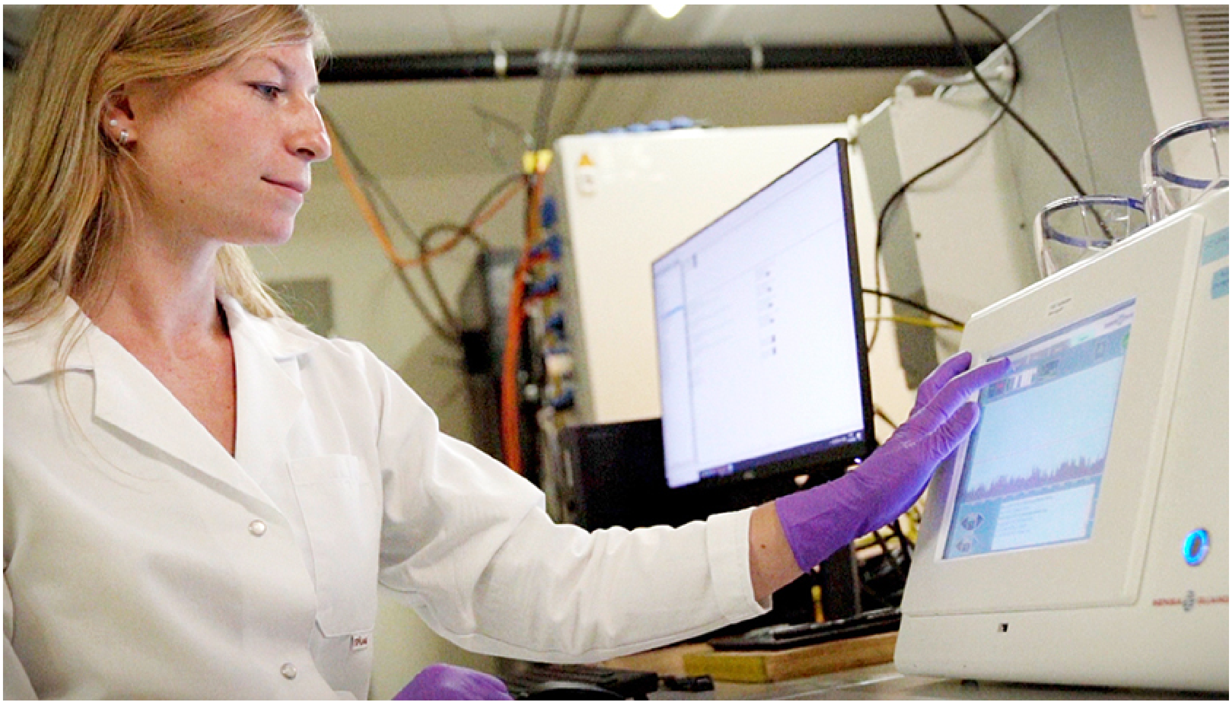

# Online biomonitoring of WWTP wastewater

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Topics: Wastewater | Pollutants | Water & Development

**Treated wastewater can be continuously monitored online with the use of organisms. This gives operators of wastewater treatment plants and discharging industrial companies the ability to respond to acute pollution quickly.**

The Swiss Waters Protection Ordinance stipulates that substances that pollute water bodies as a result of human activity may not have any deleterious effects on the plants, animals and microorganisms living there or on how the water bodies are used. Wastewater treatment plants (WWTPs) also introduce micropollutants from municipal or industrial sources into surface waters. The treated wastewater is therefore checked for problematic substances before being introduced into waters. Samples are usually taken for limited periods to this end and monitored in the lab with chemical analysis (sometimes also biotests) and laboriously evaluated.

However, the composition of wastewater can change very quickly. This is particularly the case with industrial discharge. For instance, some companies frequently change their product range and production processes, resulting in new waste products and by-products. Online biomontoring systems that use living organisms can continuously monitor the quality of treated wastewater in real time, even if the pollutants are unknown. “The behavioural changes that we use respond very quickly and sensitively to a polluting substance,” says Miriam Langer from the University of Applied Sciences and Arts Northwestern Switzerland and Eawag. “This is why we would like to use them as early warning systems.” These systems enable operators of wastewater treatment plants and discharging companies to respond to acute wastewater pollution quickly. This opens up new possibilities for identifying critical industrial wastewater and reducing the pollution directly at the source.

### Sandoz chemical accident as the trigger for online monitoring

The potential of online biomonitoring systems as early warning systems for waters has been known for some time. In the case of pollution, it is important to respond swiftly to ensure consistently high water quality and prevent accidents with lasting consequences for society and the environment. After the environmental catastrophe of Sandoz in 1986, when 30 tonnes of pesticides ended up in the Rhine following a fire, significant support was provided to promote the development of biological early warning systems. Currently, online biomonitoring systems are primarily used to monitor drinking water and surface waters. There has so far been little experience in the application of the systems at WWTPs. The Ecotox Centre has therefore initiated a project in cooperation with the University of Applied Sciences and Arts Northwestern Switzerland and Eawag to establish a suitable system for monitoring treated wastewater.

## Selecting the test systems

Online biomonitoring systems are composed of three parts: firstly, the organism that responds to the tested water with changes in photosynthesis or behaviour for example. Secondly, there is the automatic detection system that monitors the response of the organism. And thirdly, an alarm system which triggers a signal when the normal threshold value of the organism is exceeded. Various organisms are used as sensors, such as bacteria, algae, small crustaceans or fish. Representing the organisms in the ecosystem, their role is to detect changes in the water quality. Measurement parameters include luminosity (for bacteria), fluorescence (for algae), swimming behaviour and respiration (for aquatic invertebrates and fish). All these parameters can be impaired by harmful substances. The systems work in real time to detect the effect of harmful substances in the water, to which the organisms are exposed.

A suitable sensor organism for wastewater needs to satisfy multiple requirements. The organism must respond sensitively to the relevant substances. Moreover, it should be as tolerant as possible regarding the remaining composition of the wastewater. Wastewater contains significantly more complex substances than drinking water or river water and is therefore a challenge for test systems. Since all organisms react differently to potential micropollutants, there is no single online biomonitor that is appropriate for all substances. Instead, a battery of different systems that support each other is ideal. The researchers thus selected three test systems that cover different levels of nutrition. On the one hand, they chose the single-celled green algae Chlorella vulgaris in which photosynthesis activity is observed and on the other hand, two freshwater crustaceans: the water flea Daphnia magna and freshwater shrimp Gammarus pulex. A range of behavioural parameters are observed for these organisms (see the box for more details on the test systems).

## Testing at the pilot WWTP

“We first checked whether the test systems are sufficiently sensitive to respond to pollutants and can also survive well in wastewater,” explains Ali Kizgin from the Ecotox Centre. The biomonitors were therefore installed in the pilot wastewater treatment plant at Eawag. “One difficulty was that the treated wastewater is not allowed to contain any coarse particles that could block the system.” To address this problem, a membrane filter was initially integrated to prevent a high burden due to suspended matter and microorganisms in the wastewater. The organisms soon appeared to cope well with the filtered wastewater. In order to evaluate the potential of the systems for online monitoring, the researchers conducted experiments with treated wastewater in which different substances such as sodium chloride, diuron, chlorpyrifos, zinc chloride and setraline were added. Concentrations were chosen that would affect the measured parameters without killing the organisms. The results were promising. The organisms responded to the substances with measurable changes and also had no problems coping with the combination of wastewater and harmful substances.

## Successful application at a larger WWTP

As the next step, the researchers tested the system on a large scale at a medium-sized WWTP in the region. “One challenge was that we first had to have a mobile membrane filter constructed that we could take to the plant,” recalls Kizgin. Having overcome this hurdle, continued operation over the course of the six-week experiment occurred largely without problems. The researchers were fortunate to work with Eawag, which took part in the experiment with its new MS2 field platform. MS2 field is one of the first mobile measurement stations which allows the continuous chemical measurement of micropollutants in the field with a high time resolution. Detailed analysis of the data is still ongoing, but it is already clear that the observed changes in the behaviours of the creatures correlated well with the chemical verification of critical substances.

**Next steps**

Control experiments will next be conducted to confirm which of the identified substances were detected by the biomonitors and how high their sensitivity is. The test systems are also to be used at further WWTPs. “This way, we intend to create a substantial foundation for establishing online biomonitors as an additional control measure for wastewater,” comments Miriam Langer.

The online biomonitors used

The single-celled green algae *Chlorella vulgaris* responds to harmful substances with a change in photosynthesis activity. This is monitored by the device based on fluorescence measurements. The algae are cultivated in an integrated fermenter and automatically extracted for the measurement. The device compares the effect of the water sample on the algae with the effect of the reference water.

In the water flea test, the wastewater is continuously led through measurement chambers which contain the organisms. The swimming behaviour of the organisms is filmed in the chambers with a video camera. The swimming lanes are recorded and allow various parameters to be calculated including swimming depth or speed.

In the case of monitoring with freshwater shrimps, the creatures are introduced into the sensor chambers. The chambers are fitted with electrodes and are positioned in a test basin with a continuous flow of wastewater. While one electrode pair generates alternating current, a second pair measures the changes in the electrical field produced by the movements of the creatures. If the behaviour of the shrimps changes beyond the permitted percentage deviation, the system activates an alarm. This may occur, for example, if the activity of the creatures suddenly increases (flight) or decreases (severe impairment due to the test substance or death).

Cover picture: Eawag, Dean Shirley

**Video on the test system**

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