Redesigned monitoring station based on UV/Vis spectrometry
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Redesigned monitoring station based on UV/Vis spectrometry

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1 Introduction

1.1 General Background
Performance and reliability of UV/Vis spectroscopy already contributed to several early warning systems for drinking water protection. The method of "integrated on-line UV/Vis spectrometry" has opened a new perspective for detecting changes in water composition and the aim of WP3.2.2 is the exploitation of this ability of on-line UV/Vis spectrometry for drinking water source monitoring and protection; Not only can changes in parameters derived from the spectrum be monitored, UV/Vis spectrometry also offers the possibility to perform qualitative interpretation of spectral deviations from the normal source water quality, and recognition of patterns using both spectral and additional sensor signals.

A system that makes possible this type of monitoring and data interpretation will be developed. Primary targets in WP3.2.2 are:

1) build a monitoring station for calculating "integrated parameters" based on spectral and additional sensors, for actuating early-warning tasks and for providing automated data transfer to one central station (see deliverable 3.2.1)
2) develop a central station for centralised data storage, handling and access and for providing remote access to several monitoring stations. (see deliverable 3.2.1)
3) research for "integrated parameters" exploiting spectral and additional sensors signals and providing distinct information needed for early warning systems of drinking water sources (see deliverable 3.2.2).

This deliverable, the final deliverable in work package 3.2, component 3.2.2 (Development of a new early warning system for drinking water sources based on integrated online UV-VIS-spectrometry) presents a redesigned monitoring station. The redesign was based on the experience collected in WP3.2 as well as additional information collected from users and potential users of the s::can spectrometer probes in drinking water monitoring applications, especially in source water monitoring applications.
2 Requirements

The monitoring system presented in the earlier deliverables (3.2.1 and 3.2.2) was based solely around the s::can spectro::lyser™ submersible UV/Vis spectrometer probe. This probe measures a number of parameters at once, and it was found that for source water monitoring especially the parameters turbidity, nitrate, dissolved organic carbon (DOC) and temperature were of value. Furthermore, an alarm system, which scans the recorded UV/Vis spectra for changes in the shape of the absorption curve proved to be a valuable tool.

The field trial on source water monitoring was performed only at a single location (Vienna Waterworks), with a water quality that proved to be rather stable. Only rainfall events did significantly affect the composition of the water and the spectrometer probe was very well able to detect all fluctuations in the water quality. From experience at other locations, both with the UV/Vis spectrometer probes, but also from experience with other instruments and the discussion in TECHNEAU WP3.1, it has become clear that additional parameters will sometimes be required to properly characterise and monitor compositional changes in a source water. Although not all relevant parameters are available from online monitoring instruments, dissolved oxygen, ammonium and conductivity (salinity), which in surface and ground waters can be highly indicative parameters, are available for integration into a source water monitoring station on demand.

The requirement
To provide for such an expansion in the range of parameters that can be measured, a new monitoring station concept needed to be developed. This station had to have (at least) the following properties:

1) In addition to the spectrometer probe (spectro::lyser™) and the controller (con::stat) used in the earlier work performed in WP3.2, this station offers room for additional, non-spectrometer, probes.
2) The controller is prepared to manage a number of additional sensors in a flexible way.
3) The station offers the basic infrastructure (power supply, plumbing) for the sensors. The only precondition is that the additional sensor does not consume chemicals and does not generate a water stream that is a chemical waste stream.
4) All data is presented in a uniform way, so that the developed software tools for data evaluations (see deliverable 3.2.2) can be used to monitor water quality changes.
3 Results

The station hardware
The system installed during the field trial was of the following configuration:

![Figure 1: Configuration of system installed for testing at Vienna Waterworks.](image)

This configuration was used as the starting point for the redesigned monitoring station. The controller already was prepared to control additional sensors. No changes to the hardware of the controller were required.

Integrated were instruments for oxygen, a multi-parameter probe for ammonium and pH and a multi-parameter probe that can measure free chlorine, conductivity and ORP. The sensors used are the following:

- s::can spectro:lyser™ (UV/Vis spectrometer probe)
- s::can ammonium sensors (ammonium, potassium & pH probe)
- s::can oxygen sensor (dissolved oxygen probe)
- YSI 600 DW (free chlorine, conductivity and ORP sensor)

All these instruments had been available commercially and used in real applications for more than two years and have proven their performance in fully submerged as well as in by-pass installations. Therefore no additional testing of the sensor performance as such was required.
These instruments have the following specifications (based on experience in applications and installations by s::can) for operation in drinking water:

ammonium probe:
Ammonium Ion elective Electrode
Compensated for Potassium, pH and temperature

Measuring range 0.01 - 20 mg/ L \( \text{NH}_4^+ \)N
sensitivity: 0.01 mg/ L
(1 - 1000 mg/ L in waste water applications with different calibration)
Precision: 3% of the concentration reading
Response time: 1 minute
pH. measured using a glass electrode, pH 2 – 12
Potassium compensation using an ion selective electrode with measurement range 0.1 - 1000 mg/ L
Communication using RS485 Modbus directly to s::can terminal

oxygen probe:
optical measurement based on fluorescence quenching, with temperature compensation
Measuring range: 0.0 - 25 mg/ L
sensitivity 0.02 mg/ L
Precision: 0.02 mg/ L
Response time: 1 min
Communication using RS485 Modbus directly to s::can terminal

Multiparameter probe:
Free chlorine:
measurement range: 0 - 3 mg/ L
sensitivity: 0.01 mg/ L
precision: 0.05 mg/ L

Conductivity:
measurement range: 0 - 100 mS/ cm
sensitivity: 0.001 to 0.1 mS/ cm (range dependent)
precision: 0.5% of reading or 0.001 mS/ cm

ORP:
measurement range: -999 - 999 mV
sensitivity: 0.1 mV
precision: 0.1 mV

Complete probe:
Communication using RS485 Modbus directly to s::can terminal

Newly developed is a structure of panels that allows easy installation of all instruments and connection of the sensors to a single source of water. All single instruments are fully submersible, and can be installed directly in the water. However, in some cases connection to a single supply instead of directly in the water will be desirable (e.g. in case no space is available directly in the water, or access to the measurement site is too difficult to perform maintenance on the instruments). This developed structure is modular, so that any combination of instruments is possible. Figures 2 and 3
show a schematic representation of the monitoring station and a picture of the assembled system respectively.

Figure 2: schematic representation of redesigned, modular, water quality monitoring station for source water monitoring.

Figure 3: picture of the assembled system.
Newly developed for this panel was the by-pass mounting for the UV-probe. In drinking water, normally only infrequent cleaning is required (typically less than once a month). With previous installations in by-pass (often used in drinking water) the probe has to be removed from the by-pass mounting to access the windows. The new by-pass has to brushes incorporated, which can be used to clean the instrument with any need for disassembling of the set-up, thus preventing down time and possible leaks that can occur when disassembling and reassembling the system.

The panel further includes a pressure valve, to prevent gas bubbles from forming due to pressure drops over the system, a flow meter and a pressure vent to release water in case maximum allowed pressure is exceeded.

The station software
For operation of the different probes, the control and calibration protocols of the additional sensors were integrated in the operational software of the spectrometer probe. The figures in the appendix present screenshots of the different modules in the software that were integrated.

Figure 4: Window for selection of additional instruments, characterised by the type “non spectral parameter” (see top right) and selectable under the heading “Device” (in this example an YSI probe is selected).
4 Discussion and Conclusions

A new, modular, monitoring station for water quality monitoring has been designed based on the results obtained during the source water monitoring trial at Vienna Waterworks as well as additional information, such as the list of parameters for source water monitoring prepared in TECHNEAU WP3.1.

The monitoring station was built and is ready for implementation. Parameters not highly relevant for source water monitoring but interesting for drinking water monitoring purposes, such as free/residual chlorine has been incorporated already and the possibility exists for integration of further parameters; for example, the current ammonium probe can be equipped with an electrode for fluoride measurement.

The output of these stations will form the basis for the work to be performed in WP3.5 on monitoring drinking water quality in distribution networks and the development of an alarm system based on multiple monitoring locations in a single network.

The fact that the panel is composed of well prove instrument allowed rapid design and development. Also it makes it possible to introduce it on the market without the need for extensive evaluation of the included sensor; It is now being offered as a commercial product.
5 Appendix

Screenshots illustrating the windows in the operating software of the spectrometer probe that were introduced for the calibration and parameterisation of the non-spectrometer probes.

Figure 5: configuration screen YSI multi-parameter probe for conductivity etc.

Figure 6: configuration screen for the ammonium probe.
Figure 7: configuration screen for dissolved oxygen sensor.