CASE STUDY 000263

National Laboratory Service achieves high-throughput biomarker testing for SARS-CoV-2 wastewater surveillance using Gallery Plus discrete analyzers

"If you can warn local or national governments of a COVID outbreak about to occur, that's hugely powerful. Now we can see three to five days ahead if there's going to be a lot of cases presenting at hospitals. Having that early warning via quick, 24-hour turnaround on our biomarker testing, together with the molecular biology results, is something that we're really proud to have implemented. Without the Gallery Plus discrete analyzer, testing wastewater biomarkers at the scale and throughput needed wouldn't be feasible."

—Reg Godwin, Technical Specialist,
National Laboratory Service,
Environment Agency UK

Several Thermo Scientific™ Gallery™ Plus Discrete Analyzers are in operation providing high-throughput wastewater biomarker analysis at the NLS's Exeter laboratory. Photo courtesy of the NLS.

Gallery Plus discrete analyzer enables wastewater epidemiology program

Wastewater testing for SARS-CoV-2 can complement public health agencies' existing COVID-19 surveillance systems with early detection and prediction of COVID-19 spread in a community. Monitoring SARS-CoV-2 in wastewater is particularly useful where significant numbers of asymptomatic infections occur. In addition, the fluctuation of virus levels in sewage water can help agencies determine the effectiveness of preventive measures. The National Laboratory Service (NLS) of Environment Agency UK is one of the laboratories leading the way in the emerging field of wastewater epidemiology.

Wastewater samples for analysis. Photo courtesy of the NLS.

"We needed to implement the testing in a short space of time—essentially "yesterday"—and the features on the Gallery Plus system made that possible. It quickly and efficiently carries out all the analyses and is easy to use. We report results within 24 hours 98% of the time, so it's working well."

—Reg Godwin

Surveillance requires knowing how many individuals are contributing to the wastewater stream at the time of sampling so the reverse transcription-polymerase chain reaction (RT-PCR) detected amounts of SARS-CoV-2 viral RNA can be "normalized." Biomarkers, particularly ammonia and phosphate, allow NLS scientists to estimate the relative human fecal load in samples. Other factors such as pH, conductivity, and total dissolved solids are key to qualifying results.

Traditional wet chemistry approaches to measuring these biomarkers are complicated, time-consuming, and labor-intensive. However, rapid sample turnaround is essential to providing the timely information needed for public health decision-making. To meet the need for high-throughput analyses, the NLS achieves parallel measurements of key biomarkers from a single wastewater sample using the Thermo Scientific™ Gallery™ Plus Discrete Analyzer. In addition to parallel determination of multiple analytes from one sample, automation of analytical steps simplifies testing, reduces errors, and saves time and costs.

Parallel measurement boosts throughput and efficiency

The goal of Environment Agency UK's SARS-CoV-2 surveillance program is to provide scientific and governmental bodies with three to five days' advance warning of potential COVID outbreaks and trends. Given the disease progression in humans, seeing a few days into the future requires the NLS to turn around wastewater samples in 24 hours or less while running about 2500 samples a week. Traditional testing of biomarkers in wastewater involves multiple time-consuming, labor-intensive wet chemical analyses. Each test often requires a separate sample with its associated reagent consumption and waste. Overall, performing several hands-on chemical tests limits sample throughput, requires more sample, and increases costs.

Consolidated multiparameter discrete analysis with the Gallery Plus analyzer offers a faster, hands-off, single-instrument solution that can simultaneously test up to 20 parameters in one sample. The Gallery Plus analyzer increases sample throughput and efficiency by offering the two parallel measurement techniques the NLS needs: photometric analysis for ammonia and phosphate, and electrochemical analysis with the electrochemistry module (ECM) for pH and conductivity. According to Reg Godwin, Technical Specialist, National Laboratory Service, UK, "By having the ECM, we don't need as many staff and as many instruments. If we were to measure pH and conductivity separately, we'd be buying a robot or employing a lot more people. We only pour the sample once to determine ammonia, phosphate, pH, and conductivity, all on one piece of equipment. It wouldn't be possible to do the project by old-fashioned methods."

Sample capacity provides necessary sample throughput

In addition to the ECM module for pH measurement, the NLS chose the Gallery Plus analyzer because of its sample capacity. The analyzer can accommodate 108 samples and 42 reagents in separate sample and reagent disks and can run up to 350 tests per hour. "We wanted as much capacity as possible, said Godwin. "Our sample load can vary between 300 up to 500 a day, but our target is to run around 2800 samples a week over seven days of testing from Monday to Sunday. You can get more samples on the Gallery Plus system."

An NLS analyst loads wastewater samples into a Gallery Plus discrete analyzer. Photo courtesy of the NLS.

"There's a cost and efficiency saving that we wouldn't see if we were using an alternative instrument setup."

—Reg Godwin

Reduces errors, increases confidence in results

By replacing several manual tests with an automated analyzer, the NLS is able to reduce human error and variability, increasing confidence in results. "Because human error happens, manual testing potentially results in contaminating samples or even testing the wrong samples. Errors would be greatly increased, sensitivity would be worse, and the standard deviation would be a lot higher. Using the Gallery Plus instrument, we completely rule that out," explained Godwin.

Premade, off-the-shelf reagents save time, increase consistency

A choice of more than 50 ready-to-use Thermo Scientific™ Gallery™ system reagents offers labs the option to reduce time-consuming, error-prone reagent preparation. "If you don't have the facility to make them in your lab, you can buy them off the shelf. They seem to be consistent between batches, it rules out a lot of human error, and it speeds things up. We've done a comparison—we brought in reagents and made our own—there's no significant difference. Depending on supply, we switch between the two and monitor our quality control samples to see if there's any fluctuation in results. There's never been anything significant, and we've run tens of thousands of samples so far," remarked Godwin.

Streamlined sample collection and management

The ability to run multiple tests on one sample provides additional efficiencies such as reduced sample collection and simplified sample management. "To perform separate individual tests," remarked Godwin, "we'd need much more sample, which would mean samplers would have to take extra bottles with them and registering the samples onto our LIMS system would be more complex."

Simplified analysis and walkaway efficiency streamline operations

The Gallery discrete analyzers include automated procedures that simplify operation and reduce tedious manual tasks so fewer staff members are needed to run and monitor the instruments. A customizable startup procedure automatically primes and conditions the instrument prior to daily use, eliminating the need for NLS staff to manually prime each of the eight systems. After running the automatic startup procedure, a checklist reminds users to check if there are enough cuvettes and water to begin analyses. Calibration is automated, and calibration comparison tools make it easy for users to compare current and previous calibration results to ensure the instrument is performing as expected.

"When you've got eight instruments, the last thing you want to be doing is clicking the prime button several times to get the instruments ready. The Gallery Plus discrete analyzer does that for you. The startup procedure saves us a lot of time and flags any issues early on. This feature is essential in a fast-paced environment."

— Reg Godwin

> “When trends can be drawn using complementary datasets, suddenly you've got a really powerful tool and we've seen that with this project. Its usefulness feeds back to the government where they make decisions on restrictions.”
>
> — Reg Godwin

The Gallery system software clearly displays the information users need to correctly run the required tests, including estimated runtime, the sample racks loaded, and any error and warning messages. Knowing at a glance if instruments are short on water, cuvettes, or ECM rinse liquid for example, allows users to make corrections before analyses need to be suspended. Instrument maintenance tracking is integrated into operation with customizable checklists and timers that notify users when a maintenance procedure should be carried out. Godwin explained “reagent level sensing is really useful. When the reagents are getting low, you don't want to start running samples. When you've got eight instruments lined up and running at once, the last thing you want to be doing is having somebody running back and forth checking that manually.”

Automatic background level checking flags problems early, reducing needs for sample reanalysis. As Godwin described, “another neat feature is that the instrument runs a series of water blanks. It will fill each position in the cuvette with water and check the background levels at each of the 12 wavelengths. If it didn't do that, you would be finding out that you had blank issues halfway through or even towards the end of a run of samples. The result of that would be rerunning samples, and the samples might have been disposed of by then. That's the pace of work in this lab.”

Traceable maintenance

For traceability and compliance, the software captures an audit trail of all maintenance actions carried out on an instrument. Users can quickly perform specific diagnostic and maintenance actions such as cleaning probes, checking on-board incubator temperature, and conditioning using the software’s maintenance tab. “We're aiming to be United Kingdom Accreditation Service accredited, so traceability of maintenance and data, and how we get to our results is really important. The maintenance tab logs an audit trail of all the actions that the instrument has carried out with regards to maintenance,” said Godwin.

A successful program with a bright future

The Environment Agency UK’s SARS-CoV-2 surveillance program that relies on accurately trending population biomarkers is meeting its goals. According to Godwin, “We've seen an outbreak about to happen with students returning to university. We can also see trends across the country, including the spread of the virus from north to south in England. We’ve seen individual small outbreaks at seasonal times—holiday times—and with kids going back to school.”

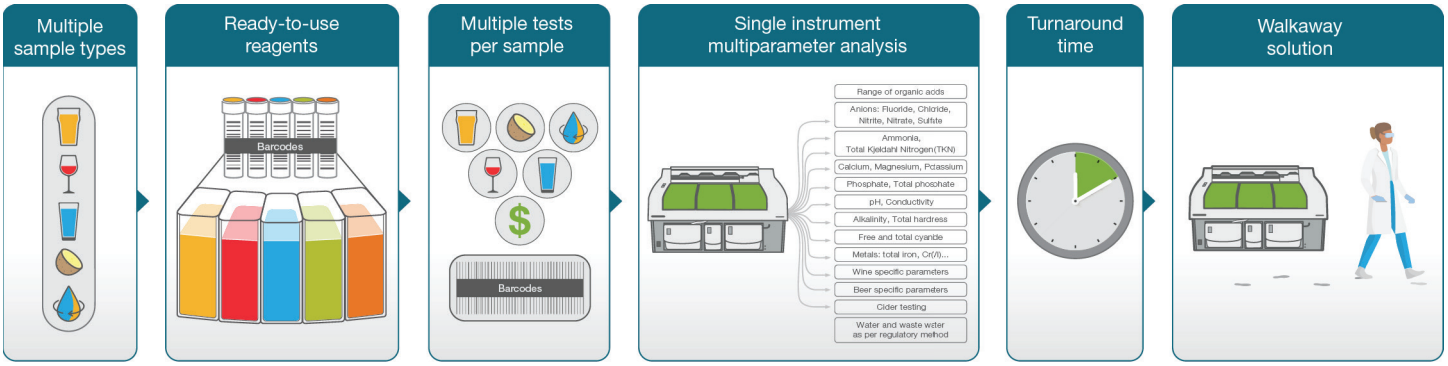

Figure 1. Gallery Plus discrete analyzers provide a complete walkaway solution for multiple sample types. Ready-to-use reagents and single-instrument multi-parameter analysis reduce sample turnaround time and costs.

Figure 2. The Environment Agency's wastewater epidemiology program dashboard displays individual molecular and inorganic trends and corrected COVID trends for health agency use.
Data courtesy of the NLS.

The success of the program has put a spotlight on the power of wastewater epidemiology when biomarker data works together with molecular biology data. "Now we see how much of a powerful tool it is. There are so many more biomarkers that can be targeted, for example organic biomarkers like estrogens, to give you an idea of the demographic that's contributing to that wastewater," said Godwin.

Conclusion

Wastewater surveillance of COVID-19 is a rapidly evolving area that holds great promise as an early, cost-effective, unbiased community-level indicator of the presence of COVID-19. However, determining the chemical reference parameters such as pH, conductivity, and population biomarkers for a large number of samples on a daily basis is extremely challenging, and until now not practical. The Gallery Plus discrete analyzer overcomes these challenges. Automated features, and parallel determination of multiple analytes from a single sample increase sample throughput and analytical certainty to support public health agencies. In addition, the analyzer's automation features provide true walkaway time for operators to perform other tasks or to monitor multiple systems.

Additional resources

Smart Note: Wastewater surveillance of COVID-19

Webinar: High throughput biomarkers analysis in wastewater for SARS-CoV-2 surveillance

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About Reg Godwin

Reg Godwin, Technical Specialist, National Laboratory Service, Environment Agency UK, has 14 years of experience in environmental and analytical sciences in commercial and public sector settings. Godwin specializes in liquid chromatography and mass spectrometry with particular experience several forensic applications such drugs-of-abuse and explosives analysis. In his current role, Godwin works on colorimetric/photometric inorganic analysis, and method development and optimization for environmental matrices. Since the emergence of the global pandemic, he has focused on setting up a wastewater testing facility to provide the government with essential data and a national early warning system for SARS-CoV-2 outbreaks.

National Laboratory Service, Exeter

About the National Laboratory Service

The National Laboratory Service (NLS) is a leading provider of high-quality environmental testing and analysis, offering excellence in science, industry-leading customer service, and tailored analytical solutions to meet the needs of its customers. The NLS offers authoritative guidance and a comprehensive range of analytical solutions to address problems of air, water, and soil pollution. Applying the very latest chemical and molecular techniques, the NLS holds one of the most comprehensive schedules of accreditation to ISO17025 and McertS standards. As a business unit of the Environment Agency, UK, the NLS is based at three facilities located in Exeter, Starcross, and Leeds, each one specializing in specific areas of environmental detection and analysis.

Find out more at **thermofisher.com/discreteanalysis**

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