Overview of the Hungarian Water Hygiene Situation

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Abstract

An overview of the 2016 water hygiene situation in Hungary is presented. Drinking water quality in most municipalities complies with the requirements of the European Union drinking water directive. Non-compliance of faecal indicators is 1-2 %. Arsenic poses the highest challenge in chemical water quality, but it is close to being resolved by the National Drinking Water Quality Improvement Programme. Other problematic parameters are either of geological origin (boron, fluoride, manganese, iron and ammonia), or derived from water treatment (disinfection by-products). Secondary water quality deterioration (both chemical and microbial) in the distribution system is a growing concern, especially leaching heavy metals (lead) and bacterial regrowth (e.g. *Legionella*). Natural bathing waters are generally excellent or good quality (over 96 % of designated bathing sites), especially on the lakes. Pools operating with water circulation and treatment usually meet the legal quality requirements. Fill-and-drain thermal pools are at higher risk of microbial contamination.

DRINKING WATER

The quality requirements for tap water in Hungary are laid down in the Government Decree 201/2001 (X.25.) (hereafter: Decree), implementing the Drinking Water Directive 98/83/EC. The parameters to be monitored and the parametric values are listed in Annex I. of the Decree. The basic requirement for drinking water is that it should be free of pathogens and harmful chemical or physical substances. The indicators for faecal pollution are listed in table A, the chemical parameters that have proven negative health effects in table B. The other tables (C-E) contain the indicator parameters which are relevant primarily for operational monitoring or signal changes in the water system. The indicator parameters have only indirect effect on the

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health of the consumers. The drinking water of a settlement is considered good and wholesome, if it complies with the chemical and microbiological requirements of tables A and B of Annex of the Decree. This, however, only records a snapshot of the situation and due to the relatively small number of samples (1-4 samples in small municipalities) it gives limited information about the water quality all year round.

The primary requirement for drinking water is that it should be free from pathogens. Contamination with waste water is the primary source of pathogens in drinking water (e.g. at pipe burst or sewage intrusion), thus the most important markers of microbiological compliance are the faecal indicators: *E. coli* and *Enterococcus*. The presence of faecal indicators in drinking water is sporadic in Hungary. Nationally, 98-99% of the water samples are compliant (*Figure 1*). This level of compliance has been stable in the past decade; the incidence of recognised water-related infectious diseases and outbreaks is in effect negligible. Non-compliance occurs primarily due to pipe bursts or in rare events due to extreme weather or other emergency. A slight declining trend can be observed for other microbial indicator parameters (colony count, *Pseudomonas aeruginosa*), mainly due to contamination of water treatment technologies and ageing of the water distribution systems.

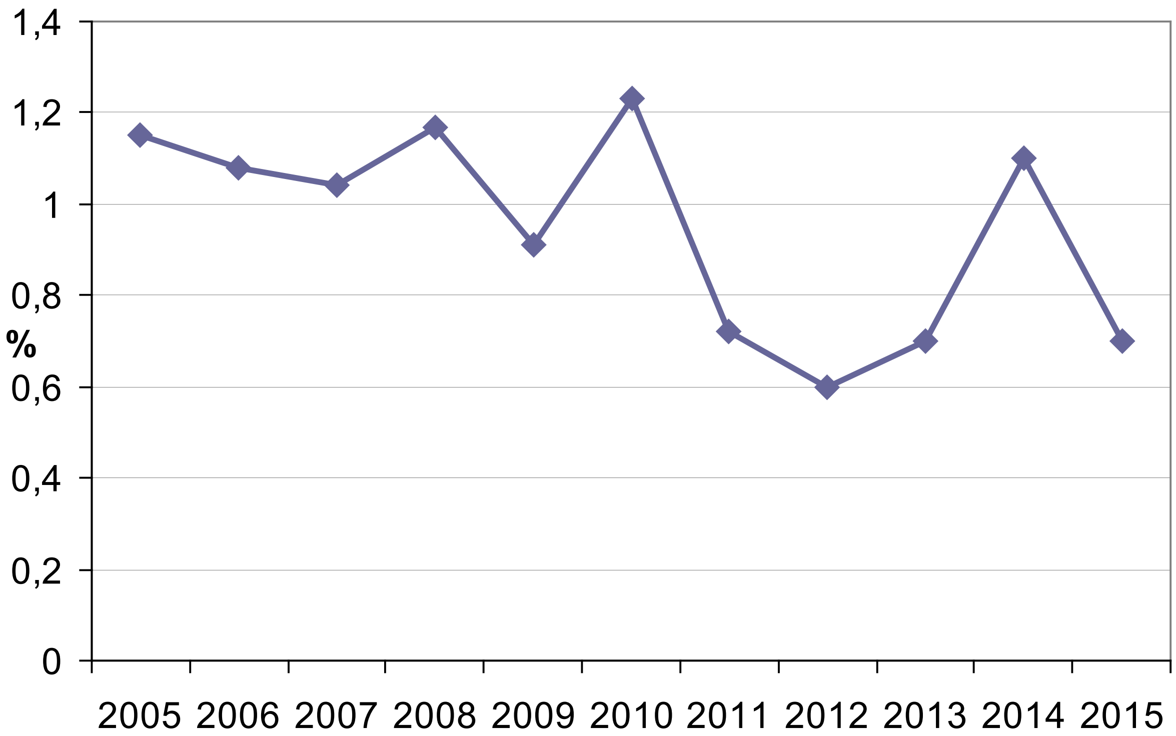

Figure 1. Non-compliance rate of E.coli in Hungarian drinking water samples

The National Communicable Disease Reporting System (https://www.antsz.hu/oszir/jarvanyugyi_szakrendszer) is built on the combination of case-based and event-based surveillance, to which laboratories and doctors (GPs, specialists and hospitals) report in accordance with their legal obligations. The number of confirmed, water-related outbreaks is very low, usually less than one per year. Infections and family outbreaks occur more frequently in those severely disadvantaged regions where access to public water supply and sanitation, as well as hygienic practices, are below the national average.

From a chemical perspective, arsenic poses the greatest challenge for the supply of safe water on the national level; both in terms of health effects and the number of affected citizens. Ten years ago, still about 1.5 million residents consumed drinking water that exceeded the public health limit value (10 µg/L) for arsenic. By 2017, this number was reduced to less than 100,000 residents connected to the public water supply (*Figures 2 and 3*).

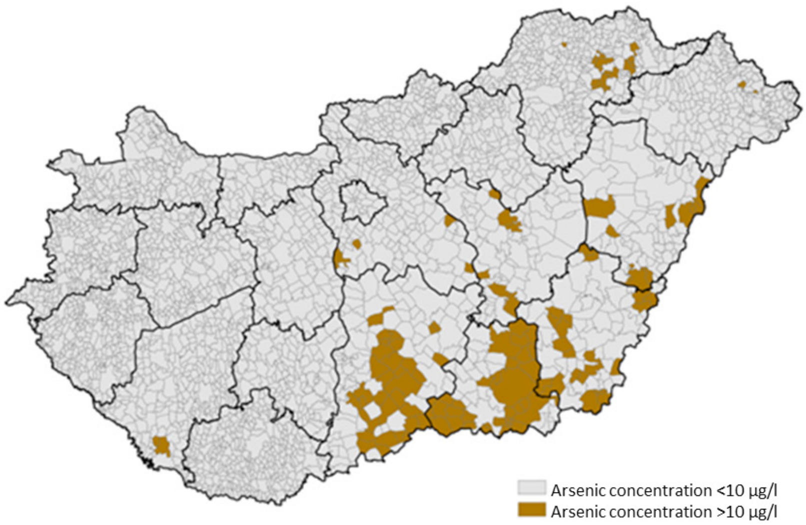

Figure 2. Distribution of Hungarian settlements with arsenic content of the drinking water above the parametric value (10 µg/L)

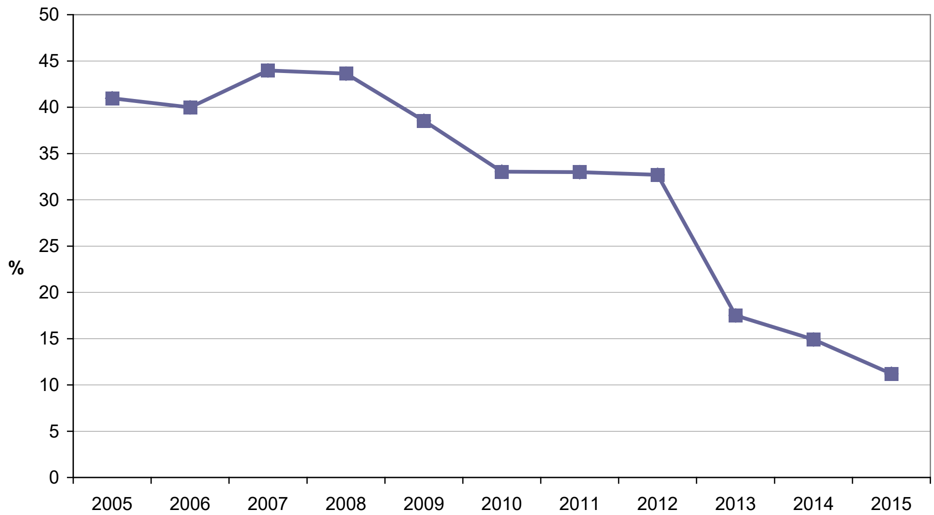

Figure 3. Non-compliance rate of arsenic in Hungarian drinking water samples

Long-term consumption of drinking water with high arsenic concentration has definite adverse health effects. This is also confirmed by Hungarian epidemiological studies. Besides the increased risk of adverse pregnancy outcomes found in settlements supplied with drinking water with arsenic level above 20 µg/L (Rudnai P et al., 2013), the Hungarian study conducted within the framework of the EU funded ASHRAM international epidemiological study showed that long-term consumption of water with an average arsenic concentration above 10 µg/L increased the risk of non-melanoma skin cancer 4.6 times and the risk of lung cancer 1.9 times. The risk of bladder and renal cancer was found to be increased at higher exposures (Rudnai P et al., 2007, Leonardi et al., 2012).

Another Hungarian study also indicated a significant association between consumption during pregnancy of drinking water with arsenic concentration of above 10 µg/L and increased risk of congenital heart anomalies (Rudnai T et al., 2014).

A significantly smaller portion of the population is affected by other chemical components that pose health risks, such as boron, fluoride, and chlorination by-products.

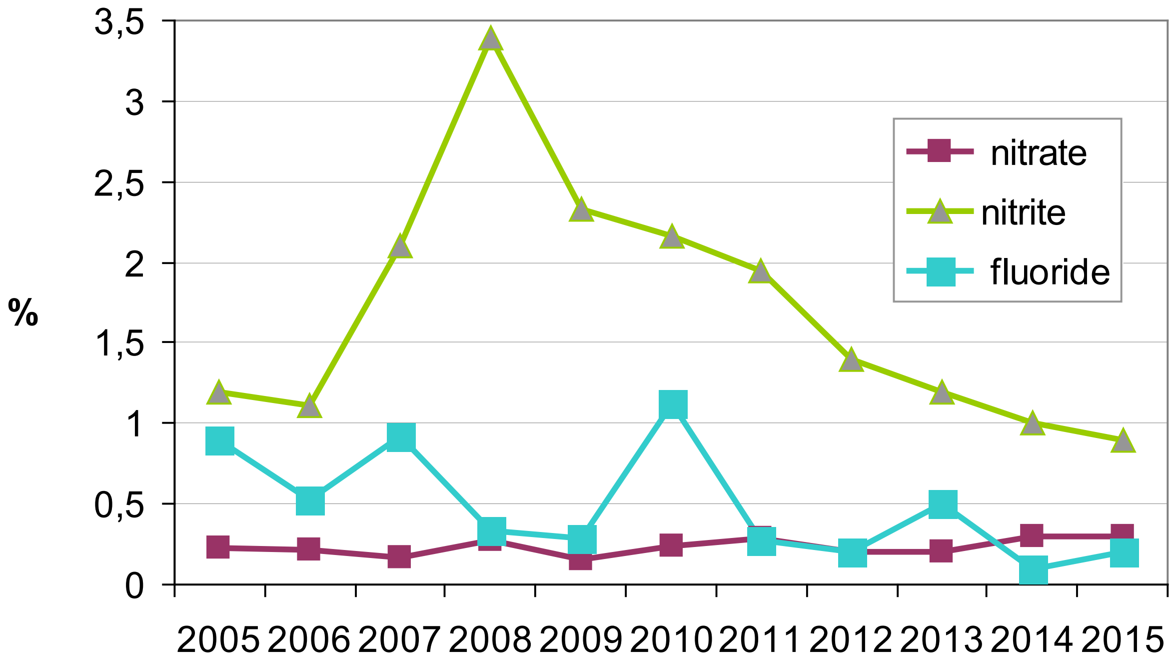

Figure 4. Non-compliance of fluoride, nitrite and nitrate in Hungarian drinking water samples

Ammonium of geological origin in the drinking water is present in concentrations above the parametric value in many areas of the country. Ammonium itself has no adverse health effect. However, due to microbiological processes during water treatment or water distribution, (especially in aged distribution networks), ammonium may be transformed into nitrite, which is hazardous for all, but especially for babies. Even relatively low amount of ammonium (0.2

mg/L) can yield nitrite in concentration above the limit value (> 0.5 mg/L). The occasional occurrence of nitrite in water supply affects 20-30,000 people. In case of non-compliance, safe water from alternate sources (e.g. bottled water) is provided for infants and pregnant women. Methaemoglobinaemia due to nitrite or nitrate in drinking water from public supply have not occurred in Hungary in the last decade (https://www.antsz.hu/oszir/jarvanyugyi_szakrendszer) (*Figure 5*).

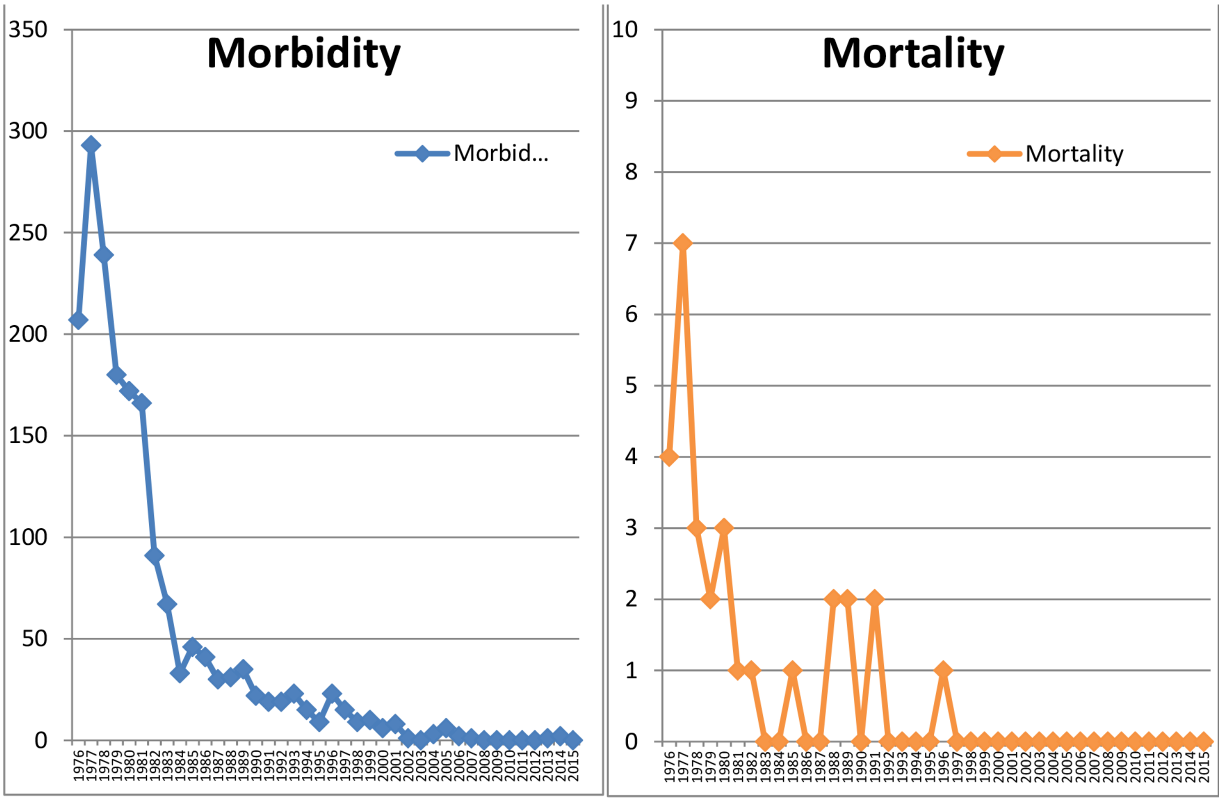

Figure 5. Morbidity and mortality of methaemoglobinaemia in Hungary, 1976-2015

In the past 5 years, mostly as a result of the National Drinking Water Development Programme, chemical water quality has improved considerably, especially with regard to the five parameters that were in the main focus of the Programme (arsenic, boron, fluoride, nitrate and nitrite). The Programme also contributed to the reduction of high concentrations of iron and manganese as these frequently co-occur with arsenic and are removed by the oxidative arsenic treatment technologies. The reduction of nitrite concentrations (which was a result of the 2007 Nitrite Action) has slowed down temporarily. New technologies were installed in many water supplies to remove ammonium of geological origin, but many of them are still in test operation, and incidental nitrite non-compliance may occur. The reduced compliance rates for disinfection by-products are also connected to the test operation and on-going optimization of new water treatment technologies.

According to international assessments, the water quality of small (< 1000 m^3/day) and large (> 1000 m^3/day) water supply systems generally differs, mostly due to the better operational practices in the latter. The difference in compliance is primarily observed for parameters where exceedance is the result of the absence of water treatment technology or its inadequate operation (e.g. arsenic, boron, fluoride, ammonium, nitrite, iron, manganese disinfection by-products), or the condition of the system (nitrite, microbiological parameters).

The good quality of drinking water confirmed by testing at the point of consumption is only one aspect of drinking water safety. End-product monitoring provides information on the quality at the time of sampling, and analysis may take up to 3 days. Therefore, international best practice (including the guidelines of the WHO) is shifting towards a risk-based approach of operation, most commonly known as water safety planning. Its core provision is the assessment and management of all risks in the water supply system from source to tap (WHO, 1984; WHO, 2004, WHO, 2011). The risk-based approach allows the recognition of adverse events before its consequences reach the consumers, thus providing a higher level of health protection. Water safety planning is a legal requirement in Hungary, entering into force in a rolling system. By 2013, water supply systems serving more than 50,000 people, by 2014, those serving over 5,000 people were required to develop water safety plans, and by 2017, the requirement is extended to all systems serving > 50 inhabitants. The plans are audited from a public health aspect in a two-tier process: the Water Hygiene Department of the National Public Health Institute evaluates the plans on a national level, with a technological and methodological focus, while on the local level, the public health department of the competent government office does the evaluation, taking local experiences into consideration. The risk-based approach of drinking water safety has been recently introduced into the European Union drinking water directive.

Secondary water quality deterioration

The samples for monitoring water quality are taken at pre-determined sampling points (e.g. public outlets, schools, city hall), therefore these refer primarily to the quality of the supplied water. The currently employed compliance monitoring system is unsuitable for assessing the secondary water quality deterioration (e.g. heavy metals leaching from the pipes, bacterial regrowth) that occurs in the distribution networks and in the plumbing system of buildings. For some heavy metals (e.g. copper, nickel, lead, chrome, cadmium), the different structural materials (pipes, fittings, taps) are the main sources of contamination. Lead is the most important of these from a public health risk perspective. It is mainly derived from lead pipes that can still be found mostly in the plumbing systems of older buildings. However, the routine monitoring of the supplied water is not capable of identifying local contaminations. This is shown by the fact that while the average compliance rate between 2011 and 2015 in the compliance monitoring was 98% for the lead in drinking water, the targeted sampling data of the National Public Health Institute in buildings at risk (built before 1970) showed 42% compliance for private homes and 70% for childcare facilities (*Figure 6*).

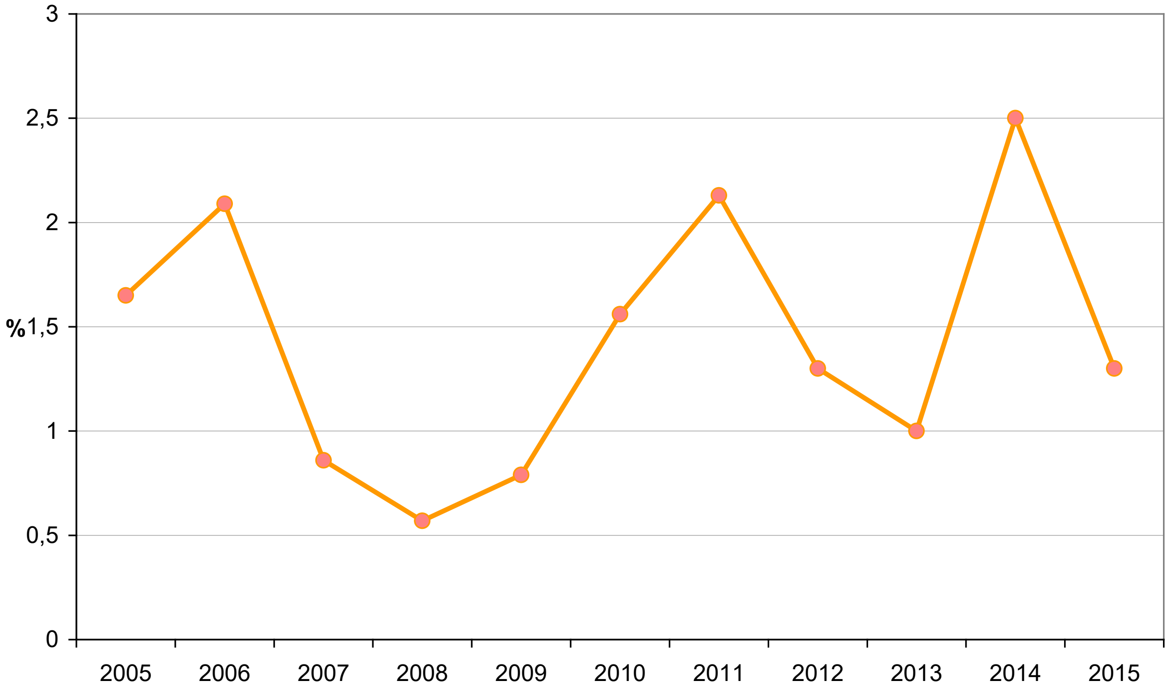

Figure 6. Non-compliance of lead in Hungarian drinking water samples

The increase in lead non-compliance does not reflect an actual adverse trend. It is partially due to stricter parametric values (in 2013, the limit value changed to 10 µg/L from 25 µg/L in the entire EU) (Drinking Water Directive 98/83/EC), and also to increased monitoring in possibly affected buildings by the public health authority as part of their dedicated work-plan. Besides leaching, bacterial contamination and biofilm formation are also risks in plumbing systems. Total colony count (indicating bacterial regrowth and biofilm formation) is high in many water supply zones, due to the aging distribution systems, high organic matter content of the water or/and high water temperature. The problem is likely to aggravate due to increasing temperature caused by climate change. Although the biofilm forming bacteria are primarily harmless environmental bacteria, opportunistic pathogens inhabit the biofilms, such as *Acinetobacter, Aeromonas, Klebsiella, Moraxella, Serratia, Pseudomonas, Corynebacterium, Yersinia* species or non-tuberculotic *Mycobacteria*. Their presence is mainly a risk for the vulnerable groups; therefore childcare and healthcare facilities and retirement homes are at the highest risk. *Pseudomonas aeruginosa*, which primarily colonizes fittings, was shown to cause water-borne nosocomial infections in Hungary. Nitrifying bacteria (ammonium- and nitrite-oxidizers) in the biofilms are also important from a public health perspective.

Another recently recognized problem is the widespread occurrence of *Legionella* bacteria in the artificial water systems. Although the number of reported legionellosis cases is low, the studies assessing the environmental prevalence of the bacteria confirm the risk of colonization in hot water systems and spa pools. In the past 5 years, 30-80 legionellosis cases were reported annually in Hungary, while the European average is 10-fold higher. The difference is presumably due to the inefficiencies in recognition and diagnosis of the disease. The hot and cold water systems of large buildings (hospitals and hotels, for example) pose the highest risk. A study of almost 2000 buildings (healthcare facilities, hotels, educational facilities, office buildings) indicated *Legionella* colonization in over half of the hot water systems. In about 30%, the bacterial counts were above the public health limit value. The ideal temperature for the growth of *Legionella* is between 20°C and 45°C, so the elevated temperature of cold water during the summer increases the risk. The implementation of Ministerial Decree 49/2015. (XI. 6.) of the Ministry of Human Capacities on the public health requirements for matrices and facilities posing a risk of *Legionella* infection, is expected to reduce public health burden (Barna, 2016). Water temperature also greatly influences the occurrence of unicellular and multicellular organisms in tap water and in biofilm. At higher temperatures, pathogens may appear in this group as well, mainly fungi such as the *Aspergillus* and *Candida* specie and the incidence of species that are primarily present in thermal- and waste water (e.g. *Giardia, Cryptosporidium, Entamoeba*) also grows. Certain amoebas, or ciliates such as *Cyclidium* or *Tetrahymena* also promote the growth of *Legionella* as host organisms.

Other compounds in drinking water that have a health effect, the future challenges of water hygiene
The regular monitoring of drinking water by the suppliers and the public health authorities only covers the parameters specified in the legislation. Although the list of required parameters is extensive, it does not include every potentially occurring contaminant which might affect the health of the consumers. The potential presence of endocrine disruptor substances (EDS), e.g. excipients used for certain plastics, industrial contaminants (PCB, PAH), certain pesticides (DDT and its derivatives, simazines), heavy metals, or drug residues in the drinking water is a general concern of the public. EDS are not monitored regularly, but study results confirmed their intermittent presence in ng/l concentration range in treated wastewater and in some surface waters (rivers, streams). Epidemiological studies could identify new risks even for well-established parameters (e.g. manganese).

The presence of constituents not monitored regularly (e.g. iodine, lithium, uranium, vanadium, etc.) in Hungarian drinking waters and their potential health effects are also investigated by the Water Hygiene Department of the National Public Health Institute. It is known that there are significant geographical differences in the iodine concentration of drinking water within the country: while some areas have iodine deficiency (in 97% of the settlements based on a 2016 study by the NPHC), in other areas excessive iodine intake from drinking water can cause thyroid disorders or goitre (e.g. Surjány or Szakállas parts of Törökszentmiklós). The beneficial physiological effects of lithium are well documented. International studies indicate that higher lithium concentration in drinking water may reduce the rate of depression and suicide. There is less available data on vanadium and uranium as water pollutants, but international experience show that these pollutants of geological origin are often co-occur with arsenic.

Dental caries is an endemic condition in Hungary. The decayed, missing, and filled teeth (DMTF) index shows that – although it improved between 1985 and 2008, from 5.0 to 2.4 – it is still significantly worse than in the Western European countries (e.g. Germany, 2009: 0.7; Denmark, 2012: 0.6 – based on the WHO Global Oral Health Database, http://www.who.int/oral_health/databases/en/). One of the reasons is the low fluoride intake. 99.5% of the population consume less than the required fluoride intake with drinking-water.

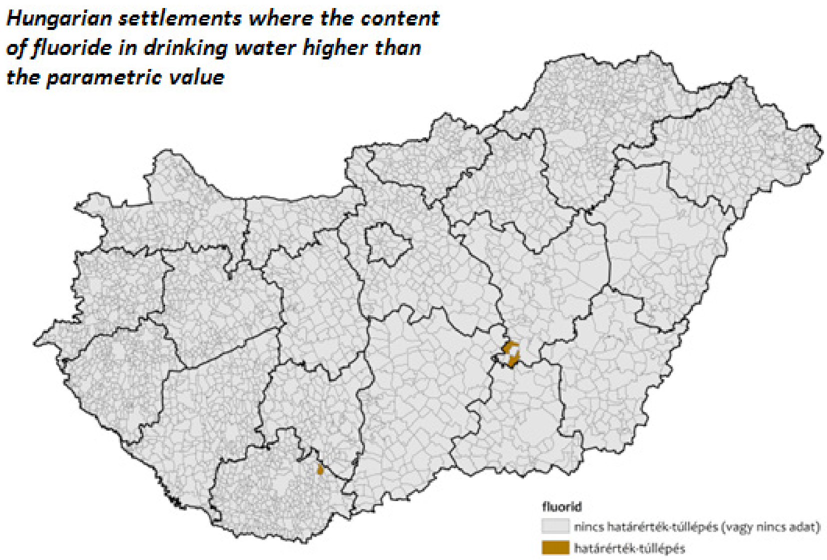

Figure 7. Distribution of Hungarian settlements with fluoride content of the drinking water above the parametric value (1.5 mg/L)

Many studies have reported an inverse correlation between the hardness of water and coronary diseases, indicating lower risk with consumption of harder water. Hardness is determined by the Ca and Mg content of the water. The protective effect is attributed to magnesium, although several studies emphasize that the Mg/Ca rate is also important (a higher rate being more beneficial). Since other environmental and lifestyle factors contribute more to the development of these diseases, the protective role of water hardness is not fully justified (WHO, 2009).

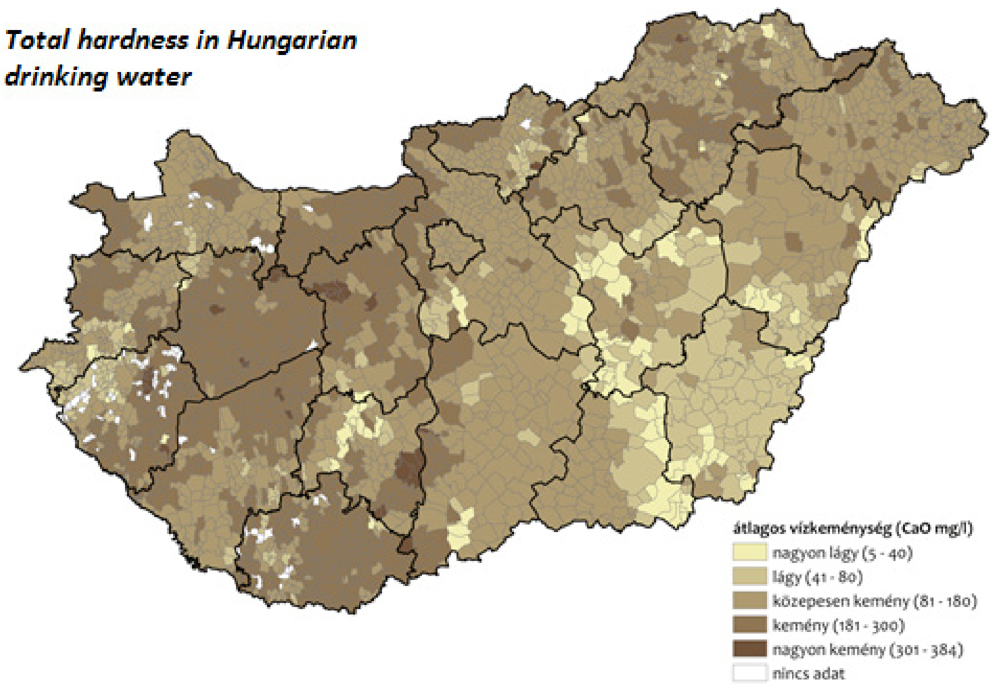

Figure 8. Total hardness of the drinking water in the Hungarian settlements

Public health risks of private water supply

In Hungary, approximately 95% of the population is supplied by public utilities, 3% is served from individual systems, and 2% uses the water of their own wells as drinking water (data from the Hungarian Central Statistical Office). The proportion of the population consuming drinking water from private wells shows significant regional differences. Based on data from the Settlement Information System (TEIR, https://www.teir.hu/), the proportion of non-supplied suburbs or farm type settlements is the highest in the Southern Great Plain and in Northern Hungary. The quality of water from dug or drilled wells is very diverse: it depends on the depth of the well, the geological features of the area, and the anthropogenic pollutants affecting the water source. Quality deterioration is primarily caused by human or animal waste (e.g. septic tanks, latrines, carcass pits, manure), pesticide- and fertilizer residue in agricultural land or geogenic pollutants. Industrial pollution is of a less frequent concern. The most common problem and the greatest public health risk is – especially with regard to infants and small children – the bacterial contamination and the presence of nitrite and nitrate in the wells. Water related methaemoglobinaemia was reported only in connection with private wells in the past decade.

The 2016 amendment to the Government Decree 147/2010. (IV. 29.) introduced monitoring requirements for private wells. The results should be submitted for approval to the public health authority. This intervention is expected to expand the knowledge and awareness of health risks associated with private wells.

Bathing water

Natural bathing waters

The Government Decree 78/2008. (IV. 3.), implementing the EU bathing water directive 2006/7/EC, regulates the quality requirements of natural bathing waters, the process of designating natural bathing sites and requirements of their operation. In Hungary, 76 freshwater bodies are used for bathing. In 2015, there were 256 registered natural bathing sites in the country, 212 on lakes and 34 on rivers. The overwhelming majority of Hungary's lake beaches are on our large lakes (Lake Balaton: 138, Lake Velence: 9, Lake Tisza: 6 beaches), the rest were established along oxbows and quarry lakes.

The quality of the bathing water is monitored 4 times a year, in accordance with the regulation, once before the bathing season and once per month during the season. One natural bathing water operates all year in Hungary, the Hévíz Lake Spa, where the water quality is monitored every month. Monitoring consists of on-site visual inspection for visible pollution, signs of seaweed growth, or algal bloom, and laboratory analysis of the water for two indicator bacteria (*E. coli* and *Enterococcus*). The classification of the beaches (excellent, good, sufficient, and poor) is based on the indicator bacteria count datasets for four years, a total of 16 samples. This method is more reliable than classification based on the result of the latest sampling, because that one indicates only the water quality at the time of sampling, potentially several weeks earlier. The current classification system indicates how high is the probability of contamination at the beach. Pollution appears too frequently at "poor" beaches to be considered safe for bathing, although there may be periods when the water quality is good. The bathing water profile compiled by public health authorities contains the detailed characterization of bathing waters, which also includes potential sources of pollution that may have adverse health effects (e.g. treated or untreated wastewater, animal manure, industrial or agricultural activities, etc.). The bathing water profiles are accessible at the websites of the county government offices, and on the website of the National Public Health Institute (http:\\oki.antsz.hu). Information to bathers on water quality and the potential pollutants is mandatory.

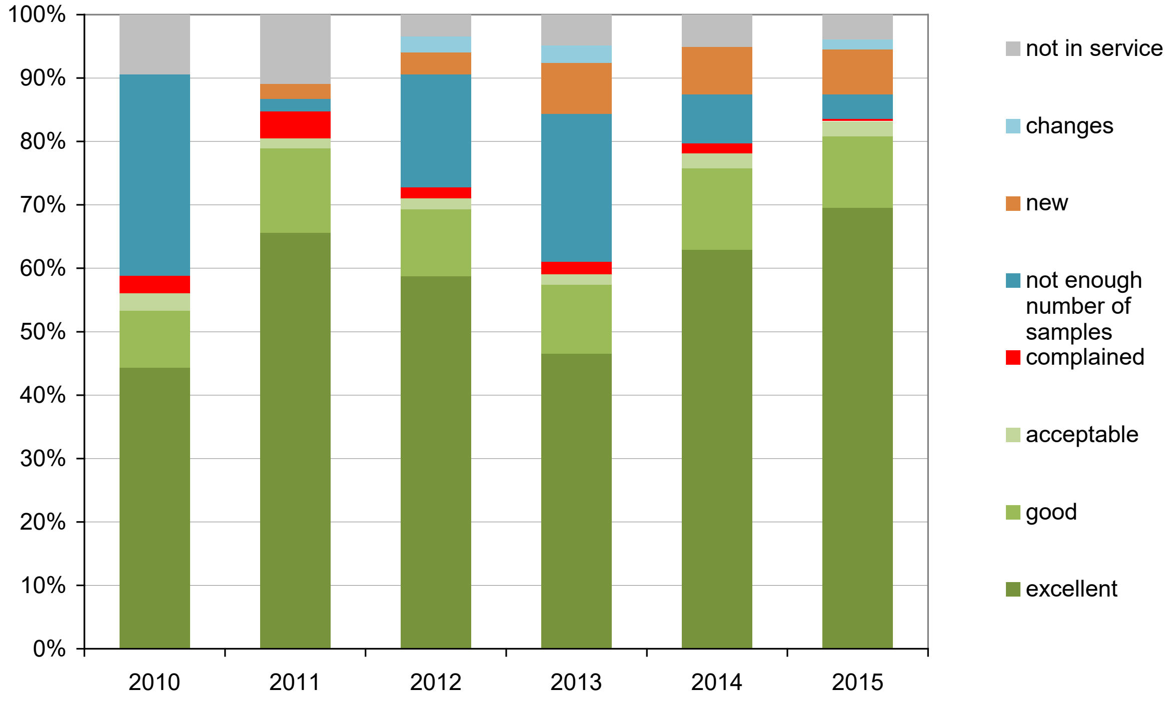

Figure 9. Quality of the Hungarian natural bathing waters

Algal blooms caused by the proliferation of toxin-producing cyanobacteria (also known as "blue-green algae") are also monitored in lakes and oxbows. Blooms are indicated by green discolouration of the water, cloudiness or foaming. Algal bloom was not reported in 2015. The classification of natural bathing waters does not include chemical parameters. Surface waters where hazardous chemical water pollution is present, or can be expected, cannot be designated as natural bathing waters. The chemical parameters used as status indicators of surface waters (e.g. nitrite, nitrate) are not a risk to human health during bathing.

Non-designated bathing sites with unknown water quality are still visited by a large number of bathers, which is also a public health challenge. The public health authorities have limited information on the number of illegal bathing sites and the number of bathers using them.

Pools and spas

Hungary, due to its fortunate geothermal characteristics, is exceptionally rich in thermal water. The recreational and therapeutic use of thermal baths has been popular for centuries and it is still one of Hungary's main touristic attractions. The number of pools is constantly increasing, especially in establishments whose primary profile is not bathing (e.g. hotels, sport centres, apartment housings). Currently there are about 1200 public baths with over 3000 pools (although there is no central registry). The technology of the sector is also rapidly improving. Pools and spas are regulated by the Ministerial Decree 37/1996. (X.18.) of the Minister of Welfare (NM) on the public health requirements of establishing and operating a public bath, but it has been basically unchanged for more than 20 years, therefore it is difficult to apply it to new water treatment technologies, pool types, and attractions. The development of a new legislation was completed in 2016 with wide professional involvement (pool operators and their professional organization, local and national public health authorities) and the coordination of the NPHC, however, government approval is still in progress. The technical board of the Hungarian Standards Office on pools (in which operators, civil engineers, water management experts and public health experts are also represented) published a series of standards, which provides help containing the best practices for the planning and operation of pools. However, the operators are not legally required to apply the standards.

Therapeutic waters and medical spas are authorized based on the requirements of the Ministerial Decree No. 74/1999. (XII. 25.) of the Ministry of Health on natural curative agents. If thermal water is used in pools, means of temperature adjustment and the water treatment technology should be chosen to cause the least harm to the biologically active components of the water. As a consequence, most therapeutic pools operate without disinfection, in a "fill and drain" mode. There is little information on the treatment options of thermal waters.

Pools and spas are supervised and inspected by the district and the county public health authorities. There is no national database on pool water quality like the ones for drinking and natural bathing waters. The local public health authorities report the aggregated data on the water quality and the hygienic conditions of pools and spas to the National Public Health Institute, however, these data are not suitable for detailed analysis. In order to monitor the water quality of pools and to inform the public, development of a regularly updated reporting and data collection system is necessary.

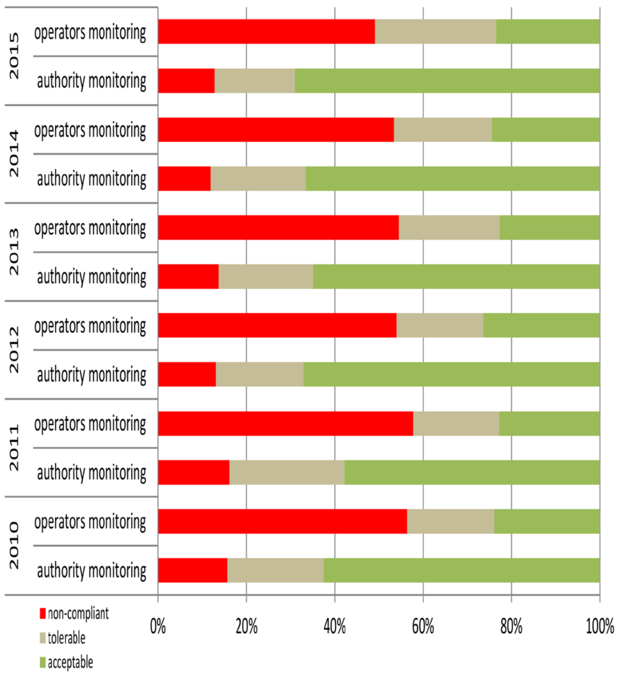

Figure 10. Quality of baths and pools operating in fill and drain mode in Hungary

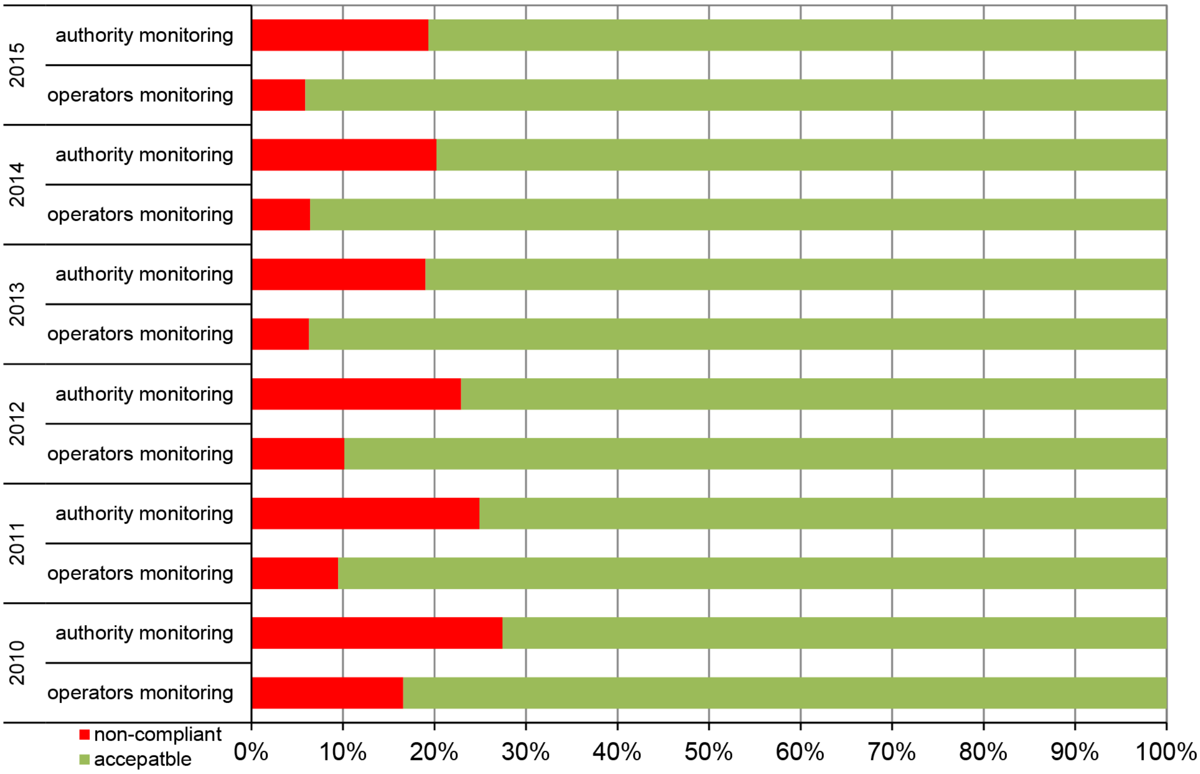

Figure 11. Quality of baths and pools operating with water treatment in Hungary

The microbial quality of pool water (especially of therapeutic baths operating in a fill-drain mode) is often inadequate, but a more detailed assessment of the problem would only be possible by analysing the currently unavailable detailed monitoring data. Whirpools and spa pools are also often non-compliant. Special regulation is necessary for these types of pools. Presently, in the absence of relevant legislation the authorities cannot forbid e.g. the use of whirpools designed and approved only for home setting in public baths. Often the authority is not even aware of the existence of pools e.g. in hotels and fitness centres. The Ministerial Decree 49/2015 of the Ministry of Human Capacities requires the risk assessment and *Legionella* monitoring of warm, aerosol generating pools, but it covers only a small segment of pool operation. In general, the compliance rates of monitoring by the operator are significantly higher than of those done by the authorities. Self-check samples are almost always taken in low attendance periods (early morning hours), while authorities take samples closer to noon or in the afternoon hours. The self-check samples therefore do not provide an accurate picture of pool water quality, and do not reflect the actual risks to the health of the bathers.

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