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Microbial Quality of Drinking and Utility Water in Tourism Facilities in Antalya

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Abstract: The microbial quality of drinking and utility water is important for public health, environmental safety, and overall well-being. Contaminated water can harbor harmful microorganisms that can cause a wide range of diseases. Governments set standards for the microbiological quality of drinking water, and it is required to regularly test and monitor the microbial content of water to meet these standards. This study investigated the microbial quality of drinking and utility water in different hotels in Antalya during high season (June – July – August – September) in 2022 and 2023. 270 water samples for each year – 540 samples in total were collected from 12 different hotels. Total coliform and *E. coli* analyses were performed via membrane filtration analysis, and the results were verified by using oxidase test and indole test. The results showed that only 1 hotel out of 12 have met the safety criteria required in the legislation. All the other 11 hotels had overall microbial counts over the legal limits. In 2022, total coliforms were detected in 8 hotels at 29 different sample spots, and *E. coli* growth was found in the water used for washing vegetables only in 1 establishment. In 2023, total coliforms were found in 11 hotels at 53 different spots, and *E. coli* was detected in the samples taken from the ice machines at 3 facilities. The results concluded that microbiological contamination occurs in drinking and utility water, especially originated from ice machines, in tourism facilities if the required hygiene and sanitation criteria are not provided.

Antalya’da Bulunan Bazı Otellerdeki İçme ve Kullanma Sularının Mikrobiyal Kalitesi

Anahtar Kelimeler
E. coli,
Toplam koliform,
Mikrobiyolojik su kalitesi,
Turizm işletmeleri,
Su hijyeni

Öz: İçme ve kullanma suyunun mikrobiyal kalitesi halk sağlığı, çevre güvenliği ve genel refah açısından önemlidir. Kirlenmiş su, çok çeşitli hastalıklara neden olabilecek zararlı mikroorganizmaları barındırabilir. Hükümetler içme suyunun mikrobiyolojik kalitesine ilişkin standartlar belirlemiştir ve bu standartları karşılamak için suyun mikrobiyal içeriğinin düzenli olarak test edilmesi ve izlenmesi gerekmektedir. Bu çalışmada, 2022 ve 2023 yıllarında Antalya'daki farklı otellerde yoğun sezonda (Haziran – Temmuz – Ağustos – Eylül) içme ve kullanma suyunun mikrobiyal kalitesi araştırılmıştır. Her yıl için 270 su örneği – 12 farklı otelden toplam 540 örnek toplanmış, membran filtrasyon analizi ile toplam koliform ve *E. coli* analizleri yapıldıktan sonra sonuçlar oksidaz testi ve indol testi kullanılarak doğrulanmıştır. Sonuçlar, 12 otelden yalnızca 1'inin mevzuatın gerektirdiği güvenlik kriterlerini karşıladığını göstermiştir. Diğer 11 otelin tamamında genel mikrobiyal sayımlar yasal limitlerin üzerinde çıkmıştır. 2022 yılında 8 otelde 29 farklı numune noktasında toplam koliform tespit edilirken, sadece 1 işletmede sebze yıkamada kullanılan suda *E. coli* üremesine rastlanmıştır. 2023 yılında 11 otelde 53 farklı noktada toplam koliformlara rastlanırken, 3 tesisteki buz makinelerinden alınan numunelerde *E. coli* tespit edilmiştir. Sonuç olarak, turizm tesislerinde gerekli hijyen ve sanitasyon kriterlerinin sağlanmaması durumunda, içme ve kullanma sularında özellikle buz makinelerinden kaynaklanan mikrobiyolojik kirlenmelerin meydana geldiği sonucuna varılmıştır.

1. INTRODUCTION

Water is a vital resource for humans, but its quality is often compromised by microbial contamination. The microbiological quality of drinking and utility water is a significant public health concern globally, as contaminated water can lead to various waterborne diseases and associated mortality [1, 2]. Vulnerable populations, including the elderly, immunocompromised individuals, and infants, are at higher risk of severe outcomes from waterborne infections.

According to Turkish regulations, drinking and utility water is defined as "water that is generally used for drinking, cooking, cleaning and other domestic purposes; and for the preparation, processing, storage and marketing of foodstuffs and other products intended for human consumption; regardless of its origin, whether in its original or treated form, whether supplied from the spring or from the distribution network; and is not offered for sale for commercial purposes" [3].

Coliforms and fecal coliforms are key indicators used in the monitoring of water quality. Their presence signals potential contamination and the risk of waterborne disease, prompting necessary actions to protect public health. By serving as early warning indicators, these bacteria help ensure that water supplies remain safe for consumption and recreational use. Total coliforms are used as an initial screening tool in water quality testing because they can be easily detected [2, 4]. If total coliforms are detected, further testing is usually conducted to determine the presence of fecal coliforms or other specific pathogens. Fecal coliforms are a subset of the total coliform group, specifically originating from the intestines of warm-blooded animals, including humans [4]. They are more specific indicators of fecal contamination than total coliforms. The most well-known fecal coliform is *Escherichia coli* (*E. coli*), which is used as a primary indicator of fecal pollution. The presence of coliforms, and especially fecal coliforms, in water is a significant public health concern. It indicates the potential for waterborne diseases, such as diarrhea, cholera, typhoid fever, and hepatitis, which are caused by pathogens that may be present in fecal matter [1, 2, 4]. The multiple-tube fermentation (MTF), a.k.a. most probable number (MPN), and membrane filtration (MF) methods are the popular reference methods used for monitoring the quality of drinking water. MTF requires 3 to 4 days while MF provides results just after 24 hours [2, 5].

Membrane filtration analysis is a widely used method for detecting and quantifying microorganisms, particularly bacteria, in drinking and utility water samples. It is commonly used in routine water quality monitoring, particularly for detecting indicator bacteria such as total coliforms and *E. coli*. These bacteria are indicators of fecal contamination and are used to assess the safety of drinking water. This method is based on membrane filtration followed by culture on a chromogenic coliform agar (CCA) medium and counting the number of the colonies of target organisms in the sample [2, 5].

Antalya is one of the biggest and busiest cities in Türkiye, which maintains its vitality in all four seasons and has many tourism facilities. Antalya is the 5th most visited city in the world according to the statistics and has long been a popular beach travel destination [6]. So the city welcomes domestic and international visitors more than ten times its own population throughout summer season, resulting in overcrowded tourism facilities. The objective of this study was to investigate the microbial quality of drinking and utility water in different hotels in Antalya during high season.

2. MATERIAL AND METHOD

For this study, drinking and utility water samples were collected from 12 different hotels which were selected from different districts of Antalya. One of the hotels was in Manavgat, 2 were in Side, 3 were in Türkler, 1 was in Avsallar, 3 were in Konaklı, and the remaining 3 hotels were in Alanya. The capacity of the hotels varied between 60 – 490 rooms. The water samples were collected aseptically with the necessary precautions during high season summer months (June – July – August – September), both for 2022 and 2023. Same hotels were included for both years of the study.

2.1. Sample Collection

Sterile glass sample containers of 500 ml capacity were used for sampling, and the containers were filled with no air pockets. All water samples were taken and transported carefully, protected from sunlight and avoided any contact to prevent contamination. Each year 270 different samples were collected for the study, and the number of samples to be analyzed from the hotels were determined according to the capacity of the hotels. Samples were delivered to the laboratory within 1 hour after collection and stored at 4±2°C.

2.2. Membrane Filtration Analysis

In order to determine the quality of drinking and utility water, all analyses were done according to the current Turkish regulations. TS EN ISO 9308-1:2004 standard method [7] was conducted by using a membrane filtration system (Sartorius T500, Germany). The samples were passed through a membrane filter with a pore size of 0.45 µm (Membrane Solutions, USA). The membrane filter was then placed on Chromogenic Coliform Agar (CCA) (Biolife, Italy). The filter, along with the medium, is incubated at 37℃ for 24 hours. After the incubation period, colonies with a color change (pink to red is marked as coliform, and blue to dark purple is marked as *E. coli*) were counted as positive.

2.3. Verification

The colonies marked as coliform were verified by using oxidase test. The oxidase test helps to differentiate between oxidase-negative coliforms and other non-coliform bacteria that might also be present. The colonies were picked from the membrane filter, and transferred on oxidase test strips. A positive result was indicated by a color change (typically to dark purple or blue) within 20-60 seconds, which were not taken into consideration. Colonies with negative oxidase test results were verified as coliforms.

The colonies marked as *E. coli* were verified by using indole test. The indole test is particularly useful in distinguishing between indole-positive bacteria like *E. coli* and indole-negative bacteria. The colonies were picked and inoculated into a broth containing tryptophan (Biolife, Italy). The inoculated broth was incubated at 37℃ for 2 to 7 days, to allow bacteria to produce indole. After incubation, 0.5 ml Kovac's reagent was added to the broth. If indole is present, the reagent reacts with it to produce a red or pink color which floats on top of the broth. A positive indole test was indicated by this red or pink color change, i.e. verifying *E. coli*. A negative indole test resulted in no color change or a yellowish color, indicating that the bacterium did not produce indole.

2.4. Calculation

The number of confirmed colonies counted on the membrane filter was calculated based on the number of *E. coli* and coliform bacteria present in the water samples. Total coliform count was calculated as the sum of all oxidase-negative colonies plus all indole-positive colonies. The number of indole positive colonies was taken into account for the *E. coli* count. These counts were used to estimate the concentration of bacteria in the original water samples, expressed as colony-forming units per 100 milliliters (CFU/100 ml).

3. RESULTS AND DISCUSSION

This study was performed to explore the microbiological quality of drinking and utility water in the tourism facilities in Antalya during June – July – August – September of 2022 and 2023. Twelve hotels were inspected, and 270 water samples for each year – 540 water samples in total were collected for microbiological analysis, and total coliform and *E. coli* analyses were performed via membrane filtration method. The results obtained from membrane filtration analysis were verified by using oxidase test for total coliforms and indole test for *E. coli*. The results are summarized in Table 1.

The first two columns in Table 1 show the hotels and the number of samples taken from each hotel. The samples were taken from different spots at each hotel, depending on the size and the capacity of the hotels. Samples were taken from preparation areas in the kitchen, snack bars, pool bars, and ice machines located in different spots. The total coliform and *E. coli* counts given in the other columns are the sum of the results of the water samples per each month obtained from all different spots.

The microbiological quality of drinking and utility water is a critical component of public health. In Türkiye, the legal limits of total coliform count and *E. coli* count for drinking and utility water are 0/100 ml [3]. In other words, no coliforms or *E. coli* are allowed in drinking and utility water.

Table 1. *E. coli* and total coliform counts for drinking and utility water samples taken from 12 different hotels

Hotel	Number of samples	Months	2022		2023	
			E. coli (CFU/ 100 ml)	Total coliform (CFU/ 100 ml)	*E. coli* (CFU/ 100 ml)	Total coliform (CFU/ 100 ml)
A	18	June	0	60	0	0
		July	0	0	0	60
		August	0	290	0	580
		September	0	280	0	840
B	24	June	0	0	0	280
		July	0	160	0	60
		August	0	0	0	2060
		September	0	0	0	0
C	24	June	0	750	0	0
		July	0	0	0	4300
		August	800	4500	0	1940
		September	0	220	0	0
D	24	June	0	200	0	0
		July	0	0	0	30
		August	0	0	0	390
		September	0	0	0	240
E	24	June	0	0	0	450
		July	0	0	0	1900
		August	0	1100	0	0
		September	0	0	0	1800
F	15	June	0	0	0	0
		July	0	0	0	0
		August	0	0	0	0
		September	0	0	0	0
G	24	June	0	0	0	1890
		July	0	0	0	0
		August	0	0	0	0
		September	0	0	0	40
H	15	June	0	0	0	0
		July	0	0	0	80
		August	0	0	0	0
		September	0	0	0	60
I	24	June	0	140	0	230
		July	0	0	0	900
		August	0	0	0	850
		September	0	610	0	60
K	24	June	0	800	0	0
		July	0	400	10	4070
		August	0	0	0	60
		September	0	0	0	290
L	24	June	0	0	20	150
		July	0	0	0	1400
		August	0	0	0	500
		September	0	0	0	300
M	24	June	0	0	0	350
		July	0	0	0	700
		August	0	280	0	0
		September	0	0	0	450

Table 1 states that only 1 hotel (Hotel F) out of 12 have met the safety criteria required in the legislation. That hotel was a relatively small and new boutique hotel compared to the other facilities. The results for all the other 11 hotels indicated that overall microbial counts for those hotels were over the limits throughout summer season.

In Hotel A, total coliform growth was observed at 6 different spots in June – July – August and September in 2022, while total coliform growth was observed at 10 different spots in 2023. These spots were mainly kitchen (water used for washing vegetables) and several ice machines at the restaurant, pool, lobby and snack bars. There was no *E. coli* growth observed for both years.

The results for Hotel B showed that there was almost no microbial growth for June and September for both 2022 and 2023. But all the positive counts for the other months came from ice machines located in lobby and beach bars. A total coliform count of 2000 CFU/100 ml of the total count (2060 CFU/100 ml) for August 2023 was from only one ice machine at the beach bar.

Hotel C had the highest total coliform counts among all the hotels. Total coliform growth was detected at 9 different spots for 2022, and at 6 different spots for 2023. These spots were ice machines at the snack bar and lobby bar, and the water used for washing vegetables and preparing breakfast. In August 2022, a total coliform count of 2600 CFU/100 ml and an *E. coli* count of 800 CFU/100 ml was found in the water sample used for washing vegetables, while the rest of total coliform count comes from other sample points such as ice boxes and water sample used in snack bars. All water samples were positive for total coliforms in August 2022, indicating a possible problem with the water system.

The microbial counts for Hotel D were relatively low, and the positive results were mainly from the water samples taken from ice machines and kitchen. There was no *E. coli* growth for both years.

In Hotel E, total coliform growth was observed at 2 different spots in 2022, while total coliform growth was observed at 3 different spots in 2023, but the total coliform counts were really high for each sample spot.

Hotel F was the only hotel that has clean and safe water. No microbial growth was observed for both 2022 and 2023.

Hotel G also had mostly clean water, except June 2023. In June 2023, water samples from kitchen and ice machines at the pool and lobby bars were tested positive for total coliforms.

Hotel H was a relatively small facility compared to others, and there were only 2 spots in 2023 where total coliform counts were above the legal limits. Both of these spots were water dispensers in the lobby and the restaurant.

In Hotel I, total coliform growth was observed at 5 different spots in June – July – August and September in 2022 and in 2023. There was no *E. coli* growth observed for both years. These spots were mainly kitchen and several ice machines at the restaurant, pool, lobby and snack bars.

Hotel K water samples were tested positive for total coliforms at 3 different spots in 2022, and 5 different spots in 2023. There was also *E. coli* growth at one spot in July 2023. The water sample taken from the ice machine at the pool had 10 CFU/100 ml *E. coli* and 4000 CFU/100 ml total coliforms in July 2023.

There was no microbial growth observed for Hotel L in 2022, but in 2023 *E. coli* was found in one sample spot and total coliforms in 4 different spots. 20 CFU/100 ml *E. coli* and 150 CFU/100 ml total coliforms were found in the water used at the pool bar in June 2023. Other sample spots tested positive were the ice machines at the restaurant and the pool bar.

The water samples taken from Hotel M were almost clean in 2022, there was only one sample from the kitchen tested positive for total coliforms. In 2023, total coliform growth was observed at 4 different spots, all spots being ice machines at the pool bars.

The present study investigated the microbiological quality of drinking and utility water in selected tourism facilities in Antalya, and the results showed that the water used in 11 out of 12 hotels was contaminated throughout the high season summer months. The studies in literature investigating the microbial water quality also stated similar results [8 - 10]. A study was conducted to evaluate water quality of several hotels in Brazil. They investigated 15 hotels and 31 water samples, and they concluded that approximately 50% of the water samples were contaminated with total coliforms. The authors suggested that there is a need for stricter control of the quality of the water used, through monitoring the internal water distribution system, adapting and complying with the requirements of the legislation [8]. Çetin et al. [9] studied the microbiological quality of the water used by food production enterprises in Kırklareli, Türkiye. The results showed that 84.3% of 83 samples exceeded the legal limit for total coliform bacteria, 37.3% for total aerobic mesophilic bacteria, 27.7% for psychrophilic bacteria, and 10.8% for *E. coli*. Kireççi et al. [10] conducted a study to determine the microbiological quality of drinking and utility water used in Kars and Sarıkamış military units. As a result, they detected *E. coli* in 30% of 1469 drinking and utility water samples. These findings state the importance of regular monitoring of microbiological water quality.

In 10 of the 12 different hotels, microbial growth was observed at the ice samples taken from different areas of the hotels. World Health Organization (WHO) stated that the water used in the production of ice that will come into contact with food must have the same chemical and microbiological quality as drinking water [11]. Microbial growth observed in ice machines and ice boxes used in hotel bars is mainly caused by inadequate hygiene and sanitation, placing ice shovels outside the shovel container in places that may cause pollution and as a result not ensuring hygiene and sanitation of the shovel container, the staff using ice shovels with dirty hands, and possible cross contamination during the transfer of ice cubes from the machine to the ice boxes. The findings observed in the present study regarding the microbiological risk of ice were in accordance with similar studies conducted in literature [12 - 14]. Gaglio et al. [12] analyzed ice cubes collected from houses, bars and pubs prepared with ice machines and produced in industrial plants, and found that almost all samples had members of the *Enterobacteriaceae* family. Hampikyan et al. [13] collected water and ice samples from 75 restaurants, 20 bars and 10 fish markets located in different regions of Istanbul. They showed that 13 water and 54 ice samples were tested positive for total coliforms, and 7 ice samples exceeded the limits for *E. coli*. Another study performed to determine the microbiological and chemical quality of ice in Georgia, USA, and they found that none of the manufactured ice had unacceptable microbial levels and 37% of the samples contained a high level of coliforms and 1% contained *E. coli* [14].

4. CONCLUSION

In this study, 270 samples were taken in 2022 and total coliform and *E. coli* analyzes were performed. In 2022, total coliform growth was observed in 8 of the hotels in different months and at 29 different spots (10.7%), and *E. coli* growth was observed in the water used for washing vegetables in only 1 hotel (0.3%). In 2023, 270 samples were taken from the same sample spots of the hotels and total coliform and *E. coli* analyzes were performed. In 2023, total coliform growth was detected in 11 of the hotels in different months and at 53 different points (19.6%), and *E. coli* was detected in the ice machines from 2 hotels and in the pool bar drinking water in one other hotel (1.1%). It was revealed that the microbial counts obtained at these samples exceeded the legal limit of 0 CFU/100 ml for total coliform bacteria and *E. coli*. The results concluded that microbiological contamination occurs in drinking and utility water in tourism facilities if the required hygiene and sanitation is not provided. The old plumping instalments, well water usage, the increase in the high season and the staff not paying enough attention to the hygiene rules were the main reasons for the failure to provide hygiene and sanitation. Another important result of this study is the most contaminated areas in these hotels were ice machines and ice boxes. Ice quality is an often overlooked but crucial aspect of food safety. Ensuring the microbiological safety of ice requires attention to the quality of the water used, the cleanliness of ice machines, proper storage, and handling practices. Regular monitoring and adherence to regulatory standards are essential to prevent the transmission of waterborne diseases and to protect public health.

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