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Microbiological contamination of water in fountains located in the city of Toruń, Poland

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Abstract

Objective: The aim of this study was determination of the level of water contamination in fountains in Toruń, Poland.
Methods: The studies were conducted at monthly intervals from May – September 2009, and consisted in the determination of the number of heterotrophic bacteria capable of growing at a temperature of 22 and 37 °C (PN-ISO 6222), as well as the number of coliform bacteria (PN-75/C-04615/05), *E. coli* (ISO 9308-1) and faecal streptococci (PN-EN ISO 7899-2).
Results: The 'Rafter' fountain in the Old Town Market Square, continuously supplied with municipal water, had the cleanest water. The highest number of heterotrophic bacteria capable of development at 22 and 37 °C was found in the fountain located in the City Park of Bydgoskie suburb. Throughout the entire research period, water from the fountain in the Old Town Moat had the worst sanitary (health) indices.
Conclusion: The recorded results indicate that water from the 3 out of 4 examined fountains, with inappropriate exploitation – bathing, water drinking, hands washing – may constitute a danger to human health. The fountains should be carefully monitored for the presence of microorganisms, or a ban on bathing in fountains should be more rigorously enforced, in order to prevent possible infections.

Key words

environment and public health, disease reservoirs, water pollution, urban health, bacteria

INTRODUCTION

Fountains are decorative elements that improve the attractiveness of parks and various city squares. Since public access to fountains is generally unrestricted, it frequently occurs that people treat fountains as bathing pools. Also animals (birds, dogs) often use fountains, and are a source of miscellaneous microorganisms. Fountains have closed water circulation systems, and filtering or disinfecting devices are seldom installed. The circulating water is therefore a prime site for the development of microorganisms and may pose a risk to health.

As it appears from the literature data, fountains often constitute foci of dangerous infections, mainly those of the digestive system. Among others, infections by the bacteria *Shigella sonnei* were recorded [1, 2], by protozoa from the genus *Cryptosporidium* and *Giardia* [3, 4], and by noroviruses [5]. According to some reports, fountains can also be a source of the bacteria *Legionella pneumophila* [6, 7, 8]. Analysis of water in fountains, conducted together with an epidemiological examination, often revealed the presence of abundant *Escherichia coli*, which indicates the poor sanitary conditions of these water reservoirs.

Nonetheless, usually no regular inspections of sanitary conditions of water in fountains are carried out, on the assumption that they are not bathing reservoirs. Since the reality is usually different, and 'No Bathing' do not deter the public from bathing in fountains, particularly children, the presented study aimed at determination of the water contamination level in fountains in Toruń.

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MATERIALS AND METHOD

Research object. The research was conducted in the city of Toruń. Water samples were collected from four city fountains located in (Tab. 1):

1. the City Park in the Bydgoskie suburb;
2. in front of the Faculty of Mathematics and Computer Science NCU;
3. the Old Town Market Square – the 'Rafter' fountain;
4. the Old Town Moat.

Table 1. Characteristic of studied fountains.

Site	Location	The water surface area	Remarks
1. City Park	A park with old copses of 25 ha, in close proximity to tram tracks and a street.	375 m^2	Closed water circulation system, concrete bottom.
2. Faculty of MCS	A square in front of the building, in close proximity to a busy street.	64 m^2	Fountain divided into 4 shallow reservoirs. Closed water circulation system, concrete bottom.
3. 'Rafter'	The Old Town Square, surrounded by tenements.	2,5 m^2	A small stone reservoir, running water.
4. The Old Town Moat	Traffic routes for pedestrians and vehicles along 3 sides, a large lawn with single trees.	150 m^2	Concrete bottom, closed water circulation system.

According to information obtained from the Municipal Services Department in Toruń (oral information), the fountains are cleaned every day (items thrown into a fountain or other contaminants are removed), whereas total water replacement takes place only once or twice during their exploitation. The fountains are not equipped with disinfecting

or filtering devices, and running water is provided only in the 'Rafter' fountain. In the other fountains, the circulation is closed.

Collection of samples. Microbiological analyses were carried out at monthly intervals from May – September 2009. Water from the fountains was collected directly into sterile bottles, and the samples transported to a laboratory in heat-insulating containers lined with ice inserts. The time between sampling and microbiological analysis did not exceed 2 hours.

Microbiological analysis. Microbiological analysis included the determination of the following:

- number of psychrophilic, heterotrophic bacteria capable of growing at a temperature of 22 °C and the number of mesophilic, heterotrophic bacteria capable of growing at a temperature of 37 °C, in accordance with the Polish Standard PN-ISO 6222 [9];
- number of coliform bacteria by the fermentation-tube method, according to the Polish Standard PN-75/C-04615/05 [10]. This analysis consisted of 3 phases: preliminary (assessment of lactose fermentation ability on Eijkman's nutrient medium), confirmatory (inoculation on the surface of Endo's medium) and complementary (Gram staining, cytochrome oxidase test and repeated lactose fermentation test on Eijkman's medium);
- number of bacteria *E. coli* by the method of membranous filters on Endo Les agar, according to the standard ISO 9308-1[11];
- number of faecal enterococci by the method of membranous filters, in accordance with the Polish Standard PN-EN ISO 7899-2 [12] on Slanetz-Bartley medium.

RESULTS

The highest number of heterotrophic bacteria capable of development at 22 °C was recorded throughout the entire research period in the fountain located in the City Park of the Bydgoskie suburb. In the basin of this fountain, 4,900 CFU/ml of collected water were recorded in May. Throughout the entire study period, the number of bacteria developing at 22°C in the water of the park fountain did not fall below 1,000 CFU/ml (Tab. 2, Fig. 1). Also in the water of this fountain the largest numbers of bacteria capable of growing at a temperature of 37°C were recorded throughout the study period – 1,500 CFU/ml. The number of both the above groups of bacteria was the lowest in the 'Rafter' fountain.

Table 2. Range of values of each group of bacteria.

	City Park in Bydgoskie suburb	Faculty of Mathematics and Computer Science	'Rafter'	The Old Town Moat
psychrophilic bacteria [CFU cm^{-3}]	1100–4900	290–3750	10–250	250–1950
mesophilic bacteria [CFU cm^{-3}]	315–1520	175–1050	5–30	150–922
coliforms [MPN 100 cm^{-3}]	150–3000	90–2500	0	950–25000
Escherichia coli [CFU 100 cm^{-3}]	0–240	20–30	0	350–1960
faecal enterococci [CFU 100 cm^{-3}]	64–176	36–368	0	710–1990

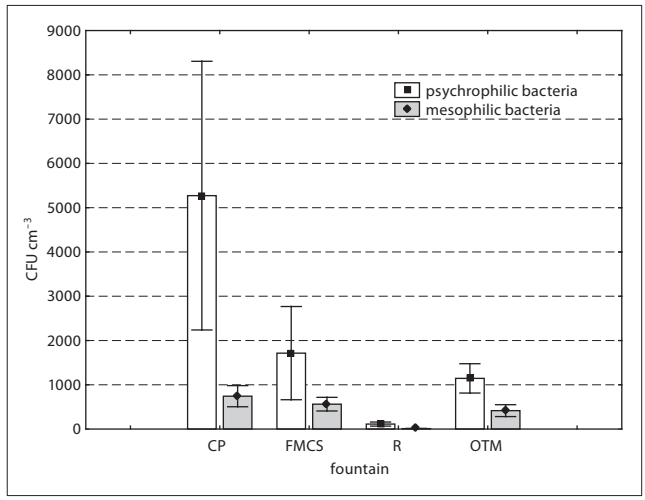

Figure 1. Average numbers (± std. error) of psychrophilic and mesophilic bacteria in the water of investigated fountains (CP – City Park, FMCS – Faculty of Mathematics and Computer Science, R – 'Rafter', OTM – The Old Town Moat).

The numbers of all bacteria groups indicating the faecal contamination of the studied fountains – coliform bacteria, *E. coli*, faecal streptococci – were the highest in the water of the fountain in the Old Town Moat. These values considerably exceeded the values recorded in other fountains, and the differences were statistically significant ($p<0.05$) (Tab. 2, Figs 2 and 3). The aforementioned groups of bacteria were not found in the 'Rafter' fountain.

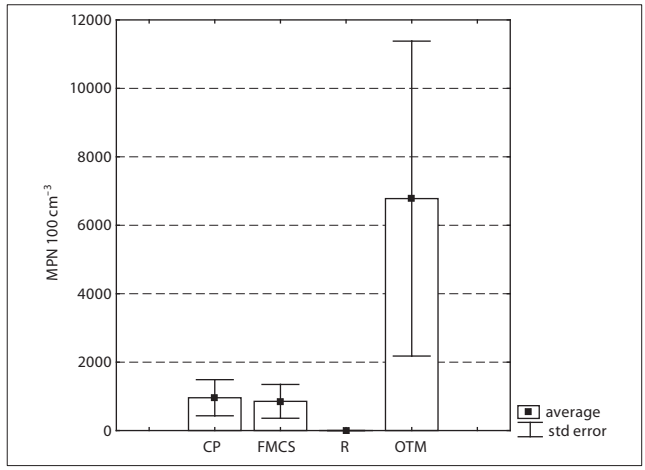

Figure 2. Average numbers (± std. error) of coliform bacteria in the water of investigated fountains (CP – City Park, FMCS – Faculty of Mathematics and Computer Science, R – 'Rafter', OTM – The Old Town Moat).

An index of faecal pollution was also defined, i.e. the quantitative ratio of bacteria *E. coli* to faecal streptococci FC/FS, which allows determination of the source of faecal contamination (animal, mixed or human origin). In the water of fountains located by the Faculty of Mathematics and Computer Science, and in the park of the Bydgoskie suburb, contamination of animal origin dominated (Tab. 3), whereas in the water of the fountain near the Old Town Moat, faecal contamination of animal origin amounted to 20%. No contamination of human origin was confirmed in any of the fountains.

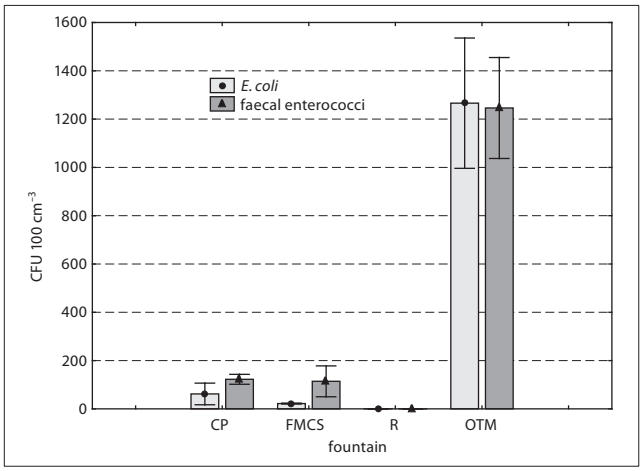

Figure 3. Average numbers (± std. error) of *E. coli* and faecal enterococci in the water of investigated fountains (CP – City Park, FMCS – Faculty of Mathematics and Computer Science, R – 'Rafter', OTM – The Old Town Moat).

Table 3. Index of faecal pollution FC/FS in the water of investigated fountains.

Values of FC/FS	City Park in Bydgoskie suburb	Faculty of Mathematics and Computer Science	'Rafter'	The Old Town Moat
Range	0–1.4	0.1–0.6	–**	0.5–1.8
< 0.7	80*	100	–	20
0.7–4	20	0	–	80
>4	0	0	–	0

* – percentage of samples in a particular category
** – not determined (FS = 0)
FC/FS<0.7 – contamination of animal origin
0.7<FC/FS<4 – contamination of mixed origin
FC/FS>4 – contamination of human origin

DISCUSSION

Fountains in towns and cities, apart from their ornamental importance, have also some climatic and health functions. First of all, fountains enrich the atmosphere with water vapour and reduce the ambient temperature. Additionally, the water spray effectively removes the dirt and dust from the air, contributing to its purification.

Fountains often serve as drinking bowls for birds. From the ecological perspective, this is favourable for the maintenance of biodiversity in the urban space. At the same time, however, these water reservoirs are one of the most important elements in the epidemiological chain. The common use of water reservoirs by humans and animals may contribute to the transmission of pathogenic species of microorganisms. Fountains located in parks and places of tourist interest are frequently visited by people. From the authors' observations and from local press reports, they are often used – despite the prohibition – as bathing places, especially by children. Therefore, the proper sanitary quality of water in fountains determines the safety of human health.

Although regulation by the Ministry of Health [13, 14] stipulate the requirements regarding the quality of water intended for human consumption and water in bathing places, there are no regulations governing the quality of water in fountains. Therefore, in the presented study, taking into account the fact some fountains are used as swimming and bathing facilities, water from the studied fountains was compared with the regulation of the Ministry of Health of 16 October 2002 on requirements for water in bathing places.

The number of heterotrophic bacteria, capable of growing at a temperature of 22 °C ranged in the studied fountains from 10 – 4,900 CFU/ml. The largest numbers of these bacteria were recorded in water from the fountain in the Bydgoskie suburb, which indicates considerable contamination of this water with organic material. The organic material could originate from the vegetation surrounding the fountain. These abundance values were only slightly lower compared with those recorded in bathing places (up to 6,880 CFU/ml) or water reservoirs in the city parks of Warsaw, which are not designated for bathing – up to 5,450 CFU/ml [15]. The 'Rafter' fountain was characterised by the smallest number of heterotrophic bacteria capable of growing at a temperature of 22 °C (on average 113 CFU/ml). This value slightly exceeds the value of the index acceptable for the water supplied to the network (max. 100 cells/ml) [16]. Whereas, with regard to the presence of sanitary indicators, the water from the 'Flisak' mountain meets the requirements defined for the water supplied to the network. This indicates that during stagnation in the basin of the fountain, the water is contaminated mainly with saprophytic microorganisms, and even though the fountain is supplied with municipal water, the water from the fountain basin is not safe for human consumption.

The presence of coliform bacteria and *E. coli* in the water is regarded not only as a criterion for faecal water contamination, but also as an indication of the potential presence of pathogenic bacteria. The number of bacteria from coliforms ranged in the studied fountains from 0 – 25,000 MPN/100ml. The number of *E. coli* ranged in the studied fountains from 0 – 1,960 CFU/100ml. Faecal streptococci are also important for the assessment of water contamination. Since these bacteria live in the water for a shorter time compared with *E. coli,* their presence allows the detection of very fresh water contamination with faecal matter. The number of faecal streptococci in the water of the studied fountains ranged from 0 – 1,990 CFU/100ml. Although the average counts of indicator bacteria exceed the desired values, they are generally lower than the highest acceptable values [13]. Only water from the fountain near the Old Town Moat exceeded the acceptable standards. The average index of faecal streptococci in water of this fountain exceeded more than three times the highest acceptable value required for bathing water. Such results are probably due to frequent bathing of pigeons in this fountain. However, not only birds influence the poor water conditions in the fountain. The faecal contamination index indicates that 80% of the contaminants are of mixed origin, i.e. they come from both animals and humans.

According to literature reports, apart from the etiological factors (viruses, cryptosporidia), large numbers of indicator bacteria were recorded in water usually in the course of investigations on 'water epidemics'. Water in a fountain can be easily contaminated with faecal bacteria originating from the bodies of bathing people. Hoebe et al. [5] recorded faecal streptococci in the quantity of 3,500/100 ml and *E. coli* in the quantity of 7,700/100 ml, whereas the number of coliform bacteria exceeded 1,000 bacteria/ml of the analysed water. In the described case, a Birmingham, UK, norovirus turned out to be the infectious factor, but high numbers of indicator bacteria generally prove the poor sanitary conditions of the investigated recreational fountain, and cessation of relevant

measures preventing the contamination (proper chlorination of water).

In the water of city fountains, apart from the studied groups of bacteria, other microorganisms may also occur, mainly fungi [17, 18, 19]. In fountains in the city of Olsztyn, Poland, Biedunkiewicz [17] reported the presence of 27 fungi species, including 23 species of yeast fungi from 13 genera (dominant type *Candida*) and 4 species of mould fungi. Almost half of the species were classified as potentially pathogenic. This author reported the presence of microfungi in water of all the studied fountains, and hence it is likely that they would also be found in the water of Toruń fountains.

Although the statistical data indicate that 'water epidemics' are relatively rare [20, 21, 22, 23], Hoebe et al. [5] believe that their quantity could be underestimated. With infections spreading from aquatic sources, patients often do not know each other and go to different medical centres; it is therefore easy to overlook the common source of infection. This assumption constitutes a further argument for the thesis that fountains should be carefully monitored for the presence of microorganisms, or the ban on bathing in fountains should be more rigorously enforced, in order to prevent possible infections.

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