COMPOSTING OF FILTER CAKE FROM A SUGAR FACTORY

By H. W. BERNHARDT and P. NOTCUTT
Sugar Milling Research Institute, Durban

Abstract

The disposal of relatively large tonnages of filter cake which cannot be used as fertiliser on distant sugar cane fields because of prohibitive transport costs is an expensive necessity for a number of sugar factories. The feasibility of composting the filter cake to produce an economically useful product is considered. Results of pilot scale composting trials conducted on filter cake from one sugar factory are presented. These show commercial promise. Practical production data are given.

Introduction

During the last two normal sugar seasons, namely in 1990 and 1991, the South African mills produced close to 600 000 tons filter cake per season with an average moisture content of 73,3%. This filter cake production represents just more than 3% of the total cane crushed. A significant proportion of the filter cake is returned to nearby fields as a soil conditioner or low concentration fertiliser but many factories are left with huge surpluses of filter cake which have to be dumped on specially allocated sites because the high transport and spreading costs of the cake cannot be justified for distant fields.

During 1992 the Biotechnology Division of the Sugar Milling Research Institute (SMRI) investigated the technical feasibility of converting filter cake into a compost that has commercial value. The potential advantages of composting filter cake are:

- the production of a marketable product
- reduction of offensive odours that are normally caused by rotting, dumped filter cake
- reduction of environmental pollution by solid waste
- weight reduction of the filter cake as a result of drying and decomposition of organic matter
- increase in the nutrient concentration in the filter cake due to the removal of water and cellulose.

Sugar factory filter cake is a more benign source of compost than municipal waste or sewage sludge because it is free of pathogenic organisms and weed seeds which have been eliminated by the high temperature juice clarification process, and the solid particles in the filter cake fall within a narrow size range. Thus no additional treatment such as pasteurisation or size reduction is necessary before or after the composting process.

The potential benefits of fresh or composted filter cake as a soil conditioner or fertiliser have been extensively investigated. Alexander (1971,1972) has reported on the significant quantities of plant nutrients in the form of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and micronutrients that have been measured in samples of filter cake from all South African sugar mills. Roth (1971) has highlighted the formation of improved soil structure, largely as a result of the relatively high content of organic constituents. Moberly and Meyer (1978) dealt with the improved water retention capacity of filter cake which is particularly valuable for germination in adverse climatic conditions. They also reported that composted filter cake was more effective in increasing the yield of cane per hectare than fresh filter cake. The difference was traced to improved nitrogen uptake by the plants in the presence of old filter cake. Navarro (1978) reported that the beneficial effects of composted filter cake were due to the introduction of heightened biological activity as a result of the rich mixture of humus producing micro-organisms present in the compost. This activity assisted nutrient uptake by growing plants to a greater degree and for much longer periods than took place as a result of the addition of the same nutrients in a sterile form.

The Composting Process

Composting of filter cake can be carried out either aerobically or anaerobically. Navarro (1978) describes an anaerobic process using a commercially available inoculum called COFUNA which consists of a selected mixture of bacterial strains. The inoculum has to be thoroughly mixed at an inclusion rate of 10% with a large quantity of filter cake (225 tons or more) and the mixture then has to be formed into a heap. In the authors' views the drawbacks of this process are the necessity of using an inoculum which has to be purchased separately, the extensive mixing required, which is a difficult operation on filter cake, and the fact that large quantities of filter cake are required for each batch. Composting is claimed to be completed after two months.

Donato *et al.* (1980) describe a very elaborate process consisting of aerobic as well as anaerobic stages. It incorporates pretreatment of the filter cake with a caustic soda-quick lime solution to break partially the cellulose-lignin bonds of the bagacillo in the cake as well as the addition of an inoculum of Bakers' yeast, *Rhizobia* soil culture and cattle rumen extract together with some ammonium phosphate and urea. A 25 day composting period is claimed for this process.

The aims of the present investigation were to find a simple process that required the minimum of additional materials, labour and equipment. Furthermore, the process should be such that the filter cake should be able to enter the composting process as it is produced without portions having to be stored until large enough quantities have accumulated. These aims dictated that an aerobic process should be considered.

The requirements for aerobic composting of organic materials include a sufficient supply of:

- moisture
- oxygen
- suitable micro-organisms
- macro and micro nutrients as well as the absence of substances that are toxic to the organisms that effect the composting.

The process consists of the breakdown of many organic constituents such as sugars, waxes, acids and lignocellulose compounds through complex biochemical reactions which are catalysed by many enzymes produced by a wide range of micro-organisms. The composted product consists of stable compounds, generally described by the word "humus", which support the micro- and macroflora and -fauna normally found in soils.

Gray *et al.* (1971) have provided an excellent overview of the groups of micro-organisms that are believed to be the main players in this process. Research has shown that it takes place in four main stages, each stage representing the predominating activity of a particular group of organisms. The stages are described by Gray *et al.* as the mesophilic, thermophilic, cooling down and maturing stages, and the transition from one stage to the next is indicated on a typical temperature profile shown in Figure 1.

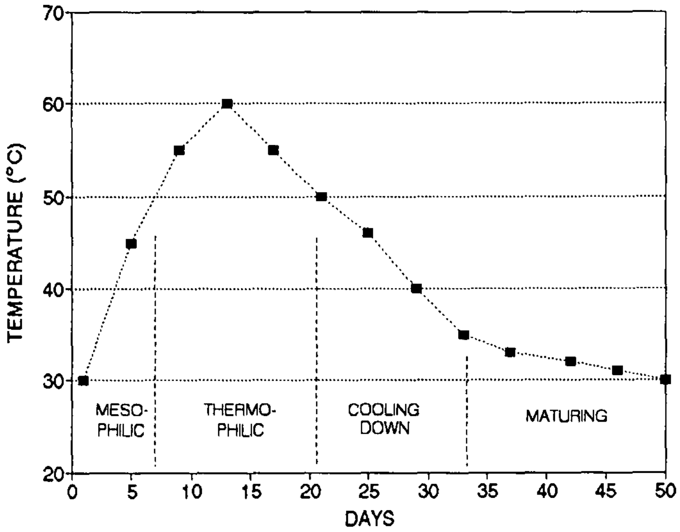

FIGURE 1 Temperature profile of typical composting process.

Temperature is a useful indicator of microbial activity. The rapid temperature rise at the beginning of the process is due to the oxidation of easily digestible components such as sugars and other small organic molecules. As the easily digestible components get depleted the rate of heat production slows down due to the slower breakdown of more complex molecules. This accounts for the cooling down period. The maturation period corresponds to the gradual conversion of partially decomposed polymers to stable humic acids. The temperature should not be allowed to rise above 65°C and the moisture should be maintained at 50-60% for an optimal composting rate (Gray *et al.*, 1971).

The questions to which the authors wished to find answers by the composting trials were:

(a) What is the best way of supplying oxygen, measured in terms of composting efficiency and minimal cost: mechanical turning, using alternating layers of bagasse and filter cake or providing forced aeration through a system of pipes with multiple aeration jets?

(b) Will colonisation of the filter cake by micro-organisms normally present in the air lead to an acceptable composting rate, or is artificial inoculation essential to the process?

The trials were conducted on a scale large enough to enable the results to be used to design a full-scale composting facility without the necessity of performing scale-up tests.

Materials and methods

The filter cake used in the tests was derived from a diffuser factory (quantities are less than from a milling tandem) and it had no smuts or boiler ash added to it. Four piles of filter cake were made. The bases of the piles were approximately 4 m long and 2 m wide and the heights approximately 1 m. The masses of filter cake deposited on each pile were recorded. The different treatments applied to each pile were:

Pile A: This pile was constructed using alternating layers of bagasse and filter cake each approximately 10 cm thick. The intention was that the bagasse interlayers would facilitate aeration. The pile was left undisturbed for the duration of the experiment.

Pile B: This pile consisted of filter cake only and aeration was provided by manual turning of the filter cake using a garden spade, the whole pile being turned once every four days.

Pile C: A starter culture of composted filter cake was thoroughly mixed with fresh filter cake in this pile which was similarly turned every four days. The inclusion rate of the starter culture was approximately 2% by mass.

Pile D: A framework of six parallel, interconnected pipes 4,4 m in length all connected to one compressed air supply was covered with a pile of filter cake that was somewhat longer and higher than the other three piles. The pipes had air holes of 4,2 mm diameter at 150 mm intervals and the air supply was maintained throughout the experiment, except when plant shutdowns caused an interruption. Unfortunately the aeration rate could not be measured. The filter cake on this pile, once laid down, was left undisturbed.

The experiment lasted six weeks. Samples were taken at weekly intervals and analysed for moisture, pH, nutrients (N, P, K, Ca, Mg) and carbon. Temperature readings were taken every four days at six points in each pile and the average was determined. Water was sprayed on the piles at intervals to prevent excessive desiccation. However, a later similar trial conducted on filter cake from the Illovo sugar factory showed that this was not necessary despite the fact that during the time of that trial very little rain had fallen.

Results and Discussion

The unpleasant sour odours that are so characteristic of piles of filter cake left to ferment without artificial aeration did not develop to the same degree on the four test piles and disappeared within a week. The temperature curves obtained from the four piles over the six week period are shown in Figure 2.

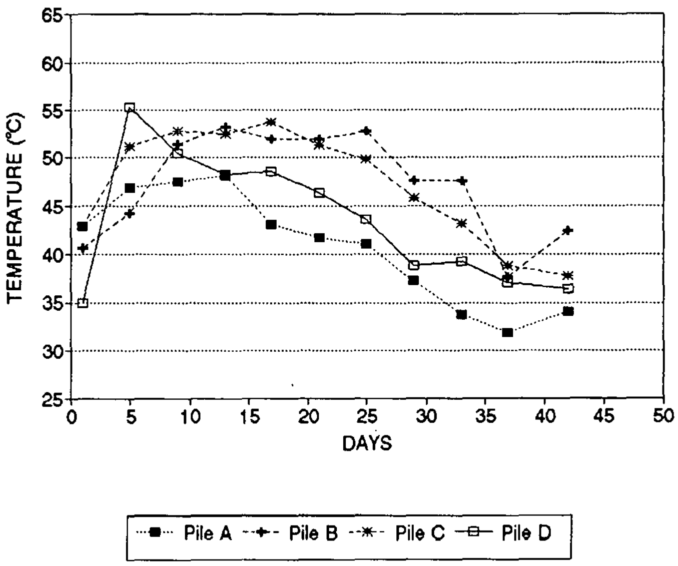

FIGURE 2 Temperature profiles of experimental piles of filter cake.

From these curves it can be seen that piles B and C which were subjected to manual turning every four days appeared to have the most vigorous and sustained overall activity. This conclusion was supported by the observation that the composted material from these two piles after the six week period consisted of a uniform mass of loose fine particles whereas that from pile A had large numbers of undigested long fibres from the bagasse layers and lumps of adhering wet particles from the filter cake layers. Pile D (which had been aerated by the pipe system) showed fairly well textured regions close to the pipes whereas at some distance away the filter cake was still sticky and lumpy. Pile B experienced a lag in the temperature rise compared to pile C but after the tenth day the temperatures of the two piles were very similar. This trend was to be expected since pile C had been inoculated with a starter culture obtained from previously composted filter cake which must have accelerated early colonisation by appropriate micro-organisms. The implication is that a suitable inoculum is beneficial, but not essential, for effective composting.

Figure 3 shows the concentrations of nutrients (on a dry basis) of samples taken from Pile B at the start and at the conclusion of the experiment. The other piles showed similar responses.

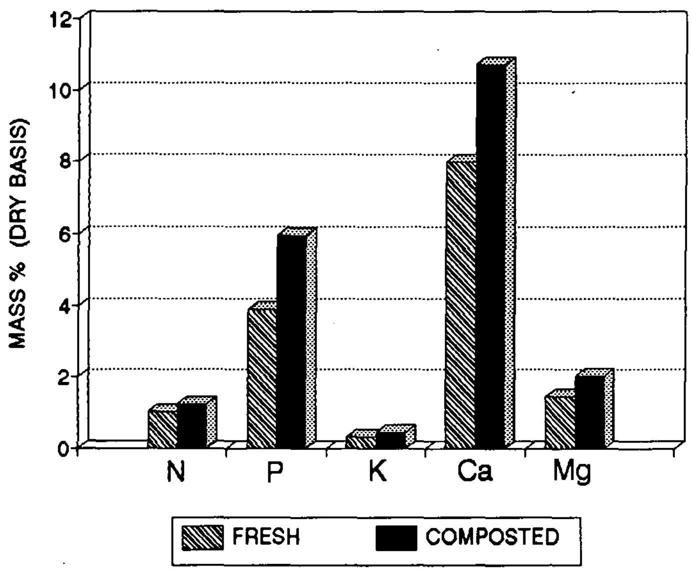

FIGURE 3 Nutrient concentrations of fresh and composted filter cake from pile C (dry basis).

The fertiliser value of the NPK nutrients in the wet filter cake before composting and of the final product are, respectively, R50,85 and R175,22 per ton. The reason for the increased concentration of all the nutrients after composting (expressed on a dry basis) is the relative decrease in carbon. The initial organic carbon content was 31,0% and the content after six weeks (in pile C) was 23,1%. It is also noteworthy that the relative increase in N is much less than that of the others since some volatilisation of N in the form of ammonia takes place during the composting process which results in a partial loss.

The C:N ratio at the beginning was 30,6 and after the six weeks it was 18,8 for compost from pile B and 17,0 from pile C. An acceptable value for inclusion in soil is 20. The moisture content of the filter cake at the beginning was 80,1% and that of the final product taken as a mixture from piles B and C was 50,1%. A weight loss of 52% was recorded for pile C. The pH of the filter cake changed from about 7,2 to 8,3 for the final product. The bulk density of the finished product was 486 kg/m^3 and it had the pleasant odour of humified organic material.

A seedling growth test was performed on a mixture of the compost from Piles B and C. This indicated good germination and initial growth. A sample of the same mixture was submitted to a compost marketing company for evaluation. The company stated that the material compared favourably with other sources of commercial compost and had an approximate bulk value of R40 per m^3. It may even be suitable for use as a seedling mix which has a higher value than the ordinary commercial compost.

Conclusions

This investigation into composting of sugar factory filter cake has shown that:

- Filter cake is an ideal medium for the production of a commercial compost which has a bulk market value of about R40 per m^3
- Mechanical turning at intervals of about four days provides sufficient aeration for aerobic decomposition
- A six week composting period is required
- No additional substances are needed to produce the compost, although the process will benefit from the admixture of old composted filter cake. Under normal climatic conditions it should not even be necessary to supply additional water.

It should be noted that these findings apply only to filter cake, not to filter cake/smuts mixtures (smuts contain a large quantity of non-compostable material).

Acknowledgments

The authors wish to thank Transvaal Sugar Limited for their financial support which enabled them to carry out this project.

REFERENCES

Alexander, KEF (1971). Analysis of filter cake from South African sugar mills. *Proc S Afr Sug Technol Ass* 45: 149-151.

Alexander, KEF (1972). A note on the analyses of composite samples of filter-cake from South African sugar factories. *Proc S Afr Sug Technol Ass* 46: 224-225.

Donato, RA, Meñez, VA and Jesena, RT (1980). A quick process of converting filter cake into a high grade organic soil conditioner. *Proc int Soc Sug Cane Technol* 17(3): 2693-2699.

Gray, KR, Sherman, K and Biddlestone, AJ (1971). A review of composting - part 1. *Process Biochem* 6(6): 32-36.

Moberly, PK and Meyer, JH (1978). Filter cake - a field and glasshouse evaluation. *Proc S Afr Sug Technol Ass* 52: 131-136.

Navarro, RO (1978). Conversion of filter cake into high-grade organic fertilizer. *Proc Philippine Sug Technol* 26(2): 107-117.

Roth, G (1971). The effects of filter cake on soil fertility and yield of sugarcane. *Proc S Afr Sug Technol Ass* 45: 142-148.