TECHNICAL BRIEF

March 2018
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

Optimisation of the Latrine Dehyrdation Pasteurisation Faecal Sludge Treatment Processor

A Water Research Commission study successfully tested an alternative technology to safely dispose of the sludge from ventilated improved pit toilets.

Background

When eThekwini Municipality was established in 1999, over 60 000 Ventilated Improved Pit (VIP) latrines were inherited from the incorporated local entities. In 2009, the municipality set out to empty over 35 000 VIP latrines, which were already full.

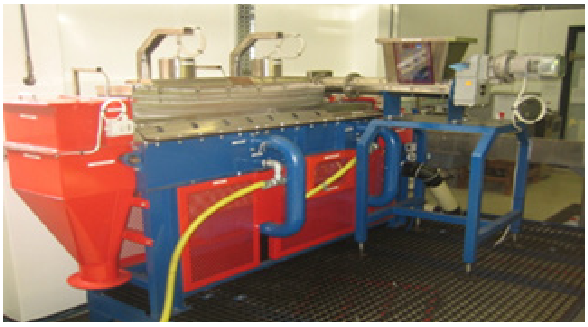
One of the challenges from this operation was the disposal of the sludge in an environmentally safe way. The initial idea was to dispose of the sludge in wastewater treatment plants, but the first trials caused overloading and dysfunction of the treatment plant.

Consequently, the municipality had to seek alternative solutions for the disposal of faecal sludge. This led to the concept of the ***LAtrine DEhydration and PAsteurisation*** (LaDePa) machine, manufactured by Particle Separation System (PSS).

This machine is used to process the faecal sludge that was removed from latrines into dry and pasteurised pellets, which can be used as a soil conditioner or fertiliser, or which could be combusted as a fuel. In the developed technology, the pellets are pasteurised and dried using a combination convective and infrared radiation heating.

A LaDePa machine small-scale prototype was installed in the Pollution Research Group (PRG) laboratory, situated at the University of KwaZulu-Natal, Durban. Its objective was to understand better the involved in drying process in the LaDePa process and optimise the operation of the full-scale machine.

The aim of this work was to characterise the LaDePa process using the laboratory-scale machine. It was envisaged that this would ultimately lead to the determination of the optimum operating conditions for drying and pasteurisation.



LABORATORY-SCALE LADEPA

The research focussed on two main aspects. The first one corresponds to the study of the drying behaviour of the faecal sludge in the LaDePa, which was done by measuring the moisture, volatile matter and ash content at different heating intensities and residence times.

Main findings

The study had several important findings. Among others, the study found that at high Medium InfraRed (MIR) emitter intensity (temperatures higher than 200°C), drying occurs the fastest and it is the most efficient. However, this was coupled with a considerable risk of undesirable thermal degradation and burning of the pellets.

At MIR emitter intensity (temperatures between 100°C and 200°C), the risk of thermal degradation is avoided but drying takes longer. Under these conditions, a residence time of approximately 20 minutes is necessary to reduce the moisture content to 20%. At low MIR intensity (temperatures lower than 100°C), drying is too slow. In all cases, complete pasteurisation is insured in less than 8 minutes.

The recommended MIR emitter intensity should be the highest one possible without thermal degradation of the pellets. For future work, it is important to determine the temperature and corresponding intensity at which thermal degradation first occurs.

Minimising the distance between the emitters and the conveyer belt would lead to energy saving due to a lower MIR intensity required to achieve the targeted moisture content and complete pasteurisation. Decreasing the pellet size leads to faster drying and a more efficient process.

The drying rate is slightly faster for faecal sludge without pre-treatment than for a pre-treated sample. Drying will be faster by increasing the air flowrate in the heating zone as it will lead to a better evacuation of the evaporated moisture from the surface of the pellets to the environment. However, the air should be heated in order to avoid a cooling effect on particle surface, which has a negative effect on drying rate.

From a phenomenological point of view, drying occurs in the constant rate period in the early stage and then pellets remain isothermal at the moisture evaporation temperature. After removal of approximately half of the moisture, the drying rate declines, indicating that the pellet surface is fully or partially dried. Therefore, the temperature at the surface increases and becomes considerably higher than at the core. If the heating flux from MIR emitters is too high, the dried surface can be thermally degraded while the core continues to dry.

FULL-SCALE LADEPA MACHINE IN ETHEKWINI

The second aspect is the biological, chemical and physical characteristics of the processed pellets. Indeed, the analysis of the Ascaris content of the processed pellets, a hardy pathogen indicator, was performed in order to determine the extent of pasteurisation. The chemical analysis in the major nutrients, namely nitrogen, phosphorus and potassium, was evaluated in order to assess the pellet quality for agriculture proposes. The calorific value, thermal conductivity and heat capacity was also determined in order to evaluate the use of the pellets as a biofuel.

The findings were summarised as follows:

- Drying provokes some chemical and physical modifications in the pellets: a decrease of the concentration of the soluble nitrogenous compounds, suggesting chemical changes of the nitrogen form in the sample; a decrease in the thermal conductivity and heat capacity, leading to globally a slight increase of the thermal diffusivity. After removing 80% of the initial moisture, these thermal properties attain a stable value.
- The dried pellets present an interesting nutrient composition in terms of macronutrients, Phosphorus (P) and Potassium (K), and micronutrients, Magnesium (Mg) and Calcium (Ca). If used for agricultural purposes, most of the phosphorous will be slowly released in the soil. A considerable part of the potassium, magnesium and calcium could be expected to be fast released in the soil, as these compounds are very soluble in water. The dried pellets would rapidly release some nitrogen, mainly as ammonium and nitrites. These forms are not the most optimal for assimilation by the plants, compared to nitrates, but they can be converted into the latter one by soil microbial activity.
- The use of dried pellets as a biofuel is a potentially interesting alternative, because of the relatively high calorific value and good thermal diffusivity of the material.

Source:

Characterisation of On-Site Sanitation Material And Products: VIP Latrines And Pour-Flush Toilets: Volume 2: LaDePa
(**WRC Project no. K5/2137**) by S Mirara, A Singh, SS Stringel, K Velkushanova and CA Buckley (2018).