BOD

COD

BTX

TOC

DOC

UV254

NO3

NO2

NH4

K+

Free Chlorine

F-

TSS

Turbidity

Color

pH

ORP

EC

Temperature

O2

O3

H2S

AOC

Fingerprints

Alarm

s::can

Intelligent. Optical. Online.

Applications
Drinking Water and
Environmental Monitoring

Application sheet - drinking water and environmental monitoring
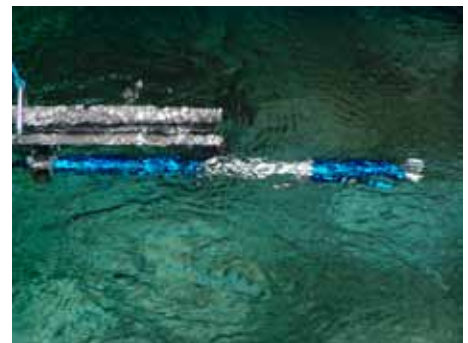
1 Introduction

Both national laws and an increasing number of supra-national recommendations are prescribing emission limits for reasons of public health. These limits may not be exceeded, and must be controlled as seamlessly as possible, in order that consumers of drinking water are not placed in jeopardy.

Furthermore, the quality of raw and/or drinking water must constantly be monitored to be able to perform controlling and/or regulating action or to implement alarms.

In order to prevent any risk to the drinking water consumers' health, the measured data must be available

1. continuously
2. without delay (in "real time")

This is the only way to allow quick reaction to changes in the water quality. These requirements can only be fulfilled by online assessment of the raw and drinking water qualities.

Online monitoring in raw and open waters using photometer instruments for individual wavelengths, a state-of-the-art technique for some years now, has proved its value – however, only following sophisticated on-site calibration, and just for individual parameters.

The spectrometer probes from s::can use the same measuring principle: the absorption of light. Yet they measure not only one or two wave lengths, they measure the a continuous optical spectrum reaching from low ultraviolet to visible light. The result of the measurement is the so called "fingerprint" (see Figure 1).
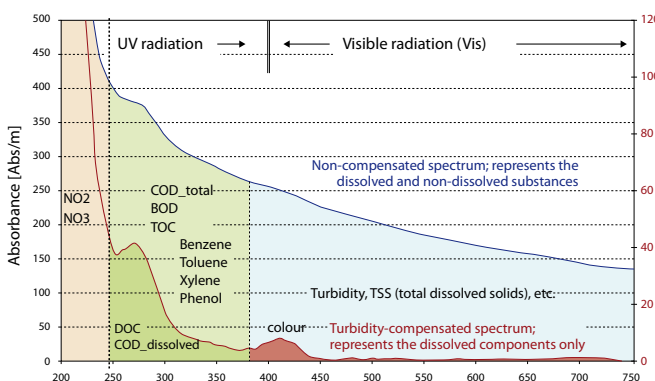

Figure 1: "Fingerprint" - absorption spectrum

This fingerprint contains much more information about the water quality than a single wavelength instrument can provide, allowing more accurate and universal measurements. The brand-new s::can submersible spectrometers can be directly immersed into the medium, making it possible for the first time to combine the advantages of probe measurement with those of spectrometry, eliminating such well-known drawbacks as sampling errors, biochemical or physical conversion after sampling, etc. The measuring technical level thus arrived at opens up completely new vistas. s::can devices are compact and versatile enough to be used in many conditions, from the 2" bore hole to open rivers and canals, vessels and containers, up to pressure and bypass pipes.

2 Parameters

2.1 Calibration

The s::can calibration methods, developed during many years of co-operative work with university institutes and several chemistry laboratories, make use of the most up-to-date statistical and mathematical procedures.

Three calibration methods can be offered:

1) "Global Calibration"
We use this method successively for individual substances and sum parameters. The parameters released are characterized by their particular selectivity, are largely free from cross-sensitivities and reach almost analytical accuracy. Thus, they are instantly and universally applicable without local calibration. Examples are organic parameters, turbidity and nitrate.

2) Verification by "Local Calibration"
The global calibrations can be adopted to the local water composition. A few local reference samples are used to verify the calibration and improve the accuracy of the results. Also a higher selectivity can be achieved with precise local calibration. This method is clearly advantageous over established UV or Nitrate photometer probes.

3) Validated advanced calibration
If a very accurate analytical-like measurement is wanted, an automated state-of-the art method using PCA (principal component analysis) and PLS (partial least square fit) can be used. The output will be a validated, extremely robust and accurate parameter set for all parameters at the same time, provided that all occurring matrices were

sampled at least once. All the spectral information is used simultaneously. The procedure is software-driven.

2.2 Organic Carbon Compounds

The parameters for assessment of organic pollution (COD, BOD5, TOC, etc.) are sum parameters whose measurement procedures evince various drawbacks: reproducibility, comparability, measurement ranges, crosssensitivities, use of chemicals, etc. Nevertheless they cannot be considered as to be absolutely "true" parameters. For this reason, increased interest has been shown in the past few years – by privates and authorities as well – in substitute measurement methods, if they provide the great advantage of time-continuity.

In terms of its methodical approach, process spectrometry features the advantage of not indirectly measuring consumed oxygen, but rather of directly measuring the concentration of oxidable organically bound carbon.

Comparison of the standard deviations of i.e. DOC lab measurements with spectral measurement values will result in substantially less dispersion for the spectral parameters; the uncertainties pertaining to the DOC (above all in the lower concentration region) are well known. Thanks to lower dispersion, when determined via UV/VIS spectrometry, a lower detection limit can be achieved. For these reasons, the SAC254 (Spectral Absorbance at 254 nm) has long been an acknowledged parameter for the description of organic carbon compounds in drinking-water analysis (i.e. after DIN38404). However, the choice of this wavelength was made above all for historical rather than analytical reasons. In most cases, organic matter generates the strongest signal at other wavelengths.
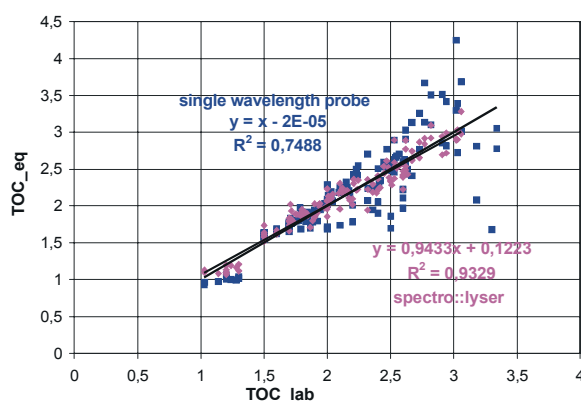

Figure 2: Comparison of spectral calibration to single wavelength calibration

Furthermore, validated spectral calibration allows much more accurate and robust measurements, as shown in Figure 2, where single wavelength measurement is compared to spectral calibration.

The comparison of DOC concentrations with data gained from UV-spectrometry of various natural water samples always yields correlations $R^2 > 0,95$.
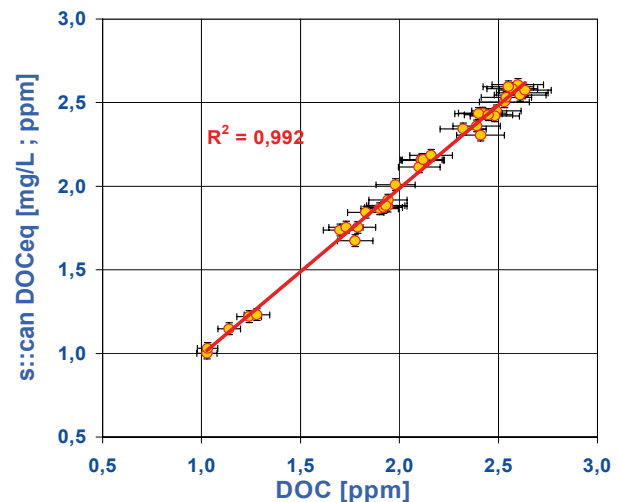

Figure 3: Comparison of spectro::lyser™ DOC_equivalents with DOC measurements / LIFE Danube river project; R²=0,99

As regards BTX, Hydrocarbons, phenols, etc., even concentration changes of down to 10 ppb are detectable with high selectivity and reproducibility using s::can´s high-resolution UV instrument. Aromatics, phenolics, hydrocarbons, and most chromophores with molar extinction coefficient e > 10⁻ will show results comparable to Benzene after calibration.
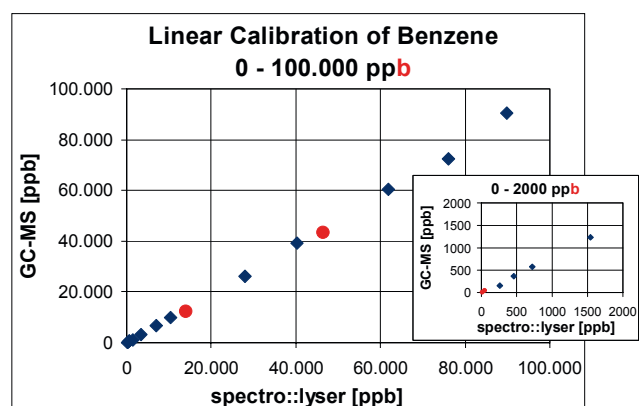

Figure 4: Linear calibration of benzene

As a rule, for most situations where a parameter for sensible alarms or control is needed, online UV spectrometry

alone will be the ideal solution - from drinking waters to waste waters. However, where results with full parameter security are needed, i.e. for testing a water's suitability for drinking water purposes, there is no passing by laboratory validation.

2.3 UV/VIS-Absorbance Spectrum (fingerprints)

A continuous UV/VIS absorbance spectrum features two substantial advantages:

1. Nitrate, turbidity and organic substances can be measured simultaneously

2. Qualitative assessment of water composition is possible

Figure 5 shows the spectra from the east bank (red fingerprint), west bank (blue) and open water (black) of an alpine lake.
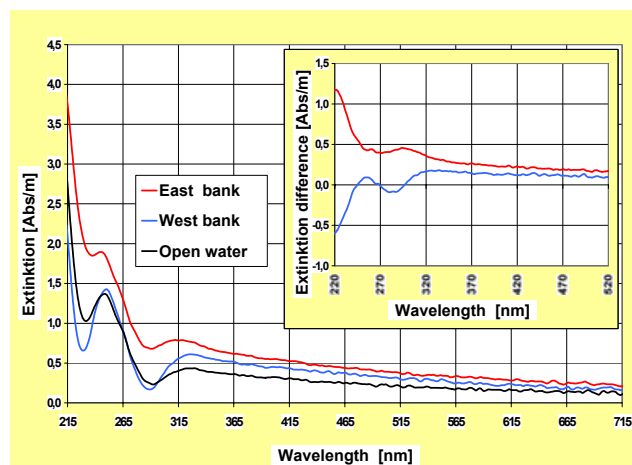

Figure 5: Absorbance spectra from an alpine lake

The differences visible in the absorbance spectra in the wavelength range of 215 to 350 nm become even more distinct using the "Delta-Spectrometry" method. Comparison of the east and west bank spectra to the fingerprint of the free water body will yield the difference (delta) spectra shown in the upper right corner of the graph above. Due to differing substance groups, the spectra take various shapes within the range determinant for the relevant organic substance. This method is capable of capturing very small variations in water composition, which is of particular benefit in early warning systems based on the s::can software moni::tool.

2.4 Turbidity

The correlation between turbidity and the spectro::lyser™ values in natural water yields very good results (cf. Figure 15), lying throughout at 0.95 to 0.99 from 0,05 FTU/NTU up to several 100 FTU/NTU.

2.5 Nitrate

The correlation between concentrations of nitrate and spectral extinction parameters results in always excellent correlation coefficients.

Nitrate produces a particularly strong signal which can be particularly easily detected. The measuring precision lies in the µg - range, the measuring ranges are from dozen up to hundreds mg/l NO3-N, depending on the measuring path length.
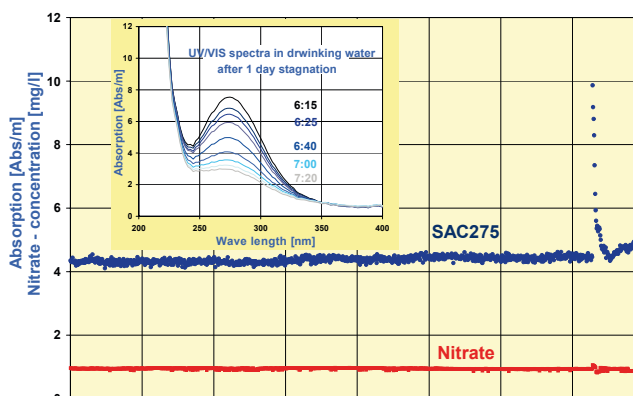

Figure 6: Figure 4: Comparison of NO3_eq with lab NO3

3 Advantages of Process Spectrometry in Comparison with Simple Photometer Probes

:: Cost efficiency

Even at minimum performance, the continuous UV/VIS spectrum enables simultaneous measurement of the parameter equivalents of organic carbon, nitrate and turbidity, for which reason only one s::can spectrometer is required, instead of three photometer probes.

:: Lower cross-sensitivity on turbidity, coloration, window deposits, etc.

Potentially interfering variables, which are not detectable using conventional one- or dual wavelength probes, can nearly always be compensated with the help of spectral

information. In cases of high solid-matter or fat content, the automatic cleaning unit is connected via an external pressure line and guarantees absolute drift-less measurements.

:: Thus greater precision

Since cross-sensitivity is substantially reduced by this means, heterodyning of measuring signals due to interference/noise is significantly less than with simple photometer probes.

:: Higher selectivity

The individual substances and/or substance groups sought can be allocated to significant spectra, for which reason they can be selectively identified.

:: Greater reproducibility

These s::can spectrometer advantages result in very high reproducibility as well as the benefit of universal applicability without the absolute necessity of local calibration.

:: Quantitative and qualitative readouts

In addition to the calibrated parameters, the qualitative spectral information (fingerprint) can be directly applied for alarm and control systems, etc. With the s::can software moni:.tool, qualitative and quantitative differentiation of carbon fractions is possible for more detailed assessment of the water, e.g. from pollution sources.
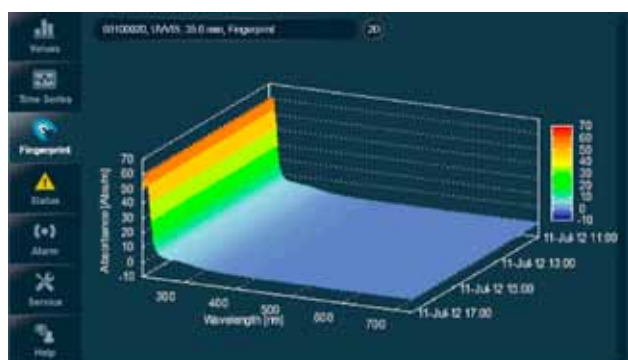

Figure 7: The spectral fingerprint visualized in s::can's software solution for water quality monitoring - moni:.tool

:: Calibration matching other substances and substance groups

Aside from the usual parameters (D(T)OC, BOD, nitrate, turbidity), other parameters can also be made available using calibration software from the UV/VIS spectrum.

4 Other Advantages of s::can Instruments

:: Extreme dynamic range

A special feature of all spectro::lyser™ is their extreme dynamic range (> 1:1000 or e.g. 1 to 1000 mg/l DOC_eq). The universal 35 mm configuration allows measurements in groundwater, river water, lake water, drinking water, etc. With the 100 mm measuring path, changes of 10 µg/l DOC are detectable, and/or individual substances such as BTX, phenols, olefins, etc. are distinguishable. Other lengths available for special applications.

:: Long-term stability

Dual-beam measurement enables all changes in the measurement system to be compensated. In addition, the spectral compensation of biological growth on windows, allows the long-term stable measurement of dissolved substances, which is the basis for continuous monitoring of water quality and for the safe and precise operation/ control of treatment plants.

:: No maintenance necessary

Virtually no maintenance is necessary because no moving parts or ageing equipment is in use.

:: Field and Outdoor Applicability

UV/VIS spectrometry technology to this date has never been available in such a compact design, enabling the use of the spectro::lyser™ even in tight spatial situations. Owing to the lightweight, robust design, and the absence of movable components coming into contact with the medium, as well as due to the 12-volt supply with sleep mode option, the instrument is also suitable for use under rough conditions and can be supplied by solar power.

:: Flexible measuring process

Intelligent evaluation algorithms adapt the hardware (exposure time, oversampling, etc.) and the measuring parameters to altered conditions of the medium.

:: High operational safety ...

... thanks to implemented self-test procedures.

:: Ease of use

Besides calibration, no setting whatever is possible.

The user remains unaffected by the complexity of the mathematical processes running in the background, i.e. he need not manipulate the measurement procedure, he merely receives the definitive measurement figures.

5 Application of spectro::lyser™ in drinking- and natural waters

5.1 Assessments and parameters

:: Measurement of UV/VIS spectra over a wavelength range of circa 220 – 720 nm
- Compensation of turbidity
- Simultaneous determination of various substances
- Differentiation between various carbon fractions
- Detection of hazardous pollution of raw water
- Detection of polluters and irregular charges
- Early detection of threads to water quality - alarm systems
- Evaluation of efficiency of water treatment processes

:: Calibration to the following parameters:
- AOC, BOD, BTX, COD, color, DOC, FTU/NTU, H2S, NO2-N, NO3-N, O3, TOC, TSS, UV254, fingerprints and spectral alarms, temperature and pressure
- Single substances: Aromatics, phenolics, hydrocarbons, and most chromophores with peak e > 10^4 will show good results comparable to Benzene after calibration.

5.2 Equipment and installation

:: Selection of measuring path length depending on substance concentration
- 35 mm for surface waters and polluted ground waters
- 100 mm for low detection limits in drinking waters and ground waters
- Other lengths available for special applications

Figure 8: spectro::lyser with 35 and 100 mm path length

:: Recommended measuring points
- in the raw water (groundwater, surface water, etc.)
- before water collection
- along water treatment
- prior to feed into the water supply
- along the supply network
- at points of consumer use (tap)

:: Evaluation if automatically hydraulic window-cleaning (using pressurised water or air) is necessary,
- applications with need of very long (several months) maintenance intervals
- in cases of increased biological activity in the water
- also operational in the sewer system when used in combination with compressed-air or CO2 bottles

Figure 9: Efficiency of the automatic cleaning - the sensor is dirty but the measuring path is free of fouling

6 Additional features of s::can measuring systems

6.1 System integration

1. Our interface terminals con::cube and con::lyte allow total system integration and most advanced visualization. They provide analogue and digital interfaces to all kind of other sensors and control systems. Complete monitoring stations can be programmed to completely meet customer´s needs concerning visualization, process control and data exchange.

2. The instrument can be operated and read with any commercial notebook/pc computer via the USB-interface and our proprietary software.

3. The instrument is also operable in data logger mode without any additional periphery. However, no continuous data access is possible in this mode.

4. In addition, s::can offers a waterproof field case (accumulator) for stand-alone operation in the field.

6.2 Operation and data transfer

- Measurement values can be integrated into automated processes (control, alarm, databases) via most known standard interfaces.

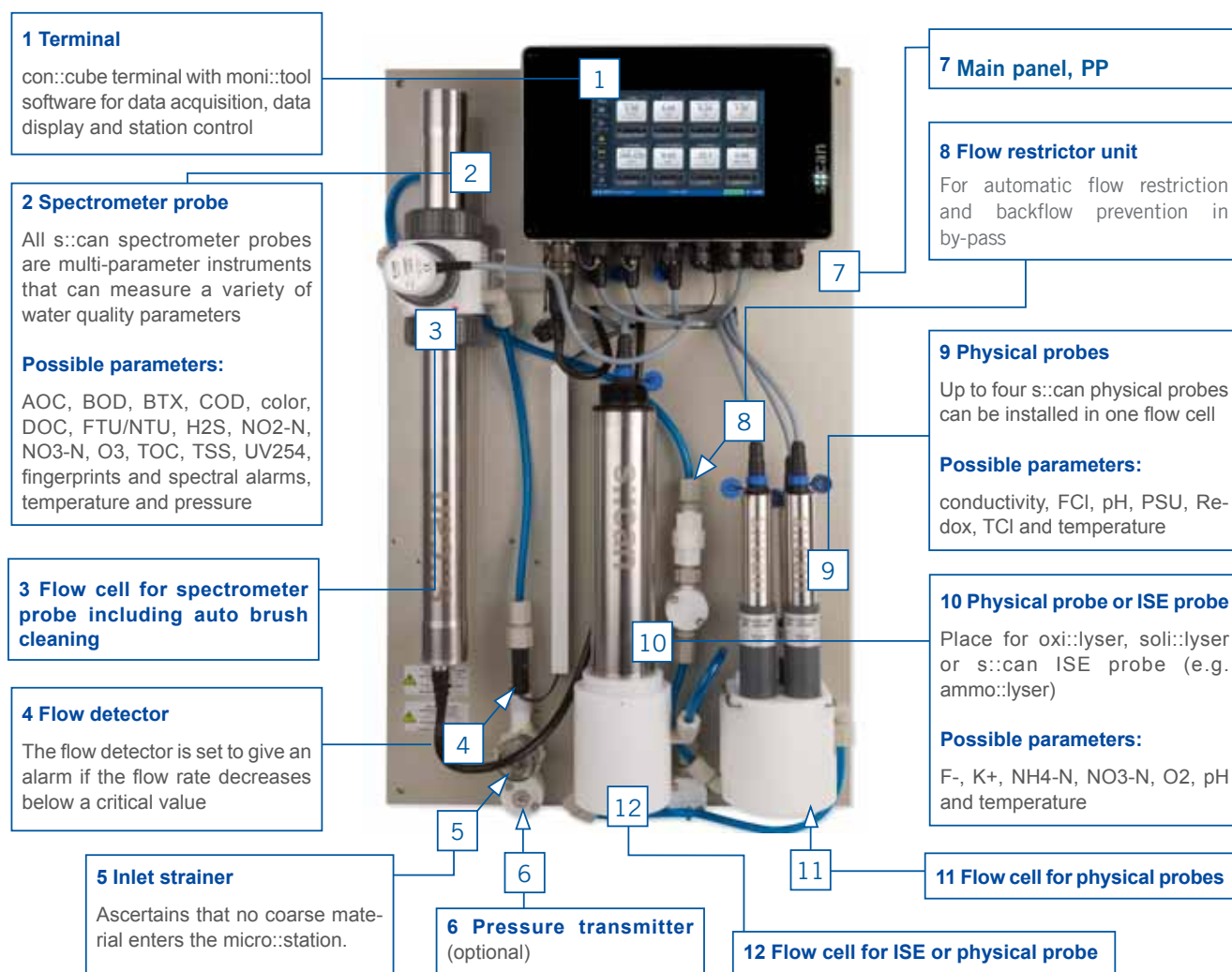## 6.3 Simultaneous water-level and temperature measurement

- Sensor for pressure-measurement integrated in the analyzer and the software.

- Estimation of flow-through if level-flow relation is known
- Sensor for temperature measurement integrated in the instrument and the software

6.5 Networking of multiple devices

Multiple measurement points can be united to a centrally operable network. Together with its associates, s::can supplies the complete equipment.

7 The s::can micro::station for drinking water - system overview

1 Terminal

con::cube terminal with moni::tool software for data acquisition, data display and station control

2 Spectrometer probe

All s::can spectrometer probes are multi-parameter instruments that can measure a variety of water quality parameters

Possible parameters:

AOC, BOD, BTX, COD, color, DOC, FTU/NTU, H2S, NO2-N, NO3-N, O3, TOC, TSS, UV254, fingerprints and spectral alarms, temperature and pressure

3 Flow cell for spectrometer probe including auto brush cleaning

4 Flow detector

The flow detector is set to give an alarm if the flow rate decreases below a critical value

5 Inlet strainer

Ascertains that no coarse material enters the micro::station.

6 Pressure transmitter (optional)

7 Main panel, PP

8 Flow restrictor unit

For automatic flow restriction and backflow prevention in by-pass

9 Physical probes

Up to four s::can physical probes can be installed in one flow cell

Possible parameters:

conductivity, FCl, pH, PSU, Redox, TCl and temperature

10 Physical probe or ISE probe

Place for oxi::lyser, soli::lyser or s::can ISE probe (e.g. ammo::lyser)

Possible parameters:

F-, K+, NH4-N, NO3-N, O2, pH and temperature

11 Flow cell for physical probes

12 Flow cell for ISE or physical probe

8 Some reference measurements

8.1 OnLine Measurements at the Tap

The NO3-N and SAC 254 and series (cf. Figure 10) originate from a measuring point in a small urban water-supply network and were measured with a 35 mm spectro::lyser ™. While the nitrate concentration in the course of the week remains at a stable level, changes are detectable in the SAC 254. This is due to the opening of a pipe that had been closed for one day. The detail in Figure 10 shows the absorbance spectra about an hour after the opening of the pipe. The water quality during this hour was compromised.
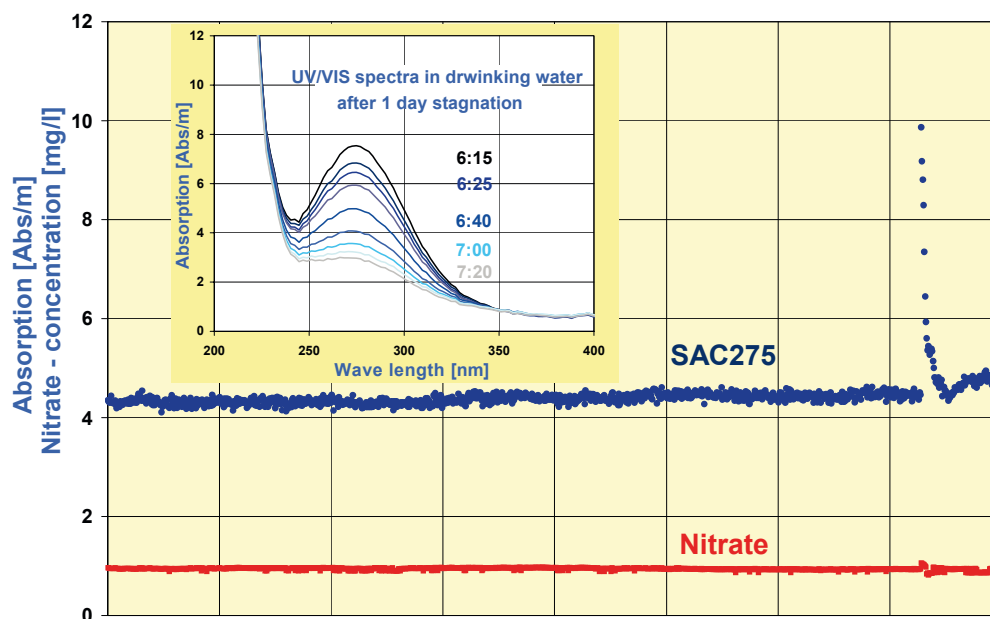
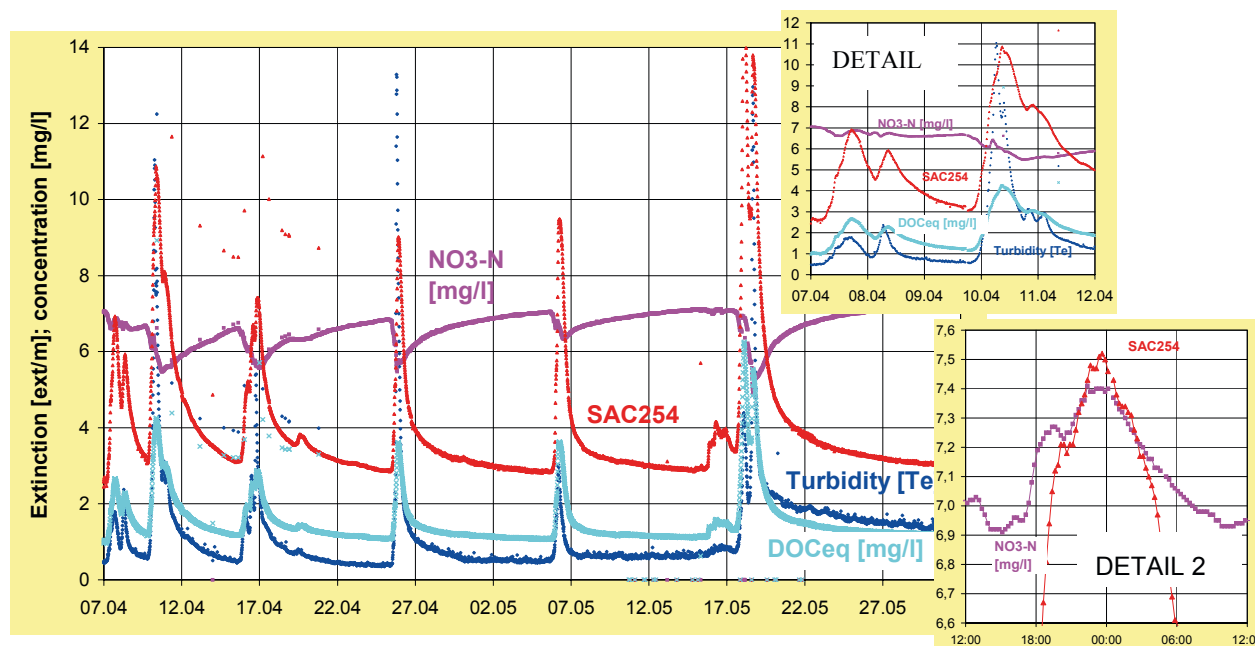*Figure 10: Time series of nitrate and SAC 254 in a water-supply network*

Figure 11: Time-series of Nitrate, SAC, Turbidity and DOC_eq in a ground-water well with strongly fluctuating water quality. Turbidity- and carbon peaks, always together with Nitrate valleys, result from the influence of a nearby river.

8.2 Measurement of ozone during water treatment

Figure 12 clearly shows the spectral peak of ozone at 260 nm. This peak is used to quantify the ozone concentration down to 0.05 mg/l, thus ensuring that the oxidation agent does not reach the network. Furthermore, this application allows the easy distinction during oxidation between carbon compounds (and/or their variations), and ozone, thanks to the spectral information available.
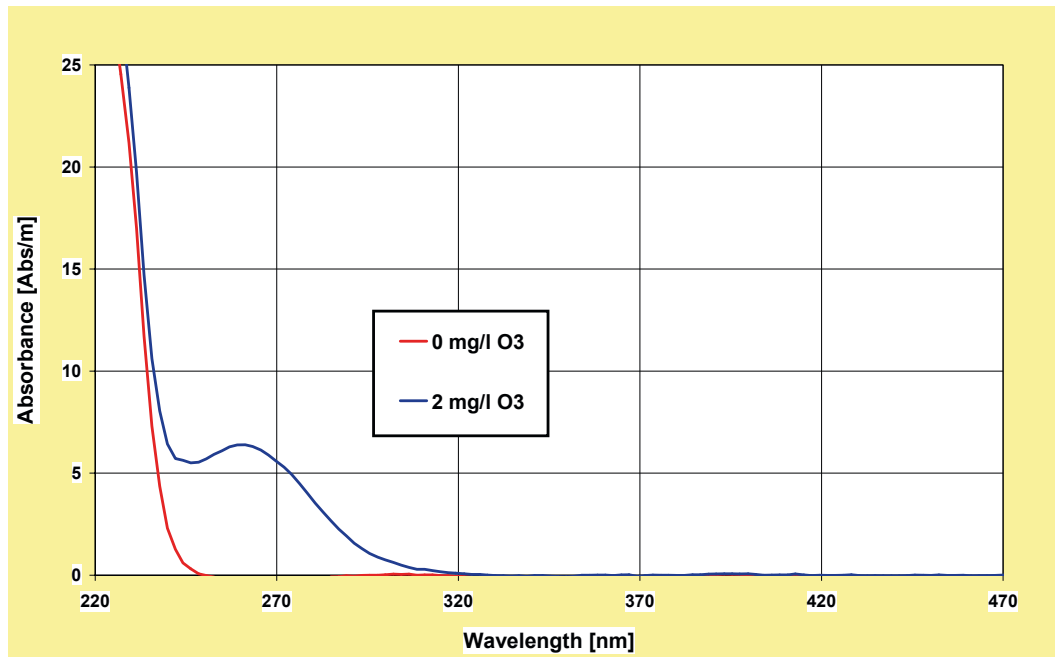

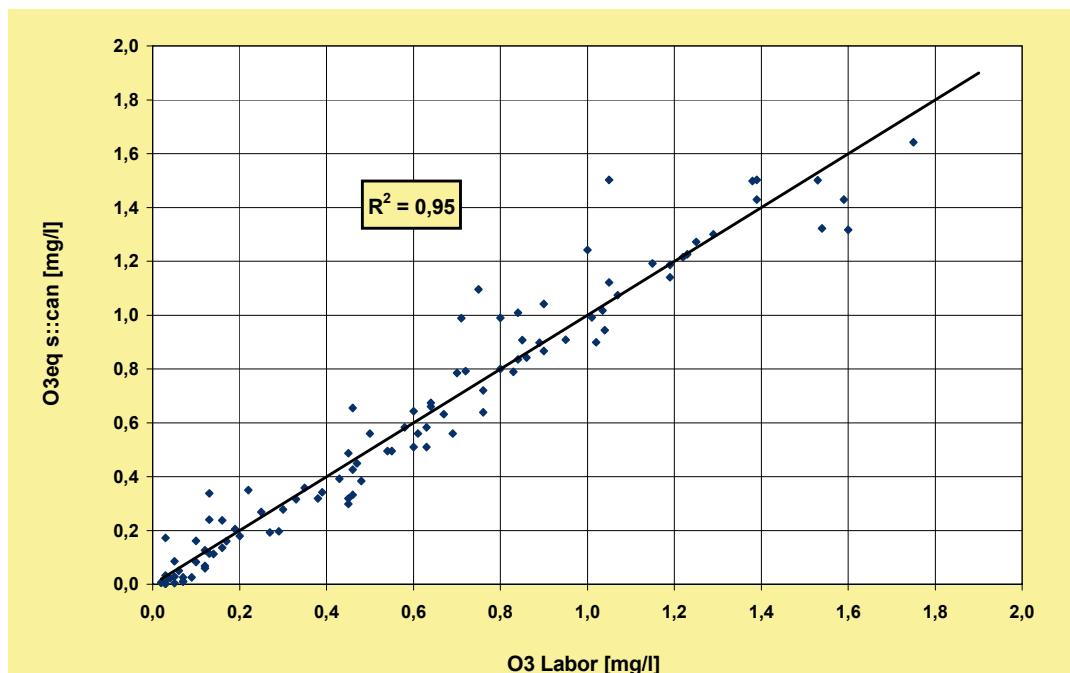Figure 12: Absorbance spectra of ozone in drinking water

Figure 13: Correlation between spectral O3 and conventional O3

8.3 Measurements in raw water/river water/bank filtrate

Figure 14 shows the spectra of river water (red fingerprint) and its filtrate following a river bank passage of 3 m (green) and 9 m (blue). The filter effect is clearly detectable in the reduction of the spectral extinction within the wavelength range from 250 to 500 nm. In this spectral region, absorbance is primarily effected by organic carbons, which are for the most part removed by the filter.
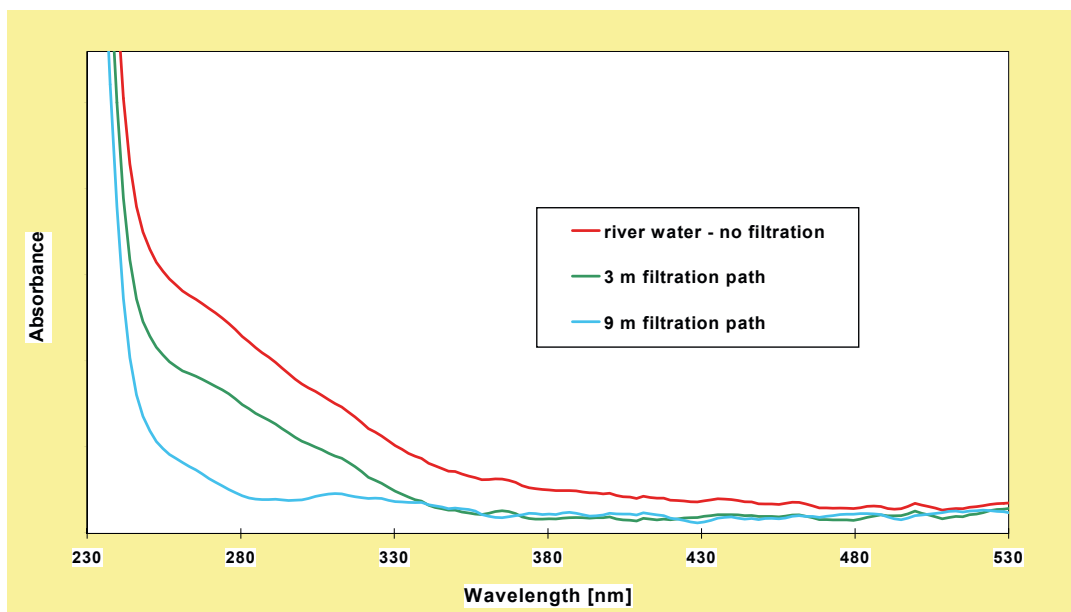
Figure 14: Absorbance spectra of surface water after various filtration path lengths

Figure 15 compares two turbidity time series measured in surface water. Over a period of more than two weeks (all together eight months), there was absolutely no deviation between the measuring values of the s::can device and those of a well proven and recognized device.
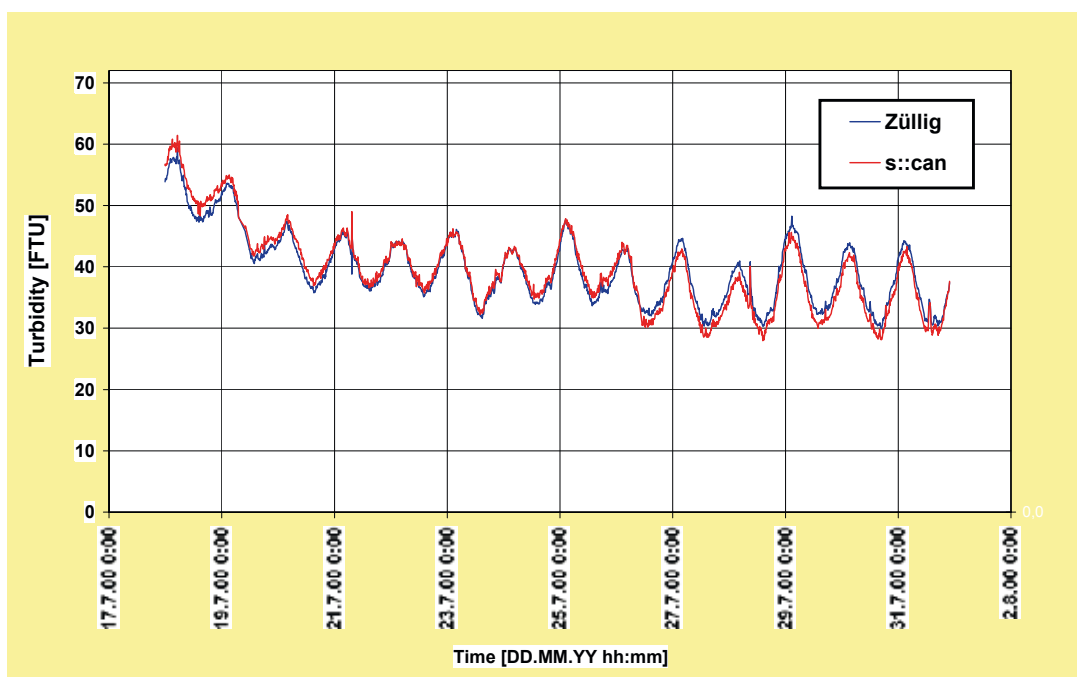
Figure 15: Turbidity time series in surface water

8.4 "Derivative spectrometry" used as a sensitive alarm parameter

Figure 16 below, clearly shows the benefit of derivative spectrometry in alarm systems. The ever returning shoulder at 420 nm in the absorbance spectrum, delineated by the thick, red, drawn-out curves, is barely identifiable. The lower illustration displays the first derivation of the spectra, and here the peak is very clearly discernible. The data originate from the point of discharge of industrial waste water into a river (blue/green color from an oil mill). The s::can software moni::tool is using these and similar methods for the detection of minimum changes of the water quality.
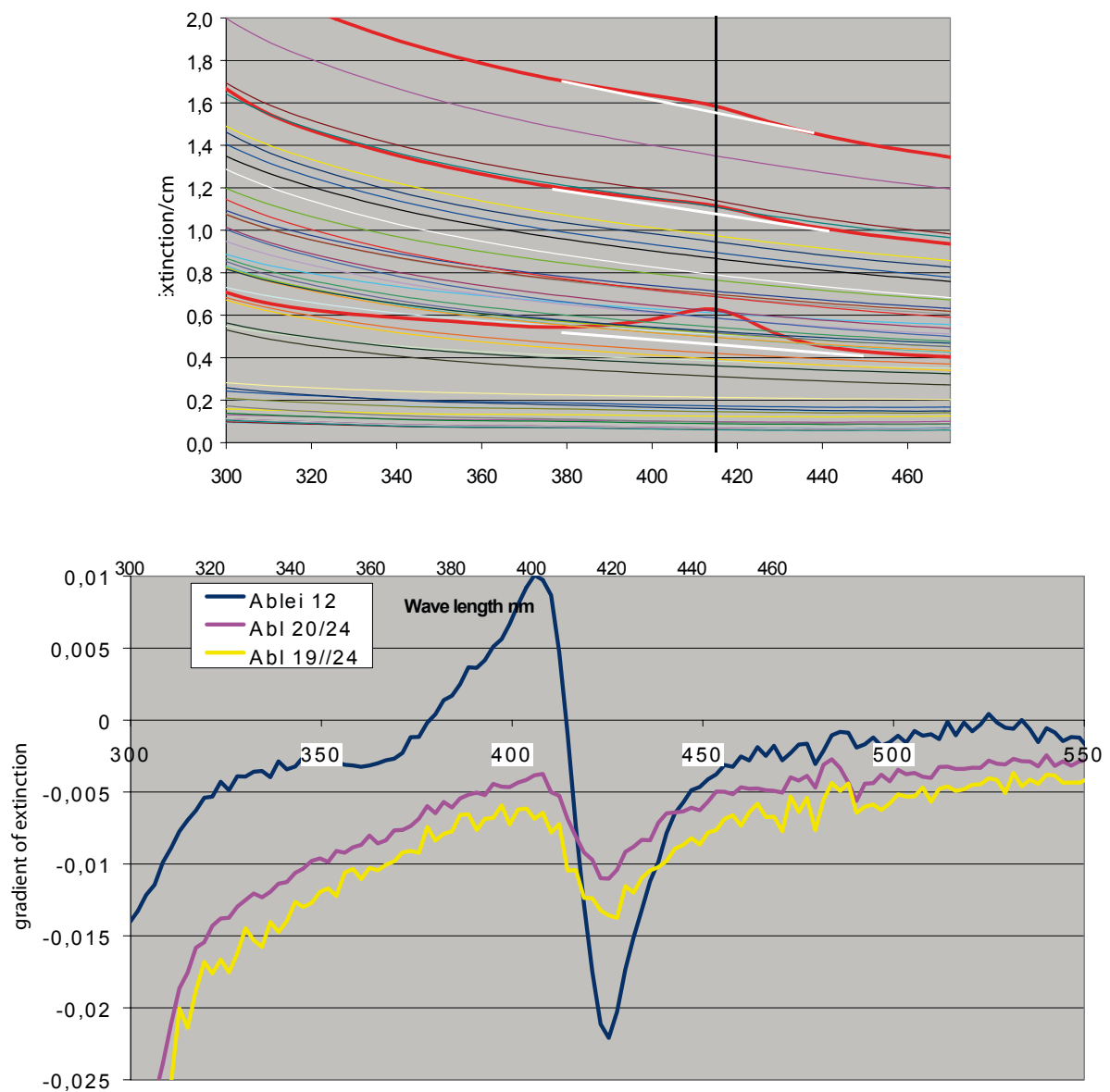

Figure 16: Derivative spectra of a dominant discharge into a body of running water

8.5 Derivative Spectrometry for Identification of Manure Pollution

Figure 17 shows absorption spectra of clean ground water, and of the same water polluted by 3 liquid manures. The spectral fingerprints of the manures are quite similar but not identical. Concentrations are clearly different. A slight shoulder around 280 nm can be distinguished.
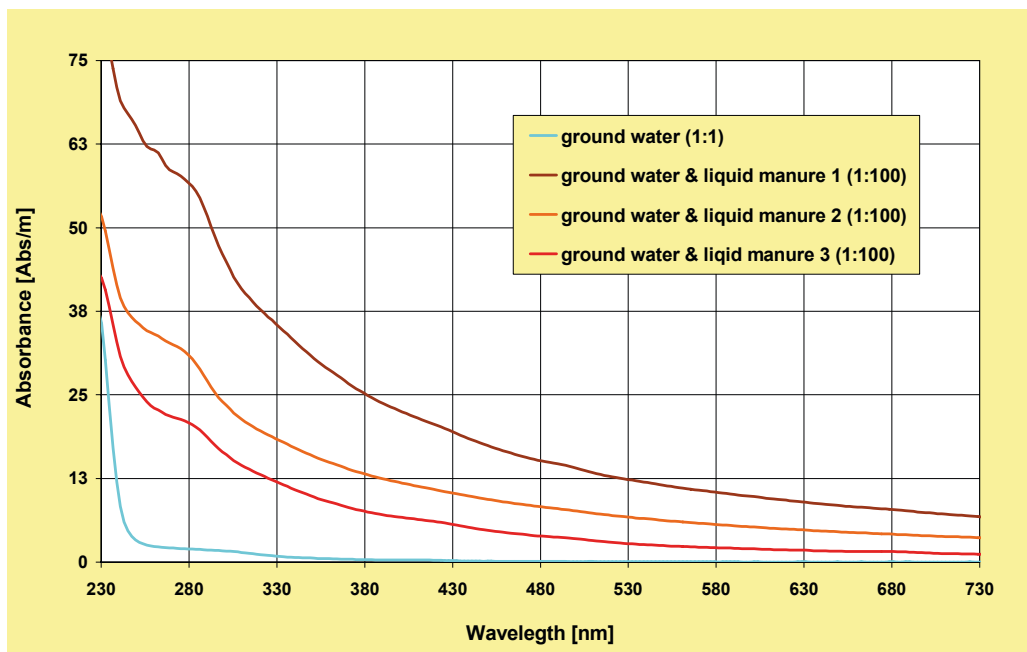

Figure 17: Ground water absorption spectra

In order to be able to better distinguish the manure from other sources of pollution, the 1.order derivative is utilised. In Figure 18, the peak around 290 nm is now clearly visible. Other sources of organic carbon, like natural humic substances (blue line), do not provide this 1rst order peak.
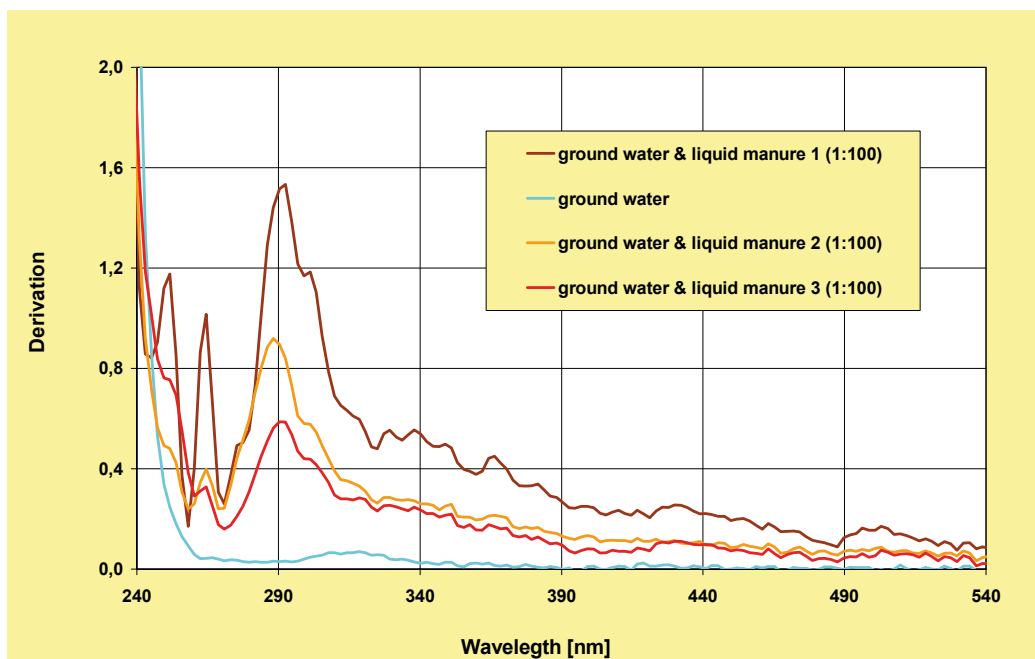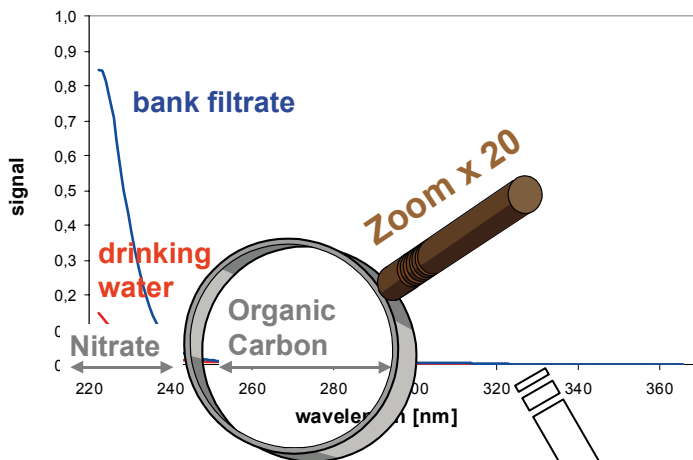

Figure 18: Derivative specta from Figure 17

8.6 Detection of small concentrations using "delta spectroscopy"

1. Use of distilled water as reference; Y – axis scaled maximally

2. Zoom enlargement of the dimension axis by a factor of 20

The extinction value at 254 nm ("classical" SAC) does not reflect at all the organic matter in the water!

3. Zoom enlargement by a further factor of 10 - total factor is now 200
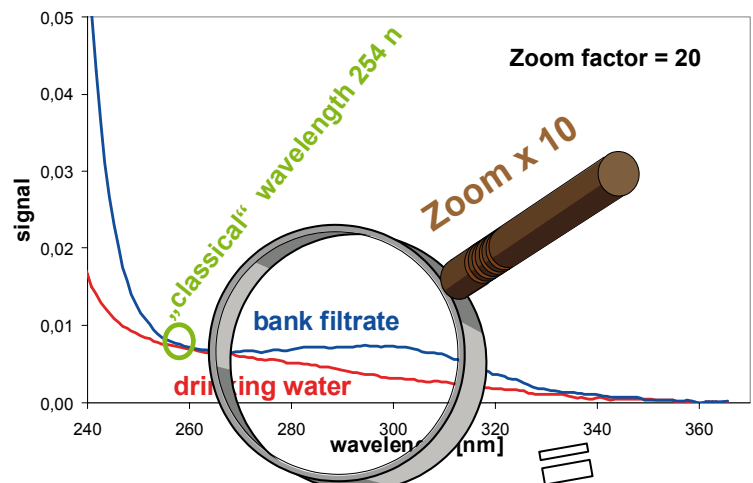
4. In order to make the difference more distinct, the drinking water is used as a reference, so that a peak in the range of the organic carbon (typical humic matter) now becomes visible in the bank filtrate. The DOC can now be calibrated to match this peak.

13
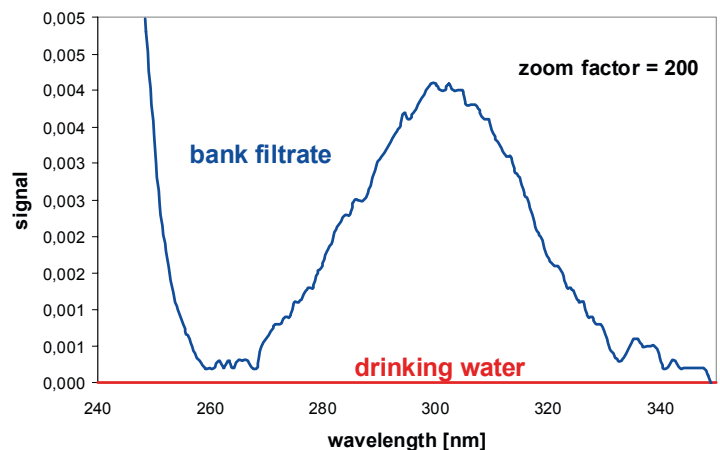
8.7 Measuring Benzene in Groundwater

Using new mathematical procedures, an extremely selective and accurate method for measuring aromatic compounds in the widest variety of matrices was found and subsequently validated by an independent laboratory. At a measuring path of 100 mm, the measuring range of Benzene and also other aromates extends from 50 to 50,000 ppb.

The measuring method can be applied in natural waters just as in processes, whereby the process measurement will tend to be simpler and even more accurate, due to less complex matrices.
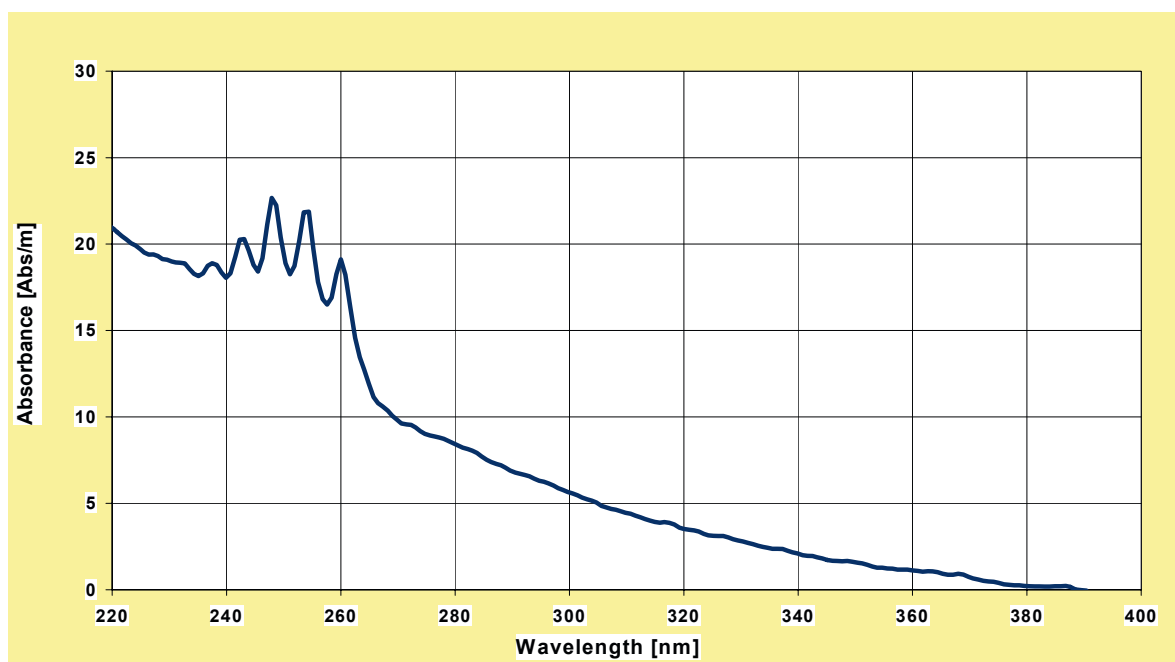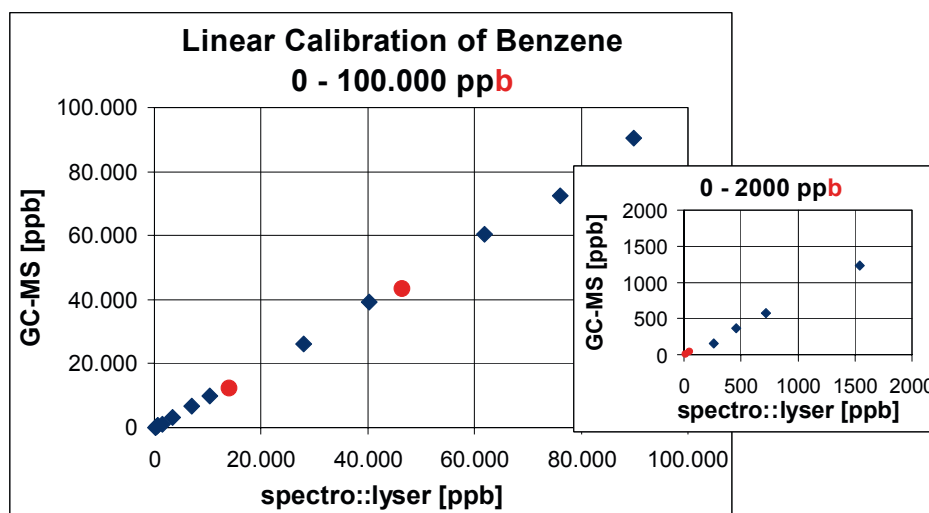

Figure 19: Spectrum of Benzene in ground water

Figure 20: Benzene calibration result

8.8 Evaluation of Contaminated Sites and Ground Waters

The investigation and monitoring of contaminated ground-waters can be greatly enhanced by measuring contaminant concentration profiles with the help of the spectro::lyser™. The optional integrated pressure sensor allows the measurement of concentration profiles in real-time. Today, this is the only method to measure such profiles without disturbing the sample.

Figure 21 shows a selection of different well profiles in the central and surrounding area of a highly contaminated site. Under consideration of the geographical position, a three-dimensional evaluation of the Benzene contamination was done. The monitoring and comparison of time-dependent trends in the wells helps to evaluate the size and location of the contamination, and to monitor the effects of remediation activities. All needed software to run one or more probes is provided by s::can on a most advanced and user friendly level and runs on all s::can terminal units.
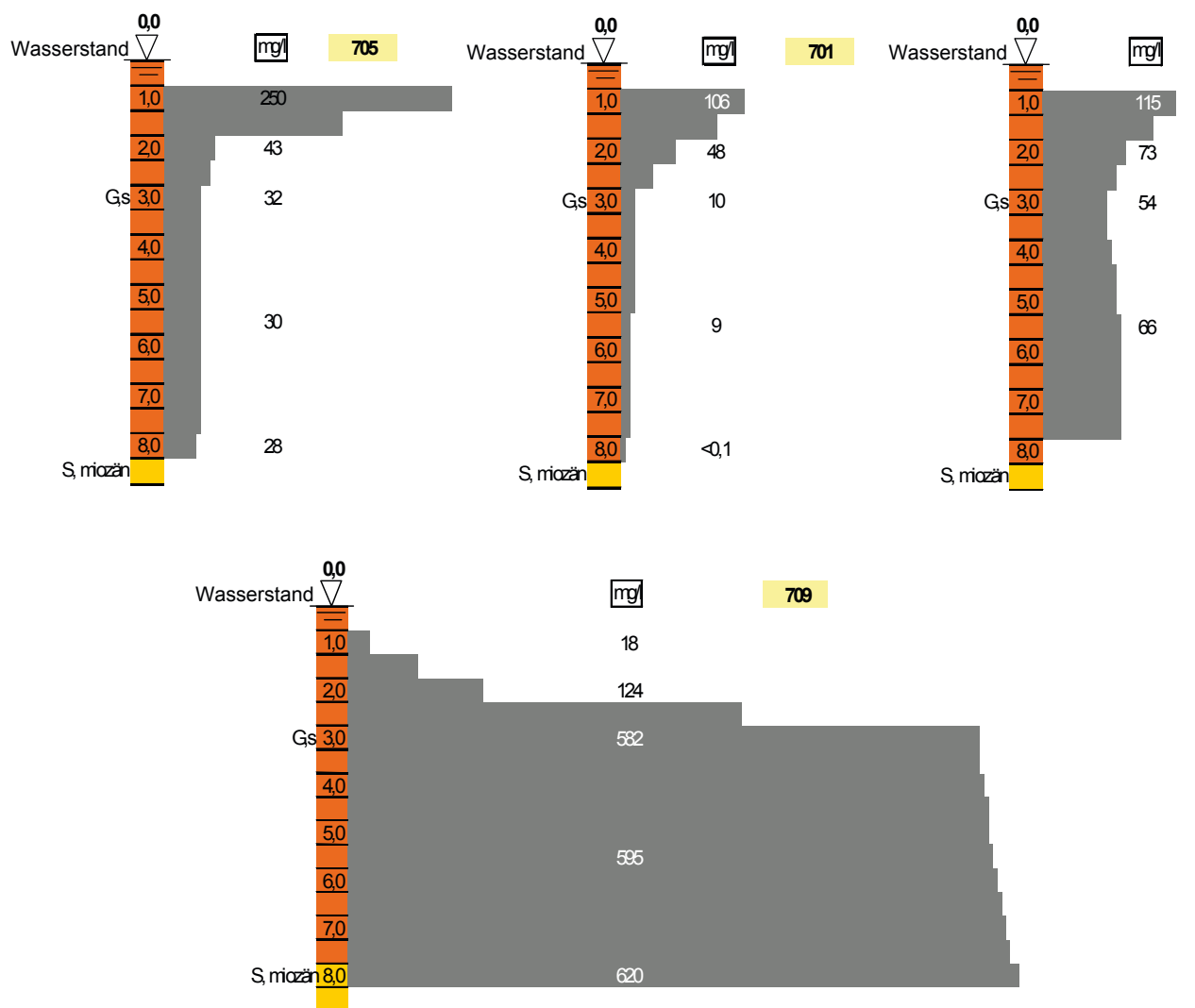
Figure 21: Vertical profiles of Benzene concentration in bore holes.

Application sheet - drinking water and environmental monitoring

Figure 22 represents a simplified application scheme of s::can spectrometer probes for the evaluation of the threatening potential and for long time monitoring underneath suspect zones and contaminated sites.

The "Delta Spectrometry" method (see chapt. 8.4) allows the evaluation and monitoring of "additional pollution" from the suspected zones, i.e. during remidiation projects.

Additional pollution from contaminated soil region = derived from delta spectrum

Alarm detection control of exceeds of maximum level

background values (reference spectra)

measured values (after contamination)

rainfall

drain water

contaminated zone

water level

non saturated zone

saturated zone

ground water flow

Aquifer

aquitard or aquiclude

ground water quality probes

Figure 22: Method for the evaluation and monitoring of contaminated ground water by insitu and online spectrometry

Method: s:.can Messtechnik GmbH, A-1020 Wien Graphics, and scientific evaluation: Fa. BLW - Boden-Luft-Wasser- Umweltanalysen GmbH, A-8010 Graz

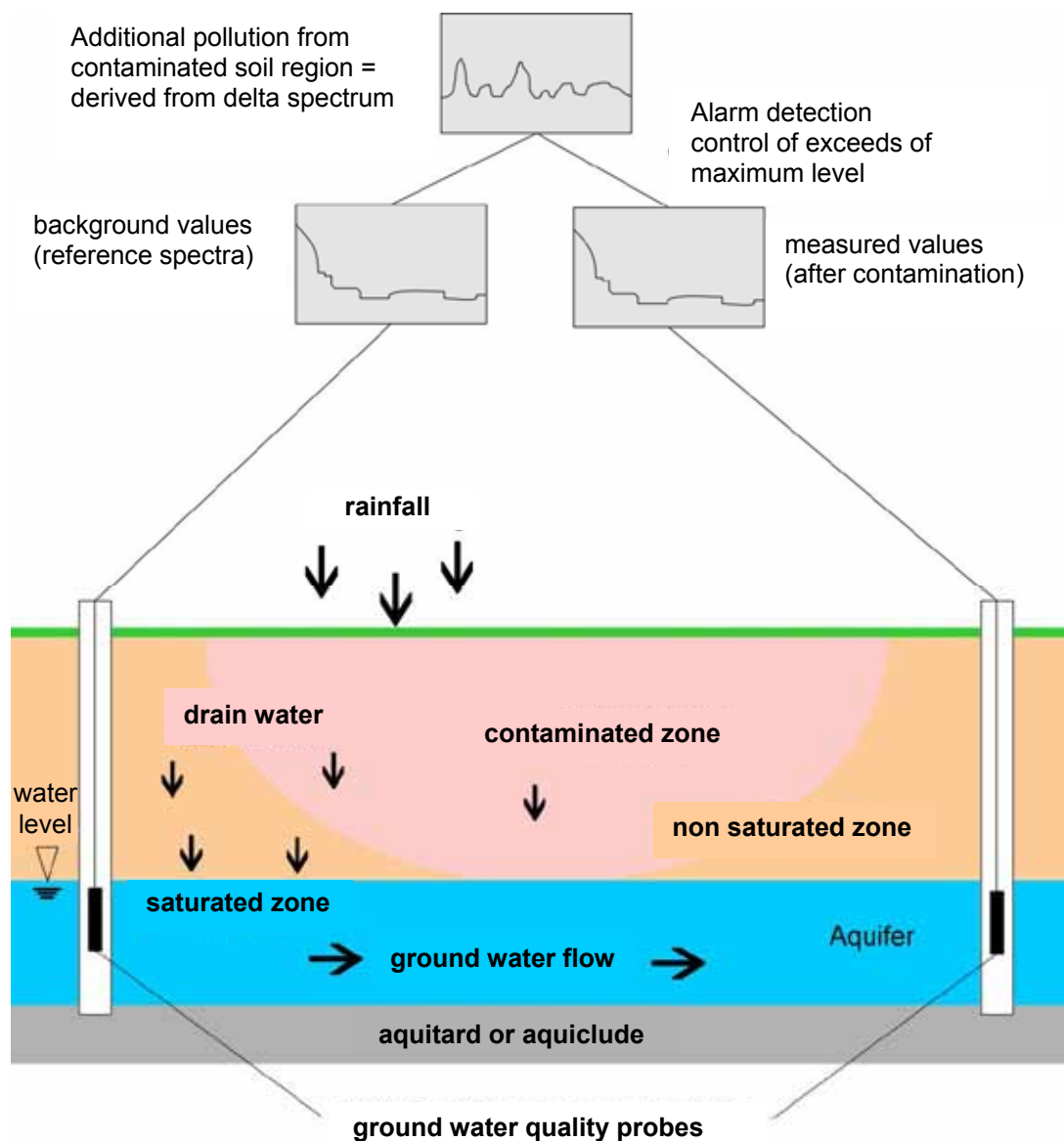# 9 Examples for typical parameter ranges in different waste water applications (spectro::lyser™)

ground water

		typical concentration ranges for this application											part number
		turbidity [NTU/FTU]	turbidity est [NTU/FTU]	NO_3-N [mg/l]	NO_2-N [mg/l]	TOC [mg/l]	DOC [mg/l]	UV254 [Abs/m]	UV254f [Abs/m]	color hazen-t [Hazen]	color hazen-f [Hazen]	H_2S [mg/l]	
spectro::lyser™ UV (turbidity est, NO_3-N, TOC, UV254, NO_2-N)	min.		0	0	0	0		0					Sp2-035-p0-sNO-010 / -075 (incl. Global Calibration g2)
	max.		60	20	1	25		70					
spectro::lyser™ UV-Vis (turbidity, NO_3-N, TOC, DOC, H2S)	min.	0		0		0	0					0	Sp1-035-p0-sNO-010 / -075 (incl. Global Calibration g5)
	max.	150		20		25	20					20	
spectro::lyser™ UV-Vis (turbidity, NO_3-N, TOC, DOC, UV254, hazen)	min.	0		0		0	0	0		0	0		Sp1-035-p0-sNO-010 / -075 (incl. Global Calibration g7)
	max.	150		20		25	20	75		300	200		
spectro::lyser™ UV-Vis (turbidity, NO_3-N, TOC, DOC, UV254, UV254f)	min.	0		0		0	0	0	0				Sp1-035-p0-sNO-010 / -075 (incl. Global Calibration g1)
	max.	150		20		25	20	75	50				

surface water

		typical concentration ranges for this application										part number
		turbidity [NTU/FTU]	turbidity est [NTU/FTU]	NO_3-N [mg/l]	NO_2-N [mg/l]	TOC [mg/l]	DOC [mg/l]	UV254 [Abs/m]	UV254f [Abs/m]	color hazen-t [Hazen]	color hazen-f [Hazen]	
spectro::lyser™ UV (turbidity est, NO_3-N, TOC, UV254, NO_2)	min.		0	0	0	0		0				Sp2-035-p0-sNO-010 / -075 (incl. Global Calibration r2)
	max.		80	10	4	25		70				
spectro::lyser™ UV (turbidity est, NO_3-N, TOC, UV254, NO_2)	min.		0	0	0	0		0				Sp2-015-p0-sNO-010 / -075 (incl. Global Calibration r2)
	max.		165	25	10	50		165				
spectro::lyser™ UV (turbidity est, NO_3-N, TOC, UV254, NO_2-N)	min.		0	0	0	0		0				Sp2-005-p0-sNO-010 / -075 (incl. Global Calibration r2)
	max.		500	70	30	150		500				
spectro::lyser™ UV-Vis (turbidity, NO_3-N, TOC, DOC, UV254, UV254f, hazen-f, hazen-t)	min.	0		0		0	0	0	0	0	0	Sp1-035-p0-sNO-010 / -075 (incl. Global Calibration r1)
	max.	200		10		25	12	70	50	80	50	
spectro::lyser™ UV-Vis (turbidity, NO_3-N, TOC, DOC, UV254, UV254f, hazen-f, hazen-t)	min.	0		0		0	0	0	0	0	0	Sp1-015-p0-sNO-010 / -075 (incl. Global Calibration r1)
	max.	465		25		50	30	165	100	165	115	
spectro::lyser™ UV-Vis (turbidity, NO_3-N, TOC, DOC, UV254, UV254f, hazen-f, hazen-t)	min.	0		0		0	0	0	0	0	0	Sp1-005-p0-sNO-010 / -075 (incl. Global Calibration r1)
	max.	1400		70		150	90	500	300	500	350	

drinking water

		typical concentration ranges for this application												part number
		turbidity [NTU/FTU]	turbidity est [NTU/FTU]	NO_3-N [mg/l]	NO_2-N [mg/l]	TOC [mg/l]	DOC [mg/l]	UV254 [Abs/m]	UV254f [Abs/m]	CLD [mg/l]	color hazen-t [Hazen]	color hazen-f [Hazen]	O_3 [mg/l]	
spectro::lyser™ UV (turbidity est, NO_2-n, NO_3-N, TOC, DOC, UV254)	min.		0	0	0	0	0	0						Sp2-100-p0-sNO-010 / -075 (incl. Global Calibration d2)
	max.		20	10	1	8	6	25						
spectro::lyser™ UV-Vis (turbidity, NO_3-N, TOC, DOC, UV254, UV254f, CLD)	min.	0		0		0	0	0	0	0				Sp1-100-p0-sNO-010 / -075 (incl. Global Calibration d3)
	max.	50		7		10	6	25	15	8				
spectro::lyser™ UV-Vis (turbidity, NO_3-N, TOC, DOC, UV254, UV254f, O_3)	min.	0		0		0	0	0	0				0	Sp1-100-p0-sNO-010 / -075 (incl. Global Calibration d5)
	max.	50		10		8	6	25	15				10	
spectro::lyser™ UV-Vis (turbidity, NO_3-N, TOC, DOC, UV254, UV254f, hazen-f, hazen-t)	min.	0		0		0	0	0	0		0	0		Sp1-100-p0-sNO-010 / -075 (incl. Global Calibration d7)
	max.	50		7		10	6	25	15		100	70		

For more information about the measuring ranges and accuracy of the spectro::lyser and our other s::can probes and sensors, please refer to our product catalogue!

Case study - Real Time Continuous Water Quality Monitoring Stations at the Ganga Basin
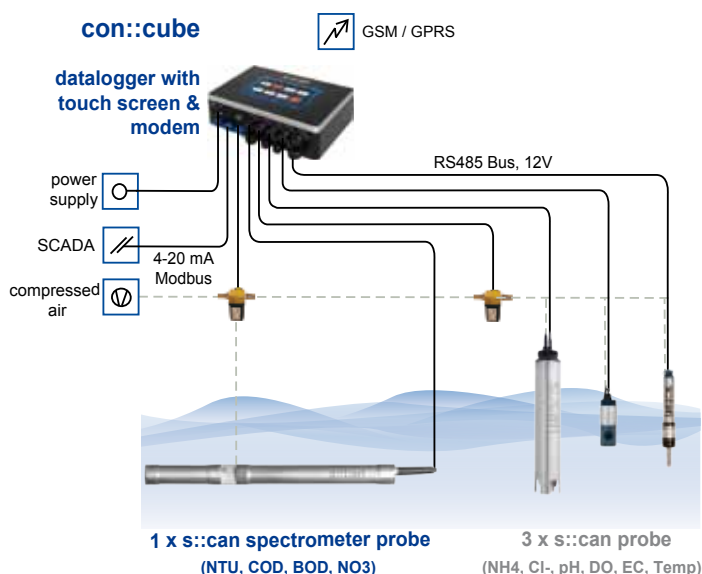
Because of the fast pace of industrialization and urbanization in India, a lot of effluent and sewage was - and still is - generated, for a major portion of which there are no effluent treatment plants. This has resulted in discharge of sewage into Indian rivers, untreated or only partially treated. Also, use of fertilizers and pesticides, lack of solid waste management practices contribute to surface water pollution as well. Continuous river water quality monitoring in order to find the polluters has become an important task in all of South East Asia.

Parameters monitored:

- **TSS**
- **COD**
- **BOD**
- **Conductivity**
- **pH**
- **Temperature**
- **NH4**
- **DO**
- **Chloride**
- **NO3-N**

Facts & Figures

Company/Institution:
Indian Central Pollution and Control Board (CPCB)

Location:
India

Date:
2012 - present

s::can Partner:
Aaxis Nano Technologies
Tritech Engineering & Testing
TechSpan Engineering

Application:
River Water

Key Products installed:
spectro::lyser
moni::tool

Introduction

The Indian Central Pollution and Control Board (CPCB) has assigned s::can and their local alliances Aaxis Nano Technologies, Tritech Engineering and Testing Pvt Ltd and TechSpan Engineering Pvt Ltd with the installation of a real time water quality monitoring network across the Ganga basin for ten parameters (TSS, COD, BOD, EC, pH, Temp, NH4, DO, Chloride, NO3-N) consisting of 10 standalone, unmanned remote water monitoring stations including automatic data transfer to a central receiving station located at CPCB central office at New Delhi.

Data transfer

The water monitoring stations provide real time data through a GPRS network. Each station is connected and capable of transmitting data to central receiving station at the CPCB headquarters and other zonal offices, the State Pollution Control Boards and the Ministry of Water Resources through the central receiving station.

con::cube — GSM / GPRS

datalogger with touch screen & modem

power supply

SCADA — 4-20 mA Modbus

compressed air

RS485 Bus, 12V

1 x s::can spectrometer probe
(NTU, COD, BOD, NO3)

3 x s::can probe
(NH4, Cl-, pH, DO, EC, Temp)

Network architecture

The monitoring network starts with 10 stations and the architecture is modular to accommodate additional stations as per future need. All the remote stations are operational in real time and the central station is able to access any remote station at any time.

Maintenance and power supply

The remote stations are field operational and tolerant to extreme environmental conditions in India, in high or low temperatures, high humidity coastal conditions and high temperature desert conditions. The stations are rugged and do not require manual intervention for at least 3 years except routine

calibration, electrode replacement on an as needed basis such as twice per year. All sensors are mounted submersed in the river, power supply is assured with solar panels and batteries at each remote station. All optical sensors are supplied with 3 years warranty from s::can.

Data validation and analysis

The online data is validated locally at each station and with the advanced con::cube / moni::tool features, all installed systems have full capability for real time event detection and contamination alarming.

The software installed at the Central Receiving Station has provision for data acquisition, data archival, data analysis, data display and report generation with parameter value graphs and it is also possible to process and further analyze all the measured and calculated parameters from these ten remote stations.

Measuring at the largest gathering of humanity

Every 12 years the Kumbh Mela celebration takes place in Allahabad at the confluence of the Ganges, the Yamuna and the mythical river Saraswati. The whole event lasts for 55 days. In 2013 more than 100 million people attended. Hindus gather to take a dip in the sacred river, which is said to wash away their sins.

Before the start of Kumbh Mela the state authorities took actions to improve the water quality of the Ganga river. Water from upstream reservoirs was released, sewage in Allahabad was treated before releasing it into the river

and the effluent discharge from industries upstream was curbed. All this led to a distinct improvement of water quality.

The BOD concentration in the river water was more than 20 mg/l before the measures. According to the monitoring stations the BOD dropped to 4.4 mg/l at the start of the gathering.

Figure 25: The results from the monitoring station in Allahabad show a considerable improvement in water quality.

On the first day of Kumbh Mela the BOD concentration started to rise again. This was mainly due to the bathing masses but compared to pollution originating from (industry) waste water the rise was small.

Figure 26: Two of the measuring stations in India and a view inside one of the stations.

Case study - Bratislava secures its water supplies with s::can

Bratislava Water Company (BVS) is responsible for the operation of water and wastewater systems of Bratislava, the capital of the Slovak Republic. The supply of safe and wholesome drinking water to a population of over 600,000 is one of the core responsibilities of BVS.

Drinking water is produced in seven central water treatment facilities from 176 raw water sources with an overall capacity of over 6300 l/s. The only treatment performed is chlorination to prevent microbiological (re)growth during distribution. Despite this high quality, BVS decided that an online water quality monitoring system is essential to ensure that this high quality is never compromised

Parameters monitored:

- **NO3**
- **TOC**
- **SAC254**
- **Conductivity**
- **Temperature**

Facts & Figures

Company:
Bratislava Water Company

Location:
Bratislava (Slovakia)

Date:
2010 - present

Application:
Drinking Water

Key Products installed:
spectro::lyser
moni::tool

Challenges

Driven by the requirement to establish an online quality monitoring and event detection system, BVS performed a multi-stage evaluation of available technologies. This consisted of the following steps:

1. Definition of requirements

2. Evaluation of suitable instrumentation based on manufacturer specified performance

3. Field test of short-listed monitoring technologies

4. Event detection capability evaluation with real water samples

Solutions

As a result of these tests, the fully submersible UV s::can spectro::lyser™ (Fig 1) was selected as the preferred instrument for BVS.

The spectro::lyser™ can be used to measure multiple parameters simultaneously (such as turbidity, TOC, nitrates) from the spectral information (Fig 2). The spectro::lyser™ was additionally equipped with four spectral alarm parameters that exploit the first derivative of the absorption spectrum to detect changes resulting from untypical,

possibly harmful, water quality events. These parameters are trained on online measurement data from the monitoring sites and then respond to deviations from the water quality observed during the training.

The conventional standard parameters (nitrate, TOC, SAC254, temperature, electrical conductivity) are used to detect probable harmful natural events affecting the raw water quality.


Figure 27: spectro::lyser installation

The spectral alarm parameters were considered to be a solution for the detection of dangerous contaminations of anthropogenic origin – especially water soluble components of oil (mainly aromatic substances), pesticides and chemical warfare agents, which were identified to be potential contaminants of reasonable risk and a very high impact.

The instruments from two suppliers were selected for further evaluation (spectro::lyser™ from s::can Messtechnik and the Trios ProPS CW from Hac Lange).

Figure 28: A screenshot from moni::tool - the software
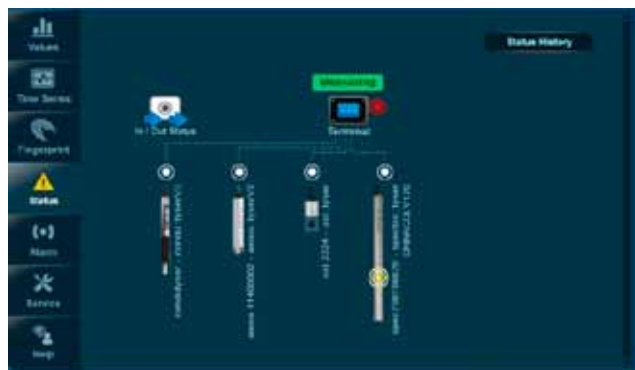
used for data visualization and data analysis.

Evaluation Results

During Phase 4 of the evaluation, several samples of water with realistic compositions were used to represent the potential contamination events that could occur. Samples of Bratislava's groundwater spiked with TOC standard, benzene and carbendazim were presented to the two monitoring systems.

This test series was executed on site to assess the sensitivity of the automatic spectral event detection features of the instruments under evaluation. Furthermore, a theoretical sensitivity analysis for a number of extremely toxic substances (such as saxitoxin), which could not be used under the available field conditions, was also performed.

The trained spectral alarm parameters of the s::can spectro::lyser™ reproducibly triggers alarms fully automatically as a result of water composition changes. The trained spectral alarm system on the spectro::lyser™ showed an unambiguous alarm in the groundwater at the following concentration levels: 1 mg/L TOC standard, 50 µg/L carbendazim, 150 µg/L benzene. Using the signal strength to determine the lowest concentrations that would trigger an alarm yielded the following results: 0.1 mg/L TOC, 25 µg/L carbendazim, 100 µg/L benzene and 50 µg/L saxitoxin.

During the spike tests the spectro::lyser™ demonstrated a higer sensitivity than the Hach-Lange supported Trios ProPS CW instruments. Because of its performance, its proven excellence in comparable applications and the availability of the easily trained and operated spectral alarm system, BVS selected the spectro::lyser™ for use in its event detection system.
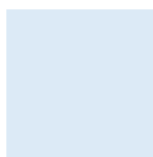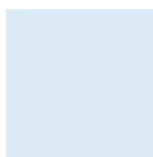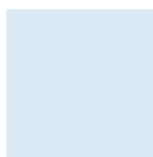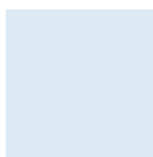
The monitoring network

The BVS established an early warning network that monitors all essential groundwater sources. This s::can early warning system monitors the raw water quality in real time, 24 hours a day. In case the groundwater quality falls outside the very strict quality limits specified, the water from the source is not used. Only after a detailed laboratory analysis has confirmed the quality of water, the source is used again. The water used for the drinking water supply is controlled continuously and only raw water of approved quality is able to enter the treatment facilities.

The results clearly show that the s::can spectro::lyser is a powerful tool for monitoring of drinking water quality and security, combining a cost-effective monitoring capability for both standard water quality parameters as well as a powerful event detection system for unknown contaminants. The small size and easy-to use package make it even more advantageous. Contaminants presented could be detected down to low µg/L concentrations and the spectral alarm system of the spectro::lyser™ additionally generated unambiguous water quality alarms at these low concentrations.

Application sheet - drinking water and environmental monitoring

10 Some selected references

List not complete - selection of s::can systems sold to customers; no trials listed;

Customer/Country	Project/Application	Stations/ Systems	Parameters	Product
City of Glendale, Arizona, USA	Water Quality and Security Network 2006 to present	12	TOC, DOC, NO3, Turbidity, spectral alarms, event detection, pH, free Chlorine	spectro::lyser, con::stat, s::can sensors
Vienna Waterworks MA 31 Austria	Water Quality and Security Network, 2001 to present	>45	FTU, TOC, UV254, Conductivity	spectro::lyser, con::stat
Canal Isabel Madrid, Spain	Water Quality and Security Network , Waste Water	20	NTU, TOC, DOC	spectro::lyser, con::stat
Massachusetts Water Resources Authority USA	Intake Protection and Distribution Monitoring 2007 – present	10	TOC, DOC, NO3, Turbidity, spectral alarms, event detection, pH, free Chlorine	spectro::lyser, con::stat, s::can sensors
New York DEP USA	Distribution Security Monitoring & Water Quality Data Analysis 2006 – present	5	TOC, DOC, NO3, Turbidity, spectral alarms, event detection, pH, free Chlorine, NH4	spectro::lyser, con::stat, s::can sensors
City of Philadelphia Water Department USA	Intake Protection and Distribution Security Monitoring. 2008 – present	3	TOC, DOC, NO3, Turbidity, spectral alarms, event detection, pH, free Chlorine, NH4	spectro::lyser, con::stat, s::can sensors
US EPA, Cincinnati, OH USA	Distribution Security Monitoring. 2005 - present	5	TOC, DOC, NO3, Turbidity, spectral alarms, event detection, pH, free Chlorine, NH4	spectro::lyser, con::stat, s::can Sensoren
San Francisco USA	Water Quality Data Analysis 2009	5	TOC, DOC, NO3, Turbidity, spectral alarms, event detection, pH, free Chlorine, NH4	spectro::lyser, con::stat, s::can sensors
Anglian Water Services Ltd. Vereinigtes Königreich	Water Security / intake protection network 2005 to present	7	NTU, TOC, Color, spectral alarms	spectro::lyser, con::stat
Linkwater, Australia	Source water monitoring and drinking water network control	>12	NTU, TOC, DOC, FCl, TCl, pH, EC	spectro::lyser, con::stat, s::can sensors
Bratislava Water Company Slovak Republic	Water Quality and Security Network 2009	5	NTU, TOC, DOC, BTX, spectral alarm	spectro::lyser, con::stat
Wellington City Council, New Zealand	Source water monitoring and drinking water treatment plant control (coagulation) 2006	5	NTU, TOC, DOC, coagulation control	spectro::lyser, con::stat
Beijing Bureau of Water Ministry of Water Resources	River Water Quality and intake protection system 2009	14	NTU, TOC, COD, BOD	spectro::lyser, con::stat
Sichuan EPA	River Monitoring	15	TSS, COD, TOC, BOD	spectro::lyser, con::stat
Canada	Drinking Water Monitoring	77	TOC, DOC, NO3, NO2, NH4, FTU, and spectral alarms.	spectro::lyser, con::stat, s::can sensors
Malaysia: ABASS, DIDM	Environmental Application	>20	TSS, NO3, COD, BOD, DO, NH4, pH, Temp	spectro::lyser, con::stat, s::can sensors
Taiwan: Freeway Engineering Bureau, governmental department	Source Water Protection	12	NTU, TOC	carbo::lyser, con::lyte
India, CPCB	River Monitoring	10	NTU, COD, BOD, NO3, pH, EC, NH4, Chloride, Temp, DO	spectro::lyser, con::cube, s::can sensors, ammo::lyser

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