

The fungal contamination of indoor pools in Sanandaj city, Iran (2017)

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ABSTRACT

The present study aimed to assess the surface contamination of indoor swimming pools in Sanandaj city, Iran and the influential factors in this regard. This descriptive-analytical study was conducted on nine active swimming pools in Sanandaj, which were selected via simple random sampling. Sampling was performed in the spring and summer of 2017 twice per season using the sterile carpet measurement method. In total, 180 samples were assessed in the study, including nine swimming pools, five surfaces, and two seasons (data collection performed twice per season in spring and summer). According to the findings, 96.7% of the samples were infected with one or more fungi. The isolated fungi were saprophytic, and no dermatophyte contamination was observed. The highest and lowest incidence of saprophytic contamination belonged to yeast species (100 positive samples) and *Ulocladium* (four positive samples), respectively. Furthermore, the number of the fungi isolated from the surface water of the swimming pools in summer was higher compared to spring. However, no significant correlations were observed between temperature, humidity, remaining chlorine, and pH with the presence of the isolated fungi. Due to the presence of various saprophytic species in swimming pool surfaces, it is strongly recommended that proper sanitary measures be taken in these environments (e.g., disinfection and complete washing of the body with water and soap by swimmers) in order for the effective monitoring and control of health.

Keywords: Swimming pool, Fungal contamination, Sanandaj

Introduction

Use of natural or artificial aquatic environments as swimming pools is a common practice in the human community. Today, every community is inclined toward the aesthetic and recreational use of water sources. Swimming is a popular sport and recreational activity, as well as an indicator of physical and mental fitness.¹

In warm seasons, swimming pools are widely used for sports and recreational activities

by many enthusiasts. However, the presence of microbial and fungal contaminations in pool water poses the risk of various infections and diseases to swimmers, especially those with poor immune function and susceptible individuals. Contamination of pool water could lead to gastrointestinal diseases, ocular complications (e.g., keratitis, especially in the individuals using contact lenses), cutaneous disorders, ear infections, and upper respiratory tract infections (especially in case of holding head under water or swallowing pool water).²

Although swimming pool water is not considered to be a major cause of the transmission of fungal diseases,³ studies in this regard have indicated that in addition to water,

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the physical environment of swimming pools could be an optimal environment for the growth and propagation of pathogenic fungi and transmission of fungal diseases due to the constant moisture content and high temperature in these environments.

Several saprophytic fungi could easily grow in warm environments, including various species of aspergillus, penicillium, mucurium, and rhizopus. Places such as the shower, split-up, sauna, and dressing room in swimming pools may be contaminated with various superficial and cutaneous fungal species (e.g., tufts).⁴⁻⁷ Fungal diseases could be caused by other factors than pathogens, such as ambient temperature, humidity, human age, occupation, living conditions, and non-compliance with health standards.⁸

According to the literature, bacterial and fungal contaminations could be caused by various saprophytic fungi, yeasts, and dermatophyte pathogenic fungi.² Dermatophyte pathogenic fungi are the fungal agents that could lead to superficial cutaneous infections, such as infections with *Tinea capitis* (ringworm of the hair) and *Tinea pedis* in the feet, nails, and skin, especially in childhood and adolescence. Athlete's foot is the most prevalent infection in this regard, which leads to fissure or cracking between the toes, as well as scabbing and severe itching of the foot. Dermatophytosis could be transmitted individually or in the contact of the skin of an infected patient with contaminated environments. In swimming pools, there is the increased risk of contact with contaminated physical surfaces, especially the humid areas in the bathrooms, saunas, pools, and dressing rooms.⁹ In a study in this regard, Jafari assessed the level of fungal contamination in the surface water of the indoor swimming pools in Yazd city (Iran), reporting that among 720 collected and cultivated samples, 495 cases (68.7%) contained a minimum of one or more fungal contaminants, while 225 samples (31.3%) had negative culture or no fungal contamination in various areas of the swimming pools. Therefore, special attention must be paid to sanitation and disinfection in order to reduce contamination in the water and environment of

swimming pools.¹⁰ Considering the complaints regarding the risk of fungal contamination in some of the swimming pools in Sanandaj (Iran) and lack of studies on the fungal contamination of the swimming pools in this city, proper investigations in this regard are required.

The present study aimed to evaluate the level of fungal contamination in the indoor swimming pools in Sanandaj city. The obtained results could be useful for the related authorities in the improvement of the health status of swimming pools. One of the limitations of the current research was the inactivity of some of the swimming pools in Sanandaj, which restricted the sampling of the swimming pools.

Materials and Methods

This descriptive-analytical study was conducted during the spring and summer of 2017. In order to assess the level of fungal contamination in indoor swimming pools, sampling was performed in the indoor and active swimming pools in Sanandaj city, including nine swimming pools (Kani, Soleiman Khater, Medical Sciences, Maleknia, Entezam, Shadi, Azad, Isar, and Garrison). The required permit for sampling was obtained from the health center of Sanandaj, and sampling was carried out in the spring and summer of 2017. The inclusion criteria of the study were public swimming pools and swimming pools with both male and female shifts.

The sterile carpet measurement method was used in order to evaluate the level of fungal contamination. Samples from the swimming pools and saunas were collected randomly at various times during the day twice per month (two weeks per month). It was attempted to collect the samples from crowded spots or the places where contact with the legs and body of the swimmers was more likely, so that contamination could be confirmed more accurately. The main surfaces included the swimming pools, saunas, showers, dressing rooms, and wardrobes.⁵ A sterile carpet (6 x 6 cm) was used for sampling, so that the cut pieces were placed in water for 24 hours so as to remove glue and other materials and rinsed with

distilled, sterilized water. After the drying of each piece in an aluminum foil, the pieces were placed in an autoclave for 120 minutes and at the temperature of 120 °C for 15 minutes.

In order to collect samples from the surfaces of the swimming pools and saunas, the sterile carpet was removed from the aluminum foil and rubbed to the sampling spots several times. Afterwards, it was inserted inside the sterilized foil again and transferred to the laboratory. The carpet was removed from the foil, and all the carpet materials were inoculated on plates immediately (s, sc, and scc), so that by the shaking of the carpet and hitting it several times on the back of the carpet slowly, all the materials could be extracted from the surface of the plates and inoculated. Following that, the carpets were incubated at the temperature of 24-26 °C for 48-72 hours (s and sc) and 21 days (scc). After the growth of the organisms, a lam was prepared from the carpets and examined in terms of contamination with dermatophytic and saprophytic fungi. In addition, temperature and humidity were measured using portable equipment in the selected swimming pools. Data analysis was performed in SPSS version 18.

Results and Discussion

The physicochemical results of the nine selected indoor swimming pools in Sanandaj city indicated the mean temperature of 28.4222 °C, mean humidity of 55.611%, mean residual

chlorine level of 1.1083 mg/l, and mean pH of 6.8222 (Table 1).

Table 1. Measured physicochemical parameters

Parameters	Min	Max	Mean	Std. Deviation
Temperature (°C)	22	32	28.4222	2.68496
Humidity (%)	49	62	55.6111	3.82784
Remaining chlorine (mg/l)	0.55	3	1.1083	0.63844
pH	5.20	8.20	6.8222	0.92305

The maximum temperature was observed in Entezam swimming pool with the mean temperature of 29.25 °C, and the minimum temperature was observed in Kani swimming pool with the mean temperature of 27.25 °C, which was not in accordance with the standard temperature range in swimming pools (24.5-25.5 °C).¹¹

The maximum and minimum moisture content were observed in the Medical Sciences (57.5%) and Soleiman Khater swimming pools (52.25%), respectively. In addition, the highest concentration of residual chlorine was observed in Padegan swimming pool with the mean level of 1.388 ppm, while the lowest concentration of residual chlorine was observed in the mineral swimming pool with the mean level of 0.6375 ppm. On the other hand, the highest pH was reported in Kani, Shadi, and Isar swimming pools with the mean value of 7.755, while the lowest pH was observed in Maleknia swimming pool with the mean value of 5.9000 (Table 2).

Table 2. Mean values of physicochemical parameters in studied swimming pools

Pool	Temperature		Humidity		Remaining chlorine		pH	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Kani	27.25	3.27470	56.00	1.91943	0.637	0.06664	7.375	0.72321
Solyman khater	28.62	1.71583	52.25	1.51744	1.337	0.19194	7.175	0.41912
Maleknia	29.02	2.54163	56.25	3.99835	1.337	0.81868	5.900	0.55251
Entezam	29.25	0.85070	56.00	3.24443	1.325	0.61184	7.100	0.99207
Shadi	28.50	4.08785	56.50	4.50146	1.325	0.69821	7.375	0.53986
Olom pezeszki	29.02	2.02273	57.50	4.13585	0.800	0.96408	6.525	0.65845
Azad	28.75	1.38127	55.75	4.43521	0.725	0.13328	6.225	0.86565
Esar	27.85	3.50751	54.50	3.28473	1.100	0.35726	7.375	0.63815
Padeghan	27.62	2.79508	55.75	4.37547	1.387	0.64213	6.350	1.17541

Among 180 cultured samples, 174 cases (96.7%) were infected with one or more

fungi. All the isolated fungi were saprophytic, and no dermatophytic

contamination was observed. The highest and lowest contamination rates of saprophytic infection belonged to yeast species (100 positive samples) and *Ulocladium* (four positive samples), respectively. The findings regarding the isolated fungal species are presented in Table 3.

According to the results of the present study, Padegan, Isar, and Maleknia swimming pools had the most frequent isolated fungal species, and Medical Sciences and Azad University swimming pools had the least frequent isolated fungal species (Table 4).

Table 3. Frequency and percentage of various saprophytic fungi and cultured dermatophytes

Types of fungus	Percentage of cultivated fungus	Number of cultivated fungus
Yeast	31.44%	100
Aspergillus flavus	15.09%	48
Aspergillus niger	15.09%	48
Alternaria	13.20%	42
Cladosporium	10.06%	32
Penicillium	8.80%	28
Geotrichum	3.14%	10
Fuzarim	1.89%	6
Oaclademium	1.26%	4
Dermatophyte	0	0
Total	100%	318

Table 4. Number and percentage of isolated fungal species in each swimming pool

Pool	Fungus									
	Yeast	Aspergillus flavus	Aspergillus niger	Alternaria	Cladosporium	Penicillium	Geotrichum	Fuzarim	Oaclademium	Total
1	N 10	2	8	6	0	4	4	0	0	34
*	% 29.41	5.88	23.52	17.64	0	11.76	11.76	0	0	100
2	N 14	6	2	2	2	0	4	0	0	30
*	% 46.7	20	6.67	6.67	6.67	0	13.34	0	0	100
3	N 10	8	6	6	6	8	0	0	0	44
*	% 22.72	18.18	13.63	13.63	13.63	18.18	0	0	0	100
4	N 10	8	4	4	2	2	0	0	0	30
*	% 33.33	26.67	13.34	13.34	6.67	6.67	0	0	0	100
5	N 10	12	4	6	4	2	0	0	0	38
*	% 26.31	31.57	10.52	15.79	10.52	5.26	0	0	0	100
6	N 14	2	2	4	2	2	0	2	0	28
*	% 50	7.14	7.14	14.28	7.14	7.14	0	7.14	0	100
7	N 2	8	6	4	4	4	0	0	0	28
*	% 7.14	28.57	21.42	14.28	14.28	14.28	0	0	0	100
8	N 12	2	10	4	8	2	0	2	4	44
*	% 27.27	4.54	22.42	9.09	18.18	4.54	0	4.54	9.09	100
9	N 18	2	6	6	4	4	2	2	0	44
*	% 40.9	4.54	13.63	13.63	9.09	9.09	4.54	4.54	0	100
1*= Kani			2*= Solyman khater			3*= Maleknia				
4*= Entezam			5*= Shadi			6*= Olom pezeshki				
7*= Azad			8*= Esar			9*= Padeghan				

The findings of the current research indicated that the highest rate of fungal contamination was observed on the surfaces in the dressing rooms of the

swimming pools, while the lowest contamination rate was observed on the surfaces of the saunas (Table 5).

Table 5. Number and percentage of isolated fungal species in various surfaces

Fungus	Surfaces									
	Locker room		Shower		Wardrobe		Sona		Around the pool	
	N	%	N	%	N	%	N	%	N	%
Yeast	22	29.72	18	27.27	20	30.3	16	32	24	38.7
<i>Aspergillus flavus</i>	12	16.21	10	15.15	12	18.18	10	20	4	6.4
<i>Aspergillus niger</i>	10	13.51	8	12.12	16	24.24	8	16	6	9.67
<i>Alternaria</i>	10	13.51	6	9.09	6	9.09	6	12	14	22.58
<i>Cladosporium</i>	8	10.81	12	18.18	2	3.03	2	4	8	12.9
<i>Penicillium</i>	6	8.1	6	9.09	8	12.12	4	8	4	6.45
<i>Geotrichum</i>	4	5.4	4	6.06	0	0	2	4	0	0
<i>Fuzarim</i>	2	2.7	2	3.03	0	0	2	4	0	0
<i>Oocladium</i>	0	0	0	0	2	3.03	0	0	2	3.22
Total	74	100	66	100	66	100	50	100	62	100

Our findings were indicative of no significant correlations between temperature, type and level of fungi ($P=0.210$), moisture content, and isolated fungi species ($P=0.460$) (Table 6).

Table 6. Correlations between temperature and humidity with fungal contamination

		df	F	P-value
Humidity	Between group	36	1.01	0.460
	Inside the group	143		
	Total	179		
Temperature	Between group	36	1.21	0.210
	Inside the group	143		
	Total	179		

The prevalence of human infections has recently increased, and one of the main causes of this issue is human contact with contaminated water.¹¹ Various domestic and foreign studies have reported the high risk of fungal disease transmission in swimming pools, which is considered to be a significant health concern.¹¹⁻¹⁵ According to the results of the present study, the mean pH during the sampling period was 6.8222 ± 0.92305 in the selected swimming pools. The recommended pH limit for swimming pools is within the range of 7.2-8.¹⁵⁻¹⁹ Furthermore, the concentration of free chlorine residual content was estimated at 0.55-3 mg/l, which was above the national standard level (1-2 mg/l).¹⁹

According to the findings of the current research, the water temperature of the studied swimming pools was within the range of 22-32 °C, which was not within the standard range of swimming pool water temperature (24.5-25.5 °C).¹⁹ In addition, the moisture content of the swimming pools was estimated at 49-62%,

which was higher than the recommended level (50-53%).²⁰ In the present study, the surfaces of the swimming pools were also investigated in terms of fungal contamination.

According to the obtained results, most common fungi species were yeasts, *Aspergillus*, *Alternaria*, *Cladosporium*, penicillium, and geotrichum. In a similar study by Nanbakhsh *et al.*, the most common fungal species were reported to be *Aspergillus*, *Candida*, dermatophyte, penicillium, mucor, phoma, and exophilla.⁵ In another research by Shadzi *et al.* conducted in Isfahan (Iran), the most common isolated fungal species were reported to be cladosporium, penicillium, rhizopus, *Aspergillus*, and yeasts, which is consistent with the results of the present study.¹⁴

In the present study, no dermatophyte fungi were isolated from the swimming pool surfaces. In a similar study performed in Sarein (Iran), the obtained results indicated that dermatophytes were not present in the swimming pools in Sarein.¹⁹ In the current research, no significant correlation was observed between the concentration of residual chlorine in water and fungal species, which is consistent with a similar study conducted in Bandar Abbas (Iran).²⁰ In another research performed in Qom (Iran), no significant correlation was reported between contamination with fungal species and residual chlorine.³

The results of the present study demonstrated no significant correlations between contamination with fungal species with temperature, humidity, and pH. In a similar study conducted by Hoseinzadeh *et al.* on the

indoor swimming pools in Hamedan (Iran), the correlation between the mentioned parameters and contamination with fungal species was not considered significant, which is in line with the findings of the current research.¹⁸

Conclusion

According to the results, dermatophytes were not present in the samples obtained from the swimming pools in Sanandaj. Among non-pathogenic species, yeasts were considered to be the most frequent species, while the lowest prevalence was attributed to fusarium and *Ulocladium*. However, no significant correlations were observed between temperature and humidity with the type and counts of the isolated fungi. In order to promote the health of swimming pools and reduce the risk of fungal contamination (especially saprophytic contamination), proper measures such as health care by swimmers, training on full-body washing with water and soap, and use of spray docks are recommended. In addition, individuals with fungal infections must be discouraged to use public swimming pools in order to prevent the transmission of the diseases.

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