The design sketch of the system is drawn with a calculation sample.

Four hundred rainwater tank systems had been constructed during 1994-1999 and monitored. Most of them are found to be workable as per concept though minor periodical cleanup should be conducted to solve clogging problem. Water quality after filtration, tested to see the effectiveness of slow sand filter, is found to be acceptable for recharge activity. Observed groundwater levels suggest that the effect of recharge to raise groundwater table during dry season is noticeable. The system is then proved to be effective for water supply storage on a household scale in the rural area, especially in the area with high rainfall amount during rainy season and moderately or low yielded aquifer. Further improvement in design is still required, and it should be considered that the application of the proposed system is expanded to other area to prove the effectiveness of the concept.

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Table 2: Water quality analysis results

Parameter	Standard	1 st (Sep.29, 1997)		2 nd (Oct.2, 1997)	
		Raw Water	Filtered Water	Raw Water	Filtered Water
1.pH	6.5-8.5	7.85	7.66	7.73	7.60
2.Turbidity(NTU)	≤ 20	45.1	2.75	92.8	24.8
3.Color(units)	≤ 15	30	5	40	30
4.Iron(total)(mg/ℓ)	≤ 1.0	0.5	0.03	0.85	0.34
5.Hardness(mg/ℓ)	≤ 300	73	69.8	69	67
6.TDS(mg/ℓ)	≤ 1500	114	98	160	137
7.Total Coliform (MPN/100mg)	< 2.2	3300	330	2800	20
8.Faecal Coliform(MPN/100mg)	no	<18	<1.8	<18	<1.8

Table 3: Water quality analysis results (poisonous aspect, Sept. 1997)

Parameter	Standard Max.		Measured Value	
	Raw Water	Pipe Water	Raw Water	Filtered Water
1.Dieldrin (μg/ℓ)	0.1	0.03	0.002	0.002
2.Aldrin (μg/ℓ)	0.1	-	0.004	0.001
3.Heptachlor (μg/ℓ)	0.2	0.1	0.002	0.001
4.Heptachlor Expoxide (μg/ℓ)	-	-	0.002	0.002
5.Lindane (μg/ℓ)	-	3	0.002	0.002
6.HCB (μg/ℓ)	-	0.01	0.002	0.002
7.o,p-DDT (μg/ℓ)	1	1	0.002	0.002
8.p,p-DDT (μg/ℓ)	-	-	0.002	0.002
9.Methoxychlor (μg/ℓ)	-	30	0.002	0.002
10.Chlordane (μg/ℓ)	-	0.03	0.004	0.003

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