RAINWATER HARVESTING IN ALGERIA: UTILIZATION AND ASSESSMENT OF THE PHYSICO-CHEMICAL QUALITY CASE STUDY OF SOUK-AHRAS REGION

RÉCUPÉRATION DE L'EAU DE PLUIE EN ALGÉRIE: UTILISATION ET ÉVALUATION DE LA QUALITÉ PHYSICO-CHIMIQUE CAS D'ÉTUDE DE LA RÉGION DE SOUK-AHRAS

A. GUEBAIL[1, 2], T. BOUZIANE[2], L. ZEGHADNIA[4], Y. DJEBBAR[3],S. BOURANENE[4]

[1]Département de Génie Civil, Faculté des Sciences et de la Technologie, Laboratoire Infra-Res , Université de Souk Ahras , Algérie
[2]Faculté des Sciences et de la Technologie, Université de Mohamed Khider, Biskra, Algérie
[3]Département de Génie Civil, Faculté des Sciences et de la Technologie, Laboratoire Infra-Res , Université de Souk Ahras , Algérie
[4]Département de Génie des Procédés, Faculté des Sciences et de la Technologie, Laboratoire Phys-MR, Université de Souk Ahras , Algérie

agebaili@yahoo.fr

ABSTRACT

In North Africa precisely in Souk Ahras city which is located in the east side of Algeria, the climate is arid to semiarid; the Rainfall is uncertain and irregular. The water as brittle resources is unevenly distributed and less available. Using rainwater harvested from the houses roofs as a solution among other seems good. The collection areas can have a different quality compared to another, according to industrial and other economic dynamics. Pollution of rainwater produced before being collected has also a decisive role in the quality of these waters.

The goal of this study is to assess the physicochemical quality of the harvested rainwater from houses roofs. Three sampling locations of harvested rainwater in two seasons of the year winter and summer and from various storage tanks (Concrete and plastic) were collected and analyzed for different quality parameters: pH, total hardness, overall mineralization, Calcium, Sodium, potassium, chloride, Nitrate) and by the way drawn the more suitable materials for collection of the rainwater according to the Algerian drinking water standards.

KEYWORDS: Harvesting water, non conventional water, rainwater quality, Souk Ahras.

RESUME

En Afrique du Nord précisément dans la ville de Souk Ahras située dans l'Est Algérien, le climat est aride au semi-aride, la pluviométrie est incertaine et irrégulière. L'eau est une ressource fragile est inégalement distribuée et moins disponible. L'utilisation des eaux récupérées à partir des toitures des maisons connues aussi par les eaux non conventionnelles s'avére une bonne solution parmi d'autres. Les zones de collection peuvent être régies par des eaux à qualités différentes, selon la dynamique industrielle et économique. La pollution de l'eau de pluie produite avant d'être collectée joue également un rôle décisif dans la qualité de ces eaux.

L'objectif de cette étude est d'évaluer la qualité physico-chimique de l'eau de pluie récoltée des toits des maisons (zones). Les eaux de pluie sont collectées et analysées à partir de trois (03) sites d'échantillonnage en deux saisons différentes de l'année, hiver et été ; Stockés dans divers réservoirs (béton et plastique) pour différents paramètres de qualité: pH, dureté totale, minéralisation globale, calcium, Nitrate). Le type de réservoir le plus approprié pour stocker de l'eau récupérée a été choisis selon les normes algériennes des eaux potables.

MOTS CLES: récupération de l'eau, eau non conventionnelle, qualité de l'eau de pluie, Souk Ahras.

ملخص

في شمال أفريقيا على وجه التحديد في مدينة سوق أهراس التي تقع شرقي الجزائر، المناخ قاحل إلى شبه جاف. هطول الأمطار غير مؤكد وغير منتظم. الماء يعتبر كمورد هش و يتم توزيعه بشكل غير متساو وغير متاح. ان استخدام المياه التي تجمّع من أسطح المنازل يعتبر حلا مثاليا من بين حلول أخرى. نوعية المياه تختلف من منطقة إلى أخرى, ربما هذا الاختلاف يرجع لاختلاف الديناميكيات الاقتصادية والصناعية وغيرها. تلوث مياه الأمطار المسبق و قبل أن يتم تجميعه لديه أيضا دورا حاسما في الحكم على نوعية هذه المياه و هو متعلق كذلك ببيئة التجميع.

الهدف من هذه الدراسة هو دراسة نوعية مياه الأمطار التي تجمع من أسقف المنازل من ناحية الخصائص الفيزيائية و الكيميائية . تم الجمع من ثلاثة مواقع مختلفة وأخذ عينات من مياه الأمطار في موسمين : الشتاء والصيف. تم كذلك و ضع المياه في صهاريج مختلفة (مصنوعة من خرسانة وأخرى من البلاستيك) وأجريت تحاليل مختلفة: درجة الحموضة، والصلابة الكلية، التمعدن الكلي، الكالسيوم، الصوديوم، البوتاسيوم، الكلوريد، النترات. و بناءا على هذه النتائج تم إختيار نوع الصهاريج الأكثر ملائمة لجمع مياه الأمطار وفقا لمعايير مياه الشرب الجزائرية.

الكلمات الدالة: تجميع مياه الأمطار ، المياه غير التقليدية، جودة مياه الأمطار، سوق أهراس.

1 INTRODUCTION

Souk Ahras is located in the north eastern of Algeria; it is characterized by a dry to semi-arid climate with a non-homogeneous of the rainfall, the evaporation rate and the intense losses in Water supply network. In Algeria, the water is a rare, a weak, and unevenly distributed on the various zones.

In areas which are known by their shortages of water resources and the progression need for water thumb the researchers especially in arid and semi-arid areas to explore other solutions, Among these solutions we have the non-conventional water methods like water harvesting technic.

A water harvesting system is a facility for the collection and storage of runoff water. Systems which harvest water from roofs or ground surfaces are classified as “rainwater harvesting”, whereas systems which collect water from water courses are classified as “floodwater harvesting”. Survey of traditional water systems has revealed that some 25 systems are used in the Arab region (Abdelaziz Zaki et al, 2006),(UNESCO Cairo, 1995).

Ancient societies have developed various rainwater harvesting technologies and constructions such as agricultural dams, runoff control methods, and reservoir or cistern construction in urbanized areas (Mays, L et al, 2013).

It is applied in a traditional way in some parts of Algeria (Guebaili A, et al, 2011) but in facts it is not very spread (Abdelaziz Zaki et al, 2006) and the Algerian government don’t allow this technic a much importance compared to the challenges and the different problems affected the water resources in the region. It attracts more and more attention in several countries as an excellent practice of sustainable water management (Tariqui, I,M., et al, 2016),(Debusk KM et al, 2013), (Domènech L et al, 2012), (Mafizur, MD, et al, 2011) and among other.

In fact the price of water in Algeria is about 26 DA/m3 (Boukhari, S, et al, 2009) which it doesn’t help the development of the water structures however the water harvesting offers an availability of water almost free.

One of the primary areas of concern regarding the use of rainwater for either non-potable or potable applications is quality (Christopher D et al, 2009). Rain water collected downstream of roofs can be used for non-food purposes and not related to personal hygiene. The use of this technics doesn’t involve creation of a double network inside buildings. In other words, the use of rainwater collected directly from the downstream of the roof is allowed outdoors.

Figure 01: Example of a system of water harvesting (Texas Water Development Board, 2005)

Figure 02: A water harvesting in a depletion of Majel in a modern villa in Tunisia Sfax (Verdeil, 2007)

The quality issues are generally more complex than those

involving only a control of the amount. The problems of quality control require different parameters which are highly variable from one location to another.

Rainwater captured and stored correctly is safe, economical and sustainable source of quality water. The dioxide carbon (CO2) in the atmosphere makes the rainwater slightly acidic (pH 5 to 6). Unfortunately, there are other substances in the atmosphere, more toxic, they react with rainwater or that dissolves in water. For instance the dioxide Sulphur extracted from cars into sulphuric acid in contact with water is one of the causes of acid rain, where the pH falls below " pH < 4".

In General, the rainwater is more or less acid compared to the quality requirements for bathing water, by Against the rainwater is also very soft water, because it contains very little minerals. The most contamination of rainwater occurs after contact with the catchment surface (roof or ground) and during subsequent delivery and storage (Waller 1989).

In this paper the quality of the harvesting rainwater from souk Ahras region was studied to assess if it is possible to enlarged the use of this water in other human daily activities according to the analysis results and the Algerian water standards.

2 METHODS & MATERIALS

The quality of water collected in a Rainwater harvesting system is affected by many factors, including (Christopher Despins et al. 2009):

1. Environmental conditions such as proximity to heavy industry or major roads, the presence of birds or rodents (Forster 1998); (Taylor et al. 2000).
2. Meteorological conditions such as temperature, antecedent dry periods, and rainfall patterns (Evans et al. 2006).
3. Contact with a catchment material and the dirt and debris that are deposited upon it between rainfall events (Simmons et al. 2001; Van Metre& Mahler 2003).
4. Treatment by pre-cistern treatment devices such as filtration or first-flush diversion (Yaziz et al. 1989; Martinson & Thomas 2005).
5. Natural treatment processes taking place within the rainwater cistern (Scott & Waller 1987; Spinks et al. 2003a).
6. Treatment by post-cistern treatment devices such as particle filtration, ultraviolet disinfection, chlorination, slow sand filtration or hot water systems (Coombes et al. 2000; Kim et al. 2005; Ahammed & Meera 2006; Sazakli et al. 2007).

The storage tanks are designed with various materials, where some tanks are recyclable polyethylene compound (plastic) and others are in concrete. The quality of water collected in rainwater harvesting system is collected from three places, where SoukAhras center-town is divided into three bands according to the activities of people as shown in figure 03.

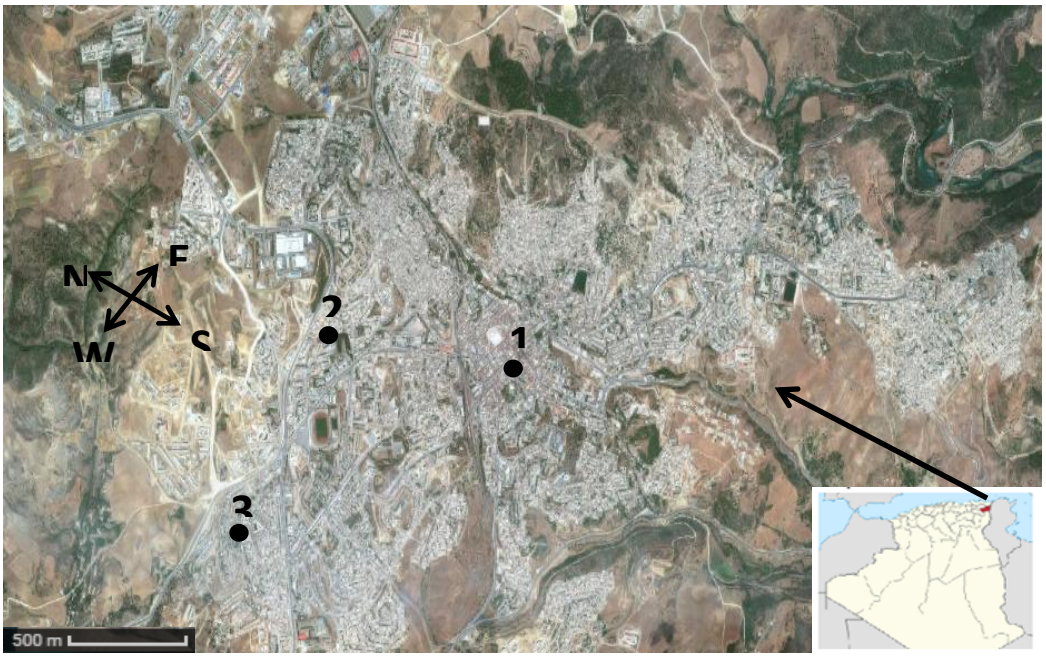

Figure 03: locations of water quality assessment (in SoukAhras map).

(Location of samples). ●

The water samples were collected in bottles polyethylene of one liter (Pacheco et al., 2001). These bottles have been previously washed with detergent, rinsed with tap water and then in distilled water. The water samples were stored in a cooler at a temperature of about 4 °C before transported into the laboratory.

Each sample was tested for his chemical and physical parameters property such as pH and many other parameters in (mg/l) like: total hardness, overall mineralization, $Ca2^{+}$, Na^{+}, K^{+},SO_4^{2-},Cl^{-},NO_3^{-} (Maoudombaye et al.2015).

To pinpoint the original state of the rainwater and to assess if it was affected by the material of the tanks before it was been collected; a control sample in the two seasons of the harvesting operation (winter and summer) was analyzed too.

The analysis results are drawn from a various samples where they will be compared with the Algerian water standards (AWS, 2000).

3 FINDINGS AND DISCUSSION

As mentioned above the harvested rainwater from the three locations was analysed and compared to the Algerian water drinks standards values as shown the following graphs:

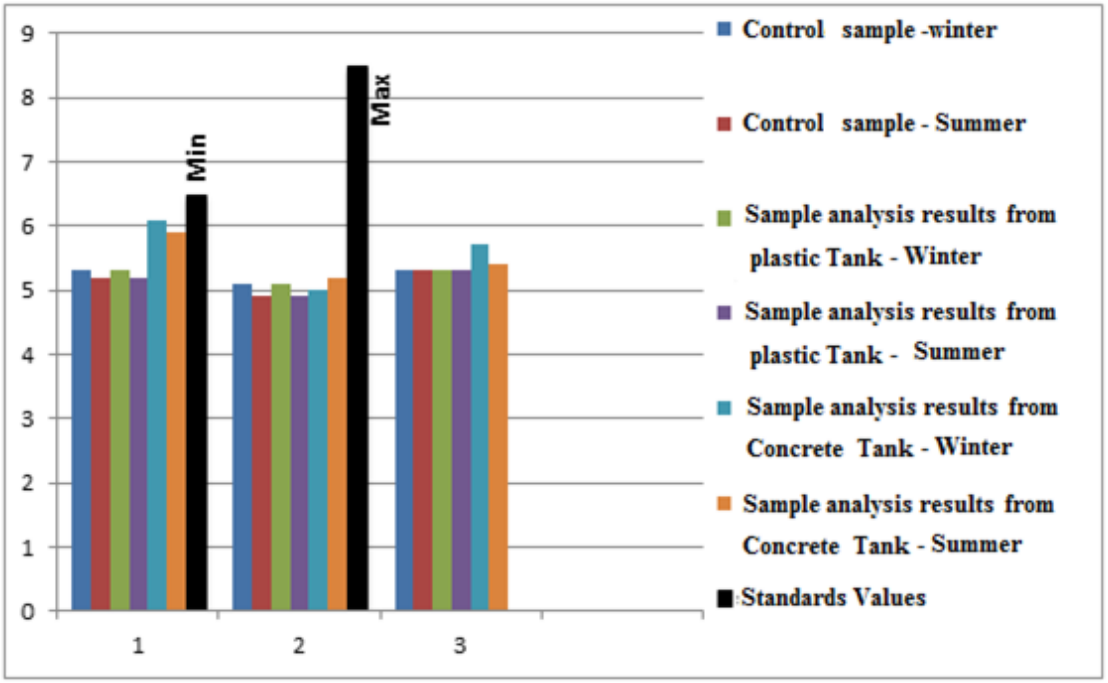

Figure 04: The PH values variation for each sample results

Through the results showed in figure 04, It seems that all the pH values are slightly acid, they are between 5 and 6 whatever the season of study; Winter or summer and for both types of tanks, plastic or concrete, with little different between the plastic tank and the concrete one, where the concrete tanks make possible to reduce the acidity of rainwater collected (Thierry G et al, 2007) idem for the control sample. The acidity of the rainwater can be explained by the dissolution of carbon dioxide in storm water making the water acidic and outside the pH range allowed according to the standard values.

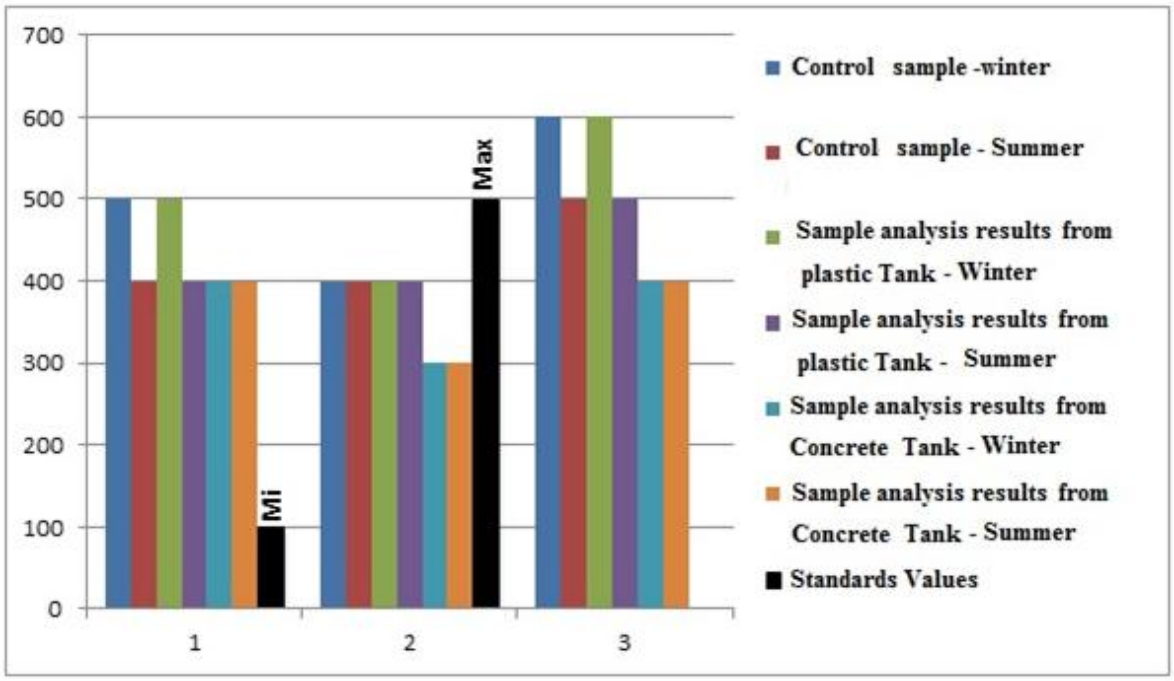

Figure 05: The Total Hardness in mg/l values variation for each sample results

Generally, the hardness values of the samples studied (figure 05) are within the range of the standard values allowed, except for the third abscissa (zone n°3) where a negligible increase of the order of 16% recorded for plastic tank and the control sample taken in winter, where it is easy to conclude that concrete can reduce the hardness of the rainwater and this can be drawn from the results of the three areas.

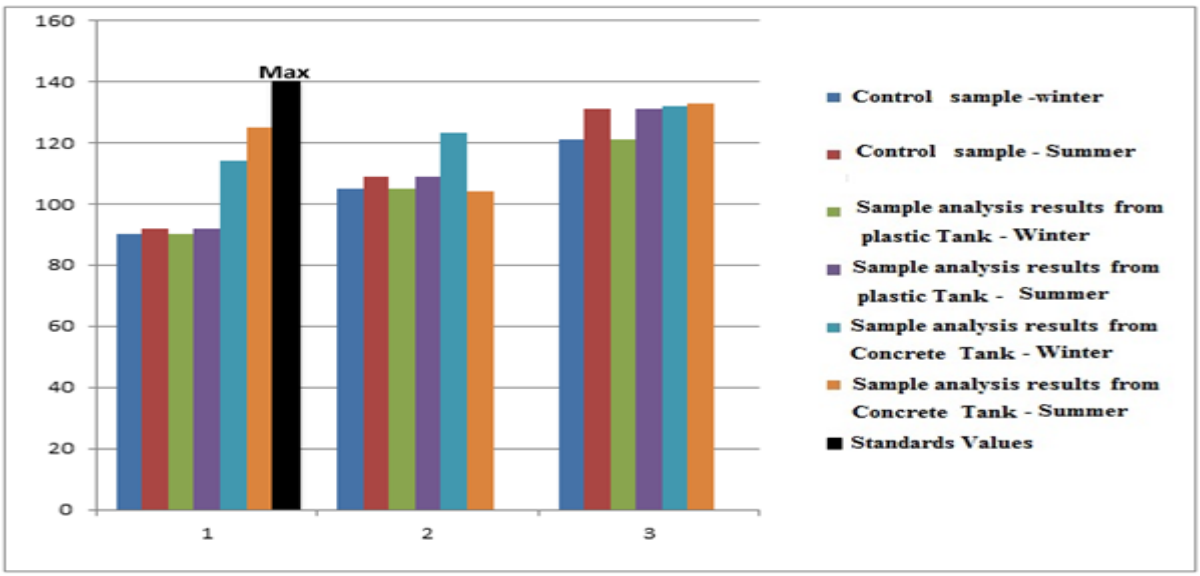

Figure 06: The Overall mineralization in mg/l values variation for each sample results

As shown in figure 06, the overall mineralization is growing from area to another, where the third one has recorded the highest concentration. The concrete tank encompass the high concentration of the overall mineralization, this can be explain by the reaction of the water with the basic components of the tank that introduce minerals in solution. The obtained results shows that the rainwater overall mineralization belongs to the Algerian drink water standards.

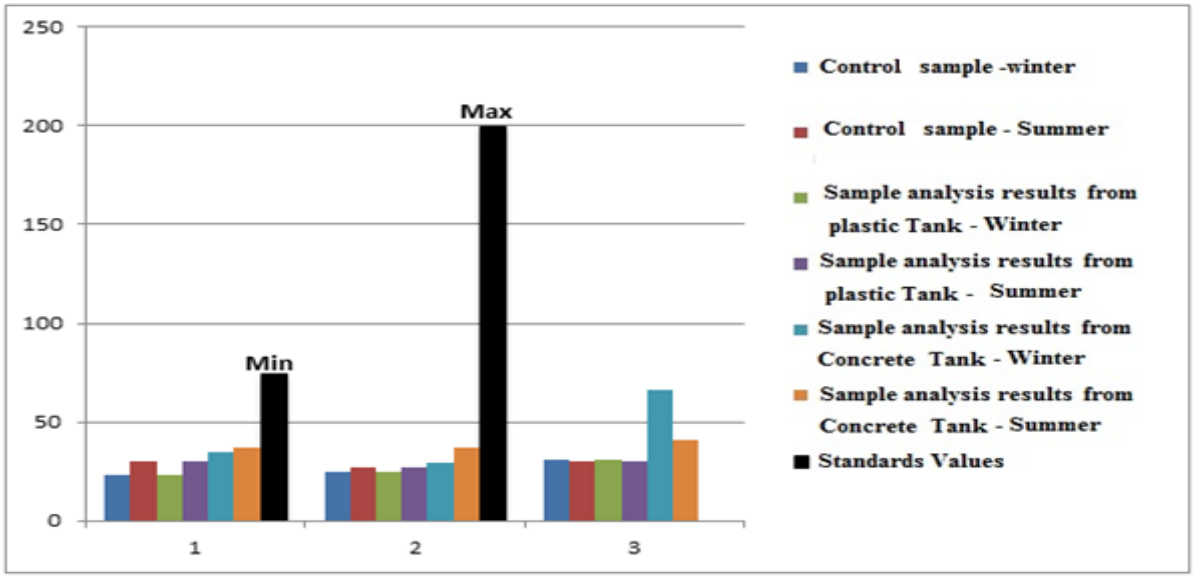

Figure 07: The Calcium, Ionized in mg/l values variation for each sample results

The water becomes loaded with calcium ions when it crosses calcareous soils so the weak values of calcium concentration recorded in the three areas is logic. But in all cases the concrete tanks have slightly recorded high values compared to plastic tanks, which can be explained that the harvested water has reacted with concrete.

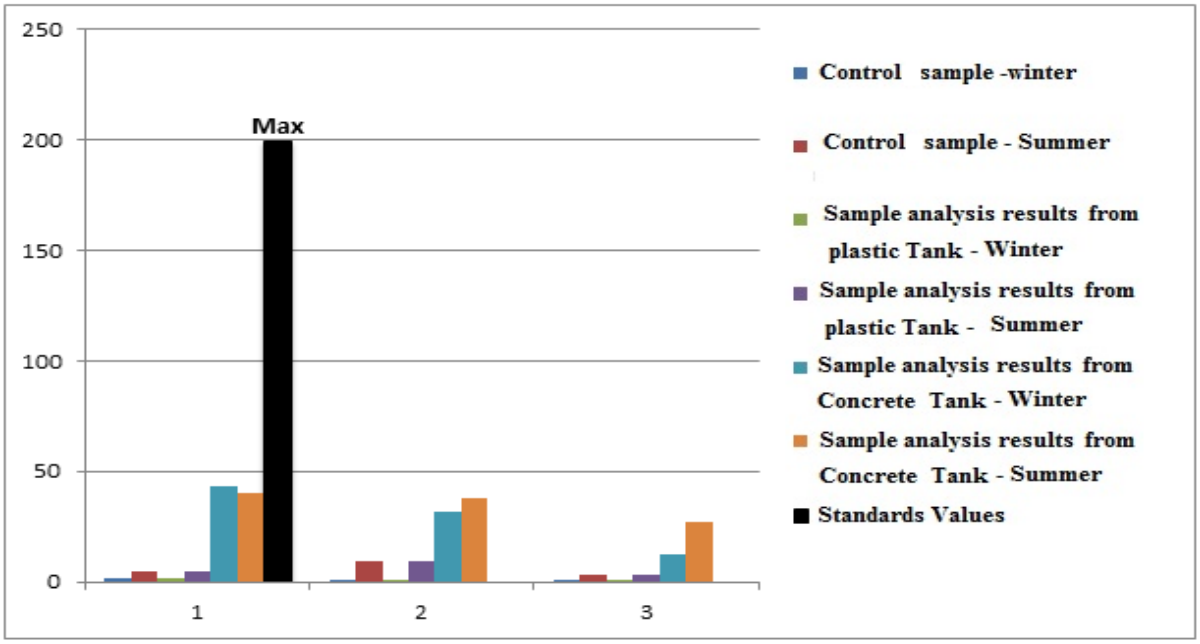

Figure 08: The Sodium in mg/l values variation for each sample results

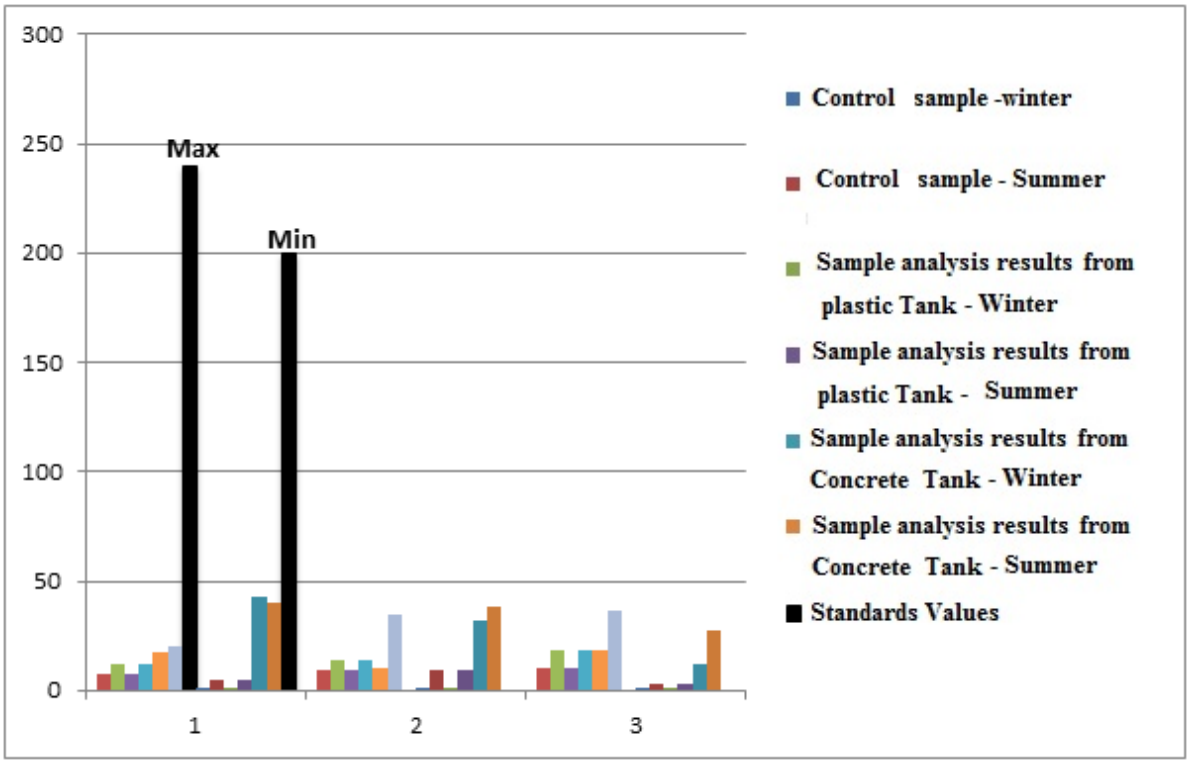

Figure 09: The potassium in mg/l values variation for each sample results

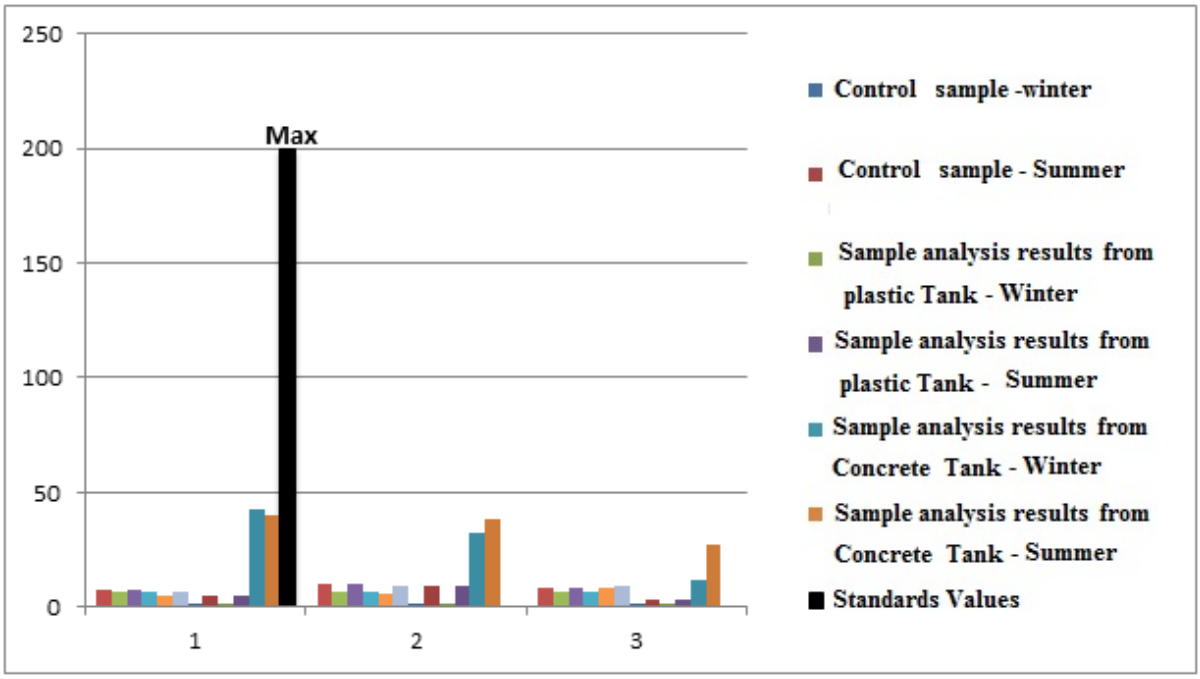

Figure 10: The chloride in mg/l values variation for each sample results

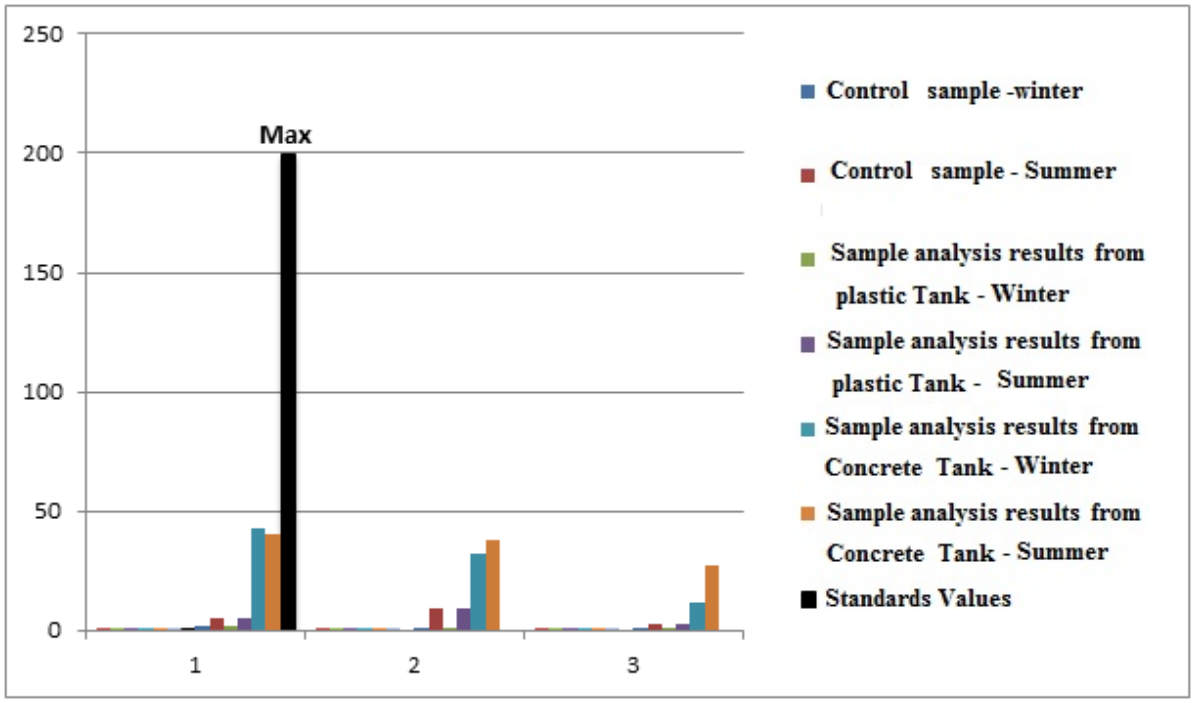

Figure 11: The Nitrate in mg/l for each sample results

Rainwater adsorbs atmospheric particles, dissolves gases in the atmosphere. These elements have natural or human origins. The quality of the rainwater reflects the quality of the air. The chemical composition of rainwater is variable, over time, and depending on the place. As shown in the figures 08, 09, 10 and 11. The results found at the level of each zone are close whatever the study element: Sodium or Potassium ion or Chloride or Nitrate. This phenomenon can be explained by the fact that all of the three places studied have quite similar activities and environments. The results shown in the figures 08, 09, 10 and 11 are all far from the Algerian drink water standards. The samples stored in concrete tanks have recorded the highest concentration of : Na, K, Cl, NO_3 compared to the other samples.

4 CONCLUSIONS

In the three samples the pH values are slightly acid due to the dissolution of carbon dioxide in storm water making the water acidic and outside the pH range allowed according to the standard values. The overall mineralization belongs to the Algerian drink water standards. For the rest of the salts: Ca, Na, K, Cl, NO_3 they are all recorded with weak values which confirm the fact that all of the three places studied are quite similar. The concrete Tanks are much more suitable for harvesting water due to the behaviour of concrete towards the quality of water. In general the collected water is weak in minerals and need for salts balance to be suitable compared to the Algerian drink water standards.

REFERENCES

[1] Abdelaziz Z, Radwan AW and Mohamed A (2006) Water Harvesting Techniques in the Arab Region. UNESCO/G-WADI Workshop on Water Harvesting, 20-22 November, Aleppo, Syria.

[2] Ahammed MM, Meera V(2006) Iron hydroxide-coated sand filter for household drinking water from roof-harvested rainwater. J. Water Sup: Res and Techno-AQUA. 55(7–8), 493 - 498.

[3] Christopher D, Khosrow F and Chantelle L (2009) Assessment of rainwater quality from rainwater harvesting systems in Ontario, Canada. J. Water Supply: Res and Techno - AQUA. 85(02) 117-134.

[4] Coombes PJ, Kuczera G, Kalma JD and Dunstan R H (2000) Rainwater quality from roofs, tanks and hot water systems at Figtree Place. Proceedings of the 3rd International Hydrology and Water Resource Symposium of the Institution of Engineers, Perth, Australia, November.

[5] Debusk KM, Hunt WF, Wright JD (2013) Characterizing rainwater harvesting performance and demonstrating stormwater management benefits in the humid southeast USA. J Am Water Resourc Assoc 49(6) 1398–1411.

[6] Domènech L, Heijnen H, Saurí D (2012) Rainwater harvesting for human consumption and livelihood improvement in rural Nepal: benefits and risks. J. Water Environ 26 465–472.

[7] Evans C A, Coombes PJ, and Dunstan R H (2006) Wind, rain and bacteria: the effect of weather on the microbial composition of roof-harvested rainwater. Water Res. 40(1) 37– 44.

[8] Khouri J, Amer A, and Salih A (1995) Rainfall Water Management in the Arab region. State of the Art Report edited for UNESCO, Cairo.

[9] Maoudombaye T, Ndoutamia G, Seid ali M, Ngakou A (2015) Etude comparative de la qualite physico-chimique des eaux de puits, de forages et de rivieres consommees dans le bassin petrolier de doba au Tchad" ; Larhyss Journal, 24 193-208.

[10] Martinson D, Thomas T (2005) Quantifying the first-flush phenomenon. Coventry, United Kingdom, DTU/University of Warwick. Proceedings of the 12th International Rainwater Catchment Systems Association Conference, New Delhi, India, November.

[11] Mays L, Antoniou, G P, Angelakis A N (2013) History of water cisterns: Legacies and lessons. Water . 5 1916–1940.

[12] Pacheco J, Marin L., Cabrera A, Steinich B. and Escolero O (2001) Nitrate temporal and spatial patterns. Environmental Geology 40 708-715.

[13] Sazakli E, Alexopoulos A, Leotsinidis M (2007) Rainwater harvesting, quality assessment and utilization in Kefalonia Island, Greece. Water Res. 41(9), 2039–2047.

[14] Scott R, Waller D (1987) Water quality analysis of a rainwater cistern system in Nova Scotia, Canada. Proceedings of the 3rd International Rainwater Collection System Association Conference. Khon Kaen, Thailand, January.

[15] Spinks A T, Coombes P, Dunstan R H and Kuczera G (2003) Water quality treatment processes in domestic rainwater harvesting systems. In: Proceedings of the 28th International Hydrology and Water Resources Symposium, Wollongong, Australia, 10–14 November.

[16] Tariqu I M, Mohabbat U M, Mostofa Amine, MG, Sahadat H (2016). Rainwater harvesting potential for farming system development in a hilly watershed of Bangladesh. Appl Water Sci. doi:10.1007/s13201-016-0444-x.

[17] Taylor R, Sloan D, Cooper T, Morton B and Hunter I (2000) A waterborne outbreak of Salmonella Saintpaul. Commun. Dis.Intell. 24(11) 336–340.

[18] Texas Water Development Board (2005) The Texas Manuel en Rain Water Harvesting, Third edition, Austin, USA.

[19] The official journal of laws of the republic state of Algeria, water drinks standards (AWS). (2000) 5 18-23.

[20] Thierry G, Martin CD, Downing P (2007) Controlling for interstimulus perceptual variance abolishes N170 face selectivity. Nature Neuroscience. 10(4) 505-11.

[21] Van M, Mahler S G, Hope V, Lewis G, Whitmore J and Gao W (2003) Contamination of potable roof-collected rainwater in Auckland. Water Res. 35(6), 1518–1524.

[22] Waller D (1989) Rain Water _ An Alternative Source in Developing and developed Countries, Water International, 14 27-36.

[23] Yaziz M I, Gunting H, Sapari N and Ghazali A W (1989) Variations in rainwater quality from roof catchments. Water.Res. 23(6) 761–765.