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**DELIVERING WATER, SANITATION AND HYGIENE SERVICES  
IN AN UNCERTAIN ENVIRONMENT**

**A novel, high-rate, anaerobic digester to treat high-solids  
waste ensuring reuse and good sanitation planning**

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*A consortium of UK universities is working on developing a novel anaerobic digester that will treat pit latrine waste and transform it into a safe and valuable product. Physico-chemical characteristics of fresh human waste and pit latrine sludge are being determined. This is informing the development of a bioreactor containing biofilms, or slimes, of several microbial 'trophic' groups growing preferentially on distinct surfaces and materials. The ecologically-engineered bioreactor design will optimise the efficiency of the treatment and underpin successful digestion of high-solids waste. The potential use of the digestate will be reused in agriculture to recycle nutrients and prevent environmental, and watercourse pollution. Attitudes to sanitation, as well as to resource recovery from, and reuse of, waste, are being investigated so the participatory sanitation planning process can work effectively.*

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## **Introduction**

If pit latrines are used for sanitation in dense urban areas it is essential to find a solution to properly dispose of, and treat, the waste to prevent contamination of people's environments (Holden 2008). Municipal sewage works often cannot accept pit latrine sludge (Bhagwan et al 2008) or are located far from residential areas. A treatment method that can transform pit latrine waste into a safe – and preferably valuable – product is required.

This challenge has been taken up by a consortium of UK universities who are developing a novel anaerobic digester which can treat pit latrine waste that typically has a higher solids content than waterborne sewage. The *Transforming Waste Consortium* is not only focused on developing the technology but also on investigating how the products of the digestion can be reused, as well as what is required to incorporate the technology into a city-wide sanitation plan. The consortium consists of the Universities of Glasgow, Newcastle, Cranfield, Sheffield, Ulster and the Institute of Development Studies. It is funded by the UK Engineering and Physical Sciences Research Council (EP/J00538X/1). The following sections outline the various components, and the latest results, of the project, which is due to finish in 2015.

## **Waste characterisation**

Pit latrine sludge has very different characteristics to waterborne sewage (Bhagwan et al 2008). Understanding these characteristics is vital to design the novel digester. The consortium started with a review of existing literature on both fresh human waste and pit latrine sludge. We found a plethora of data on fresh faeces and urine, particularly in medical publications, which we have been able to statistically analyse. Key findings include a positive correlation between the wet mass of faeces produced per person per day and the individuals' dietary fibre intake. It was also interesting to learn that there are potentially more solids by mass in the urine produced per person per day than in the faeces. For treatment, the chemical oxygen demand (COD) is a key consideration, and in faeces the median concentration is 1448 mg COD/g. Indeed, that the variation in faeces, even of those produced by the same individual on the same diet

(Silvester et al 1997), was surprising. Thus, it is clear that treatment systems need to be resilient with respect to a wide variety of inputs.

Pit latrine waste was found to be less well characterised. As a result, we are making measurements on pit latrine waste during a sampling campaign in Kanyama, Lusaka, Zambia. Measurements include pH; particle size distribution; total solids; and soluble COD concentrations, amongst other parameters. By taking samples during pit emptying, depth-resolved measurements of the parameters in the pit is possible.

### **Anaerobic digester design**

The novelty of the anaerobic digester is based on the selection and distribution of targeted trophic groups of microorganisms within the system. Biofilms were collected from full-scale, anaerobic bioreactors in the UK, Ireland, elsewhere across the EU, the US and China and screened for the potential to degrade domestic wastewater. The biomass was incubated with domestic wastewater, and degradation potential was assessed by production rates of methane, hydrogen and soluble metabolites, to identify the most active and likely-competent samples.

Targeted trophic groups, including hydrolysing species, acetogenic bacteria, hydrogenotrophic methanogens and acetoclastic methanogens were isolated from the biomass using specially-developed, high-throughput enrichment strategies. Further experiments are testing biofilm formation on several different plastics, such as polyethylene and polyvinylchloride, to assess interactions between biofilms comprising specific, relevant trophic groups and the distinct material surfaces.

The final digester will be a down-flow bioreactor system, employing combinations of the trophic-group-specific biofilms and the selected materials chosen to support the growth of targeted species. This will have a low hydraulic retention time (i.e. high rate) and will be resilient to the high-solids waste expected.

### **Reuse potential**

The fieldwork in Lusaka also entails collecting data on phosphate, potassium and nitrogen concentrations in the pit latrine waste and in the effluent of a newly-installed, full-scale, conventional, anaerobic digester. This will help to understand the concentrations of nutrients in the waste both before and after digestion. Further work will then develop technologies to facilitate the reuse of these nutrients.

### **Attitudes to sanitation planning**

To successfully implement technology of this kind, it needs to be incorporated into sanitation plans. In turn, sanitation plans should be participatory, but all stakeholders need to have a good understanding of reuse so the plans they develop are socio-culturally acceptable (Mara 1996). Fieldwork in India and Zambia explored the importance of assessing and understanding knowledge and attitudes to sanitation and reuse at both the household and institutional levels. This has an impact on planning for and implementing sanitation interventions at scale. In Nanded, Maharashtra, India, community-led waste management initiatives would have been more successful if more attention had been paid to ensuring institutional and social sustainability. In Lusaka, Zambia, incorporating knowledge and attitudes of stakeholders involved in a new Faecal Sludge Management Scheme (including the newly-installed, full-scale anaerobic digester mentioned above) has improved the whole planning process.

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