Summary Report from Scientific Workshop on

Measurement of Greenhouse Gases from Sanitation and their Relationship with Microbiological Processes within Sanitation Systems

hosted by the Environmental Biotechnology Network (Environmental Biotechnology Network – A BBSRC/EPSRC NIBB) and the University of Leeds

Dates: 27-29 January 2025 at the University of Leeds

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Biotechnology and Biological Sciences Research Council
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Background

Interest in greenhouse gas emissions (GHG) from sanitation, and their relationship to biological processes within the sanitation value chain, is on the rise both in countries with established utilities and infrastructure (generally high-income countries) and in countries which have significant deficits in infrastructure and services (often low- and middle-income countries). The push to reduce GHG emissions is partially driven by interest in accessing climate finance for sanitation investments. In the development 'WASH' sector in particular this is leading to calls for rapid development of 'climate resilient sanitation' investments, while in mature industries such as in the UK significant policy changes are underway, in addition to current net-zero targets. However, it is doubtful whether the current understanding of the microbiological and chemical processes which drive emissions or the empirical evidence from direct measurement of emissions form a sufficiently robust basis to support many of the nascent investment proposals which are on the table. The level of understanding of the science of emissions is not yet strong enough amongst implementers to make informed decisions.

Aims and objectives

In view of this, EBNet convened a workshop of leading researchers working on the measurement and mitigation of GHG emissions and their relationship to the microbiological processes within sanitation systems, with the following objectives:

1. To share experiences and map existing research efforts, particularly in the measurement and modelling of emissions from sewered and non-sewered systems and their relationships to operating and microbiological conditions across the entire sanitation value chain, including from stored containments, emptying, transport, treatment and disposal/reuse of sullage, sewage, septage and feacal sludge.
2. To consider options for a joint data platform which could form the basis for an open access resource that could be used in future for the formulation of sanitation investments where emissions estimates are relevant and useful.
3. To consider and potentially initiate the process of writing a position piece which sets out the challenges and gaps in accessing empirical data to inform strategies for mitigation of emissions from sanitation, and proposes a risk-based approach to selection of interventions for optimising high quality sanitation investments with optimised emissions profiles.
4. To initiate a network of researchers working in the field (levels of formality and links to other initiatives to be discussed).

The workshop

The workshop was held at the University of Leeds. An Attendance list and an outline agenda are attached as Annexe 1. Participants were invited to share pre-reading papers and materials for other participants to read ahead of the session. Lightening talks were given by most participants – these are listed in Annexe 2

Key points from the roundtable discussion

Terminology is problematic

Globally, on site sanitation (pits and tanks) are thought to be almost as large a source of GHG emissions as centralised Waste Water Treatment Plants. In the US and EU only around a quarter of the population are using these off-sewer systems but they are widespread globally and will continue to be built over the coming 30 years. WWTP get built comparatively very rarely, so off-sewer systems offer significant scope for innovation.

Most pits and tanks are not well designed, or not properly operated, and even when well designed and operated offer very limited treatment. Primarily pits and tanks are storing excreta. The liquid effluent fate is usually ignored. Terminology used to describe such systems in the published literature and in the field are inconsistent, internally contradictory and unclear. The characteristics of faecal sludge are highly variable. As a consequence of all these challenges empirical data are often impossible to interpret. Data used in national emissions estimates are based emissions factors which are based on poor quality and confusing empirical data, applied in turn to poor quality information about the nature of sanitation systems that exist. As such any local or national estimates have to be treated with extreme caution.

Empirical data is patchy, skewed and unreliable

Standard operating procedures for measuring greenhouse gases in sanitation are in their infancy. There is a bias towards measurement of emissions from wastewater treatment plants where there has been more research funding directed historically compared to measurements in pits and tanks. Low cost methods for measuring emissions are being developed (notably by the SCARE project, by CACTUS). There is an appetite for measuring emissions particularly in the development WASH space, where many people are keen to use emissions as a way to unlock additional funding for the sector. The group noted that this risks (and is already resulting in) an upsurge in publication of unreliable low quality data which could lead to substantial confusion in the field.

We lack a full understanding of the microbiological processes and ecological characteristics that drive emissions in sanitation systems.

A lack of theory of microbial communities in sanitation systems is a major obstacle to engineering solutions. We lack and understanding of the micro biological drivers of emissions (and indeed of all processes inside sanitation systems). Simulation experiments are one way to investigate this although there was not agreement on this point. Machine learning offers some prospects of moving forward in this area.

Action Areas and Follow Up Actions

The workshop spilt into three operational working groups to consider actions under priority headings. The following recommendations for follow up actions were agreed:

Develop Standard Operating Procedures for Measuring Greenhouse Gas Emissions

There is an appetite to develop standard operating procedures and 'minimum data requirements' for measuring greenhouse gas emissions. The focus of any new work should be on measurements in systems that are off sewer - i.e. pits and tanks and feacal sludge treatment facilities, where methods have been less well developed and SOPs are absent.

The work would require some collaboration to pool data, and to develop standard approaches, including 'minimum data requirements', 'lists of recommended approaches and equipment', 'standard approaches to microbiological and genetic profiling of sludges' and 'proforma SOPs' that could be used as a starting point for any data collection.

The group floated the idea of an ex-ante approval process (akin to pre-registering a review on the Cochrane Collaboration) to ensure that there is a cachet to the generation of high quality reliable data using standard methods.

Recommendations:

1. **To form a collaborative community of practice and seek funding to develop SOPs for GHG measurement (see recommendation 1 below).**

Curate a platform for sharing of quality assured emissons data

A second group debated how to house and curate high quality data for wider use by the sanitation sector. This would be linked to the use of approved methods, pre-registration of studies, and quality control of raw data and data analysis to ensure publishing of reliable data. Large grants could potentially incorporate a protocol review panel to own this role

Actions:

1. **The small number of groups currently collecting data (initially participants at this workshop) will form a collaborative community of practice to share data and develop a curation strategy**
2. **An online workshop to discuss the idea to be led by SEI (Daniel Ddiba lead)**

Work towards better understanding of microbiological and biochemical processes and ecological characteristics driving emissions

In the arena of theory there is a need to find ongoing synergy and collaboration, learn from one another, share existing work and look for low hanging fruit. Key tasks include making sure that funders know that this issue is important.

Recommendations/Actions

1. **Write a 'fundamentals' paper – Tom Curtis and Bill Sloan**
2. **Write a policy/ implications paper for researchers – i.e. for RAEng Policy Centre or similar**
3. **Consider potential for a Marie Curie training network or similar**
4. **Consider a CDT in the BBSRC remit**

Annexe 1: List of participants and Agenda

Participants

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Agenda

Day 1	**Monday 27th January – Weetwood Hall Hotel, Headingley, Leeds**
18.00	Assemble at Weetwood Hall Hotel
19.00	**Dinner – Weetwood Hall Restaurant**
Day 2	**Tuesday 28th January – Seminar Room 5, Level 2 Nexus Building, University of Leeds**
08.15	Meet at Parkinson Steps, University of Leeds Walk down to Nexus Building
08.30	Welcome, introductions, aims of the workshop
09.00-11.00	Rapid research exchange: Each team/ researcher makes a short, lightning (6 minute) talk on aspects of their current research, Q&A **Includes refreshments**
11.00-13.00	Facilitated discussion on the state of knowledge (1) Mapping the state of knowledge/ confidence in the science of emissions across the sanitation value chain
13.00-14.00	**Lunch**
14.00-15.30	Smaller group discussion on the state of knowledge (2) Challenges in empirical measurements – identification of key knowledge and equipment gaps (separate on CH_4/ N_2O/ CO_2)
15.30-17.00	Possible lab/farm field visit (to be confirmed) OR discussion on relationships between microbiological processes and emissions.
19.00	**Dinner – Tharavadu, Leeds City Centre**
Day 3	**Wednesday 29th January – Seminar Room 5, Level 2 Nexus Building, University of Leeds**
08.30-11.30	Break in to working groups 1. Problem identification and prioritisation 2. Working groups identify issues and develop work plan 3. Report back **Includes refreshments**
11.30-12.30	Discussion
12.30-13.00	Next steps and A.O.B.
13.00	**Close**

Annexe 2: Lightning talks:

Sam Wilson (Newcastle)

Methane sensors. Cost of data storage falling sharply. Sensors can be made for <£400

Caetano Dora – Functional ecology of onsite sanitation systems

>60% of human excreta enters environment without being treated.

On site sanitation systems are just storing excreta – not treating.

Michel Kordahi (Texas A&M)

Sociotechnical infrastructure systems, hidden emissions

Haoran Duan (New South Wales)

Mitigating GHG Emissions from centralised WWTP – holistic mitigation

Cindy Priadi (Indonesia)

Data gathering with Ben and Jack

Ben and Jack (Leeds)

Recently travelled to Indonesia. Built flux chamber on site and tested it.

Yuqing Yan (Princeton)

Oversimplification and misestimation of N20 emissions from WWTP.

Tom Curtis (Newcastle)

On site sanitation is regarded as 'primitive' but this is not the case in terms of the research needed.

Half the world will still be using OSS in 2050.

Mark Elliott (Alabama)

25% of people in US use OSS. A drain field is essential. Areas with a particular soil type which is impermeable when wet and cracks/moves when dry cause major problems.

Cost of installing sewers is prohibitive.

Bill Sloan (Glasgow)
Large project in Scotland, investigating onsite sanitation decentralised sytems e.g. on islands. Potential to use heat from septic tanks for heat pumps.

Carlos Domingo Felez (Glasgow)

N20 measurements

Cindy Smith (Glasgow)

Molecular ecology of trace gas production

SCARE project – Baba Ngom (Polytechnic du Theis), Olivia Reddy (Bristol), Prativa Poudel (Kathmandu)

Faecal sludge sampling. Key drivers of emissions – system design, volume, depth.

Systems are heterogenous

Linda Strande – EAWAG

MEWS – management of excreta, waste water and sludge

Faecal sludge highly variable. Systems highly variable. Try to average across city.

Miller Camargo-Valero (Leeds)

CACTUS, SCARE and EMISI projects

Faecal sludge pellets – re-use of waste

Measurement of greenhouse gases from sanitation