ASSESSMENT THE QUALITY AND QUANTITY OF HARVESTED RAINFALL FROM DIFFERENT CATCHMENTS SYSTEMS STUDY CASE: NORTH WEST OF LIBYA

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ABSTRACT

This study was conducted in north west of Libya which receives an average annual rainfall about 200- 250 mm. Due to the limitation of water resources in the study area for domestic use, the study aimed to evaluate the quality and quantity of harvested rainwater from different catchments including cisterns near asphalt roadway, open surface from mountain and hill aspects, dams lakes, house roofs and direct precipitation. Statistical analysis based on historical data of rainfall in the study area was conducted to detect the probability of rainfall occurrence with suitable return periods. The results of analysis highlighted the availability of rainfall for harvesting purpose. Harvested rainwater physical, chemical and microbiological characteristics have been investigated on the basis of samples collection and determination of parameters composition analysis. It was found those Common anions and major cations as well as the metals Pb, Cd, and nitrate generally matched the WHO guidelines and Libyan Stander of Drinking Water. Cd concentrations in the collected samples near the roadway appeared to be higher than the guideline values. The results showed that no Faecal Coli forms were detected in water samples except in the samples collected from cisterns near the asphalts roadways and the dam lakes. These findings revealed that microbiological parameters were affected mainly by the cleanliness level of catchments areas, while chemical parameters were influenced by the human activates and the nature of the catchments areas.

Keywords: Harvested Rainwater, Rainwater quality and quantity, catchments systems.

INTRODUCTION

Harvested rainwater may be the only source of water supply for many rural and remote households where no other water supply is available .Rainwater harvesting for domestic use is becoming increasingly popular as the availability of good quality water is declining. In urban and suburban environments, rainwater harvesting could help public water systems reduce peak demands and help delay the need for expanding water treatment plants. Rainwater harvesting can reduce storm water runoff, non-point source pollution, and erosion in urban environments. Rainwater is valued for its purity and softness and is generally superior for landscape purposes to most conventional public water supplies. Rainwater harvesting can be used for both indoor and outdoor purposes in residential, commercial, and industrial uses. In the study area, rainfall is sufficient to make rainwater harvesting reliable and economical source of water even during short-term droughts. Homes in remote areas with no access to other sources of water supply depend on rainwater for all their needs. In addition to residential use, there are many examples of rainwater harvesting systems being used in commercial and industrial purposes. Public facilities, such as schools and community centers have started harvesting rainwater to conserve water supplies (Heijnen 2001). Rainfall is the most unpredictable variable in determining the potential rainwater harvesting for a given catchment. Developing rainfall probability or frequency curves based on past rainfall data is available tool for decision makers to make a rapid preliminary assessment about the likelihood of success of a rainwater harvesting project (Anush et al 2003). According to the probability or frequency analysis of annual totals rainfall specific to an area, the rainfall harvesting potential sites and the return periods of each event can be calculated (Wifag, Hassan 2007). Among the several factors that influence the rainwater harvesting potential of a site, the catchment characteristics are considered to be the most important. The harvested runoff depends upon the area and the type of the catchment over which it falls as well as surface features. Rainwater harvesting can be categorized according to the type of catchment surface used, and to the implication and the scale of activity in the area. Rainwater collecting and storage systems need to be monitored in a similar fashion as any other piece of important infrastructure around the house or the institution. The practice of collecting rainwater harvesting can be classified into two broad categories: land-based rainwater harvesting occurs when runoff from land surfaces is collected in furrow dikes, ponds, tanks and reservoirs, Roof-based rainwater harvesting which refers to collecting rainwater from roof surfaces. Roof-based rainwater harvesting results in much cleaner source of water and provides water that can be used for potable indoor purposes. The quality of rainwater harvested is one reason to use rainwater as primary drinking water source. The need for quality water has been well documented and is crucial for human and ecosystem health (Mintz et al, 2001).For the quality reasons, harvested rainwater for human consumption is preferably collected from roof catchments. The livelihood approach promotes the use of runoff water also for productive purposes, such as small scale irrigation for domestic food production, watering small stock, watering tree nurseries etc. The quality of harvested rainwater depends upon many factors such as air quality, system design and maintenance, materials used, rainfall intensity, length of time between rainfall events, as well as water handling. In addition to the harvesting and handling of rainwater, the environmental surroundings of the catchment system play an important role in water quality. Because of rainwater catchment systems are usually open to environmental hazards, there are several ways contaminants can into enter the rainwater system. (Gould et al, 1999). In industrialized urban areas atmosphere pollution has made rainwater unsafe to drinking (Thomas and Green, 1993) and (Gould, 1999). The bacteriological quality of rainwater collected from land surface or ground catchments are generally poor. From properly managed rooftop catchments, equipped with storage tanks with good covers and taps, water with relatively high quality can be collected though. This water is typically suitable for drinking and commonly meets the drinking water standards of WHO (Yaziz et al, 1989). In a study developed by (Sazakli et al, 2007) reveled that microbiological parameters were affected mainly by the cleanliness level of catchment areas, while chemical parameters were influenced by the sea proximity and human activates. The purpose of this research is to assess the quantity and quality harvested rainwater collected from various land surfaces Catchments near rural areas.

MATERIAL AND METHODS

The location of the study catchment areas is shown in Fig. (1). The macroclimate regime of the study area is generally of one rainy season per year appears during the period from October to May. For the quantity issues, rainfall data were collected from several metrological stations for a period of 36 years from 1970 to 2006 expressed in mm. Statistical analysis was carried out to detect the probability of rainfall occurrence with suitable return periods and to assess the availability of rainfall for harvesting. The rainfall data were ranked and plotted on probability paper according to Weibull formula.

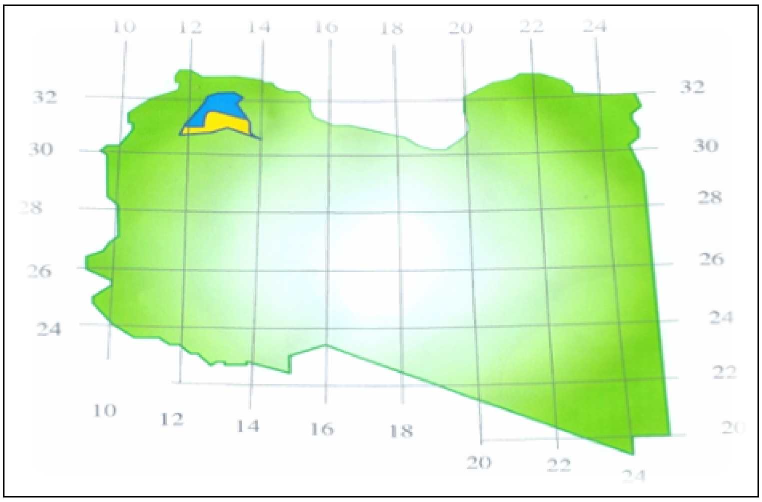

Figure (1) Location of the study area

For the quality issue, harvested rainwater from different catchments including cisterns near asphalt roadway, open surface from mountain and hill aspects, dam lakes, house roofs and direct precipitation, were investigated for there quality in total seventy samples of rainwater were collected during the rain season 2006-2007.

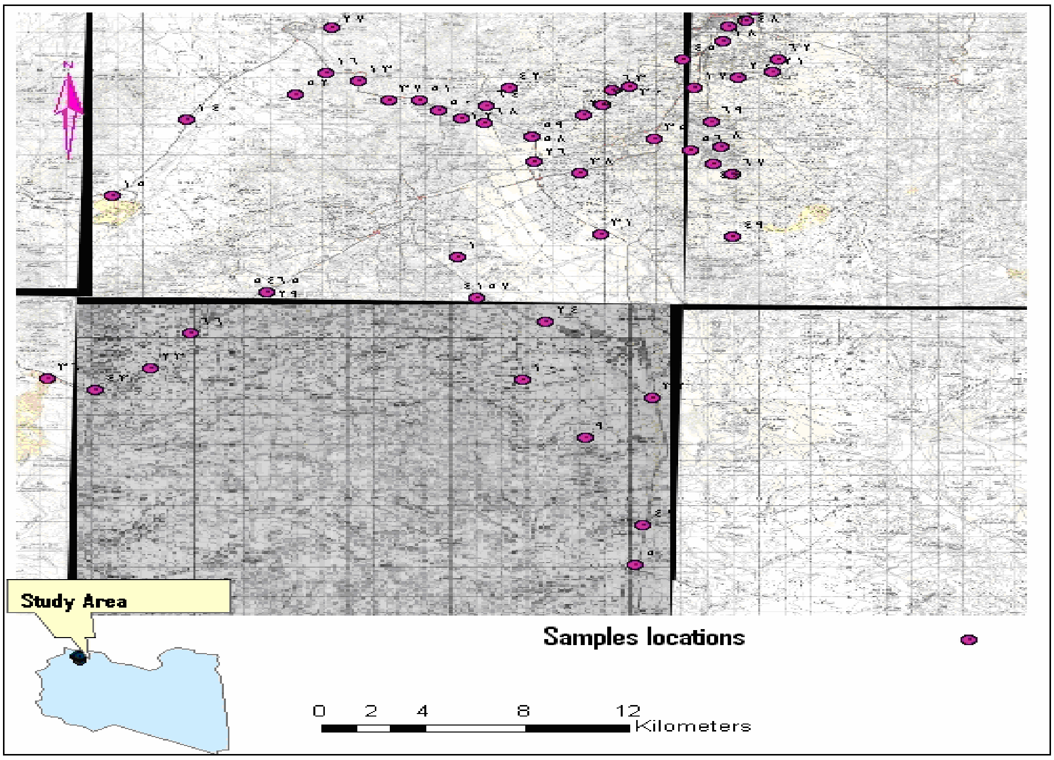

Figure (2) Location of the samples collected from the study area by GPS

Figure (2) shows the locations of the samples collected from the study area. The collected samples were analyzed for physical-chemical and biological parameters according to the methods of analysis set by LEPA.

RESULT AND DISCUSSION

Rainwater availability

Rainwater availability is very important indicator for any sound rainwater harvesting project. The study area is subjected to an average annual rainfall of about 250 to 350 mm per year according to the data collected from the metrological stations in the study area. Rainfall pattern based on the annual rainfall for the period from 1970-2007 are shown in Fig. (3). It appears that the average yearly rainfall amount received in the study area is favorable for rainwater harvesting systems.

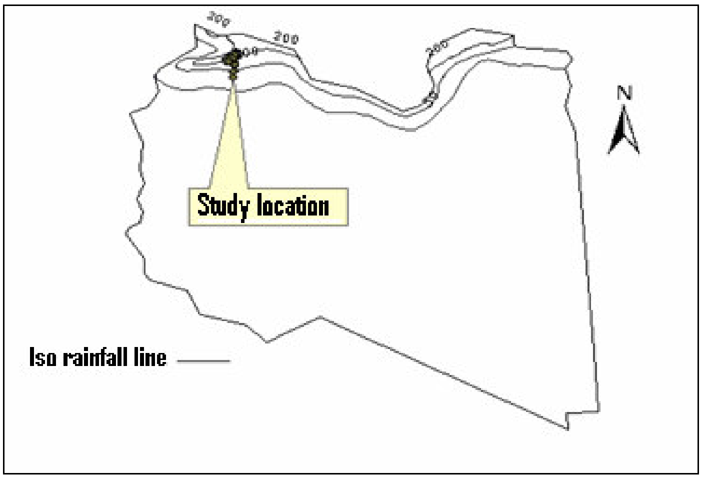

Figure (3) annual rainfall in the study area

Rainfall probabilities and return period calculations

To estimate the probability or frequency of events of a given magnitude of rainfall will occur or be exceeded, the probability analysis were conducted for the annual rainfall data records of the years 1970 to 2007. The plotted curve of the probability analysis (rainfall data from one metrological station) is shown in Fig. (4).

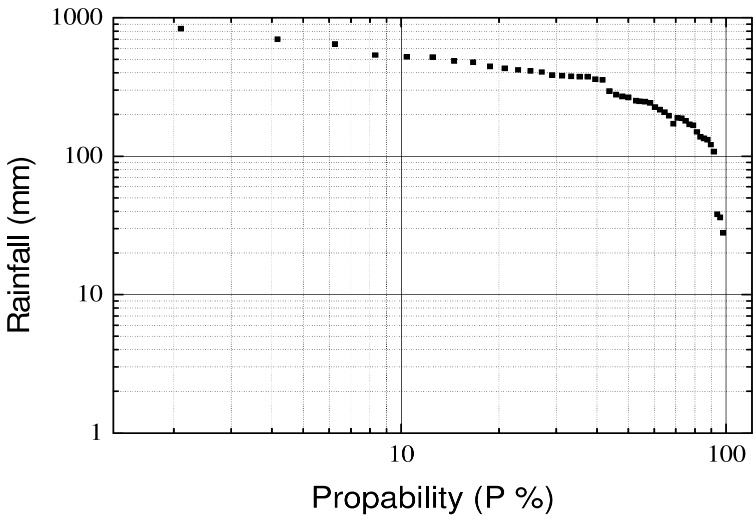

Figure (4) Probability analysis for the annual rainfall

From this figure, it is possible to obtain the probability of occurrence of a specific magnitude of rainfall. Inversely, it is also possible to obtain the magnitude of the rain corresponding to a given probability. The return period can easily be derived once the probability P (%) is known (1 /probability).

Figure (5) shows the return period curve of the rainfall for the study area. According to the probability of annual totals rainfall subjected to the study area, the analysis show that the probability of occurrence of annual rainfall of 200-250 mm or more is around 60-70 %. This means such rainfall magnitude will occur once every year. The results of analysis indicate that there is suitable amount of rainfall for harvesting purpose in the study area.

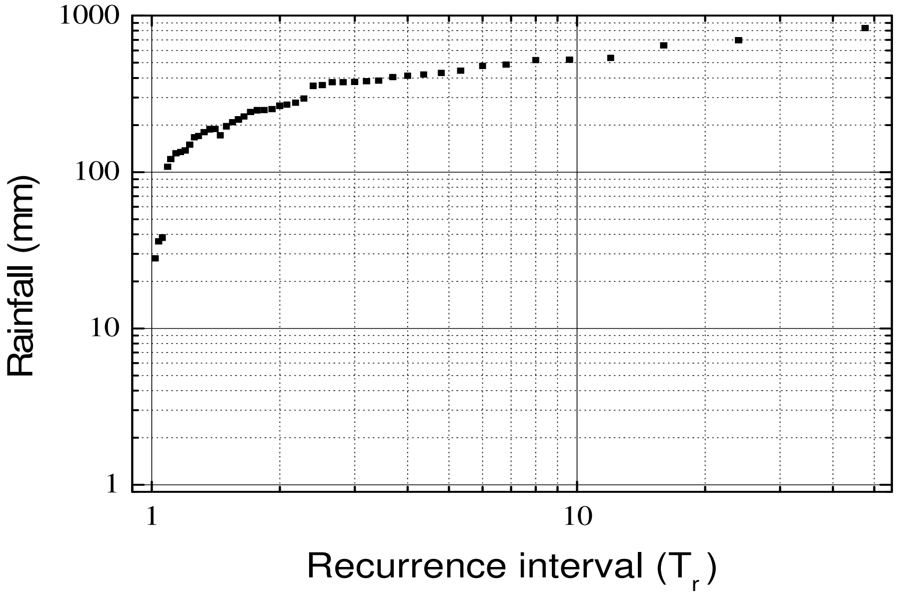

Figure (5) Return period for the rainfall events

Quality of the Harvested Rainwater

The main constrain on using harvested rainwater for different uses have been the water quality aspects. For the quality issue, the results are presented graphically (Figs. 6-10). Based on the figures, it can be observed that the electrical conductivity (EC) of the collected water samples remained consistently low. They range from (30 - 977) µs/cm, Fig. (6). They were in the limits approved by the WHO guidelines. The results also indicated the absence of any salinity problems

Table 1: different sites in the study area for collected samples

Sample No.	Sample site	Sample site description	Sample source
1-8	Site # 1	direct precipitation	Direct rainfall
9-30	Site # 2	open surface(mountain and hills aspect)	Runoff
31- 40	Site # 3	cisterns near asphalt roadway	Runoff
41- 45	Site # 4	dams lakes	Runoff
46 -70	Site # 5	houses roofs	runoff

The WHO has suggested a limiting value of 500 mg/l of TDS for potable water. In the present investigation this limit is not crossed on any of the samples under study. However in the samples collected from site # 3 (cisterns near asphalt roadway), the TDS value is about to reach the minimum permissible limit, Fig. (6). The TDS values are acceptable for domestic use and agricultural purpose. From Fig. (7), it is observed that the pH of the water samples was in the normal range and only minor fluctuation in pH was recorded. The pH values were within the limits set for domestic use as prescribed by WHO. The average pH levels of the waters samples were about 7.4, which suggested that there were no serious acid rain problems in the study area. Major cations, Ca^{2+}, Mg^{2+}, Na, and K^{+}, in collected water samples were investigated. The results of the analysis show values range between (48.8-71.32), (8.2-35.5), (7.8-33.9 l), (5.8-16.6) mg/l respectively, Fig. (8). The major anions HCO_3, SO_4, and Cl in the water sample show concentrations ranges between (95.6-188), (13.13-176.3), (18.5-83) mg/l respectively, Fig. (9). It is observed that the heights amounts of both cations and anions are measured in collected water samples from cisterns near asphalt roadways. The collected samples from direct precipitation registered very low values for both cations and anions. In general the concentration of cations and anions in collected samples from different catchment areas fall well within approved limit by WHO. The data presented in Fig. (10) show acceptable values of NO_3 concentration in the water samples from the different catchment areas. These values range from (0.75-9.4 mg/l).Very low concentration was observed in the waters samples collected from direct precipitation, where the highest concentration were measured in waters samples collected from a dam lakes.

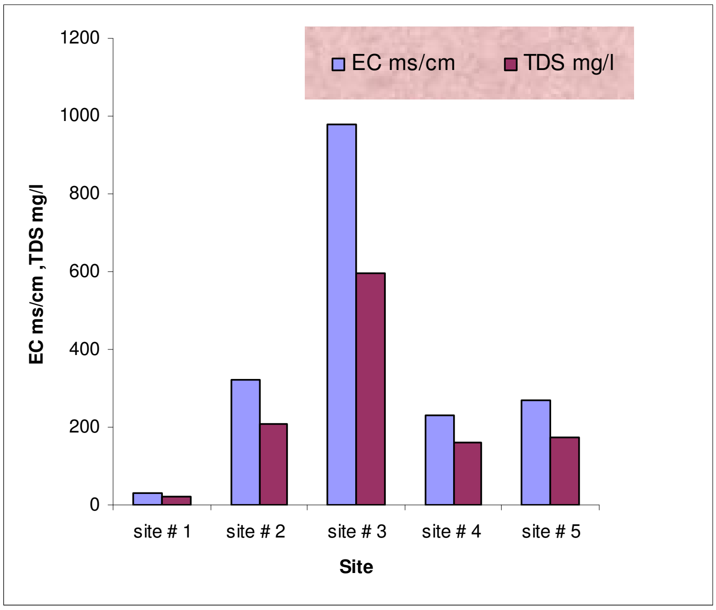

Figure (6) TDS and Electric Conductivity of the water samples from different sites in the study area

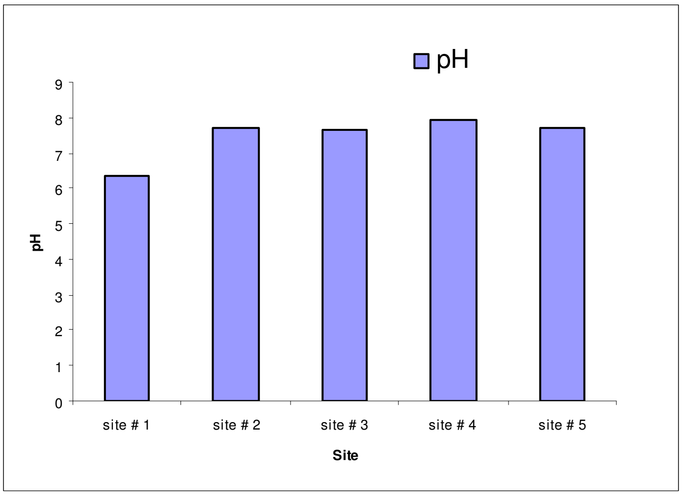

Figure (7) pH of the water samples from different sites the study area

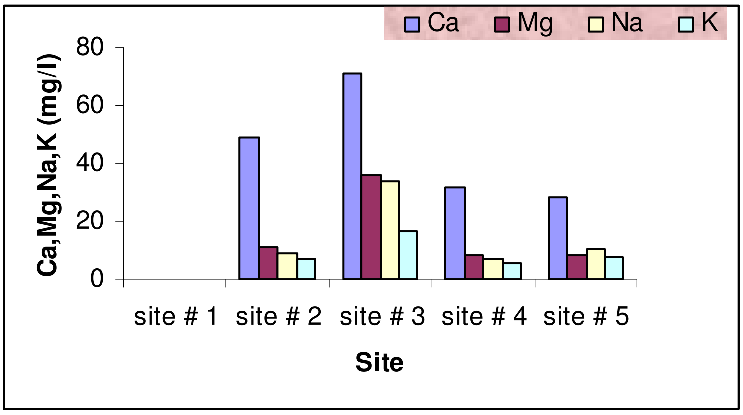

Figure (8) Calcium, Magnesium, Sodium and Potassium of the water samples from different sites the study area

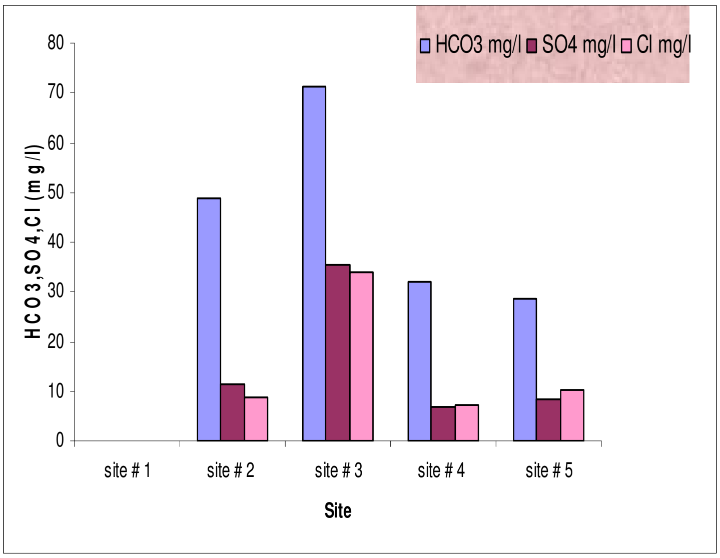

Figure (9) Bicarbonate, Sulfate and Chloride of the water samples from different sites the study area

The relatively low levels of NO_3 concentration in waters samples collected from direct precipitation can be attributed to the absence of any industrialized sources in the study area, while the relatively high concentration can be attributed to non point source of municipal wastes from landfill and agricultural activities in the study area which can be transported by runoff processes. In the all waters samples, nitrate concentrations remained consistently low and in the limits approved by WHO. The results of analysis indicated that the heavy metals concentration of Lead and Cadmium were mostly below the limits sit by WHO of 0.05 and 0.005 mg/l respectively Figure (10). Very low concentrations where observed in the waters samples collected from cisterns near asphalt roadways and dams lakes which can be attributed to traffic and other vehicles products which carried by runoff to the cisterns. In this study Fecal Coli form bacteria, which are an important bacteriological parameter for the different catchment systems, were investigated. The results (Table 2) show that no Fecal Coli forms were detected from both direct precipitation and house roofs.

Table 2: bacteriological analysis for waters samples

Parameter	Site# 1	Site # 2	Site# 3	Site# 4	Site # 5
Fecal Coliforms	Non detected	detected	detected	detected	Non detected

Fecal Coli forms were detected in the samples collected from cisterns asphalts roadway, the dams lakes and open surface (mountain and hills aspect) catchment systems. These findings revealed that microbiological parameters were affected mainly by the cleanliness level of catchment areas and also influenced by the human activates.

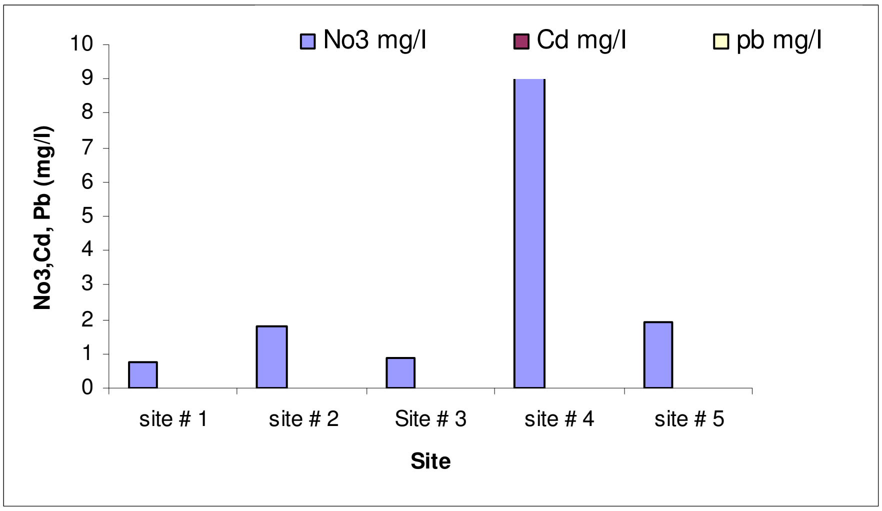

Figure (10) Nitrate, Cadmium and lead of the water samples from different sites the study area

CONCLUSION AND RECOMMENDATIONS

The present investigations suggest that the average yearly rainfall amount received in the study area is favorable for rainwater harvesting systems. According to the annual totals rainfall that the study area is subjected to, large amounts of rainwater can be harvested in the study area and can be used for difference purpose. The quality of harvested rainwater depends upon factors, but mainly the cleanliness level of catchments and human activities. The results of this study showed the application of an appropriate rainwater harvesting technology can make the utilization rainwater possible as valuable and in many cases necessary water resource. Based on the data presented earlier, the following recommendations are made:

- Building rainwater harvesting systems far enough from existing cesspits.
- Building sediment trap basins and cleaning the catchment area more frequently during the rainy season.

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