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The Quality of Ornamental Water within Shopping Malls in the United Arab Emirates

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Abstract

Ornamental water fountains in shopping malls are mainly built for decorative purposes however; they might fail to meet the required standards set to ensure public health safety. Microbial contamination of indoor ornamental water could pose a serious potential risk to human health, particularly children and the elderly who could get infected by either direct contact or aerosol inhalation. Although the United Arab Emirates (UAE) is famous for its exquisite shopping malls that are routinely monitored and inspected for cleanliness, there are currently no unified standard regulations regarding microbial risk assessment for ornamental water. Cleaning and disinfection of the water is the responsibility of the mall management that resorts to a certified maintenance company which runs its own quality testing and follows its own guidelines. The objective of this study is to examine water quality from indoor ornamental fountains, and compare the different guidelines implemented with regards to microbial quality assurance and public safety. A time-series experimental design was utilized. Three main shopping malls within Abu Dhabi city were randomly selected for the study. Sampling and collection of biofilm swabs from water fountains and baseline sources were performed before and after cleaning in each mall. Sterilized containers where used to collect the water samples, and sterilized gloves where used throughout the whole process to prevent contaminating the water samples or the water feature. For examining the microbiological indicators of water quality, all samples were analyzed by the membrane filtration method and cultured on selective/differential media to determine total coliform count and other more specific bacteria like *Staphylococcus aureus*. The results of this study showed significant differences in the microbial profiles of ornamental water in the three malls with higher growth (CFU/100 ml) in 2 of the 3 of the decorative features examined. Moreover, the results showed differences between the results before and after the cleaning of the feature. Although, the average microbial growth from samples per each mall was within the limits for public health safety, this study emphasizes the important need for establishing proper guidelines for ornamental water within indoor malls in Abu Dhabi to ensure public safety at all times.

Keywords: Ornamental water; Shopping malls; United Arab Emirates; Microbial contamination

Introduction

Recreational water features in many parts of the world follow specific guidelines to protect public health. Indoor ornamental water is water which is located in closed buildings with no direct exposure to sunlight or natural air [1]. Decorative ornamental features instantly bring a sense of tranquility to any space and are very often used in hotels and malls. However, if the water fountains or other indoor water structures are not maintained properly, they would host microorganisms that may risk the health of the individual who get in contact with the water from these features. Indoor ornamental water could be potentially highly risky to human health, particularly when one or more of the following factors are present: the feature is routinely stagnant with accumulation of solid waste, and or the feature is located at walkway, near seating area, or food court because this would increase the possibility of outbreak of infectious disease [2]. Maintenance of the fountain is the key solution to protect the public. Some chemical solutions, like chlorine and other biocidals, are often added to the fountain to prevent microbial contamination and ensure water stays clean and smelling fresh [2].

Protozoa and viruses are the main causes of waterborne disease associated with decorative water features [3]. Thus, developing a risk assessment and monitoring guideline is imperative. Outbreaks may occur since many of the decorative water features are reachable by people, and sometimes water is sprayed at high attitude. Microorganisms can enter the air when a human or animal sneezes, or by the wind. If a human sneezes, the microorganisms leave the lung to the air, and the moist particles. Thus, if someone else breathes the microorganisms into their lungs they might get sick. Moreover, if the water becomes contaminated, with the absence of an effective cleaning and disinfection regime, microbial biofilms can establish themselves and become very difficult to eradicate with basic cleaning techniques [1]. *E. coli* and some other coliforms is often an ideal organism to indicate fecal contamination of water. Fungi can become abundant if organic matter like food waste accumulates in the water and become potentially pathogenic [4].

Indoor ornamental water features that are built for decorative purposes only are not usually restricted to the guidelines of interactive water like swimming pools for instance. The Pool Water Advisory Group (PWAG) in the United States declared that a formal risk assessment is required to assess the microbiological risks from decorative water features [4]. PWAG also stated that decorative water features create aerosols and cause splashing around the area where the

feature is located. Slippery surface would result in slip and fall injury, and risk of infectious disease because of cross contamination. Poor hygiene, food leftover, and solid waste thrown in the decorative water would create a living environment for bacteria and fungi and other microbes [5,6]. Several studies have documented cases in which people who interacted with ornamental water; through either inhalation of aerosols or direct contact; later developing diseases [7-11].

Abu Dhabi city in the UAE is famous for its exquisite indoor shopping malls which are popular places where residents and tourists would spend their time especially during hot and humid weather which lasts for around 8 months throughout the year. Although malls are routinely monitored and inspected for cleanliness, there are currently no unified standard regulations regarding microbial risk assessment for ornamental water. Cleaning and disinfection of the water is the responsibility of the mall management that often resorts to a certified maintenance company which runs its own quality testing and follows its own guidelines. The objective of this study is to examine water quality from ornamental fountains within different malls in the UAE and compare the different guidelines implemented with regards to microbial quality assurance and public safety.

Methods

Ethical approval

This study involved the process of collecting samples from several decorative water features in several malls within Abu Dhabi city. Abu Dhabi Municipality has been informed and the Health Awareness Department (HAD) permitted the study and the process of collect samples from mall properties. Members of HAD escorted the process of collecting samples from the malls. Consent form was signed by the malls management.

Sample collection and field measurements

Three different shopping malls designated as (A), (B) and (C) were randomly selected as representative malls within Abu Dhabi. The study utilized a time-series experimental design with samples being collected before and after cleansing. The timeline of sample collection was based on the cleaning and maintenance schedule of each mall. Site (A) and (C) follow similar maintenance procedure, where and automated chlorine machine is used, and the water is changed on a weekly bases on the beginning of each week. However, site (B) follow different procedure where it drained the water completely by the end of the week, and no chemical is used to disinfect the water throughout the week. All sampling was conducted between November and December 2013. One single fountain feature was chosen from each site, total of 3 fountain features where included in this research. For water collection, samples were taken in four different 250 ml containers, with total of 1,000 ml water samples collected from each site. Control samples were simultaneously collected for each mall from the baseline source. Swabs were collected from the corners of the feature to investigate biofilm formation using sterile swabs. A worksheet log about the cleaning method and its frequency was completed after questioning the maintenance and management staff (Table 1). Moreover, physical and chemical parameters like pH, turbidity, temperature and chlorine content which affect the disinfection regime were all examined using disposable water quality quick test kits. All samples were kept on ice during transportation from the site to the laboratory to prevent further growth and contamination. Control microbial strains were all ATCC and cultured in parallel to experimental samples for referencing.

Microbial analysis

Agar media were prepared based on to the manufacturer's instruction and properly stored in a refrigerated environment. All water samples were analyzed by the membrane filtration method which utilized 47 mm filters with 0.45 μm pore size prior to culturing on selective and differential agar media to determine mainly fungal growth and total coliform count [12-15].

Maintenance Worksheet log
1. Site ID:
2. Water source (Base line):
3. Do they follow specific guidelines regarding maintenance process (is it provided by the government)?
4. What type of circulation method is in the fountain?
5. Type of filters used?
6. What are the maintenance regulations! Maintenance procedure (cleaning Procedure, chemicals used, etc.?)
7. Cleaning schedule? (daily/weekly)
8. From how long it was built?
9. Materials of the fountain?
10. Do they use posters to provide notifications to public who come near?
Pictures of the water features, surrounding area, and close-up pictures of suspected malfunction to be taken at the site.

Table 1: Worksheet Log for General Maintenance and Cleaning Method

Swabs were directly inoculated on nutrient agar plates. For each site, 6 filters were placed on 6 types of agar media and incubated for 24 hours at 37°C. The different types of agar media were: Mannitol Salt Agar (MSA) which is selective for gram positive Staphylococci and Micrococcaceae, Eosin-Methylene Blue (EMB) which is selective and used for differentiation of the various coliforms (gram-negative bacilli) and fecal coliforms (enteric bacilli), Sabouraud Dextrose Agar (SDA) which supports the growth of fungi that cause infection of the skin, hair, or nails [16], MacConkey agar (MAC) which is selective for gram-negative bacteria, and differentiates lactose fermentation gram-negative bacteria. Results for growth were expressed by colonies forming unit per 100 ml of water (CFU/100 ml).

Results

After the incubation period, significant differences were observed between the samples collected from the three sites A, B and C (Table 2). The management for each mall indicated that there are no specific regulations or laws regarding the maintenance procedure applied for the indoor water feature. However, each mall is required to have a cleaning regimen. As a result, each mall is following a different procedure based on the maintenance company they contract with. International regulations indicate that water features should be monitored for pH and choline residual level; because the disinfecting power of chlorine increases at lower pH [14,15]. Only site (B) is not using chlorine in cleaning and disinfection method. However, on a weekly basis they drain the water completely from the feature and refill it with water from the baseline. On the other hand, site (A) and (C) use an automated chlorine machine that pumps chlorine into the feature automatically. Tested samples showed different levels of microorganisms for test #1 (samples collected after 24 hours after cleaning) and test #2 (before cleaning). The baseline samples, which were obtained from desalinated plan, were used as control samples in this study to represent the quality of water provided from the source. All baseline samples showed no growth for both bacteria and fungi. Results from all three sites, inoculated in 6 different types of agar media in two different tests are shown in Figures 1 and 2.

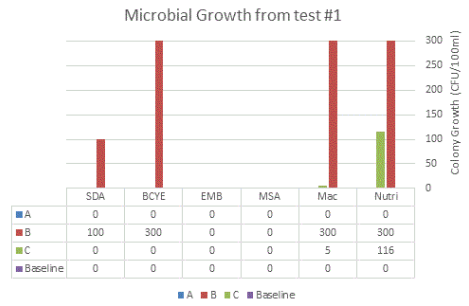

Figure 1: Microbial Growth for samples collected from sites A, B, C, and baseline source. All samples were collected at least 24 hours after the cleaning procedure. Results were expressed by colonies forming unit per 100 ml of water (CFU/100 ml).

Results from test #1 showed growth pattern for samples based on the site from which they were obtained from. Site (A) showed no growth on all agar media used. However, site (C) showed growth on nutrient agar and MacConkey hence indicating the presence of gram negative bacteria. The nutrient agar showed growth of 16 yellow colonies, and more than 100 small colonies around the edge of the filter while Mac agar showed growth of total of 5 yellow and light-purple colonies. Samples from site (B) had the highest growth. Since no chlorine was used in the features, germs and microbes were able to exist in water within the feature and this directly increased the risk of algal growth. SDA agar showed 120 colonies, and this indicated the presence of fungi and mold in the water. More than 300 colonies formed on the nutrient agar, Mac, and EMB. Mac media and EMB differentiate for lactose fermenting gram negative bacteria. Mac agar showed more than 300 colorless colonies around the rim of the filter. Colonies on Mac agar indicated the presence of Enterobacteriaceae, like Salmonella and Shigella, which appear colorless because they are none-fermenters.

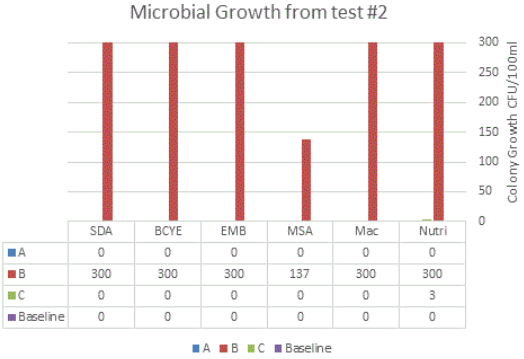

Figure 2: Microbial growth for samples collected from sites A, B, C, and baseline source. All samples were collected at least 24 hours before the cleaning procedure. Results by colonies forming unit per 100 ml of water (CFU/100 ml)

Test #2 was conducted 1-2 weeks after test #1 based on the cleaning schedule of the mall, and it was collected before the cleaning procedure was applied to the feature. Results from test #2 showed little difference compared with the first test. High microbial growth for samples collected from site (B) was again observed. Site (A) showed no growth on all agar media used. Growth on SDA media plate confirmed the presence of fungi and mold in the water sample taken from site (B) only.

Results from the swab culture revealed significant growth in all of the agar media. SDA media plate showed growth of mold and fungi on the surface of the features located at site (A) and (B).

Discussion

This study was done to determine the level of safety among indoor water features, including microbial analysis and visual inspection. Also, the results were compared with the different guidelines implemented with regards to microbial quality assurance and public safety. These three malls have, on average, around 50–80 visitors per day around the area of the fountain. This number increases to 250+ visitors during weekends/holidays. In such busy malls, cross contamination can occur frequently.

Sample ID	Site A (SA)	Site B (SB)	Site C (SC)
Date collected	26.11.2013	27.11.2013	26.11.2013
pH	7-7.2	7-7.5	7.5-7.4
Temperature	20°C	20°C	20°C
Residual Chlorine residual/ml	0.1-0.3 mg of residual chlorine/ ml	No chlorine added	1.5-1.8 mg of residual chlorine/ ml
Swab collected	Collected from the feature corners	Collected from the feature corners	Collected from the feature corners and the wood edges
Visual inspection	The feature has emerging lights	The feature has low flow sprinkles and emerging lights	The feature is designed as a waterfall (5" high), with a water flow from the top, also it has sprinkles and emerging lights
Comments	The feature is surrounded with restaurants and seating area.	The feature is located in the central pathways of the mall near seating area.	The feature is surrounded with restaurants and seating area.

Table 2: Inspection Parameters for Water Samples from Sites A, B, C and Baseline Source

The results showed differences in microbial growth profile between the three sites. While site (A) showed no growth in the two tests, this does not confirm the absence of microorganisms in the feature. However, this result proved that daily cleansing and the maintenance procedure applied was efficient in this particular mall. Site (C) showed higher growth in test #1 (after cleaning) as compared to test #2 (before cleaning), which may indicate that cleaning and inspection of chlorine level on a daily basis could improve the condition of the water in the decorative feature. Nevertheless, the results from swabs obtained from site (A) and (C) demonstrated the possibility of biofilms and waterborne bacteria existing around the feature's surface. Both features located at site (A) and site (C) were surrounded by café shops and seating areas. Regardless the decorative design; this increases the possibility of cross-contamination. The location of the ornamental fountain has a significant impact on the possibility of cross-contamination. This is because of the air flow circulation. A fountain that is located at the air circulation path or in the middle of the area would have high risk of transmitting aerosols in the air [3].

Site (B) showed key differences in growth compared with site (A) and (C). Since no chlorine was used in the features from site (B), germs and microbes were able to exist in water within the feature, and after a week the water color changed too. The results also indicated the presence of fungal contamination in the water and the surface of the features. The maintenance in site (B) is based on changing the water in the feature, with fresh water from the baseline in weekly bases. Water samples obtained before and after cleaning of the feature from site (B) shows high colonies growth compared with site (A) and (C), and compared with the ideal colony count per 100 ml. thus, more research was done with samples from site (B). Different dilutions were examined to configure an accurate result. Moreover, the visual inspection on site (B) showed that the water had changed in color, and the surface of the feature showed rust/biofilm accumulative on the surface of the feature. Changes in color/odor of the water are a direct indicator that a significant amount of bacteria exists in the water, and could provide conditions for biofilms to form [3]. This could result in serious infectious outbreak if not controlled. The European Guidelines for Control and Prevention of Travel Associated Disease have set the safe amount of colonies growth/ml in water samples obtained from water features. They stated that microbiological tests should result in colony count less than 100cfu/ml, and preferably less than 10 cfu/ml [13]. There must be less than 10 CFU of *Pseudomonas aeruginosa* per 100 ml, and there should be no coliforms or *Escherichia coli* in 100 ml [13].

The World Health Organization [17-27] states that since it is difficult to identify the specific level of potential risk of any particular pathogens found in the water due to many variables like the immunity of the individual exposed or the invasiveness of the pathogen in the water. Consequently, WHO concludes that any water containing pathogenic organisms cannot be considered safe.

Recommendation

The results of this study state demonstrate that if indoor ornamental water features are not maintained and controlled probably, this could lead to potential risk to the public health. In order to prevent and minimize the outbreak of infection disease, risk assessment and risk management should be considered. A full management plan should be followed by owners or operators of ornamental features. Maintenance procedure, maintenance log, and emergency procedures should be provided for workers and staff in charge of the maintenance. Decorative water features must display warning signs to provide awareness to the visitors of the mall.

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