Quality Assessment of Stored Harvested Rainwater in Zliten City

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Abstract:

Despite the high level of dependence on rainwater for drinking, little is done for monitoring the water quality of tanks receiving rainwater in Naima, Zdo, Suk- Althulataa and Aljumah areas. For this reason, it is very important to evaluate the quality of rainwater collected and stored in storage tanks. In this research study, Thirty-six samples of harvested rainwater from different storage tanks within these four areas were collected and analyzed for different quality parameters (pH, Turbidity, TDS, COD, NO_3,NH_4,Cu, Fe, Pb, Cd and microbiological contaminations).

The results of the analyses were compared with water quality guidelines of World Health Organization (WHO) to evaluate its suitability for potable and domestic uses. The resulted data indicate that water quality in these tanks varies depending on location and catchment area. The study shows that harvested rainwater may not be always suitable for direct drinking, without treatment, but could be used for other domestic purposes, especially in Zdo area. While in Sokalthlathaa area, the investigation for different quality parameters in the rain water samples showed that the water sample are within the permissible limits of the World Health Organization drinking water quality guidelines.

Keywords: Rainwater harvesting, Storage tanks, Physicochemical, Microbiological, Zliten.

Introduction:

The problems in water sources have become directly one of the most important problems in human lives [1]. Many regions around the world are adopting rainwater harvesting to overcome the increasing demand of water. Rainwater is an important source of fresh water especially for those who live in rural areas. Rainwater harvesting has received increased attention worldwide as an alternative source of potable and non-potable water supplies [2], and as solution to overcome the increasing demand of water [3]. Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surfaces, steep slopes or rock catchments using simple techniques such as tanks and cisterns more complex techniques such as underground check dams [4], [5]. The quality of water collected in a rainwater harvesting system is affected by many factors, which include, the roof materials, environmental pollution such as the

presence of dirt's, debris and birds or rodents dropping on roofs and rainwater catchments [6], [7] and the type of storage materials for harvested rainwater. Contaminants such as bacteria, heavy metals, have found their way into water supplies due to inadequate treatment and disposal of waste [8], [9], and [10]. Roof catchment is the common method of rainwater harvesting and is widely used to provide urban populations with alternate water supplies [11] on the other hand roof surfaces are often viewed as potential sources of contamination for rainwater. Furthermore higher levels of heavy metals and other chemicals that can harm human health [12], [13] - [14]. Could be found heavy metals including lead and cadmium among others may cause diseases such as rheumatoid arthritis, cancer, and heart failure [15]. Microbial indicators presence in stored rainwater is a common problem reported in different developed and developing countries [16], [17]. The risk of microbiological contamination of rainwater during collection and storage in the home has long been recognized [18], [19]. Microorganisms found to be carried by birds and animal vectors, each of these microorganisms are known to cause gastroenteritis and other illnesses [20]. The quality of rainwater is directly related to the cleanliness of the atmosphere, and quality of material used for catchment surface, gutters, and storage tanks [21]. Due to the harmful and toxic effects, the main goal of this paper is to identify and quantify sources of contaminations in harvested water storage in tanks.

Materials and Methods:

Study area and collection of rainwater samples:

Thirty-six samples of collected rainwater from various storage tanks in these four areas (Naima:3; Zdo:3; Sokalthlathaa:3 and Aljumah:3) in

Zliten city, it is located about 150 km east of Tripoli. Which is located at latitude of 32°27′50″ (N) and longitude of 14°34′21″(E). Three samples are collected of each tank in February 2015 .Rainfall of 25 to 50 mm can occur. 26 millimetres is the average annual rainfall for the country [22]. The temperature values were in the range of 25 to 27 ºC. The rainwater tanks were constructed from concrete. After collection, rainwater samples were transferred without any treatment into clean 1½ liter polyethylene bottles, tightly covered by caps, and stored in a dark, cool place in the laboratory, then analyzed (pH, Turbidity, TDS, COD, NO_3, NH_4, Pb, Fe, Cd, Cu). Additionally, these samples were tested for contamination of biological and microbiological contents (TCC, E.Col. and FC bacteria).

Physicochemical, heavy metals and bacteriological analysis:

The electrical conductivity, total dissolved solids was measured using a JENWAY 3540 Bench combined pH, conductivity, TDS meter (UK). Turbidity was measured using a digital nephlo- turbidity meter at the Food and Drag Control Center. The determination of heavy metals was carried out using the flame atomic spectrophotometer as described in standard methods [23]. Samples for microbial analysis were kept with a sterilized capped bottle to arrest the further growth of bacterial prior to analysis. These samples were tested for contamination of biological and microbiological contents. TCC, E.Col., and FC bacteria tests were carried out according to standard methods for water and waste water examination [23]. Results of analysis were further compared with permissible limits of the World Health Organization drinking water quality guidelines [24]. The investigated storage tanks were underground tanks and built as a separate unit located at a distance from the building. Most of these tanks receive rainwater from roof tops and catchment yards. Water can be easily

extracted by water pump. In order to eliminate the effect of solids settlement, samples were taken from different depths of the tanks.

Statistical analysis :

Descriptive statistical analysis was employed for the data obtained. Mean and standard deviation were determined. The parameters were tested for any significant difference amongst the storage tanks.

Results and Discussion:

The obtained results are shown in Table (1) and Table (2);

Table 1. Pollutants concentration for four areas (values: mean ± SD).

Areas	Naima	Zdo	Sokalthlathaa	Aljumah	WHO Limits*
pH	7.59 (±0.26)	8.33 (±0.50)	7.32 (±0.37)	7.83 (±0.35)	8.5
Turbidity (NTU)	0.48 (±0.33)	1.92 (±0.52)	0.38 (±0.21)	1.50 (±0.76)	5
TDS mg/l	317 (±103)	410 (±101)	271 (±78)	397 (±69)	500
COD mg/l	18.1 (±6.94)	27.9 (±4.40)	9.20 (±1.71)	8.69 (±1.29)	100
NO_3 mg/l	2.72 (±1.22)	5.40 (±1.30)	0.67 (±0.64)	0.85 (±0.29)	10
NH_4 mg/l	0.062 (±0.03)	0.081 (±0.061)	0.034 (±0.019)	0.043 (±0.045)	--------
Pb mg/l	ND	0.0059 (±0.03)	ND	0.0183 (±0.01)	0.05

Areas		Naima	Zdo	Sokalthlathaa	Aljumah	WHO Limits*
Fe	mg/l	0.039 (±0.02)	0.070 (±0.02)	0.026 (±0.02)	0.160 (±0.03)	0.3
Cd	mg/l	ND	0.001 (±0.01)	ND	0.002 (±0.01)	0.003
Cu	mg/l	ND	0.080 (±0.02)	ND	0.129 (±0.08)	2
TC	MPN/100ml	3.1 (±1.68)	8.3 (±1.36)	ND	1.7 (±0.76)	0
Fecal Colif.	MPN/100ml	2.3 (±1.01)	5.6 (±2.54)	ND	1.5 (±0.73)	0
(E.Coli)	MPN/100ml	1.2 (±1.10)	3.9 (±1.41)	ND	0.67 (±0.39)	0

*Source: (WHO, 1989).

Table 2. Water quality according to the type of the catchment area (values: mean ± SD).

parameter		Top roof	Land catchment
pH		7.4 (±0.71)	8.2 (±0.90)
Turbidity	(NTU)	0.62 (±0.12)	1.36 (±0.33)
TDS	mg/l	279 (±81)	432 (±40)
COD	mg/l	9.53 (±1.35)	27.23 (±4.88)
NO_3	mg/l	0.81 (±0.85)	4.51 (±0.40)
NH_4	mg/l	0.028 (±0.01)	0.073 (±0.04)

parameter		Top roof	Land catchment
Pb	mg/l	ND	0.065 (±0.03)
Fe	mg/l	0.047 (±0.03)	0.084 (±0.02)
Cd	mg/l	ND	0.003 (±0.01)
Cu	mg/l	0.007 (±0.01)	0.015 (±0.01)
TC	MPN/100ml	1.6 (±1.41)	5.8 (±1.32)
Fecal Colif.	MPN/100ml	1.2 (±0.97)	4.6 (±1.35)
(E.Coli)	MPN/100ml	0.5 (±0.33)	2.8 (±0.55)

The results indicate there is a significant variation in water quality depends on the area characteristics, such as weather conditions, industrial, urban agricultural activities, and environmental cleanness. Concentrations of COD, NO_3 in samples taken from Zdo area were significant different from other areas (Table1). This might be due to presence of cesspools and septic tanks in near distance to the rainwater harvesting tanks. This result complies with study conducted by [25]). While Aljumah and Zdo area had high significant ($P<0.05$) (Table1), concentrations of heavy metals than other areas, respectively which may be due to rainwater harvesting tanks in Aljumah area located near distance to the cement plant and in Zdo area located near the Sewage, [10] indicated to the same reasons (Table1). In Zdo area also had high significant ($P<0.05$) concentrations of COD, NO_3

and biological contaminates than other areas (Table1). This can also be attributed to proximity to the sewage pools. Sokalthlathaa area had lower pollutants concentration ($P<0.05$) than other areas (Table1).

In houses, rainfall is usually collected from two catchments areas, house roofs, and /or the land around the storage tank. Roofs made of reinforced cement concrete. Roofs are contaminated as a result of air pollution [26]. Rooftops are usually free of organic contaminants, a reason that very low concentrations of COD and NO_3. Land catchments area is exposed directly to contamination sources [27]. Possible sources of contaminants include fertilizer, pesticides, chicken and livestock manure, sewage and decaying plants [28]. All these pollutants are washed with rainfall to the storage tank causing increase in water contaminants, which result in a higher concentration of COD, NO_3 and biological contaminants. It was found, for the samples collected from roof top catchments that the average concentrations of TC, FC and Ecoli. were lower ($P<0.05$) than average concentrations samples collected from land catchments (Table 2), quality of tank-stored rainwater is impacted directly by direct depositions by birds and small mammals, decay of accumulated organic debris, and atmospheric deposition of airborne micro-organisms and chemical pollutants [29], and is often noticed due to bacterial growth within the storage tank with the existence of required growth elements [30].

The presence of Iron (Fe), Lead (Pb) and Cadmium (Cd) copper (Cu) in samples taken from tanks that receive rainwater through land catchments these was higher significant ($P<0.05$) than samples taken from tanks that receive water from top roof (Table2). This might be due to not cleanliness of the atmosphere or the catchment surface [21] and inadequate treatment and disposal of waste (human and livestock), industrial discharges [10],

with increased transportation, and other anthropogenic activities [8]. This results indicated that harvested rain water from roof tops have better quality than water collected from the land catchments this agree with results were reported by [31] and [32].

Conclusions and Recommendations:

Rainwater harvesting is an attractive option for increasing available water resource in the drought and arid regions. The results indicated that the collected water is heavily contaminated with microbes especially in Zdo area, so that it becomes unsuitable for direct drinking purpose without treatment, but could be used for other domestic purposes.

The study results also showed that there are variations in water quality according to the location. Harvested rainwater in Zdo area has lower quality than harvested rainwater in

Naima, Sokalthlathaa and Aljumah areas may be due to it location near the sewage. While harvested rain water in Aljumah area has high heavy metals concentrations than other areas because of the cement plant in this area. The quality of harvested rainwater is found to be strongly affected by the catchment area. Harvested rain water from rooftops has better quality than rain water harvested from land catchment. Finally, several environmental conditions should be taken into consideration to improve water quality such as proper design, operation, and periodical maintenance of collection systems, cleanness of catchment area and protection of collection systems against septic tanks leakages.

Recommendations :

In order to have good quality of harvested rainwater, it is recommended that:

1- Rooftop and land catchment must be cleaned before the rainfall season.
2- Locating cesspools at a far distance from the harvested rainwater storage tanks to prevent any leaching of containments.
3- Harvested rainwater samples should be collected and analyzed on regular basis from the storage tanks before using the water for drinking purposes.
4- Adding some disinfecting agents such as chlorine might help in reducing the risk of biological contamination.

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