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Some Technical Aspects of Composting

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Abstract

The development of composting techniques is essential to the low input sustainable agriculture. This paper presents an evaluation of composting system, compost materials, aeration & temperature effects, compost maturity, and operational concerns for compost utilization.The composting of organic waste is markedly affected by the nature of the feedstock and the operational temperature employed for the process.These two major parameters are critically examined in this paper,with references to the decomposition of the organic waste.Future research should concentrate on the indications of stability and environmental problems.

1. Introduction

Organic waste is useful resources for agriculture, but it is unsuitable for fertilizers as it is. To use it as fertilizers, it should be processed so that it become easier and safer to apply.

Composting is defined as a thermophilic biological process involving the decomposition of putrescible organic waste into a relatively stable humuslike end product(2).

Composting is one of the effective ways for these purpose ,and this method is widely introduced by many farmers. But there are often those cases where no adequate processing is given on account of the absence of correct understanding of the composting system for organic waste.

The purpose of this study is to provide some basic information needed to make choices in developing an engineering design basis for integrated organic waste composting. This paper reveals some results of technical research on the open aerobic composting process.

The following sections explain the fundamentals of the open type composting process and review some factors of an operating compost facility.

2. Open composting process system

The composting process may be physically achived in basically two types of systems: Open(Windrow, Aerated Static Pile) and Closed(Enclosed Mechanical Units) types of various design which usually supply continuous mixing and positive aeration.

This paper deals with the open type composting system. The basic steps in both the windrow and aerated static pile composting systems are similar and are illustrated in the aerobic composting process flow diagram in Fig.1. The sequential steps in the windrow and aerated static pile methods are as follows:

1) Sludge is delivered to the site and usually mixed with a bulking agent: The purpose of the bulking agent is to decrease the moisture content of the mixture,control the optimmum C/N ratio of the mixture,increase porosity of the sludge and assure aerobic conditions during composting. Various bulking agents can be used including wood chips, bark chips,rice straw and hulls, and unscreened or finished compost has been used. Generally, one part sludge is mixed with two to three parts bulking agent by volume(6,7).

2) Windrow or pile are constructed by placing the sludge-bulking agent mixture in windrows or static piles(6).

3) Pile or windrow are aerated for 15 days(static pile) or 21 days(windrow) by forced aeration or mechanical turning. aeration rates are 50-200 L/min./m^3 to assure aerobic conditions(6,9).

Temperature in all parts of the compost mass should be maintained at 60°C or bellow for at least 48 consecutive hours(3).

4) Windrow or pile are dismantled and the sludge-bulking agent mixture moved to a curing pad for an additional 30 days. Curing provides time for additional stabilization and drying of a finished compost. The curing piles are not mechanically aerated(8).

5) The sludge-bulking agent mixture is screened to recover and reuse the bulking agent. It may be possible to screen the mixture before curing if it has dried sufficiently to permit screening and to prevent the development of anaerobic conditions(5).The finished compost can be used or stored.

2-1. Windrow Composting

The windrow process composting is conducted in uncovered areas and relies on natural ventilation plus periodic turning to maintain aerobic conditions.

The sludge-bulking agent mixture is spread in windrows with a triangular cross section normally 2.5 to 4.3 m wide and 0.9 to 1.8 m high(6).

An alternative method to mixing the bulking agent and sludge before forming the windrow is placing the bulking agent as a base for the windrow. The sludge is then dumped on top of the bulking agent and spread. A rotary tiller then mixes the sludge and bulking agent forms the mixture into a windrow. Several turnings about 8 to 10 times are necessary to adequately blend the two materials.

Fig.2(8) illustrated that windrows that are turned more often have smaller hot zones(>55°C). For the most rapid and complete inactivation of pathogens, a hot zone encompassing a large portion of the windrow is preferred. Research has shown that a turning frequency of three times per week provides a satisfactory pathogen kill and ensures an adequate drying rate(5,6,8).

2-2. Aerated Static Pile Composting

In the forced aeration static pile process the pile remains fixed,as opposed to the constant turning of the windrow, and a forced aeration system maintains aerobic conditions.

Flow diagram of static pile method for composting is illustrated in Fig.3(3). Advantages of the aerated method include lower land requirement, improved drying and better process control and performance during inclement weather. However the process is much more capital intensive than the windrow method, requiring installation of expensive aeration and odor control facilities(2,3).

All of the principles discussed before concerning windrow construction, pile size apply equally well to the windrow process.

3. Materials Suitable for Composting

Many biomass materials show active decomposition accompanies by rise in temperature. However, some of these materials are considered unsuitable for composting. For example, grass, straw, and foliage are generally more valuable as feeding materials for livestock.Therefore, byproducts and disposable products are generally considered for composting. These matertials range from animal waste, with a high fertilizer value, to straw with a minimal fertilizer content. In one extreme, these materials are composed only for the purpose of prmoting land stability in land reclamation projects(4,7).

The materials presently used for compost are listed in Table 1(4). Materials for compost can be devided into two groups such as fibrous and nitrogenous types. On the basis of the fundamental principle in composting is to provide appropriate porosity, C/N ratio, density, moisture content and particle size(7). These materials are considered suitable for composting.

3-1. Fibrous Materials

Biomass characterized by fibrous materials seldom go through decomposition rapidly in its original state. Straw lacks moisture content, and because of numerous gaps in its structure it further dries up in the ventilated environment. Husk is produced by drying and removing the hulls from rice. Because of the drying procedure, moisture content is low and its protective glasslike surface layer is highly impermeable to the effects of microorganisms. Hence, in its raw form, straw does not decompose easily. Bark produced as part of lumber production also lacks moisture content(3,7).

3-2. Nitrogenous Materials

In the raw state, this group of material lacks porosity and generates a foul odor. Initially, these materials group may possess some porosity, but as decomposition progresses, the structures break down and lose porosity. The main points in composting are to provide porosity, sufficient piling up for heat generation and aeration to prevent an anaerobic environment for microorganisms.Further attention is necessary to ensure appropriate moisture content and density in the pile materials. As composting continuous, the above conditions, become harder to maintain and, for this purpose, aeration or turning of the compost mass becomes necessary(3,7).

4. Control of the Temperature and Aeration

Oxygen is not only necessary for aerobic metabolism and respiration of microorganisms in composting, but also for oxidizing the various organic molecules present in the composting mass.

One of the main function of aeration is a supplying oxygen, so that a low level aeration limits to composting process. Aeration is essential in order to make a rapid degradation of grganic matter by aerobic microbes, and also important to evaporate the water during degradation process, which leads to control of composting temperature(2,7).

Aeration during composting is directry proportional to microbial activity. Therefore, there is a direct relationship between aeration rate and temperature in compost mass. The suitable temperature based on oxidation for organic matter into carbon dioxide and water was between 40 and 70°C(7).

Temperatures which enhance microbial activity are in the range 28-55°C with a highest consumption of oxygen(2).Favorable temperature of composting ranged from 50-60°C which was determined by autothermal sensor where aeration rate was controlled. For these reasons, Rutgers process has developed a composting method which controls temperature through forced aeration in conjunction with temperature feed back control as shown in Fig.4(2,3).

Excessively high temperatures inhibit growth in most of microorganisms present, thus slowing down decomposition of organic matter(3). Aeration rate in optimal temperature between 50 and 60°C will be 50-200L/min./m^3 to avoid limiting of oxygen supply(9). Control of aeration rate is also useful for the rapid composting of organic matter than a constant aeration rate(3,9).

5. Compost Maturity and Utilization

The use of compost provides organic matter and reduces soil acidity. It also improves physical structure of soil and penetration of air and water. Compost promotes plant growth, suppresses plant disease and reduces soil erosion.

Compost can be used in landscaping and land reclamation and as a pollution prevention strategy. Compost can be applied in two broad ways, as a soil amendment or as a mulch. Based on a review of application of compost, the amount needed to be effective was 70t/ha(5).

Compost maturity is important in terms of potential phytotoxic effects, temporary nutrient imbalances and possible odors from immature composts. Unfortunately, compost maturity is difficult to define precisely and even more difficult to measure.

Various methods and indexes of estimating the degree of maturity have been proposed as shown in Table 2 (4). Several research projects are in progress to develop a practical method to estimate compost maturity quickly for compost facility operating personnel.

6. Operational Concerns

Operation and maintenance of a compost facility are subject to solid waste regulations. Leachate generation is dependent on the initial moisture content of materials and natural precipitation conditions. Leachate from sludge compost contained fairly high levels of BOD and COD(5). Ordor is controlled by maximizing decomposition rate, which involves temperature control. A compost allowed to reach 65°C had offensive odor while a pile in the 45-48°C range was judged least offensive(3). Bulking agents are useful in process control and odor prevention(7).

Moisture content, temperature in compost mass, aeration rate are responsible for disinfection and pathogen destruction and affect odor generation. Low moisture content creates more dust and high mositure encourages anaerobic conditions and odor generation. Temperature is the most significant factor in pathogen destruction. Aeration is necessary for the proper aerobic environment and to control moisture and temperature(3,4,5).

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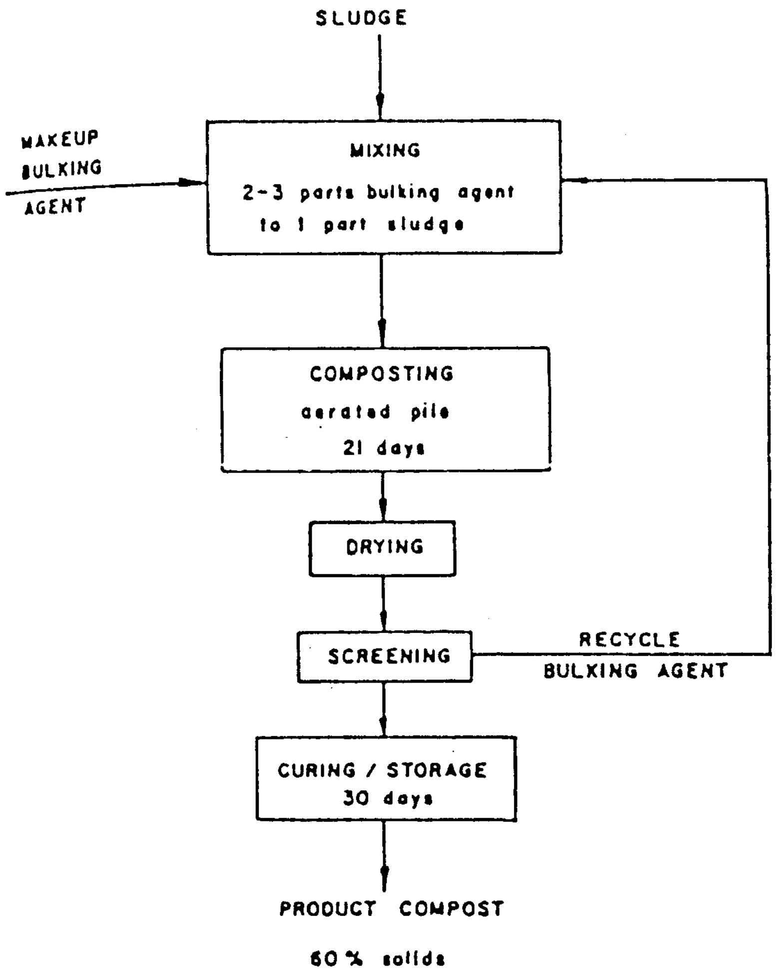

Fig. 1. Flow diagram of aerobic composting

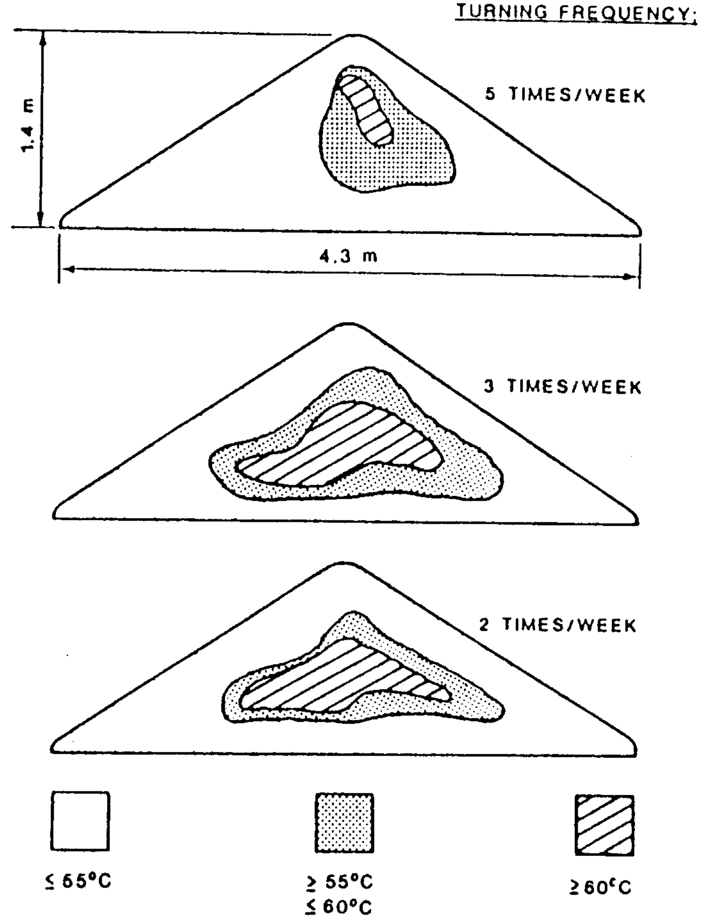

Fig. 2. Effect of turning on windrow temperatures

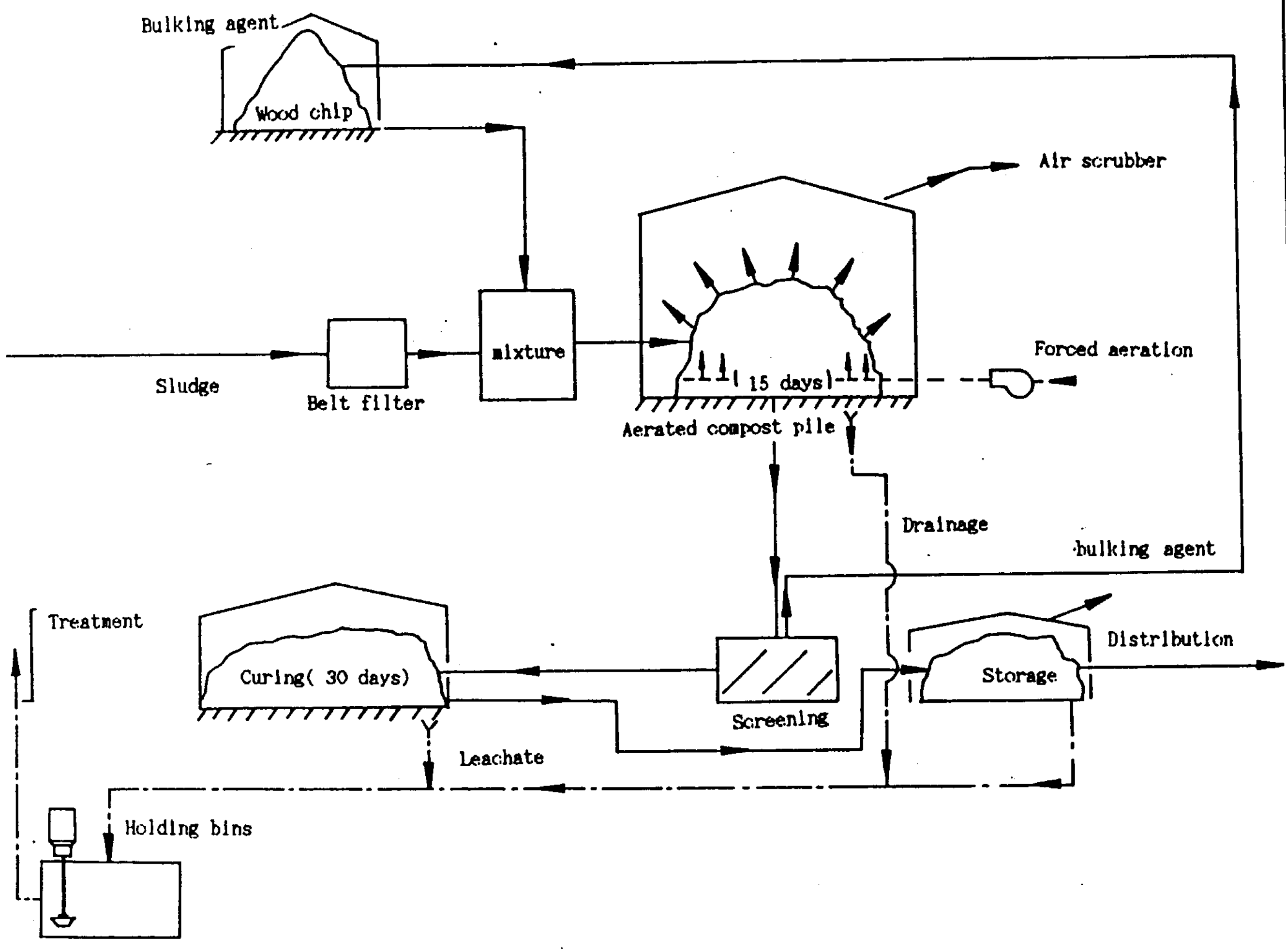

Fig. 3. Flow diagram of static pile composting

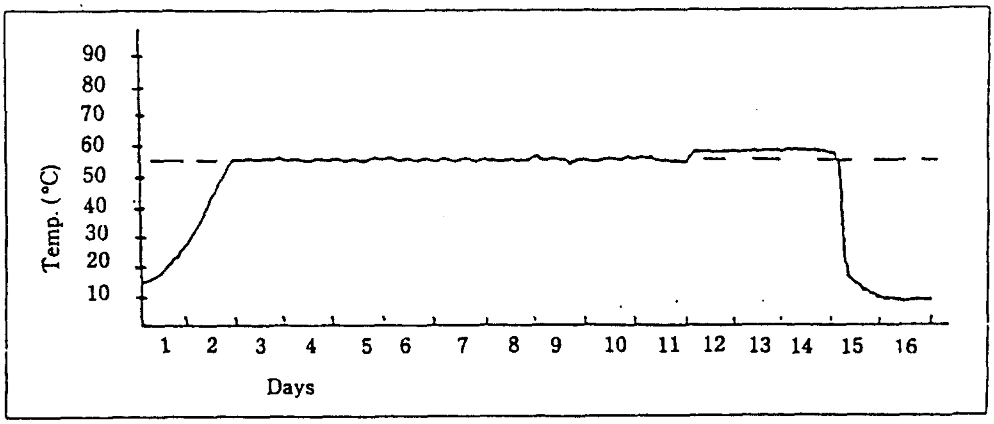

Fig. 4. Typical temperature graph

The temperature for each probe is automatically plotted by the computer on a graph to allow for visual monitoring

Table 1. Materials for compost

Material	Characteristic
Straw Husk Sawdust Pulp Bark	porous, low moisture content, not easily fermented without treatment
Animal waste Sludge night soil sludge sewage sludge Municipal refuse	sloppy, high moisture content, offensive smell, easily fermented

Table 2. Methods and indexes of estimating the degree of maturity

A. Estimation based on microbial activity	D. Chemical estimation
1) Biochemical oxygen demand (BOD)	1) C/N ratio of solid phase
2) Chemical oxygen demand (COD)	2) C/N ratio of water extract
3) CO_2 evolution	3) Ratio of carbon in reducing sugars to total carbon
4) Enzymatic activity	4) Organic matter content
B. Biological estimation	5) Detection of nitrate
1) Germination test	6) Absence of ammonia
2) Seedling experiment	7) Gel chromatography of water extract
3) Pollen tube culture test	8) Cation-exchange capacity (CEC)
C. Physical estimation	E. Estimation based on humic substances
1) Temperature in pile	1) Circular paper chromatography test
2) Odour emission	2) Content of humic compounds
3) Color change	