

ASSESSMENT OF KNOWLEDGE AND USE OF RAINWATER HARVESTING IN A RURAL COMMUNITY OF EDO STATE

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ABSTRACT

In areas of low rainfall or high altitude, rain water harvesting (RWH) becomes an important source of water supply for domestic use. The study assessed the practice of rain water harvesting in a rural community in Edo state Nigeria. Using a cross sectional study design , a pre-tested structured interviewer administered questionnaire was administered to selected households. A structured observational checklist was used for assessment of quality of rainwater harvesting system.

Data was analysed using SPSS version 20, results were presented as frequencies, with statistical test applied where appropriate. Ethical clearance was obtained from the Ethical review board of the Irrua Specialist Teaching Hospital, Irrua.

Findings show 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 purposed. RWH practice was found to be unsatisfactory in the majority of households. Health education should focus on informing households on appropriate design and maintenance of RWH systems.

INTRODUCTION

1.1 BACKGROUND

Water is essential to man, animals and plants; without water, life on earth would not exist. An adequate supply of safe water is a prerequisite for the socio-economic development of a community. Good drinking water quality is also essential to the health and well-being of all people. Acceptable water quality occurs when there are no bacteria of faecal origin present that may cause human diarrhoea and other life-threatening diseases (e.g. typhoid fever), there is no levels of chemicals (e.g. heavy metals) or chemical substances that would cause harm to human health, and water does not have a bad taste or smell [1].

Rain water is a form of precipitation in which liquid water falls to the earth's surface. It forms a major part of the hydrologic cycle in which water from the oceans evaporates, condenses into clouds and precipitates back to the earth and eventually returns to the ocean via streams and rivers, to repeat the cycle again. [2,3]. Rainwater can be harvesting using roof and other above ground catchments and stored in tanks for use.

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 [4-6]. The concept of RWH is both simple and ancient, and systems can vary from small and basic, such as the attachment of a water butt to a rainwater downspout, to large and complex, such as those that collect water from many hectares and serve large numbers of people [7].

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).

In rural areas, the most common technique is small-scale rooftop rainwater harvesting [8]. The quality of rainwater is directly related to the cleanliness of catchment gutters and storage tanks. In certain areas, roof rainwater is usually of good quality and does not require treatment before consumption. Rooftop catchment of rainwater can provide good quality water, clean enough for drinking, as long as the rooftop is clean, impervious, and made from non toxic materials.[9]. In other areas, rooftop catchment surfaces collect dust, organic matter leaves and bird droppings, which can contaminate the stored water and cause sediment build up in the tank.

Sometimes, materials or coatings of the storage tank may cause adverse taste or odour, and some metals can dissolve to give high concentrations in water [10]. 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 tend 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 [9,10]. Where automatic diverters to prevent the first 20-25 liters of runoff from being collected in the storage are not available, detachable down-pipe can be used manually.

Storages need to be protected with covers to discourage mosquito breeding and algal growth. Cracks in the wall and withdrawal of water using contaminated pots can contaminate stored water. Mechanisms such as taps or outlet pipes that enable hygienic abstraction of water are preferred. Cartridge filters or other treatment at the point of consumption may be installed to ensure better quality of drinking water and reduce health risks [10]

Household rainfall catchment systems are appropriate in areas with an average rainfall greater than 200mm per year, and no other accessible water sources. Rainwater harvesting in urban areas can provide supplemental water for the city's requirements, to increase soil moisture levels for

urban greenery, to increase the ground water table through artificial recharge, to mitigate urban flooding and to improve the quality of groundwater. [11,12]. In urban areas of the developed world, at a household level, harvested rainwater can be used for flushing toilets and washing laundry. Indeed in hard water areas it is superior to mains water for this. It can also be used for showering or bathing. It may require treatment prior to use for drinking. As rainwater may be contaminated, it is often not considered suitable for drinking without treatment [1,12].

1.2 STATEMENT OF THE PROBLEM

One reason safe drinking water is of paramount concern is that 75% of all diseases in developing countries arise from polluted drinking water [13.] Each day some 25,000 people are said to die from their every day use of contaminated water. Millions more suffer from frequent and devastating water borne illnesses. [14] . 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. The provision of water for domestic and other uses in rural and urban centers is one of the most intractable problems in Nigeria today [15] and .fifty two percent (52%) of Nigerians have no access to improved drinking water supply [16].

As much as one-tenth of the global disease burden could be prevented by improving water supply, sanitation, hygiene and management of water resources. Such improvements reduce child mortality and improve health and nutritional status in a sustainable way [17] The absence of public water system in the rural areas and the inability of water facilities to function effectively in the towns and cities of Nigeria have made it impossible for most of her population to have access to portable water [15].

Water scarcity in many countries places considerable strain on communities which rely directly on rainfall to sustain their livelihoods. Irregularity in timing and distribution of rainfall may leave many communities without access to water for even the most basic daily requirements. Projected changes in climate in the future may result in even greater irregularities in the availability of water for daily use. [18].

Nigeria is endowed with enormous surface and groundwater resources, yet the provision of potable and safe water supply is still inadequate.[19] 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.[19]

Apart from air, and dietary intake, drinking water plays an important role in the bodily intake of trace elements. The concern that trace elements in drinking water presents potential health hazard if they are present in higher than recommended concentrations prompted several regulatory bodies like WHO, to establish maximum allowable concentrations for these elements in drinking water supplies [20,21]. Despite the seeming intractable problem of water scarcity in Nigeria , the high neonatal and childhood mortality of which diarrheal disease

accounts for as much as 28%, and the common practice of RWH, particularly in Edo state, there is little attention paid to the assessment of the state of RWH systems.

LITERATURE REVIEW

The increasing demand of growing populations on water, coupled with expanding industrialization and lack of political commitment by government in the provision of urban water supply works has left many urban centres facing water supply shortages. The implementation of rainwater harvesting on domestic allotments has emerged as a viable solution to these supply crises, with potential to decrease demand on municipal supplies, mitigate storm water discharge and reduce infrastructure costs for new housing developments .

2.1 BRIEF HISTORY OF RWH

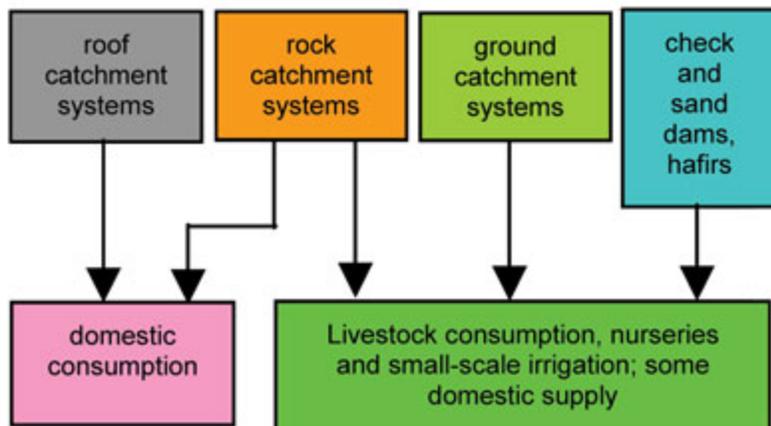
Rainwater collection is one of the oldest means of collecting water for domestic purposes. In India, simple stone-rubble structures for impounding rainwater date back to the third millennium BC [22]. It was also a common technique throughout the Mediterranean and Middle East. Water collected from roofs and other hard surfaces was stored in underground reservoirs (cisterns) with masonry domes. In Western Europe, the Americas and Australia, rainwater was often the primary water source for drinking water. In all three continents it continues to be an important water source for isolated homesteads and farms [23].

Rainwater harvesting is practiced worldwide. It is estimated that approximately 40% of households in South Australia use rainwater to supplement the supply of drinking water, as is done in several regions such as South-East Asia. In Malaysia, for example, rainwater is also used for commercial purposes including car washing via the placement of plastic collection tanks in places like parking lots [21,23]. Indeed interest in rainwater harvesting grew rapidly over the last two decades. It is of particular importance and relevance for arid and semi-arid lands, small coral and volcanic islands, and remote and scattered human settlements. The increased interest has been facilitated by a number of external factors, including:

1. the shift towards more community-based approaches and technologies which emphasize participation, ownership and sustainability;
2. the increased use of small-scale water supply for productive and economic purposes (livelihoods approach);
3. the decrease in the quality and quantity of ground- and surface water;
4. the inability of governments particularly in developing countries to provide sustainable pipe borne water supplies
5. the flexibility and adaptability of rainwater harvesting technology;
6. the replacement of traditional roofing (thatch) with impervious materials (e.g. tiles and corrugated iron);

7. the increased availability of low-cost tanks (e.g. made of ferro-cement or plastics) [23].

Rainwater harvesting can be categorized according to the type of catchment surface used, and by implication the scale of activity (Fig 1)



2.2 PRACTICE OF RWH

Rain water provides adequate sources of water for rural communities especially in rainy seasons. A study conducted of rain water harvesting activities in Matara and Badulla district, Sri Lanka, reported that households used rain water for 65% of their water demand and only 33% fetched from other water sources. As a result there was a reduction in more than 50% water collected from dug wells. In another region of Sri Lanka, Dematawelihinna, less than 10% of the rain water users used it for drinking purposes. Most reason for not drinking rain water was found to be the perception of water quality. Lacks first flush or filters in these system thought to be contributing to low confidence in water quality [24]. A study conducted in Badulla district Sri Lanka revealed that rain water harvesting increased the water consumption and water security in the household as much as 80% during the wet season [25]. A study conducted in 2005 in Inginitiya in Kurunegala district recorded that majority (95%) of the households used water from the rain water tank for drinking, while 91% used it also for cooking [26]. Another survey conducted in the Southern Province on tsunami resettlement areas in Sri Lanka, showed that more than 80% of the households use the rain water for drinking purposes [27].

2.3 QUALITY OF WATER FROM RWH

Rainwater is relatively free from impurities except those picked up by rain from the atmosphere, but the quality of rainwater may deteriorate during harvesting, storage and household use. Wind-blown dirt, leaves, faecal droppings from birds and animals, insects and contaminated litter on the catchment areas can be sources of contamination of rainwater, leading

to health risks from the consumption of contaminated water from storage tanks. Poor hygiene in storing water in and abstracting water from tanks or at the point of use can also represent a health concern and should be minimized by good design and practice. Well designed rainwater harvesting systems with clean catchments and storage tanks supported by good hygiene at point of use can offer drinking-water with very low health risk, whereas a poorly designed and managed system can pose high health risks. Microbial contamination of collected rainwater indicated by *E. coli* (or, alternatively, thermotolerant coliforms) is quite common, particularly in samples collected shortly after rainfall. Pathogens such as *Cryptosporidium*, *Giardia*, *Campylobacter*, *Vibrio*, *Salmonella*, *Shigella* and *Pseudomonas* have also been detected in rainwater. However, the occurrence of pathogens is generally lower in rainwater than in unprotected surface waters, and the presence of non-bacterial pathogens, in particular, can be minimized. Higher microbial concentrations are generally found in the first flush of rainwater, and the level of contamination reduces as the rain continues. Storage tanks can present breeding sites for mosquitoes, including species that transmit dengue virus [23,24].

METHODOLOGY

2.1 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. Located between Latitude 6° 45'N and Longitude 6° 08'E, the area has Mean annual rainfall of 1500mm and mean temperature range of 27°C to 35°C . The community is made up of 10 quarters or hamlets. Inhabitants are mainly Esan in origin, predominantly peasant farmers and petty traders. Geographically, the community is upland, with soil mainly laterite, but fertile for farming.

2.2 STUDY DESIGN

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

2.3 STUDY POPULATION

Study population comprised households within the community. Household head or any adult within the household aged over 18 years and who meet the inclusion criteria were invited to participate. Inclusion criteria is : 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. Consenting . Exclusion criteria is household with no adult present at the time of the study, non-consenting.

2.4 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 [28], non-response rate of 10%. Sample size was calculated as 232.

2.5 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.

2.6 RESEARCH ASSISTANTS

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.

2.7 DATA COLLECTION METHOD

Data was collected using quantitative data collection tools: a survey questionnaire, checklist and bacteriological assessment of water quality.

- The survey questionnaire focused on demographic characteristics of the respondents, practice of RWH, knowledge of water related disease and perceptions of water quality.
- The checklist provided a tool for assessing the state of the reservoir.
- Assessment of physical and bacteriological quality of water provided an objective assessment of the physical quality of the water , bacterial type and load. For Water quality assessment , water samples will be collected from 15% of survey households, selected through random sampling. For all reservoirs, water sampling was done using guidelines of the World Health Organization for the quality of drinking water in a sterile container provided by the Public health laboratory of the Edo state Ministry of Health, Benin. Every bottle were marked with an identification number corresponding to the questionnaire number and submitted for analysis within 4 hours of collection. The Microbiological quality of the water was assessed quantitatively through the enumeration of colony forming units (CFU) of *Escherichia Coli*, which was used as an indictor for faecal contamination [9,12].. Samples with 0 coliforms /100mls will be graded as excellent, 1-10 coliforms /100mls acceptable, and 10 coliforms/100mls as polluted.

2.8 PRETESTING OF THE DATA COLLECTON TOOL

The survey questionnaires was pretested amongst 20 households in a neighboring community for validity.

2.9 DATA ANALYSIS

The completed questionnaires were screened for completeness, coded and entered by the researcher into the Statistical package for scientific solutions (SPSS) version 17.0 software for analysis. Discrete data were presented as proportions (percentages) while continuous variables such as age were expressed as means \pm standard deviation. Where continuous data was skewed, median values were stated as well. Statistical analysis of difference 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.

2.10 ETHICAL CONSIDERATION

Ethical clearance to conduct this research was obtained from the Irrua Specialist Teaching Hospital Ethics Committee. Permission to conduct this study was sought from the Traditional ruler and Council of chiefs in the Local Government Area. Informed consent was obtained from each respondent before the conduct of interviews after adequate information must have been given to the respondents by the interviewers. Confidentiality and privacy was respected during the course of interview. To ensure confidentiality, households were identified by alphabets, and for respondent's, serial numbers were used rather than name. Respondents were informed that there was no penalties or loss of benefit for refusal to participate in the study or withdrawal from it. There will be no risk of harm or injury to the participants during or after the study is conducted. All data were kept secure and made available only to the researcher. At the end of the study, the researcher, in collaboration with the Public Health department of the Irrua Specialist Teaching Hospital, gave health talks to participating families.

RESULTS

The result is presented under the following sub-headings:

- Socio-demographic characteristics
- Assessment of RWH practice
- Knowledge of water borne disease
- Perceptions of water quality
- On-the-spot assessment of RWH system

DISCUSSION AND CONCLUSION

The study was carried out to assess the practice of RWH in a rural community in Edo state. The large number of households who tap and store rain water for use has been reported not only in the country, but in other parts of the world, especially where rain fall is limited, and ground water is deep below the surface.

The study showed that rain water was harvested primarily from rooftops. In Brazil, Argentina and Paraguay, RWH is done using surface water collected into cisterns or surface ponds. For quality reasons rainwater for human consumption is preferably collected from roofs. The use of runoff from non-roof top s, often described as the livelihood approach, promotes the use of runoff water for productive purposes, such as small scale irrigation for domestic food production, watering small stock, watering tree nurseries, brick-making etc. For these purposes, the quality of runoff water harvested from other surfaces, such as a slope, does not create a problem. The runoff is stored in ponds or small underground storage tanks [23].

Rain water is considered the purest form of water, except where environmental pollutants reduce water quality. 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, subject to rust, and the overhanging vegetation observed in over one-third of houses, has the disadvantage that pollution of water from dead leave and bird droppings can make the water unsafe for drinking in it's untreated state.

The greater proportion of reservoirs that were built with cement and partly submerged in the ground was noted in the study site. 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. [29] Another benefit of surface tanks over sun-surface ones, which are partly or completely underground, is that water can be easily extracted through a tap just above the tank's base [5].

The common practice of washing gutters and reservoirs yearly, was also documented in a study carried out in South Australia [30], and which is in contrast to the three to four monthly interval recommended [31] . Rainwater users can reduce their risks of disease from contaminated rainwater consumption by regular maintenance. [31]

The average length of time reservoirs had been in use was similar to what was reported in South Australia [30]. 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 metal, as was reported in a previous study in Mkpata community, Swaziland [32]. Gutters are generally made of metal or plastic, and have also been constructed from bamboos sticks and wood [23].

The use of first flush diverters , leaf control devices on reservoirs and leaf control screen on gutters by less than 20% of households is lower than what was reported in South Australia, where it was found to be 30.8% households, 57.2%, and 25.5% respectively [30]. 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 tend 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.[31,32] 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. Studies have often shown deficiencies in the use of rainwater catchment systems and components cited include: lack of maintenance; inadequate disinfection of the water; poorly designed delivery systems and storage tanks; and, failure to adopt physical measures to safeguard the water against microbiological contamination [31]. 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.

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 [27]. This figure is a far cry from the value of 30% observed in a study carried out in Ethiopia [12]. Slightly above half of all households surveyed claimed to treat the drinking water , most commonly with water guard. Made of chlorine compounds, water guard is easily obtained from 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 [33].

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 [34]. While it is most imperative to treat rain water from tanks particularly in a developing country like Nigeria, where pollutant in atmospheric air readily contaminate rain water, it is also important to note that the quality of rainwater is ensured by a natural treatment chain in the tank. This system reduces the presence of bacterial and metal contaminants. Bacteria, organics and chemicals form flocs that become biofilms on surfaces or settle to the bottom of the tanks to form sludge. The processes of flocculation, settlement and biofilms in tanks act to improve the quality of rainwater. [31]

Personal hygiene was the most common use of harvested rain water among households studies. This is similar to what was observed in Kaduna, in the northern part of the country [15]., During dry seasons, some families supplemented harvested water with

water from stream, contrary to what was reported in Kaduna [15], 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, [35]. 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 color were minimal.

The poor knowledge of water borne disease noted among respondents in the present study is worrisome, as should stir up active campaigns by health workers. Little wonder that diarrheal disease may be ascribed to other causes such as eating sweet items, instead of polluted water.

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 the Christians to be 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 had not been visited by health or project officers from non-profit health education programmes since installation of water storage system [36]. 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.

The low microbial content of the water observed may be due to the fact that the study was done during the rainy season, so much of the dirt may have been washed off with the first rains.

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 instruction as 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.

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