Paper presented at XI IRCSA conference August 2003, Mexico

Health Risk Due to Drinking Domestic Roof Water Harvested

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Introduction

Since rainwater harvesting systems are classified as individual systems there are no public health regulations for constructing, maintaining and testing the quality of the collected water. Lack of regulation result in variation in design, no incentive for maintenance or testing for water quality. As a result, the water quality of most systems is not know and varies from system to system.

Recommending domestic roof water collection for drinking has direct health concerns due to biological and chemical contamination and indirect health issue due to disease-causing insect vector breeding in the tanks. Contamination of rain water systems has been linked with a number of human infections (Brodrinbb *et al,* 1995; Murrell and Stewart, 1983) and chemical intoxication (Body, 1986). Many studies have looked at microbiological (Lye, 1987; Fujioka and Chinn, 1987; Fujioka *et al* , 1991; Hable and Waller, 1987; Waller *et a.,* 1984) and chemical (Gumbs and Dierberg, 1984; Olem and Berthouex, 1989; Sharpe and Young, 1982; Young and Sharp, 1984) contamination of roofwater collection.

This paper will look at chemical and biological issues as well as specific health issues posed by very low cost domestic rainwater harvesting systems in a study conducted in 3 countries.

Biological Risks

Biological risk occurs due to consumption of contaminated rain water. The World Health Organisation (WHO) recommended method to search for microbiological indicator of fecal pollution uses a “fail-safe” concept, namely if fecal indicators are shown to be present, then it must be assumed that pathogens could also be present. Due to the large number of *Escherichia coli* present in the feces of both mammals and birds, this species is used as indicator of fecal pollution in drinking water.

Escherichia coli sampled from different tank designs in 3 countries studied recorded overall less than 100 in 100 ml of rainwater. According to WHO recommended standard this is “intermediate risk” levels. This is far less than the number of *E.coli* levels recorded from other rural sources such as wells. Except, in urban locations in Addis

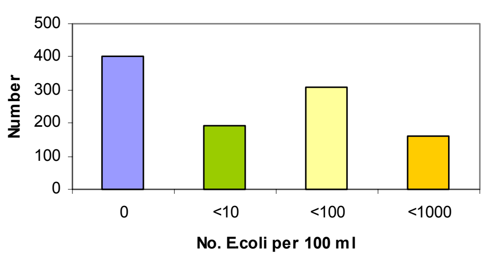
Ababa, recorded *E.coli* levels in rainwater harvesting tanks higher than in water from the alternative (standpipe) sources. And also, at urban Colombo, Sri Lanka where alternative sources is a standpipe, *E. coil* is low. But the shallow wells in the same location which are been used for mainly washing purposes are highly contaminated. Higher level of *E.coli* recorded from the rain water tanks in Colombo would be due to poor conditions of their roof. Table 1, summarises our findings (about 1000 FC measurements spread over 8 communities).

Table 1: Levels of *E.coli* recorded in rainwater collection tanks in different locations

	Mean Number of *E.coli* recorded in 100ml of Tank water / water from other sources					
Country	**Ethiopia**		**Uganda**		**Sri Lanka**	
Location	Urban (Addis Ababa)	Rural (Alaba)	Urban (Kampala)	Rural (Mbrara)	Urban (Colombo)	Rural (Aranayaka)
Rainwater	40	21	10	5	68	74
Other sources	5	34	20	6	150	76

Of the 1062 samples taken 37.7% samples conformed to WHO guidelines of zero *E.coli* per 100 ml of Rain water values, 17.8% recorded <10 *E.coli* per 100ml of rain water, WHO low risk criteria, 29.2% samples recorded <100 *E.coli* per 100 ml of rain water, WHO intermediate risk, 15.2% samples recorded <1000 *E.coli* per 100 ml of rain water, WHO high risk criteria and no samples contained more than 300 *E.coli* per 100 ml of rainwater.

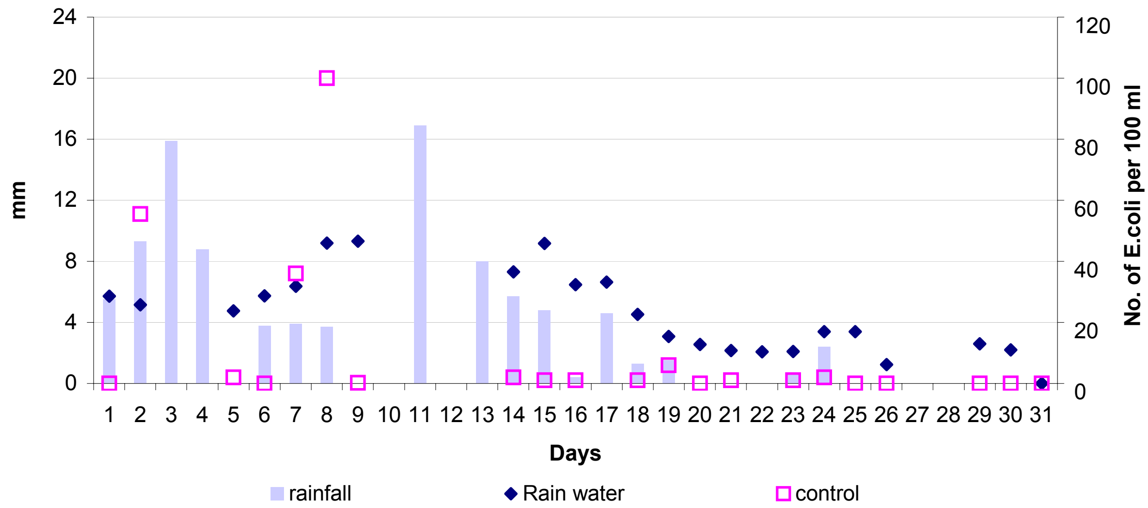
Figure 1: Distribution of FC per 100 ml of RW Samples



0 A (blue) In conformity with WHO guidelines
1–10 B (green) Low risk
10–100 C (yellow) Intermediate risk
100–1000 D (orange) High risk
1000 E (red) Very high risk

E. coli levels in the tanks are influenced by rainfall (2). High levels are recorded immediately after the rains. The bacterial levels die off within 7- 10 days, if no fresh contamination occurs. Use of first flush and keeping water stored can reduce the risk of contamination.

Figure.1: *E. Coli* recorded from Rainwater Tank in Addis Ababa in September 2003



Risk due to type of tank

Four different model types were tested in the 3 countries and water quality surveyed to assess if the quality is influenced by type of tank.

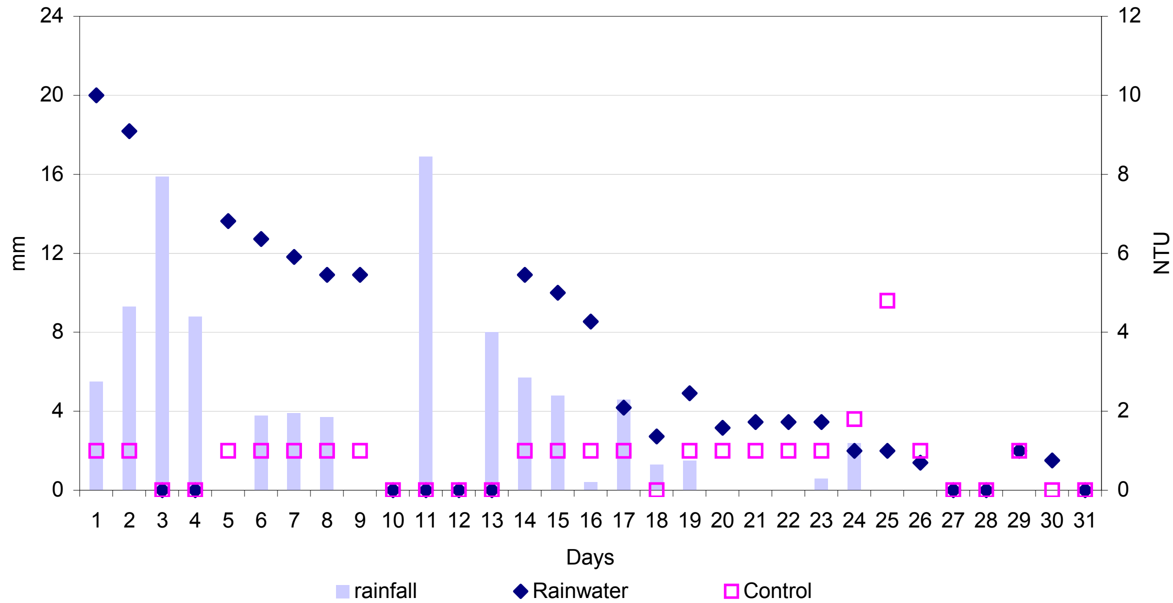
Types of tanks tested were barrel tank, thatched underground tank, tube tank and ferro cement dome tank.

There was no significant difference between *E.coli* pattern recorded between different tank types, Ferro cement, Thatched, Barrel or Tube tanks. *E.coli* levels in all 4 tanks are high with the onset of rains, levels decrease during the dry period. In larger tanks E.coli levels are lower during the rainy season. In smaller tube tank since the water storage time is less, and fresh contamination comes with the rains the *E.coli* levels levels are higher.

Risk due to Chemical and Physical Quality

The chemical and physical quality of rainwater may not directly cause health risk but can influence water disinfection methods and promote bacterial growth. However, physical and chemical quality of drinking water directly affects the acceptability to consumers. High level of turbidity can protect microorganisms from the effect of disinfection, stimulate the growth of bacteria and give rise to significant chlorine demand. Effective disinfection requires that turbidity is less than 5 NTU; ideally, median turbidity should be below 1 NTU.
Turbidity recorded from all locations were below 5 NTU except in Ethiopia where it was recorded average 10 NTU in Addis Ababa and 7 NTU in Alaba. Turbidity in the tanks correlates with rainfall pattern, high turbidity is recorded soon after rains Figure 2. Except in barrel tanks turbidity is initially high, then remains constant and does not correlate with rainfall pattern. This is due to the effect of sand filter that is used in the these tanks.

Figure 2: Turbidity recorded from rain tanks in Addis Ababa, September 2002



It is important that the pH should be in the optimal range (less than 8.0) for disinfection with chlorine. pH recorded from all locations comply with the recommended standards except for slightly more alkaline values recorded at cement tanks. pH in the cement tanks decrease during the wet season and increase during the dry season. Initial pH is high in all tanks, gradually it decreases during the rainy season and increase again after the rains stops. pH in other tanks remains constant. More acidic pH were recorded in the urban sites Colombo, Sri Lanka. This could be due to influenced by local pollution from exhaust fume from vehicles.

Table 1: pH levels Recorded in Rainwater Collection tanks in different locations

	Mean pH recorded in Rain water					
Country	**Ethiopia**		**Uganda**		**Sri Lanka**	
Location	**Urban (Addis Ababa)**	**Rural (Alaba)**	**Urban (Kampala)**	**Rural (Mbrara)**	**Urban (Colombo)**	**Rural (Aranayaka)**
Rainwater	8.2	8.1	8.8	7	5.6	9
Other sources	8.1	8.0	7.5	7	5.5	8

Risks from vector born disease

Mosquito borne disease like malaria, dengue, yellow fever and filariasis are of primary concern, especially in tropical countries. Aedes spp, that carry dengue and yellow fever, have been the mosquitoes most commonly found in rain water storage tanks and vessels. In the 20 tanks sampled in Kampala Uganda, 16 tanks recorded no mosquito presence and 4 tanks (partially below-ground domed design) recorded 3-10 adult mosquitoes and 4-8 larvae. In Colombo, Sri Lanka lower numbers of larvae (4-5) were recorded in 4 of the 20 tanks tested (mostly barrel type).). However, no instars were recorded from any rain water tanks in Colombo. Rural site, Aranayaka in Sri Lanka, did not record any mosquitoes larvae through out the study. Since dengue and filariasis is prevalent in both rural and urban sites in tropical countries the risk of disease-carrying mosquitoes breeding in the rain water tank is present

Earlier research in Delhi India (Mittal *etal* 2001) had indicated \that well-screened roofwater stored in darkened tanks has a low nutrition level – too low to permit mosquito larvae to complete their development to pupae and then adult form. So it is not clear from these studies whether the results actually indicate successful mosquito breeding or not.

Risk from the physical design of the system

Health risk due to use and presence of the rainwater harvesting system can arise either from children falling into the tanks or from lifting heavy lids or tank bursting. The former two risks can occur mainly in underground tanks and the latter mainly in above-ground tanks. There has also been at least one reports of the asphyxiation of a mason entering a newly rendered tank.

Conclusions

Overall 37.7% of the samples taken from both rural and urban locations sampled met the WHO recommended value of zero *E.coli* in 100 ml of rain water. This is similar to results obtained in New Zealand by Simmons *etal*, (2001), where 44% of the sample recorded zero *E.coli* values and 56% of the samples were recorded >1 *E.coli* per 100 ml of rain water. WHO recommended guideline of low risk E coli. (<10 per 100 ml of rain water) was recorded from 55.7% of the samples. Varied results have been reported in other countries with different systems, climate and locations. Theo *etal* (1985) reported absence of *E.coli* in 57% of the systems in Micronesia. Similarly in Wirojanagud etal (1989) reports 50% of the samples contain no *E.coli*. Government of Thailand (1989) found only 29% samples from rainjars in Thailand met the WHO recommended standard. From the urban samples, mainly from Addis ababa in Ethiopia 57% of the samples contain no *E.coli.* This higher compared to bacterial quality from rural sites where only 25.9% of the samples record no *E.coli.* But this would be due to different tanks types and not locations. Tanks sampled at Addis Ababa are all barrel tanks.

Water quality recorded from barrel tanks was observed to be better in terms of *E.coli*, turbidity. Alkalinity is too high initially in cement tanks, however this is reduced at the second rainy season or at the end of the rain season, after the tanks get washed of cement. Larger tanks with longer residence time give on average, cleaner water than smaller tanks.

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