Trends in sewage sludge treatment and recycling

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Sludge Production and Resource Value

Treatment and recycling of sewage sludge – or biosolids – has led the way in providing examples of efficient resource utilisation.

Every day in the UK we dispose into sewers about 2,500 tonnes of solid organic material, which, when settled at sewage works, forms a volume of around 80,000 cubic metres of primary sludge (or 32 Olympic swimming pools). When conversion of the soluble components of sewage are also taken into account, the total, before reductions in mass due to sludge treatment processes becomes nearer 4,800 tonnes of dry solids. This has an energy content of around 91 million MJ, which could be sufficient as electrical energy for 500,000 houses. And if all this energy could be converted to electrical power, it might be worth £2.5m per day.

Of course, sewage sludge is not only potential energy. Beneficial nutrients abound, chiefly as nitrogen and phosphorus, but a full range of micronutrients and humus value as well. Each tonne of sludge dry solids has about 60kg of nitrogen, and 30kg of phosphorus. An estimated fertiliser value of sewage sludge, on the basis of its nutrient value alone, is in the region of £8 per tonne of dry solids.

Sewage and sludges have long had a value. "London muck" was used in the 18th century for horticulture, although by the mid-19th century the extent of its use led to one of the first inquiries into the dangers of using sewage as a soil improver and fertiliser. By the 1850's there was great enthusiasm for the nutrient value of sewage, and enthusiasts such as Mechi and Chadwick thought that sale of sewage might be profitable.

Changing Technologies

These discussions continue, although technologies are now much more sophisticated. In the last 30 years sewage sludge treatment and use of by-products has evolved from the relatively limited range of single tank anaerobic digestion, incineration, lagoons, lime-treatment or no treatment, to almost always being treated in some form, commonly to a high level of hygiene using complex technologies.

The greatest change is in development of advanced anaerobic digestion processes; these include thermal and enzymic hydrolysis pre-treatments. Thermal hydrolysis, such as those of Cambi and Veolia, use autoclave conditions at temperatures and pressures in the region of 170°C and 10 bar for 30 minutes before flash expansion which "explodes" cell material, and increases the proportion of readily biodegradable material. Enzymic hydrolysis is less extreme, using multiple acid stages and thermophilic conditions to reduce pathogen content and enhance degradability. These treatments produce sludges (or other biowastes) that, after digestion, meet and exceed microbial quality that in the UK classify it as "enhanced treated" and suitable for the widest range of agricultural improvement purposes.

In the UK, the expansion of advanced anaerobic digestion processes has been driven initially by agricultural quality requirements, and has been further justified by the demonstration that at least 10% more biogas may be recovered and used for energy generation. Installation and use of these advanced processes in the UK accounts for more than 20% of the sludge processing capacity. Davyhulme, in Manchester, has a maximum capacity of 7% of UK sludge production, and the combination of the new plants at Bran Sands and Howdon treat another 5%.

Amongst current excitement for new processes it should not be forgotten that the fundamental organics conversion process of methanogenic anaerobic digestion remains central. Benefits of testing and analysis of materials to be used in digestion are commonly reported, together with new understanding of the kinetics of processes.

These all build into better security in operating processes, and understanding how qualities of feed materials affect the process outcomes. Thus short term batch digestion tests can be used to measure aspects of process kinetics, impacts of pre-treatments and digestion temperatures, whilst modelling and process simulations provide opportunities for improved process prediction and operational adjustments. Indeed, process simulations are increasingly used in training to respond to different treatment works scenarios.

Agricultural Use

The amount of sewage sludge produced in all EU countries is expected to increase, at least to 2020, to a total of about 13 million tonnes dry solids per year. Putting this into perspective, sewage sludge is less than 5% of total farm and biowastes, but does attract particularly close attention.

Our recent assessment of sludge production and use in the EU[1] found that about 42% of EU sludge is currently used in agriculture, with a small increase to 44% expected by 2020. During this time the proportion of incinerated sludge is expected to increase from 27% to 32%, whilst the proportion disposed to landfill will decrease, from 14% down to 7%. Although the proportion used in agriculture remains similar, the total mass will increase by about 18%.

These increases, together with competition from other biowastes, mean that there is increased pressure to ensure that sewage sludge is treated efficiently and to a high quality, so that the environmental beneficial route of agricultural recycling can be maintained.

Strong public views in some regions reject agricultural use of sewage sludge. There are concerns about presence of the historically low concentrations of potentially toxic elements, and newer concerns over a wide range of organic bioactive substances, such as antibiotics, organo-metallics, pathogens, endocrine disrupting substances, and nano-particles. Sewage sludge has been described as a pollution sink for many organic substances which leads to a substantial risk to the health of soil. Although these views are not widespread they show the importance of maintaining production of high quality well monitored digestates from all sources, not just sewage sludge, that can be demonstrated to be beneficial soil improvers and fertilisers, and thereby reduce our dependence on other fertiliser sources.

The Future

What happens in the future? Our conservatively designed processes, based on relatively unsophisticated technologies have predominated. We are now much better at monitoring a range of treatment conditions and outcomes (gases, solids, individual components, physico-chemical conditions) from individual treatment stages. We will expect to use these integrated with other analytical, simulation, training and management tools to achieve reliable treatment, energy and resource recovery operations, which I think, would enthral those pioneers of the 19th century.

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Reference

[1] *EC (2010) – Environmental, economic and social impacts of the use of sewage sludge on land. Final report. Parts 1, 2 and 3. Report prepared for DG Environment by Milieu, WRc and RPA. www.ec.europa.eu/environment/waste/sludge/index.htm*