Figure 1. A comparison of aeration on 2 identical plants using RTC and conventional fixed DO control

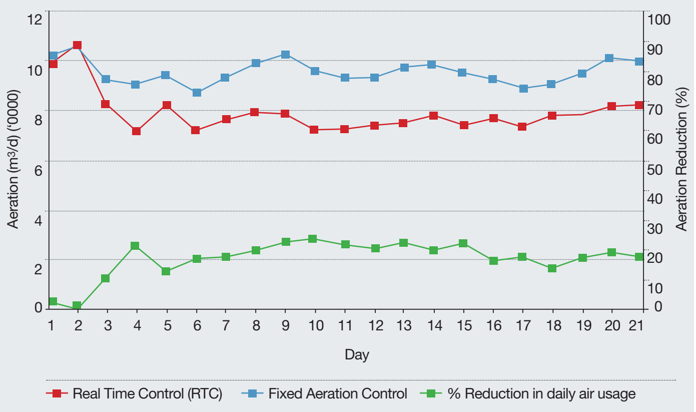
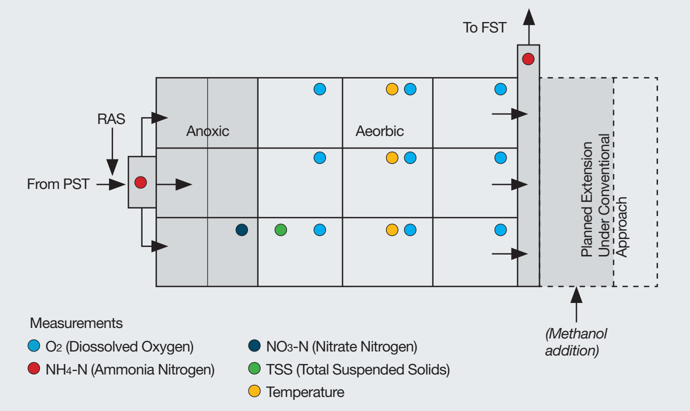


Figure 2. MLE process at site showing proposed extension to 4-stage Bardenpho and RTC instrumentation.



Capital outlay can decrease by up to 95 percent when using RTC instead of the conventional approach of expanding the treatment plant.

needs on a more advanced level by using instrumentation to measure the parameter being treated for in real time and by applying the required treatment in terms of either aeration or chemical. This advanced function gives operators the confidence to move away from the standard approach so that in times of low load or concentration significantly less power or chemical can be applied to meet the required output. As a result, operating costs can be greatly reduced with minimal capital investment. For example, typical savings in aeration can reach 15 to 25 percent in a well-operated plant.

Advanced process control offers additional advantages. More often than not, process optimization is thought to come with an element of consent failure risk. However, nothing could be further from the truth. Increased process visibility, achieved by the ability to measure and take action in real time, enables the treatment facility to react to abnormal conditions, which are often the reason for failure.

RTC provides wastewater treatment facilities the capability for tighter control, so its implementation can often offset the requirement for civil upgrades in instances of tightening consents or population increase. A growing number of projects have reflected this trend. Capital outlay can decrease by up to 95 percent when using RTC instead of the conventional approach of expanding the treatment plant. For example, a Modified Ludzack Ettinger wastewater treatment plant under consideration for expansion was faced with the need to meet new discharge consent levels. The plant, located on the south coast of the United Kingdom, was configured with 3 lanes to meet a total nitrogen (TN) consent of 15 milligrams per liter (mg/l). The

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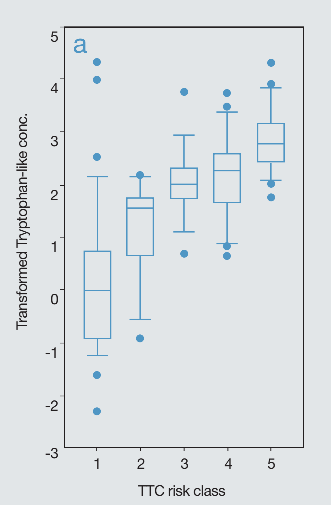
Field-based tryptophan sensor maps drinking water quality

A research team developed a new way to measure faecal pollution in groundwater by using Chelsea Technologies' UviLux field sensor that measures the protein tryptophan. **Dan Lapworth** of the British Geological Survey reports on recent research in Zambia that shows for the first time the sensor can be used in the field to rapidly assess the biological quality of drinking water.

Many types of bacteria found in wastewater and sewage cause diarrhoeal diseases and cholera, which kill 1.8 million people every year, 90 percent of whom are children under 5, according to the World Health Organization (WHO). Waterborne pathogens are typically inferred from the presence of surrogate indicator organisms such as thermo-tolerant coliforms. Their time-consuming analysis requires suitable laboratories and specialist-trained personnel, which can limit sampling resolution, particularly during critical pollution events. However, a quick, cheap, and accurate method of measuring this type of pollution is urgently needed in order to help efforts to provide safe drinking water.

A solution may now be available for Kabwe, Zambia and for water supplies throughout the world. A British Geological Survey team led by the author, along with colleagues Daniel Nkhuwa from the University of Zambia, Steve Pedley of the University of Surrey, and the Lukanga Water & Sewerage Company Limited in Zambia have collaborated to develop a new way to measure groundwater pollution by using a field sensor that measures a protein called tryptophan, an indicator of wastewater sources. Recent research published by this team (Sorensen et al., 2015) has shown for the first time that this sensor can be used in the field to rapidly assess the biological quality in drinking water sources.



Kabwe is a transport hub and an old mining town in central Zambia. Many of the townspeople cannot afford water bills, and the lack of investment led the municipal water system into a spiral of decline. This situation is mirrored across many towns in sub-Saharan Africa. Today, the town continues to grow in a haphazard manner, and sanitation is poor, with only 11 percent of low-income households having access to a latrine or toilet. Most of the poorer residents rely on water from shallow wells, and richer households have access to their own deeper boreholes provided by the unreliable municipal water system. But are these self-supply water sources safe? Does the risk change between the wet season and the dry? These are just a few questions that local government staff need to answer urgently, but they cannot obtain enough monitoring data from wells and boreholes during the year.

In Kabwe, the research team found that the amount of tryptophan measured by the probe corresponded very closely with bacteriological contamination in both the wells and boreholes. It confirmed that most of the shallow

The tryptophan sensor is quick, reagentless, and cheap, so it can enable rapid surveys of dozens of wells and boreholes across the town.

Left: The research team samples ground-water from shallow wells in Kabwe, Zambia.

Opposite left: Relationship between sensor (centered on tryptophan peak), tryptophan-like concentration, and thermo-tolerant coliform risk class (TTC). WHO risk classes are defined using thermo-tolerant colony forming unit counts/100mL as <2 (class 1, no risk), 2 to <10 (class 2, low risk), 10 to <100 (class 3, intermediate risk), 100 to <1000 (class 4, high risk), >1000 (class 5, very high risk).

Opposite right: Chelsea Technologies Group tryptophan sensor used to carry out the research.

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> This field tryptophan sensor can be used to test drinking water supplies within seconds and provides a good indicator of bacteriological contamination.
>
> **James Sorensen, British Geological Survey**

groundwater, which the poorest people in the town were using, was unsafe throughout in both the wet and dry seasons, but that the deeper groundwater was generally free from faecal pollution outside the city limits, unless the borehole had been poorly constructed.

The advantage of the tryptophan sensor is that it is quick, reagentless, and cheap, so it can enable rapid surveys of dozens of wells and boreholes across the town, which is impractical to achieve with traditional thermo-tolerant coliforms testing. Furthermore, the generally low turbidity and constant temperature of ground-water ensures that the uncertainty in the sensors values is greatly reduced when compared to applications in surface waters.

In Africa, where data scarcity and institutional capacity is a massive issue, this technique could provide a step-change in the ability to gather water quality data at a much higher spatial and temporal resolution. It has the potential to be used as a tool alongside conventional counting techniques to monitor water quality point failures and interventions to improve source protection.

The Kabwe project was funded jointly by the UK National Environment Research Council (NERC), the Economic and Social Research Council (ESRC), and the UK Department for International Development (DFID) as part of the Unlocking the Potential of Groundwater for the Poor (UPGro) international research program. Although the research from the UPGro grant has now finished, others are taking an interest, including the US-based charity Water for People, which asked BGS to trial the sensor in rural areas of India undergoing sanitary inter-ventions. Here, the sensor was successful at identifying bacterio-logical contamination in drinking water due to poor borehole completion, and the team was rapidly able to test up to six different supplies per hour and quickly map water quality from groundwater supplies in rural communities. BGS is now also undertaking a new NERC-funded project to develop the use of this type of sensor for monitoring raw water quality using real-time telemetry within the UK water industry.

Background

Several studies have highlighted the use of fluorescence as a rapid reagentless wastewater indicator (Baker 2001, Lapworth et al. 2008; Henderson et al. 2009). These observations are based on the good correlation between tryptophan-like fluorescence (a protein bio-marker), labile organic carbon, and microbial activity. A number of portable fluorimeters targeting the tryprophan peak are now commercially available as in-situ or roaming field sensors. A recently published paper by Khamis et al (2015) compares the performance of two commercially available field sensors and their sensitivity to turbidity and temperature effects.

Author's Note

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