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# Assessment of microbial quality in household water tanks in Dubai, United Arab Emirates

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**ABSTRACT**

Provision of safe, accessible, and good water quality in the community is an important step towards reducing various waterborne illnesses. However, improving the quality of water should include spreading awareness to the public regarding the importance of cleaning their household water tanks. The aim of this study was to investigate the microbial quality of water of household water tanks in Dubai. The water samples from household water tanks were collected from forty houses, and a questionnaire was given to the residents to determine the history of the water tanks. The membrane filtration technique was used to quantify heterotrophic and total coliform bacteria on plate count agar and the violet red bile agar respectively. The overall results of this study have shown that 18 out of total 40 household water tanks contained different types of bacteria concentration level beyond local and widely accepted international standards. The overall results of this study indicated that there is a lack of awareness among residents regarding the importance of maintaining proper sanitation and hygiene of the household water tanks.

**Keywords:** Heterotrophic bacteria, Household water tank, Microbial quality, Total coliform

## 1. Introduction

Waterborne illnesses caused by bacteria found in contaminated household water tanks increases the risk of spreading waterborne diseases and may lead to many infectious outbreaks. World Health Organization (WHO) data on the burden of disease suggest that approximately 3.2% of deaths (1.8 million) and 4.2% of disability-adjusted-life years (61.9 million) worldwide are attributable to unsafe water, sanitation and hygiene [1].

Water has the potential of transmitting a variety of enteric diseases such as cholera, typhoid fever, infectious hepatitis, amoebic and bacillary dysentery [2]. The main transmission routes are by consumption, contact or transfer that can be easily prevented by the strict provision of maintaining good hygiene and sanitation, and implementing easy methods that will reduce or eliminate the presence of pathogenic microorganisms and filter the contaminated water to provide safe water for human usage and consumption [3]. According to WHO, water, sanitation and hygiene contribute in preventing at least 9.1% of global disease burden and 6.3% of all deaths [4]. Several studies indicate that the lack of awareness regarding the importance of maintaining clean and hygienic household water tanks contributes to increasing waterborne diseases [5-7]. By increasing awareness about the importance of maintaining clean water tanks by using easy and effective methods will reduce the chance of pathogenic microorganism survival and disease transmission [5-7]. To ensure that the water supply that reaches households is safe; is not just the responsibility of an individual, or household members, it's the joint responsibility of the community and health authority [3, 5].

The microbiological safety of water supplies is at present assured by monitoring for the absence of the total and fecal coliform bacteria [2]. The total coliform group is a large collection of different kinds of bacteria and the fecal coliform group is a sub-group of total coliform and has fewer types of bacteria [8]. *Escherichia coli* (*E. coli*) is considered an important indicator of fecal contamination of water, and the majority of water quality analysis used worldwide mainly includes the examination of *E. coli* presence in water for the determination of water contamination [9]. There are several serotypes of *E. coli* that play a major role in intestinal and extra-in-



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testinal diseases such as urinary tract infections and it is strongly considered that *E. coli* is the only true reliable indicator of fecal pollution in water [10]. There is a strong relationship between water safety and quality and the outbreaks of waterborne illnesses due to the occurrence of *E. coli* O157 in the water [11]. A study showed that *E. coli* could survive up to 25˚C in de-chlorinated water because household water pipes and water tanks are, usually, covered and in a cool, warm area [12]. A solution to this problem is the importance of chlorinating the household water pipes and tanks at least twice a year might improve the quality and safety of water, and reduce the possibility of *E. coli* survival and transmission through the use of water [12].

A study reported the storing treated potable or drinking water in household tanks might lead to post-treatment contamination, introducing coliform bacteria and possible opportunistic pathogens into the water supply [7]. However, several studies showed the relationship between the quality and safety of water and the presence of bacteria causing illness especially *E. coli*, *Pseudomonas aeruginosa* (*P. aeruginosa*), total coliforms (fecal coliforms) and more, including the risks of being exposed to the various bacteria which are considered as causing negative effects on human health [13-14] (6, 20). A recent study in Oman showed the presence of several opportunistic pathogens in the household water tanks [15]. Currently, the UAE is the world's third largest per capita of the water consumer after the United States of America and Canada [16]. Almost all homes in Dubai are connected to the potable water supply from the concerned municipality which means an increase in water demands and water supply will lead to difficulties in monitoring and managing the quality of water reaching households especially at the point of end use. There hasn't been a particular study conducted in the UAE on the quality of water in households, particularly the microbiological quality of the household water tanks.

The objective of this study was to assess the microbial contamination level of potable water in household water tanks in Dubai, UAE. The assessment of heterotrophic bacteria, *E. coli*, *Salmonella* and *P. aeruginosa* contamination, was carried out, and relevant information pertaining to tank use and maintenance was documented to evaluate the factors affecting water quality.

## 2. Materials and Methods

### 2.1. Sample Collection and Survey

A consent form and the questionnaire were provided to the household participants prior to taking sample from their house water tanks. The survey included information related to family size, maintenance history, number, age and location of water tanks. Pre-sterilized bottles of 1 L size were used to collect samples from the household water tanks of seven different residential areas in Dubai, UAE. These areas were Al Safa, Al Barsha, Hor Alanz, Zabeel, Al Mankhol, Jumeirah and Mirdif. In total, 40 household water tanks samples were collected from 40 homes and transported on ice to the laboratory within 1-2 h of sampling.

### 2.2. Enumeration of Bacterial Species

The membrane filtration procedure was used to enumerate the bacterial species [17]. Appropriate volumes of water samples were filtered through 0.45 mm, sterile filters (Sartorius, Germany). The quantitative analyses by membrane filtration technique were carried out in duplicate. Culture media and incubation conditions used were: (a) Plate count Agar (PCA) (HiMedia, India) for heterotrophic bacteria count (36˚C, 24-48 h); (b) Violet Red Bile Agar (VRBA) (HiMedia, India) for *E. coli*, *Salmonella gallinarum*, *P. aeruginosa* and *Enterobacter aerogenes* (at 44˚C, 24-48 h).

### 2.3. Physical and Chemical Analysis

The physico-chemical parameters of water samples such as pH, temperature, turbidity and residual chlorine were measured by procedures according to Standard Methods for the Examination of Water and Wastewater [16].

## 3. Results

In this study, the occurrence of heterotrophic and total coliform bacteria in household water tanks was studied. The maximum and minimum ranges of physical and chemical parameters are shown in Table 1. Most of the household water tanks were directly exposed to sunlight and measured temperature of household water samples ranged from 31˚C to 34˚C. The ambient air temperature at the time of sampling was found between 37-40˚C. The pH range varied between 6.5 and 7.5. The free chlorine varied between maximum 0.08-0.01 mg $L^{-1}$. The turbidity of household water samples fluctuated between 0.17 to 2.5 NTU. The microbiological analysis results of this study are shown in the Table 2. The heterotrophic bacterial count of 21 water samples was found to be in the range of 1-100 CFU/100 mL, whereas 12 samples were found with a count of more than 200 CFU/100 mL. Only seven household tank water samples were found with a zero heterotrophic count. However, a total of 22 out of 40 household water tank samples were found with a zero total coliform bacteria. In 11 samples, total coliform (TC) count was found to be in the range of 2-80 CFU/100 mL, whereas in the remaining 7 water samples TC count was found beyond the countable range (more than 200 CFU/100 mL).

The overall recovery of the various groups of bacteria detected in 40 household water tank samples on the VRBA [18] media is shown in the Table 3. The occurrence rate of bacteria detected on VRBA media in a descending order of frequency was:

**Table 1.** Physical and Chemical Parameters of Water from Household Water Tanks

| Parameters | Minimum | Maximum |
|---|---|---|
| Temperature (˚C) | 31 | 34 |
| pH | 6.5 | 7.5 |
| Turbidity (NTU) | 0.17 | 2.5 |
| Residual Chlorine (mg $L^{-1}$) | 0.01 | 0.08 |

*P. aeruginosa*, *Salmonella gallinarum*, *E. coli* and *Enterobacter*

**Table 2.** Microbiological Analysis of Household Water Tanks

| Microbial counts (CFU/100 mL) | Number of water samples tested | Water quality category (as per Dubai Municipality /WHO guideline) |
|---|---|---|
| Heterotrophic count | | |
| 0 | 7 | Excellent |
| 1-10 | 8 | Satisfactory/suspicious |
| 11-30 | 1 | Unsatisfactory |
| 31-100 | 12 | Unsatisfactory |
| ›200 | 12 | Unsatisfactory |
| Total number of samples (n) | 40 | |
| Total coliform count | | |
| 0 | 22 | Excellent |
| 1-10 | 4 | Satisfactory/suspicious |
| 11-30 | 1 | Unsatisfactory |
| 31-100 | 6 | Unsatisfactory |
| ›200 | 7 | Unsatisfactory |
| Total number of samples (n) | 40 | |

**Table 3.** Occurrence Rate of Various Bacteria in Household Water Tanks

| Types of bacteria and other microorganisms | Number of positive water samples* | Colony count range (CFU/100 mL)** |
|---|---|---|
| *Pseudomonas aeruginosa* | 12 | 1-›200 |
| *Salmonella gallinarum* | 9 | 5- ≥ 200 |
| *Escherichia coli* | 1 | ›200 |
| *Enterobacter aerogenes* | 1 | 53 |
| Unidentified bacteria | 13 | 3- ≥ 200 |
| Fungus | 4 | 2-3 |

*Growth on Violet red bile agar (VRBA); **colony forming unit

*aerogenes*. Thirteen samples were found contaminated with unknown bacteria, whereas four samples had fungal contamination. The knowledge of family members/owners and history of the household water tanks was evaluated using questionnaire shown in Table 4.

## 4. Discussion

The microbial analysis of the household water tank samples showed that more than half of the household water tanks (33 out of 40 water tanks) were unsafe for consumption due to the occurrence of various types of bacterial and fungal contaminants in the water tanks. On the other hand, the questionnaire analysis showed that 23 out of the 40 household's owners do not use water filters yet as they use tap water for consumption purposes such as drinking and cooking, and 20 out of the 23 households had contaminated water tanks. Regardless of the system of water collection, a similar study on assessing the microbiological quality of drinking water from 102 household tanks in Bermuda have shown that 90% of the water tank samples analyzed were contaminated with total coliforms and approximately 66% of the samples showed contamination with *E. coli* [7]. However, in this study, nearly 45% of the household water tanks were found contaminated with coliform bacteria. This result indicates that there is a potential risk of consuming contaminated water supplied by the water tanks and taps mainly families who do not use water purification systems or any other methods that might reduce microorganisms in water.

In addition to that, in the microbial analysis of water tank samples by using a selective medium such as VRBA, have shown the occurrence of four different types of bacteria such as *P. aeruginosa*, *Salmonella gallinarum*, *E. coli* and *Enterobacter aerogenes*. At least 18 household water tank samples found containing these bacteria with most frequent one *P. aeruginosa* followed by *Salmonella gallinarum*. *E. coli* and *Enterobacter aerogenes* were detected only on one occasion. In this study, *P. aeruginosa* was most frequently observed (12 out of 40 household water tanks). This result indicates that there is a high probability of exposure of household members to this bacterium through tap water. A study on identifying the role of tap water as a source of endemic *P. aeruginosa* showed that a total of 72 cold water samples taken in ICU patient's room, 49 water samples (68.1%) were positive for *P. aeruginosa* and this shows that there is a possibility of finding *P. aeruginosa* in tap water in households with contaminated water tanks [14]. A recent study in Oman revealed that the storage reservoirs at pumping station and water distribution lines to residential houses complied with local drinking water standards, however, regrowth of several opportunistic pathogens occurred in the household water tanks [19]. It might be the case in this study as well where due to water tanks conditions and maintenance history, several household

**Table 4.** Household Water Tanks Features and Residents Behaviors Documented by Questionnaire

| Sample no. | Household (Locality in Dubai) | Household age (years) | Number of household members | Number of household water tank (WT)* | Age of WT usage (years) | Number Of times WT have been changed | Do you clean your water tank? | Do you use certain chemical for cleaning? | Did you know that WT should be cleaned? | Who is responsible of cleaning the WT? | Do you have water filters? | Do you use tap water for consumption? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Al Safa | 22 | 9 | 1 | 10 + | Never | No | No | No | DM** | No | No |
| 2. | Hor Alanz | 16 | 12 | 2 | 5 to 10 | 1 | No | No | Yes | Cleaning Company | No | Yes |
| 3. | Hor Alanz | 16 | 12 | 2 | 5 to 10 | 1 | No | No | Yes | Home owners | No | Yes |
| 4. | Nad Al Hammer | 12 | 9 | 1 | 10 + | Never | No | No | No | DM | No | Yes |
| 5. | Al Wasl | 16 | 8 | 1 | 10 + | Never | Yes | Yes | Yes | Cleaning Company | Yes | Yes |
| 6. | Al Safa | 5 | 12 | 3 | 5 to 10 | Never | No | No | No | - | Yes | Yes |
| 7. | Al Safa | 5 | 12 | 3 | 5 to 10 | Never | No | No | No | - | Yes | Yes |
| 8. | Al Safa | 31 | 6 | 1 | 1 to 5 | 1 | No | No | No | Home owners | No | Yes |
| 9. | Mankhool | 25 | 10 | 1 | 5 to 10 | 2 | No | No | Yes | Home owners and DM | No | Yes |
| 10. | Mirdif | 21 | 4 | 2 | 10 + | Never | Yes | No | No | DM | Yes | Yes |
| 11. | Al Qouz | 7 | 12 | 1 | 1 to 5 | Never | No | No | No | DM | No | No |
| 12. | Al Qouz | 7 | 12 | 1 | 1 to 5 | Never | No | No | No | DM | No | No |
| 13. | Al Safa | 11 | 10 | 2 | 10 + | Never | No | No | No | DEWA*** | No | Yes |
| 14. | Al Safa | 11 | 10 | 2 | 10 + | Never | No | No | No | DEWA | No | Yes |
| 15. | Zabeel | 4 | 15 | 1 | 1 to 5 | Never | No | No | No | Home owners | Yes | |
| 16. | Al Wasl | 19 | 6 | 3 | 5 to 10 | 1 | Yes | No | No | - | Yes | Yes |
| 17. | Al Barsha | 10 | 10 | 1 | < 1 y | 3 to 5 | No | No | No | - | No | Yes |
| 18. | Al Barsha | 11 | 11 | 2 | 10 + | Never | No | No | No | DM | No | Yes |
| 19. | Al Barsha | 11 | 9 | 3+ | 1 to 5 | 1 | No | No | No | Cleaning Company | Yes | Yes |
| 20. | Al Barsha | 11 | 9 | 3+ | 1 to 5 | 1 | No | No | No | Cleaning Company | Yes | Yes |
| 21. | Al Towar 1 | 28 | 9 | 2 | 1 to 5 | 3 to 5 | No | No | No | Home owners | No | Yes |
| 22. | Al Towar 1 | 28 | 9 | 2 | 1 to 5 | 3 to 5 | No | No | No | Home owners | No | Yes |
| 23. | Nad Al Hammer | 12 | 9 | 1 | 10 + | Never | No | No | No | DM | No | Yes |
| 24. | Al Wasl | 19 | 6 | 3 | 5 to 10 | 1 | Yes | No | Yes | Home owners | No | No |
| 25. | Mirdif | 11 | 7 | 1 | 5 to 10 | Never | No | No | No | Home owners, DM & WT companies | Yes | Yes |
| 26. | Al Safa | 22 | 10 | 3+ | 10 + | Never | No | No | No | - | No | Yes |
| 27. | Jumeirah 2 | 5 | 6 | 2 | 1 to 5 | 3 to 5 | No | No | Yes | Home owners & DM | No | Yes |
| 28. | Police Shaabiya | 27 | 10 | 1 | 10 + | Never | Yes | No | No | Home owners | No | Yes |
| 29. | Al Wasl | 21 | 9 | 1 | 10 + | Never | No | No | No | DM | No | No |
| 30. | Al Barsha | 11 | 11 | 2 | 10 + | Never | No | No | Yes | DM | No | Yes |
| 31. | Al Barsha | 11 | 9 | 3+ | 1 to 5 | 1 | No | No | No | Cleaning Company | No | Yes |
| 32. | Al Barsha | 11 | 9 | 3+ | 1 to 5 | 1 | No | No | No | Cleaning Company | No | Yes |
| 33. | Al Towar 1 | 21 | 9 | 3 | 10 + | 1 | Yes | No | Yes | Home owners | No | No |
| 34. | Al Towar 1 | 21 | 9 | 3 | 10 + | 1 | Yes | No | Yes | Home owners | No | No |
| 35. | Al Towar 1 | 21 | 9 | 3 | 10 + | 1 | Yes | No | Yes | Home owners | No | No |
| 36. | Al Safa | 22 | 10 | 3+ | 10 + | Never | No | No | No | - | No | Yes |
| 37. | Al Safa | 22 | 10 | 3+ | 10 + | Never | No | No | No | Home owners | No | Yes |
| 38. | Al Safa | 22 | 10 | 3+ | 10 + | Never | No | No | No | DM | No | Yes |
| 39. | Police Shaabiya | 16 | 12 | 3 | 10 + | 3 to 5 | Yes | No | No | - | No | Yes |
| 40. | Police Shaabiya | 16 | 12 | 3 | 10 + | 3 to 5 | Yes | No | No | - | No | Yes |

*WT = Water tank; ** DM = Dubai Municipality; ***DEWA = Dubai Electricity and Water Authority

water tanks were found contaminated with various bacteria. Among various factors that can contribute to regrowth of different types of bacteria are temperature, biofilm formation, air, soil and animal fecal matter contamination [15, 19, 20]. The strong relationship between water temperature and microbial growth is reported in several studies [7, 12, 20]. These studies showed that when the temperature of the water reaches above 15℃ the occurrence of coliform and heterotrophic bacteria was significantly higher. It means that when the weather gets warmer, water temperature increases and the possibility of microbial growth in the water also increases. In this study, the temperature of water samples varied between 31˚C and 34˚C and it was probably one of the main factors that might have contributed to the growth of the microorganisms in the household water tanks. However, possibly by air and soil borne contamination is also higher as majority of water tanks were not cleaned on a regular basis.

The questionnaires that were given to the participants, prior to taking water samples from the water tanks, were analyzed to understand the general history of the household water tanks and other related issues that examines whether household owners use certain methods that might affect the occurrence of bacteria in the water tanks and in the household water taps such as cleaning the water tanks, using filters and changing water tanks. The results of the questionnaires (Table 4) have shown that the age of the household participants ranged from 4 y to 31 y with an average of nine to ten family members living in an each house. The number of members living in a household probably affected the presence of bacteria in the household water tank due to the different range and rate of water consumption per day. The results also showed that half of the household water tanks included in the study (n = 20) were used for more than 10 y, whereas only 12 water tanks were used for less than 5 y. Furthermore, 21 household water tanks were never replaced, 6 water tanks were replaced 3 to 5 times and 13 water tanks were replaced once or twice (the number of replacements of the water tank was analyzed since the household water tank was firstly installed till the time of this study). The number of years that the water tanks have been used is one of the main concerns because a longer the period of water tank use, the higher the chance of microbial growth in the water tanks especially when the environmental conditions (especially high ambient air temperature above 35˚C) promotes microbial growth. Also, 30 household water tanks (75%) were never cleaned either by using certain chemicals or by contacting qualified companies for cleaning water tanks or by the house owners themselves. Out of the 20 household water tanks (50%) that have been using their water tanks for more than 10 y, 12 of them were never been cleaned which was nearly 30% of the total water tanks. Most of these household water tanks were found contaminated with various bacteria. The reason behind this is because 29 out of 40 of the participants did not know that water tanks should be cleaned and the importance of maintaining good hygiene and sanitation of the household water tanks [3].

Moreover, the questionnaire also examined whether residents used water filters at the point of end use or not. The results have shown that out of the 40 families studied, 31 houses had not used water filters while the rest used water filters. In addition, at least 23 household members directly used their water supply for consumption purposes such as drinking, cooking and tea and coffee preparation. This means that the members of the households that use water tanks for long periods of time without maintaining good sanitation and hygiene of the water tank and without the use of water filters have a higher chance of being exposed to opportunistic microorganisms. Furthermore, households where their water tanks have been cleaned (n = 10), regardless of the age of the water tank, all of the ten household water tanks were unsafe for human use and contained bacteria. The analysis of the questionnaires the results showed a lack of awareness regarding the importance of maintaining proper sanitation and hygiene of the household water tanks. Also, the majority of the families included in this study, i.e. 29 out of 40 household participants did not know that water tanks should be cleaned. The importance of maintaining safe water for consumption purposes reported in several studies [1]. The results of a study conducted by Nath et al. [3] showed that the provision of safe water at household level could reduce diarrheal and other enteric diseases by 6-50%, by using simple methods for water treatment such as water filters. According to the WHO nearly 3.2% of deaths (1.8 million) and 4.2 of disability-adjusted-life years (61.9 million people) worldwide are caused by unsafe water [1]. Another study emphasized that simple and cost effective method could be used in households to eliminate and reduce microorganisms causing waterborne illnesses [4]. There are several useful technologies such as nano-filtration, reverse osmosis system and distillation system for water treatment that can maintain safe water for human utilization [21].

## 5. Conclusions

In conclusion, microbiological quality of household water tanks in Dubai for the presence of various types of bacteria in household water tanks was studied. In addition, the history of the household water tanks and the homeowner's knowledge regarding water tank maintenance was investigated. The heterotrophic bacteria count was found to be in the range of 1-100 CFU/100 mL for 25 water samples. However, in the remaining 15 water samples HBC was found over 200 CFU/100 mL. TC count was found to be in the range of 2-80 CFU/100 mL of 25 water samples, whereas in 15 water samples TC bacteria were found in the range of over 200 CFU/100 mL. The microbiological analysis showed the occurrence of *P. aeruginosa*, *Salmonella gallinarum*, *E. coli* and *Enterobacter aerogenes* in the household water tanks. The questionnaire study showed that there is a lack of awareness concerning the importance of maintaining proper sanitation and hygiene of the household water tanks. A long term regular study is needed to determine the microbial quality of water starting from the water distribution lines, the household water tanks, point of end uses such as washroom and kitchen tap. Furthermore, comprehensive studies are required to determine the exact identity of microorganisms that occur in household water tanks. Moreover, a detailed study on the relationship between the microbes and the chemical content (disinfectants, nutrient) of household water tanks and the survival of microorganisms against various disinfectants is highly recommended.

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