JOURNAL OF ENGINEERING RESEARCH

Refereed and issued twice annually by the
Faculty of Engineering - University of Tripoli

Issue 30 September 2020

POTABLE WATER STORAGE CAPACITY EVALUATION IN THE METROPOLITAN AREA OF TRIPOLI

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الملخص

يعد نظام إمدادات المياه في بلديات حاضرة العاصمة طرابلس والتي تشمل بلديات: طرابلس المركز، أبوسليم، حي الأندلس، سوق الجمعة، عين زارة، تاجوراء، قصر بن غشير غير موثوق به. حيث أن أجزاء كبيرة من مياه الإمداد الحضري تعاني من التدهور الهيكلي والإنقطاعات المتكررة والتوصيلات غير القانونية بالإضافة إلى بعض المعوقات الأخرى. ونتيجة لذلك، يعاني سكان العاصمة من نقص في المياه، وانقطاع متكرر للمياه وضغوط منخفضه بشبكة التوزيع خصوصا خلال ذروة الطلب اليومي. تم في هذه الدراسة تقويم السعة التخزينية للمياه بمنظومة إمداد المياه في حاضرة طرابلس، حيث تم تجميع البيانات المتعلقة بحالة خزانات المياه العلوية والأرضية المتاحة وذلك من خلال الزيارات الميدانية والمقابلات الشخصية مع المتخصصين بالشركة العامة للمياه والصرف الصحي في طرابلس وجهاز تنفيذ مشروعات الإسكان والمرافق. أشارت هذه الدراسة إلى وجود عجز في السعة التخزينية للمياه حاليا. كما تضمنت الدراسة توصيات حول كيفية الاستفادة من نظام إمدادات المياه للقضاء على العجز الحالي.

إجمالي السعة التخزينية المائية المتاحة 863,932 متر مكعب، وتبلغ السعة التخزينية المائية الفعالة منها 208,210 متر مكعب. كما تقدر نسبة السعة المائية الفعالة للخزانات الأرضية والخزانات العلوية 24,6%، 11,5% على التوالي.

ABSTRACT

The water supply system of the metropolitan area of Tripoli (including municipalities of: Central Tripoli, Aubuslem, Hay-Alandulus, Sug Alguma, AinZara, Tajura, Quser Ben gsheer) is considered to be unreliable; significant parts of the municipal water suffer from structural deterioration, disruption, and illegal connections as well as other problems. As a result, the inhabitants of the metropolitan experience water inadequacy, frequent water outages and insufficient water pressures during the daily demand peaks. This study assessed the water storage capacity for the municipal water supply system in the metropolitan area of Tripoli. The data on the available water storage in the metropolitan area of Tripoli was collected from numerous visits to the General Company of Water and Wastewater (GCWW) and the Housing and Infrastructure Board (HIB) offices in Tripoli. The required storage capacity was calculated based on different arithmetical and estimation methods. This study indicated a deficit of storage for the current and future water storage capacity requirements. The study also included recommendations on how to utilize the water supply system to eliminate the deficit.

The available total capacity of water storage tanks was calculated as 863,932 m^3, while the available active water storage capacity was only 208,210 m^3. The active ground storage represents 24.6%, while the active elevated storage represents 11.5% of the available total storage capacities respectively.

KEYWORDS: Available Water Storage Capacity; Required Storage Capacity; Metropolitan Area of Tripoli.

INTRODUCTION

The main water resource in Tripoli is the Man-Made River (MMR), which supplies the city of Tripoli by about 500,000 m^3/day of water through pipelines and storage facilities. However, The MMR reliability is considered to be very low as it suffers from disruption and illegal connections along the whole main pipeline and main pumping stations and the storage tanks are out of service. Consequently, the inhabitants of the metropolitan experience water inadequacy, frequent water outages and insufficient water pressures during the daily demand peaks and frequent water outages during maintenance and repair or emergency outages, such as disruption to significant parts of the municipal water system due to armed conflicts. The consequences of those incidents forces people to provide their own illegal source of water wells which might be contaminated and leads to aggravating other serious problems like the drop-in underground water table level or the intrusion of seawater into groundwater. This study is considered as a contribution to achieve high reliability system in Tripoli by fulfilling the following objectives:

- Identify and calculate the available storage capacity in Tripoli.
- Obtain a suitable pattern of the demand curve depending on previous study to represent the metropolitan area of Tripoli.
- Estimate the required storage capacity in Tripoli using different methods.
- Identify if there is a relationship between storage capacity and water outages and whether the storage is enough to meet daily variations and emergencies.

WATER SUPPLY SYSTEM IN TRIPOLI

The evolution and growth of cities is tied directly to the evolution of water supply systems. Water supply system is the facilities for meeting water requirements for consumers and all public sectors, including water for domestic, commercial and light industrial uses, also to provide water for firefighting and other public needs. And since the water storage system is an essential component of a water supply system, it has to be adequate and sufficient to fulfill the water storage requirements and public water demands.

The water supply system used in Tripoli is the gravitational system. Water is supplied from Sidi AlSayeh ground tank located in South Tripoli through the MMR system. Storage capacity, being an essential component of a water system, influenced the objective of this study which is to assess the available water storage capacity for the municipal water supply system in the metropolitan.

METHODOLOGY

The study started by collecting data on the water storage tanks that are existed in the metropolitan area of Tripoli from visits to the GCWW and the HIB offices [1]. The data included information on the existing storage tanks both ground and elevated, such as location, capacity, water supply sources, and the structural and operational conditions of the tanks.

The required storage capacity components to cover the storage requirements for the metropolitan was first estimated using data from a previous study that was carried out at the East part of Tripoli [2]. The data of this study was collected in 2017 in a residential area for twenty single-family houses to conduct the residential water demands. The

residential water demands for all families were aggregated regardless of the family size, daily behaviors and time intervals. The required storage capacity was calculated using different arithmetical and estimation methods to calculate the equalization, emergency and fire storage capacities based on the data of the previous study [2] that shows the variation of residential water demand. The equalization storage capacity was calculated using different methods, some are arithmetical, and others are estimated based on empirical knowledge and previous results. The arithmetical methods included three methods: The Mass Curve, Sequent Peak Analysis and the analytical method [3-5]. These methods are considered to be accurate as they are based on realistic data. While the estimated methods were used only as a general guideline. The fire storage capacity was calculated using the National Board of Fire Underwriters (NBFU) formula in the USA and the American Water Works Association (AWWA) standards as cited in [5]**.** As there is no formula for determining the amount of emergency storage required, it was therefore determined based on the water demand during the period of emergency [3,5]. Furthermore, future predictions were conducted to estimate the required storage capacity for twenty years later using the same approach for the current year.

RESULTS AND DISCUSSION

The Available Water Storage Capacity

For evaluating the available water storage capacity, the collected data from the GCWW [6] and the HIB office [7] of the existing storage tanks in the metropolitan showed that 75.4% of the ground water tanks, and 88.5% of the elevated tanks were inactive (Table 1).

Table 1: The current storage capacity in m^3 [1]

Storage type	Condition		Total
	Active	Inactive	
Ground	204,660	628,430	833,090
Elevated	3,550	27,292	30,842
Total	208,210	655,722	863,932

The total number of water tanks in the metropolitan area is 180. There are 31 ground tanks, 8 of them are active. The total numbers of elevated tanks are 149; only 16 of them are active as shown in Figure (1a). Figure (1b) shows that 23.7% of ground storage capacity is active while 72.66% of total storage capacity is inactive; the active and inactive elevated storage capacities are 0.41% and 3.71% of total storage capacity respectively.

Given that the capacity of the ground tanks ranges from 120 to 200,000 m^3 and the capacity of the elevated tanks ranges from 50 to 2,500 m^3 it can be noticed that most of the water storage capacity comes from the ground tanks especially Sidi AlSayeh ground tank that has a capacity of 200,000 m^3. In addition, the results showed that most of the ground tanks are in a good structural condition unlike most of the elevated tanks which require major maintenance program or may needed to be dilapidated.

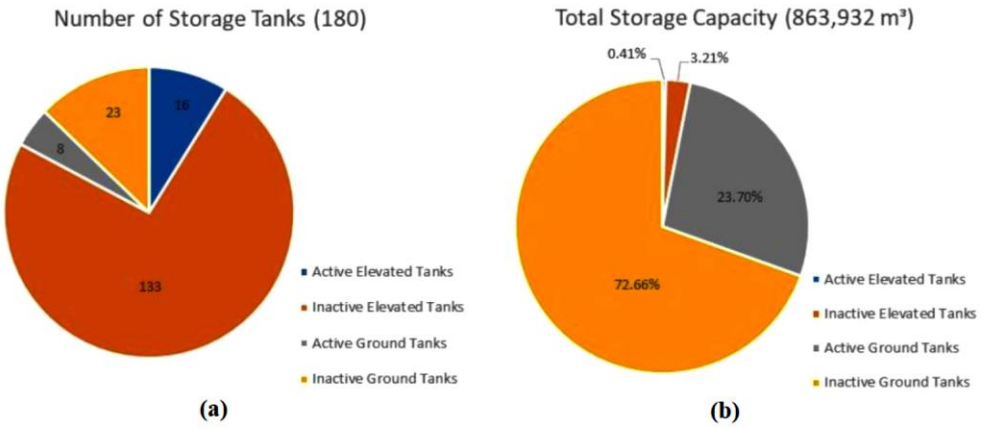

Figure 1: Data collected on ground and elevated tanks in the metropolitan [1]

It was found out that many of the elevated tanks are inactive due to material (concrete and reinforced steel) deterioration as shown in Figure (2) [1]. Some elevated tanks have not been but in services due to structural design mistakes such as shown in Figure (3).

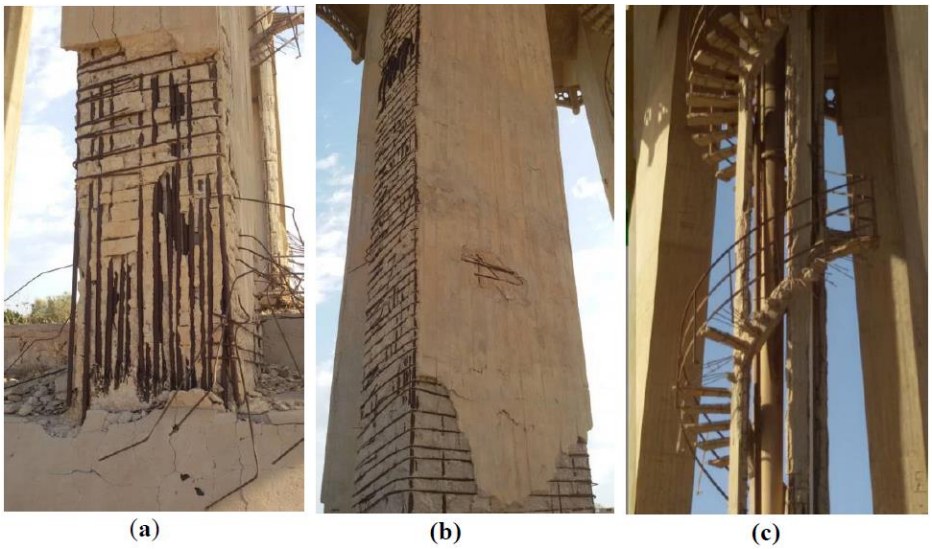

Figure 2: Photos of deteriorations of construction materials of inactive elevated tanks located in Sug-Alguma Municipality.

Figure 3: Photo of inactive elevated tank due to structure design faults in Central Tripoli Municipality [1]

Figure (4) below show the condition of the elevated tanks as they suffer from leakage and other maintenance defects [1].

Figure 4: Photos of inactive elevated tank due to water leakage

The Required Water Storage Capacity

For evaluating the required storage capacity, different arithmetical and estimation methods were used to calculate the equalization, emergency and fire storage capacities based on the data of the previous study [2] that shows the variation of residential water demand as shown in Figure (5).

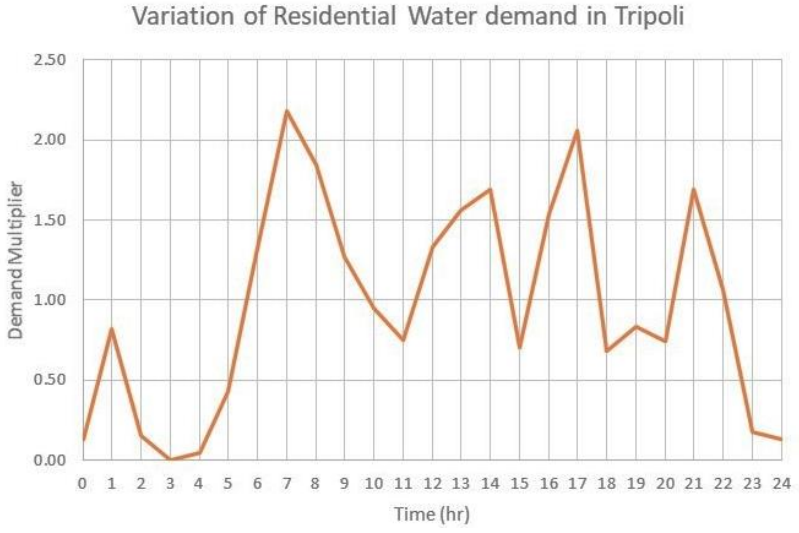

Figure 5: Variation of residential water demand in Tripoli [1]

Since the data used from the 2017 study [2] was only representing the residential demand, the effect of non-residential demand and losses were taken into account by using data collected from the GCWW about the amount of water delivered to residential and non-residential consumers, as the non-residential users rely on municipal infrastructure to fulfill their water needs, but the schedule of their water demands vary based on the type of user [8]. The amount of water consumed for irrigating green areas represented about 17.6% of the remained MMR water supply [9]. The total losses represents 44% of the total amount of water supply allocated to Tripoli which is divided into two types; main and secondary losses, the main losses due to illegal connections along the main pipeline

reduces the total amount of water supply by 20%, the secondary losses due to leakage and illegal connections within the network represent about 24% of the total amount of supply [10]. The total diurnal demand curve was determined after adding all demand components to calculate the required storage capacity components as shown in Figure (6).

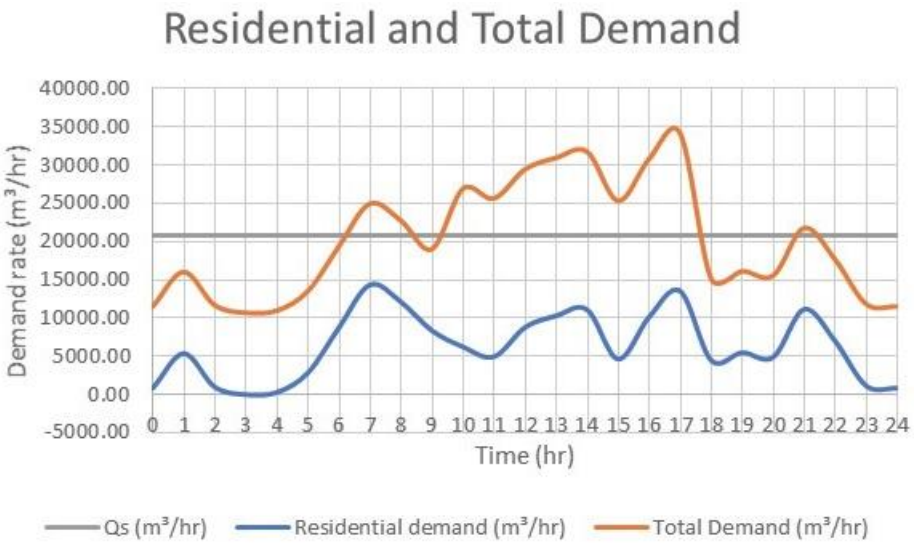

Figure 6: The total diurnal demand curve [1]

By using the total demand curve Figure (6) the required storage capacity was calculated starting with the equalization storage that was 78,661 m³, the fire storage that was calculated as 14,170 m³, and the last estimated storage volume required for emergency was 372,560 m³. Adding up the three mentioned volumes gives the required storage capacity, and due to the low performance of the distribution network and for a reliable storage system, a larger volume was taken in consideration, which yields a required storage capacity of 500,000 m^3 equal to the total daily requirements for the metropolitan. Finally, after evaluating the required storage and the available storage capacities, a deficit of 295,000 m³ was calculated for the current year. A future required storage capacity was also estimated as 645,000 m^3 for the year of 2040, which resulted an amount of deficit of 436,137 m^3. This deficit in water storage must be provided to supply water during emergencies and high demand peaks in order to maintain an adequate pressure in the water system. As a solution, to cover the amount of deficit, the main pumping stations of Airport Road, Ain Zara and Al Sowani Road are suggested to be operated so the storage tanks of the pumping stations can be used along with the other storage tanks in the metropolitan which all together represent a storage capacity of 655,722 m^3. It can be also recommended, that areas reserved by the elevated tanks that has structural defects can be utilized by ground tanks that has larger capacities.

CONCLUSION

This paper has focused on assessing the water storage capacity in the metropolitan area of Tripoli for the year of 2019. The calculated available storage capacity was compared to the calculated required storage capacity and as a result, it was indicated that the available water storage capacity is not enough for the storage requirements to fulfill

the daily needs during high demands with adequate pressure, nor to cover water outages during emergency periods. The following points illustrate the foremost outcomes of the study:

1- The total capacity of water storage tanks was 863,932 m^3, of which only 208,210 m^3 was considered as the available storage capacity due to the large number of water tanks that suffer from design, operational or structural defects.
2- Most of the inactive ground water tanks were in a good structural condition, whereas the elevated tanks suffered from severe structural defects and require major maintenance.
3- The required storage capacity was taken as 500,000 m^3. Therefore, an amount of 295,000 m^3 of deficit storage capacity was determined, and due to the lack of this capacity the water gets wasted.
4- The future required storage capacity for 2040 was about 645,000 m^3, which resulted an amount of deficit of 436,790 m^3.
5- If the inactive storage capacity of 655,722 m^3 is activated, the deficit of the current and future storage capacities will be completely covered.
6- The storage available inside the houses was not taken in consideration, where it could have reduced the amount of deficit.

RECOMMENDATIONS

Further studies are suggested to be carried out including; evaluation of the structural and operational conditions of the existing storage tanks, determination of the strategic location of the storage tanks to distribute the dedicated amount of water storage evenly to the consumption points, the possibility of replacing the elevated tanks by ground tanks accompanied with variable speed pumps, and a research study on the cost of maintenance and repair to the storage system.

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