Final Project Summary

Project title	**END-O-SLUDG- Marketable sludge derivatives from sustainable processing of wastewater in a highly integrated treatment plant**		
Project number	**RD-2010-3743**	**Final Project Report**	**PR544**
Start date	**1 January 2011**	**End date**	**31 December 2013**
AHDB Cereals & Oilseeds funding	**Nil**	**Total cost**	**Nil**

What was the challenge/demand for the work?

Safe treatment of wastewater is one of the most important challenges of modern society. Treating wastewater creates sewage sludge, the treatment is highly energy intensive but its processing is more environmental friendly than not processing it at all. Europe produces nearly 9.4 million tonnes of sewage sludge annually out of which only 50% of the sludge is recycled and remainder is incinerated adding greenhouse gases to the environment. However, in the UK, sewage sludge is a valuable resource of plant nutrients and nearly 80% of the total sludge produced is recycled.

The challenges:

1. Lack of efficient treatment technologies
2. Gaps in our knowledge of nutrient management
3. Absence of evidence that the sludge treatment techniques pose minimal threat to the public and the environment.

How did the project address this?

The END-O-SLUDG programme of work focused on the research, development and demonstration of a number of novel processes affecting the sustainability of sludge management in Europe.

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What outputs has the project delivered?
Some of the key research and developmental findings have been summarised below: A. <u>Sludge reduction investigation:</u> In this project, several techniques were investigated to reduce the sludge. One of these techniques was Dissolved Air Floatation (DAF). The technique consisted of injecting micro-air-bubbles into the sewage sludge. The bubbles were able to separate floating matter present in the sludge. In a pilot scale project, DAF in combination with primary sedimentation (sewage retention in the storage tanks, followed by sediments removal), more than 99% of total soluble solids (TSS) were removed. This improved TSS removal resulted in 59% reduction in the organic load, compared to activated sludge process, where sludge is treated by using air and Bio-floc, containing bacteria and protozoa. B. <u>Sludge treatment investigation:</u> One of the key objectives of the project was to improve the efficacy of the sludge treatment. This was achieved by; 1. Enzymatic hydrolysis: Leads to solid/liquid separation of the sludge by incubation at 42°C for 48 hrs. Liquid fractions can be converted to biogas in smaller more efficient digesters, making it more economical. Whereas, the digested solid fractions can be converted into BIOPOL, an excellent source of phosphorus with a potential to be used as a commercial fertiliser. 2. Prebiotic technique: In order to supress a rapid growth of *Escherichia coli* (*E.coli*) in the digested sludge, a population of competitive microorganisms (probiotic culture) was used. This culture reduced the amount of available nutrients rapidly to avoid colonisation of harmful *E.coli* in the sludge cake. In liquid cake extract medium, the probiotic culture reduced *E.coli* growth up to 1000 fold in comparison to control. C. <u>Development of added value derivatives from sludge:</u> One of the key challenges of the project was to design build and test a process for making a fertiliser product from the sludge cake. The END-O-SLUDG consortium developed and tested

a range of sludge-based fertiliser products, in the form of Organo-Mineral-Fertilisers (OMF). The product development and pilot manufacturing was carried out by the partners i.e. the equipment was developed by Waterleau (Belgium), sludge was supplied by United Utilities (UK), and engineering services were provided by Valsave Engineered Solutions (UK).

A pilot plant was set up at United Utilties, combining Waterleau's sludge granulation technology with the dehydration technology supplied by Valsave. It demonstrated the ability to manufacture OMF according to strict fertiliser specifications, through a low cost, sustainable manufacturing process.

The OMF manufacturing process relied on 5 main steps (Figure 1):

1. Digestion of the sludge to recover biogas for renewable energy production.
2. Dewatering the digested sludge to make biosolids cake.
3. Addition of vital supplements (N & P) to provide a balanced product with predictable nutrient release characteristics.
4. Formation of the fertiliser granules with a narrow particle size distribution.
5. Removing any remaining moisture to produce a pasteurised, free flowing, and virtually dust free fertiliser.

The manufacturing process made use of combined heat and power (CHP) and other sources of waste heat with a guaranteed nutrient content (NPK of 10:4:4). However, more research is required to improve the technology and reduce the cost of OMF production so that it's cheaper to manufacture and use.

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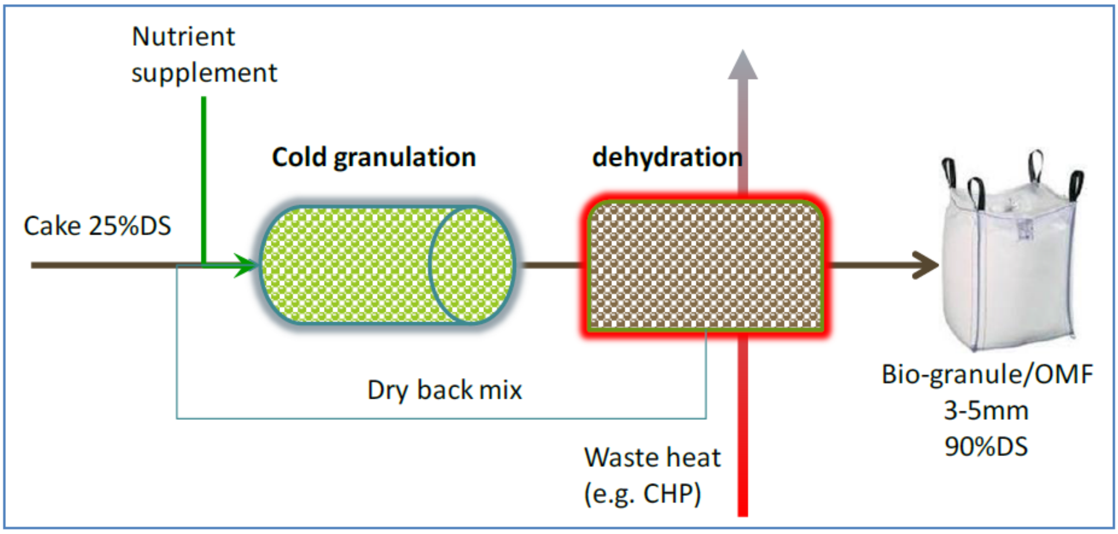

Figure 1: A conceptual diagram of the two-stage process for bio-granule/OMF production. Adapted from 'End o Sludg' final report figure-8, courtesy of United Utilities, UK.

D. Market development activities:

Much of the market development activities focused on the use of OMF in crop trials, which are essential in the development of the theoretical basis of nutrient management for the product. The prototype product, OMF, manufactured during the project could easily and accurately be spread by using a standard twin spinning disc fertiliser spreader up to a bout width of 24 m. In farm-scale trials, the OMF gave similar yields to the conventional fertilisers when applied to cereals and grassland crops.

The application of OMF on the same soil for 5 years had very little effect on the level of heavy metals and potentially toxic elements (PTEs) and did not affect the earthworm numbers suggesting no adverse environmental or health impacts on the food chain. The level of PTEs in the soil after applying OMF between 2007/8 to 2012/13, were less than 20% of the permitted legal limit in the soil. Market data, technical performance results together with the product safety data and environmental findings were collated to provide a substantial body of evidence in support of the case for End of Waste for OMF as a new sludge derivative.

Although, OMF is not being produced as part of a defined production process, nonetheless, it can be concluded that OMF has a discernible market capability, potentially allowing it to meet the key requirements that define End of Waste status.

Further, the pollutants present in sludge do not pose a significant threat to crops and even if there is crop uptake, the levels do not exceed the regulatory safety limits.

E. Management and sustainability of the product:

Management and sustainability studies were concerned with factors controlling colonisation and persistence of harmful bacteria (using *E. coli* as a model), right from the point at which the sludge reaches the farm, and incorporating the results into a risk-assessment model.

The pathogen content of treated biosolids varies depending on the treatment process which should be known prior to land application. The Safe Sludge Matrix recommends that all biosolids are treated to reduce pathogen contents by 99%. Laboratory studies showed that the clay content is an important factor influencing pathogen survival, and the effect of sewage sludge may vary, depending on the soil texture, its mineralogical composition, temperature, soil moisture contents and the pathogen type in question. Hence, this should be taken into account when assessing the survival capacity of pathogens introduced to the soil environment via sludge application.

Who will benefit from this project and why?

The END-O-SLUDG project has developed a series of sludge derivatives that can be adjusted to suit local conditions, and whose production is applicable to a range of wastewater treatment plants. With an emphasis on the whole wastewater treatment system, it provides an integrated approach to the development and implantation of novel products from sludge. The OMF has

great potential to be a sustainable option for sludge management, having social, economic and environmental benefits.

If the challenge has not been specifically met, state why and how this could be overcome
Not applicable

Lead partner	• United Utilities, UK
Scientific partners	• Chemical Engineering and Environmental Technology Department, Universidad de Oviedo, Spain • Natural Resources Department, Cranfield University, UK • Crop and Environment Research Centre, Harper Adams University College, UK • Teagasc - The Irish Agriculture and Food Development Authority, Ireland
Industry partners	• Nijhuis Water Technology, Belgium • WATERLEAU Global Water Technology, Belgium • Hipsitec, Spain • COGERSA, Asturias, Spain • Natural Resources Department, Cranfield University, UK • Carrs Agriculture Ltd., UK • Sustainable Resource Solutions Ltd., UK • Valsave Engineered Solutions Ltd., UK • Demeter Technology Ltd, UK
Government sponsor	• The European Union • AHDB, Cereals and Oilseeds, UK