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Ocena bezpieczeństwa chemicznego i mikrobiologicznego wody pitnej w sieciach rozdzielczych wykonanych z tworzyw termoplastycznych

Abstract

Despite continuous modifications and optimisation of the composition of plastics used in the construction of drinking water transmission networks, they undergo degradation faster than expected, which may adversely affect the final quality of drinking water. The aim of this dissertation was to comprehensively assess the degradation mechanisms occurring in thermoplastics used in the construction and regeneration of drinking water distribution systems, in particular polyethylene (PE) and poly(vinyl chloride) (PVC) pipes and polyurea coatings (PMS and PMN) – and to determine their impact on the chemical and microbiological quality of water supplied to consumers. The designed test cycle included the verification of five main research hypotheses concerning both structural and morphological changes in materials and secondary chemical and microbiological contamination of drinking water. The tests were conducted under model conditions, on a semi-technical scale, as well as on a real water supply network. The characteristics of the tested materials and the identification of microplastics (MP) generated during the ageing processes were carried out using SEM/EDS, ATR-FTIR and Raman spectroscopy. The migration of water-soluble degradation products of plastics was monitored using GC×GC/ToF-MS and extraction techniques (SPE, SPME), while flow cytometry was used to assess the MP content in biofilms. The results confirmed that all analysed materials undergo progressive degradation under operating conditions, leading to changes in chemical structure (oxidation, dehydrochlorination, hydrogen bond breakdown), deterioration of mechanical properties, and the formation of microdamages and increased surface roughness. These phenomena result in the release of MP particles into water, as well as the migration of numerous chemical compounds, including phthalates, aldehydes, ketones and chlorinated compounds, which adversely affect the organoleptic quality of water and promote the growth of heterotrophic bacteria. Among the identified MP, fragments of plastics used in the construction of water supply infrastructure predominated, and their concentration in the distributed water correlated with the distance from the treatment plant. In turn, biological analyses showed that the degradation products of installation materials promote the formation of mature biofilms capable of accumulating MP. The MP water pollution indicators confirmed a high chemical and ecological risk throughout the analysed distribution system, confirming the postulated decline in the quality of water transmitted through ageing plastic pipes. The results obtained provide guidance on the implementation of Directive (EU) 2020/2184, which requires manufacturers to identify and assess risks in the drinking water supply chain, considering the risks arising from the operation of water supply infrastructure and their impact on the chemical and microbiological safety of drinking water in distribution networks made of thermoplastics.