Multiple Wastewater Parameters with a Single Analyzer

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On-line analysis has been used for monitoring and process control in wastewater treatment for approximately 20 years. The on-line analysis market started with cabinet analyzers. Cabinet analyzers require sample preparation systems that contain components such as pumps and filtration units. These components increase the cost of ownership and require maintenance.

This was the reason to develop in-situ analyzers in the mid 1990s. The probes are immersed directly in the channels or basins of the wastewater treatment plant. The results provide the real conditions directly at the sampling point. By doing so additional costs for pumps, pipe work and their maintenance are avoided.

Today STIP Isco is launching the new in-situ analyzer STIP-scan. This analyzer is based on UV/Vis-spectroscopy and allows the measurement of multiple parameters simultaneously. In comparison to conventional cabinet and in-situ analyzers it is possible to measure nitrate, spectral absorption coefficient (254 low), chemical oxygen demand (COD), total organic carbon (TOC), total solids (TS), sludge volume (SV) and sludge index (SI) with one simple probe. No chemicals are needed for calibration or operation of the analyzer. In addition, the analyzer operates with essentially no maintenance.

Fig. 1: STIP-scan in an aeration tank of a wastewater treatment plant

STIP-scan: The measuring cycle

STIP-scan is a UV/Vis-spectroscopic sensor which operates on the principle of light absorption. The core of STIP-scan technology is a miniaturized spectrometer: A xenon lamp sends light flashes through a measurement cell containing the sample. After being transmitted through the sample, the light is collected and recorded by a photo diode array spectrometer in the wavelength range between 190 and 720 nm.

The water sample does not require any pretreatment and is drawn directly at the sampling point. The quartz settling chamber also serves as the spectrometer cell. Immediately after sampling, particles and sludge flocs start to settle.

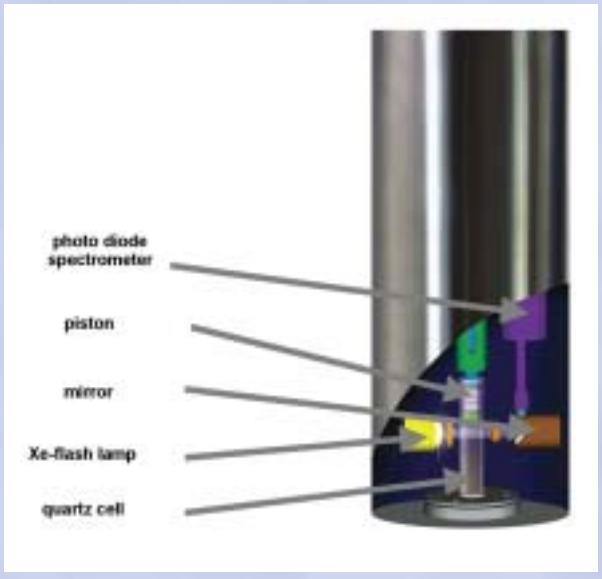

Fig. 2: Cross section of the UV/Vis-spectroscopic sensor STIP-scan.

The settling conditions in the measuring cell are not influenced by turbulence outside the measuring system.

During the settling process, continuous, rapid measurements are taken of the total solids (TS in g/l) using the absorption of visible light. From the results of the settling kinetics, a settling curve is recorded and the sludge volume (SV in ml/l) is calculated. The sludge index (SI) is calculated from the two parameters shown in Fig. 3.

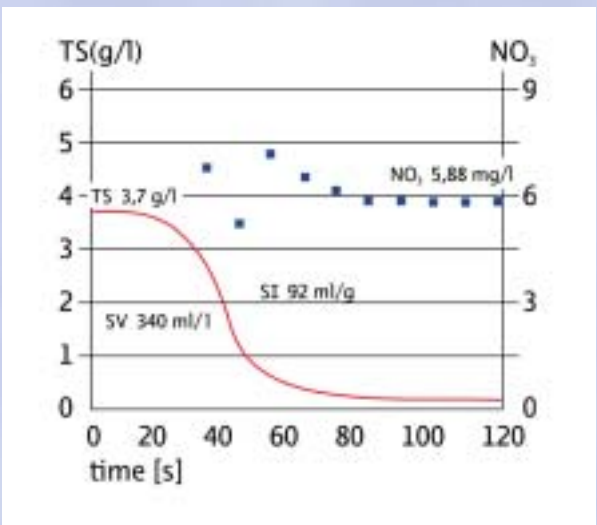

Fig. 3: Settling curve and nitrate concentration measured using a STIP-scan probe.

Particles in the light-path normally influence the accuracy of the measurements. The settling procedure compensates for this interference, making the resulting data very accurate.

After approximately 30 seconds of settling, the sample is sufficiently clear for analysis. Nitrate, spectral absorption coefficient (254 low) and chemical oxygen demand (COD) or total organic carbon (TOC) are measured. The system determines the end of the measuring cycle when the measured values become stable. The sample is expelled out of the measuring cell and a new measurement cycle is initiated. Depending on the settling characteristics of the wastewater, the complete measurement cycle takes between 1 and 5 minutes.

STIP-scan: The spectroscopy

One prerequisite of UV/Vis spectroscopy is the presence of chromophoric groups in the sample water. The direct translation from the Greek language means "color giving groups". They show absorption in the UV/Vis range by transferring light energy into an electronic excitation (vibration and rotation) of molecules. Chromophoric groups usually are double bond systems like C=C, C=O, C=N or N=O or triple bond systems in the molecules. Aromatic compounds also absorb in the UV range. Nitrate consists of N=O bonds and absorbs light between 190-230 nm. Chromophoric groups are common in natural and anthropogenic organic compounds. Generally, these molecules show absorption between 230 and 500 nm. The exact values of the absorbed wavelength depend on the type of the chromophoric group and the structure of the molecule. Many naturally occurring molecules consist of chromophoric compounds that absorb UV: humic and fulvic acids are examples. As chromophoric groups are often hydrophilic, they increase the solubility of organic molecules into water. This is the reason why UV light can be used for dissolved organic carbon (DOC) detection. Characteristic spectral absorption can be calibrated against COD or TOC standard laboratory tests and the UV-based parameter with good correlation.

Nitrate and some organic molecules exhibit absorption in a narrow spectral range. With other UV-analyzers it is impossible to differentiate between nitrate and other organic absorption bonds, which can lead to false positive and inaccurate results. With STIP-scan, a mathematical algorithm is implemented which compensates for the interfering influences, resulting in reliable measurements of nitrate and COD or TOC in the water sample.

In addition to nitrate and COD or TOC, STIP-scan also provides the 254 low. Originally used in drinking water applications, the 254 low is a well established parameter often used to indicate organic loads in natural waters. Due to the use of one absorption wavelength (at 254 nm), the parameter gives limited information. COD and TOC better represent organic loads and are environmentally more relevant.

STIP-scan: Easy elimination of interfering effects

The fluctuation of the lamp intensity,

precipitation and discoloration of the cell are usually limitations of spectroscopic measurements. These effects have been taken into account when developing STIP-scan. Each time a sample is drawn or expelled, the inner part of the quartz cell is mechanically cleaned by special seals on the piston. This cleaning routine prevents the formation of precipitates.

Discoloration is compensated for by means of a reference measurement before each measurement cycle. The sample piston stops, and the light-beam of the spectrometer is directed through a hole in the piston. The drift of the light source and any potential discoloration of the cell are then automatically compensated for. STIP-scan typically does not need cleaning or calibration and is essentially maintenance free.

STIP-scan: Applications

The STIP-scan can be used in a variety of applications. The analyzer can be used in municipal and industrial wastewater treatment plants. The system can be installed in the inlet, in the aeration basin, and in the effluent.

In addition to the stated parameters the spectrum can be used as an additional source of information. In industrial plants specific organic compounds often exhibits a characteristic absorption spectrum. A defined absorption value within the spectrum can be used as an alarm level. Malfunctions in the plant and potential danger for the environment can be detected quickly and reliably.

Apart from wastewater treatment plants, nitrate as well as TOC or COD can be detected reliably in river monitoring applications. An overview of applications and the correlating parameters is given in table 1.

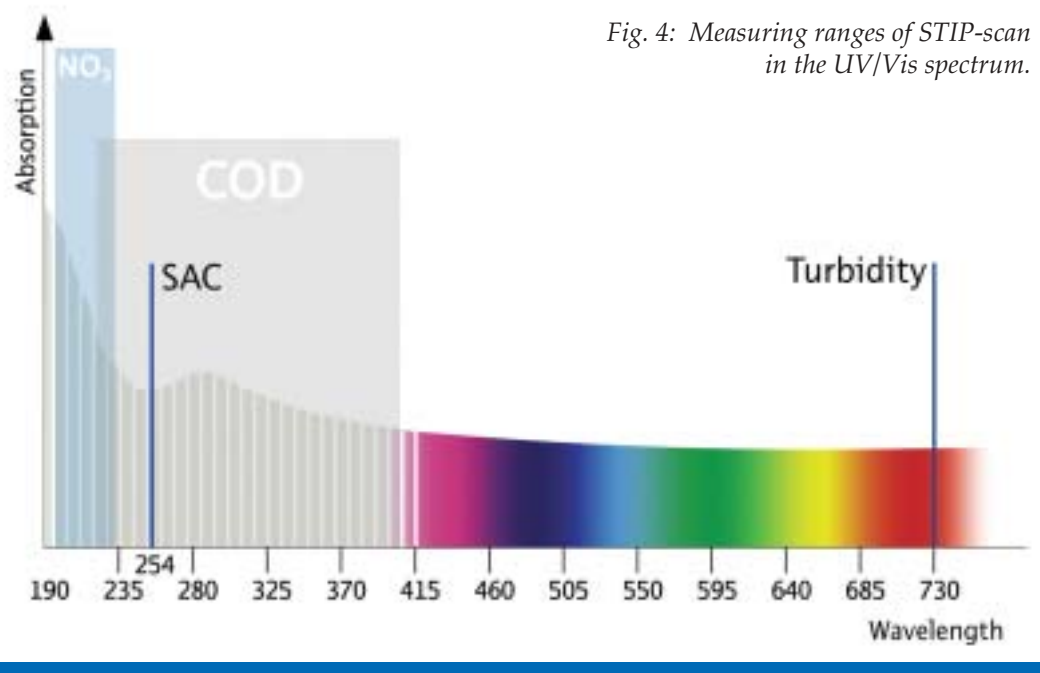

Fig. 4: Measuring ranges of STIP-scan in the UV/Vis spectrum.

Tab.1: Potential applications of STIP-scan

Application	Parameter
Municipal wastewater treatment plant	
Inlet	COD or TOC
Aeration basin	Nitrate, COD or TOC; TS, SV, SI
Effluent	Nitrate, COD or TOC
Industrial wastewater treatment plant	
Inlet	COD or TOC, UV-spectrum
Aeration basin	Nitrate, COD or TOC; TS, SV, SI, UV-spectrum
Effluent	Nitrate, COD or TOC
River monitoring	Nitrate, COD or TOC, 254 low

Conclusion

With STIP-scan STIP Isco has developed a system based on a simple but exact measurement technology, which operates without any sample preparation. The analyzer is easy to handle and very user friendly. It requires no chemicals and essentially no maintenance. Multiple parameters can be measured in one operation cycle. A large quantity of information is generated which can be used for the optimization of treatment plants or river monitoring applications.

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