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Investigation on the Concentration of Chemical Contaminants in Swimming Pools in Shahroud, Iran

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Abstract

Background: *Swimming pool and similar aquatic environments are polluted as a result of emitting the chemical and biological compounds produced in swimmers' body including urine, sweat, saliva, body cells, body dust, respiratory and gastrointestinal tract microorganisms. Thus, in the present study, the concentration of chemical contaminants was investigated in swimming pools in Shahroud, Iran.*
Methods: *This descriptive and cross-sectional study was conducted in 6 active swimming pools in Shahroud, Iran in summer 2016. In this study, the arameters of Paraben, Triclosan and Hydroquinone were measured in the laboratory. Water sampling was carried out every 10 days, when the pool was occupied by a large number of swimmers. Cosmetics was measured by a high-performance liquid chromatography apparatus equipped with a detector. The results were analyzed using SPSS software (ver.15).*
Results: *6 swimming pools were studied in the current study. The results of the study proved the existence of cosmetic compounds like hydroquinone, PropylParaben and Triclosan with maximum average in part per billion(ppb), as for swimming pools used by the ladies, their corresponded amounts were obtained as 243, 1672.11 and 200.8ppb, respectively whereas for Jacuzzi, these amounts were obtained as 616.33, 1625.88 and 57.92ppb, respectively.*
Conclusions: *This study was the first study investigated the concentration of the cosmetic compounds existing in swimming pools from different areas of Iran, and the findings of the study showed that, swimming pools with high rank of health standard have a better state.*

Keywords: Cosmetic, Swimming pools, Shahroud.
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Introduction

Swimming is a popular sport ensuring the public health. However, many studies suggested that, being exposed to the swimming pool water might lead to a variety of health risks, such as increased asthma and allergy, associated with microbial infection and hazardous chemical compounds.[1] Swimming pool water is polluted by the dissolved substances originating from human body fluids[2-5] and personal-care products.[6]

Recently, researchers have conducted a number of studies on the adverse effects of the personal care products' applications and disinfection by-products (DBPs) formed in swimming pools.[7-9]

As mentioned previously, Propyl Paraben, hydroquinone and Triclosan are the main pollutants observed in swimming pools, which can have an exacerbating effect on each other. Obviously, cosmetic compounds contain a high proportion of these substances used by ladies every day. [9, 5] Structure of Propyl Paraben is shown in figure 1. Parabens, a group of alkyl esters of p-hydroxybenzoic acid (PHBA) are used as antimicrobial preservatives in foods, cosmetics, and pharmaceuticals in wide range.[10-12] As the routine preservatives in various cosmetics and sun care products, parabens may be transferred into the swimming pool water by a large number of swimmers. Moreover, because of the active phenolic hydroxyl groups, parabens can be easily transformed to mono- and di-chlorinated derivatives in chlorinated water.[6]

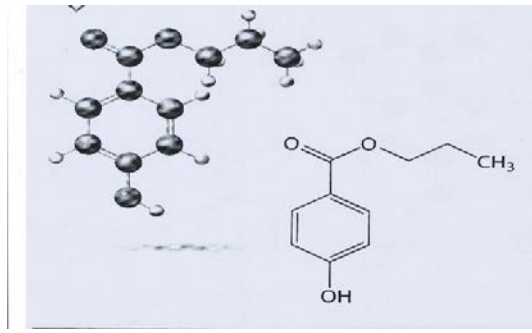

Figure 1.Structure of Propylparaben

Thus, during disinfection of swimming pool water, parabens may react with free chlorine to form chlorinated parabens, which are more stable in environment and also more toxic than its corresponding parent parabens.[13] Therefore, humans might be exposed to parabens and their chlorinated derivatives through different pathways in swimming pools (inhalation, ingestion, and dermal absorption).[14,15]

Several studies have demonstrated that, parabens and chlorinated derivatives exhibit endocrine-disrupting properties, modulating or disrupting the endocrine system and causing harmful effects on both animal and human health.[16] In March 2011, in Denmark, the usage of the substances like propylparaben, butyl paraben, and their salts has been banned in cosmetic products for children under 3 years old.[17]

Therefore, more attention should be paid to the potential risks of being exposed to these compounds, especially for children, who are more likely to be adversely affected by environmental contaminants than adults, from the other side since, they weigh lighter than adults, they are expected to undergo behavioral and physical development so rapidly.[18]

So far, a scarce set of data has proved the presence of parabens and their chlorinated derivatives in pool water samples.[19] Parabens are only analyzed in the limited swimming

pool water samples by gas chromatography with flame-ionization detection (GC 2010) and gas chromatography-mass spectrometry.[5]

Although parabens are widely applied in personal care products, with the exception of butyl paraben, benzylparaben, and di-chlorinated propyl paraben, but most parabens and their chlorinated derivatives are not found in the water samples. Surprisingly, methyl paraben, one of the most commonly used parabens is also free of swimming pool water samples. Therefore, the pollution level of parabens is required to be further investigated in more swimming pools. Structure of Triclosan is shown in figure 2. Triclosan (TCS) as an antiseptic is widely used. In September 2016, Triclosan usage was banned from health products following the risk assessment by the FDA[a]. Triclosan is readily absorbed into human oral mucosa and skin, and is found in various human materials.[20] Adverse effects of TCS related to the human health have been documented as shown in figure 3.

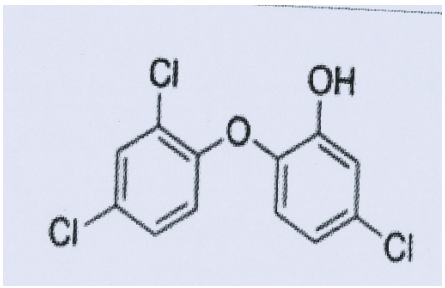

Figure 2. Structure of Triclosan

The use of hydroquinone as a cosmetic skin-bleaching agent has been limited since January 2001. Since, it has been known to be capable of destroying the DNA. Daily use of hydroquinone causes its accumulation in the body as absorption into the skin is faster than expulsion in the body.[21]

Structure of hydroquinone is shown in figure 4. Hydroquinone is also considered as a skin irritant in humans. Chronic (long-term) occupational exposure to hydroquinone dust can result in eye irritation, corneal effects, and impaired vision. No information is available on the reproductive, developmental, or carcinogenic effects of hydroquinone in humans.[22]

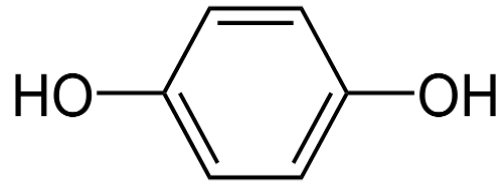

Figure 4. Structure of hydroquinone

In the present study, the occurrence and distribution of parabens, triclosan, and hydroquinone were simultaneously determined in water samples collected from 6 swimming pools in Shahroud, Iran.

The present study was aimed to evaluate the microbial and chemical quality of water in women and men's swimming pools in Shahroud city, Iran with emphasis on chemical compounds present in the cosmetics and sanitation products.

Materials and Methods

In the present study, all swimming pools located at Shahroud, Iran (6 pools) were investigated from September 2015 to June 2016. Being treated by chlorine or a combination of ozone and free chlorine, all swimming pools were disinfected. Samples were taken within a 15-day period. All samples were collected in 1-Lamber glass bottles, and were washed with methanol and deionized water before use. Approximately 30 cm below the water surface, two samples were collected and their excessive free chlorine was removed by adding ascorbic acid to avoid further reacting with parabens. The samples were stored at 4 ° C and were transferred to the laboratory.

4 ml of water sample was centrifuged in pH of 7.5-8. Then, 2 ml of methanol was added, and after sampling using 100 ml of chloroform, the mixture was mixed for 30 seconds. A HPLC 1100(Agilent USA) set was used in order to have a precise perspective of the extracted compounds of our samples. Finally, the sample was filtered through a 0.45-µm nylon membrane (Whatman, UK); and15 µL of this solution was injected into the high-performance liquid chromatography system for analysis.

The SPSS software (ver.15.0.) was applied to estimate the correlations between the Propyl Paraben, hydroquinone and Triclosan concentrations. Due to the small volume of samples in each group (9 samples in each group) the non-parametric Mann-Whitney U test was used.

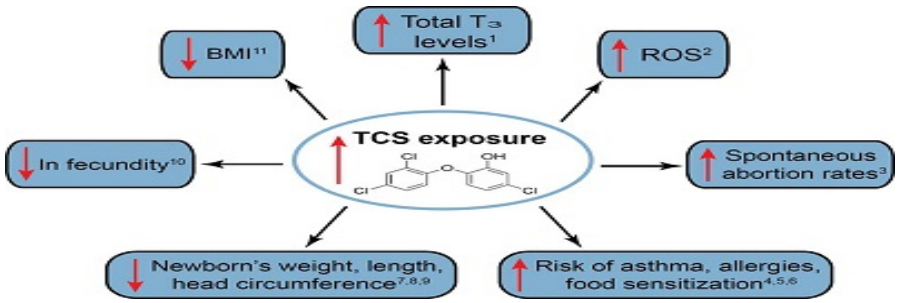

Figure 3. Human health effects now been documented for TCS21

Results

Figure 5 shows the chromatogram soluble in Propyl Paraben, Triclosan and Hydroquinone.

The results showed that, the mean concentration of propylparaben, hydroquinone and triclosan in swimming pools were equal to 243, 1672.11 and 200.8 ppb, respectively and in Jacuzzi; they were obtained as 616.33, 1625.88 and 57.92 ppb, respectively. The results also showed that, the amount of propylparaben, hydroquinone and triclosan was higher in the women's pool than the men's pool, and this difference was statistically significant (Table 1). The $P<0.05$ was considered as statistically significant.

The results on the concentrations of 3 target compounds in the water samples of swimming pools are summarized in table 1. The present study proved the existence of cosmetic compounds like hydroquinone; Propyl Paraben and Triclosan with maximum average in part per billion (ppb). The concentrations of all cosmetics were higher in the women's swimming pools.

Discussion

The results showed that, the amount of cosmetics is very high in water samples of women's swimming pools. This result is not consistent with the studies conducted in other countries, probably attributed to the high level of cosmetics consumption in Iran.

Masanori et al. (2014) in a study, for the first time, detected the chlorinated parabens by-products in swimming pool water. The results of this study have raised concerns regarding the chlorinated by-products of active ingredients used in personal care products.[23] The results of our study are not consistent with the results of the study by Masanori et al, possibly due to the high cosmetics consumption pattern in Shahroud, Iran. Weatherly et al (2017), in their study described triclosanṡ exposure routes and levels as well as metabolism and transformation processes.[20] In this study, sex was significantly correlated with the concentration of cosmetics. This finding is in line with the results of studies investigated the parabens in swimming pool water in Japan; is also consistent with the results of a study conducted in USA.[23,24] The observed difference appears to be due to lack of complete body rinsing before entering the swimming pool. In general, the relative concentrations of parabens would reflect its consumption patterns in different research areas. Kooyers et al (2005) showed that, daily use of hydroquinone causes its accumulation in the human body.[21]

The results of other studies confirm the relationship between the use of cosmetics with concentrations of paraben, hydroquinone and triclosan in swimming pool water. Parabens and its ingredients were detected in environmental waters in Ria de Aveiro, Portugal and urban river in South China.[24,25] The highest concentration of parabens was reported in the form of methylparaben in Japan.[26]

The toxicity of parabens and by-products tested on aquatic organisms showed that, toxicity increased by chlorination. [27]

Activities by pool users such as showering and pre-swim shower prior to entering the pool could significantly both reduce chemical and microbial anthropogenic pollution, as well as the formation of DBPs in swimming pools.[28,29]

Shower experiments have shown that, the majority of pollutants were eliminated within the first 60 seconds of showering.[25]

New treatment processes such as the use of AOPs, membrane filtration ozone/hydrogen peroxide treatment, and filtration could potentially reduce the concentrations of chemical contaminants and their precursors.

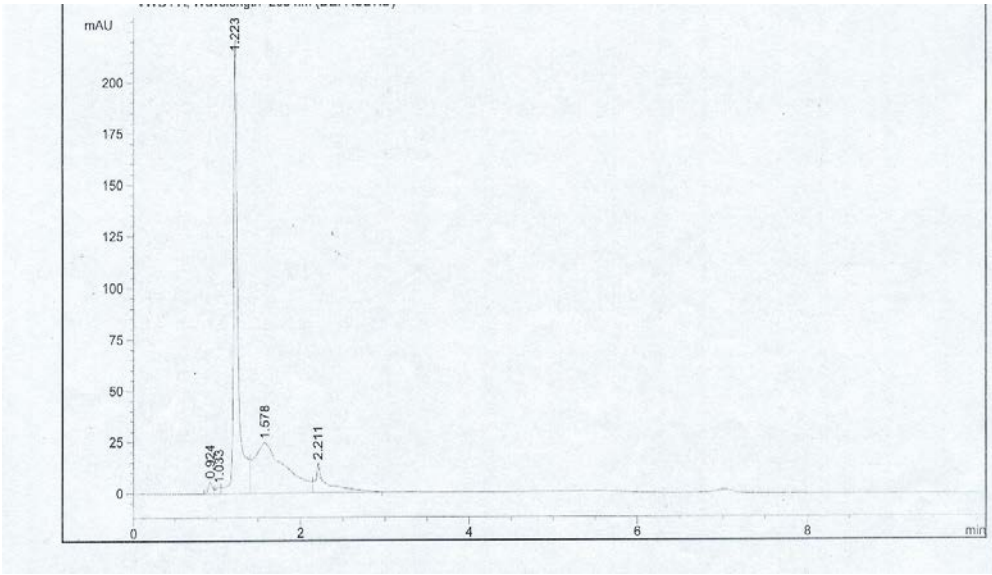

Figure 5. Chromatogram including Propyl Paraben, Triclosan and Hydroquinone

Table 1. kinds of chemicals in Shahroud swimming pools

Place	Sex	Kind of material	Average Ppb	Standard deviation	P.V
Swimming pool	Men	Paraben	68.27	10.92	<0.001
	Women		243	9.84	
Swimming pool	Men	Hydroquinone	1355	25.29	<0.001
	Women		1672	31.12	
Swimming pool	Men	Triclosan	50.68	19.29	<0.011
	Women		200.8	44.96	
Jacuzzi	Men	Paraben	202.66	2.95	<0.001
	Women		616.33	7.24	
Jacuzzi	Men	Hydroquinone	1437	33.78	<0.001
	Women		1625.88	25.13	
Jacuzzi	Men	Triclosan	26.47	1.03	<0.001
	Women		57.92	2.04	

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Conflict of Interest

The authors declare that they have no conflict of interest.

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