Utilisation of recycled wastewater as an alternative source of water used for fire-fighting purposes by fire brigades in the Czech Republic

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Abstract. The article focuses on the possibility of using recycled wastewater for fire-fighting purposes by fire brigades. The article briefly defines the most serious hazards that may arise by using recycled wastewater in the field of fire protection. The text also contains a brief definition and comparison of critical microbiological indicators corroborating water contamination. The indicators are defined on the basis of existing national standards and legislative regulations of the Czech Republic for the field of fire protection. Furthermore, the article determines framework defining qualitative limit values of microbiological indicators for fire water sources. Based on the framework specified above, it was possible to determine that the current limit values for permissible microbiological pollution of surface water allow using recycled wastewater as an alternative source of fire water under existing national legislation.

1. Introduction

Water is one of the essential components that play a vital role in the existence of any organism on Earth and probably in the universe. The fact of the matter is that without water, all the living nature would very probably cease to exist. Research conducted for example in desert areas or while analysing data from cosmic bodies searching for traces of water provides us with clear evidence. Thus, water is rightly considered fundamental condition when considering whether or not life is or was possible somewhere in the universe.

Water has also become indispensable for the diverse needs of fire brigades. Currently, fire brigades focus not only on fire-fighting but also on a variety of activities related to a wide range of different events. Requirements for water resources and their supply can, thus, directly depend on specific types of events the brigades have to face. Moreover, these requirements may vary both in time and space.

Water resources have been enduring increasing pressure in order to fulfil the social, economic and environmental needs of the growing world population. Water is not evenly distributed in the world [1], and currently only 0.5% of the world's water resources can be used to supply fresh water needed by the human population and the ecosystem on Earth. Approximately 1.8 billion people still suffer from inadequate access to freshwater and around 2.5 billion people live in areas that need to strengthen and improve the sewerage and wastewater treatment system significantly [2]. In 60% of European cities with over 100,000 inhabitants, groundwater resources are consumed much faster than they can recover, and at the same time, more than 40% of the water supply is lost due to leakages, accidents or simply due to inadequate quality of water infrastructure (mainly due to its age). Furthermore, it is necessary to emphasise that water is needed for the production of almost every product in the world, and, thus, all industries are somehow dependent on water [3].
2. Recycled wastewater
The European Water Innovation Partnership has identified five main priorities in this field, including water reuse and recycling. Aquatic ecosystem, as well as freshwater supplies, used mainly for drinking purposes, face ever-increasing pressures caused by climate change [4, 5], extreme meteorological events, water scarcity, increasing degree of urbanisation [6], growing population on the planet [7], or environmental pollution [8, 9, 10]. The World Health Organisation has recognised support for the global use of wastewater as a response to increasing drinking water scarcity, population growth and related food security issues. Among other topical issues belong increasing level of environmental pollution due to poor disposal of hazardous chemicals and wastewater or the increasing potential of resources of wastewater, manure, and the so-called greywater.

Stress on Europe's water resources is increasing, which leads to its shortage and deterioration in quality. This stress can be characterised by discrepancies in demand and availability of water resources over time and space [11]. Pressures on water resources have encouraged a more proactive approach, as well as different considerations regarding the use of alternative water resources as a strategic alternative to complementing and protecting natural water resources. In the European Water Resources Protection Plan, the European Commission explicitly underlines the need of seeking new solutions of issues related to water originating from urban, industrial and agricultural environments. Proposed solutions should consequently contribute to economic, social and environmental issues, which play key role in implementation of reuse and recycling processes in real life. Water reuse and recycling yields many benefits such as increased water availability, integrated and sustainable use of water resources, a change in perceiving drinking water (drinking water should only be used for drinking; recycled water for non-drinking purposes), reducing excessive abstraction of surface and mainly groundwater, reduced energy consumption compared to using deep drilling operations to reach groundwater sources, water import or desalination, reduced nutrient burden, reduced fertiliser use, and increased environmental protection by restoring streams, wetlands and ponds. The re-use of recycled water has been addressed by the European Union, as well as relevant international authorities that have already introduced several directives [11]. At the same time, there are researches that try to use recycled water in other sectors [12, 13]

3. Risks arising from the use of recycled wastewater
Poorly treated wastewater tends to “rot” when it is kept for some time. This is mainly due to the presence of organic substances that serve as food for various bacteria, viruses and fungi. If a building or area using recycled water is connected through, for example, internal (recycled) water supply system, there is always a risk of unintentional connection of this system with the drinking water distribution. In the best case, only the drinking water inside the building will be contaminated; in the worst case, contaminated water can spread out to the public water supply network. This phenomenon is called “cross-connection,” and belongs among quite frequent causes of contamination of drinking water in the public water supply systems [14, 15].

Among the most significant risks associated with the use of recycled wastewater in connection with fire-fighting belong to the following phenomena:

- Risks related to human health (presence of bacteria and viruses, etc.). Recycled wastewater may contain coliform bacteria, thermos-tolerant coliform batteries, E. coli bacteria or intestinal enterococci, which may endanger people's health. These microbiological indicators are part of the human, as well as warm-blooded animal, digestive tract. It is necessary to determine hygienic limits for the intervening components of the Integrated Rescue System and other participants involved in the liquidation of the event where such waters have been used for rescue, destruction and restoration work;
- Risks associated with long-term accumulation of such waters (ageing and decay of water, multiplication of microorganisms, etc.). In terms of long-term accumulation, water degradation can and probably will occur, which can make such water harmful even for fire brigades. Besides, individuals who are not equipped with appropriate protective equipment may come into contact with long-held water (for example, in the course of water handling);
• Risks associated with the cross-connection phenomenon (outbreaks of epidemics, contamination of water infrastructure, etc.). When you create water supply using recycled wastewater, i.e. an alternative source of firewater, there will always be a low probability of interconnecting it with the drinking water supply lines. It should be stressed that the significant risk is the human factor, whether intentional or unintentional.

The hazardous aspect of recycled wastewater and its use lies in setting the sanitary limits regarding potential health consequences for people who came in contact with such water [16, 17]. This is one of the reasons why hygienists are somewhat sceptical about the use of recycled water in areas where people can easily come into contact with it and inadvertently swallow it [18].

4. Determining limit values for microbiological pollution in recycled wastewater intended for fire-fighting purposes

At present, you may encounter risks associated with contaminated water, for example, during swimming, water sports or recreation at waterways. The legal system of the Czech Republic deals with microbiological contamination of watercourses, for example, in connection with their use for bathing on the declared bathing profiles and in the course of extracting of water for its treatment to produce drinking water [19, 20]. The limit values of microbiological indicators are included in the Government Order on Permissible Pollution of Streams [21].

All national standards and legislation rely on the establishment of faecal pollution indicators. They comprise intestinal bacteria (thermo-tolerant coliform bacteria and intestinal enterococci) corroborating direct contamination of surface waters by untreated or insufficiently treated wastewater. The presence of E. coli can also be used as indicator of faecal contamination because E. coli belongs to a sub-group thermo-tolerant coliform bacteria, and accounts for an average of 60% of their number in surface waters.

The international research currently targets issues that have not yet been fully reflected in national water management practice. For example, researchers focus on the occurrence of pathogenic microorganisms in various types of surface water. These microorganisms can be found in sediments and biofilms, which may serve as their potential reservoirs, and at higher flow rates, for example during heavy rainfalls, they can be released into flowing water. Furthermore, research or modelling of microbiological pollution of water at various flow rates, especially during torrential rains. For example, an epidemiological study was carried out at German inland natural swimming ponds in order to establish safe values of microbiological indicators when no statistically significant difference between the experimental and control group has been attested. The resulting values were as follows: intestinal enterococci 25 cfu/100 ml, E. coli 100 cfu/100 ml, and Clostridium perfringens 10 cfu/100 ml [22].

The Czech Fire Water Resources Standard recommends to primarily utilise natural water and multi-purpose water sources as fire water sources [23]. Multi-purpose water sources are currently most presented by water supply systems, the local water supply of towns and municipalities and internal water supply lines that distribute drinking water. Such multi-purpose water sources comprise mainly of hydrant networks that have been installed for fire-fighting purposes in the built-up areas. The demands on such multi-purpose water sources are much stricter than for natural water sources in terms of system diagram of water flow from the source to the consumer [24]. Moreover, the degree of risks likelihood is also higher. However, the most serious threat to this system is the risk of contamination of the transported drinking water through the distribution system. Such threat may result not only in endangering the health of consumers, but also in interrupting the supply of drinking water, and at the same time, it may cause inactivation of part or even the entire distribution system. When water sources of natural origin are used for fire-fighting purposes, there is no restriction due to contamination of the source. It is assumed that the potential contamination of these sources can be eliminated due to the dilution effect and, therefore, there are no legislative or normative restrictions.

To define fire water within the limits of microbiological contamination, we can adhere to a standard that sets the requirements for surface water quality and its classification [25]. The standard divides water quality into five classes, with Class I presenting unpolluted water and Class V representing very
heavily polluted water. Although the water quality has been significantly improved in the Czech Republic compared to the period 1991 - 1992, there are still short stretches of watercourses in our country with the V. Class water quality. According to the primary classification, most watercourses fall into the III. Class, polluted water. The number of stretches of waterways falling into I. and II. [26]. Class gradually increases. This suggests that the levels of microbiological contamination should be within the limit of the III. Class to avoid deterioration of the current state of surface water quality.

The limit values for the discussed III. Class of surface water quality shall not reach for thermo-tolerant coliform bacteria the value of 20,000 cfu/100 ml, and for intestinal enterococci 2,500 cfu/100 ml, with a characteristic value derived from the study set with a predetermined probability not exceeding C90. If we take into account the microbiological parameters stipulated in the Government Order on the permissible surface water pollution [21], the limit values for thermos-tolerant coliform bacteria are set at 2,000 cfu/100 ml (P95 percentile), with maximum (P90 percentile) at 4,000 cfu/100 ml. For intestinal enterococci, limit values are set at 1,000 cfu/100 ml (P95 percentile), and 2,000 cfu/100 ml for P90 percentile. The Government Decree also sets limit values for the E. coli indicator, namely 900 cfu/100 ml (P95 percentile), and 2,500 cfu/100 ml (P90 percentile).

If we compare these two fundamental national regulations, we can conclude that recycled wastewater can also be used in the field of fire protection based on the set limit values for microbiological pollution.

5. Conclusion

Recycling and climate change are currently the most commonly cited slogans in the world. In some areas of the world, natural resources have already ceased to be sufficient for mankind, which leads to a significant excess of demand over supply. Implementation of recycling potential will probably belong among evergreens in the upcoming century, not only in the field of plastics but also water resources. Climatic changes are already felt at the beginning of the 21st century, and forecasts expect their deepening throughout the century, even the optimistic scenarios. These changes also have a negative impact on the fire safety of buildings and built-up areas where many regions can witness a gradual reduction of the available capacity of firewater sources.

Wastewater recycling for its subsequent use still represents only very little known field and has not been spread much in the Czech Republic. Recycled water can be, however, utilised in the field of fire protection where it is not necessary to comply with as strict quality limits as for drinking water. The current limitation in the use of such water in the Czech Republic lies mainly in the setting of sanitary limits in response to the possible health consequences of people handling the recyclate and in the national legislative where the best-purified wastewater is still treated as wastewater.

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