Initial Situation

Water distribution networks are constantly at risk of intentional or unintentional contamination. The German Drinking Water Regulation prescribes regular sampling for specific bacteria and chemical substances for this reason. However, analyzing water in special labs is a very time-consuming process. It would therefore not be possible to promptly warn the public in the event of an attack. Their field of application is also restricted as unknown or unexpected toxic substances cannot be detected with standard methods.

There is considerable interest in sensors and software systems for answering the following questions in order to protect the health of the public: What is the source of contamination? What degree of dispersion and effect of the toxic substances can be expected? What measures are needed to keep damages to a minimum? The Fraunhofer IOSB has developed the AquaBioTox broadband sensor for this purpose (in cooperation with the Fraunhofer IGB) and a real-time capable management tool (SMaRT-OnlinWDN) for simulating the dispersion of constituents within water distribution networks.

AquaBioTox broadband sensor

An online-capable broadband test procedure for drinking water conformity is required for early recognition of health-threatening contaminations in drinking water which responds rapidly and reliably, is resistant to false alarms, permits operation by persons without scientific qualifications and is economical with respect to the costs of acquisition and maintenance. No such sensor system is currently available on the market.
The AquaBioTox online-capable broadband toxicity sensor functions on the basis of the »taster principle«: The vitality of highly sensitive biological organisms, which are exposed to a drinking water line bypass, is monitored online by a camera with automatic image exploitation in order to diagnose significant changes within a short timeframe.

In order to achieve high broadband capability with respect to potential scenarios involving toxic contamination, several different biosensor components are integrated in the AquaBioTox system concept. They include, for example, different bacterial strains, which change their fluorescence when contaminated. Organism vitality is diagnosed online by means of automatic image exploitation. Machine learning methods are applied in order to merge different sensor information (biosensors and physical-chemical parameters such as conductivity, pH-value or turbidity) to produce a conclusive overall diagnostic result.

The effectiveness of the AquaBioTox sensor has been verified in extensive lab tests and in test operation on a decommissioned pipe section located on the grounds of the Berlin Wasserbetriebe. The functionality of the broadband sensor system was verified on the basis of representative test substances.

**SMaRT-Online**\( ^{\text{WDN}} \): Real-time-capable simulation of constituent dispersion

An early warning and safety management system should therefore make it possible for the water utility to quickly and efficiently take counter measures. The development of such an early warning and safety management system is the object of the current German French SMaRT-Online\(^{\text{WDN}}\) project.

The goals of SMaRT-Online\(^{\text{WDN}}\) are:

- To optimally allocate suitable sensors for the reliable detection of contamination in drinking water within a water distribution network
- To reliably report contamination by means of an alarm-generating module
- To localize the contamination source using an accompanying online simulation model and
- To use »look-ahead simulations« as a basis for determining countermeasures in the event of an alarm.

SMaRT-Online\(^{\text{WDN}}\) is based on a simulation model operated online, which can be used to render the actual operational state of the entire supply network virtually in real-time. The system is currently being realized in cooperation with the Berliner Wasserbetriebe, the Straßburg Water Utility (CUS), Veolia, Water Technology Center (TZW), 3S-Consult and French research partners (IRSTEA, ENGEES) and is being tested with the application partners.

![Diagram](image-url)