Intelligent water systems and real-time condition monitoring

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WATER TECHNOLOGIES

Ensuring water quality with intelligent water networks

Introduction:

Water network operators, such as water utilities and local councils, are tasked with the vital role of ensuring safe, reliable, high-quality water supply to the public. However, water quality can be affected by a vast range of factors throughout the various stages of its journey from source to customers' taps. Real-time condition monitoring enables the detection of any changes in water quality or other variables as soon as they occur within a network. As a result, it can be instrumental in ensuring the quality of the product reaching end users, preventing potential health and safety issues, maintaining reliable supply and gaining a fuller understanding of the network for optimal operation.

Access to clean potable water is one of the essential backbones underpinning a nation's development, the health and quality of life of its inhabitants, and the functioning of its economy. In Australia, drinking water quality standards are specified by the Australian Drinking Water Guidelines. These guidelines provide a framework for the management of drinking water supplies and define acceptable parameters for various physical, chemical and microbiological water quality measures. Some of the key water quality measures included in the guidelines include pH, turbidity, colour, total dissolved solids (TDS) and levels of various chemicals such as chlorine, fluoride and others. Australian public health laws require drinking water suppliers to develop and adhere to a quality assurance program. Additionally, Australian states and territories may enforce their own regulations regarding drinking water quality.

Drinking water from catchments or other sources is treated at the water network operator's treatment plants before entering the distribution network and being transported to customers. The treatment processes used in any given case depend on the particular water source and other factors, such as how far the water will have to travel in the distribution network before reaching end users. Common treatment processes include sedimentation, coagulation, flocculation, various types of filtration, disinfection (using chlorine, chloramine and/or ultraviolet light), fluoridation, and pH correction. These processes ensure that any potential pathogens or contaminants that may pose a risk to human health are removed, and that the water has acceptable taste and aesthetics. Chemicals added to the water during treatment, such as chlorine gas or chloramine (a compound of chlorine and ammonia which provides longer lasting disinfection and is therefore often used when water must travel longer distances before reaching end users), also serve to keep it disinfected as it travels throughout the distribution network to end users.

However, environmental conditions and other factors within the network can still affect water quality, resulting in changes in its aesthetics, taste or even safety for drinking. Factors that can negatively affect water quality and supply include climate, network faults, leakage, seepage, variations in flow, metal leaching,

construction and maintenance activities, the condition of pipes and other infrastructure, the build-up of algae or other microorganisms, and more.

As a result, water network operators must control and monitor water quality, as well as other parameters such as pressure and flow, to detect any issues and ensure that drinking water is reaching the consumer without deviation in quality. This monitoring is increasingly important as water network infrastructure ages. Some Australian water network infrastructure has been in operation for over a century and is nearing the end of its service life, meaning it may be more prone to faults with the potential to affect water quality.

Extensive water quality sampling is undertaken throughout drinking water networks in Australia. Sampling locations depend on the characteristics being examined, but generally include locations at the water source, the inlet and outlet of water treatment plants, and locations throughout the distribution system, including the point of supply to the consumer.

While some water quality tests are completed in the field, samples are generally also sent to a laboratory to achieve the most accurate results for the widest range of attributes. There they are tested for dozens of key water quality characteristics including taste, colour, odour, microorganisms and chemical content. However, these forms of sampling and testing can be time-consuming, may require staff to navigate potential health and safety hazards, and lab testing involves a delay between collection of the samples and receiving the results. This creates a potential delay in response to any problems detected.

In recent years, innovations in intelligent water networks have vastly improved the reliability and operation of water networks. For instance, real-time pressure and flow monitoring data loggers, which transmit pressure and flow data from sensors located throughout the water network to a central location for analysis, were used to great effect to reduce non-revenue water loss during the millennium drought in Australia. Now, analytical sensors are available with the capability to measure not only operational parameters such as pressure and flow in real-time or near real-time, but also various water quality indicators, for a more comprehensive overview of the system.

High-quality, accurate sensors transmitting water quality data from locations throughout a water network can complement lab and field sampling and assist network operators to adhere to the ADWG and their regulatory obligations, in addition to providing an array of other significant benefits to them and their customers. These benefits may include increasing customer confidence and safety, enabling efficiency improvements, and facilitating a faster response to any faults or water quality issues.

This paper will address how smart monitoring solutions that provide high-resolution monitoring of critical water quality parameters – such as the Chloroclam® water quality monitor and the Hydraclam® water turbidity and pressure monitor offered by Evoqua Water Technologies – can be employed within drinking water systems for a truly intelligent water network.

1. Water quality monitoring for intelligent water networks

1.1 Going beyond manual sampling

When it comes to monitoring and controlling water quality, lab testing provides a high level of accuracy and can measure the widest array of different parameters. However, the process of manually taking the sample, transporting it to the lab where testing is undertaken, then waiting to receive the results can be time-consuming, and can result in a delay between an water quality issue occurring within the network, its detection, and the mobilisation of an appropriate response or corrective action.

As some issues of water quality can be hazardous to human health, network operators must take measures to minimise any delays as much as possible.
Even water quality issues that don't endanger the safety of water for human consumption, such as discoloration or taste issues that might result from network maintenance activities, can inconvenience consumers and cause customer dissatisfaction if the issue is not resolved quickly or those affected are not forewarned.

Furthermore, accessing laboratory-based testing can be difficult for small and remote systems, and tests for some water quality parameters (such as temperature, free and total chlorine and monochloramine) must be undertaken within an extremely short time of sampling for accurate results.

Field tests can be undertaken for some water quality parameters, but these may require staff to manually collect samples in conditions that pose potential health and safety risks, or to work with potentially hazardous chemicals. Field-testing can be time-consuming, and can be less precise than other testing methods.
For instance, colorimetric diethyl-p-phenylenediamine (DPD) testing may be used in the field to measure chlorine concentrations. However, this requires staff to be out in the field visiting various locations around the network to undertake tests, which can be inefficient and time-consuming, and the colour comparison method doesn't provide highly precise measurements.

Deploying devices capable of real-time remote monitoring of water quality parameters in key locations around a water network can complement manual sampling to help solve some of the aforementioned issues, provide another control point in support of the Australian Drinking Water Guidelines (ADWG), and result an additional system improvements to benefit network operators and their customers.

1.2 The benefits of intelligent water systems

Remote sensors measuring key water quality parameters throughout the water network can provide vital data in real-time or near real-time, complementing field and laboratory-based testing methods, and reducing delays in detecting and responding to issues.

Among other benefits, this multi-measure approach can help to safeguard health and safety, improve customer satisfaction, and result in high-quality continuous data that can be utilised in a range of different ways to optimise network performance.

1.2.1 Water quality data in real-time

Utilising remote communications-enabled analytical sensors to collect and transmit water quality and quantity status data in real or near real-time means that water network operators can detect water quality or other issues as soon as they occur. This can help limit the duration of these issues or sometimes even mean they can be corrected before they inconvenience customers or become serious enough be hazardous to human health.

While pressure and flow monitoring enables early identification of network faults like leaks or bursts, sensors measuring key water quality parameters throughout the network, such as chlorine levels or turbidity, can detect potential water quality problems.

For instance, declining chlorine levels within a section of the network could be identified before they become low enough to provide inadequate disinfection, enabling action to be taken to fix them before anyone becomes ill.

Water quality monitoring is also particularly important in areas where maintenance or construction activities on or near the water network are underway. For instance, recently in Victoria construction contractors installing recycled water connections for non-potable use accidentally connected the recycled water through the drinking water supply of three homes, resulting in a shandy of Class A recycled water and clean drinking water coming out of the customers' taps. In this case, customers were told to watch out for and report any changes in water quality during and after construction. However, real-time water quality monitoring at the point of supply to the customer could potentially have alerted network operators to this issue earlier, before the customers drank the water and noticed the problem.

Overall, real or near real-time monitoring technologies, and the alarm capabilities of such technologies, can result in considerable improvements in response time to problems within the water network.

Additionally, by collecting continuous data on various parameters within the network, this type of monitoring also enables the correlation of different data

points, resulting in a more comprehensive understanding of the system. For instance, increases in turbidity or increases or decreases in chlorine levels could be correlated with different variables (for instance, weather events, pressure, and demand on the system). In some cases, this enhanced understanding of the network can even be used to predict faults before they occur, such as identifying pipes at risk of breaking, working out where seepage is likely to occur in the network, or identifying potential chlorine dead zones.

In this way, intelligent water networks can help network operators' move towards proactive, rather than reactive, control of their systems and prevent quality and quantity failures before they affect customers. This can also aid them in countering the effects of ageing infrastructure within the network.

The availability of high-quality continuous data also allows for improved, more comprehensive compliance reporting.

In some cases, remote water quality monitoring can also reduce the required frequency of manual sample collection for particular locations. Reducing the need for staff collecting samples in the field can result in fewer health and safety risks to personnel and more efficient human resource allocation for the water network operator.

The end result is better service for customers, resulting in greater customer satisfaction, higher consumer confidence and fewer complaints, as well as enhanced public health assurance, easier regulatory compliance for utilities and local councils, and better peer comparisons.

1.2.2 Supporting hydraulic modelling and enabling better planning

Real-time monitoring of critical system parameters supports more accurate hydraulic modelling, allowing for enhanced long-term planning and for network management strategies and other decision-making processes to be better guided. Monitoring data from sensors within the network can be used to ensure hydraulic models are properly calibrated to reflect the system they represent.

This not only allows existing problems and their causes to be identified, but can also be used for long-term planning to ensure adequate water supply and quality into the future and to investigate how the system might respond to different changes.

Zones prone to water quality issues or where infrastructure is no longer performing adequately can be easily identified, enabling long and short-term strategies to address them to be formulated.

Reducing the number of unknowns within the water network provides the utility or local council operating the network with greater confidence when allocating their resources, meaning that reactive strategies can be improved. Maintenance,

replacement or network augmentation activities can be scheduled where they are most urgently required and undertaken as efficiently as possible.

Hydraulic models calibrated from real-time monitoring data can also be instrumental in enabling operators to optimise network performance and efficiency through activities such as rezoning of distribution networks and valve adjustment.

All in all, system monitoring of operational and water quality parameters can aid in not only preventing serious problems within a drinking water, but can also be used to optimise network operation and make significant product or service level improvements in both the short and long-term, reaping an array of benefits for both the network operator and their customers.

2. The Chloroclam® water quality monitor and Hydraclam® water turbidity and pressure monitor

Evoqua Water Technologies offers two smart network solutions to provide high-resolution real-time monitoring of critical water quality parameters, as well as pressure and turbidity.

The Chloroclam® water quality monitor measures free or total chlorine and temperature within the water distribution network, while the Hydraclam® water turbidity and pressure monitor transmits measurements of pressure, low-range turbidity and electrical conductivity.

The Chloroclam and Hydraclam monitors are compact, ruggedly designed, weather resistant, and portable loggers. They connect to existing fire hydrant points in the reticulation network, so no mains tapping is required. They are suitable for long-term monitoring of an area or can be easily installed in a temporary location (for example, to monitor water quality in an area during or after network maintenance activities).

Working together, these products enable water distribution system managers to optimise their operations and ensure regulatory compliance by providing a comprehensive, near real-time view of water quality throughout the network.

2.1 Chloroclam water quality monitor

This battery-powered, GPRS/GSM and current 3G-enabled device provides free or total chlorine measurement using the Wallace & Tiernan® FC1 or TC1 membrane probes, while also measuring temperature.

Key features of the Chloroclam include:

- Can access the water main via the hydrant point enabling rapid and simple deployment/recovery while taking data from location close to customers' taps
- Wireless communications and alarming

- High accuracy industry standard membrane sensor
- Continuous remote chlorine monitoring
- Data is recorded on a robust internal data logger
- Remote data access via the internet
- Low power: internal power supply will allow deployment for 12 months (based on sampling every 15 minutes and three data uploads per day)
- Optional input and power supply for external pressure transducer and flow monitoring
- Submersible robust IP-68 enclosure

Using the Chloroclam monitor, drinking water network operators have been able to optimise network re-chlorination, understand water age and identify chlorine dead zones in their networks, resulting in enhanced water quality.

In many cases, the Chloroclam monitor has also reduced the need for time-consuming manual diethyl-p-phenylenediamine (DPD) testing, and has reduced health and safety issues associated with manual dosing and handling of sodium hypochlorite.

Additionally, the Chloroclam monitor integrates with a smart phone app, which visualises the chlorine residual reading in real-time. The app can be used for on-site calibration adjustments of the Chloroclam monitor via Bluetooth communications.

Alarm capability means that operators are immediately alerted to any issues, enabling fast response.

2.2 Hydraclam water turbidity and pressure monitor

The battery-powered Hydraclam monitor has the ability to measure pressure, low-range turbidity and electrical conductivity (which can be used to determine TDS).

Key features of the Hydraclam include:

- Sampled remote monitoring of turbidity and pressure
- Can access the water main via hydrants
- Quick and easy installation
- Wireless communications and alarms to alert users of turbidity and pressure breaches in near real-time
- Data accessed via secure website
- Battery powered operation and communications allow hassle-free review of quality data feed
- Data collection to assist strategic planning and meet regulatory requirements
- Plug-and-play in minutes
- Achieve near real-time turbidity data from multiple points in your network at low cost

The Hydraclam monitor enables early detection of water quality issues, so that any problems within the network can be responded to as soon as possible.

The water quality parameters measured by the Hydraclam monitor also help water utilities to calibrate hydraulic water models, understand the flow patterns of mixed water sources and predict water discolouration events in the network, among many other planning and operational applications.

2.3 Advanced communication capabilities and seamless integration with existing systems

Once data is logged on the instruments, it is transmitted to a secure web portal where it is mapped and presented in various forms, and alerts are sent if required.

The web portal incorporates Google Maps for device visualisation and network location, and incorporates the functionality for user-defined alarms that can be sent via SMS or email.

The web portal also offers a data analysis tool to correlate the data that is being transmitted from the field devices. Additionally, sampling frequency and data upload times can be adjusted by the customer to suit their particular water system's needs and their data requirements.

These functionalities provide the network operator with a more complete picture of chlorine behaviour and decay through the distribution system so they can be assured adequate disinfection is being provided, as well as a enabling a comprehensive view of turbidity and other water quality parameters.

Data can also be transmitted directly to the network operator's SCADA platform via a DNP3-RTU (remote terminal unit), where it can be used for visualising events and obtaining variation alarms to help ensure the safety and quality of drinking water being delivered through the network.

2.4 Additional services ensure successful monitor installation

Evoqua Water Technologies also provides mechanical protection (enclosure/housing) options for both sensors, fast and safe connection, fittings and instructions.

The high portability and robust design of the loggers enables customers to rapidly deploy them across their network zones for permanent or temporary use.

3. Conclusion

Supplying safe, reliable, high-quality drinking water to the public is an essential service provided by water network operators such as water utilities and local councils. However, the aesthetics, taste and even safety for consumption of drinking water can be negatively affected by any problems at any point within the water network, from water source, to treatment plant, to distribution network and point of supply to customer. Therefore, to ensure the drinking water reaching the customers does not deviate from acceptable quality parameters, water quality must be monitored.

Remote monitoring devices located throughout the network and transmitting data on key water quality parameters, as well as pressure and flow, can complement lab or field-based testing methods to enhance water quality assurance and enable fast response to any problems that occur. They may also enable more efficient allocation of resources and reduce health and safety risks to staff and consumers. Additionally, this data allows operators to gain a better overall understanding of their system in order to predict potential issues before they eventuate, aid better network management, and make hydraulic models more accurate and representative of the system, supporting better long and short-term planning.

The Chloroclam and Hydraclam monitors available through Evoqua Water Technologies provide a comprehensive remote monitoring solution, transmitting accurate measurements of chlorine levels, turbidity, pressure and temperature in near real-time. By utilising these devices within drinking water systems, network operators can realise significant benefits for themselves and their customers, while increasing consumer confidence and supporting regulatory compliance.
To learn more about how Chloroclam and Hydraclam monitors can help assure water quality within your network contact Evoqua Water Technologies at:

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