Sludge to fertiliser:

End-o-Sludg pushes the boundaries of wastewater sludge reuse

The research project End-o-Sludg has the aim of turning sludge into a fertiliser product that gives predictable and balanced results to farmers and can be dealt with outside of EU waste regulations. **BILL McCANN** reports on the ongoing work to prove the viability of selling processed sludge as coated fertiliser pellets, and the predicted advantages of this over other sludge disposal methods.

A multi-million Euro European Union-funded research project is almost a third of the way through a three-year programme designed to herald Europe's water industry into a new era of sludge management.

It is an ambitious aim and some in the industry might even describe the claims for some of the expected results as extravagant. But, when the 14 partners to the €5.5 million ($7.8 million) End-o-Sludg project met in September to present the outcomes of their first nine months' work, they reported generally good progress.

Just the project title, End-o-Sludg, gives an indication of the game-changing intention of the work. One of the principal objectives is to move away from the concept of sludge as a waste by deriving from the base material a range of balanced nutrient products that can be marketed throughout Europe as fertilisers for the agriculture and horticulture industries.

That means achieving 'end of waste' status within the terms of the EU Waste Framework Directive, so that the product will not have to be dealt with under waste licensing regulations. This task is in the hands of Sustainable Resource Solutions Ltd (SRS), one of 14 project partners. As SRS development manager John Miller explains, this involves developing a quality protocol to satisfy the regulator, in this case the Environment Agency (EA) for England and Wales, that the waste can be converted into a marketable product.

Fortified fertiliser

The project objective is to produce Organo Mineral Fertiliser (OMF), a composite in granular form in which the organic material of the base sludge is fortified with known additions of potash and urea, offering a specific and more predictable agronomic performance than is achievable by sludge alone.

A healthy wheat crop treated with OMF formulation fertiliser. Credit: Harper Adams University College.

For regulatory approval the quality protocol must include a specification of product formulation and must also give evidence of a market for the product and show that it is capable of improving crop growth while not posing any threat of environmental damage.

At this stage SRS can interact only informally with the regulator while gathering information from other project partners on the results of crop trials with the prototype material, and is awaiting development and proving of the pilot plant that will output OMF in practical volumes.

A one tonne/day plant is envisaged in which a feedstock of digested sludge cake will be granulated, coated with urea and supplemented with potash in a staged process. The granulator and coater are being manufactured respectively by Waterleau Global Water Technology of Belgium and Valsave Engineered Solutions Ltd of the UK.

End-o-Sludg is co-ordinated by the UK's United Utilities Water plc and led by the company's Technology Development Manager, Dr Son Le. He sees the OMF product as a key element of the project, providing a truly sustainable outlet to agriculture and, at the same time, addressing the historically intractable problem of public perception.

Referring to the massive problem of sludge disposal in Europe, he notes that neither of the two possible end outlets, agricultural recycling and incineration, have proved popular with the public. 'Nobody wants incinerators in their back yard. Any application immediately brings entire communities up in protest.'

He relates the recent experience at United Utilities where the economic regulator, Ofwat, had approved company expenditure for incinerator construction but the initial planning application met with 'very vocal' opposition from the local community.

Legal advice was that pursuing the application would lead to a Public Inquiry and to a process that might drag on for up to five years with no guarantee of success. So the incinerator plan was abandoned.

Other UK companies are apparently the same in seeing a limited future role for incineration. Two incinerators are indeed operating satisfactorily on the east side of London for Thames Water, but elsewhere the practice looks to be in retreat. Yorkshire Water's only plant is said to be nearing the end of its operational life and Severn Trent has stopped operating its incinerator.

Agriculture is therefore the favoured route in the UK and much the same can be said for Europe in general. Exceptionally large numbers of farm animals in the Netherlands do necessitate resort to incineration because the available land area is not sufficient to cope with the animal manures and municipal sludges. But in Germany, widely thought to favour incineration, it is only the three most populous Länder (states) where that is the case, the remaining 13 Länder recycling to agriculture.

As Son points out, that too raises public resentment. Irrational or not, many people recoil from the idea of cereal crops being grown on sewage sludge.

For that reason there had to be a move away from the traditional concept of agriculture as an outlet for disposal of a waste, and the logical next step was to work with a different set of stakeholders – the farming community – to assess its value as a fertiliser. And that, says Son, is 'not very much'.

'It has a reasonable content of nutrients, nitrogen and phosphorus, but they are not in balanced proportions and the rate at which they become available to crops is not predictable. Probably 20% of the nitrogen becomes available in the growing season when it is applied, but the rest becomes locked up and is only mobilised over several years. That makes it difficult for a farmer to assess his likely crop yield – and therefore his income – and that is the main reason why sludge is not favoured very widely in the farming community. The majority of farmers would rather pay for a chemical fertiliser so that they have a better idea of the expected yield.'

Developing a sludge-based product capable of overcoming farmers' reservations and competing with the chemicals had been an ongoing process for upwards of five years before End-o-Sludg began in January.

Making sludge useful

Son Le was heavily involved, as was the Natural Resources Department at the UK's Cranfield University, also partners in End-o-Sludg. They worked on plot scale trials at the university farm in Silsoe, eastern England and, as chemist Ruben Sakrabani of Cranfield explains, the focus then was on nitrogen – improving soil fertility by getting more of the nutrient into the soil.

Now, in the current project, he says the focus has moved to making phosphorus more available and also to the issue of metal build-up in soils.

Also involved in that aspect of the project, in addition to United Utilities, are Demeter Technology Ltd (UK), the Crop and Environment Research Centre of Harper Adams University College, UK and Teagasc, the Irish Agriculture and Food Development Authority.

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> **Dr Son Le**

Crop trials have now moved on to farm scale in Shropshire, western England, and to other sites around the country, especially in the important arable areas of eastern England, testing the developing product on different soils and in varying climatic conditions.

While these are major factors in agronomic performance, there are also effects arising from the interface with water industry regulations, in particular those that govern the permissible limits for additions of nitrates and of heavy metals to soils. Demeter's Anne Noble, while acknowledging the need to eliminate dangerous elements such as cadmium from soils, describes micronutrients such as zinc and manganese as 'the important missing link'.

'Plants need them as well as nutrients. They help to provide disease resistance and they act as catalysts, for example increasing the ability of plants to utilize nitrogen. The problem is that the regulations limit heavy metal inputs (in sludge) to such an extent that the soils can become deficient. The crops are continually taking out these trace elements but we are not replacing them.'

A research challenge for the future, she says, is quantifying the amounts needed; not something to be addressed during End-o-Sludg. 'It would need a more detailed study of individual fields. This product will be marketed just on nutrient balance.'

Son Le points to a more basic regulatory impact, the designated Nitrate Vulnerable Zones (NVZ) where the weight of nitrogen applied in any one year, and therefore the weight of sludge cake, is limited in order to reduce the threat of nitrate runoff to watercourses.

He says this raises a serious phosphorus management problem because water industry practice in the NVZs is to apply an amount of sludge cake, that makes full use of the permitted nitrogen limit, equivalent to what the growing crop can utilize. Because of the typical proportions of nitrogen and phosphorus in the cake this means applying two to three times the amount of phosphorus the crop needs.

With limited land banks forcing return to some fields in successive seasons, this can lead to phosphorus accumulation at what Son describes as 'an alarming rate'. A widespread problem when, in England for example, designated NVZs cover 62% of farmland.

Thus the idea of the OMF is to bring up the nitrogen proportion with the urea coating and to complete the nutrient balancing with the addition of potash.

Asked about progress towards the OMF, Son explains that the crop trials are ongoing in parallel with other areas of work, most importantly the engineering packages centred on advances in sludge treatment at the wastewater plant and the downstream processing to output the finished granules.

'We are not quite there yet. We have produced enough granules for the small scale trials at Cranfield but for the farm trials we have had difficulty in making enough material. In some plots we have used 'completed' granules but in others we had to apply a basic granule and then an additional application for the urea. So chemically the same formulation, but [the] physical format [is] not the same.'

Associated aims

Engineering makes up a large part of the project, not only in the design and manufacture of the OMF production plant but in several other areas where advances in sludge treatment and associated processes are aimed for.

Amongst the claims of expected results are:

- An annual reduction of greenhouse gas emissions of nearly five million tonnes CO_2 across the EU by 2020.
- A reduction in the cost of treating

Trial plots of maize, wheat and oilseed rape in western England. Credit: Harper Adams University College.

and disposing of sludge of at least €100 ($142)/tonne dry solids treated.
- A new €17.5 billion ($24.8 billion) environmental equipment market for the European industry.

All this could come from a new look at sludge removal processes in the primary and secondary treatment stages and at new approaches to pre-treatments that could vastly improve gas production and overall efficiency of the anaerobic digestion process.

Asked if these claims might be a little extravagant, Son describes them rather as aspirations, but based on estimations of the impact of the project in those different areas, such as greenhouse gas reduction or sludge processing costs. 'In each of those areas we made a number of assumptions as to the amount of energy that might be saved, for example, or the amount of materials that might be gained.

'We made a proposal to the Commission in which all those assumptions were stated, with appropriate background information. The proposal went to an Assessment Panel of experts who looked at all the assumptions and the figures and they supported our application. They felt those numbers were reasonable. I am not saying that we will achieve those aspirations, just that those figures are based on reasoned assumptions.'

Achievements will vary. He believes they could be only three years from a commercial product with OMF, whereas work on sludge removal efficiency is more speculative.

Here he points to the relative inefficiency of the primary sedimentation process, removing only 60 to 70% of the suspended solids and therefore leaving finer suspended solids and all the colloidal material and dissolved organics to go forward, imposing a heavy load on the secondary treatment plant. 'Compared to the United States, dissolved air flotation (DAF) is not much used in the UK. In End-o-Sludg we are proposing to use it as part of a process to reduce that load on the secondary plant,' he says.

'We think it may be possible to eliminate conventional secondary treatment altogether by passing primary tank effluent to a DAF unit and then an advanced adsorption unit in series. The former to take out fine suspended solids and colloidal material and the adsorption unit to deal with the dissolved organics. A lot of development work will be focused on that adsorption process and we are also looking at improving the DAF process. This could mean big savings on the power that would be required in the activated sludge process.'

In another engineering component, project partners will seek to improve anaerobic digestion efficiency with research on advanced pre-treatments, such as enzymic hydrolysis, to increase volatile solids destruction and biogas production. Son says: 'The aim is to thicken up the sludge feed to the digester, but not by using traditional methods like belt thickeners that use costly chemicals, polymers, to aid the process.

'We are looking at a new method called inverted phase fermentation. It is a technique developed by United Utilities in conjunction with Cranfield University. It allows the sludge to be split into two separate phases, with a solid phase of up to 11% solids. That means a much more concentrated sludge feed into the digester, greatly increasing the solids loading on the digester than has been the case, with say 4 to 5% solids. That could double the processing capacity and, in some situations, pre-empt need for new construction.'

That is a potential advance that could have far-reaching consequences within the UK water industry, which has a very large anaerobic digestion capacity much associated with the requirements for sludge reuse in agriculture. Son believes that, in many cases, these assets are not being best used because they are processing quite watery sludges.

Included in this arm of the research is a new look at another matter associated with the quality requirements for agricultural reuse – *E. coli* regrowth in the sludge cake.

Since 1998 agricultural reuse in the UK has been bound by the so-called Sludge Matrix, which defines two broad quality categories for reuse – conventionally treated and advanced treated sludge. Anaerobic digestion is the general process used for the former category, where the requirement is for 99% destruction of pathogens. Advanced treated sludges on the other hand – much less restricted as to when and on what crops they can be used – have to show a 6 log pathogen reduction and be free from *Salmonella*. Since achieving the latter standard involves costly pre-treatments such as thermal hydrolysis the net effect of the Matrix has been that most operators opt for the lower standard. They then recycle to land where the crop restrictions do not apply, mainly land growing wheat and other cereal crops.

According to one industry source many thermal hydrolysis plants (the Cambi process) have been installed since 1998, but that has generally been for other reasons. Specifically it results in significantly greater gas production from the digestion process and shows advantage over whole life costs compared to other treatments (although enzymic hydrolysis is now seen as a competitor process).

End-o-Sludg is looking at the suppression of *E. coli* regrowth in sludge cake by inoculating with other strains of bacteria that will compete with the indicator organism, depriving the latter of any food source for regrowth.

Success there would be one more step to raising public confidence in agricultural recycling but, as Son emphasizes, the main thrust of End-o-Sludg is to achieve end-of-waste status for some of the products, particularly the OMF.

'This is particularly important for the industry because, with the current regulations, it does not matter what you do to sludge, at the end of the day it is still a waste and still governed by waste licensing regulations - and that is a big handicap for us,' says Son. 'Agreeing end-of-waste criteria with the regulator will allow us to take these new products out of the waste management regulations.' ●