POOL WATER OVERCHLORINATION IN TIMIS COUNTY, ROMANIA: CASE-STUDY

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Abstract:

Objective: The aim of the study conducted was to investigate residual chlorine concentrations in pool water from Timis County, Romania over two years (2016-2017). Material of study consisted of a sample of 50 pools from Timis County from which were collected and analyzed 154 water tests.

The Method was an observational inquiry (case-study) of the residual chlorine concentrations considering spatial and temporal distribution and comparing with actual standards (4 groups of residual chlorine concentrations were considered).

Results: Average concentrations of residual chlorine exceeded 0.5mg/l in 30 investigated pools. Monthly mean concentrations of residual chlorine exceeded 0.5mg/l 20 of the 24 months of the investigation period. The maximum value of residual chlorine monthly mean concentration was recorded in July, 2017 and the highest average concentration at the pool I3. An Anova Oneway analysis indicated a statistically significant difference ($F=30.312$, Sig.0.000) between the 4 groups of residual chlorine concentrations: over 1.5 mg/l / (0-0.5mg/l, Sig.0.000; 0.5-1mg/l, Sig.0.001, 1-1.5mg/l, Sig.0.009).

Conclusion: There is an over-chlorination of pool water of Timis County, Romania, with spatial and temporal variation and statistically significant differences between groups of residual chlorine concentrations.

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Keywords: residual chlorine, pool water, Timis County, case-study.

Introduction

Pool water chlorination is an important preventive measure against infectious diseases transmitted through water to and between swimmers (Elmir et al., 2007). Additives (cyanuric acid and its compounds) are used in order to stabilize residual chlorine (Wahman, 2018) and keep its disinfectant action. On the other hand water chlorination becomes itself a risk factor for swimmers due to the compounds that result, such as trihalomethanes (THMs), when chlorine and organic material interact in water (Cyril et al., 2012; Hoda & Shang-Lien, 2018). Exposure of swimmers in indoor swimming pools to disinfection byproducts (Kogevinas et al., 2010) and to chlorinated water (Nickmilder & Bernard, 2007) produced severe health effects such as allergies (asthma) and genotoxicity. Different guidelines and regulations were considered for pool water chlorination depending on type, location or added substances to preserve chlorine with a variation of maximum admitted chlorine concentrations between 0.5-1.5 mg/l, even 5 mg/l (National Collaborating Center for Environmental Health Canada, 2011; Health Canada, 2009) or 0.5mg/l (WHO, 2008a). An analysis of good practices regarding pool water disinfection with chlorine needs to be performed in the area at the community level in order to see if the actual regulations are implemented.

The aim of the performed study was to investigate residual chlorine concentrations in pool water from Timis County, Romania over two years (2016-2017), considering spatial and temporal distribution and comparing with standards.

Material and method

The study was performed on a sample consisting of 50 pools from Timis County (78% from Timisoara, main city of the county) from which were collected and analyzed 154 water tests. The water analysis of residual chlorine concentrations in pool water followed the SR EN ISO 7393-2:2002 procedures (ISO, 1985; ISO, 2017; Environmental Health, 2013). The method was an observational inquiry (case-study) considering temporal and spatial distribution and comparing with WHO standards for drinking water (WHO, 2008a). For each pool the number of water tests recorded was in conformity with the usual monitoring schedule and varied from 1 (27 pools), 2-9 (21 pools) to 14-21 (2 pools). Four groups of residual chlorine concentrations were considered: 0-0.5 mg /l; 0.5-1 mg/l; 1-1.5 mg/l; over 1.5 mg/l. The maximum admitted concentration of residual chlorine / liter of water was considered in the applied

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procedures 0.5 mg (WHO, 2008a). Four groups (one with normal concentrations and three groups surpassing the WHO standards) were used to compare between them.

Agreement to access primary evidence, while keeping this evidence confidential and respecting the personal data protection law, was asked and received from the Leadership of the Public Health Direction Timis. The agreement of the “Victor Babes” University of Medicine and Pharmacy’s Ethical Commission was requested and obtained for this study.

Statistical analysis (frequency, means, Anova Oneway analysis) was performed by the aid of the SPSS 20 Program.

Results

Temporal distribution

Monthly mean concentrations of the residual chlorine measured in pool water of Timis County were very high (0.5-3.25mg/l) exceeding maximum admitted concentration (0.5mg/l) (WHO, 2008a) in 20 of the 24 months of the study (figure 1).

Figure 1: Monthly mean concentrations (mg/l) of residual chlorine in pool water compared with WHO standards

Source: Author

Figure 2: Average concentrations (mg/l) of residual chlorine in investigated pools` water (each pool has a code) compared with WHO standards

Source: Author

The highest numbers of residual chlorine measures by Public Health Direction Timis in pool water were performed during the summertime (may-august: 8-21).

Spatial distribution

Mean concentrations of residual chlorine were the highest in the water of 5 pools (I3=11.62 mg/l; P2=11.15mg/l; I2=6mg/l; M2, M4=4mg/l) and surpassed the maximum admitted concentration (0.5 mg/l) in the water of 25 other pools. In two pools the water was insufficiently chlorinated (less than 0.05 mg/l). The water was correctly chlorinated in only 18 pools (figure 2).

The most frequently checked pool by Public Health Direction Timis for its chlorine level was situated in an industrial unit in Timisoara (32 water tests in 2 years), being followed (as checking frequency) by another industrial unit's pool (14 water tests) and by 21 private public pools (between 2 and 9 water tests). 27 pools were verified for residual chlorine only once in two years.

Comparison results of the residual chlorine concentrations groups

When we compared the 4 groups of residual chlorine concentrations (table 1) recorded during the study conducted, we noticed differences between them, both in terms of number of determinations and average concentrations. An Anova Oneway analysis indicated a statistically significant difference ($F=30.312$, Sig.0.000) between the 4 groups of residual chlorine average concentrations as follows: over 1.5 mg/l / (0-0.5mg/l, Sig.000; 0.5-1mg/l Sig.0.001, 1-1.5mg/l, Sig.0.009).

During the summertime, residual chlorine concentrations were more frequently determined by Public Health Direction Timis (99 determinations, 64.28%) than during the other three seasons. Average concentrations of residual chlorine were almost similar during the summer and the entire study period for three groups of concentrations (0-0.5mg/l, 0.5-1mg/l and 1-1.5mg/l) and higher during the summer than the entire study period for the group over 1.5mg/l (table 1). The average concentration of residual chlorine for the entire study period was 1.26mg/l, surpassing WHO standards, but still normal by Canadian Standards.

Table 1: Average concentrations and number of determinations considering the groups of residual chlorine concentrations

Groups of residual chlorine concentrations	Entire study period		Summertime	
	Number of determinations	Average concentrations mg/l	Number of determinations	Average concentrations mg/l
0-0.5 mg/l	55	0.21	38	0.21
0.5-1mg/l	41	0.64	26	0.66
1-1.5 mg/l	21	1.2	14	1.21
over 1.5 mg/l	37	3.88	21	4.84
All groups	154	1.26	99	1.18

Source: Author

A statistically significant difference (Anova Oneway) was also found between groups ($F=13.85$, Sig. 0.000) during the summer, as follows: 1-1.5mg/l / (0-0.5mg/l, Sig. 0.000; 0.5-1mg/l, Sig.0.000). For a group over 1.5 mg/l there was no statistically significant difference in relation to the other groups. Variation of residual chlorine concentrations inside this group was very large, both during the summertime and during the entire study period (figure 3).

In Romania the standards of swimming pools are similar with the standards of drinking water with a maximum admitted concentration of 0.5mg/l, in order to be safe for swimmers and bathers. In the performed study we recorded only 55 water tests with residual chlorine concentration under 0.5 mg/l (13 pools-all water tests +12 pools-1 water test), 104 water tests (23 pools-all water tests +12 pools-1 water test +2 pools 2 water tests) exceeding the maximum admitted concentrations (MAC). If we consider Canadian regulations for residual chlorine concentration with MAC 1.5 mg/l, we recorded 117 water tests (from 37 pools: 28 pools-all water tests, 9 pools-not all the water tests) with residual chlorine level under 1.5 mg/l and 37 water tests (17 pools: 8 pools-all water tests + 9 pools-not all the water tests) over 1.5 mg/l.

Figure 3: A box plot representation of residual chlorine concentrations during entire study period (A) and during the summer (B)

Source: Author

Discussion

In the performed study we investigated the residual chlorine concentrations in 50 pools and found 23 pools which surpassed 0.5 mg/l (WHO, 2008a) and 8 pools that surpassed 1.5 mg/l (National Collaborating Center for Environmental Health Canada, 2011) for all water tests. Average concentrations for the entire study period (1.26mg/l), during the summer (1.18mg/l) and monthly mean concentrations of residual chlorine indicate an over-chlorination more extended in time when considering WHO standards (during 20 months) than when considering Canadian standards (8 months—figure 1). Spatial distribution of residual chlorine concentration averages reveals the same higher extension of over-chlorination when considering WHO MAC (30 pools) than when considering Canadian MAC (14 pools). There is a statistically significant difference between the average concentration group (over 1.5mg/l) and the other groups (0-0.5mg/l, 0.5-1mg/l and 1-1.5mg/l) and a high variation of the recorded values over 1.5 mg/l (figure 3). All these results suggest an over-chlorination of pool water in Timis County and an imbalanced position between two risks: infectious diseases when it is insufficiently chlorinated and the health effects of chlorination by products when it is over chlorinated. Each pathology was approached in a good deal of recent literature:

- **Microbiological pollution** of recreational waters prompted communities' leaders to develop strategies to optimize monitoring schemes of recreational waters (Gutiérrez-Cacciabue et al., 2014), monitoring of microbiological quality of ambient waters (Poma et al., 2012), to create methods of microbial quality simulation of water resources including infectious risk (Schijven et al., 2015), to test microbial resistance of cutaneous germs from adult and children bathers in marine waters (Plano et al., 2011) or to investigate through specific tests *Bacteroides* from sewage-polluted waters (Fenga & McLellan, 2019).
- **Health effects of disinfection by-products** exposure were investigated by researchers paying attention to associations: between testicular hormones at adolescence and attendance at chlorinated swimming pools during childhood (Nickmilder & Bernard, 2011), health effects and exposure to water disinfection by-products in a swimming pool (van Veldhoven et al., 2018), bladder cancer and water disinfection by-product exposures (Freeman et al., 2017) and between current and past concentration of THMs in water throughout France (Corso et al., 2018).

Good practices of pool water chlorination in Timis County indicate the tendency to keep the water as close as possible to the standards of drinking water (WHO, 2003a & 2003b), in order to avoid health

effects of Trihalomethanes (by-products intensively studied regarding health effects in the Past, in our area). On the other hand, high biological charge of swimming pool waters prompted the owners of the pools to increase chlorine concentrations, as it resulted in this study with the evident purpose to avoid transmission of infectious diseases. Therefore, the discovered values are closer to Canadian standards (specified for pool water), still being present a water over-chlorination with a temporal and spatial distribution and a large variation of concentrations over 1.5 mg/l. A limit of this study is that it is an observational one. Another limitation resulted from the contractual obligation to keep confidential the personal data statistically processed and therefore representing the spatial distribution results by codes and keeping confidential other information regarding the investigated pools.

Conclusions

There is an over-chlorination of pool water of Timis County, Romania, with spatial and temporal variation and statistically significant differences between groups of residual chlorine concentrations. Results obtained in this study raise new research questions: “Is the standard for drinking water safe for pool water, too?”, “What is necessary to do regarding pool water disinfection in order to keep the balance between the risk of infectious diseases and the risk of residual chlorine by-products on health?”. High variation of residual chlorine concentrations discovered in pool water in Timis County reveals problems in water chlorination techniques that need to be solved.

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