RAPID DETECTION OF RISKS TO MICROBIAL SAFETY OF WATER USING BACTCONTROL

RAPIDLY DETECTING FAECAL POLLUTIONS RELATED TO MICROBIAL INFECTIONS, RECENTLY INCLUDING COVID-19

Summary

Many microbial diseases can be transmitted via faecally polluted waters. Unfortunately, this also is the case for SARS-CoV-2, the virus causing the current pandemic of COVID-19. BACTcontrol has been proven to be a valuable online tool, testing water with a high frequency for enzymatic activity indicating faecal pollution. BACTcontrol from microLAN / Aqualabo can be used as an early-warning-system for these high-risk situations, triggering protective responses, including immediate testing for the presence of this coronavirus using qPCR methods, .

Water should be safe, for drinking, washing and cleaning (tap water) and for irrigation, swimming or other purposes (surface water and groundwater). It is essential to rapidly detect faecal pollution, a strong indication of the possible presence of microbial pathogens (viruses, bacteria, protozoan parasites).

Currently, the world's main concern is stopping the COVID-19 pandemic, so this leaflet is emphasizing the value of BACTcontrol in this joint effort. However, our long-term objective is to limit all diseases transmitted via faecally contaminated water.

BACTcontrol has been proven a reliable tool for rapid detection of (faecal) microbial pollution

Throughout the world, online BACTcontrol monitors from microLAN / Aqualabo since 2014 have shown their value in the protection of drinking-water and surface water by companies and institutions. BACTcontrol operates by sampling water continuously, online (Figure 1 and 2) , and by frequently measuring the activity of the enzymes of E. coli (Figure 3), a bacterium present in the intestines of humans and warm-blooded animals, which has been proven to be a very good indicator of recent faecal contamination of water and food. Enzymatic activity of other indicators can be measured as well: of total coliforms, of enterococci or the total microbial activity.

Track record of protection of water by BACTcontrol – some examples

Examples of the application of BACTcontrol in protecting water against viruses and other pathogens:

- Prague, the capital of the Czech Republic, in May 2015

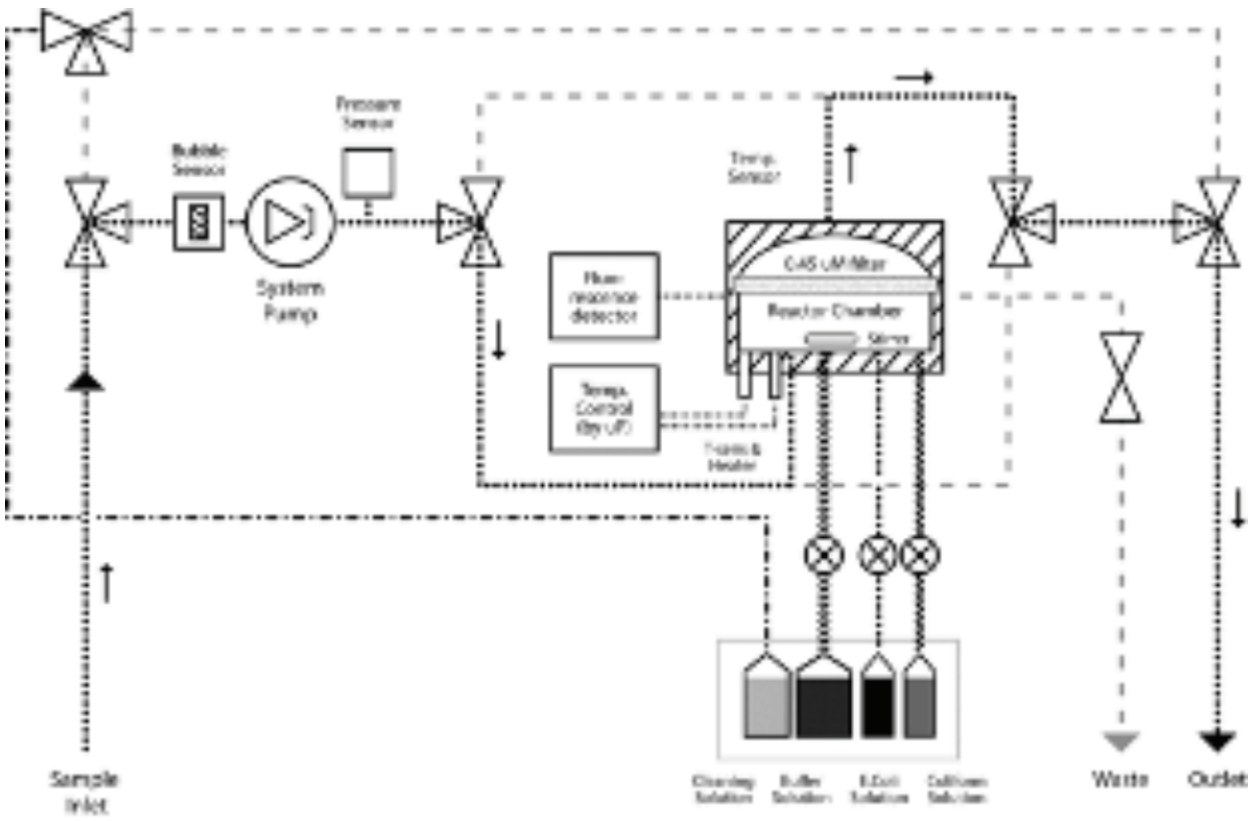

Figure 1: Schematic overview of the BACTcontrol system

suffered from a norovirus contamination. This was caused by an aged and leaking sewer pipe line which was above a water distribution line.

The BACTcontrol was used to rapidly detect the source of the contamination in the distribution network. It is now being applied in the same system as a first-line QC control for incoming samples on the laboratory.

- Kallehaverenden, Denmark, in 2016 children were falling ill

Figure 2: Picture of the BACTcontrol system.

after being exposed to water from a pool on the beach. The BACTcontrol was used to monitor the E. coli levels in the adjacent river (Figure 4). Samples were collected when levels peaked to identify and trace the source of the contamination using qPCR. The same tiered approach is applicable to monitor faecal levels in surface waters at risk of containing the new coronavirus.

Early warning of the risk of contracting COVID-19 via water

currently is highly essential; when the virus is in the water you use, social distancing is not enough. During the current COVID-19 pandemic, screening has shown presence of the causative SARS-CoV-2 virus in stool samples, sewage and wastewater within large communal wastewater treatment plants throughout the world. See outline 1 in the appendix for more information.

The effluent of wastewater treatment plants has always been commonly regarded as a possible threat to the microbial safety of surface waters serving as sources for drinking-water production and recreational purposes. The qualitative detection (absence/presence with qPCR) of SARS-CoV-2 in sewage wastewater has recently been introduced as a complementary tool for detecting and mapping the circulation of this coronavirus in human populations. Surface waters at risk can be monitored with this method. CSO (combined sewer overflows) events significantly increase the concentration of culturable viruses, like adenoviruses, and noroviruses in receiving waters. Absence of SARS-CoV-2 today is not warranting the absence of the virus tomorrow, however.

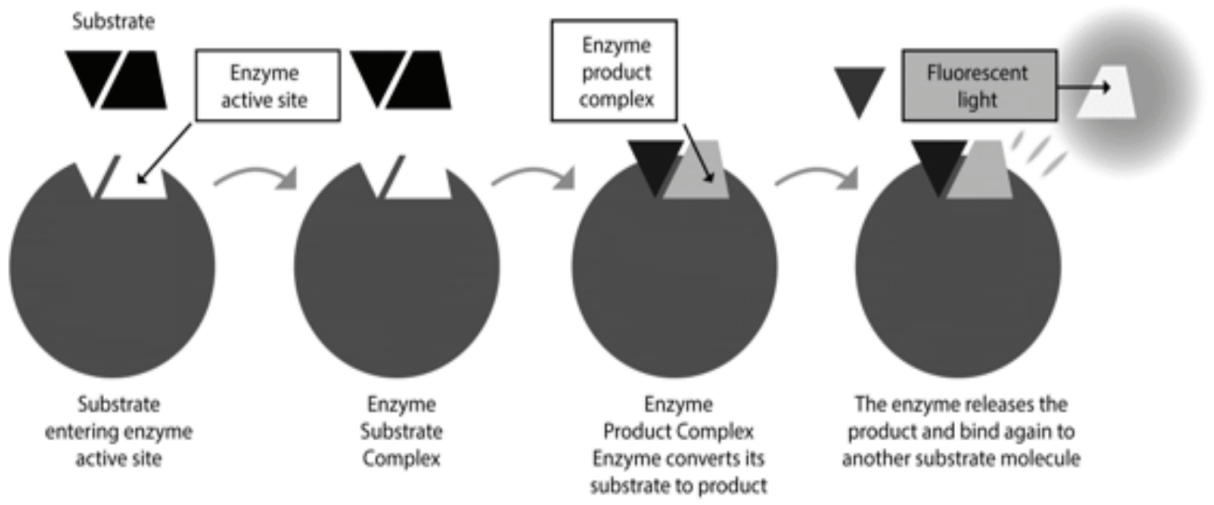

Figure 3: Schematic overview of the enzymatic reaction

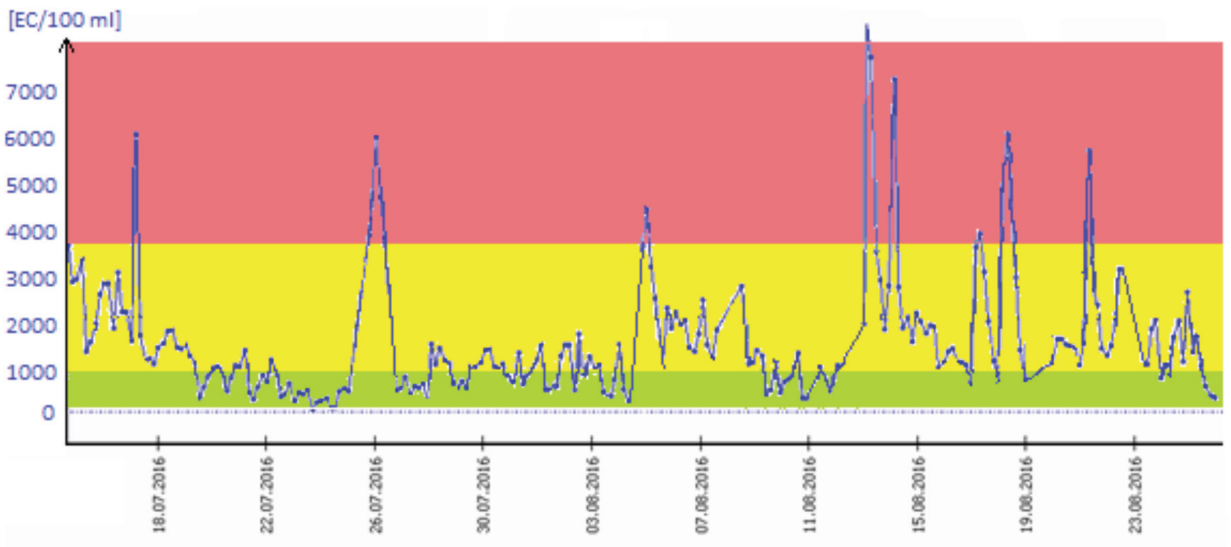

Figure 4: Recurring peaks (in the red zone) of E. coli (EC) enzyme activity levels by the BACTcontrol are reliably indicative of faecal contaminations (expressed as E. coli cell equivalents). A qPCR device was subsequently used to identify pathogens present in the samples collected as a response to the early detection of these peaks.

Inline, high frequency monitoring of SARS-CoV-2 is not feasible, but fortunately it is for detecting the start or an increase of faecal pollution in surface waters and drinking-water, using the BACTcontrol. Thus, the BACTcontrol provides the first step in the tiered approach for cost-effective screening for the risk of SARS-Cov-2 in water.

Research project testing the tiered approach

Currently, a research project is started in The Netherlands to test the effectiveness of BACTcontrol in the tiered approach of rapidly detecting SARS-CoV-2 in waters as described above. See outline 2 in the appendix for more information.

Conclusion

The tiered approach offers the advantage of detecting changes of levels of the faecal indicator E. coli within 1.5 - 2 hours using BACTcontrol, followed by identification of (viral) pathogens using a mobile qPCR-system. The toolkit combines an online low-cost detection method applied at a high frequency (continuous sampling) with a high-cost identification method applied at exactly the riskiest moment: when it matters.

Appendices on next pages expand on the following outlines:

- Outline 1.: The causative agent of COVID-19, SARS-CoV-2, is detected in stool samples, sewage and wastewater.
- Outline 2.: Research project for validation of the applicability of the online BACTcontrol combined with the mobile qPCR station as a tiered early-warning-system for the presence of (viral) pathogens due to faecal contaminations.

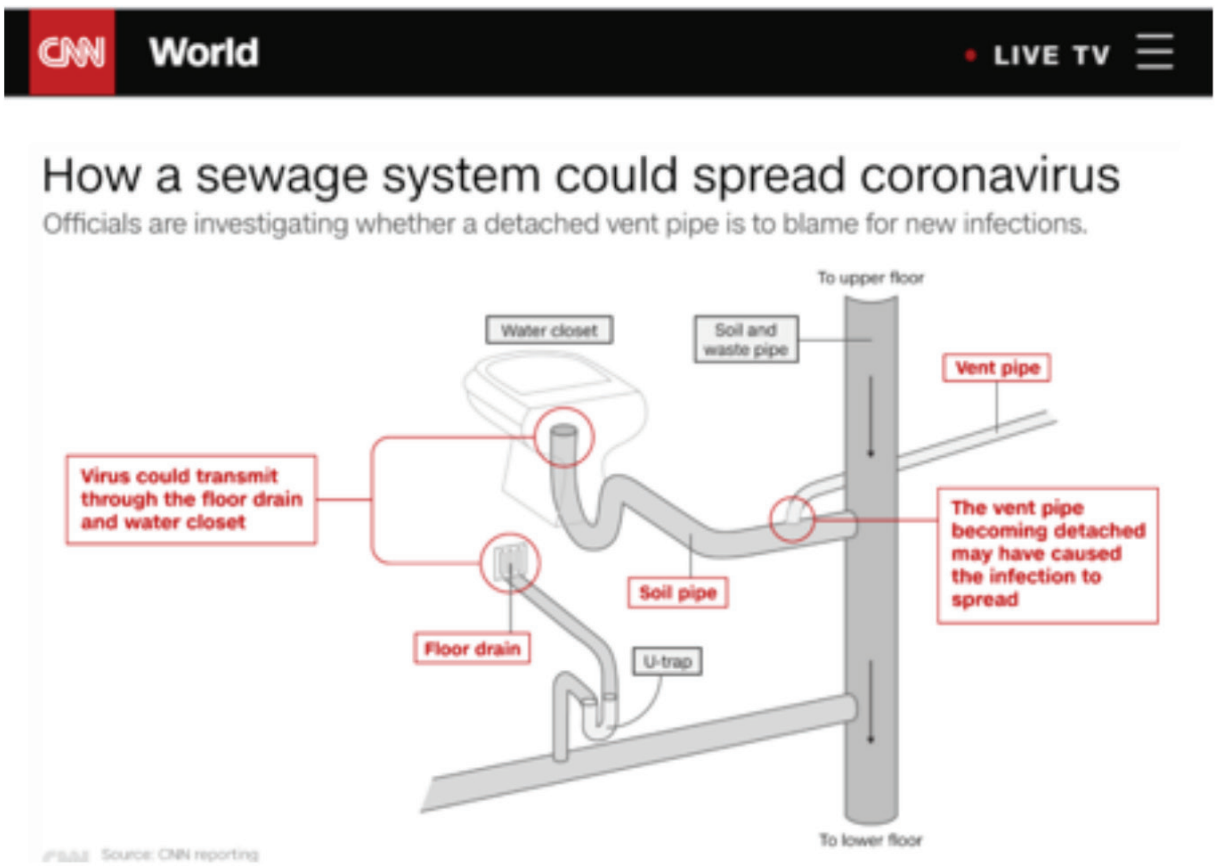

Figure 5: health officials in Hong Kong evacuated residents from an apartment block over the fear of the coronavirus which may have been transmitted via the building's pipes. Two residents living on different floors of the building had been infected, health officials said. Three more cases have since been linked to the same building. This has happened before: During the 2003 severe acute respiratory syndrome (SARS) outbreak, pipes became a major source of transmission. At one housing estate, there were more than 300 infections and 42 deaths after defective plumbing allowed the virus to spread through the building (Source: CNN).

Sources

Appels, J., Baquero, D., Galofré, B., Ganzer, M., van den Dries, J., Juárez, R., Puigdomènech, C. and van Lieverloo, J.H.M. (2018) Safety and quality control in drinking water systems by online monitoring of enzymatic activity of faecal indicators and total bacteria. In: Skovhus, T.L. and Højris, B. (eds.) Microbiological Sensors for the Drinking Water Industry. IWA Publishing, London, UK, 300 p.

Rodríguez, R.A., Gundy, P.M., Rijal, G.K. et al. The Impact of Combined Sewage Overflows on the Viral Contamination of Receiving Waters. Food Environ Virol 4, 34–40 (2012).

Outline 1: The causative agent of COVID-19, SARS-CoV-2, is detected in stool samples, sewage and wastewater

The virus that causes COVID-19, SARS-CoV-2, has been detected in the faeces of some patients diagnosed with the viral disease. According to the United States Centres of Disease Control and Prevention (US CDC): "SARS, a similar coronavirus, has been detected in untreated sewage for up to 14 days. In the 2003 SARS outbreak, there was documented transmission associated with sewage aerosols".

Sewage surveillance for SARS-Cov-2 is now being performed throughout the world, for example:

- In France: "Time course quantitative detection of SARS-CoV-2 in Parisian wastewaters correlates with COVID-19 confirmed cases": by Eau de Paris.
- The Netherlands: "How sewage could reveal true scale of coronavirus outbreak. Wastewater testing could also be used as an early-warning sign if the virus returns": by KWR Water Cycle Research Institute.
- USA: "Track severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in wastewater, with the goal of developing a tool to predict future outbreaks": by CDM Smith.
- India: "Coronavirus can spread through sewage systems, says CPCB in its latest guideline"
- Australia: "This is a major development that enables surveillance of the spread of the virus through Australian communities": by CSIRO.

Additionally, SARS-CoV-2 has been shown to be transferable to terrestrial animals (cat, dog, tiger, lions, ferrets), increasing the risk of faecal pollution of surface waters by overland rainwater run-off in wildlife areas. Monitoring of surface waters used as drinking-water sources, fishing or recreational purposes

Outline 2: Research project for validation of the applicability of the online BACTcontrol combined with the mobile qPCR station as a tiered early-warning-system for the presence of (viral) pathogens due to faecal contaminations

Fast, onsite measurement methods for assessing the actual microbiological water quality can provide essential information for an up-to-date insight into health risks. In the past, the basis has been laid for 2 separate methods that could provide this insight: the online BACT control and mobile qPCR for fast, on-site monitoring of faecal indicators and viruses.

The aim of the project is to validate the online BACTcontrol and mobile qPCR, to link the measurement results of the sensors to the guidelines for water quality (such as the WHO and WFD European guidelines) and to investigate whether these techniques can be applied to surface water as an Early Warning system for fecal contamination and viruses.

The ultimate social goal of this pilot is safe microbiological water status in urban and rural areas through improved quality monitoring. This information is very valuable in supporting government decisions and in providing up-to-date public safety information / warnings. The results of this research will make a significant contribution to equipping the government bodies involved in the analysis of water quality with a toolkit to support cities and water managers in monitoring water quality.

With this project, the technology suppliers will have results from a case study and validation data to demonstrate that the new technology is at least as good as the conventional methods. A fast, onsite method for assessing current microbiological water quality provides essential information for alerting to a current health risk

The intended ultimate social impact is safe water quality in urban and rural areas through improved quality monitoring. Due to the fact that rapid quality changes may occur, the availability of technology with which measurements can be carried out quickly and frequently is important for the cities and water managers. This information is very valuable in supporting event and security decisions and in providing up-to-date water safety information / warnings. They can also gain fast and detailed insight into pollution sources as a basis for efficient water quality management which is the basis for structural measures to improve water quality.

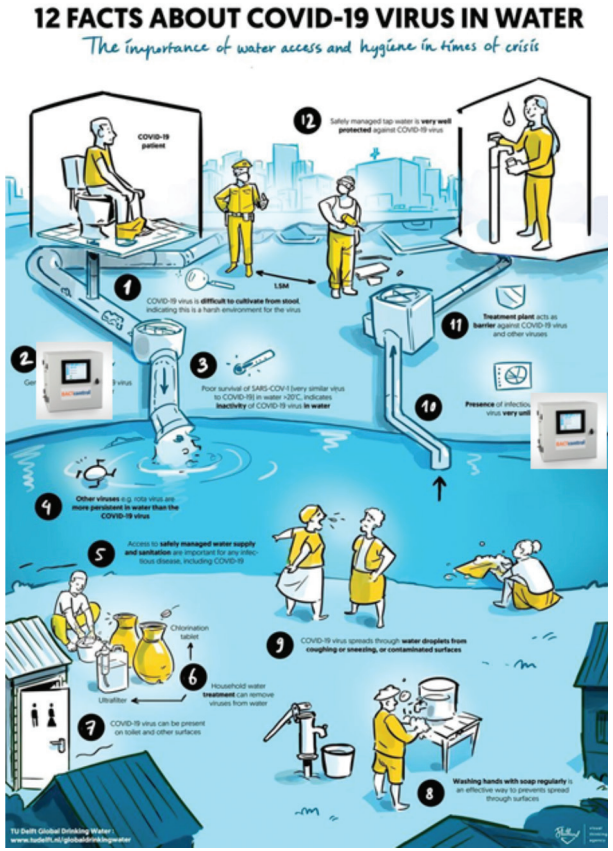

Figure 6.: Overview of 12 facts about the COVID-19 virus in water. The illustration details the importance of water access and hygiene during this global pandemic, and what behavioural changes people in rural communities can make to best prevent the spread of the COVID-19 when using water (Prof. dr. Gertjan Medema from the TU Delft, the Netherlands).

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