Low Cost Rainwater Harvesting: An Alternate Solution to Salinity Affected Coastal Region of Bangladesh

CCTC 2013 Paper Number #1569705485

Islam. K. Z. 1, Islam. M. S. 2, Lacoursière J. O. 3 and Dessborn L. 3

1 Jessore PBS-2, Bangladesh Rural Electrification Board, Bangladesh
2 North South University, Dhaka, Bangladesh
3 Kristianstad University, Kristianstad, Sweden

Abstract

This study investigated the prospect of rainwater harvesting as low cost alternate freshwater supply along the coastal region of Bangladesh, which is considered one of the most affected countries in the world due to climate change and resulting sea level rise. Data were collected on the present state of freshwater supply, sources and quality, average rainfall in the region, dry spell period during dry season, family size, water use nature, rain water quality, etc. A most suitable and economic size and material to use was proposed then. Finally, a questionnaire survey was conducted about the acceptability of rainwater for drinking purposes.

Keywords: Bangladesh, Coastal region, Climate change impact, Fresh water crisis, Rainwater harvesting, Design of storage tank, Cost analysis, Management options.

Resume

Cette étude a porté sur la possibilité de récolter l'eau de pluie comme solution d'alimentation en eau douce à faible coût le long de la région côtière du Bangladesh, considéré dans le monde comme étant le pays plus touché par les changements climatiques et l'élévation du niveau de la mer qui en résulte. Des données ont été collectées sur l'état actuel de l'alimentation en eau douce, les sources et la qualité de l'eau, la pluviométrie moyenne dans la région, la période de sécheresse durant la saison sèche, la taille de la famille, le type d'utilisation de l'eau, la qualité de l'eau de pluie, etc. Une proposition a ensuite été faite sur le matériel à utiliser le plus approprié et économique. Enfin, une enquête par questionnaire a été menée sur l'acceptabilité de l'eau de pluie comme eau potable.

Mots-clés : Bangladesh, région côtière, impact des changements climatiques, crise de l'eau douce, récolte de l'eau de pluie, conception d'un réservoir de stockage, analyse de coût, options de gestion

1. Introduction

Bangladesh is a tropical country located between 20° 34’ and 26°38’ N latitude and 88° 01’ to 92°41’ E longitudes. This country experiences a heavy rainfall during monsoon, generally between 1,500 and 3,500 mm. The Satkhira district averages nearly 2,200 mm rainfall per year.
Monsoon usually covers from May to October and occasional rainfall in November. During this period, it gets abundant rainwater, which could reduce the dependency on groundwater at least for 6 months. It is revealed from the literature that about 15% of the total supply can be met by harvested rainwater. Satkhira district has around 3858 km² of land with a roof area of 0.56 km² as there are around 5,000 concrete houses [4]. Institute of Water Modeling (IWM) recently estimated that with the current amount of rainfall, around 149,160 million liters of water can be harvested during monsoon. Urban and rural water supply in Bangladesh is mainly based on groundwater, which is free from pathogenic microorganisms and available in adequate quantity in shallow aquifers. But, for a densely populated area like Satkhira district, where the population density and shrimp cultivation are increasing rapidly, it is not feasible to use the groundwater for long term because the groundwater table continues to deplete. Therefore, there is an urgent require to supplement the groundwater. The micro components of drinking, cooking and dishwashing of domestic water demands using pure water are very significant from health perspective for a family. In the countries where the rainwater is available, these water demand components could be satisfied partly or fully if the rainwater is collected and stored properly near a household.

According to the ADB report 2011, Salinity level has been increasing in the last several years in the Khulna, Bagerhat and Satkhira district. Prolonged dry weather and rising sea levels are expected to increase saline levels even more. Moreover, salinity originally started after the Farakka barrage operation in India in 1975, which reduces the flow of Gorai river. This river is a distributary’s of Ganges river and a major source of freshwater in this division. The present drinking water source is mainly from groundwater drawn from deep and shallow tube wells. A large area of Satkhira and Jessore districts currently suffer from recurring and worsening water logging that can be exacerbated by increased rainfall and rising sea levels caused by climate change.

![Figure 1: Annual Rainfall in Bangladesh](image)
The search for a new water resource is an essential for that division. Rainwater is the only source, which is easy to collect individually and with a minimum cost. The only thing needed is the roof of the house to harvest water and a container to store it. In southwest part of Bangladesh where arsenic water contamination, water table depletion, salinity increase and drinking water collection problem, people have to find alternative sources of water. One potential solution is the use of rainwater to reduce the shortage of water for safe drinking, cooking and dishwashing purposes [7]. The main objective of the study is to develop a sustainable rainwater harvesting system in rural areas of Bangladesh and to assess its feasibility and acceptability to the rural people, especially to rural areas of Satkhira district.

In the present context, rainwater harvesting is seriously considered as an alternative option for sustainable water supply in Bangladesh. Although the establishment cost of this method is burdensome for low income group, rooftops in rural or urban houses can be designed to collect rainwater solving the challenging issues of minimizing the storage cost, management and allocation the water use by water quality. In the case of rainwater harvesting system building, at first stage of construction, investments in money, time, and design are minimal for adopting rooftop rainwater harvesting [11].

2. Materials and Methods

2.1 Description of the Study area:

The study site has been selected to represent climatic conditions where atmospheric water could be considered to secure safe drinking water for southwest part of Bangladesh. Patkelghata in Satkhira district was selected for its flat landscape marked by a little climatic fluctuation in climatic by the incidence of rain throughout the year.

Figure 2: Location of study site, Satkhira district, Bangladesh [14].
2.2 Water collection from municipality:

Comprised between 21°50' to 22°50' of latitude north and 89° to 89°20'' of longitude east, Patkelghata is located in the Satkhira district on the southwest part of Bangladesh, at 6 meter (20 feet) above the sea level. The territory extends over an area of 344km$^2$ covered mainly by plains.

The water supply of the local population is made from surface water, underground water and rain water during monsoon. A small proportion of villagers are connected to modern facilities of water supply such as municipal water supply. The Satkhira municipality has deep tubewell and one overhead tank. The pipe network distribution system is situated around the town. People outside of the town collect drinking water from Satkhira town. The distance of Satkhira municipality is 14 kilometer. Recently, a non government organization has installed deep tube well in Patkelghata and made a local water supply network. This piped water supply system could supply only one kilometer radius from its pump house. So, the majority of people have to fetch water from district municipal water supply system.

2.3 Climatic and Meteorological Data Analysis

The climate of Bangladesh is characterized with high temperature, heavy rainfall, excessive humidity and seasonal variation. In rainy season, rainfall occurs due to north-easterly winds and annual rainfall varies from 1500 to 2800 mm i.e. 1.5 to 2.8 m$^3$ of rainwater was available per square meter of catchment area each year for development of rainwater based water supply system [7]. Monthly average precipitations in Satkhira show distinct seasonal variations with maximum in July (ca. 375mm). This district experiences regular rainfall all year round, the locality of Patkelghata has highly variable rainfall and a distinct short dry season from December to March.

![Monthly average Rainfall](image)

Figure 3: Monthly average rainfall in Satkhira district [5].

2.4 Dimensioning of Rainwater Collection Systems

The volume of rainwater was estimated by the system assessed through the Rational Equation and the dimensioning the required storage set in accordance to the method of Ahmed and Rahman [2].

2.5 Potential rainwater harvesting flow rate:
EIC Climate Change Technology Conference 2013

The potential for rooftops (catchment) to collect rainwater is dependent on the area of the interception surface, the intensity of the rain and the nature of the catchment material.

For this study, a family consisting of five members having water demand of 5 l/capita/day for 3 months (for only drinking and cooking purpose) was considered. The available rainwater was estimated by the equation [2].

\[ Y = \frac{(f \times A \times R)}{1,000} \text{ m}^3 \]  

Where \( Y \) is the amount of water yielded per month,
\( f \) is the catchment’s efficiency or coefficient of available runoff,
\( R \) is monthly rainfall (mm) and \( A \) is the catchment area in square meters.

The available rainwater was estimated by the equation [2].

\[ A = \frac{0.365 (q N)}{(f I)} \]  

About 25% of the rainwater should be presumed to be lost by evaporation and for washing the catchment area using first rain that produces inferior quality rainwater.

The Eq. (ii) can be written for an average annual rainfall of 2.46 m/year, and a coefficient of runoff of 0.70 in the following form [2]:

\[ A = 0.212 q N \]  

2.6 Catchment area calculation

There are different types of roofs found in southwest coastal region in Bangladesh. The rural people are poor and unable to make extra catchment for rainwater harvesting. Therefore the traditional roof made by tiles, CI sheets or tin, concrete or straw have to be used as roof catchment. Different types of roof orientation in the rural area were considered for rainwater collection catchment area. Concrete roof is plain and parallel to ground surface. Tile, tin and straw made roofs look like triangles.

Concrete roof area is calculated by multiplying width and length. CI sheet or tin and tiles made roofs different than concrete roof. This type of roof area is calculated in a different way.

Catchment area, \( A = L \times W \)  

(L=length and W= width)
2.7 Rainwater collection procedure

Rainwater has no bacterial content. The quality of rainwater prior to interception is more dependable than that of other water resources. There are four types of roof structures available in that area. Samples are collected from normally found rural household roof made of corrugated sheet (tin), roof tiles, reinforced cement concrete and paddy straw. The samples were collected from the middle of June to the end of August, 2011.

Normally the samples were collected after 20 to 30 minutes of heavy rainfall. The physical and chemical tests were conducted for color, total dissolved solids, lead, turbidity, hardness, acidity, pH, nitrate, fluoride. The chemical analysis was performed according to the standard methods for the examination of water and wastewater. On the other hand, microbiological tests were conducted for total coliform (TC) and fecal coliform (FC). Each rainwater sample was tested. The samples were tested at BADC water testing laboratory.

2.8 Questionnaire survey

A structured questionnaire was developed to understand the people’s knowledge, view and opinion for the rainwater use in daily life. The questionnaire was developed by discussion with rural people. The questionnaire surveys were conducted with various groups of inhabitants of that area. The groups consisted of students, farmers, religious leaders (Imams), teachers and housewives. The survey was conducted among the students and teachers of Haruner Rashid College, Patkelghata, Tala upazilla, religious leaders were different parts of the district. Farmers and housewives were from Patkelghata area of Satkhira district.

3. RESULTS

3.1 Proposed low cost rain water harvesting system

Based on rural housing of the southwest region, a rain water harvesting system in rural area consists of Roof catchment, Gutters, down pipes, First flush devices, Filter chamber and Storage tank.
Figure 6: Proposed design and typical rural rooftop rainwater harvesting diagram.

Cost assessment of rainwater collection system:
Table 1: Estimation of rainwater collection system

<table>
<thead>
<tr>
<th>Structural material</th>
<th>Unit price($)</th>
<th>Total price($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gutters 10 m</td>
<td>0.31</td>
<td>3.1</td>
</tr>
<tr>
<td>Pipe (2 inch φ) 16 feet</td>
<td>0.5</td>
<td>8</td>
</tr>
<tr>
<td>Pipe (3/4 inch φ) 1 feet</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Cup (Holler type) 1 piece</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>T socket 1</td>
<td>0.63</td>
<td>0.63</td>
</tr>
<tr>
<td>Tap 1</td>
<td>0.82</td>
<td>0.82</td>
</tr>
<tr>
<td>Lock 1</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td>Great ball (2 inch ) 2</td>
<td>5.63</td>
<td>11.25</td>
</tr>
<tr>
<td>L Ibo 2</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Brick(9.5&quot;×4.5&quot;×2.5&quot;) 50</td>
<td>0.06</td>
<td>3.13</td>
</tr>
<tr>
<td>Tank (1000 liter) 2</td>
<td>97.5</td>
<td>195</td>
</tr>
<tr>
<td>Labor</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Annual maintenance</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>260.87</strong></td>
<td></td>
</tr>
</tbody>
</table>

By keeping in mind that this research aims to promote an inexpensive and easy way to get fresh water to meet the needs of rural population, the entire system has to deal with first of all the financial aspect of each household and secondly to promote the use of local material in the concept. After all the calculations, a total amount of $261 would be necessary for building and operating whole system. The table presents the list, unit price and total price of all materials that would be required.

3.2 Storage tank capacity:
According to equation (iii) the minimum catchment’s area, A required for collection rainwater for a rural household is 6 m$^2$. The annual water requirement of a rural family (six members) in the south west region of Bangladesh is 11 m$^3$. The annual yield of rainfall is calculated 8.26 m$^3$ by the minimum catchment area 6.09 m$^2$ and estimated to be enough to fulfill the required demand of water. Usually rainfall occurs during 45 days in Bangladesh. For storage calculation minimum duration between rainfalls is taken 60 days. So, sixty days demand is 2000 liter and it is suggestion to build storage tank = 2000 liter capacity.

![Figure 7: Storage tank size for various rural families](image)

### 3.4 Questionnaire survey findings
The questionnaire survey results that were very important for this study are described below step by step.

#### 3.5 Roof materials:
Different types of roofing materials are used in rural areas in Bangladesh. These include cement concrete, tiles, CI/ metal sheet, straw with or without polythene covering. About 47 percent households in rural area have Tin (Corrugated iron on metal sheet). On the other hand, concrete and tiles have the same percentage (24%). These roofing materials are suitable for rainwater catchments. Few people use straw as the roofing materials. However, this can be used with some modification such as polythene covering for straw.

#### 3.6 Roof Area (m$^2$):
There is no data available on the average roof size in rural areas in Bangladesh. In the field survey, it was found that about around 58 percent of household’s roof are within 25 to 50 square meters. About 22 percent of roofs are within 9.5 to 25 square meters. On the other hand, about 11 and 9 percent roof size is within 50 to 100 square meters and above 100 square meters. The minimum catchment area was estimated 6.09 m$^2$ to be enough to fulfill the required demand of water.

#### 3.7 Household size in rural area of Bangladesh:
Household size is one of the important parameter in designing a rainwater harvesting system. It is related to the total water demand, catchment area and storage volume. About 64 percent families have 4 to 5 persons and 89 percent families have 3 to 7 persons. The average household size is taken as 6 for the calculation of design storage capacity.
3.8 Drinking water sources:
Tube well is very popular drinking water source all over in Bangladesh. In the survey, twenty one households were collecting water from a tube well. Similarly twenty four households collect water from a municipal water supply. Deep tube well is used to collect water for municipal water supply. Open well and pond water is not popular for drinking purpose due to contamination.
A question was used to investigate the distance from home to water sources. According to the survey, about 18 percent people collect pure drinking water from 10-15km and same percentage from 500m, 16 percent people collect pure water from 1-5km. Similarly only 17 percent people collect water from their own shallow tube-well.
A question was set to know the reason for collecting water from long distances. They have water around them but the water is polluted by arsenic and has high iron and hardness. The smell of tube-well water is not good and there is not any pure water supply system. Out of 45 people’s opinion, 19 persons indicated arsenic and 22 persons find water contain high levels of salt. Many people have stomach pains and are aware about arsenic contamination and water hardness. For that reason, they collect water from long distances.
In this survey, about 85 percent of people are harvesting rainwater at the time of monsoon. Similarly, approximately 82 percent of people drink rainwater and about 96 percent use rainwater for cooking. All people in this survey agreed that rainwater is safe for drinking. Almost all students and teachers agreed to the question that quality and supply can be improved by harvesting rainwater after 15 minutes. On the other hand 9 farmers have no proper idea about rainwater quality and one farmer want to boil for quality improvement.
Nearly all people in this region use rainwater for cooking purpose in the rainy season. Though they have water around them but they have to collect pure water from long distance. Rural people know that rainwater is safe for drinking and cooking. However, they cannot use rainwater properly due to lack of rainwater harvesting technology and implementation. Local government such as Union Parishad and Upazilla Parishad and local NGOs can implement rainwater harvesting system at household level. Many government departments such as Department of Agriculture Extension, Public Health Engineering Department and Local Government Engineering Department could be engaged for RWH system implement and support. Moreover, all attendants have same opinion about raising awareness to implement rainwater harvesting system. Political and religious leader can take part to increase awareness. Similarly, mass media should be most effective way to increase awareness.

3.9 Rain Water quality:
To obtain accurate, reliable and representative data, the water samples were collected after 15 minutes of rainfall. The tests were conducted for two times and the values of different parameters were compared with those of standard drinking water in Bangladesh.

<table>
<thead>
<tr>
<th>Name of Parameter</th>
<th>Unit</th>
<th>Bangladesh Standard limit</th>
<th>Open air</th>
<th>Tin</th>
<th>Tiles</th>
<th>Concrete</th>
<th>Straw</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>6.2</td>
<td>6.3</td>
<td>6.25</td>
<td>6.35</td>
<td>6.45</td>
</tr>
<tr>
<td>EC</td>
<td>μS/cm</td>
<td>600-1000</td>
<td>101.7</td>
<td>105</td>
<td>107</td>
<td>115</td>
<td>290</td>
</tr>
<tr>
<td>TDS</td>
<td>mg/L</td>
<td>1000</td>
<td>71.19</td>
<td>80</td>
<td>75</td>
<td>80</td>
<td>203</td>
</tr>
<tr>
<td>Iron</td>
<td>mg/L</td>
<td>0.6-1.0</td>
<td>0.2</td>
<td>0.5</td>
<td>0.2</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Ppb</td>
<td>50</td>
<td>&gt;10</td>
<td>&gt;10</td>
<td>&gt;10</td>
<td>&gt;10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/L</td>
<td>0.05</td>
<td>0.032</td>
<td>0.029</td>
<td>0.028</td>
<td>0.029</td>
<td>0.029</td>
</tr>
<tr>
<td>Color</td>
<td>TCU</td>
<td>15</td>
<td>10</td>
<td>12</td>
<td>12</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>10</td>
<td>0.80</td>
<td>0.82</td>
<td>0.80</td>
<td>0.82</td>
<td>0.83</td>
</tr>
</tbody>
</table>
4. DISCUSSIONS

Rainwater harvesting is a potential alternative water source at present all over the world. Zhu et. al. (2004) opined that rainwater harvesting has vast socio-economic importance in areas where all water sources are scares or polluted. Islam et. al. (2010) expressed that rainwater harvesting is ideal for Bangladesh due to plenty of rainfall during monsoon. Traditional collection system renders rainwater harvesting quite feasible at the household level. Disadvantages of rainwater harvesting include a significant space requirement for the storage tank and low mineral salt in rainwater. Mineral salt may be added to harvested rainwater to counter the problem of low mineral salt.

Satkhira is one of the densely populated districts of south west coastal region of Bangladesh. So, the space requirement for storing harvested rainwater constitutes a significant obstacle to implement the system. Rainwater harvesting is performed in several countries, but the quality indicators of rainwater vary from place to place due to environmental conditions (including potential pollution sources) and level of cleaning and maintenance during the collection and storage period. Of late, Government of Bangladesh has taken a decision in principle recently to furnish a new rule that each and every new building must have the rainwater storage system (The New Nation 2009) and this is a good indication to implement this alternative water source system effectively.

Different materials can be used as gutters and down pipes. The cost of G.I. pipes is very high comparing to other materials. PVC pipes are cheap and available in coastal region of Bangladesh. The PVC pipes are suitable for gutters and down pipes. A storage tank is the most expensive component of rainwater harvesting system. Storage tanks are constructed from different materials. Now plastic tanks are cheap and available all over Bangladesh. The costs include gutters, down pipes, tap, storage tanks and labor cost. By keeping in mind that this research aims to promote an inexpensive and easy way to get fresh water to meet the needs of rural population, the entire system has to deal with first of all the financial aspect of each household and secondly to promote the use of local material in the concept. After all the calculations, a total amount of $261 for 2000 liter capacity would be necessary for building and operating whole system. However, Dakua (2012) found that a rainwater harvesting system with 15000 liter capacity costing is $1620. Low cost rainwater harvesting system will be sustained in coastal areas.

The first test result for color for rainwater collected from straw made roof, 30 NTU, exceeded the acceptable limit. The color content level of rainwater in other roofs was found within the standard limit. Most people can detect colors above 15 true color units (TCU) in a glass of water. Levels of color below 15 TCU are usually acceptable to consumers, but acceptability may vary (WHO, 2008). High color could also indicate a high propensity to produce by-products from disinfection processes. No health-based guideline value is proposed for color in drinking-water.

The pH value is an important safe drinking water quality parameter. The standard pH values of rainwater vary approximately from 6.5 to 8.5. The values may differ due to the mixing of other chemical components from the air or roof catchment or from storage tank. Khemani et al. (1989) expressed that the pH values in Indian cities Agra and Delhi have been found to have decreased by 2.8 (9.1 to 6.3) and 0.9 (7.0 to 6.1) units, respectively after the period of two decades during which the old cities developed industrially to a great extent. The main cause for the decrease in the pH values was a significant increase of acidic components and decrease of soil-oriented components in the rainwater. Ariyananda (2005) stated that the pH values in the cement tanks decrease during the wet season and increase during the dry season. She
investigated the pH values of rainwater in different countries. She also recorded the mean pH value in urban area of Ethiopia was 8.2, 8.8 in Uganda and 9 in rural area of Sri Lanka. The pH values of collected rainwater were found 7.63 to 8.8 with a mean value of 8.35 (Sazakli et al. 2007). They had collected the rainwater into ferro-cement storage tanks. The rainwater was collected from the cement-paved hill slopes and it served as catchment areas. But some of the other studies reported that the pH values for rainwater varied from 4.17 to 6, which means the rainwater of those places is acidic (Mantovan et al. 1995; Chang et al. 2004). The pH values of the rainwater of this study were within the Bangladeshi standard and the values were from 6.2 to 6.45, which indicated that the collected rainwater was acidic. But the test results of this research were with in the acceptable range of Bangladeshi drinking water standard.

Iron is an essential nutrition element in human life. Minimum daily requirement of iron for human body depend on age, sex, physiological status and range from about 10 to 50 mg per day. According to WHO, groundwater may contain iron (II) at concentrations up to several milligrams per liter in the water when directly pumped from a well. Usually taste is not noticeable at iron concentrations below 0.3 mg/liter. The test results of all samples are with in acceptable limit except straw sample that exceed the permissible limit.

In a number of countries, the World Health Organization interim arsenic guidelines of 0.01 mg/L have been adopted as the standard. However, many countries have retained the previous WHO guideline of 0.05 mg/L as the national standard. Many European countries have adopted the WHO provisional guideline of 0.01 mg/L as their national standard. A number of Countries where the national standard for arsenic in drinking water remains at 0.05 mg/L include Bangladesh, China and India. The collected samples are below the Bangladesh national arsenic standard.

When the storage period elapsed three months then some total coliforms bacteria were found in the stored rainwater (8, 9 and 11/100 ml respectively). This total coliform might enter into the tank mixing with air through the inlet of the storage tank. To avoid such kind of contamination, the storage tank should be well monitored and maintained during the stored period. To reduce total coliform from the stored rainwater, locally made sand filter can be used. Public acceptability of the degree of hardness of water may vary considerably from one community to another, depending on local conditions. The taste threshold for the calcium ion is in the range of 100–300 mg/l, depending on the associated anion, and the taste threshold for magnesium is probably lower than that for calcium. It is not a pollution parameter but is a quality indicator. In some instances, consumers tolerate water hardness in excess of 500 mg/l (WHO 2008). Depending on the interaction of other factors, such as pH and alkalinity, water with hardness above approximately 200 mg/l may cause scale deposition in the treatment works, distribution system and pipe work and tanks within buildings. Soft water, with a hardness of less than 100 mg/l, may, on the other hand, have a low buffering capacity and so be more corrosive for water pipes. No health-based guideline value is proposed for hardness in drinking-water (WHO 2008).

5. CONCLUSION AND RECOMMENDATION

From this research, the rainwater harvesting was a very useful and acceptable potential source of safe water for drinking and cooking purposes in the water scarce and the arsenic contaminated areas. In the saline and arsenic contaminated areas, this source might be an alternative water source. Also at the area like Satkhira, where there is scarcity of safe drinking water, rainwater harvesting may be very useful. The minimum catchment’s area required for collection rainwater for a rural household has found 6 m². In addition the annual water requirement of a rural family based on six members in the south west coastal region of Bangladesh has calculated 11 m³. Finally, it can be suggested that average rural houses based
on six members build storage tanks with a capacity of 2000 liter. Moreover, a low cost rain water harvesting system is proposed. The cost of the system is $261 and it is affordable in coastal region.

The questionnaire survey revealed the roof orientation and structures of rural house roof which could be used as catchment (to collect the rainwater) and available size of rural house roof areas. The survey result also revealed that the roof condition of the selected area is suitable to use as catchment for rainwater. Moreover, the available average sizes of the roofs are suitable for rainwater harvesting system. The test results showed that the quality of rainwater was acceptable as safe drinking water without any treatment in southern part of Bangladesh.

Rural people know that rainwater is safe for drinking and cooking. However, they cannot use rainwater properly due to lack of rainwater harvesting technology and implementation procedure. A detailed survey on the rainwater acceptability in water scare area like Khulna division could be conducted to get the clear picture of the water requirement. Social campaign is needed to create awareness about the rainwater as good alternative option.

Moreover, this test result was applicable only for this area, because there would be spatial variation of quality of rainwater due to variation of air quality or the environment. Further study should emphasize careful handling of the storage tank and closing of the inlet. Also rainwater storage tanks may be used in future studies. Care should be taken during storage period to ensure that coliform cannot enter into the tank. So, the water can be used for the whole storage period as safe drinking water. In case of necessity, the water tank can be chlorinated as per standard guidelines.

Finally, one could also recommend that once such systems are in operation, an investigation of the microbiology and the chemistry of the collected stored water in different areas should be initiated to monitor the proper operation and management of the systems. This could be the subject of further study.

REFERENCES


