THE PRODUCTION OF ORGANIC FERTILIZER

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Introduction

The essential difference between inorganic and organic fertilizers lies in the relative energy states of the elements.

Inorganic fertilizers are chemical compounds in stable low energy states while organic fertilizers are labile compounds in high energy states.

This difference in energy states determines the widely different characteristics and processing requirements of inorganic and organic fertilizers i.e.

(i) Organics are bulky (low density) and contain relatively low concentrations of most plant nutrients. Inorganics are dense and contain high concentrations of only a few plant nutrients.

(ii) Inorganics are easily stored and relatively inexpensive to transport. Organics usually have poor shelf-life and are relatively expensive to transport.

(iii) Inorganics are produced by energy/capital intensive chemical and physical processes (irreversible chemical reactions) while organics are produced by low energy/low capital intensity physical processes.

Raw materials

Chicken litter

The litter from intensive chicken production represents both a considerable waste disposal problem and a resource for the animal feeds and organic fertilizer industry. Good hygiene requires that litter be removed from production sites regularly. Litter from laying batteries is removed once a week. It consists of pure faeces and urine generated at the rate of 30kg/day per 1 000 birds. Litter from broiler production sites is cleared once per cycle (about 8 weeks) and consists of faeces and urine absorbed on bedding material such as wood-shavings, wheat straw, peanut hulls and paper. Litter from breeding sites is similar to that from broiler sites but is removed only once every 60 weeks. One obtains 40 kg/day litter per 1 000 chickens from broiler and breeding sites.

Table 1 reflects typical chemical analyses of the various types of chicken litter.

Cattle manure

Intensive cattle feeding in feedlots and dairies leads to the generation of considerable quantities of manure (about 1,8t per cattle unit p.a.) The manure is usually removed from the pens once or twice a year. Table 2 contains typical chemical analyses of cattle manure.

TABLE 2. Chemical analyses of cattle manure on an 'as is' basis.

N	P	K	Ash	Moisture
		%		
1,5 - 2,5	1,0 - 2,0	1,5 - 2,5	40 - 50	15 - 30

Sewage sludge

Three types of sludge are generated at biological wastewater treatment works.

(i) Raw sludge consisting of solids settled out from the wastewater as the first stage of the treatment process.

(ii) Activated sludge consisting of biomass produced by the aerobic digestion of nutrients in the wastewater.

(iii) Digested sludge produced by the anaerobic stabilisation of activated and raw sludge.

Table 3 contains typical chemical analyses of the various types of sludges.

TABLE 1. Chemical analyses of various chicken litters on an 'as is' basis.

	N	P	K	Ash	Moisture
			%		
Broiler litter	3,5 - 4,5	1,5 - 2,0	1,5 - 2,0	10 - 15	15 - 35
Breeder litter	3,0 - 3,5	1,5 - 2,0	1,5 - 2,0	15 - 25	15 - 25
Layer litter	1,5 - 2,0	1,0 - 1,5	1,0 - 2,0	40 - 50	30 - 60

TABLE 3. Chemical analyses of various types of sewage sludge on a 'dry basis'.

	N	P	K	Ash	Ca	Mg	S
				%			
Raw sludge	4,0 - 5,0	2,0 - 3,0	0,5 - 1,0	20 - 30	3,0 - 5,0	1,5 - 1,7	1,5 - 2,
Activated sludge	5,0 - 6,0	3,0 - 5,0	0,5 - 1,0	35 - 45	3,0 - 5,0	1,8 - 2,2	2,5 - 3,
Digested sludge	3,5 - 4,0	2,0 - 3,0	0,5 - 1,0	40 - 50	3,0 - 5,0	0,5 - 1,0	1,5 - 2,

Processing

All organic fertilizers are produced by simple physical processes described in the flowsheet in Figure 1.

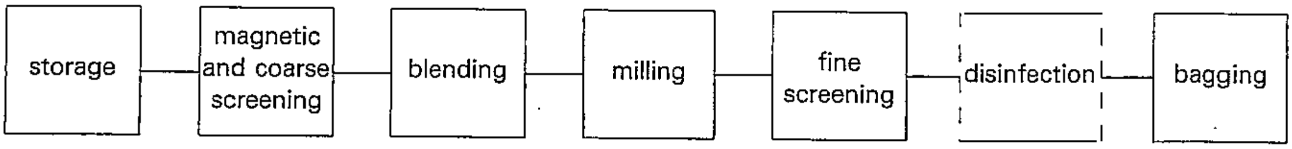

Fig 1. Flowsheet of production process for organic fertilizer.

The degree of intensity and the mechanism of each unit operation varies according to the nature of the raw material. We shall discuss the unit processes in more detail:

Storage

Raw materials are often stored in piles or windrows. It is very difficult to store organic material in silos or even bunkers. The flow of material in such containers depends on slip between the material and the walls. Organic material tends to oxidise biologically in containers, causing condensation at the walls that severely limits slip. Recently we have developed a roll-on-roll-off bin system for storage at Springs.

Magnetic and coarse screening

Coarse screening is employed to remove large rocks and debris from the raw material. Recent experiments indicate that gravity separators could be the best coarse screening devices for most raw materials.

Powerful magnets are used to remove the remarkably large quantities of iron and steel scrap from the organics.

Blending

Some plants employ pug and pan mixers but good mixing is usually achieved simply by tumbling the materials as they move through the plant. Several manufacturers blend both organic and inorganic constituents to produce their fertilizers.

Milling

Various types of mills are used.

Sewage sludge is milled in horizontal shaft high speed mills to yield relatively finely divided products.

Chicken litter is usually milled in vertical shaft open mills. These mills are really lump breakers and mixers.

Cattle manure may be processed in the same way as sewage sludge. However, it is usually milled and blended in windrows using mechanical composting devices such as the 'Scavenger'.

Fine screening

Fine screening is usually the rate limiting step in an organic fertilizer plant. Most plants use vibrating screens for the final classification of the product. We believe the eccentric motion screens are the most effective for 'sticky' organic materials.

Some plants recycle the oversize to a high speed hammermill. Several just dispose of the oversizes. Others compost the oversizes thus making the material friable and suitable for recycling through the plant.

Disinfection

Most organic fertilizer plants do not disinfect the raw material in any way.

However, there are several reasons why a degree of disinfection should be practised. These are:

(i) Public health risks related to the unrestricted use of animal wastes. Regulations have been promulgated in RSA and most developed countries to restrict the use of sewage sludge on cropland.

(ii) Organic fertilizers with reduced bacterial populations are far more stable than those that have not been biologically processed. Instability leads to rapid nutrient loss, accompanied by water and gas generation with concomitant poor shelf life.

Heat, chemical and radiation disinfection processes are technically feasible.

Heat

Disinfection by heat is probably the best known technique. It is applied to certain sewage sludges (the Zimpro process) and to layer litter using various fossil fuels as sources of energy. The high temperatures and pressures tend to destroy plant nutrients and the energy costs are prohibitive.

Heat generated during the thermophilic phase of composting can effectively destroy pathogens. Such composting processes are relatively inexpensive if they are carefully controlled to avoid excessive loss of plant nutrients and energy.

Chemical

Several chemicals have been used to disinfect organic materials.

Methyl bromide and ethylene dibromide are well known fumigants that have been applied to chicken litter and sewage sludge. Fumigation with these chemicals is inexpensive if done on a relatively small scale in remote areas.

Propionic and formic acids have also been successfully used to disinfect sewage sludge although the costs of these techniques are not well documented.

Recently, we have considered ammonification as a means of both disinfection and enrichment of organic materials with plant nutrients.

Radiation

Gamma — radiation from both Co60 and Cs137 sources has been successfully used to disinfect sewage sludge. Both the capital and operating costs are high although unit costs decrease rapidly with increasing throughput.

Beta-radiation (high energy electrons) is a less capital intensive and energy efficient means of disinfecting organic materials. We operate an electron accelerator at Springs to disinfect both sewage sludge and broiler litter. Operating costs are twenty-five percent higher than those of a conventional organic fertilizer plant of similar capacity adding only between R5/t and R10/t to the costs of production.

We have tested microwave irradiation of organic materials but found it to be relatively ineffective when compared with Gamma and Beta-radiation.

Bagging

Considerable controversy exists about the nature of the packaging required for organic fertilizers. Several manufacturers believe that the products should be sold in bulk to defray costs. Indeed, it is the general practise to distribute relatively low value organic fertilizers eg. cattle manure and unprocessed chicken litter in bulk.

Some manufacturers believe that processed organic fertilizer should be sold in airtight plastic bags to ensure anaerobic conditions thus reducing the rate of biological oxidation and nutrient loss. Others believe that this procedure leads to bags bursting due to gas generation and deliberately puncture their plastic bags. Claims abound of moisture absorption from the atmosphere via pores or even stitching holes. Our view is that neither the observations nor the rationalisations are consistent and we have launched a thorough investigation into the bagging or organic fertilizer.

Product

It is important to consider the characteristics of the fertilizers produced from the raw materials by the processes described here. They are:

(i) A material of relatively low bulk density with relatively low concentrations of most of the sixteen essential plant nutrients.

(ii) A fertilizer which is biologically labile on the shelf and in the soil yet providing a source of energy and nutrients for soil microflora.

(iii) A material whose nutrients mineralise relatively slowly in the soil (Figure 2) and at different rates and to different extents in different types of soil.

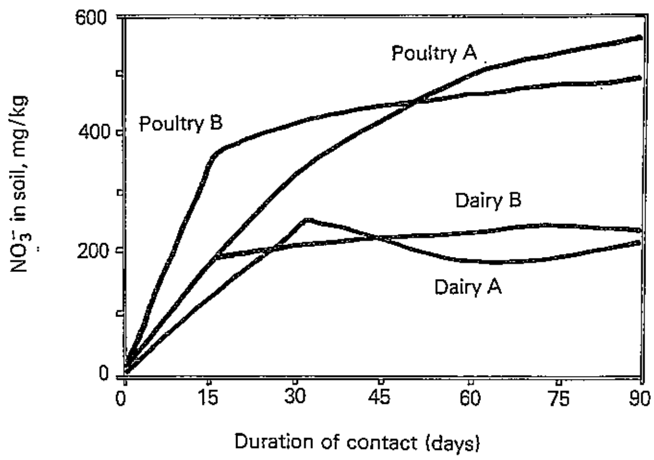

FIG. 2 Nitrate accumulation in two soils, A and B, from two sources, dairy and poultry litter.

(iv) A product which serves as a good substrate in blends with more concentrated inorganic fertilizers.

(v) Plant nutrients that are less susceptible to leaching by water and to fixation in the soil matrix.

Conclusion

As the population grows the generation of concentrated organic residues will grow. Many of these residues constitute potential sources of plant and animal nutrients. Although organic plant nutrients in RSA cannot exceed 3% of the total plant nutrient requirements, particular synergy occurs when inorganic nutrients are blended with organics. Greater marginal returns are achieved on crops fertilised with both organics and inorganics. The production processes described in this paper add the values of consistent quality, enriched plant nutrients, ease of distribution and ease of application to the organic raw materials derived from animal and plant residues.