Application Note

Enhancing the safety of a scout camp's temporary water network with BactoSense

Abstract

The federal camp „mova," organised by the Scout Movement Switzerland, hosted over 30,000 participants in Goms. A temporary water network was set up to secure the drinking water for this large-scale event. Ensuring high-quality drinking water was a priority and was achieved through a comprehensive self-control strategy involving hazard analysis, on-site monitoring, online and field measurements, and laboratory testing. These strategies can be deployed to real water distribution networks as well. BactoSense proved itself as a valuable tool for bacterial monitoring in drinking water network surveillance, because of its quick measurement cycles, compact size and rugged housing, suitable for harsh environments.

Keywords
drinking water, network surveillance, network commissioning

Cover picture: Aerial view of mova scout camp in Goms, 2022 (picture provided by Mova Media)

A temporary network and its self-monitoring concept

The camp's water supply system faced numerous challenges due to its size and temporary nature. Microbiological risks were a central concern. A comprehensive self-monitoring plan based on the Swiss guidelines for best practices in drinking water supplies (W12) [1] and a professionally built network were essential to manage those risks effectively.

The temporary water network covered over 9 km of pipes, delivering water from the springs of the Obergoms and Goms communities to the camp. The network was organised into distinct subnetworks (Figure 1) with multiple surveillance points where various parameters were measured, including temperature, total cell count (TCC), aerobic mesophilic bacteria count (HPC), and specific Enterococci and E. coli counts. The results are represented with a traffic light system. Green signifies that all parameters are OK, yellow signifies minor issues with one or two parameters, and orange and red signify a major breach with faecal indicator bacteria, the colour depending on the intensity and number of the measurements.

In compliance with the self-monitoring concept, BactoSense, bNovate's flow cytometer, was installed at Point H (Figure 1). The device automatically provided continuous data on TCC and the HNA/LNA ratio (strongly over weakly fluorescing cells). In addition, manual measurements of samples from other subnetworks were performed with BactoSense, allowing for the quick, on-site determination of TCC in cells/ml (see Figure 3). These tests clearly exemplified how flow cytometry offers speed and sensitivity advantages over heterotrophic plate count (HPC) analysis for the general detection of bacterial growth [2].

Challenges of rapid commissioning and fluctuating use of the network

Time constraints and fluctuating water consumption patterns proved challenging for the system. The network had to be installed and commissioned quickly, and delays in other infrastructure components affected the stability of the network. The system was released despite some areas not being fully operational, resulting in partial water stagnation within the network before the arrival of the scouts on 23.08.2022 (Figure 2). Stagnation events are characterised by an increased number of cells detected and larger clouds on the dot plot. Flushing proved to be an effective measure to counter stagnation events. The arrival of 30,000 participants caused a rapid increase in water consumption, leading to less stagnation but also to pressure drops and potential contamination risks with back-flowing water.

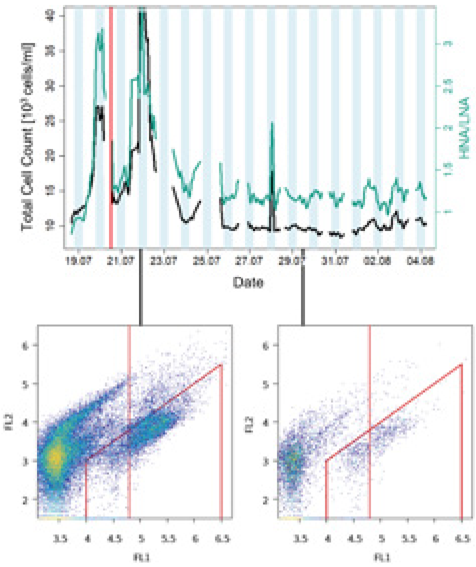


Figure 2: Temporal course of total cell count (TCC) and the high nucleic acid/low nucleic acid (HNA/LNA) ratio at the online measurement station (Point H, Figure 1). The camp took place from 23 July to 6 August 2022. Initially, the online measurement station analysed water from the Ulrichen network and later from the Münster network. A red line in the upper graph indicates the division from the Ulrichen subnetwork and the switch to the Münster network. The two dot plots illustrate the difference between low and high water consumption before and after the arrival of the participants. Only during the night from 27 to 28 July was an increase in cell counts recorded. This rise was attributed to heavy rainfall during the same period (25 mm of precipitation on the 27. July).

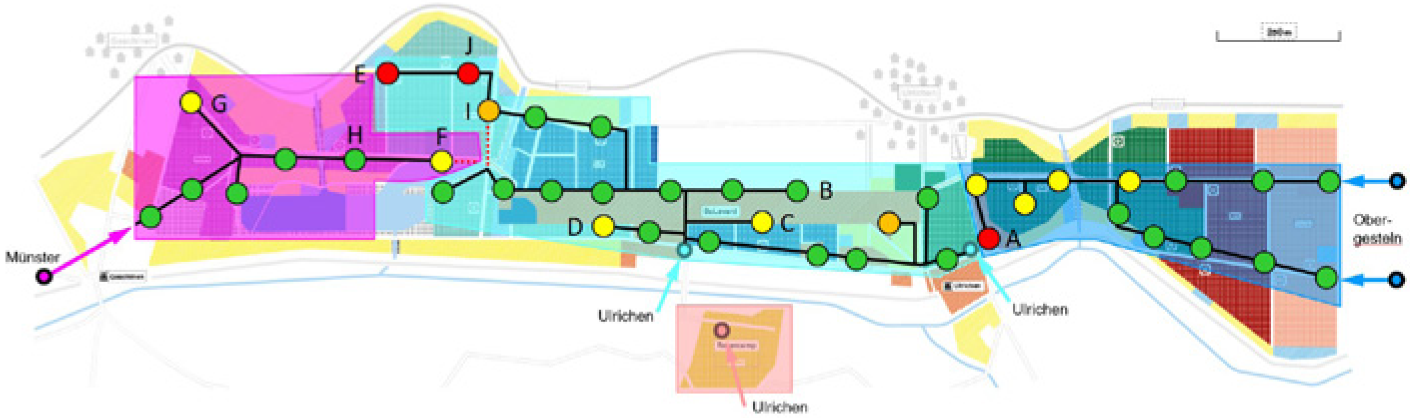


Figure 1: The temporary network with the four subnetworks Münster (violet), Ulrichen (turquoise, pink) and Obergesteln (blue). At point H, BactoSense was permanently installed and provided continuous measurement data. Manual grab samples for BactoSense were taken randomly or when there was a concern. The advantage of BactoSense over classical plating methods is that results are achievable within 20 mins. At point J, a contamination event occurred, which will be discussed in section „Complementarity between rapid detection and lab analysis".

Complementarity between rapid detection and lab analysis

During the camp, laboratory and BactoSense samples were taken for self-control at critical control points disseminated throughout the network. The focus was placed on areas with stagnation, endpoints, and points of consumption for sensitive consumers (emergency practices, childcare facilities). Laboratory analyses were crucial in confirming the nature of the contamination, but on-site monitoring with BactoSense allowed for quick interventions (Figure 3). When a microbiological warning value was exceeded, an assessment of the overall situation was conducted, and measures were taken accordingly. These ranged from intensified monitoring of a specific location to flushing sections of the pipeline, and even to emergency chlorination. The network system could be rapidly protected through additional chlorine dosing to the incoming water, which ensured safe water consumption for the participants.

Figure 3: Chronological listing of laboratory findings and results of offline measurements of the BactoSense for water sampling points I and J at the sanitary tracts (compared to Figure 1). The blue bars represent the TCC measurements from the setup of the system (BactoSense installation on 19.07.22) until the end of the study. Days without bars indicate that no samples were analysed offline with BactoSense. NN (not detectable) denotes days when samples were taken for laboratory analysis, but no faecal indicators were detected. There is no laboratory data for days marked with NA (unavailable). The red stars indicate days with positive laboratory findings. Note that the laboratory results mentioned were obtained one to two days in advance of the official lab report. In essence, if a positive result appears on the list, it means the outcome was received within a maximum of two days. The faster results provided by BactoSense enabled faster response measures.

From 1 to 3 August, a contamination incident was identified (Sanitary Tract Point J), as indicated by the dot plots generated by manual sampling with BactoSense (Figure 4) and verified by lab results, confirming Enterococci's presence. The uncontaminated sample displayed a typical dot plot for that measurement point with a TCC of 12,090 cells/ml, while in the second - contaminated - sample, a clearly distinguishable secondary cluster was observed with a TCC of 636,140 cells/ml, signifying the presence of a contamination event. This more than 50-fold increase of cells/ml is an indicator of issues in the water pipelines. Using fingerprinting techniques [3], bacterial contaminations can be compared by further analysis of the generated Flow Cytometry Standard (FCS) files, all of which consistently exhibit a shift to a different bacterial pattern. The ability to measure TCC on-site and within 20 minutes allowed for targeted sampling and follow-up measurements in the laboratory, as well as the prompt initiation of measures to ensure the drinking water quality for approximately 30,000 people over two weeks.

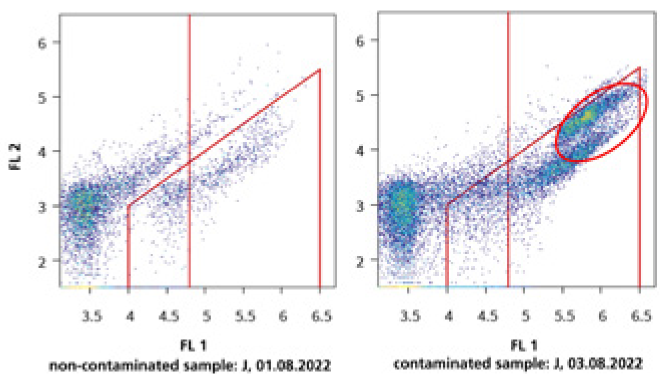
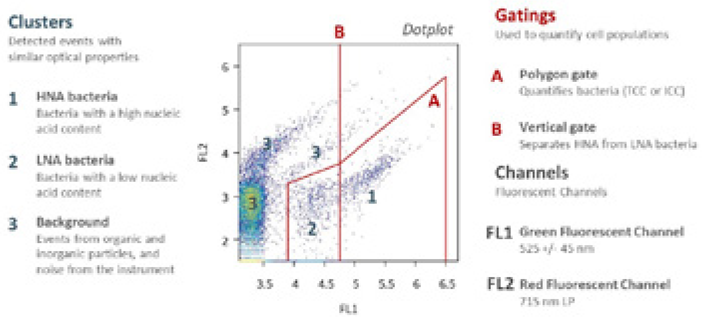


Figure 4: Comparison of a non-contaminated sample (01.08.2022; TCC=12,090 with a contaminated sample (03.08.2022, TCC=636,140) taken from sanitary tract J. A shift in the bacterial population was visible within the contaminated sample (red circle). On that day, contamination with Enterococci was confirmed.

In conclusion, the successful management of the temporary drinking water infrastructure at the „mova" federal camp demonstrated the importance of proactive planning, self-monitoring and swift action to ensure safe drinking water. The challenges faced underscored the need for continuous assessment and adaptation, with both on-site monitoring and laboratory analyses playing crucial roles in maintaining water quality. Using on-site flow cytometry with BactoSense provided real-time information for effective decision-making. This experience is a valuable lesson in the effective management of large-scale, temporary water supply systems.

Excurse: Dot plot analysis

The analysis of BactoSense dot plots primarily focuses on two clusters: high nucleic acid content (HNA) and low nucleic acid content (LNA) bacteria (as shown in Figure 5). Gate A contains either Total Cell Counts (TCC) or Intact Cell Counts (ICC). Standard gates provided with BactoSense typically encompass the most relevant scenarios. Within the HNA group, there is an abundance of thriving and well-growing bacteria, including pathogenic strains. If you possess the fingerprint of potentially pathogenic bacteria, this knowledge can facilitate the early detection of contamination risks [3]. The gates effectively filter out background interference, inorganic particles and instrument noise.



Benefits

- Microbial quality control of the water within 20 minutes instead of days
- Constant surveillance of the water network
- Quick response time in case of contamination
- Support of self-control measures according to guidelines
- Fingerprinting allows for contamination detection
- Rugged and compact design of BactoSense makes it possible to be deployed in harsh environments

References

This application note is based on an article in Aqua and Gas:
Oechslin et al. “Ein Flowcytometer im Pfadilager”, 28. November 2022, Aqua & Gas

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bNovate Technologies SA
Ch. Dent d’Oche 1A · CH-1024 Ecublens
Tel. +41 (0)21 552 14 21
info@bnovate.com · www.bnovate.com