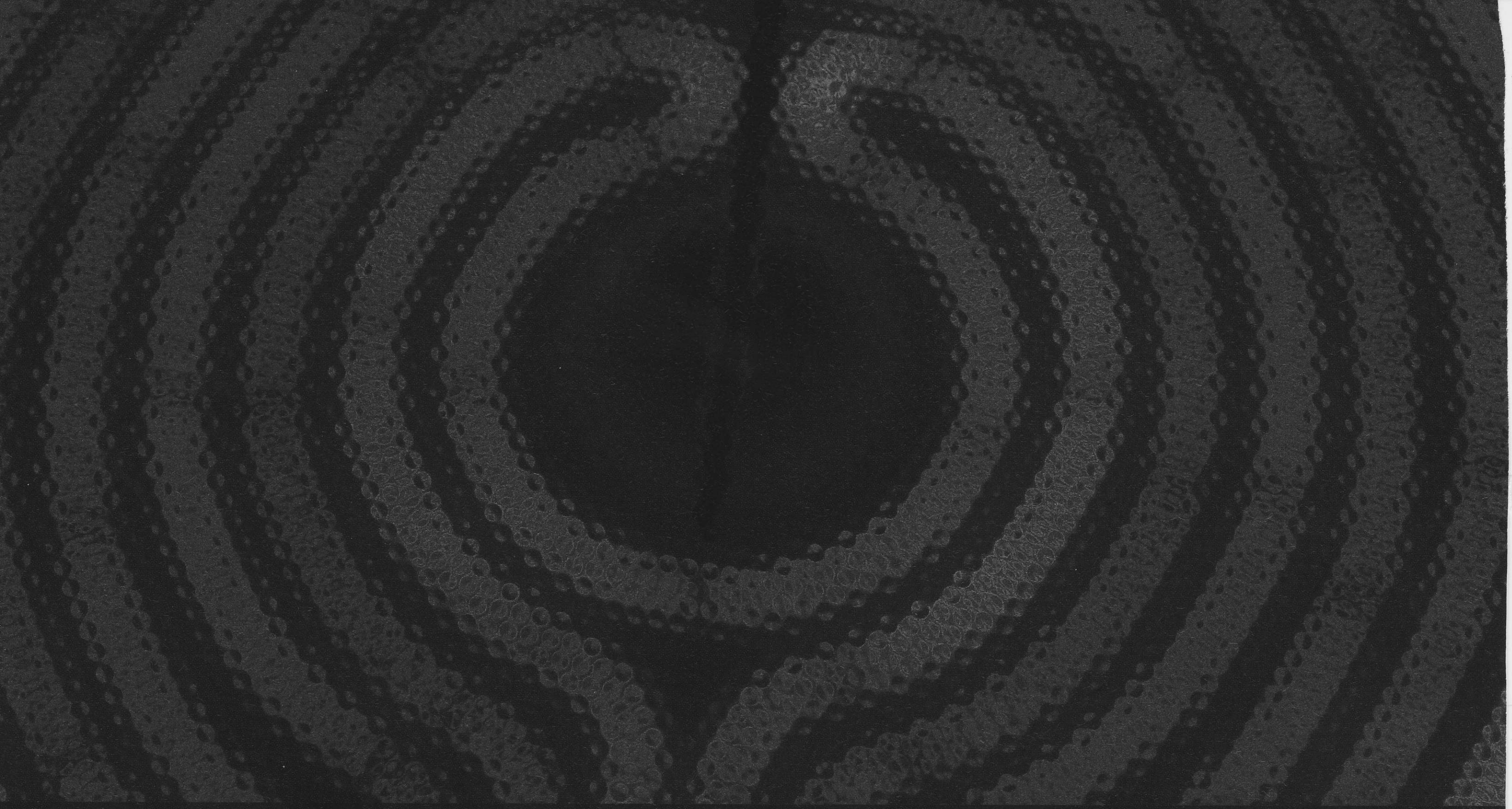


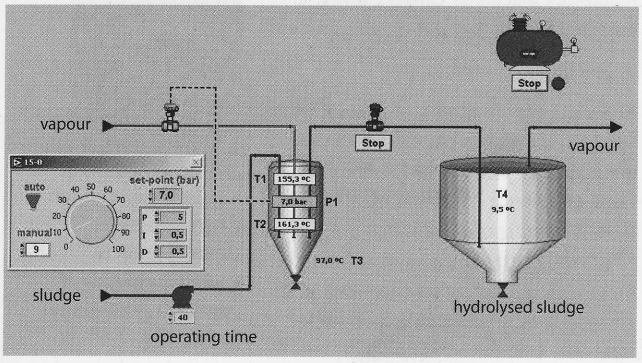
Turning up the heat

Sara Perez-Elvira, Maria Fdz-Polanco and **Fernando Fdz-Polanco** explain the benefits of thermal treatment for sewage sludge

TREATING wastewater often turns into a problem that is not so much about treating water, but about treating sludge. In conventional activated sludge processes, up to 60% of the initial domestic wastewater's chemical oxygen demand (COD) is removed as primary and secondary sludge. Hence, a wastewater treatment problem is converted into a sludge treatment and management challenge. Recent research in Spain suggests that thermal pre-treatment of sludge can give considerable benefits, both in terms of process efficiency and in terms of treating waste sludge.

On-site reduction of sludge is a popular option, in particular through anaerobic digestion (AD). However, the rate-limiting step of solid hydrolysis makes it necessary to implement a pre-treatment unit prior to the digester.

Figure 1: process schematic



Thermal hydrolysis (TH) pre-treatment has also proven to be of great interest. The advantage of a combined TH+AD process is that the energy input needed for the hydrolysis process is thermal energy, so the process is energetically self-sufficient. We have conducted pilot-scale studies for a combined TH+AD process, to analyse the feasibility of the technology for full scale installations. From a sustainability standpoint, this system transforms sludge waste into a useful by-product with an energy and agronomic value.

Pilot plant

The pilot plant (see Figure 1) consists of two units: one for thermal hydrolysis pre-treatment, the other for anaerobic digestion of the treated sludge. To aid transportation to and assembly at the municipal wastewater treatment plant of Vic, Barcelona, each unit is physically independent.

Thermal hydrolysis unit

In the thermal hydrolysis unit (see Figure 2) the sludge cells are disrupted and the intracellular content is released to the media, which makes the sludge becomes more soluble and more biodegradable. The secondary sludge is first concentrated in a centrifuge in order to minimise the water content, before being pumped to a 200 l feeding tank, which is connected to the 20 l total volume hydrolysis reactor by a progressive cavity pump (Pmax = 12 bar).

The continuous feeding rate to the reactor is set at 26 l/h. Inside the reactor, the sludge is heated to 170 °C (pressure 7 bar) with direct steam injection for about 30 min. Based on P and T values measured in the reactor, the automatic valve located at the steam line is opened and closed, maintaining stable operation conditions. The continuous exit from the reactor and flashing to atmospheric pressure (steam explosion effect) is achieved with an automatic valve which connects the reactor to the 100 l flash. The decompression valve opening/closing is temporised so that the volume that arrives at the flash matches up with the sum of the sludge feeding and the heating steam condensed in the reactor. Both temperature (pressure) and time (level) are automatically controlled with valves that modify the steam entrance from the boiler and the sludge exit from the reactor to the flash.

A data acquisition and control system is used to measure and record pressure and temperature, and allows an automatic control of the steam inlet, the reactor level, and the hydrolysed sludge exit to the flash.

anaerobic digestor

In the anaerobic digestion unit (see Figure 2) the pre-treated sludge is degraded to methane, and only a small stabilised sludge residue is left. The hydrolysed sludge is stored in tanks and, when cooled, poured into the feeding tanks of the anaerobic digestors. Both reactors are similar (V=200 l), except for the temperature: one reactor operates in the mesophilic range (35°C) and the other in the thermophilic range (55°C). The digestors are placed in parallel and the feed is continuously pumped at the bottom, leaving from the top after 12 days residence time. The effluent is collected for further analysis, and the biogas produced is measured.

Two years of bench/pilot-scale investigations have led to the following conclusions:

technical feasibility

Continuous thermal hydrolysis pilot plant: The pilot plant trials confirmed that the process is technically feasible. After analysing all operating parameters, we can now proceed to the process engineering development of a full scale plant.

Anaerobic digestion pilot plant: We verified the efficiency of real thermal hydrolysis through two continuous anaerobic digesters working in the mesophilic and thermophilic range. The study collected comprehensive information on sustainability parameters: biogas production, solids removal, polyelectrolyte dosage and dewaterability, viscosity change and pathogen elimination.

economic feasibility

In all the cases studied, thermal pre-treatment was cost effective. The fixed capital cost of our continuous technology is up to 30% lower than that of commercial batch systems. For a 500,000 inhabitants sewage treatment plant, the payback time is 2–3 years and the net benefit afterwards is $400,000/y.

innovation

Continuous vs batch process: In the last ten years, several European sewage facilities have implemented sludge thermal hydrolysis pre-treatment. Unlike commercial batch processes, this system features continuous operation, which optimises energy consumption.

Steam explosion: Application of continuous steam explosion enhances the thermal effect and achieves a more effective cell lysis. This technology is often used in batch with paper wastes, but its use in a continuous sludge treatment is completely innovative.

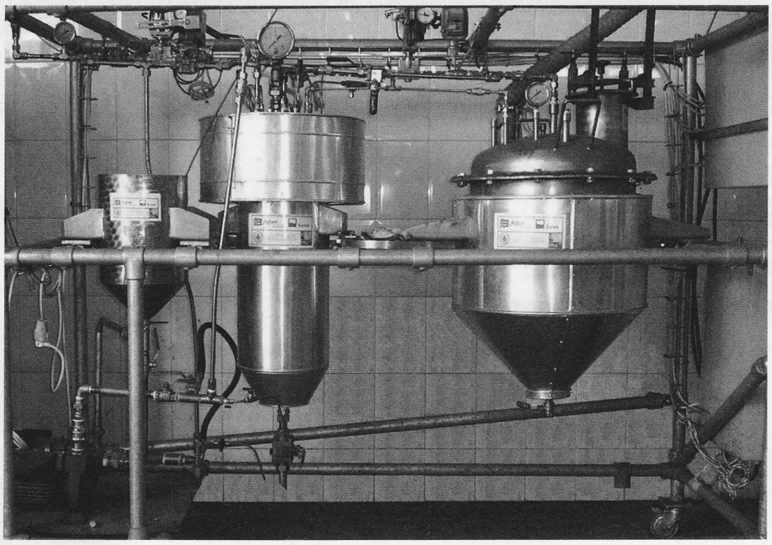


Figure 2: The hydrolysis unit

Energy integration: The main advantage of a thermal process in comparison to those based on electricity relies on the energy integration possibilities. As the economic viability of a thermal process is generally related to the energy consumption, it's crucial to optimise the energy balance, and this is only possible with continuous operation (batch processes lead to significant energy losses).

The energy integration is based on exploiting the high temperature and enthalpy of the hot streams of sludge, vapour and off-gases, in order to minimise the heating needs.

All of the produced biogas is used to generate 'green electricity', making the hydrolysis process self-sufficient in energy.

environmental Impact.

Sludge disposal: The process removes 40% more volatile solids after pre-treatment than conventional systems. Using identical polyelectrolyte dosage, the post-centrifugation cake is very dry. Because of this, the system produces only half the amount of sludge for disposal than conventional plants.

Agricultural use: Thermal pre-treatment guarantees total sludge disinfection, easily reaching EPA parameters for A-class sludge.

Power production: Thermal pre-treatment allows the plant to produce 40% more biogas than without pre-treatment. All this biogas can be burnt to produce 'green electricity' with a very high added value. The steam used to heat the hydrolysis reactor is generated from exhaust gases.

wider application

New plants: The traditional 20 days sludge retention time for digestion can be reduced to 10 days. This halves the required digestor's volume.

Revamping: When enlarging the wastewater treatment plant capacity, the sludge treatment line can be maintained since the digesters capacity can be tripled. The enormous change in rheological properties enables the operation with very high sludge concentration, using moderate mixing energy and keeping conventional mixing equipment.

Co-digestion: The plant makes it possible to increase the organic loading rate, taking advantage of a parallel biogas production increase. Different co-substrates as crops, industrial effluents or solid wastes can be used to increase 'green energy' production.

In conclusion, thermal treatment of waste sludge from water treatment plants offers considerable advantages to municipalities. We hope that the short payback time of only two to three years, coupled with the saving of $400,000/y for an urban sewage plant (500,000 inhabitants) will convince councils around the world that thermal sludge treatment is a worthwhile investment, even in the current economic climate.

acknowledgement

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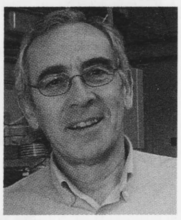

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