**Application of Bacterial Lignin Degraders to Enhance Gas Release from Landfill**

**Introduction** Lignocellulose is the major component of plant cell walls, and is therefore found in all woody materials in landfill sites, as well as in cardboard and newspaper, and other pulp/paper products. Lignocellulose contains 40-50% cellulose and 20-25% hemicellulose, regular polysaccharides that can be broken down by many soil bacteria, but also the aromatic heteropolymer lignin (20-30%), which is relatively inert, and very slowly degraded. Consequently, the breakdown of lignin is a rate-limiting step in the breakdown of lignocellulosic waste in landfill and suspected to be one of the reasons for the long "tail" in methane emissions from landfills. If lignin degradation could be enhanced through either chemical or biological means, there is potential to enhance the rate of gas release from landfill, which would increase the amount of useful gas generated by landfill sites, but also potentially to reduce the time taken to regenerate the site for alternative land use.

**Background** On the NERC-funded INSPIRE project (2014-2017), led by Dr Devin Sapsford (Department of Engineering, Cardiff University), Professor Bugg's research group at the University of Warwick discovered a new group of 10 soil bacterial lignin degraders from municipal solid waste, 4 of which were facultative anaerobes not previously observed as lignin degraders. These four strains (*Agrobacterium* sp., *Lysinibacillus sphaericus*, *Comamonas testosteroni*, *Paenibacillus* sp.) were able to enhance the rate of gas release from MSW or compost containing 1% lignocellulose by 3-4 fold under microaerobic conditions in a 0.5 litre laboratory experiment (Rashid et al, 2017). This work was presented by Prof. Bugg to the Landfill Gas Group in London in July 2018, who encouraged him to take the work forward to test its application in larger scale experiments and in a field trial. Subsequent discussions with Dr. Robert Gregory (Gregory Environmental Consulting Ltd) has led to the following proposal.

**Proposed Research** The research comprises two PhD projects which will run in parallel. Both PhDs will involve collection and monitoring of data from field trials, which will supplement core studies (detailed below) in Warwick and Cardiff.

1. **Field Trials** The joint field trials will be carried out at landfill sites close to Warwick University (e.g. Ling Hall, Rugby, Veolia; Packington, Meriden, Suez). Pin wells will be inserted close to existing gas collection points, allowing the application of cultures of the four different bacteria to the surface of the landfill waste. Gas release will be monitored, in comparison with control sites, for duplicate treatments, over 1-12 months.

2. **Laboratory-based Column studies and BMP testing** (Dr. Devin Sapsford, Cardiff University). 20-50 litre columns containing MSW supplemented with lignocellulose. The columns will be treated with cultures of the four different lignin-degrading bacteria, for up to 2 years, with variable size of bacterial inoculum. The columns will be monitored for (a) gas release (b) changing composition of the lignocellulosic material (c) microbial population at different depths vs time. This will be supplemented by Biomethane Methane Potential testing on lignocellulosic fractions and landfill gas modelling.

3. **Microbiology and Biochemistry** (Prof Tim Bugg, University of Warwick). In addition, the leachate will be collected, and monitored for the presence of the applied bacteria by 16S rRNA sequencing. The leachate will also be sampled for the presence of additional bacterial lignin degraders.

If the work demonstrates the feasibility of larger scale enhancement of landfill gas, then the expectation is that the work would be taken forward via industry-led Innovate UK or Knowledge Transfer Partnership funding, but this work is needed to generate the first larger scale data.