



Biological Engineering

Wastewater Innovation at Scale



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Location



1 Who we are

An international centre of research excellence and experimentation for wastewater management technology. Newcastle University's new Biological Engineering: Wastewater Innovation at Scale (BEWISe) facility is the first of its type in Europe in large-scale wastewater treatment research using bacteria. The facility is based at Northumbrian Water's sewage treatment plant at Birtley, near Gateshead.

At BEWISe, Newcastle University and Northumbrian Water Group are working together to:

- speed up innovation in sustainable wastewater treatment
- experiment with low-energy biological treatment technologies
- develop low-cost ways to generate energy from waste
- reduce emissions from wastewater treatment
- solve other contemporary issues using the latest science

We need to do more, at lower cost, and with minimal environmental impact.

Wastewater treatment plays a vital role in the circular economy by recycling water to the natural environment. However, it is energy intensive. It accounts for 1.5% of total UK electricity use and significant greenhouse gas (GHG) emissions. But there is nearly ten times as much chemical energy in wastewater than the energy we use to treat it. In the future, wastewater could become a source of low-carbon energy generation.

Besides energy and emissions reductions and nutrient recovery, society faces additional challenges to protect the aqueous environment. We must ensure the safety of water and prevent burdens on existing infrastructure.

In response to these and other challenges, we are developing a new suite of beneficial sustainable technologies. Ideally these technologies are:

- simulated at the computer
- trialled in the lab
- translated to real world application

2 What we offer

- Innovation and practical application at large scale.
- Research using a continuous supply of real wastewater at a scale that reflects the complexity of real full-scale wastewater treatment, at an affordable cost to academia.
- Physico-chemical characteristics of the wastewater and the treatment processes that are continuously monitored.
- Ample sampling points that allow further chemical and biological analyses.
- The capability to explore different types of bacteria and identify how they behave in different sewage treatment processes.
- The resources to reduce the costs and timescales of designing novel biological treatment processes.

We investigate sustainable approaches to wastewater treatment that have rarely been tested before at this scale. We test and replicate different elements of the wastewater treatment process. This allows us to develop new ways of treating wastewater with greater confidence.

We are speeding up the transition from existing energy-intensive GHG-emitting treatment processes to low-carbon alternatives with lower running costs.

We carry out research on ambient low-temperature wastewater treatment systems for renewable energy generation.

3 Equipment available

3.1 Wastewater Ring Main

The facility continuously receives both settled sewage and raw screened de-gritted sewage from a population equivalent of >30,000 in a pumped ring main around the site. This allows access to fresh wastewater for our treatment technologies and for use by individuals with their own equipment or sensors. The flow, pH, temperature and dissolved oxygen are continuously monitored.





3.2 Activated Sludge

The facility houses two Activated Sludge (AS) tanks with connecting secondary clarifiers, constructed from HDPE (high-density polyethylene). They are each mounted onto a stainless steel skid.

- AS tanks: 1.7m height × 1.2m width × 1.5m length
- clarifiers: 1.8m height × 0.3m width × 1.6m length

The AS tanks receive wastewater via adjustable pumps which control the hydraulic loading rate. These are taken off a ring main of either settled sewage or raw sewage from the main Birtley treatment works. The wastewater enters the aeration tank where organic pollution in the wastewater is broken down when used as a food source by bacteria.

After several hours, the bacteria (the 'activated' sludge) separates from the treated water in the secondary clarification tank by settling. Part of the settled sludge is recycled into the AS tank. The rest is pumped out to waste. We can use this mechanism to set any desired solids retention time. We can also control the pH to ensure the process works optimally.

The treated effluent flows over the top of a weir and back into the Birtley treatment works. Both the AS tank and secondary clarifiers have multiple ball valves to take samples from key areas of interest. The pH, dissolved oxygen, temperature and suspended solids are measured continuously.

3.3 Trickling Filters

The facility houses two cylindrical Trickling Filters (TF) approximately 2m high by 1m wide with connecting secondary clarifiers similar to those on the AS. They are constructed from HDPE and mounted onto a stainless steel skid each.

Each TF tank has removable baskets that can be filled with either rock or plastic media. The baskets are removable so that we can sample and replace the filter media as necessary. The filter media provides a large surface area on which bacteria can grow.

As with the AS systems, wastewater is taken off the ring main via pumps. Wastewater is fed from the top by a slowly spinning pipe. It then trickles down the whole length of the filter media on which the bacteria grow. The bacteria use the organics in the wastewater as a food source to grow, with excess bacteria separated out in the clarifier just as in the AS.



3.4 Upflow Anaerobic Sludge Blanket (UASBs)

In a UASB reactor, bacteria are used to convert waste in the water into methane which could be used as a source of energy – often to power a wastewater treatment plant or to be fed into the gas grid. There are three 5m tall reactors that can be used individually or as replicates with a controllable hydraulic loading rate. The reactor is automatically pH controlled using dosing pumps to ensure an optimum pH for the anaerobic processes.



3.5 Microbial Electrochemical Fuel Cells

Microbial electrochemical fuel cells (MECs) are also emerging technologies working towards net zero. MECs use bacteria to degrade the waste and pass electrons from it onto a battery circuit to generate electricity. It can also be used to create hydrogen, which is a carbon-free energy source. There are 64 replicate MECs housed in three 1 m³ tanks.



3.6 Wetlands/ Lagoons

There are two independent durable opaque tanks consisting of a metal frame and a polymer liner. Each tank holds approximately 4.5m^3 of fluid and a maximum operating water depth can be 1m. Each tank can operate in isolation, although could be connected in series. They can also be divided to provide up to eight replicate tanks. These tanks have flexible inlet and outlet arrangement and piped distribution networks. This allows them to be operated as down flow or upflow reactors. They can be used without media (like a lagoon or waste stabilisation pond) or with media (like a wetland or filter) and receive either submerged or passively aerated open flow. The hydraulic loading rate can be controlled via inlet pumps connected to a short residence time sump fed by the wastewater ring main.



3.7 Additional Resources

1. Bench / Lab Space and Plug Socket

2. Small lab where the following can be analysed:

a. Chemical Analyses

- Chemical Oxygen Demand (COD)
- Ammonium concentration
- Nitrate concentration
- Nitrite concentration

b. Gravimetric Analyses and Storage of Biological Samples

- Total / Volatile Suspended Solids Analysis
- Fridge Storage
- Freezer Storage

3. Biological Analyses (at Newcastle University)

- Biological oxygen Demand BOD-5
- Flow Cytometry
- Community Analysis – DNA
- Quantitative PCR
- DNA – Sequencing
- DNA- Bioinformatics analysis
- Fluorescence in-situ Hybridisation (FISH)
- Optical Coherence Tomography (OCT)

4. Chemical Analyses (at Newcastle University)

- Ion Chromatography Anion analysis
- Micropollutant Analysis

Note: Northumbrian Water Group Scientific Services also provide commercial analytical services.

4 Applying to use the Facility



BEWise is available to academia and industry to make innovations in wastewater treatment a reality for the water sector.



If you have any queries, or if you would like to speak to a member of the BEWise team to be sure that your application is relevant please email: **bewise@ncl.ac.uk**

You can also complete an Expression of Interest Form and the full Application Form online at **www.ncl.ac.uk/be-wise/the-facility/apply/**

Find us here: **<https://tinyurl.com/ycx24m46>**

