Microbiological Monitoring in a view into the future

Real-time monitoring | In Austria an interesting new technology has been developped that will significantly change water treatment processes in the beverage industry and make them more efficient: the ColiMinder, an at-line instrument for fully automatic monitoring of microbiological water quality in the process.

The microbiologIcal quality of water is still determined today - as it has been for over 150 years - by a 1-5 day manual laboratory test, which is written down in all legal regulations and must be adhered to by corresponding test protocols.

Wolfgang Vogl, founder and managing director of VWMS, the company that manufactures the ColiMinder, compares the current situation to driving in a car "in which the windshield is opaque. The driver can only see in the rearview mirror what he ran over yesterday, but he can't ever see what's going on right in front of him." The view on microbiologal levels in beverage bottling was indeed not possible in real time until now.

In beverage production, however, microbiological water quality is of particularly critical importance: On the one hand, it is not constant, as microbes can multiply rapidly. Furthermore, microbiological contamination in the bottling process or in the end product is a worst-case scenario for every beverage bottler in terms of follow-up costs and effort, and such contamination can have immediate health consequences for the consumer.

Due to the long duration of the so-called culture-based methods, in which the microbes are artificially multiplied in the laboratory under optimal conditions and the cell colonies resulting from proliferation of bacteria serve as a measure of the microbial load, the microbiological water quality is not available as a real-time parameter.

Therefore, it is not possible with these methods to decide on the basis of the laboratory results whether, for example, a filter or a bottling line is still in order from a microbiological point of view. Or whether production must be stopped in order to carry out cleaning. It simply takes far too long for the laboratory results to arrive.

The new technology can solve exactly this problem by providing the information about the microbiological water quality within 15 minutes. An actual measured result is now available as a basis for decision-making, and production can continue as long as the quality is in order. The intervals for clean-in-place (CIP) can thus be extended while at the same time safety is increased

Approach of Measurement Technology

The underlying measurement technology does not work on the basis of the traditional culture-based method, but uses the fact that all living organisms have a metabolism, and enzymes are needed to catalyze this metabolism. With an automated enzyme assay, which has been used in medicine for decades, the enzymatic activity of the target organisms present in

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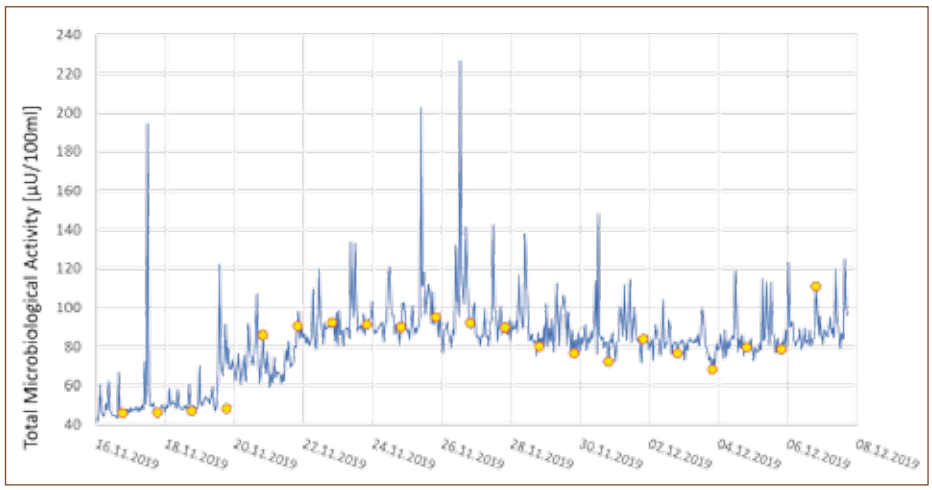

Table 1 Example of a timeline of microbiological activity in a drinking water pipeline; blue line: measured course of microbiological activity, yellow dots: two manually taken samples per day

beverage production

the sample can now be measured and a quantitative statement can be made about the degree of contamination

Practical Application

The device is installed directly in the production process, not in the laboratory. It takes the sample and measures fully automatically, providing a result on the degree of microbiological contamination within 15 minutes. Manual grab asmples can also be inserted at any time.

The system can fully automatically monitor various process steps or critical control points in water treatment, production and bottling, and it provides direct visualization of the microbial dynamics of a process.

The timeline generated from the measurement data and visualized online shows any change in microbial contamination. The shape of the timeline can also provide further valuable information about the origin of the contamination: bacterial growth or the build-up of biofilm, for example, show a different curve progression than a defective filter. In addition, the system can send real-time alerts when a defined limit for bacterial contamination is exceeded.

A measurement of the sum parameter of total microbiological activity allows reliable detection of any type of microbial contamination, because all living organisms contribute to the measurement signal, whether they are bacteria such as E. coli, coliforms, enterococci, Pseudomonas, other bacteria or algae, mold, yeast or biofilm.

Measurement Technology	Drinking water spiked with Rainwater (v%)				Drinking water spiked with Groundwater (v%)			
	0.01 %	0.1 %	1 %	20 %	0.01 %	0.1 %	1 %	10 %
OPT (cells/mL)	1/11	2/11	7/12	10/11	0/11	1/12	8/11	10/11
FCM-C (cells/mL)	0/3	1/4	4/4	4/4	0/4	4/4	4/4	4/4
FCM-C fingerprint (Bray Curtis)	1/4	4/4	4/4	4/4	2/4	4/4	4/4	4/4
ENZ (µU ALP/100mL)	3/3	4/4	4/4	4/4	2/2	3/3	4/4	5/5
ATP (pg ATP/mL)	2/6	6/6	6/6	6/6	3/6	4/5	6/6	6/6
FCM-H (cells/mL)	0/12	0/12	9/9	12/12	0/9	6/9	12/12	12/12
Coliform plate counts (CFU/100 mL)	0	0	1	1	0	0	1	0
Enterococci plate counts (CFU/100 mL)	0	0	0	0	0	1	0	2

Table.2: Comparison of different technologies for rapid online measurement of microbiology; the ratio indicates how many samples are above baseline compared to the total number of samples of the corresponding contamination level; green: 75-100%, yellow: 50-75%, orange: 25-50%, red: 0-25% reliability; the technology ENZ, "enzymatic detection method", presented in this article is outlined in green (from [1]).

How are the results used?

The measurement result obtained is simple and unambiguous to interpret, since the measured enzymatic activity provides a direct answer to the question "How high is the microbiological contamination of the sample?

The ColiMinder is also used in other applications than beverage production, for example, for monitoring water quality in the re-use of process water, raw water for drinking water production or bathing water. In these cases, other reagents are also used that allow, for example, specific measurement of fecal contamination.

In food and beverage production, however, it is recommended to use the reagent for "Total Microbiological Activity" to determine the total load of living organisms in the sample.

Sensitivity and reliability of the results

As demonstrated in practice by the use of such a system in mineral water bottling, for example at Romaqua, Romania's largest mineral water bottler, the sensitivity of the technology is sufficient to reliably monitor the microbiological quality of mineral water.

A scientific study published in 2021 in the journal Water Research concluded that the ColiMinder is the most sensitive among the compared instruments for measuring the microbial quality of drinking water [1].

In this study, the tested devices or measurement approaches had to detect the artificial contamination of drinking water with rainwater and groundwater at different concentration levels. The ColiMinder was the only system capable of reliably detecting even the minimum contamination of 0.01 percent in the test (Fig. 2, outlined in green). The study's authors conclude that the detection limit of the ColiMinder could therefore be even lower than the lowest concentrations tested in this study.

This reliability is also reflected in many installations in which the devices have

been reliably delivering measurement results in continuous operation since 2015. The analyzers calibrate themselves automatically at regular intervals, so that no manual recalibration is required. Thanks to the sophisticated system for fully automatic cleaning and calibration, the maintenance effort is limited to refilling the consumables.

Compliance testing versus operational process monitoring

The analysis system enables the bottler to carry out operational monitoring of microbiological quality, as already recommended e.g., by the WHO and also in the EU Drinking Water Directive. The almost-real-time measurement of microbiological quality with high temporal resolution enables corrective measures to be taken even before limit values are exceeded. This helps companies to meet the specified limits at a high safety level and at attractive costs.

Although there is no direct and generally valid conversion between the two methods due to the different measurement approaches of the culture method and the ColiMinder, a correlation table can be created by comparing measurements of the same sample with both methods, which can then be used for the conversion. However, the system does not replace the legally required bacterial tests to determine CFU.

Application Fields

Several well-known companies in the beverage industry are already using this method to monitor water treatment, critical control points (CCPs) in production and for checking the final product.

Romaqua, for example, has validated the ColiMinder internally and is already using it at two different production sites for continuous monitoring of source water at the inlet to the production line, but also for measuring manual grab samples from the process. Romaqua also checks each of its product batches before delivery, thus saving the long wait for laboratory results.

Table. 3 Monitoring of the microbiological quality of the spring water supply at Romaqua, Romania's largest mineral water bottler.

The more complex the water treatment process and the production plant, the more important it is to monitor microbiological quality in a timely manner, as microbial contamination can potentially arise within any component of the plant.

Filters, for example, are potential sources of in-process microbial contamination, as the retendate side of each filter provides an ideal breeding ground for microbial growth. Microbes can be distributed throughout the process if the filter malfunctions or breaks down. Therefore, it can be used to monitor the integrity of any filter (RO, UF, NF) or membrane. If defined threshold values are exceeded, an immediate warning message can be sent to the responsible persons and the problem can be solved in time.

With its standard two sample inputs, the device can also be used for monitoring process performance "before/after".

What the technology can't do (yet)

Tests in cooperation with well-known companies of the brewing industry have shown that the method is able to measure water and relatively clear beverages, but with the current state of the art an automatic and direct measurement of beer, strongly colored or cloudy beverages is not yet possible.

The team of VWMS GmbH is currently working on several parallel research and development projects, for example to enable measurement of such products by automatic filtration as well as alternative measurement methods. As the latest innovation, a reagent specifically for the measurement of mineral water with a high mineral content was presented in the fall of 2021.

Summary and outlook

The rapid and automatic measurement of the microbiological quality of water opens up completely new possibilities in quality monitoring and process control roles in the beverage industry.

Decisions to stop production for cleaning can now be taken evidence-based and final products can be tested within 15 minutes before delivery to avoid long waiting times for the laboratory result.

The ability to reduce the number of clean-in-place processes not only saves costs, but also reduces the use of resources.

The deployment for re-use of process water can additionally help to significantly reduce water consumption of a production facility.

The new technology thus not only helps to increase process efficiency and product

product safety and thus save costs, but also decisively supports a sustainable and careful use of the valuable resource water.

VWMS GmbH - Vienna Water Monitoring Solutions - offers with the presented technology a solution that makes it possible to make processes in beverage production with regard to safety, efficiency consumption of resources more efficient, safe and sustainable.

Wolfgang Vogl, the inventor of the worldwide patented technology, takes up the image of the car driver once again: "With the ColiMinder - metaphorically speaking - the view through the view through the previously opaque windshield windshield is possible; the driver can now see what is in front of him and react immediately. This automatically makes him a better and safer driver.

Literature

1. Favere, J.; Waegenaar, F.; Boon, N.; De Gusseme, B.: „Online microbial monitoring of drinking water: How do different techniques respond to contaminations in practice?", Water Research, 202, 2021, https://doi.org/10.1016/j.watres.2021.117387.