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On the way to on-line monitoring of microbial drinking water quality

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Background
Microbial contamination is a major threat to drinking water quality, and monitoring the microbial water quality is a way to ensure good and safe drinking water. However, grab sampling and long incubation times for growth based methods may lead to late responses (several days) which may be too late to allow for relevant correcting actions. This calls for methods which can provide results rapidly - ideally in real time. Microbial water quality is not restricted to pathogens or indicator organisms, since increased microbial numbers and activity may reflect the management and functionality of microbial processes in the treatment such as back washing of biological rapid sand filters. Furthermore they may become essential in distribution systems to monitor the efficiency of the disinfection or in cases without disinfection residual where reparations of pipes, stagnant water, or ingress of water in case of leakages challenge the water quality.

Several approaches have been taken to monitor the microbial water quality - one is a biochemical parameter Adenosine TriPhosphate (ATP), since it is an energy carrier molecule present in all living cells. Monitoring of ATP in drinking water is a promising technique because firstly, ATP is an indicator of total microbial activity, meaning that only active microorganisms are detected, and the detection is not restricted to a specific microbial type.

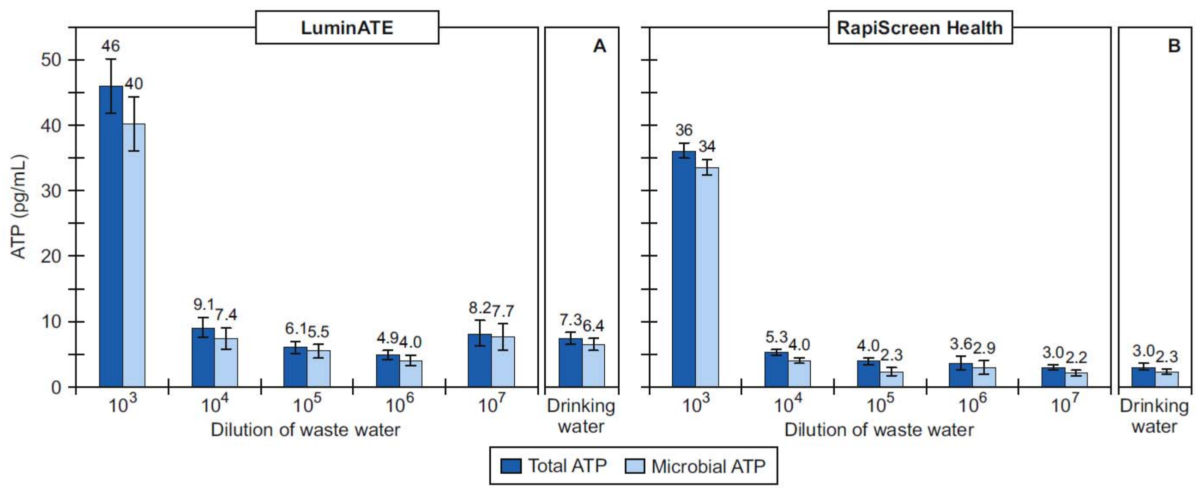

Figure 1. Example of detection by ATP measurements in drinking water contaminated waste water. Total and microbial ATP concentrations (arithmetic mean with standard deviation) in drinking water and drinking water contaminated with wastewater of various dilutions. Two different kits were investigated: A) LuminATE reagent kit was applied for ATP measurements and B) RapiScreen Health reagent kit was applied for ATP measurements. (Vang et al., 2014).

Secondly, ATP analysis can provide results in a few minutes, creating a great potential for real time monitoring. We have successfully demonstrated the use of ATP as a measure for ingress of contaminating water in drinking water systems (Figure 1), and to monitor the effect of backwashing rapid sand filters on the effluent microbial quality of the filtered drinking water (Vang et al., 2014).

ATP is often measured by grab sampling where the samples are brought back to the laboratory for analysis. To improve this approach and to develop a sensor which can analyze the water quality online, a set-up has been developed where the sample is analyzed in a flow-through system. To improve this method several processes has been optimized e.g. thermal lysis of the microbial cells to reduce the consumption of reagents, as well as the addition of various buffers to enhance the extraction efficiency and the stability of the released ATP. Also a range of enzymes and different commercial reagent kits have been investigated to select optimum combination of sensitivity, robustness and cost efficiency.

Another approach to monitor the microbial water quality is to monitor enzyme activity in terms of Alkaline Phosphatase (ALP) which is produced in most microbial cells and which can use 4-Methylumbelliferyl-Phosphate (MUP) which is a fluorescent substrate. This is measured in a fully automated instrument BACTcontrol (microLAN) with an analysis time of 40 minutes but with a cycle time (from one result to the next) of about 90 minutes, and where the phosphatase activity is determined by measuring the fluorescence associated with the formation of 4-methylumelliferone (MUF) (Figure 2).

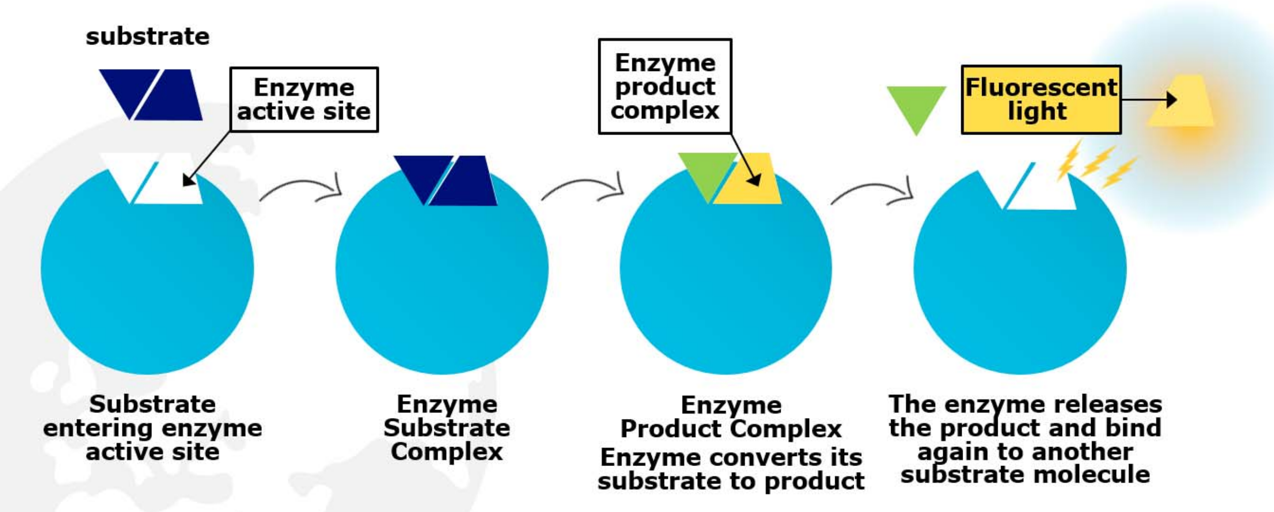

Figure 2. Principle in the measuring of the increase in fluorescence is permanently monitored.

The investigation at water works

Two different approaches were compared: the BACTcontrol Total Activity online analyzer (Figure 3) and ATP analysis, and these two measurements were compared with other viability assays through simultaneous measurement at two different water companies: Aigües de Barcelona (AB), and Cetaqua, Spain, and Nordvand, Gentofte, Denmark. The eight-month long investigation included both the drinking water treatment plant (DWTP) and the distribution network (DN), i.e. multi-source chlorinated tap water from Barcelona DN and three types of process water from the DWTP (sand-filtered water, GAC-filtered water and treated water), as well as biologically treated ground water.

The investigation involved changes in the water source e.g. shifting from surface water to groundwater. Also the effect of reactivation of catchment pumps could be detected in some cases, which may be explained by mobilization of stagnant water in the treatment train.

Figure 3. The BACTcontrol installed in a test rig at Aigües de Barcelona, the water supply for Barcelona, Spain.

Acknowledgements

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References

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