BTO Executive Summary

Use of natural viruses in monitoring water treatment processes

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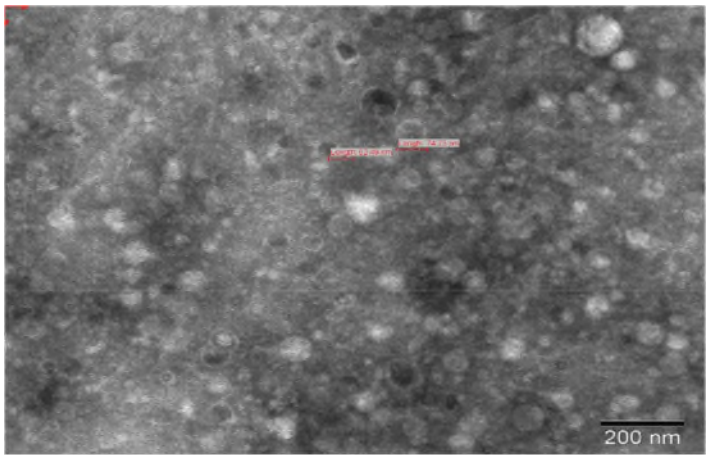
Pathogenic viruses are a significant microbial hazard in the production of drinking water. Determining how well the treatment (stages) remove such viruses is therefore crucial. It is still currently not possible to routinely determine the removal of pathogenic viruses in full-scale drinking water treatment, because the concentrations of the pathogenic viruses present in the raw water are too small. Natural viruses however occur in very high concentrations in surface water. With these natural viruses it was possible to determine the virus removal rate over the total treatment train at two locations where drinking water is produced from surface water, and at two locations where bank filtrate is used. The natural viruses also revealed the virus removal in the different process stages. This study shows that the removal of viruses through physical processes in a full-scale water treatment plant can be rapidly and routinely measured through the use of the natural viruses. In this way, the microbial safety of drinking water can be far better demonstrated.



An electron microscope image of a water sample, showing a large variety of natural viruses.

Interest: contain breakthrough of pathogenic viruses

Viruses are infectious in low numbers, and the presence of pathogenic viruses in drinking water is a health hazard for the consumer. It is therefore important that the water treatment processes sufficiently remove pathogenic viruses. But it is not possible to measure the removal of actually pathogenic viruses at a production location, because their concentrations in the raw water are very small. For this reason, an effective method is needed to reliably assess the removal of pathogenic viruses. Raw water contains significant quantities of natural viruses. Some of these natural viruses could possibly serve as process markers for the removal of pathogenic viruses.

Approach: natural viruses as process markers

A number of natural viruses were measured at four production locations, specifically: in the raw incoming water, following each treatment stage, and in the outgoing water. Use was made of a Q-PCR method, which, on the basis of the DNA of the selected natural viruses, can determine the number of these viruses in the water.

Results: natural viruses quantify the virus removal through the process stages

Three of the tested natural viruses were already present in very high concentrations in the raw water, and their concentration decreased following the various process stages.

At the production locations that use surface water for the production of drinking water, the numbers of the viruses measured decreased as a result of coagulation sedimentation, of slow sand filtration (SSF) and three-stage filtration, and of Ultrafiltration (UF). UF showed the most consistent removal, namely, between 3 and 4 log units.

At the production locations that use bank filtrate, the number of natural viruses following soil aquifer treatment dropped to below the detection limit, indicating that this stage removes the viruses very effectively.

These natural viruses thus provide a precise picture of the removal of these viruses by the different treatment processes. Natural viruses make it possible, for the first time, to rapidly and routinely measure the removal of viruses by different physical treatment processes. This will make it possible to much better guarantee the removal capacity of pathogenic viruses by treatment processes in the future.

Implementation: better quality control and lower probability of infection by pathogenic viruses

By measuring the numbers of natural viruses present at different stages of the treatment, the drinking water production locations can routinely determine the physical virus removal at each process stage. The removal capacity of a process can in this way be much better monitored, and anomalies that had previously not been noticed can be identified. Moreover, through the regular measurement of natural viruses, the virus removal can be optimised or adjusted to specific conditions. This method also makes it possible to determine, in a precise and routine manner, the integrity of ultrafiltration, reverse osmosis and bank-filtration processes, and to adjust them when necessary.

Report

This research is described in the report *Natuurlijke virussen om de verwijdering van virussen door zuiveringsprocessen te bepalen* (BTO 2020.009). One application of natural viruses is also described in: *Monitoring the integrity of reverse osmosis membranes using novel indigenous freshwater viruses and bacteriophages.* (Hornstra et al, Environ. Sci.: Water Res. Technol. 2019).

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