academicJournals

Vol. 5(12), pp. 479-487, December 2013
DOI: 10.5897/JPHE2013.0582
ISSN 2006-9723 ©2013 Academic Journals
http://www.academicjournals.org/JPHE

Journal of Public Health and Epidemiology

Full Length Research Paper

Assessment of rain water harvesting systems in a rural community of Edo State, Nigeria

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Accepted 7 November, 2013

The study assessed the practice of rain water harvesting (RWH) in a rural community in Edo state, Nigeria. Using a cross sectional study design, pre-tested structured interviewer administered questionnaire were administered to 232 selected and consenting households. A structured observational checklist was used for assessment of household rainwater harvesting system. Water was collected from 15% of houses and tested for bacteriological quality. Data was analysed using statistical package for social sciences (SPSS) version 16. Results were presented as frequencies, with statistical test applied where appropriate. Findings showed that RWH was practiced by over 80% of households, with the roof top as the catchment area. Stored water was most commonly used for personal hygiene purposes. Majority of the 30 water samples tested had unacceptable levels of total coliform, while one sample had *Escherichia coli*. Health education should focus on enlightening households on appropriate design and maintenance of RWH systems.

Key words: Assessment, harvesting, rainwater, rural.

INTRODUCTION

Rainwater harvesting (RWH) is any human activity involving collection and storage of rainwater in some natural or artificial container either for immediate use or use before the onset of the next season for domestic, agricultural, industrial and environmental purposes (Kemp, 1988; Kun et al., 2004; Mati et al., 2005). The concept of RWH systems can vary from small and basic, such as the attachment of a water bucket to a rainwater downspout, to large and complex, such as those that collect water from many hectares and serve large numbers of people (Gur, 2010; United Nations Environmental Programme (UNEP), 1982). In rural areas, the most common technique is small-scale rooftop rainwater harvesting (Pacey and Cullis, 1986).

Rainwater harvesting technology involves three basic stages, namely catchment areas (rooftops and land surfaces), conveyance systems (plastic or corrugated iron gutters) and collection devices (storage tanks) (UNEP, 1982). . The quality of rainwater is directly related to the cleanliness of the atmosphere, cleanliness and quality of material used for catchment surface, gutters and storage tanks (Ariyananda, 1999). In areas where the rooftop is clean, impervious, and made from non toxic materials, roof rainwater is usually of good quality and does not require much treatment before consumption (Lekwot et al., 2012). The concentration of contaminants associated with a given rainfall event tend to reduce exponentially with time following the beginning of the

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event. Therefore, diverting the initial portion of runoff away from the storage device will mean that the quality of water entering storage is improved and the need for subsequent treatment reduced or even eliminated altogether (Kuntala et al., 2011; World Health Organisation (WHO), 2004).

Availability of adequate and clean water for household uses is an enormous problem for rural households in developing countries (Mwendera, 2006). RWH has the potential of meeting the water needs of these rural communities (Pacey and Cullis, 1986). Likewise, rainwater harvesting in urban areas can provide supplemental water for the city's requirements (Devi et al., 2012; Gould and McPherson, 1987).

One reason the provision of safe drinking water is of paramount concern is that 75% of all diseases in developing countries arise from polluted drinking water (Third World Academy of Science (TWAS), 2002). Each day, 25,000 people die from use of contaminated water and several more suffer from water borne illnesses (Mason, 1996). About half of the people that live in developing countries do not have access to safe drinking water and 73% have no sanitation, some of their wastes eventually contaminate their drinking water supply leading to a high level of suffering. More than five million people die annually from water-borne diseases. Of these, about four million deaths (400 deaths per hour) are of children below age of 5 years. The lack of safe drinking water also stunts the growth of 60 million children per year (WHO, 1996; WHO-UNICEF, 2000). Contamination of drinking water by urine of the rodent species '*Mastomys natalensis*' has been implicated in the spread of a disease, Lassa fever, an acute viral haemorraghic disease endemic in parts of West Africa, including Nigeria (Acha and Szyfres, 2003; Heymann, 2008; McCormick et al., 1987, Public Health Agency of Canada, 2010). As much as one-tenth of the global disease burden could be prevented by improving water supply, sanitation, hygiene and management of water resources (Vilane and Mwendera, 2011; WHO, 2004).

The provision of water for domestic and other uses in rural and urban centres is one of the most intractable problems in Nigeria today , with 52% of Nigerians lacking access to improved drinking water supply (Lekwot et al., 2012; Orebiyi et al., 2010). Nigeria is endowed with enormous surface and groundwater resources, yet the provision of potable and safe water supply is still inadequate. (Nwankwoala, 2011). The Millennium Development Goals (MDGs) of halving by 2015 the proportion of people without sustainable access to adequate and affordable safe drinking water will be hard to achieve due to low levels of existing coverage, but this will become almost impossible if sustainability levels cannot be improved (Nwankwoala, 2011). Despite the seeming intractable problem of water scarcity in Nigeria, the high neonatal and childhood morality due to diarrheal diseases and the common practice of RWH, particularly in Edo state, there is little attention paid to the assessment of the state of RWH systems.

MATERIALS AND METHODS

Study area

The study was carried out in Usugbenu, located in Esan Central local government area, Edo state, in the South-south geopolitical region of Nigeria. The community, having one political ward (ward 6) and a population of less than 4,000 lies along latitude 60° 10' and 60° 45' north of the equator and between longitudes 60° 10' and 60° 30' east of the Greenwich Meridian, within the tropical region. Sited on a relatively flat plateau called the Esan plateau, the area lies about 466 km above sea level. The water aquifer is put at about 150 m. The tropical climate is dominated by high temperature, high humidity and heavy rainfall. The area is characterized by two distinct seasons, the wet season which lasts between March and November and the dry season which lasts between November and February. The community is made up of 10 quarters or hamlets. Inhabitants are mainly Esan in origin, predominantly peasant farmers and petty traders. Christianity is the major religion. The community suffers a lack of public utilities and infrastructure.

Study design

A descriptive cross sectional study design was utilized for the study.

Study population

Study population comprised households and their houses within the community. Household head or any adult within the household aged over 18 years and who met the inclusion criteria were invited to participate. Inclusion criteria was that they should have been living in the community for not less than one year, as this was enough time to have built a water harvesting system and used it for water supply considering the two seasons prevalent in the community and the giving of consent. Households with no adult present at the time of the study, or where consent was not given, were excluded.

Sample size calculation

Sample size was calculated using the formula for prevalence study with z as 95%, p set as 84% being the prevalence of people who were aware of sources of rainwater contamination in a study carried out in Uganda (Baguma et al., 2010), and non-response rate of 10%. Sample size was calculated as 232.

Sampling technique

Multi stage sampling technique was used for sample selection. The community was desegregated into quarters and 50% of the quarters selected. In each selected quarter, a count of the number of houses was undertaken, and proportionate allocation used to determine the number of houses required from each cluster. Using a count of the number of streets/roads in the cluster, an estimate of the average number of houses per street was obtained, and the number of houses required for participation per street calculated. Random sampling was used to select houses in each street. In all selected houses, the head of household or in his/her absence, an adult who meets the inclusion criteria was invited to participate. Research assistants included final year medical students of the Ambrose Ali University, on posting in the Department of Community Health. They were trained for one-day on questionnaire administration to enable uniformity in data collection.

Data collection methods

Data was collected using quantitative data collection tools: a survey questionnaire, checklist and bacteriological assessment of water quality. The survey questionnaire was adapted from that used in a previous study (Mosley, 2005) and focused on demographic characteristics of the respondents, practice of RWH and perceptions of water quality. The survey questionnaire was pretested amongst 20 households in a neighbouring community for validity. The checklist designed by the researchers with input from experts in the field and a checklist used in an earlier study (Mosley, 2005) provided a tool for assessing the state of the RWH system. Scores were assigned to a set of ten pre-determined criteria that included the level of completeness of the system, quality of the individual components present, nature of reservoir, quality of reservoir, presence or absence of lid and tap on the reservoir, presence of overhanging vegetation and state of roof. A score of two '2' was assigned to a criteria where present and in good condition, one '1', when present but in poor condition and zero '0', where absent. Highest possible score for any system was twenty points. Points for each house were summed up and graded. A score between 0 and 10 was graded unsatisfactory system, and > 10 satisfactory system.

For water quality assessment, water samples were collected from 15% of survey households (Kuntala et al., 2011) selected through random sampling. For all reservoirs, water sampling was done using guidelines of the American Public Health Association (APHA) (1985) and National Standard of Drinking Water Quality (NSDWQ) (2007). Water was collected aseptically in autoclaved 25 cl plastic bottles provided by a public health laboratory. Samples were transported in black plastic bags containing ice and brought promptly to the laboratory within 2 hours, kept in refrigerator at 4°C and examined within 16 hours of collection.

Samples were analyzed using standardized bacteriological methods for water quality analysis (Cheesebrough, 1987; WHO, 1984) to determine the degree of contamination. All samples were analysed for total bacterial count and *E. coli*. The microbiological quality was assessed by most probable number (MPN) method (Fawole and Oso, 2001). Total coliforms was indicative of environmental contamination (from bird faeces, dead leaves etc) and *E. coli* of human faecal contamination (Abott et al., 2012). Samples with MPN of total coliforms as 0 coliforms/100 ml were graded as excellent, 1 to 3 coliforms/100 ml acceptable, and 4 to 10 coliforms/100 ml as suspicious and >10 coliforms/100 ml as unsatisfactory. *E. coli* was recorded as either absent (MPN 0/100 ml *E. coli* detected), or present (MPN > 1/100 ml *E. coli*) (Mechenian and Andrews, 2004).

Data analysis

The completed questionnaires were screened for completeness, coded and entered by the researcher into the statistical package for social sciences (SPSS) version 16.0 (SPSS Inc, Chicago IL 60606-6412). Discrete data were presented as proportions (percentages) while continuous variables such as age were expressed as means ± standard deviation. Statistical analysis of differences between proportions were carried out using of chi-square test. Statistical significance was set at $p < 0.05$ for all values of the chi square test. Ethical clearance was obtained from the Teaching hospital's ethical committee. Verbal approval for the study was obtained from the traditional head of the community. Informed consent was obtained from each respondent before the conduct of interviews.

RESULTS

Two hundred and thirty two eligible respondents were included in the study. Mean age of respondents was 41.8 ± 15.6 years. Male respondents made up 164 (70.7%), Christianity was the predominant religion, 214 (92.2%). One hundred and fifty six (67.2%) respondents were unskilled, and the majority, 154 (66.4%) were married. Mean number of households in a house was 1.1 ± 0.4 years; average length of stay in the community was 29.9 ± 18.8 years. Mean income per month was given as ₦17,551.7 ± ₦9,063.8 (Table 1). One hundred and ninety three (83.2%) of 232 households practiced rain water harvesting in their homes. These respondents were asked further questions on RWH. Of this number, all (100.0%) collected rainwater from roof tops.

Maintenance of reservoir and roof surfaces

Sixty one (31.6%) claimed to have ever washed their gutter systems. Forty (20.7%) respondents claimed to have a mechanism for diverting first rains, 24 (12.4%) respondents claimed to have leaf control screens in the gutters and 39 (20.2 %) respondents claimed to have leaf control devices on their reservoirs. Devices were mainly in form of wire gauze and mesh (Table 2). One hundred and seventy (88.1%) claimed to have ever washed the reservoir in their houses since occupancy. Of this number, the majority, 146 (85.9 %) claimed it was washed over a year ago, while 24 (14.1%) had washed once within the past one year. One hundred and thirty nine (72.0%) claimed to have ever replaced or repaired their reservoir. One hundred and eight (56.0%) respondents claimed their roof had ever been changed or repaired.

Household use of harvested rain water

Water was said to be piped indoors by 92 (47.7%) respondents and be available outdoors by 101 (52.3%). Most common use for stored water was for personal hygiene by 179 (92.7%). Others were: domestic chores by 178 (92.2%), cooking 178 (92.2%), irrigation purposes/animal husbandry by 139 (72.0%). Least common use was for drinking by 147 (76.2%) (Figure 1). Seventy seven (52.4 %) of the 147 respondents who

Table 1. Demographic characteristics of respondents (N = 232).

Variable	Frequency	Percentage
Sex		
Male	164	70.7
Female	88	29.3
Educational level		
None	23	9.9
Primary	39	16.8
Secondary	132	56.9
Tertiary	38	16.4
Religion		
Christianity	214	92.2
Islam	14	6.0
Position in household		
Male head of household	117	50.4
Female head of household	23	9.9
Others	92	39.7
Educational status		
None	23	9.9
Primary	39	16.8
Secondary	132	56.9
Tertiary	38	16.4
Marital status		
Married	154	66.4
Widowed/ separated	31	13.4
Single	47	20.3
Socioeconomic status		
Unskilled	156	67.2
Semi-skilled	53	22.8
Skilled	23	9.9

used harvested rain water for drinking claimed to treat the water before use. Of this number, most common method of treatment was the addition of water guard (chlorination) to the water by 43 (55.8%). Boiling and filtering of water was carried out by 19 (24.7%) and 15 (19.5%), respectively.

Assessment of water quality by health authorities

Thirty seven (19.2%) respondents claimed their RWH system had ever been inspected by local authorities. One hundred and sixty one (83.4%) respondents claimed never to have carried out any form of quality assessment of the harvested water, 8 (4.1%) had checked for physical quality, and 24 (12.4%) had done microbiological assessment. One hundred and sixteen (60.1%) respondents claimed to have ever seen leaves, insects and reptiles in the water contained in their reservoirs.

Perception of adequacy of water

Harvested water was judged sufficient for family use throughout dry season (without the need to get water from alternative sources) by 70 (36.2%) respondents, and inadequate for 123 (63.7%) respondents. Other sources of water commonly used in dry season included streams, commercial boreholes, commercial water tankers and water vendors using wheel barrows.

Perceptions of water quality

Water was said to have smell all the time by 23 (11.9%) respondents, and sometimes by 54 (28.0%). Water was said to have taste all the time by 7 (3.6%) and sometimes by 47 (24.4%). It was said to have colour all the time by 16 (8.3%) respondents and sometimes by 54 (28.0%).

On-the-spot assessment of RWH system

Of the 193 houses where RWH was practiced, the roof was surrounded by a concrete parapet in 8 (4.1%) houses, corrugated iron sheet in 122 (63.0%) and long span aluminium in 63 (32.9%) of houses. Vegetation was overhanging the roof catchment area in 78 (40.4%) of houses. One hundred and thirty two (68.4%) had reservoirs submerged into the ground, 38 (19.7%) had surface reservoirs and 23 (11.9%) had both surface and underground reservoirs. Reservoirs were predominantly made of cement, 147 (76.2%), while 22 (11.4%) and 24 (12.4%) were of long-span aluminium and poly(vinyl chloride) (PVC), respectively. Mean length of time since reservoir was built was 12.7 ± 12.9 years, and mean length of time since reservoir was in actual use was 9.7 ± 7.0 years.

One hundred and seventy houses (88.1%) had gutters in place, while for 23 (11.4%) houses, water collection from roof top was freefall. Of those with gutters, the majority, 116 (68.2%) were poly vinyl chloride, while 46 (27.1%) and 8 (4.7%) corrugated metal sheets and metal poles, respectively.

Gutters were present and found to be in good condition (without obvious cracks) in 96 (56.5%) of 170 houses, and in poor condition in 74 (43.5%) houses. A down pipe

Table 2. Respondents manner of protection of RWH system.

Variable	n (%)	
	Yes	No
Ever washed gutter	61 (31.6)	132 (68.4)
Ever washed reservoir	170 (88.1)	23 (11.9)
Presence of filter screens/ leaf control devices		
In gutter	24 (12.4)	169 (87.6)
Over reservoir	39 (20.2)	154 (79.8)
Presence of first flush diverters	40 (20.7)	153 (79.3)

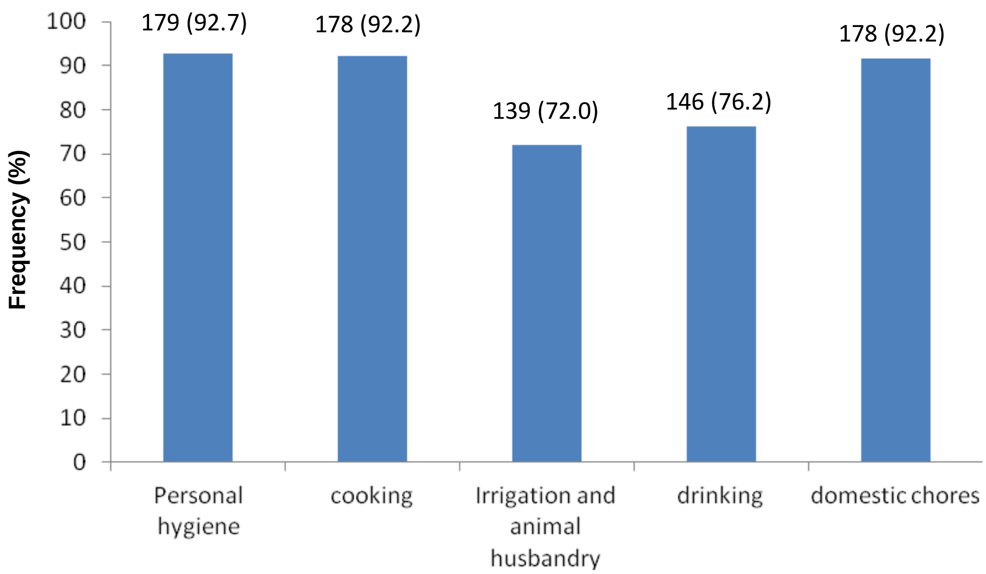

Figure 1. Household use of harvested rain water.

connecting the gutter with the reservoir was found in 94 (55.3%) houses. A lid was found to be present and tight fitting in 16 (8.3%) reservoirs, absent in 15 (7.9%) and present but not tight fitting in the majority, 159 (83.7%). The reservoir inlet was screened in 77 (40.5%) houses (Table 3).

Overall, the condition of RWH system was judged to be satisfactory in 70 (36.3%) houses and unsatisfactory in the majority, 123 (63.7%). There was no significant association found between state of RWH system and occupation of head of household (P = 0.95). State of RWH system was significantly associated with gender of head of household (P = 0.00), religion (P = 0.00) and marital status of head of household (P = 0.00) such that singles, Christians and female headed households had better practice of RWH.

Micro-bacteriological assessment of RWH

Laboratory analysis of water collected from 30 houses randomly showed mean count for MPN of total coliforms was 12.7 ± 32.0 coliforms/100 ml (median 7.0, range 0 to 180). The larger proportion of samples 12 (40.0 %) were classified to have suspicious levels of total coliforms. Five (16.7%) samples were graded excellent and 4 (13.3%) satisfactory, 9 (30.0%) samples were graded unacceptable. Only one sample was positive for *E. coli*.

DISCUSSION

The study showed that rain water was harvested primarily from rooftops. In Brazil, Argentina and Paraguay, RWH is

Table 3. On- the- spot assessment of RWH system (n = 193).

Variable	Frequency (%)
Nature of roof	
Corrugated iron sheet	122 (63.0)
Long span aluminium	63 (32.9)
Concrete with parapet	8 (4.1)
Completeness of system	
Gutter present	170 (88.1)
Downpipe present	94 (55.3)
Quality of gutter	
Good condition	96 (56.5)
Poor condition	74 (43.5)
Quality of surface reservoir (n=61)	
Intact, and outwardly water-tight	44 (72.6)
Non-intact or patched	17 (27.9)
Presence of tap	
Yes	23 (11.9)
No	170 (88.1)
Lid	
Present and tight fitting	16 (8.3)
Present not tight fitting	159 (83.7)
absent	15 (7.9)
Overhanging vegetation	
Present	78 (40.4)
absent	115 (59.6)

done using surface water collected into cisterns or surface ponds (Smet, 2005). For quality reasons, rainwater for human consumption is preferably collected from roofs as surface water is highly polluted. Where roof tops are rusty and covered with dirt, rain water collected from roof tops may have higher chemical contents than otherwise. Most of the rooftops in the present study were of corrugated iron sheets, which are subject to rust with time. The presence of overhanging vegetation observed in over one-third of houses has the disadvantage that pollution of water from dead leaves and bird droppings can make the water unsafe for drinking in it's untreated state. Though there is little agreement on the effect of roof composition on concentration of dissolved metals and other trace elements in water (Foster, 1996; Hart and White, 2006; Van Metre and Mahler, 2003), leached minerals and organic matter from trees may impart smell and colour to the water contained in the reservoir.

The greater proportion of reservoirs that were built with cement and party submerged in the ground was noted in the study site. This is contrary to what was observed in Swaziland (Vilane and Mwendera, 2011). Above ground storage makes access to and maintenance of the tank easier. Advantages of below-ground tanks include structural support of the soil, temperature moderation and protection from vandalism. However, it is more difficult to detect and repair leaks in these storage containers. Expansion and contraction of soil, particularly clay-rich soils, can lead to cracking, leaking and structural damage if proper reinforcement of the tank is not present (Barnes et al., 2010). Another benefit of surface tanks over sub-surface or underground tanks is that water can be easily extracted through a tap just above the tank's base (Benes, 1975).

The common practice of leaving gutters and reservoirs unwashed for up to a year was also documented in a study carried out in other parts of Esan land (Marcus, 2011), South Australia (Perera et al., 2011) and New Zealand (Abott et al., 2012) and which is in contrast to the three to four monthly interval recommended (Coombes and Abott, 2010). Rainwater users can reduce their risks of disease from contaminated rainwater consumption by regular cleaning (Coombes and Abott, 2010).

The average length of time reservoirs had been in use was similar to what was reported in South Australia (Rodrigo et al., 2010). The importance of this finding is that increase in family size or activity may warrant the addition of more reservoirs to cope with increasing water demand. Also, the use of a particular reservoir for long periods will require that attention is paid to the maintenance of the reservoir to prevent it from being an additional source of hazard to users.

Gutters were predominantly made from PVC, contrary to what was reported in a previous study in Mkpata community, Swaziland (Signwane and Kunene, 2010) where they were mainly metal. Gutters have also been constructed from bamboos sticks and wood (Smet, 2005). The use of first flush diverters, leaf control devices on reservoirs and leaf control screen on gutters by less than 30% of households is lower than what was reported in South Australia, where it was found to be in use in 30.8%, 57.2 and 25.5%, of households, respectively (Rodrigo et al., 2010). Research has shown that the initial 'first flush' of runoff is more polluted than subsequent flows and that the concentration of contaminants associated with a given rainfall event tends to reduce exponentially with time. Therefore, diverting the initial portion of runoff generated by a storm away from the storage device will mean that the quality of water entering storage is improved and the need for subsequent treatment reduced or even eliminated altogether (Singwane and Kunene, 2010). The absence of gutter screens and first flush systems in the study area, implies that first rains are not diverted and go on to contaminate reservoir water. It is important that health educators ensure that households understand the use and see the need to incorporate these devices during construction of RWH systems in their homes.

The finding that the tanks were usually cleaned, though at differing timings, has been observed in other studies (Ariyananda and Aheeyer, 2011; Rodigo et al., 2010). The low frequency with which water collection tanks were washed in this study is similar to what was found in South Australia (Rodrigo et al., 2010). It is recommended that the reservoir be cleaned annually (Coombes and Abott, 2010).

Harvested rain water was used for drinking by about 76% of households, similar to what was reported in a previous study carried out in Sri Lanka (Lanka Rain Water Harvesting Forum, 2010). This figure is a far cry from the value of 30% observed in a study carried out in Ethiopia (Devi et al., 2012) and 42% in selected communities in Esan land (Magnus, 2011). Slightly above half of all households surveyed claimed to treat the drinking water, which is slightly higher than what was reported in some communities in Bangladesh (Rana, 2009) and West Bengal (Kuntala et al., 2011). Most common method for purification was use of water guard. Made of chlorine compounds, water guard is easily obtained from the local chemist, can be applied with no adverse health effects and when compared to boiling of water, more cost effective. Boiling was the more common method for water treatment in a study carried out in 9 provinces in Sri Lanka (Ariyananda and Aheeyer, 2011). On the contrary, a study carried out in three villages in Paikgacha Thana, Khulna in Bangladesh found as much as 66% of households drinking water from RWH systems without any form of treatment (Rana 2005). It is most imperative to treat rain water from tanks particularly in a developing country like Nigeria, where pollutants in atmospheric air readily contaminate rain water.

Personal hygiene was the most common use of harvested rain water among households studied. This is similar to what was observed in Kaduna, in the northern part of the country (Lekwot et al., 2012). During dry seasons, some families supplemented harvested water with water from stream, contrary to what was reported in Kaduna (Lekwot et al., 2012), where the hand dug well was more popular. Rain water harvesting in the study site was found to be the main source of water for household use during rainy season, with some turning to alternative sources during dry season. This was similarly observed in Trinidad (Dean et al., 2012). The latter study also found respondents satisfied with quality of harvested water, as was also observed in the present study where complaints of water having smell, taste or colour were minimal. The finding of better managed RWH systems among female headed households and singles is not surprising, as women are generally more interested in the health and safety of their families, and pay closer attention to matters of sanitation and hygiene. The better practice among Christians may be as a result of their being more in a monogamous relationship, with closer family ties and attention to health of family members.

Most respondents reported that there had never been any inspection of their RWH system. This situation is unfortunate, as government health departments are meant to be fore-runners in the protection of health and drinking water quality through inspection and supervision of constructed domestic RWH systems. Similar reports have been documented in Uganda , where about 61.5% of households had not been visited by health or project officers from non-profit health education programmes since installation of water storage system (Baguma et al., 2010). Very few households had ever checked their water for chemical or microbiological contamination. Individuals could also be encouraged to subject collected rain water to laboratory investigation.

Microbiological indicators have been used to determine or indicate the safety of water for drinking. Coliforms are considered the primary indicators of faecal contamination. Their presence in drinking water indicates that disease causing organisms could be in the water system and may pose an immediate health risk (Raina et al., 1999; Tebutt, 2007).

Total coliform content of water from most of the reservoirs in this study was far higher than what is recommended by the WHO and similar to what has been reported in some studies (Agbabiaka and Sule, 2010; Okorafor et al., 2012; Ibe and Okpienye, 2005). Likely sources of total coliforms will be from faecal matter of birds, rodents, dead insects either deposited on the roofs, gutters or where tank lid is not sealed tightly, or even from the tank itself. The low proportion of samples with *E. coli* which indicates that most of the water samples are free from recent faecal contamination, was similarly found in a study conducted in some communities within the vicinity of the study area (Magnus, 2011) and contrary to what was found in Ogun state (Aina et al., 2012). The finding of high coliform counts with no *E. coli* present is also reported in a study carried out in New Zealand (Abbott et al., 2007).

Conclusion

The study shows gaps in the implementation of RWH in this community, a factor that can increase pollution of water and spread disease. Aggressive health education is required to give the necessary enlightenment to the standard design for a RWH system, and motivate the people to comply. Advocacy to local leaders may help in this regard. Government should play an active role in addressing the gaps observed in the installation of RWH systems to prevent disease outbreaks.

ACKNOWLEDGMENT

The authors wish to acknowledge the effort of the data collectors. Their gratitude also goes to the community leaders and member of the community for their participation.

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