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Water Security and Alarm Systems based on UV-Spectrometry

Threats to drinking water more offensive ?

The prevention against risks like from accidental discharges has been good practice for drinking water managers for a long time. The threat from intentional discharges is relatively new and has become more offensive to our minds since the terrible terrorist attacks of September 11, 2001. In addition, the horrible Tsunami catastrophy of December 26 in Southern Asia with its immense deterioration of drinking water sources and infrastructure showed us that we should not forget about the immanent natural risks that our drinking water systems are exposed to every day.

Sensors for early warning and alarm systems

There is a relatively new and urgent need for the instrumental identification of contaminants in a stage as early as possible, forming the vital basis for any following intervention activity including treatment and operations decisions.

Methodically, we can distinguish between

1. direct measurement of toxicity by microbial cultures and caged organisms
2. immuno-assay technologies, "electronic noses"
3. advanced process analysers (GC/MS, AOX, LC/MS etc.); time resolved optical methods, like UV, IR, ATR or fluorescence spectrometry
4. monitoring of broadband characteristics with the help of diverse conventional physical and chemical sensors and tracking of deviations from a trained reference status

With regard to the last method, such a system must be "trained", which is a tricky task that is prone to generate unacceptable false alarm probability as long as only non-selective surrogate parameters like pH, conductivity, turbidity, DOC etc. are available. The manager is left alone with the decision whether a DOC increase of i.e. + 1 mg/l is to be considered "good" – by natural fluctuation - or "bad" – by a contamination. However, a contamination mirrored by an increase of 1 mg/l of DOC could be quite harmful to drinking water consumer.

The contribution of real-time UV-spectrometry

Real-time UV-spectrometry fills the gap between instruments of group 3 and group 4. No other method is known today that could provide a comparable suitability for alarm systems. The high potential of UV-spectrometry for alarm systems is mentioned in the new USA "Guidelines for Designing an Online Contaminant Monitoring System", 2004, www.asce.org/static/1/wise.cfm#WISE.

Now engineers of s::can Messtechnik, Vienna, have developed a completely new method to detect slightest changes and deviations from the "normal" reference state of a water, instrumentally based on their well-proven spectro::lyser, and on their recently released software package ana::larm.

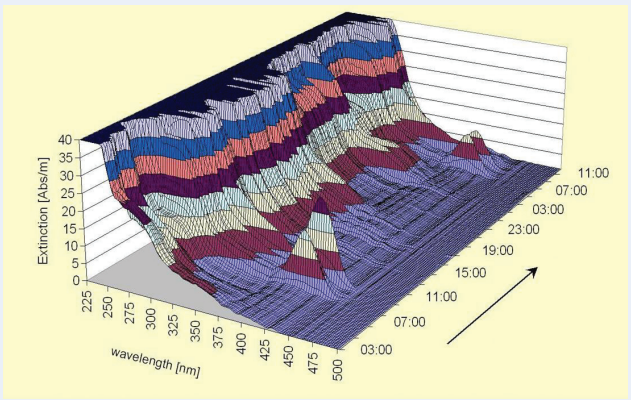
The spectro::lyser is an extremely sensitive submersible UV-Vis-Spectrometer with 100 mm optical pathlength. Changes at a low ppb level of DOC-equivalents can be traced. The instrument is available with full stand-alone capability (integrated data logger and battery), or as a part of a network of autonomous solar-powered field station, providing the telemetric control and data transfer from several field sensors or stations to a central data bank / management system, accessible via any web browser.

The ana::larm software has been specifically developed for alarm systems based on thousands of spectra from many years of field experience, and is already successfully used in several applications in Europe. The training of the alarm parameters can be done by the instrument automatically, or is done manually guided by the provided PC software.

How to define alarms vs. the baseline of "Normality"

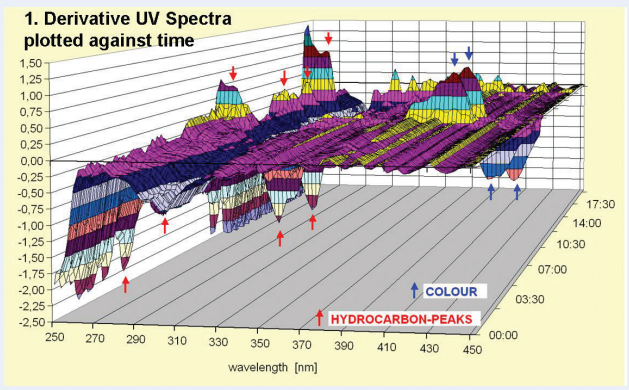
One simple strategy is to monitor specific substances like T(D)OC, Nitrate, Turbidity, aromates, phenols, hydrocarbons etc., by use of s::can's standard algorithms. In this way, the spectro::lyser can replace several complicated and expensive on-line analysers.
However, although UV-Vis-spectroscopy is sensitive down to the low ppb-range for many organic pollutants, it will not be selective enough to indicate the type of pollutant at the drinking water level. Thus the more advanced strategy is to use the new ana::larm software that evaluates the UV spectrum in a qualitative way and produces alarms in the way described in pictures 1 to 3. Immediately, actions can be started, like shutting down valves in order to prevent that potentially dangerous substances can enter the drinking water system, depending on the level of exceed. Next action would be to (automatically) take a sample and find out in the lab about the origin of the spectral anomaly.

How does it work ?



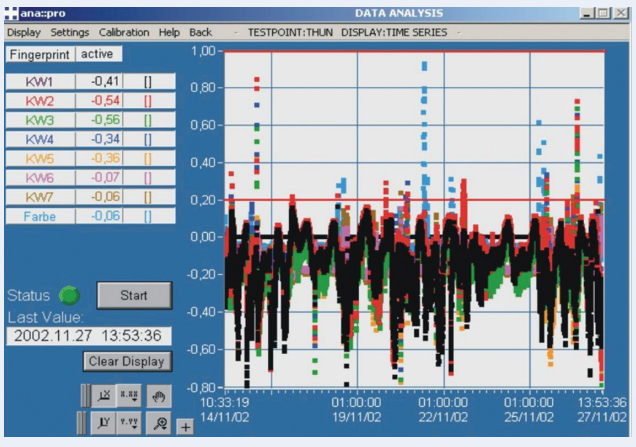
STEP 1:

3-D spectral monitoring of a polluted water channel over time.



STEP 2:

3-D-derivative spectrometry for the detection of abnormal emissions. The derivatives of the online spectra are used to identify deviations from "normal" spectral features.



STEP 3:

ana::larm implements max. 8 virtual contaminants. Sensitivity and several alarm levels can be adjusted individually with respect to risks involved and acceptable false alarm levels.

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