

RECOMMENDATIONS FOR IMPROVING RAIN WATER QUALITY,

(a study conducted in 2 districts in Sri Lanka)

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Abstract

Rainwater harvesting has gained popularity in rural areas of Sri Lanka during the last few years. Number of water supply projects some with foreign funding has included rainwater harvesting as a technical option in their planning. The technology has been disseminated by Lanka Rain Water Harvesting Forum and has been successfully taken on by the government sector as well as the non-government sector throughout the country. The greater attraction of the rainwater harvesting system is the low cost, simple design and construction technology, independence of central system, accessible and easily maintained at household. However, studies have found that for drinking and cooking people still prefer to use known groundwater to unknown rainwater. Reluctance to drink rainwater collected from the rooftop thought to be a perception of water quality. Quality of rainwater collected depends on when it is collected (after the first rain), how it is stored as well as method of use.

In order to recommend and to convince the people as well as the implementers on the quality of rain water, a comprehensive, systematic survey of quality was conducted in 2 dry zone districts in Sri Lanka, where it is extensively practised at household levels. The different types of rain water harvesting tanks in these districts were identified and selected for testing biological, chemical, physical quality of collected rain water as well as presence of mosquitoes and other insects in the tanks over one year period.

The tank systems that were studied are Ferro cement above ground, Ferro cement partial underground tank and brick under ground tanks of 5000 litre capacity. In both districts a drinking water wells was sampled as the other available source of drinking water for comparison of quality.

This study compares rain water quality collected in different types of rain water tanks in two districts in Sri Lanka and gives recommendation for improving quality of rain water and ensure long term popularisation of rain water systems.

1. Introduction

Sri Lanka has an average annual rainfall of 2400 mm with a range of 900mm in the dry zone and 5000 mm in the wet zone. The rainfall is bi-modal and varies both seasonally and spatially. In the dry zone more than two- third of the rain falls during the wet season (NE monsoon) from October to March of which 70% falls between October and December. The large variation in rainfall leads to spatial and seasonal variations in water supply.

Due to the bimodal pattern of rainfall in Sri Lanka rain water harvesting systems which collect, store and save rain water during the rainy seasons for usage during the dry season are feasible. People of Sri Lanka have used rainwater for both domestic and agricultural purposes for many centuries. Traditionally rainwater was collected for domestic use from rooftops into barrels, domestic containers and small brick tanks. In recent years there has been a revival of rainwater harvesting and research has been conducted to improve this technology. In 1995, the Community Water Supply and Sanitation project initiated by the Government of Sri Lanka with World Bank funds introduced rain water harvesting as a water supply option in Badulla and Matara districts. Since then, government and non- government organisation throughout the country have promoted rain water harvesting.

Rainwater harvesting has brought relief during time of drought and water scarcity for many people living in rural areas of Sri Lanka. At present, more than 15,000 rain water harvesting systems are in operation throughout the country. While the concept and technology of rain water harvesting has become popular there is still reluctance among the people to use rainwater for drinking purposes even though householders use rain water for cooking, washing, toilet and gardening.

Consumption of rainwater is related to the perception of quality (Ariyananda T., 2001) .

Rainwater tanks are generally not tested for water quality; therefore households have no knowledge of the quality of water, only a perception of water quality. In order to recommend and convince the people with confidence to use rainwater as a drinking water source, as an adaptation measure in time of drought, a comprehensive, systematic survey of rain water quality is needed.

2. Methodology

2.1. Study site

A survey was conducted in two districts, Puttalam and Kurunegala in the North Western province of Sri Lanka (figure 1). The locations selected within the 2 districts falls within the dry zone and has an annual rain fall of 1311 mm at Maho weather station in Kurunegala district and 1144 mm at Palavi weather station in Puttalam district.

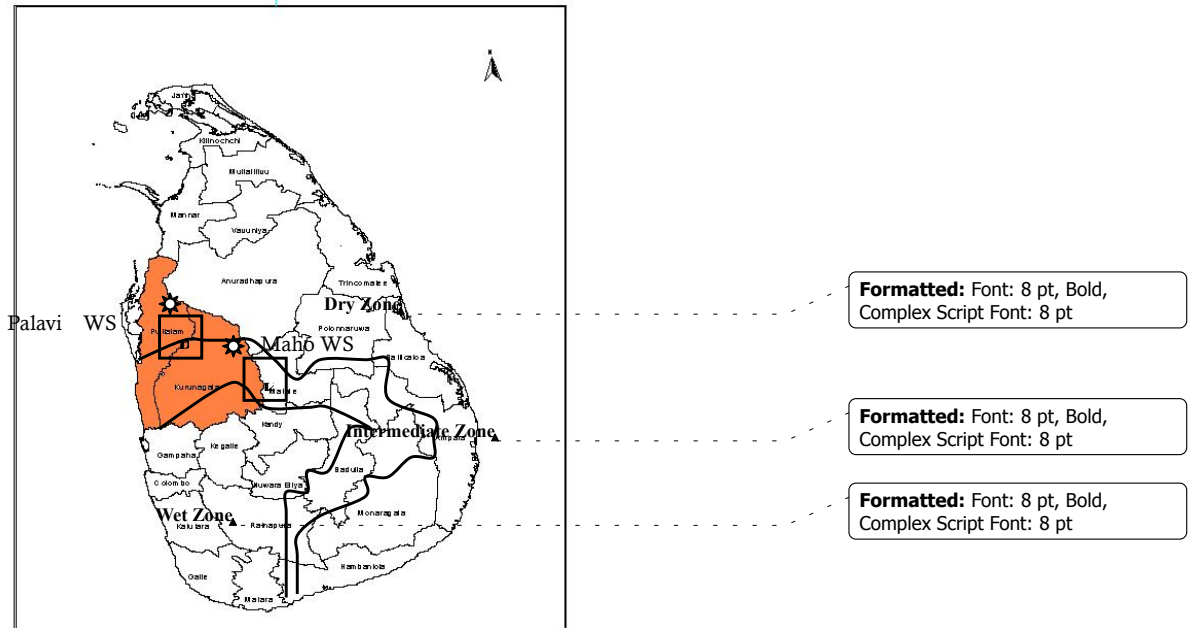
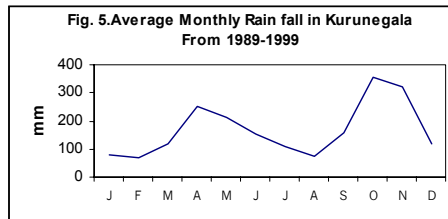
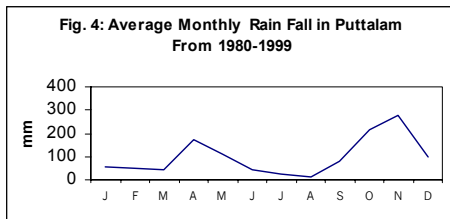


Figure 1: Map of Sri Lanka showing the rain fall zones and sampled locations

Even though both districts receive adequate rain fall in absolute terms, there is a long period of low or no rain fall between the two monsoons. In the Puttalam district the dry period extends from January to April and again from June-September (Figure 4). In the Kurunegala district similar dry periods are experienced (Figure 5). During the dry period most water sources such as shallow wells and reservoirs (agriculture tanks) dry up and people have to trek a long distance in search of clean drinking water. The only available water sources for the community during the dry season are the tube wells. However, the water in almost all tube wells is either saline or mineralized.



An initial survey was conducted to select 5 households with rain water harvesting tanks in selected areas in Kurunegala and Puttalam districts. During the initial survey more than 20 households having rain water tanks were visited in each districts and only the households which were operating, maintaining and using system and interested in the survey was selected for the monitoring. In both districts a drinking water wells was sampled as the other available source of drinking water for comparison of quality.

Kurunegala district

Five systems with four different storage tank types were selected in 2 villages: Nalewa and Eramuduwewa in Kurunegala district (figure 2) . The tanks selected at Nalewa were ferro-cement, partially underground (fig: 8) and underground with thatched/tar roofs (fig:9) constructed with the assistance of by Lanka Rain Water Harvesting Forum (LRWHF) in 2002. The tanks selected at Eramuduwawe were above-ground ferro-cement (Fig:7) and under-ground brick (2) (Fig: 6), constructed with the assistance of the Dry Zone Participatory project in 1999. All tanks were of 5,000 liter (5 m³) capacity.

Table 2. Details of households selected for survey in Kurunegala district

Household No.	Village	Type of tank	Type of roof
K01	Nalawa, Ambanpola	thatched roof	G.I.
K02	Nalawa, Ambanpola	partially underground – ferro	Tile/G.I
K03	Eramuduwawe, Ambanpola	ferro-above ground	tile
K04	Eramuduwawe, Ambanpola	brick under-ground	tile
K05	Eramuduwawe, Ambanpola	brick under-ground	G.I./tile

Puttalam district

Five systems were selected from Pottuwilpura, Madurankuliya, Kaladi (2) and Thabbowa in Puttalam district (figure 3). All tanks were ferro-cement above-ground (figure 8) since only these were built in Puttalam district. Pottuwilpura and Madurankuliya tanks were constructed with the assistance of LRWHF in 1999, Kaladi tanks were constructed with People's Rural Development Association (PRDA) in 1999, and the Thabbowa tank was constructed in 2002 with the assistance of the Third ADB Water Supply and Sanitation project.

Table 3. Details of Households selected for survey in Puttalam district

Household no.	Village	Type of tank	Type of roof
P01	Pottuwilpura	ferro-above	tile
P02	Madurankuliya	ferro	tile
P03	Kaladi	ferro	tile
P04	Kaladi	ferro	tile
P05	Thabbowa	ferro	tile

Table 4: The construction cost of different types of tanks of 5m³ capacities

Tank type	Cost in SL Rs.
Above ground Ferro-cement tank (1999)	15,000

Under ground Brick tank (1999)	14,000
Ferro cement Partial under ground tank (2002)	6,500
Under ground thatched roof tank (2002)	4,500

US \$ 1= SL Rs. 100

2.2. Physical, chemical and biological quality of rain water in rain water

The collection tanks were monitored over a period of 10 months for

a. Physical quality

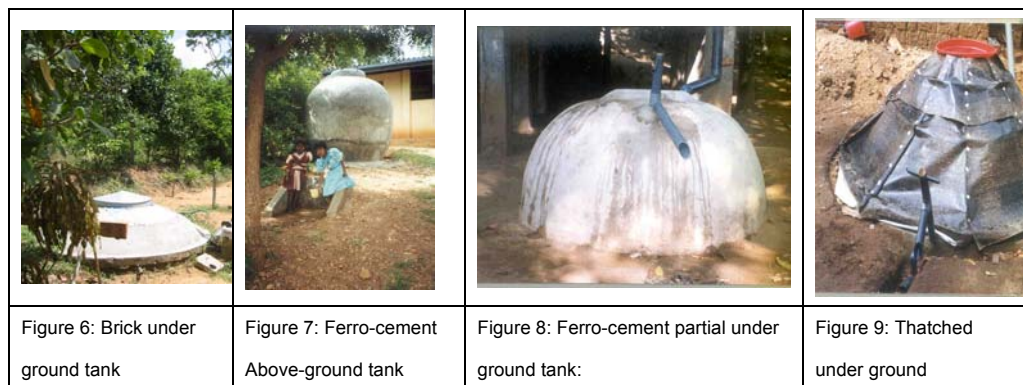
- Temperature, Turbidity

b. Chemical quality

- pH, Total Dissolved Solids (TDS), Conductivity ,Zinc, Copper

c. Bacteriological quality

Bacteriological quality was measured by the presence of *Escherichia coli* . *E.coli* is abundant in human and animal faeces. Therefore the presence of *E.coli* in drinking water indicates potentially dangerous contamination by disease causing pathogens . Presence of *E.coli* is measures by membrane filter method using Oxfam- DelAgua water testing kit.



3. Result and Analysis

Table 1.1 Physical and Bacteriological Quality of Rain water collected from different tanks in Kurunegala and Putalum District.

Type of RW tank/source	Source No.	Roof Type	Turbidity (NTU)	TDS Mg/l	Temp. °C	<i>E.coli</i> per 100 ml water (± Standard Deviation value)
Thatched roof	K01	G.I.	0-11.3 (±4.15)	51-442 (±137)	27.5-30.7 (±1.4)	7-245 (±94.9)

Partial-under ground- Ferro	K02	G.I.	0-2.96 (±1.02)	36-120 (±30)	27-33.2 (±1.9)	0-6 (±2.1)
Ferro-above	K03	tile	0-0.86 (±0.37)	9-121 (±32)	26.4-31 (±2)	0-1000 (±348.8)
Brick under ground	K04	tile	0-0.51 (±0.19)	0-82 (±23)	27.2-29.2 (±1)	0-1000 (±339.1)
Brick under ground	K05	G.I/ tile	0-0.47 (±0.17)	29-93 (±20)	28.5-31.4 (±0.9)	0-2 (±1.3)
Ferro-above	K05	tile	0(±0)	50-50	30.3-30.3	0
well	W01		0-3.17 (±1.1)	74-857 (±284)	26.9-29.5 (1±.4)	0-200 (±77)
Sri Lanka Standard for drinking water quality (max. desirable level)			<5	500	100	0

(± Standard Deviation value)

Table 2. Physical and Bacteriological Quality of Rain water collected from different tanks in Putalum District.

Type of RW tank/source	Source No.	Roof Type	Turbidity (NTU)	TDS Mg/l	Temp. °C	<i>E.coli</i> per 100 ml water (± Standard Deviation value)
Ferro-above	P01	tile	0-0.04 (±0)	40-144 (±39)	27.8-30.4 (±1.3)	0-3 (±1.3)
Ferro-above	P02	tile	0-3 (±0)	22-123 (±32)	26.2-31.3 (±1.9)	0-27 (±9.9)
Ferro-above	P03	tile	0-28.3 (±10.2)	596 (±178)	26.6-27.7 (±0.6)	3-1000 (±504)
Ferro-above	P04	tile	0.27 (±0.1)	17-423 (±167)	27.2-30.5 (±1.2)	0-32 (±1.3)
Ferro-above	P05	tile	1.32 (±0.5)	47-50 (±2)	27.9-28.6 (±0.4)	0-1000 (±404)
Well	WP01		2.64 (±1)	90-770 (±481)	29.4-30.9 (±1.1)	10-1000 (±700)
Sri Lanka Standard for drinking water quality (max. desirable level)			<5	500	100	0

level)				
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NB (*P03 was filled with well water during sampling period)

Turbidity in rainwater tanks fall within the Sri Lankan standard for drinking water quality in all tanks in both district , except for the thatched roof under ground tank K01 in Kurunegala district and P03, in Puttalam district, which recorded above the standard level. As the tank K01 is not sealed on top, there are chances for surface water run off and dirt to fall in to the tank. The tank P03 was filled with water from a near by well during the sampling period. Thereafter this tank was used as other source of water for comparison. High levels of TDS too recorded from P03. Well water too records high level of TDS in both districts and are not suitable for drinking during the October month.

Temperature in all tanks falls well within the recommended standards. Generally higher temperatures were recorded from the above-ground tanks than from the under-ground tanks. pH in all rain water tanks sampled in Kurunegala district fall within the recommended standard except in partially under-ground ferro cement tanks (K02) which had recorded slightly higher pH than the standard. This could be due to re-plastering of the upper dome portion of the tank. Conductivity too is higher in this tank (K02) and Thatched roof tank (K01) also recorded higher values during January. pH recorded from tanks in Puttalam district falls within the recommended standards.

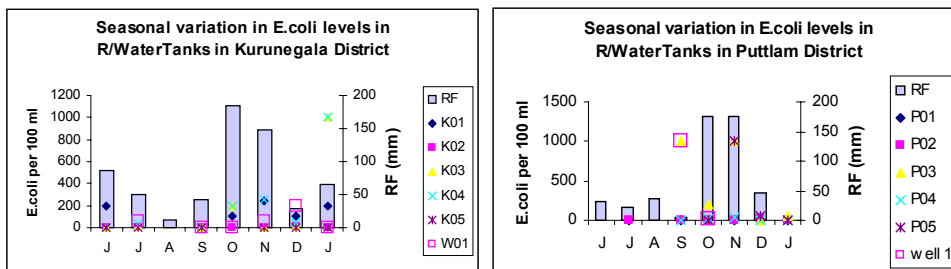
TDS and Conductivity were low in rain water tanks since rain water does not contain minerals and has very little dissolved substances. Since the mineral content of the water depends on the surface it passes over and collecting rain water from roof surface will have minimal minerals added to the water.

Zn was recorded only in ferro-cement partially under-ground tank (K02) and brick under-ground tank(K05). Both these tanks receive water from G.I. roofs. However, levels fall within the recommended standard levels. No appreciable Cu content was recorded in any of the tanks or well water.

E.coli levels in the ferro-cement rain water tanks were generally lower than the under ground tank, in Kurunegala district. Water in the brick underground tank (K05) and partially under ground ferro-cement tank (K02) with GI and tile roof recorded better bacterial quality. This is probably because G.I roofs get heated and any contamination on the roof is neutralized on the roof surface. A similar observation was recorded by Vasudevan et al (2001).

Low *E.coli* levels were recorded from 3 of the Puttalam tanks. High *E.coli* levels were recorded from P03 which contained well water. High *E.coli* levels were also recorded from the wells in this area.

Seasonal Change in Physical and Biological Parameters



Figures 10 and 11: Variation in *E. coli* levels in Rain water Tanks in Kurunegala and Puttalam

Districts compared with the Rain fall pattern in nearest station during the year. Seasonal rainfall pattern in the Kurunegala district is similar to the rain fall pattern in the Puttalam district. However, the total amount of rainfall received is higher at Maho Meteorological Station in Kurunegala district (554.4 mm June- Dec 2003) than the rainfall at Vanathavillu in the Puttalam district (492.7 mm June- Dec 2003) . The study shows higher bacteria levels in rainwater tanks during the rainy season in both districts (Figure. 10 and Figure 11). Most of the rain water tanks sampled did not have a proper first flush system therefore contamination on the roof get in the tanks with the rain.

Turbidity too in the rain water tanks is high during the rain period, indicating dust and debris from the roof getting in to the tank with the rain. TDS and conductivity is not affected by the rain fall pattern in the rainwater storage tanks in both districts, where as conductivity is higher in well water during the dry season and reduces during the rainy season.

Comment: I actually did not really see that, maybe the scale is too small?

4. Discussion and Conclusion

Bacterial levels recorded from rain water tanks are at low (<10) to intermediate (<100) risk levels according to WHO recommended standard (WHO, 1993). Out of 58 rain water samples tested for *E. coli* , 41% contained zero *E. coli* bacteria (WHO recommended standards), 62% of the rain water samples contained less than 10 bacteria (WHO low risk level) and 72% of the samples contained less than 100 bacteria (WHO intermediate risk level).

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All other parameters tested comply with SL standard and WHO recommended standards for drinking water, except slightly high level of pH in one tank due to cement dissolving. Water quality in shallow wells in both districts does not comply with recommended standards for biological and chemical quality due either to bacterial contamination from cess pits and/or to high mineral contents. During the dry season the minerals contents in the wells increase and make it less suitable for drinking. Then the householder has to go 1-5 km in Puttalam district and 1-3 km in Kurunegala district to fetch drinking water. During the dry season, at Nalawa in Kurunegala district a well owner limits the well water to 1 pot per household.

No chemical pollution was recorded in any of the rain water tank. A trace of Zinc was recorded in three rain water tanks. Two of these tanks are located in households having part G.I roof.

Therefore, there is an indication that roof material would be the source of Zinc.

Since all the ferro cement above ground tanks contained well sealed lids mosquitoes larvae were not present. Brick underground tank reported presence of mosquito larvae at one incidence during the wet season during cleaning. Mosquito larvae were reported from the thatched roof tank both in the dry and wet season since tanks can not be completely sealed. Other insects such as ants were reported in both the brick under ground tank and thatched roof tank.

Interview with households surveyed revealed that rainwater is been used for drinking by 70% of the households. Other uses of rainwater are for cooking, washing, toilet use, gardening and for livestock. One household use it for commercial activity such as ornamental fish tanks.

5. Recommendations

5.1. Technical

- All rain water tanks should be fitted with filter and first flush system to improve bacterial and physical quality of water.
- Householder should be made more aware on Operation and Maintenance of the tanks
- Corroded GI roof can be source of metal contamination (Zn) of rain water, therefore care should be taken to replace corroded GI sheets.
- Rain water tank should be securely covered for protection as well as to prevent dust and runoff as well as insects getting into the tank.

5.2. Financial and Other implications

- Introduce a loan scheme or a subsidiary to households to bear the initial cost of constructing a tank. Since this the main constraint in replicating the technology.
- Drinking rain water should be encouraged in dry zone district where the groundwater is both mineralized and contaminated. High content of calcium and minerals thought to be the cause of high incidence of kidney problems in the dry zone areas.
- Quality rainwater should be popularized therefore more people will be encouraged to use for drinking.

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