

Study and Evaluation of Stored Drinking Water Characteristics Using Three Types of Roof Water Tanks in Kirkuk Governorate, Iraq

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Abstract: The scarcity of safe drinking water is one of the problems faced by the majority of cities in the world. Kirkuk city is one of these cities, which suffer from a shortage of drinking water. People have adopted the use of different rooftop tanks to overcome this problem. This research focuses on studying the effect of storage time on the five main characteristics of drinking water, which include, acid index (pH), electrical conductivity (EC), total suspended solids (TSS), total dissolved solids (TDS), and turbidity (Tr). Three types of tanks were used predominantly (galvanized metal, plastic, and aluminum tanks). By analyzing the results, the characteristics of three samples of municipal source water obtained. Three samples were taken from each tank at different periods (4, 8, and 12 days). The results showed that the storage time affected the characteristics of drinking water. These characteristics differed from one tank to another. Metal tanks showed an increase in total dissolved solids, due to the evaporation process, even as plastic and aluminum tanks showed an increase in pH. The properties of all storage water tanks changed with times, but overall, the results were within the Iraqi limitation for drinking water. It was not easy to only depend on the results of this study to believe that any one type of water tank was better than the other, as the values of most of the variables studied had varied from one type to other. However, many studies have indicated a number of health risks, and most significantly with regard to plastic tanks, which are said to contain dangerous organic compounds that can be transferred to water. Metal tanks can cause zinc leakage, caused by a number of environmental factors at high levels. Aluminum tanks also can have an effect on the water in tanks.

Key words (drinking water; storage; Kirkuk; rooftop tanks)

دراسة وتقييم خصائص مياه الشرب المخزنة لثلاثة أنواع من خزانات مياه السطح في

محافظة كركوك بالعراق

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الخلاصة: ندرة المياه الصالحة للشرب واحدة من المشاكل التي تواجهها غالبية المدن في العالم. مدينة كركوك هي واحدة من هذه المدن، التي تعاني من نقص في مياه الشرب الناس تكيفت لاستخدام خزانات مختلفة في السطح للتغلب على هذه المشكلة. ويتركز هذا البحث على دراسة تأثير وقت التخزين على الخصائص الرئيسية الخمسة لمياه الشرب التي تتضمن مؤشر الحمضية (pH) والتوصيل الكهربائي (EC)، ومجموع المواد الصلبة العالقة (TSS)، مجموع المواد الصلبة الكلية (TDS)، والعكورة (Tr). تم استخدام ثلاثة أنواع من الخزانات الشائعة الاستعمال (المغلقة المعدنية والبلاستيكية والألومنيوم). من خلال تحليل نتائج خصائص ثلاث عينات لمياه المصدر مع ثلاث عينات مأخوذة من كل خزان وفي فترات مختلفة (4، 8، 12) يوم. تبين النتائج أن وقت التخزين لها تأثير على خصائص مياه الشرب. ويختلف هذا التأثير من خزان إلى آخر. خزانات معدنية تظهر زيادة في مجموع المواد الصلبة الذائبة بسبب عملية التبخر بينما خزانات البلاستيك والألومنيوم تظهر زيادة في درجة الحموضة. بمرور الوقت تغيير خصائص الماء المخزون في جميع خزانات المياه ولكن عموماً، النتائج ضمن حدود المواصفات العراقية لمياه الشرب. فإنه ليس من السهل فقط اعتماداً على نتائج هذه الدراسة تحديد أي نوع من هذه الخزانات أفضل من غيرها لاعتبارات عديدة، حيث تراوحت قيم معظم المتغيرات التي درست من نوع واحد إلى آخر ضمن حدود المواصفات العراقية. بيد أن العديد من الدراسات تشير إلى عدد من المخاطر الصحية، والأهم من ذلك فيما يتعلق بخزانات بلاستيكية تحتوي على المركبات العضوية الخطرة يمكن أن تنقل إلى المياه. خزانات معدنية يمكن أن يسبب تسرب الزنك بعدد من العوامل البيئية في المستويات العليا. يمكن أن يكون لخزانات الألومنيوم أيضاً آثار على الصحة العامة.

1. INTRODUCTION

One of the most important challenges of the twentieth century is the provision of drinking water suitable for human consumption [1, 2, 3]. In most countries of the world, especially those that suffer from water shortage, the society uses reservoirs of various capacities for keeping sufficient quantities of this water for daily use. The problems of water quality in storage tanks can be classified as chemical, physical, and microbiological. The deterioration of water quality probably results from the excessive storage period of the water in many reservoirs. The excessive and long period of holding and storing water may cause chemical changes and microbial growth [4]. The reservoirs of water, especially water reservoirs, can be a potential health hazards if they are not placed in the proper place and, are not properly constructed and safely maintained [5]. These tanks vary in size and type, and are made of galvanized

metal, aluminum, and recently, a new type of polymeric materials (plastic tanks) has been used. Water pollution problem in roofs tanks of houses depends on many factors. They are affected by physical factors (plankton), chemical factors (leakage of some components of reservoirs, such as, zinc and others), and biological factors (bacteria and viruses). This type of water pollution may cause many health problems, such as, cholera, poliomyelitis, malaria, diarrhea, hepatitis, typhoid, renal failure, bilharzia, liver disease, and cancer [6, 7, 8]. The most significant risks and health problems caused by pollution of water in the domestic tanks are due to the chemical contamination of a number of components of these reservoirs [9]. Tanks that are made of aluminum, over time and due to weakness of sustainability, affect the nature of the stored drinking water[10]. Even as the metal reservoirs (galvanized) may cause leakage of a certain amounts of heavy metals, especially zinc and cadmium[11]. Also in plastic reservoirs, some of its organic compounds may leak into the water and provide a conducive environment for the growth of bacteria [12, 13]. Concrete reservoirs may be a habitat for the presence and spread some of microbial species, which can stick to their coarse surfaces and become difficult to clean [14]. Reservoirs that are made of asbestos, are considered to be an important source of a number of pollutants that can cause cancerous tumors to grow[15, 16]. In recent times, many people have resorted to the use of plastic storage tanks based on their belief that they are good for the safety of their health and environment. However, many recent studies indicate that there are many potential health and environmental risks involved, due to the leakage of some of the plastic organic components into the drinking water, which may lead to several serious diseases [17, 18]. This study can evaluate the impact of the material of the storage reservoir on the water quality in roof water reservoirs, in the city of Kirkuk, Iraq. The overall objective is to determine how the materials used to construct household water storage tanks impact the quality of water in household storage reservoirs.

2. MATERIALS AND METHODS

The study was conducted on three types of surface water tanks used in houses of Kirkuk city. The first type was made of metal material (galvanized), the second was made of plastic, and the third type was made of aluminum. The water quality test was conducted on three samples, for each tank type, at three different periods (4 days, 8 days, and 12 days) in May 2017. All tests were conducted at the Laboratory of Environmental and Pollution Department in the College of Technical Engineering, in Kirkuk (North Technical University). The total number of samples was 27, as also a control sample from the source of filling the reservoirs, without storage. The physical and chemical properties of stored water including pH, electrical conductivity, total suspended solids (TSS), turbidity (NTU), and total dissolved solids (TDS) were measured for each sample after the storage periods and compared with the control sample taken from the water source without storage.

3. RESULTS AND DISCUSSION

The results of water properties obtained by sampling water of all types from storage roof tanks, at three different periods, and the control sample (average and standard deviation) are illustrated in Table (1), shown below.

Table (1): Physical and chemical properties of water from three types of demotic tanks, before and after the storage periods.

Type of Tank	Storage Period	pH	Electrical conductivity ($\mu\text{S}/\text{cm}$)	Total suspended solids (TSS) (mg/l)	Turbidity (NTU)	Total dissolved solids (TDS) (mg/l)
Metal Tank (galvanized)	4 days	7.27 ± 0.2	737 ± 95.3	840.2 ± 41.5	4.21 ± 0.31	788 ± 8.5
	8 days	7.24 ± 0.1	824 ± 83.2	1019 ± 69.4	4.3 ± 0.44	912 ± 55.43
	12 days	7.22 ± 0.3	1302 ± 124.8	1123 ± 100.2	4.36 ± 0.35	1210 ± 32.7
Plastic Tank	4 days	7.82 ± 0.02	943 ± 120.2	128.1 ± 20.9	4.13 ± 0.21	133.5 ± 22.4
	8 days	7.87 ± 0.07	864 ± 98.4	68.9 ± 13.1	4.11 ± 0.22	75.6 ± 13.8
	12 days	7.91 ± 0.01	756 ± 112.7	34.2 ± 35.4	4.08 ± 0.31	38.3 ± 9.22
Aluminum	4 days	7.92 ± 0.03	1085 ± 95.7	310.2 ± 25.4	4.22 ± 0.11	1480 ± 70.5

Tank	8 days	8.11 ± 0.06	1013 ± 88.4	175.4 ± 12.8	4.14 ± 0.13	718 ± 40.8
Tank	12 days	8.2 ± 0.02	723 ± 82.3	155.3 ± 10.2	4.05 ± 0.12	612 ± 66.2
Control Sample (source of water)		7.2 ± 0.01	458 ± 102.5	245.4 ± 8.2	4.44 ± 0.01	510.6 ± 10

For pH values, the study found that the highest pH value was (8.2 ± 0.02), recorded in the water sample of the aluminum tank type after a storage period of 12 days, where the lowest value was (7.2 ± 0.01) for the control sample as shown in Figure (1). The increase in the value of pH in the water from the aluminum tanks, in comparison to other types, may be due to the occurrence of chemical reactions in water.

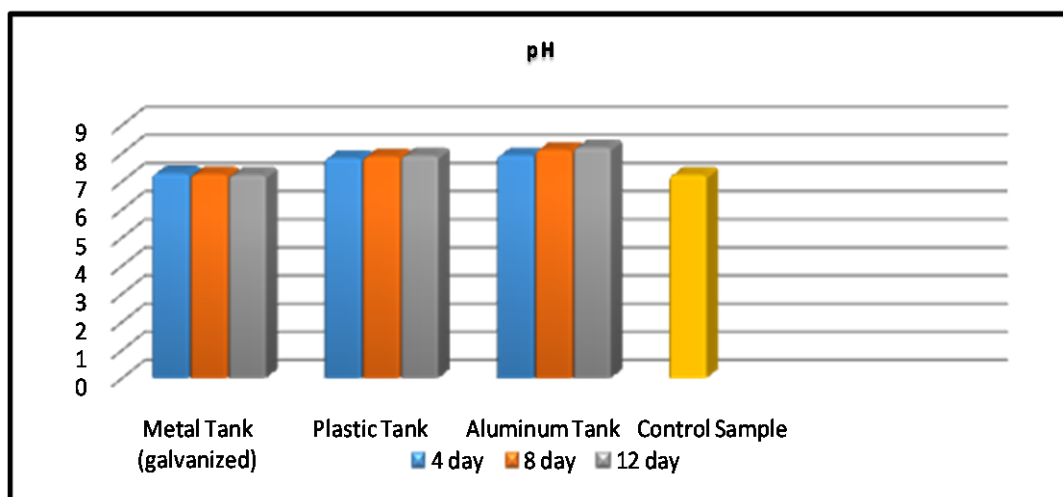


Figure (1): Average pH values of water samples after three periods of storage in three types of storage tanks.

One of the significant chemical reactions that occurred in the stored water was an increasing pH values, as storage facilitated the absorption of heavy elements that could exist in water for various reasons, such as, the elements that leaked by corrosion in the pipe of the water distribution system, as the readiness of these elements depending on the value of pH. The increase in the value of pH leads to the propagation of living organisms and changing the standards of water. These results are similar to the results of many studies that dealt with drinking water produced in drinking water treatment plants[20] . A study was carried out in Baghdad and the pH value ranged between (6.63 and 7.9), also the study, where the samples were collected from the Al-Wahda and Al-Qadisiyah water treatment plants, from July 2015 to April 2016, and the results of pH values ranged between (7.15 and 8.55). The pH values in this study for each types of tanks and the control sample were within the permissible limits for the Iraqi criteria and the World Health Organization (WHO) standards for drinking water (6.5 – (8.5).

The results of electrical conductivity (EC) for water samples from the metal tank (galvanized) ranged from (737 μS/cm) for a storage period of four days to (1302 μS/cm) for a storage period of twelve days, even as, the results of samples from the plastic tank ranged from (943 μS/cm) for a storage period of four days to (756 μS/cm) for a storage period of twelve days.. On the other hand, the electrical conductivity of the water samples for the aluminum tank ranged from (1085 μS/cm) for a storage period of four days to (723 μS/cm) for a storage period of twelve days. The electrical conductivity value for the sample of water from the control was (458 μS/cm), as shown in Figure (2) below.

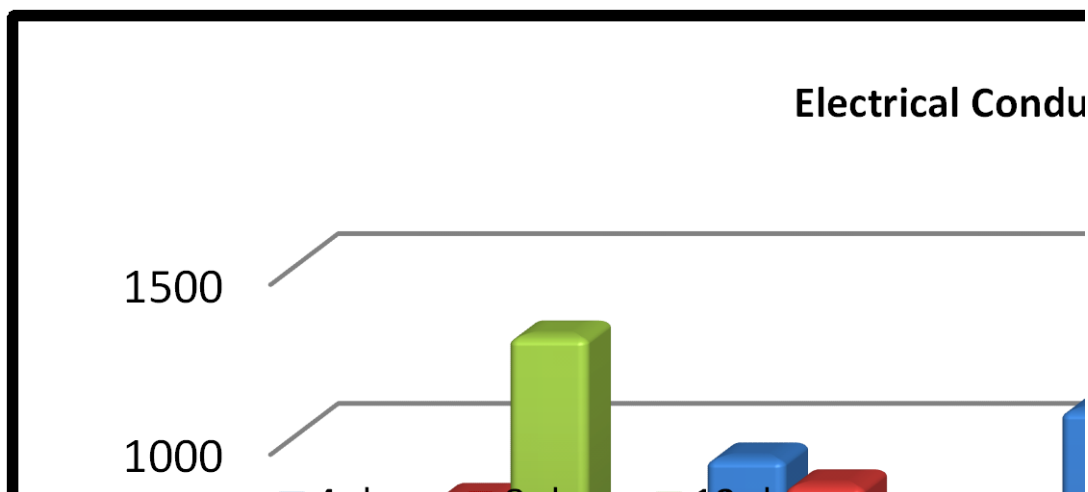


Figure (2) Average electrical conductivity values of water samples after three periods of storage in three types of storage tanks.

The increase in values of electrical conductivity for water samples in metal reservoirs (galvanized) compared with the other types of reservoirs, is perhaps because the evaporation process in these types of reservoirs is more than the other types. This process will increase the concentration of total dissolved solids and increase the concentration of salts that exist in the water, which are responsible for increasing the values of (EC). The results of this study are very similar to the results of other studies conducted on drinking water in other parts of Iraq, for example Al Azawi found that the EC values of the water samples in the study ranged from (713.5 µS/cm) to (1108 µS/cm) [19]. The values illustrated are within the Iraqi permissible limits and the WHO standard limits, which is (1500 µS/cm).

The results of the tests for total suspended solids (TSS) in water samples recorded the highest values for the water samples stored in the metal tanks (galvanized), where their values ranged from (840.1 mg/L) to (1123 mg/L), even as the lowest values of TSS were found, in water samples obtained from the tanks made of plastic, where their average values ranged from (756 mg/L) to (943 mg/L). The results of the TSS for each sample are illustrated in Figure (3).

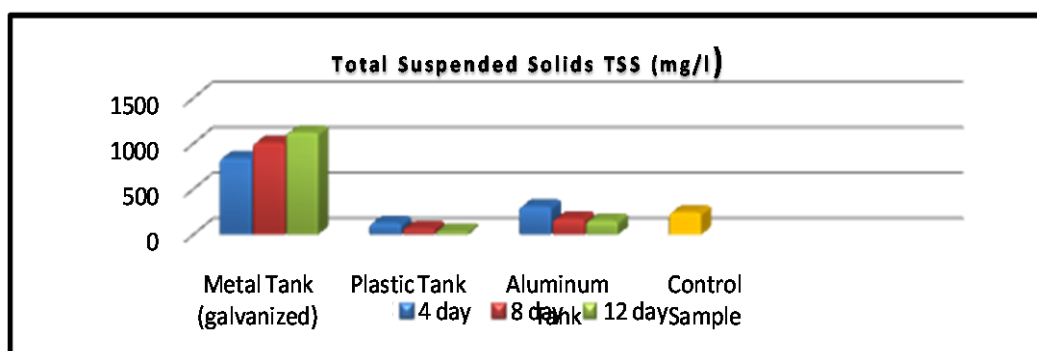


Figure (3): Average values of total suspended solids in water samples after three periods of storage in three types of storage tanks

The reason of high values of (TSS) in water samples stored in metal reservoirs compared to the results of other types of reservoirs may be attributed to the leakage of the internal coating of reservoirs into water and the spread of microorganisms because this type of reservoir provide suitable environment for the growth and reproduction of microorganisms, as the spread of organic and inorganic chemicals. However, the results of this study were within the allowed standards for Iraqi limits as well as the (WHO) standards limits. The study found that the highest rate of TSS was found in the water samples from the aluminum tank, where it ranged from (612 mg/L) to (1480 mg/L) and the lowest values were found in the water samples from the plastic tank, which ranged from (38.3 mg/L) to (133.5 mg/L). However, the values of water samples from the metal tank (galvanized) ranged from (788 mg/L) to (1210 mg/L). The total dissolved solid in the control water sample was (510.5 mg/L), as shown in Figure 4.

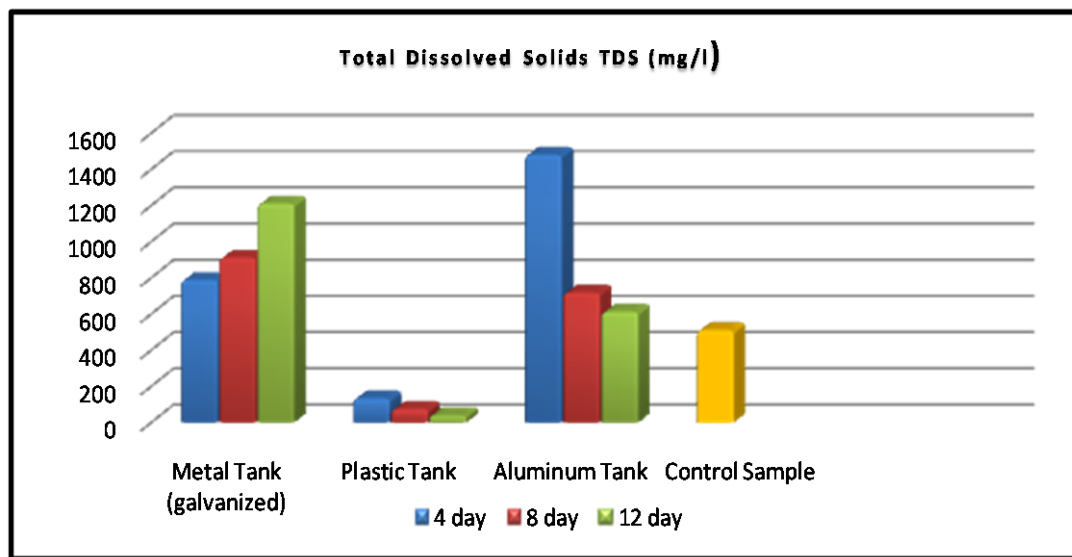


Figure (4): Average values of total dissolved solids in water samples, after three periods of storage, in three types of storage tanks.

These results were similar to the results of many studies on drinking water, conducted at different locations in Iraq, both in the production plants and in the sites where it was used (homes). For example, Al Azawi found that the total dissolved solids ranged from (401 mg/L) to (759 mg/L) in their study, which was conducted on potable water samples collected from Al-Wahda and Al-Qadisiyah water treatment plants, from July 2015 to April 2016. The average value of the TSS in this study for each type of sample was within the acceptable standards of Iraqi limits and the WHO limits, which was (2000 mg/L). The results of this study for water turbidity for all types of water samples as well as for the control sample were very similar and ranged from (4.05 NTU) to (4.45 NTU). All results were within the limits of the permitted specifications of Iraqi standards as well as the WHO standards, which was (5 NTU), as illustrated in Figure (5).

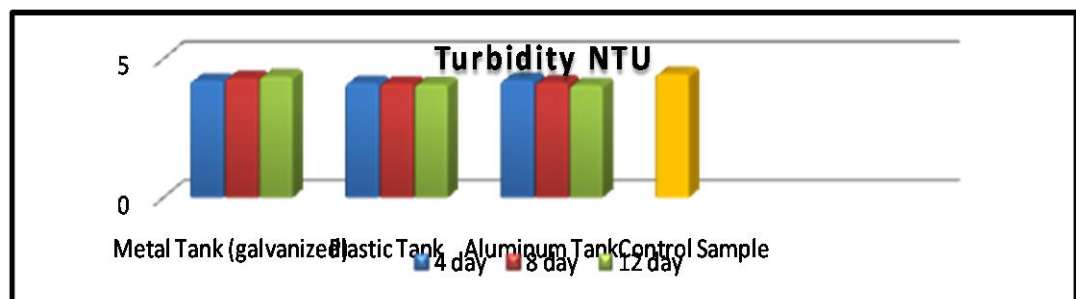


Figure (5): Average turbidity values of water samples after three periods of storage in three types of storage tanks.

Based on the results of the tests on water samples and their conformity with Iraqi and international (WHO) standards, it was found that the physical and chemical properties of all types of water samples under study were similar to the limits allowed in the standard specifications. It is not easy to consider that any one of water tank under study is better than the other depending only on the results of this study; the values of most of the variables studied have varied from one type to another. However, many studies indicate a number of health risks, most notably with regard to plastic tanks, where dangerous organic compounds can transfer to the stored water. Metal tanks can cause zinc leakage, due to a number of environmental factors at high levels. Aluminum tanks can also have significant effects on stored water.

4. CONCLUSION

Examining the method and the extended period of time for storing drinking water, in cities that suffer from a shortage of drinking water, is very important, to avoid their effect on public health. It is also important to choose the appropriate method for storage and safe periods for storage. However, this study has not been able to identify the best tank quality to choose from, due to divergent results of properties for each type of tank used. It is very clear that the water properties had changed after storage, although they were within the parameters permitted and within the

specifications of the local and international organizations. It needs further a comprehensive biological and chemical test to accurately choose the best type of tank and save storage time.

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