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Surveying Hygiene Indices of Water of Swimming Pools in Kermanshah City (Iran), 2015

[1]Younes Sohrabi, [2]Kamran Tari, [3]Seyedeh Shadi Charganeh,
[1]Farshad Rahmani Tabar, [1]Diyari Abdollahzadeh and [4]Mahdi Dabirian
[1]Department of Environmental Health Engineering, Students Research Committee,
Kermanshah University of Medical Sciences, Kermanshah, Iran
[2]Department of Environmental Health Engineering, School of Health,
Qazvin University of Medical Sciences, Qazvin, Iran
[3]Department of Environmental Health Engineering, School of Health,
Zabol University of Medical Sciences, Zabol, Iran
[4]Social Determinations in Health Promotion Research Center,
Hormozgan University of Medical Sciences, Bandar Abbas, Iran

Abstract: Water hygiene in swimming pools is paramount knowing that it affects the swimmer's health. Failure to meet hygiene standards in swimming pools increases the risk of several diseases in swimmers. The present study is aimed at examining hygiene indices of swimming pools water located in Kermanshah City-Iran.The study was carried out as a descriptive and cross-sectional study in 21 public swimming pools in 2015. Free residual chlorine, PH, turbidity, heat resistant coliform and HPC were examined and the results were compared with Iran National Standard (11230). The results showed that residual chlorine, PH, turbidity, heat resistant coliform and HPC were desirable in 92.2%, 100%, 99.7%, 91.3% and 91.7% of the cases respectively. Highest levels of residual chlorine, heat-resistant coliform and HPC were observed during fall and these indices were at minimum level during winter. In addition, highest levels of residual chlorine, heat-resistant coliform and HPC were obtained in August-September.The results showed that quality of water in swimming pools located in Kermanshah city was at average level and there was a need to improve quality of water of swimming pools in this city. It is possible to improve quality of swimming pools water by permanently monitoring free residual chlorine and PH levels.

Key word: Water, swimming, pool, swimming, Kermanshah

INTRODUCTION

Because of direct contact between the human's body and water in swimming pools, they have high potential of being a source of contamination (Rasti *et al*., 2011; ISIR, 2008). Increase in popularity of the swimming pool in absence of a reliable monitoring and maintenance services may lead to several risks to the public health. Swimming is a sport and leisure activity from physical and psychological viewpoint and it can be a great help in improving health and welfare of individuals provided that health concerns of these facilities are addressed properly. One of the main hygiene concerns is quality of water in swimming pools (Mansoorian*et al*., 2013). From health standard viewpoint, swimming water, like drinking water, need to have specific physical, chemical and microbial specifications; otherwise, this joyful hobby or sport might lead to outbreak of variety of diseases (Panyakapo *et al*., 2008; Lourencetti *et al*., 2010). The swimming waters are prone to be polluted by body hair and oil of the swimmers, microbes of reproductive system, digestion, respiratory system microbe and other bacteria and unwanted materials from the swimmer's body. The more a swimming pool is used by individuals, the higher the rate of pollutions in the water and higher the health risks for the swimmers. Therefore, public swimming pools are a potential threat to health of the users (Zazouli *et al*., 2015; Abedi *et al*., 2014). These risks are categorized in three categories of physical, chemical and microbial risks and in general, microbial risk and the diseases are more serious (Zangiabadi *et al*., 2011; Abedi *et al*., 2012). Among the communicable diseases under consideration, typhoid fever, dysentery, trachoma, leptospirosis, ringworms, skin infections, schistosomiasis, itching,

Corresponding Author: Mahdi Dabirian, Social Determinations in Health Promotion Research Center,
Hormozgan University of Medical Sciences, Bandar Abbas, Iran

respiratory diseases, sinusitis and ear and throat infection are notable. For instance, mycobacterium mornium causes eyes, ears and skin infections which leads to granuloma (Moeinian *et al*., 2016; Farzianpour *et al*., 2014). Several studies have been conducted on swimming pool water in Iran and other countries. Among many, studies in Isfahan (Nikaeen *et al*., 2010), Shiraz (Neghab *et al*., 2004), Ouromieh (Nanbakhsh *et al*., 2004), Zanjan (Nourian *et al*., 2006), East of Greece (Nichols, 2006), Sant Galen in Sweden (Barben *et al*., 2005), Naples-Italy (Guida *et al*., 2009), Munich and Lipzing Germany (Schoefer *et al*., 2008) and Eman in Jordan (Rabi *et al*., 2007) are notable. All these studies have reported relative contamination in different sections of public pools with funguses like dermatotitis (Azizjalali and Behrangi, 2009; Kazemi-Fard *et al*., 2006), index microorganism like pseudomonas and specially aeruginosa (Schoefer *et al*., 2008), coliforms (Rabi *et al*., 2007), streptococcus (Nikaeen *et al*., 2010; Neghab *et al*., 2004), staphylococcus (Yousefi 2009) and variety of parasites (Nanbakhsh *et al*., 2004) in particular. Studies have highlighted necessity of codifying pools hygiene controls and standards to avoid communicable and prevalent diseases. Therefore, implementation of an efficient management and permanent monitoring system in swimming pools is essential to make sure that the water used in the pools is hygienic, treated and in line with public health codes (Hambly *et al*., 2010). Microbial indices such as Heterotroph Pallet Count (HPC) and coliform bacteria are the main indices of effectiveness of disinfection measures; coliform and fecal streptococcus are the main fecal contamination indexes; and staphylococcus aureus and pseudomonas aueroginosa are the main health risk indices of swimming pools (Bahmani *et al*., 2015). Taking into account importance and diversity of communicable diseases and microorganisms in swimming pools, microbial quality control in swimming pools is of great importance. Therefore, the present study is an attempt to survey hygiene indices in swimming pools water in Kermanshah City.

MATERIALS AND METHODS

The study was carried out as a descriptive cross sectional study on 21 active public swimming pools in Kermanshah. Parameters like turbidity, PH, residual chlorine and microbial residual were examined in 2013 in a 12 months period. Two or three samples were collected from each pool every month and the samples were tested in a health center. The samples for microbial assessment were collected in sterilized bottles with wide opening (250 mL) containing 10 drops of sodium thiosulfate. The samples were handled in ice and analyzed immediately in laboratory. Residual chlorine and pH were measured at the site. Turbidity was measured by a turbiditymeter and the rest of the tests were carried out in laboratory based on available standard methods (APHA *et al*., 2005). The data was analyzed in SPSS and the findings were compared with the standards (ISIR, 2008).

RESULTS AND DISCUSSION

The results of the measurements and the standards are listed in Table 1 for comparison. Table 2 and 3 list the results based on the sampling month.

As listed in Table 2, the highest and lowest levels of residual chlorine, health-resistant coliform and HPC were observed in fall and winter respectively.

As listed in Table 3, highest levels of residual chlorine, heat-resistant coliform and HPC were observed in September and October. Increasing popularity of swimming pools and poor supervising and monitoring measures can create a serious threat to the public health (Mansoorian*et al*., 2013). Literature review showed that

Table 1: Frequency (%) of different hygiene samples in public pools located in Kermanshah City (n = 21)

Variables	Number of sample in 12 month	Desirable	Undesirable	Iran national standards (11203)	WHO standard
Residual chlorine (ml/L)	760	793 (92.2%)	67 (7.8%)	0.6-1	≤1
PH	794	794 (100%)	0	7.2-7.8	7/2-7/8
Turbidity (NTU)	428	427 (99.7%	1 (0.3%)	Max: NTU0.5	≥0.5
Heat resistant coliform (MPN/100ml	437	399 (91.3%)	38 (8.7%)	<1 per ml (Iran national standard,No.3759) based Iran national standard (9412) and WHO standard	-
HPC	437	401 (91.7%)	36 (8.3%)	-	>200

Table 2: Frequency (%) of physical, chemical and microbial parameters based in season (N = 21)

HPC		Heat resistant coliform (MPN/100 mL)		Turbidity (NTU)		PH		Residual chlorine (ml/L)		
Undesirable	Desirable	Undesirable	Desirable	Undesirable	Desirable	Undesirable	Desirable	Undesirable	Desirable	Season
5 (5.5%)	87 (94.5%)	5 (5.5)	87 (94.5%)	1 (1.1)	91 (98.9)	0	198 (100%)	9 (4%)	195 (96%)	Spring
10 (7.9%)	118 (92.1%)	11 (8.6%)	117 (91.4%)	0	119	0	265 (100%)	15 (5.7)	250 (94.3)	Summer
18 (14.4%)	107 (85.6%)	19 (15.2%)	106 (84.8%)	0	125	0	207 (100%)	29 (14%)	178 (86%)	Fall
3 (3.3%)	89 (96.7%)	3 (3.3%)	89 (96.7%)	0	92	0	124 (100%)	14 (7.6%)	170 (92.4%)	Winter

Table 3: Frequency (%) of physical, chemical and microbial parameters based in months (N = 21)

HPC		Heat resistant coliform (MPN/100 mL)		Turbidity (NTU)		PH		Residual chlorine (ml/L)		
Desirable	Undesirable	Desirable	Undesirable	Desirable	Desirable	Undesirable	Desirable	Undesirable	Desirable	Months
3 (10%)	27 (90%)	3 (10%)	27 (90%)	0	30 (100%)	0	54 (100%)	4 (6.7%)	56 (93.3%)	Mar. Apr.
2 (5.5%)	35 (94.5%)	2 (5.5%)	35 (94.5%)	1 (2.7%)	36 (97.3%)	0	74 (100%)	5 (6.8%)	69 (93.2%)	Apr. May
0	25 (100%)	0	25 (100%)	0	25 (100%)	0	70 (100%)	0	70 (100%)	May Jun.
3 (8.9%)	31 (91.1%)	3 (8.9%)	31 (91.1%)	0	25 (100%)	0	74 (100%)	1 (1.4%)	73 (98.6%)	Jun. Jul.
4 (8%)	46 (92%)	4 (8%)	46 (92%)	0	50 (100%)	0	101 (100%)	6 (6%)	95 (94%)	July. Aug.
3 (6.9%)	41 (93.1%)	4 (9.1%)	40 (90.9%)	0	44 (100%)	0	90 (100%)	8 (8.9%)	82 (91.1%)	Aug. Sep.
13 (30.3%)	30 (69.7%)	11 (25.6%)	32 (74.4%)	0	43 (100%)	0	43 (100%)	15 (34.1%)	29 (65.9%)	Sep. Oct.
5 (12.2%)	36 (87.8%)	7 (17.1%)	34 (82.9%)	0	41 (100%)	0	82 (100%)	9 (11%)	73 (89%)	Oct. Nov.
0	41 (100%)	1 (2.5%)	40 (97.5%)	0	41 (100%)	0	82 (100%)	5 (6.2%)	76 (93.8%)	Nov. Dec.
1 (3.2%)	31 (96.8%)	1 (3.2%)	31 (96.8%)	0	32 (100%)	0	32 (100%)	4 (6.3%)	60 (93.7%)	Dec. Jan.
0	28 (100%)	0	28 (100%)	0	(100%)28	0	28 (100%)	3 (5.4%)	53 (94.6%)	Jan. Feb.
2 (6.3%)	30 (93.7%)	2 (6.3%)	30 (93.7%)	0	32 (100%)	0	64 (100%)	7 (11%)	57 (89%)	Feb. Mar.

hygiene of swimming pool water was effective on controlling disease among swimmers. A study by Paul Roy in the USA showed that measuring PH, residual chlorine and number of users of a pool gives a reliable measure (confidence level of 95%) of microbial contamination (Mehdinejad, 2003). The present study indicated that residual chlorine was at desirable level in 92.2% of the cases and 7.8% of the cases failed to meet the standards (Table 1). Residual chlorine level less than the standards leads to higher turbidity, which in turn accelerates growth of algae and microorganisms. This problem can be solved by increasing the level of residual chlorine and adjust pH level (Mansoorian*et al*., 2013). A study by Ghaneian in Yazd showed that 44.18% of the samples met the standards of residual chlorine while in 55.82% of the cases, residual chlorine was higher than the standards (Ghaneian *et al*., 2012). Rabi *et al*. (2007) showed that residual chlorine in 49.4% of public pools in Aman- Jordan met the standards (Rabi *et al*., 2007). Khodadadi *et al*. (2009) carried out a study in Birjand-Iran and reported the residual chlorine in public pools was in undesirable level in 75% of the samples. Comparison of the obtained results and those of other studies indicates that residual chlorine level in our study was in better condition than that reported by other studies. The results also indicated that residual chlorine in the swimming pools under study was in better condition during spring (Table 2). Consistently, shahriari in Gorgan measured residual chlorine level based on seasons and reported that during spring, the index was in the best condition (Shahriari *et al*., 2011). Our results showed that the samples were at standard level regarding PH level (Table 1). Similar studies in Oroumieh, Zahedan isfahan and Shahrekord indicated that mean PH level was at standard level (Nikaeen *et al*., 2010; Nanbakhsh *et al*., 2004; Sohrabi *et al*., 2003; Fadaei *et al*., 2005,). Low pH level of water accelerates decay process of the installation, causes eyes and skin irritation and reduces chlorine in water and quality of water (Nikaeen *et al*., 2010; Borgmann-Strahsen, 2003). Sodium carbonate can be used to adjust pH level; while, excessive use of sodium carbonate increases the risk of respiratory and allergic problems and increases sediments and turbidity of water. To reduce pH, diluted muriatic acid and sulfuric acid can be used (Uyan *et al*., 2009). Our results showed that 99.7% of the samples were at desirable level regarding turbidity and only 0.3% of the samples failed to meet the standards. Taking into account importance of turbidity in microbial hygiene of water, standard level of turbidity for swimming pool is 0.5 NTU (ISIR, 2008). The purpose of measuring turbidity is to determine transparency of water. High turbidity causes problems such as decrease in performance of disinfection process and reduction in effectiveness of disinfection agents (Mansoorian*et al*., 2013). Ghanian in Yazd reported that 13.6% of the samples had turbidity higher than the standards (Ghaneian *et al*., 2012). Other studies have emphasized on necessity of examining public pools water with regard to microbial pollutions (Mansoorian*et al*., 2013). Our results from 21 public swimming pools in Kermanshah showed that 8.7% and 8.3% of the smples were in undesirable condition regarding heat-resistant coliform and HPC, respectively (Table 1). Mansourian *et al*. (2013) carried out similar study in Kerman City and found that 82% of the samples were in desirable condition from microbial contamination viewpoint; this figure in our study was 92%. Results of microbial quality examination showed that heat-resistant coliform and HPC levels were at minimum levels during winter (Table 2). Shahriari *et al*. (2011) reported that swimming pools in Gorgan had no microbial contamination during spring. In addition, the results showed that heat-resistant coliform and HPC were at highest level during Summer and fall between September and November (Table 2 and 3). Shahriari *et al*. (2011) reported in their study in Gorgan that highest coliform and pseudomonas aeruginosa level was observed in fall and the highest facal streptococcus level was in Summer. Chlorine measurement showed that highest residual

chlorine concentration was observed in fall; apparently, lack of residual free chlorine is a great contributor in higher microbial contamination. In this regard, our results are consistent with (Shahriari *et al*., 2011; Zazuli *et al*., 2015; Rakestraw *et al*., 1994) in addition, Martins *et al*. (1995) found a negative relationship between residual chlorine and bacteria contamination. Some of the risk assessment methods must be used in water pool for assessing health risk factor (Yarmohammadi *et al*., 2016). Technical committee of nosocomial infections is useful in management of pollution of water pool, etc (Vatankhah *et al*., 2014). knowledge, attitude and performance of staff of water pools in relation to job's environmental health must be useful in pollution of water pool (Almasi, 2016).

CONCLUSION

Knowing that the highest concentration of free chlorine residual was observed in fall, it appears that lack of free residual chlorine explains higher microbial contamination in this season. Therefore, free residual chlorine is an effective factor in reducing microbial agents and turbidity, which needs to be monitored continuously. To have better control over disinfection agents, PH level must be monitored regularly. we recomended Effects of Administrative Interventions on Improvement of Safety and Health in Workplace is proven must be done in water pool (Ebrahimi *et al*., 2016).

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