

16 Cape Town drinking water monitoring solution from Metrohm

On 28 July 2010, the General Assembly of the United Nations declared clean water and sanitation as a fundamental human right! This underlines the importance of water and hygienic standards that have to be checked by national and regional water and sanitation departments. An excellent water quality is not only crucial for the local population of the City of Cape Town and the tourist industry, it was also highly important for a successful hosting of the 2010 Soccer World Championship! ProcessLab water analysis systems from Metrohm are used to monitor the drinking water quality.

Cape Town drinking water

The drinking water of the City of Cape Town largely originates from unpolluted mountain catchments and is treated according to national and international drinking water standards in the city's water treatment facilities. There are nine main water treatment plants and some smaller ones within a distance of up to 80 km off from the city center. Cape Town's water treatment and distribution system is currently supplying more than 3.5 Million residents spread over almost 2500 km².



The operators of Cape Town drinking water treatment plants benefit from the easy operation of ProcessLab: analysis are performed fully automatically.

One of the most important tasks is to maintain a good water quality throughout the whole distribution system up to the customers tap. This can be assured by adding chlorine gas to the water to obtain an adequate amount of free residual chlorine at all points in the network. The modular ProcessLab analyzer platform from Metrohm is used to analyze the Cape Town water quality. Using built-in data network functionality, all analytical data are available immediately to all authorized managers.

Requirements for a new analyzer system

Plant operators in all water treatment plants ensure a safe and reliable drinking water production around the clock. They draw samples from the water processing stream at various sampling points that have to be analyzed quickly and therefore on-site. A suitable analyzer has to determine Free Active Chlorine (FAC; consists of dissolved chlorine and hypochlorite), pH value, temperature, P alkalinity*, M alkalinity**, and total water hardness fully automatically.

In the past, titrimetric methods with visual endpoint determination using color indicators have been used. Therefore, the results depended on the operator's perception. Results were written down in a paper logbook in each plant and had to be collected by calling the plant operators. This procedure was labor-intensive and error-prone.

It takes a few minutes to two hours for the water from the different treatment plants to reach the City of Cape Town. It is inevitable to centrally monitor, store, and manage the analysis results of all water treatment plants and to make them immediately available to all area and plant managers. With proper water and sanitation management in place, in case of issues, there will be sufficient time to take countermeasures.

A new, easy-to-use analyzer had to be free from all these drawbacks, enabling Cape Town a secure and reliable water treatment plant operation.

*P alkalinity: phenolphthalein alkalinity obtained by titrating to pH 8.2

**M alkalinity: methyl orange alkalinity obtained by titrating to pH 4.3



Unpolluted mountain catchments and reservoirs provide the water treatment plants with high-quality raw water.

Metrohm solution: networked ProcessLab analyzer system

Metrohm's automated water analyzers MATi (Metrohm Automated Titration System) for laboratory analysis and the atline analyzer ProcessLab fulfill Cape Town's requests. In 2007, the authorities contacted Metrohm and had several MATis installed in the Scientific Services' laboratories of the Water and Sanitation Department of Cape Town. Very positive experiences led to the implementation of a ProcessLab demo system. Fully satisfied, the City of Cape Town decided to buy additional eight ProcessLab systems in 2009. They were installed at the water treatment plants in early 2010.

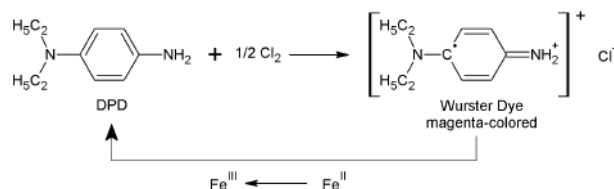
Easy operation and reliable results

ProcessLab is a modular and fully-customizable analyzer for automated process analysis (atline analysis). Its operation is based on the same **tiamo**[™] methods that are already used for several MATi systems in the Scientific Services main laboratory. The methods now feature fully automated electrode calibration as well as record keeping of calibration data. ProcessLab analyzes samples within minutes with a much higher repeatability and accuracy compared to the old manual determination methods. Working with ProcessLab is so easy: After collecting water samples from various sampling points at different stages of the water treatment process, the operator directly brings them to the analyzer. There he enters his user name and password, simply selects the method, and starts the determination.

Excellent data availability and safety

The nine ProcessLab analyzers installed in the water treatment plants are the clients of a **tiamo**[™] client-server network. The central **tiamo**[™] server is securely located within the IT Department of downtown Cape Town civic centre. The client-server database ensures that new results from the clients are immediately transferred to the central server. Trouble-free operation of any client connected is also supported by storing all their methods on this server. All systems are equipped with uninterruptible power supplies (UPS) to guarantee all-time availability of the analyzers. On the clients, the access to sensitive functions and methods is protected from alteration by the plant operators – to ensure consistent data.

All analytical data, including curves (especially titration curves), are immediately available to all area and plant managers, the quality monitoring department, and management. They now have sufficient time to take countermeasures right from their office desks, if necessary. Data transmission over distances of up to 80 km from the clients to the server is achieved via the technical network of the City of Cape Town using Ethernet connections and wireless point-to-point connections.



DPD is used to detect free active chlorine.

Training and maintenance by Metrohm Service Engineers

More than 100 Cape Town plant operators received training by Metrohm Service Engineers on topics like general use, care, and maintenance of ProcessLab. The accurate determination of the different sum and individual parameters as well as electrode calibration was discussed too. Metrohm also optimized and adapted the applications to local conditions (e.g., hard or soft water). A service and maintenance contract for the next two years makes sure that the systems keep running smoothly.

Method and parameters measured by ProcessLab

In Cape Town, the nine ProcessLab analyzers determine the following parameters of various process water samples fully automatically:

- Free Active Chlorine (FAC)
- P and M alkalinity
- pH value and temperature (pH can also be determined under N₂ atmosphere)
- Total water hardness (only if necessary at specific plants)

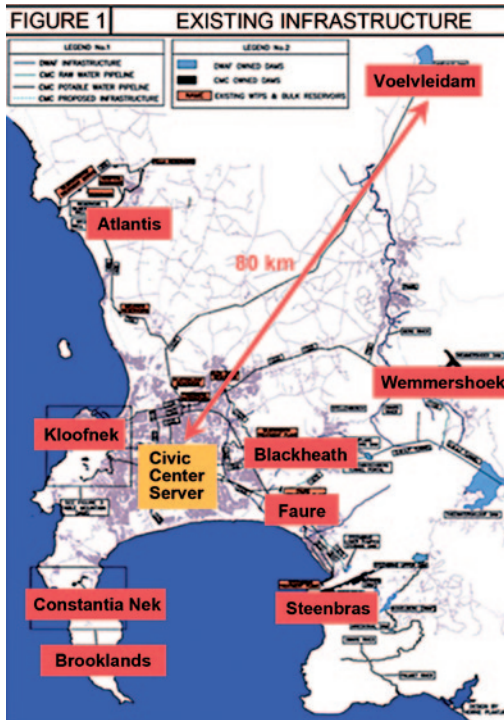
Prior to each analysis, the 100 mL overflow pipette and the titration vessel are cleaned by rinsing with sample to be analyzed. The runoff is collected in a waste container. This is followed by a three-cycle rinsing step with deionized water using four spray nozzles.

The sample is then aspirated into the overflow pipette using peristaltic pumps. A solenoid valve is opened to transfer the sample by means of a transfer pump from the overflow pipette into the titration vessel. After all auxiliary agents have been added via additional peristaltic pumps, the analyses are performed. In the end, the spent solution is disposed of in the waste container and the titration vessel, sensors, magnetic stirring bar, tubing, and burette tips are rinsed with deionized water.

Free Active Chlorine (FAC)

Chlorine gas is used for the chlorination of drinking water. Free active chlorine destroys disease causing bacteria contained in the water. To ensure safe drinking water, after final chlorination in the water treatment plant, chlorine has to be topped up at several places throughout the whole water distribution system network.

DPD (N,N-diethyl-p-phenylenediamine) is used to detect free active chlorine in the ProcessLab DPD titration method. DPD is oxidized by chlorine to form a magenta-colored, mesomerically stabilized, semiquinoid salt (Wurster Dye) as the primary oxidation product. The magenta-colored species is then titrated (reduced) in a phosphate buffered medium with ferrous ammonium sulfate to the colorless endpoint using a separate gold electrode.



Map with the Cape Town main water distribution system and the main water treatment plants located up to 80 km off from the city center.

pH value & alkalinity

pH value and alkalinity serve as typical sum parameters and are required to be within certain limits. The alkalinity is determined by titration using hydrochloric acid as titrant with an Aquatrode plus sensor. The P alkalinity (acid capacity up to pH 8.2, K_A 8.2) is determined by titrating to pH 8.2 and the M alkalinity (acid capacity up to pH 4.3, K_A 4.3) by titrating to pH 4.3. Various process water samples are collected on an hourly basis; the analyses are performed automatically including calibration.

Soft water needs to be stabilized to protect the distribution system network as well as the consumers' plumbing and appliance from corrosion. This is done by first adding lime to an alkalinity of 30 mg/L as CaCO_3 and then CO_2 to correct the resulting water pH of 9.2. It is very important that pH value and alkalinity are monitored regularly.

pH measurement under nitrogen atmosphere

Measuring the pH value of the very soft, ion deficient, low alkalinity water of treatment plants Voelvlei and Brooklands posed a special challenge. During pH measurement, the slightest exposure of the water sample to atmospheric CO_2 caused an immediate pH drop (formation of carbonic acid). To ensure accurate results, nitrogen from a connected cylinder is used to transfer the aspirated sample from the overflow pipette into the titration vessel and, at the same time, to purge the titration vessel prior to sample introduction, and to cover the water sample with nitrogen before and during pH measurements. This process is automatically controlled by ProcessLab.

Total water hardness

Total water hardness – the sum of calcium and magnesium hardness – is determined according to Metrohm Application Bulletin AB-033 (see www.metrohm.com/com/Applications) by photometric titration with EDTA using Eriochrome Black T indicator. Raw borehole water (abstracted groundwater from a borehole) used by the Atlantis water treatment plant has a very high calcium content and needs softening by means of an ion-exchange resin. Hardness determination on the raw borehole and the final softened water is important for operating cost effectively. The ProcessLab now accurately determines the total hardness and facilitates the water softening process.

Summary

The Water and Sanitation Department of Cape Town can obtain and guarantee an excellent drinking water quality by operating a Metrohm drinking water monitoring system. Plant operators can easily determine Free Active Chlorine (FAC), pH value, temperature, alkalinity, and total water hardness of various water samples fully automatically and with high precision using ProcessLab. A client-server database ensures that new analysis results from the water treatment plants are immediately transferred to the central server for monitoring purposes and data storage. Results are fully traceable and countermeasures can be taken early, if necessary. ProcessLab provides the information to optimally and cost-efficiently soften hard water or stabilize soft water. Comprehensive Metrohm support, including user training and maintenance, assures a smooth operation of the monitoring system.