Real time water quality monitoring at Rand Water

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Abstract

Monitoring water quality in the provision of drinking water involves a comprehensive program, testing the water from ‘cradle to grave’. Water quality monitoring of raw water begins in the catchment, followed by water quality monitoring at the purification sites, and culminating in quality monitoring within the distribution network, down to the tap. This comprehensive program entails the taking of water samples within a vast area, transport of samples to a laboratory, production of water quality data, and follow up actions to ensure the consistent delivery of potable water which meets required quality standards. Whilst the associated time delays in obtaining the requisite data may be accommodated in catchment quality monitoring, such delays present challenges in responding to water quality non-conformances within the distribution network.

Technological advancements now provide solutions to the timely provision of water quality data to ensure the uninterrupted delivery of high quality potable water. The advent of real time monitoring instruments provide data instantly allowing for immediate responses to water quality challenges. Rand water has deployed online analysers to achieve twenty four hour monitoring of key water quality parameters such as pH, conductivity, turbidity and chlorine residual. Rand Water currently boasts one of the most comprehensive on-line monitoring systems, operating over 1000 online water quality monitoring analysers.

This presentation will provide a holistic view of Rand Water’s efforts in deploying emerging technologies for real time water quality monitoring to underpin both quality control and quality assurance, towards achieving the uninterrupted supply of healthy drinking water. Current technologies will be looked at and other emerging technologies will be covered with a view to being considered for future deployment.

1. Introduction

Rand Water extracts raw water from the Vaal Dam and this raw water is purified in Vereeniging at two separate purification stations, namely the Zuikerbosch and Vereeniging Stations. The purified water is then pumped to booster stations located south of Johannesburg, where secondary disinfection of water is carried out as water is pumped further north into the distribution system. This value chain is depicted in figure 1.
Raw Water

Water from the Vaal dam is abstracted for purification at the Vereeniging and Zuikerbosch water purification plants. The incoming raw water quality is measured in newly constructed online laboratories. A total of 5 new raw water laboratories were constructed in 2012 to house the raw water analysers. The parameters pH, electrical conductivity and turbidity are measured in these facilities. The instruments used for raw water analysis differ from the conventional analysers being more robust in design and handle higher concentrations of turbid water. Data from these analysers are stored on the InSQL database and is used to monitor the incoming water quality. A total of thirty three instruments are installed to determine raw water quality.

Coagulation and Flocculation

The initial steps in the purification of raw water is the coagulation, flocculation and sedimentation process. During this process sodium silicate is added to the incoming raw water. High range conductivity analysers are used to ensure that the activated sodium silicate is dosed in correct amounts. Automated online titrators are also used for measurement and control of the activation of the sodium silicate. During these processes pH meters are also used to determine if the correct amounts of lime are dosed to increase the pH of the raw water. This is a very harsh environment with pH levels ranging between 10.0 and 11.6. The harsh environment has led to investigations to seek alternative measuring technologies going into the future. Twenty instruments are currently installed and another fifteen are currently undergoing testing to determine the feasibility of their performance.
Sedimentation
At the outlet of the sedimentation tanks turbidity meters are installed. These analysers are used to ensure that the sedimentation process is operating optimally. The instruments on these processes are used only to assist operators and are not used for automated control purposes. Forty instruments in total inform the operators of required changes to process operations, and process controllers respond accordingly to any significant changes in turbidity.
Carbonation
The next step in the purification of water is carbonation which entails the lowering of the pH levels from the sedimentation tanks by the use of carbon-di-oxide. Here pH meters are used both as measurement and control functions. Both inlet and outlet pH values are analysed and these values are used electronically to control the dosage of CO₂. The signals are send to a PLC (Process Logic Controller) which open and closes the dosage valves. A total of seventy five instruments are installed to monitor the carbonation bays.

Figure 4. Carbonation

Filtration
Upon lowering the pH of the water, the water is then released into the filter houses. Each filter in Rand water is equipped with online Turbidity meters. In past years these analysers used infra-red light sources but studies demonstrated challenges with this technology and the move to white light nephelometers was made. The data from these analysers is sent to the SCADA system in the operations control room where it is used to monitor individual filters for potential breakthrough. The filters backwash cycles can be run on a fixed 48 hour cycle or be washed when a filter’s outlet turbidity exceeds the allowed discharge turbidity. Currently four hundred analysers are installed to monitor the filters at Rand Water and a further ninety six are being installed.
Primary disinfection
The final step in water purification is disinfection with chlorine. In past years chlorine was injected from the chlorine rooms and a contact time of between 5 and 15 minutes was allowed to permit sufficient disinfection of the water. Chlorine levels in the water were then measured in the outgoing kiosk. Based on these chlorine readings, a signal was sent back to the chlorine room where the dosages were controlled. Advances in technology have permitted increased precision with which disinfection can be achieved. Dedicated amperometric analysers are now being utilised to measure and control the dosing of chlorine. The amperometric analysers were selected over colorimetric analysers because of its continuous measurement capabilities and better controlling of dosage via the PLC. Twenty such analysers are currently being used to control the disinfection of water.
Final monitoring at purification plants
After chlorination the water is ready to leave the purification plants and enter the distribution system. This is when the final water quality is measured for compliance to Rand Water production standards as well as the South African national standard, SANS 241. Facilities on sites created in the past to carry out these functions did not meet the basic requirements of ISO 17025. Hence Rand Water embarked on a project to upgrade these facilities and have them accredited.

Newly constructed online laboratories at both purification stations now house highly accurate online analysers which have been subjected to rigorous evaluation as per Rand Water’s online instrument selection protocol. Analysers were selected for their measurement capabilities and have been standardised throughout Rand Water. These on-site facilities are fitted with air conditioners, as well as temperature and humidity sensors to control the instrument environment. Limited access to these site laboratories are controlled with the use of biometric access control.

Six online laboratories for monitoring of potable water are fitted with eighty online analysers which measure parameters including pH, electrical conductivity, turbidity and free chlorine. These parameters are measured on the 20 pipelines leaving the purification plants. The data generated by these analysers are analogue signals 4 – 20 mA or digital Profibus (process field bus) signals. The data from these analysers are displayed on a HMI (Human Machine Interface) inside the respective facilities. Operators interrogate the HMI for real time analysis values (as well as historical trending if the need arises). The data is also sent to a central InSQL data base from where it is displayed on the SCADA (Supervisory Control and Data Acquisition) PC via a LAN (local area network) system which is installed in the control rooms. These analysers deliver real-time continuous readings that can be updated every second. Daily reports are generated from the InSQL database and sent to top management (as compliance figures).
Incoming booster site monitoring
When the water has entered the distribution network it is pumped to the four booster pumping sites. Here the incoming water quality on the 13 incoming pipelines is also monitored by new online laboratories with the same specifications as the ones at the purification plants. At booster sites the parameters of pH, electrical conductivity, turbidity and total chlorine are measured and the data is treated in the same manner as at the purification plants (HMI, SCADA InSQL). Currently fifty two analysers provide the required data at booster sites.

Secondary disinfection
At the booster pumping sites the water is chloraminated (secondary disinfection). The new upgraded chlorine facilities deviate from the conventional dosage philosophy by making use of a feed forward system. The chlorinated water coming in is measured by means of online chlorine analysers to determine residual chlorine levels in the system. This value is used to determine how much further disinfection is required to meet the required disinfectant residual levels. After the appropriate level of chlorine is dosed, the appropriate amount of ammonia is added (4:1 ratio).

After chloramination the water from the 4 booster sites (supplying 25 pipelines) is monitored for seven different parameters within new online laboratories. At this final monitoring point the water is analysed for pH, electrical Conductivity, turbidity, free chlorine, total chlorine, ammonia and monochloramine. One hundred and seventy five analysers are installed at this point to provide the required data.

Distribution
In the distribution system some key reservoir sites have been fitted with online analysers. At these sites pH, conductivity, turbidity and Combined chlorine is analysed and the data
and is sent to a central point using a radio link. In future this way of data collection will be changed to a 3G or wireless connectivity network.

There are also hypochlorite dosage plants that have analysers which are used for the measurement and control of tertiary disinfection.

**Future online projects**

A project is under way to increase the monitoring in the distribution network. Analysers for quality control (QC) and quality assurance (QA) are to be installed at strategic locations. An assessment is underway and currently 150 sites have been identified as possible areas that require monitoring. At these sites a series of parameters have been identified that will fulfil QC, QA and research requirements.

The parameters identified include the following: monochloramine, ammonia, free and total chlorine, pH, nitrite, nitrate, oxygen, turbidity, conductivity, temperature, oxidation reduction potential (ORP), total organic carbon (TOC) and dissolved organic carbon (DOC).

With the changes in the SANS241 requirements the nitrification of the water has been highlighted as a problem area. To monitor nitrification, nitrate and nitrite analysers are to be installed in the distribution network. A study to assess the availability and accuracy of these analysers in the market is currently being undertaken.

2. **Conclusion**

The consistent supply of healthy potable water in any country is a challenge. However in a water stressed country like South Africa, this responsibility faces larger challenges. To maintain the supply of quality potable water to some twelve million consumers in Gauteng and neighbouring provinces, Rand Water has embarked on real-time monitoring of water quality in its entire supply chain. Significant successes have been realised in the monitoring of raw and treated water, although harsh environments within the water purification process are receiving attention to employ more robust instruments.

Projects are currently underway to provide equally adequate monitoring within the distribution network. The installation of real-time quality monitoring instruments within the distribution network will significantly enhance quality control, quality assurance as well as research and development at Rand Water in its quest to consistently supply world class drinking water to its consumers.