EXPERIMENTING WITH A HOUSEHOLD COMPOSTER

S.M.W.T.P.K. ARIYARATHNA, P. KETHARASWARI, R. SHANTHINI AND K.S. WALGAMA*

*Department of Chemical Engineering and *Department of Engineering Mathematics, Faculty of Engineering, University of Peradeniya.*

ABSTRACT

Fabrication, installation, start-up and the consequent execution of a household composting unit occupying only about one square-foot of land space have been experimented. The composter was fed with kitchen wastes from a real household. The method of feeding and the maintenance of the composter required to reach high temperatures in the range of 55°C to 60°C within the composter are reported. Such high temperatures ensured good control on odour nuisance and fly breeding. It also reduces the amount of pathogens and the weed seeds present in the composting mass. The final product of the composting operation can readily be added to the soil to order in enrich the soil properties.

INTRODUCTION

A household composter can convert the organic wastes from the kitchen and the yard into a final product known as compost, or humus. Adding the compost to the soil is an excellent way of giving back the nutrients to the soil when compared to the artificial fertilizers which are part of the environmental problem today, than the solution. Compost also helps to promote a rich soil structure.

Maintaining a household composter in one's back yard is an age old method that has been practised around the world, including Sri Lanka, from time immemorial and can still be found in the village environment where space is not a major limitation.

The composter of this study is designed particularly for households with limited land space. The composter used takes up only about one square-foot of land space. And, it is inexpensive and easy to fabricate. It can be kept at a reasonably close distance from the house, to aid convenient waste disposal. The household wastes fed to the composter require no special preparation except that the wastes should be free of non-decomposable materials. Easy input-output handling of the composter and protection from pets and pests are also ensured.

Frequency and method of feeding the composter are vital factors in maintaining a healthy composter. They are not only useful in controlling fly breeding and objectionable odour nuisance but also in achieving a high temperature (55°C-60°C) zone within the composter so as to obtain a fairly disinfected final product that is relatively free of pathogens and weed seeds.

THEORETICAL CONSIDERATIONS

Composting is a biological decomposition process in which microorganisms such as bacteria, fungi and moulds break down organic matter in the presence of oxygen in order to obtain carbon as their energy source and carbon, nitrogen, phosphorous and other nutrients to build new cells. This process is also known as aerobic oxidation.

Aerobic oxidation of the organic matter is started mainly by the mesophilic microbes that work in the temperature range of 20°C-45°C. Under aerobic conditions, carbon is oxidized to CO_2 and a great deal of energy is released in the form of heat during this process. If the composting mass is large enough to hold this heat then the temperature of the composting mass will rise. Beyond 45°C, the mesophilic microbes can not survive and they begin to die or move to the cooler part of the composting mass.

Thermophilic microbes, a type of microbes that thrive at temperatures 45°C-70°C, then invade the mass. Reaching the thermophilic stage is important because most of the pathogens and weed seeds are killed off at temperatures around 60°C. Thermophilic microbes will keep decomposing material until either it gets too hot for them or they used too much of material to sustain their population. At the end of this stage, the temperature of the composting mass decreases and it cools off. The cooling compost attracts the mesophilic microbes which grow feeding on any remaining organic materials, including dead microbes. These organisms give the final properties for compost. This last stage is known as the curing stage. Ammonia, which is toxic to germinating seeds, is produced in the first two stages and is removed in the curing stage. If we add more organic material at this stage or turn the pile to move the outer material to the center, the cycle of different microbial stages will start all over again.

Good aerobic composting requires a proper balance of oxygen, moisture content and foods. Oxygen is usually supplied as air which reaches the organisms by diffusion. Moisture required for the growth and multiplication of the microbes is in the range of 40% to 60% by weight. In the case of food, there should be a fraction of nitrogen in the organic matter. Usually it is expressed as C/N ratio which should be in the range of 25-35 for optimal composting. Kitchen wastes are often highly nitrogenous and used alone they have insufficient carbon to fulfill the composting process. That is, the C/N ratio is not in the proper range. If it is so, protein rich material will smell bad. So it is essential to mix the kitchen wastes with some amount of carbonaceous materials, such as dried grass clippings, hay, shredded paper and sawdust.

If the moisture content is too high or if the composting mass is compressed or if there is a large number of active microbes then there will be a dearth of oxygen within the composting mass. Consequently, an anaerobic zone would be created. Anaerobic decomposition is a slow process and it produces only a little amount of heat. The temperatures of the composting mass therefore does not rise high enough to disinfect it. The final products of anaerobic decomposition are mainly ammonia, methane, hydrogen sulfide, and humus. Humus is a dark and pleasant smelling soil-like material and hydrogen sulfide gives off a very objectionable odour. Complete oxidation of the products of anaerobic decomposition gives the same final products as that of the aerobic decomposition which are mainly CO_2, H_2O, nitrates, sulfates, phosphates and other nutrients. No foul smell is therefore associated with the aerobic process. Most composting systems do contain anaerobic zones.(Gotaas, 1956, Suess,1985,Lardinois and van de Klundert 1993).

SETTING UP THE COMPOSTER

An aluminum sheet that was rolled into a cylinder having 30 cm diameter and 75 cm height was used as the holding unit for the kitchen wastes. The aluminum sheet was perforated with 3 - 4 mm diameter holes placed 1 cm apart in order to facilitate air to diffuse into the composting mass within the holding unit. A synthetic wire mesh (used for creating shades in the gardens) was used to line the inner wall of the holding unit to protect the composting mass from possible fly infection. The holding unit so fabricated was placed erect within a wooden frame that was held firmly in place by a suitable hook-and-wire arrangement. The legs of the wooden frame extended 10 cm below the bottom of the aluminum cylinder. Thereby, a 10-cm high space between the bottom of the aluminum cylinder and the surface of the earth was maintained to facilitate convenient removal of the composted mass from the bottom of the aluminum holding unit.

Kitchen waste free of non decomposable materials such as polythene bags and plastic items was weighed and fed to the holding unit from the top. Paper free of coloured ink could be a part of the composter input provided it was torn into small pieces. The top of the holding unit was kept covered by a wide wooden plank wrapped in an aluminium sheet to protect the composting mass from rain and insects and also to avoid loss of heat that was generated during aerobic composting.

The state of the composting mass within the unit was judged by its temperature only. To measure the temperatures at different levels of the composting mass within the unit, 12 additional holes were drilled on the aluminum sheet vertically above each other as shown in Fig. 1. These holes were numbered from 1 to 12 starting from the bottom of the aluminum holding unit. Hole 1 was 6 cm above the bottom of the aluminum cylinder and the other holes were placed at 11, 15, 20, 26, 32, 37, 42, 48, 54, 59, 64 cm, respectively, above the bottom of the cylinder which was 10 cm above the surface of the earth as shown in Fig. 1. The height of the composting mass within the composter was recorded as the number of the hole to which the surface of the composting mass was closest to.

Sawdust was used to fill the holding unit up to the second hole inside and outside the unit. This step was necessary to prevent pests such as cockroaches from entering the composting mass from below and also to avoid the composting mass being pulled out from the bottom of the holding unit by birds, rats and others. Besides, sawdust serves to absorb the excessive moisture that is generally a major constituent of the kitchen wastes.

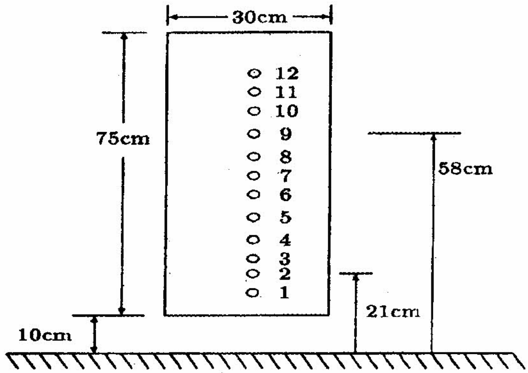

Fig. 1. Front elevation of the aluminum holding unit showing the holes used for temperature measurements. The manner in which the holes were numbered are also shown.

PERFORMANCE OF THE COMPOSTER

The kitchen waste was weighed and fed to the holding unit which was already filled by sawdust up to the second hole. The record of the mass input to the composter is shown in Fig. 2. Height of the composting mass within the holding unit and the temperatures at different levels of the composting mass were recorded starting from the fifth day. Fig. 3 shows the history of the recorded maximum temperature within the composting mass. Fig. 4 shows the height of top surface level of the composting mass (marked by small circles) recorded as the number of the hole to which the top surface was closest to. This figure also shows the height at which the maximum temperature was recorded (marked by pluses) in relation to the height of the top surface level.

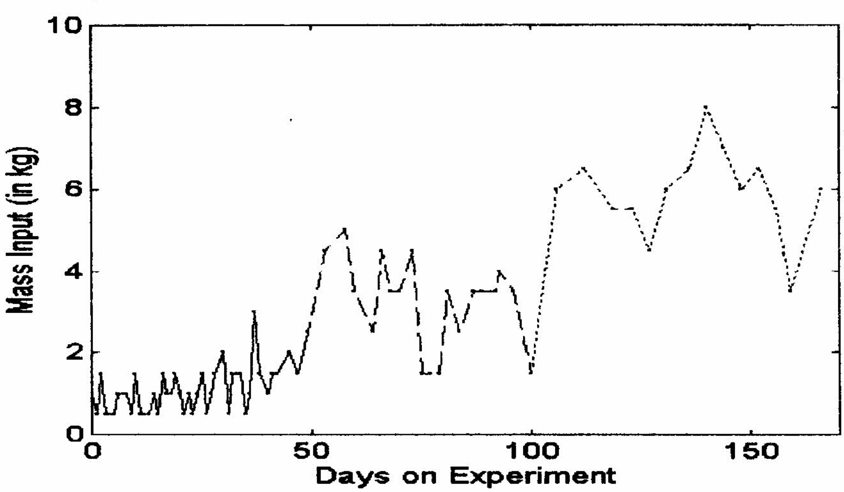

Fig. 2. Record of the mass input (in kg) to the composter.

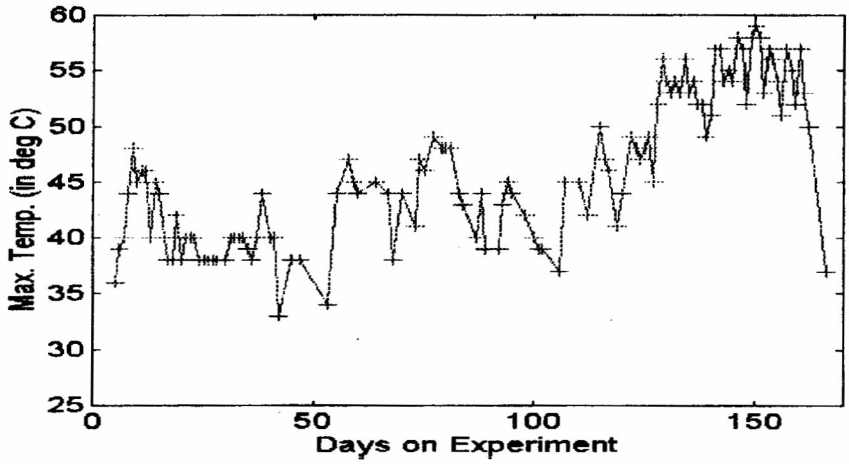

Fig. 3. Recorded maximum temperature (in °C) within the composting mass.

Initially, kitchen wastes weighing in the range of 0.5 to 1.5 kg were added on daily basis. The maximum temperature profile reached a maximum of 48°C on the 9th day and then dropped to 40°C on the 13th day. This maximum temperature was recorded at level 1 during the first 13 days and then it moved to a point below level 1. It is of interest to note that the height of the composting mass also fell from level 4 on the 10th day to level 1 on the 14th day. The abrupt fall of the top surface level from the 3rd hole level to the first hole level on the 13th day may be owing to the presence of fly larvae that was first observed on the 10th day of composting. The number of larvae of about 1 cm length was considerably high on the 13th day. The larvae not only consumed the incoming mass at a very high rate, they also started to move the composting mass to the outer side of the holding unit through the space between the earth and the bottom of the aluminum sheet. Partially composted kitchen wastes were found outside the composter on the 14th day. All these wastes and the sawdust around the composter bottom were collected and fed back to the composter on the 28th day. The space between the aluminum sheet and the earth floor was at this stage blocked tightly by use of bricks.

The daily addition of kitchen wastes to the composter was continued until up to the 49th day and the conditions within the unit were observed to remain more or less the same. The height of the composting mass never went above the 2nd hole which was 21 cm above the ground level. On the 49th day, a total of 49 kg of wastes had been added to the composter and the height of the composting mass steadied at level 2. This meant that about 49 kg of kitchen wastes were contained within a volume of about 15 litres. A composter with a feature of nearly vanishing mass is certainly very attractive from the point of view of kitchen waste disposal if not for the top surface of the composting mass retaining a considerable number of fly larvae.

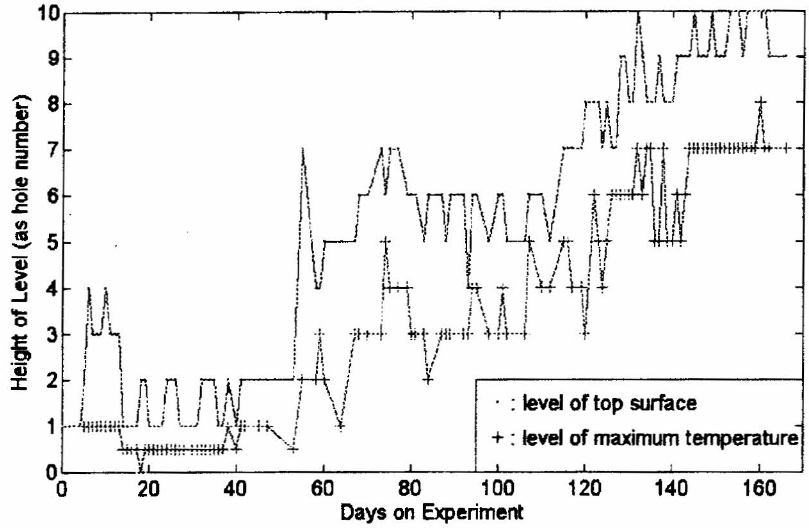

Fig. 4. Height of the top surface level of the composting mass and the height at which maximum temperature within the composting mass was recorded.

The maximum temperature of the composting mass stayed around 40°C between the 13th day and the 49th day which was not high enough to effectively disinfect the composting mass and therefore the presence of fly larvae. Birds of several kinds started to flock to the composter to feed on the larvae that came out of the composting bin and thereby maintaining a control over the fly population. Within the composter of course the larvae thrived on the incoming kitchen wastes. To reduce the larvae population within the composter, it was realized that the temperature of the composting mass should be brought up. That can be achieved by increasing the volume of the composting mass so as to retain the heat that is generated during the aerobic oxidation of the organic material, since organic material is a good heat insulator.

After experimenting with a composter for the next 70 days, the following procedure was adapted in maintaining the household composter. Composter was fed once in four days with about 3.5 to 7 kg of kitchen waste that was accumulated in a closed container. Each waste input to the composter was preceded by well turning the top part of the composter and the addition of 0.5 to 1 kg of dried grass clippings. Turning helped to moderately aerate the composting mass and also to transfer some amount of the heat contained in the composting mass to the incoming kitchen waste. This heat was useful in heating up the fresh kitchen waste and thereby removing some amount of moisture from it. Turning therefore seemed to be very helpful in maintaining good aerobic conditions within the holding unit that encouraged temperature build up. Turning the composting mass also helped to bring the cooler, larvae-ridden outer part of the composting mass to the centre where the temperatures get high enough to kill-off the eggs of the flies. The grass layer between the old and the new composting mass seemed to give an air-cushion effect to the composting mass that helped to save the composting mass from getting too compressed to have the oxygen needed for aerobic decomposition. Besides, dried grass clippings might have provided the carbon required to compensate the nitrogenous nature of the kitchen wastes in order to bring the C/N ratio to the range suitable for efficient aerobic oxidation.

The maximum temperature during the last 30 days remained in the range of 50°C to 60°C (see Fig. 3), with the maximum temperature steadying at level 7. The top surface of the composting mass remained above level 9 which was 58 cm above ground level. At the 160th day, there was about 177.5 kg of kitchen wastes and about 10 kg of dried grass clippings added to the composter. All these wastes collected over 160 days of kitchen activities were contained within a volume of 41 litres. The top surface of the composting mass however retained a certain number of larvae which apparently helped in breaking down the fresh input to a size suitable for microbial degradation. Further reduction in the size of the larvae population might be possible if the input mass was chopped into small pieces prior to feeding the composter. It would, however, be a very inconvenient exercise for an ordinary household to perform and therefore it was not recommended as a routine procedure.

CONCLUSIONS

Experimenting with the household composter of this study has shown that turning the composting mass well and adding a layer of dried grass clippings prior to adding the kitchen wastes collected over four days in a closed container is certainly a good way to maintain a household composter of a typical household that generates 0.5 to 1.5 kg of kitchen wastes. Such procedure ensures a high temperature zone within the composting mass which disinfects the composting mass and controls fly breeding. High temperatures also indicate that good aerobic conditions prevail within the composter and therefore no foul smell is associated with the household composter. Experiments have been carried out at present to increase the maximum temperature of the composting mass to 65°C and also to further control fly breeding without compromising the convenience that the composter described in this paper offers.

ACKNOWLEDGEMENTS

We gratefully acknowledge Ms. P. Batuwitage of the Ministry of Environment for introducing us to a household composter unit that can be operated in a continuous mode which inspired us into a series of experiments with household composters. We also greatly appreciate the enthusiastic contributions of Dr. Jayanthi P. Edirisinghe of the Faculty of Science of University of Peradeniya for her help in identifying the larvae that were present in the household composter that was experimented.

REFERENCES

Gotaas, H.B. (1956) Composting, World Health Organization, Geneva.

Suess, M.J. (1985) Solid waste management, World Health Organization, Copenhagen.

Lardinois, I. and van de Klundert, A. (1993) Organic waste., TOOL, Amsterdam and WASTE consultants, Gauda.