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SOME OF THE MEASURES FOR REMOVAL PATHOGENIC MICRO ORGANISMS ([Legionella spp.] IN THE WATER DISTRIBUTION SYSTEM
EXPERIENCE FROM REGULATION OF PUBLIC SWIMMING POOLS IN THE CZECH REPUBLIC

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ABSTRACT

This paper summarizes the main known health risks related to use of swimming-pools, both of microbiological and chemical nature, and describes the development of respective public health regulation in the Czech Republic since the 1950s. Current Czech public health regulation for swimming-pools is presented in more details. Information on state control, results of water quality monitoring in 2017, and knowledge on reported health problems related to bathing in swimming-pools are also included.

Keywords: swimming-pools – bathing – public health – regulation

1. INTRODUCTION – HEALTH RISKS RELATED TO SWIMMING-POOLS

Every person attending swimming-pools leaves there their inevitable “footprint” consisting of various chemicals (both natural human excreta and traces of cosmetics) and millions of bacteria and other microorganisms. Over the last century, a number of evidence on infectious diseases transmissible through water in swimming-pools or showers or via the surfaces around the pool has been collected:

- enteric infections (caused by Shigella, E. coli O-157, Cryptosporidium, Giardia, Adenoviruses, Enteroviruses, VHA, Noroviruses, etc.);
- eye infections (Adenoviruses and other viruses, Pseudomonas aeruginosa);
- skin infections (P. aeruginosa, S. aureus, Candida, Epidermophyton floccosum and Trichophyton spp. "athlete’s foot", mycobacteria, Molluscipoxvirus hominis contagiosum, Papillomavirus/verruca plantaris/etc.);
- infection of hair follicles (P. aeruginosa "hot tube folliculitis");
- ear infections (P. aeruginosa "swimmer’s ear");
- infections of urinary tract (P. aeruginosa, Mycobacterium avium etc.);
- infections of respiratory tract (Legionella spp. – aerosols (?), P. aeruginosa, Mycobacterium spp., viruses, etc.);
- primary amoebic meningoencephalitis (Naegleria fowleri – free-living amoeba), etc. [1].

This knowledge and evidence have triggered some measures to decrease the risk of infection. Free chlorine in water proved to be – to a certain extent – an effective barrier to limit transmission of infectious germs, but it was later found to also have negative side effects, forming toxic disinfection by-products – mixture of halogenated nitrogen and carbon compounds [2, 3]. These may irritate eyes, respiratory tract, or skin as acute health effects, and increase the risk of asthma and allergy, and probably, also, cause some cancers as chronic health effects [1, 4].

Water in swimming-pools or showers, also, represents a suitable environment for some kinds of microorganisms, such as Legionella, non-tuberculose mycobacterium, Pseudomonas, amoeba, etc.

2. FIRST REGULATORY MEASURES IN THE CZECH REPUBLIC

Widespread use of manmade swimming-pools creates the necessity to protect public health and regulate this activity as effectively as possible. This contribution describes experience from regulation of swimming-pools in the Czech Republic. The first legal act establishing system of regional public health authorities and giving them power to regulate water quality and environment of swimming-pools was the Act 4/1952 Coll. on hygienic and epidemiologic care. Based on this
act, the Ministry of Health issued more detailed obligatory guidelines in 1954 [5]. These guidelines covered following issues: construction of pools, water recirculation, change-rooms, showers, toilets, lightening, ventilation, heating, first-aid station, cleaning and maintenance, water treatment and disinfection, water exchange (replacement), safety of staff, documentation and responsibilities of visitors. Requirements for water quality were still quite undeveloped: free chlorine (0.1 – 0.3 mg/L), transparency, water temperature, without purid or faecal odour. More detailed requirements on water quality and its control were envisaged (as guidance for public health authorities), but probably were not officially published.

The second legal act was the Act 20/1966 Coll. on public health care, replacing the act from 1952. The Ministry of Health issued in 1978 also amended guidelines for swimming-pools [6] and in 1977 for saunas. It covered similar issues like previous guidelines, with some new ones (e.g. source of raw water and water supply; more types of pools including paddling pools) and some more elaborated old ones (capacity of pools, definition of minimum water treatment with obligatory disinfection, requirements for intensity of water recirculation, etc.). There was a clear instruction for method of water sampling, and more detailed requirements for water quality were included – microbiological parameters: coliform bacteria, colony counts at 37 °C, micrococci, pathogenic staphylococci, Pseudomonas aeruginosa (and generally no pathogenic microorganisms), chemical parameters: oxidisability (COD), ammonia, free chlorine (0.2 – 0.5 mg/L), and pH value. These guidelines were in force until the end of 2000.

3. CURRENT REGULATORY FRAMEWORK IN THE CZECH REPUBLIC

New, more legally based, and more detailed and specific concept was introduced with new Public Health Act (258/2000 Coll.) since 2001, which – with series of amendments – is currently still in force.

3.1. Public Health Act

The basic requirements on operation of swimming-pools are defined in the Public Health Act (258/2000 Coll. as amended), specifically in the articles (§) 6 to 66. The act distinguishes five types of manmade pools with partially different requirements: swimming pools (water temperature up to 28 °C), bathing pools (water temperature above 28 °C), pools for infants and toddlers (up to age of 3 years), paddling pools, and cooling pools in saunas. The bathes (tubes) designed only for one person with complete replacement of water after each client are exempted from this regulation.

Operators of these pools used by public are obliged to:

a) Accept the measures to prevent health damage of pool visitors.
b) Ensure that water in the pool and shower complies with quality requirements.
c) Shut down the pool not complying with maximum acceptable limits for microbiological parameters (and inform the public and regional public health authority about it) until remedial measures are taken and water complies again.
d) Control water quality daily for selected parameters by own analysis.
e) Ensure that water quality control for defined parameters is done by accredited laboratory and the result is sent in defined electronic format to national database.
f) Comply with hygienic requirements for building, operation, maintenance, cleaning, indoor quality, and monitoring of water.
g) Elaborate operational rule and submit it for approval to the regional public health authority.
h) Keep proper documentation.

More detailed specification of these requirements is defined by executive decree No. 238/2011 Coll. – see below. The Public Health Act, also, defined the role, responsibilities, and competences of public health authorities, as state control bodies. They carry out the control if the operators comply with above mentioned requirements, they approve operational rules, may issue order for operators to monitor water quality in higher frequency or not to use water in pool for bathing (closing the pool).
3.2. Decree on hygienic requirements on swimming-pools

Detailed information and requirements are defined in executive decree No. 238/2011 Coll. [7]. It covers following issues: source water for pools, construction and material requirements, capacity of the pool, cleaning and drainage, specific requirements for pools for infants and toddlers, paddling pools, and pools in health-care facilities; requirements for water treatment, disinfection, and recirculation of water, requirements for water quality and its control (including sampling and analytical methods), requirements for change-rooms, showers, and toilets, minimum intensity of lighting, and indoor-air quality (relative humidity, air temperature, intensity of ventilation, and concentration of trichloramine – 0.5 mg/m3). As water treatment is not able to remove efficiently all the chemicals, which serve as precursors of disinfection by-products, operator is obliged to partially replace pool water with new one – at least 30 l/visitor/day (indoor pools), or 60 l/visitor/day (outdoor pools).

Water quality parameters may be divided into five groups according to their purpose:

a) microbiological quality (E. coli, colony counts at 36 °C, Pseudomonas aeruginosa, Staphylococcus aureus, Legionella spp.);
b) aesthetic quality (transparency and turbidity);
c) disinfection efficiency (pH value, free chlorine, redox-potential);
d) markers of chemical load and necessity of water replacement (TOC, nitrates);
e) chemical safety (bound chlorine, chlorate, chloride, ozone).

The operator of the pool is obliged to control water quality daily (or several times daily) for free and bound chlorine, redox-potential, pH value, transparency, and water temperature by himself (herself). He (she) has to order analysis in accredited laboratory for all microbiological parameters, TOC, nitrates, and turbidity (frequency differs according to type of pool and parameter – from once per 2 weeks to once per 3 months).

The decree defines maximum acceptable limits for microbiological parameters (combination of breaches of specified limits for at least two parameters at the same time) when it is necessary to shut down the pool and make immediate remedial measures.

4. DATA ON WATER QUALITY AND STATE CONTROL

Each result of pool water analysis done by laboratory, either on request of operators or public health authorities, has to be sent in defined electronic format to the national database. The database serves primarily to the Regional Public Health Authorities, which, thus, have immediate overview and knowledge if the operators do the controls as required and what are the results.

There are about 3 thousand public pools currently operated in the Czech Republic (part of them only seasonally operated). In 2017, in total of 662,176 individual results of pool water quality were included by laboratories in the national database, of which about 91 % come from pool operators, and about 9 % from public health authorities. The overview and results are presented in table 1.

Table 1: Summary data on swimming-pool water quality, Czech Republic, 2017.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No. of analyses</th>
<th>Out of limit</th>
<th>Maximum found</th>
<th>Limit value</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>87,348</td>
<td>469</td>
<td>940</td>
<td>0 CFU/ 100 ml</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>87,174</td>
<td>1,223</td>
<td>1,600</td>
<td>0 CFU/ 100 ml</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>105,312</td>
<td>782</td>
<td>600</td>
<td>0 CFU/ 100 ml</td>
</tr>
<tr>
<td>Colony counts at 30°C</td>
<td>88,237</td>
<td>7,182</td>
<td>28,000</td>
<td>100 CFU/ 1 ml</td>
</tr>
<tr>
<td><em>Legionella species</em></td>
<td>60,144</td>
<td>426</td>
<td>82,000</td>
<td>10 CFU/ 100 ml</td>
</tr>
<tr>
<td>Transparency (°)</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>clear visibility of whole bottom</td>
</tr>
<tr>
<td>Turbidity</td>
<td>41,200</td>
<td>2,462</td>
<td>39</td>
<td>0.5 ZF</td>
</tr>
<tr>
<td>pH</td>
<td>30,438</td>
<td>2,038</td>
<td>9.9</td>
<td>6.5 – 7.6</td>
</tr>
<tr>
<td>Free chlorine</td>
<td>31,529</td>
<td>4,194</td>
<td>10</td>
<td>0.3 – 0.6 mg/L or higher (*)</td>
</tr>
<tr>
<td>Redox-potential (ORP)</td>
<td>14,167</td>
<td>3,437</td>
<td>1,015</td>
<td>&gt; 700 mV (**)</td>
</tr>
</tbody>
</table>
The results show about 3.7% non-compliance with hygienic limits, with the highest non-compliance for microbiological indicator colony counts at 36 °C (8%) and free chlorine (13%), not taking into account redox potential (24%), which is not easily measured offline. From more serious health indicators, the most common non-compliance was found for bound chlorine 7.3%, *Pseudomonas* 1.4%, *Staphylococcus* and *Legionella* both 0.7%, and *E. coli* 0.5%. In 2017 the Regional Public Health Authorities made a total of 2,715 controls of operators of swimming pools. Considering that some operators operate facilities with more pools, it is approximately one control per pool facility per year. Some controls are concluded with penalty to operators. Just for illustration, data from one region (Moravian-Silesian Region) shows that the authority made 314 controls in 2017, and ordered 35 penalties for the total sum of 132,000 CZK (about 33,000 HRK), i.e., one penalty for about 3,770 CZK (about 800 HRK) on average. Penalty is usually up to 10,000 CZK (about 2,500 HRK) as these are possible to issue on site during the control. More serious breaches of operational rules or repeated problems with water quality may be fined by much higher penalty of 50,000 CZK (about 12,500 HRK) or even more, – these are rare, but are issued still from time to time. Administrative procedure is, however, necessary in such cases.

5. KNOWLEDGE ON REAL HEALTH DAMAGES RELATED TO SWIMMING-POOLS

The most obvious and probably, also, the most serious health risks related to swimming-pools are drowning (4 cases in 2016 in the Czech Republic) and injuries with long term consequences or even fatal consequences (no statistics available). Information on real health problems related to hygienic conditions of swimming-pools and occurring in the Czech Republic is scarce. Partially, it may be due to good quality and relatively safe pool environment, partially, because many diseases which may occur in this context are not notified and investigated. During the last 5–10 years, only several small outbreaks of hot tube folliculitis and irritation of eyes and respiratory tract in children have been recorded. However, the issue of pool safety is still taken seriously by public health authorities because of mementos of outbreak of primary amoebic meningoencephalitis in swimming-pool in Usti nad Labem, when 16 young people (age 8–25) died between 1962 and 1965 [8, 9].

To find out more about health problems related to bathing and swimming in all kinds of bathing facilities or places (both manmade and natural), the project of self-reporting online questionnaire has been running since 2009 in the Czech Republic. Although the most entries come from natural bathing places, 21 cases of health problems were reported, also, from swimming-pools: gastrointestinal diseases (11), skin problems (6), respiratory diseases (5), disease of ungenital tract (4), and ears problems (1).
6. CONCLUSIONS

There are several factors which make contemporary swimming-pool environments more risky for health in comparison with situation 30 – 50 years ago: building new large water parks with new attractions producing aerosols (new exposure pathways); long time stay in water parks in warm and humid (wet) environment makes skin more vulnerable to infections; aging of population and more people with chronic diseases who are more sensitive to infections; migration of people worldwide (transmission new pathogens and diseases between continents), etc.

Czech Republic has developed quite extensive regulation on swimming-pools over the last 60 years. Although the regulation is primarily focused on hygienic criteria and health risks, it covers, also, a lot of construction and technical features as they directly or indirectly influence water quality and health. However, probably more optimum model would be to have national technical standard covering most of the construction and technical aspects of building and operation of swimming-pools, and hygienic regulation would only refer to this standard, which could be updated more easily than a decree. The European standards [e.g. 10] are not referred to in Czech regulation and are not used in practice.

Comprehensive regulation is, surely, a basic element for public health protection, but effective enforcement, supplemented with continuous education of operators and visitors (on proper hygienic and safe behaviour), is of the equal importance.

LITERATURE


