MONITORING TO MANAGE WASTEWATER POLLUTION

Wastewater pollution from stormwater overflows or combined sewer overflows (CSOs) was in the news a lot in 2021, with Southern Water receiving a record fine of £90 million for unpermitted sewage discharges in July, and other water companies under scrutiny for polluting watercourses by environmental campaigners and the general public.

The Environment Agency is currently undertaking an investigation into more than 2,000 sewage treatment works to check whether they are being operated in compliance with their environmental permits. In response to public pressure, the finalised, post Brexit UK Environment Bill includes a statutory duty for water companies to achieve a progressive reduction in the negative impacts of CSOs, and a requirement to monitor river water quality upstream and downstream of each CSO. This is in addition to strategic priorities for Ofwat and the water companies it regulates, to significantly reduce the discharge of sewage from CSOs in the next pricing review (PR24) amongst other targets to drive performance from 2024-2029. Another related issue is property flooding from the sewer network, especially in cellars below ground level. So how can water companies reduce wastewater pollution from sewer networks? Using Yorkshire Water as an example what are some of the contributing factors? What measures are already in place to tackle wastewater pollution? Which extra technologies do water companies need to tackle leakage? And what innovations are on the horizon to tackle this issue?

Taking Yorkshire Water as an example, the scale of the challenge becomes obvious. The area served by Yorkshire Water has approximately five million customers in 2.6 million properties, 1,087 km of rivers, with 1 billion litres of sewage treated per day. Assets to operate and maintain include 12 long sea falls, 640 sewage treatment sites, 56,000 km of sewer, 2,700 pumping stations, 2,241 permitted storm overflows and more than 2 million manholes. Properties with cellars below ground level, typically Victorian terraces, are more prone to internal flooding. "The majority of flooding incidents are from lateral sewers serving Victorian terraces," explains Thomas Ogden, innovation technical specialist at Yorkshire Water, "there are very few manholes on lateral sewers, so there's a need for monitoring devices to go in gullies or soil stacks – we have 2,000 property level monitors." Mr Ogden says that external property flooding is more of an issue in housing stock from the 1960s and 1970s onwards, as in this case there are generally no cellars, more manholes, a smaller network of sewers with narrow pipe diameter (150mm) and very little flow. Mr Ogden provides a wish list of technology that Yorkshire Water would find useful to address property flooding (Table 1).

Table 1: Technology wish list to address property flooding

- Enhanced network mapping e.g. a GPS device to flush down a toilet
- Devices to detect blockages in gullies, soil stacks and shallow manholes
- Lower cost devices to enable a large-scale rollout
- Smaller sized devices for discreet installation

In terms of wastewater pollution of watercourses, the majority of pollution incidents are from the sewer network, for example from rising mains, pumping stations, and from treatment works. A large proportion of the Yorkshire Water sewer network is within 50 metres of a watercourse, for example highway gullies, highway drains, and underground watercourses are often close to watercourses. There are currently 3,500 level monitors in the sewer network or about 1 per 15 km of sewer network, located to monitor CSOs and pollution hotspots in particular. There are 20 designated bathing waters (including one inland bathing water). Water companies are now monitoring discharges to watercourses, to comply with the 2021 Environment Bill. "It is no longer enough to know if spills are occurring," explains Mr Ogden, "we want to know the volume of the spill and the make up of the spill, to understand the impact on the river water quality during heavy rainfall." Mr Ogden says that analytics are needed to link the datasets for levels, flow and water quality together and provide a better understanding of the overall picture. You can only manage what you can measure, and various technologies could help improve understanding (Table 2).

Table 2: Technology wish list to address wastewater pollution of watercourses

- Lower price devices to allow a larger scale rollout
- Measurement of discharge volume and concentration at CSOs
- Measurement of river water quality
- Cost effective identification of misconnections at surface water outfalls

In addition to the wish lists in Table 1 and 2, Mr Ogden suggests other technological solutions that would help including full pipe monitoring, power harvesting, ease of installation, low-cost flow monitoring and analytics to enable corrective action at the right time. Full pipe monitoring would help to identify blockages earlier than just point monitoring at a manhole which will only detect blockages once the sewage backs up the pipe (image 1). Power harvesting would help to extend asset life, enable an increase in the frequency of readings and the dial in frequency. Mr Ogden says that ideally monitors should be quick and easy to install; configuration should be possible through a web-based platform, with all installation data available online; and site information should be collected to enable a correct first time response (photos, access, traffic management details). Flow monitoring should be low cost, and ideally permanent online flow monitoring rather than the expensive flow surveys which are currently undertaken. Importantly analytics are needed to combine all the data with rainfall predictions, including long range weather forecasts to predict when a developing blockage will cause a problem and when to intervene. Analytics could also help to quantify environmental harm.

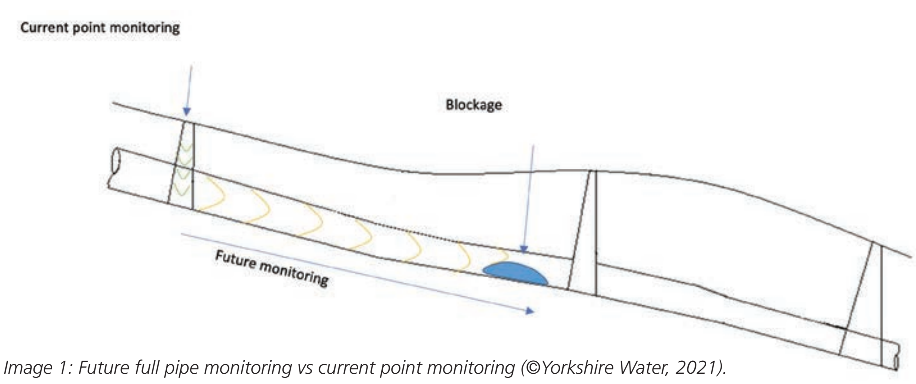

Image 1: Future full pipe monitoring vs current point monitoring (©Yorkshire Water, 2021).

Various innovative technologies are available or in development to monitor water pollution, from a low-cost device which can monitor basic parameters up to a full-blown AI based sewer network control system. A brief overview of a selection is provided in Table 3. Some of these help to address the technology gaps identified above.

With the current drive to cut sewage spills, water companies will be seeking technological solutions to help them go beyond regulatory requirements and meet customer expectations.

TECHNOLOGY	APPLICATION, METHOD AND BENEFITS	STAGE OF DEVELOPMENT
Wireless water quality monitor in a small robust casing	Can monitor changes in water quality by measuring basic parameters: electrochemical potential, pressure, temperature Proxy measurement of water quality | Real time data via radio and mobile phone network, sent to base stations and on to an online database to visualise the data | Can enable high spatial resolution due to low cost – many could be deployed across a river catchment.	Prototype has been made, trials are underway, manufacturers are interested. Partners are sought to develop the prototype to market.
Biosensor	Can measure microbial load and toxicity in wastewater for process control | Electro-active bacteria e.g. Geobacter on the electrode create an electrical current which is proportionate to Biological Oxygen Demand (BOD) | Can be used to predict biodegradable organic matter (BOM)	Prototypes have been trialled for more than 3 years with continuous settled sewage. **Seeking partners:** Sensor manufacturer or for system integration (software & hardware) To develop prototype into commercial device or direct to market
Biosensor	Real-time microbial performance monitoring in wastewater | Direct measurement of exoelectrogenic microbial metabolic activity | Enables water companies to quantify microbiology to better understand wastewater treatment | Can be used to improve energy performance by siting one biosensor before and one after the Biological Aerated Flooded Filter (BAFF). BAFF units can be turned off during periods of low microbial loads. This can lead to an energy saving of 10-20% per site, or savings of £50,000 - £100,000	On the market.
Autonomous water quality monitor	Multi parameter system combined with solar PV to generate its own power | Currently developed to include pH, temperature, conductivity sensors but can be adapted. Energy harvesting enables • Higher data frequency • Less maintenance costs • More sustainable	Lab tested, seeking partners to run larger scale proof of concept
A smart water monitor	Sample at different depths in a water column using one device | A relatively low cost system | Fully autonomous | Solar PV to top up battery | Multi parameter probe | Sensor agnostic | No chemical reagents needed | Comms to integrate with customer requirements | Real time data visualised on an app dashboard | Alerts and notifications can be set | Patented system | Short or long term monitoring solution Applications include: • Upland catchment quality and flow monitoring • Inland water quality • Lake and pond health monitoring • Early river pollution warning • Urban river quality monitoring • Industrial effluent discharge monitoring • Slurry discharge monitoring • Reservoir water quality • Drinking water quality trunk mains monitoring • Combined sewer outfall flow monitoring • Wastewater outlet monitoring • Bathing water quality monitoring • Fish farm effluent monitoring	Benchmarking of product data has been undertaken with Anglian Water against the gold standard water quality sondes. Seeking partners to run larger scale proof of concept
Sewer blockage monitor	Proactive detection of fatbergs and other blockages | Lower cost than other inspection techniques | Incorporates telemetry data capture and analysis | Low cost, easy installation and low maintenance sensors | Uses machine learning | ATEX certified | Robust in harsh environments | Battery life of 10 years	Monitor has been proven to work, already being used by Thames Water. Idea is being patented. Lots of commercial interest. Field trials in the summer of 2022.
Real time multiparameter water quality sensor	Secondary measurement of BOD/COD/coliforms | Stable, low maintenance fluorescence-based sensors | Can be used to monitor bathing waters and watercourses for recreational use | Can be used for BOD compliance for wastewater treatment works | Can be used for aeration control at WwTW, saving energy and carbon | Patented, disruptive technology | Institute of Water Innovation Award Winner 2021	On the market Deployed around the world, including in the UK, US, Asia, Europe & South America
Smart level sensor	Level sensor for sewers | Relatively low cost for mass deployment | Quick and easy installation | Complements existing monitoring | Can help improve network performance | Level data can be integrated with forecast and actual rainfall data in the machine learning software provided, to provide alerts to take action to prevent spills | Built in NB-IoT | Configurable sampling and logging of level data | Remote configuration including firmware upgrades	On the market
AI based sewer network control	To reduce the number and volume of CSO spills | Provides a Storm Overflow Assessment | Framework which can help to prioritise investment in CSOs, WWTP overflows and tank discharges based on environmental impact, public visibility and frequency parameters | Proactive monitoring and control | 1st and 2nd flush of sewers could be contained to protect watercourses | Sluice gates can be automated and controlled by AI | Uses simple surrogate measurements | Relatively quick to install and implement | Low cost spill/no spill/duration and quantity response | Can reduce the need for construction of storage, cut associated costs and carbon emissions.	On the market

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