

# AN EASY-TO-CONSTRUCT HOUSEHOLD ALUMINIUM COMPOSTING UNIT FOR KITCHEN WASTE DISPOSAL & ITS PERFORMANCE

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The proposed composting unit is an easy-to-construct aluminium holding unit on wooden frame, occupying only about a 2 feet by 2 feet land space in one's backyard, which converts the household kitchen waste into compost in a pleasant and convenient manner. The performance of one such composting unit fed with biodegradable kitchen and yard wastes of a real household has been assessed. A total of 177.5 kg of kitchen wastes and 10 kg of dried grass clippings fed to the composting unit over 160 days filled only 41 litres of the composting unit, which has a total volume of 60 litres. The temperatures of the composting mass within the unit remained, in general, in the range of 40 to 50°C, which were about 15 to 25°C above the ambient temperature. The investigation with different feeding loads to the composting unit shows that feeding a larger load at a time, and turning the composting mass well before feeding a new load would raise the temperatures of the composting mass to the range of 55 to 60°C, which ensures better performance of the composting unit.

## 1 Introduction

For decades, kitchen wastes from most households in Sri Lanka have been ending up in landfills, which today have become an acute environmental problem and a health risk. The main reason for the failure of such centralised approach is owing to the difficulties in managing an extremely large volume of garbage collected in one place on daily basis. This volume of garbage could be reduced, if part of it were treated at the source level itself. Thus, composting the kitchen wastes at the household level could contribute significantly towards solving the problems faced by the local authorities in solid waste management.

Composting is a biological decomposition process in which micro-organisms convert organic matter into a final product known as compost. Composting in the presence of oxygen, which is usually supplied with air, is known as aerobic composting. For good aerobic composting, the moisture content of the composting heap should be in the range of 40% to 60% by weight (Gotaas 1956). If the moisture content is too high, or if the composting mass is too compressed to permit oxygen to get in contact with the degrading organic matter, then an anaerobic zone would be created. Anaerobic decomposition in a household composting unit must be avoided since it generates foul-smelling gases such as hydrogen sulphide, unlike in an aerobic decomposition (Suess 1985). The C/N (that is, carbon to nitrogen) ratio of the composting mass should be in the range of 25-35 for best composting (Gotaas 1956). Kitchen wastes are often highly nitrogenous, and used alone they have insufficient carbon to fulfil the composting process. If it is so, protein rich material will smell bad. So it is advisable to mix the kitchen wastes with some amount of carbonaceous materials, such as dried grass clippings, dried leaves, shredded paper and sawdust (Lardinois and Klundert 1993).

Maintaining a household composting unit, which converts the organic wastes from the kitchen and the yard into compost, in one's back yard is an age-old method that has been practised around the world, including Sri Lanka, from time immemorial. Such composting units, differing from each other in shape and size, can still be found in the village environment where space is not a major limitation. In today's urban settlements, however, space available for a typical household is limited. Considering this factor, the Ministry of Environment introduced as early as in 1992, the use of barrels, which are opened at either ends with holes drilled on the side, as household units in which organic kitchen and yard wastes could be converted into compost.

The aluminium composting unit of this study is an alternative to the barrel. Like the barrel, it takes a land space of about 2 feet by 2 feet, and therefore it could be used in households with very limited land space. The unique feature of this unit is that it is very easy to self-construct this unit. Like the barrel, it can be kept at a reasonably close distance from the house to aid convenient waste disposal. The household wastes fed to the composting unit require no special preparation except that the wastes are free of non-decomposable materials. Easy input-output handling of the composting unit, and protection from pets and pests are also ensured.

Construction, starting-up and maintenance of the aluminium composting unit, which are described in sections 2 and 3, are planned so as to maintain conditions required for good aerobic composting within

the unit. Three runs of the composting unit were carried out over a 10-month period, and the results obtained are reported in section 4. Method of feeding the composting unit and the maintenance necessary to raise the temperatures of the composting mass as high as 55 to 60°C are also discussed in this section.

## 2 Construction of the Aluminium Composting Unit

### 2.1 Construction of the Basic Aluminium Holding Unit

A 100 cm by 75 cm thin aluminium sheet, which costs about Rs 150/= at today's rate, was bought. The aluminium sheet was spread on the ground, and small holes were made all over the sheet, approximately about 1 inch apart from each other, using a wire nail (3 inch long) and a hammer. The perforated sheet was rolled into a cylinder of about 30 cm diameter and 75 cm height as shown in Fig. 1. The two ends of the aluminium sheet that were touching each other were joined together by folding them onto each other. (It was also possible to have fixed them together using small nuts and bolts.) The basic aluminium holding unit in which the kitchen waste turns into compost was now ready. The small holes on the sheet would help air diffusing into the composting mass within the holding unit.

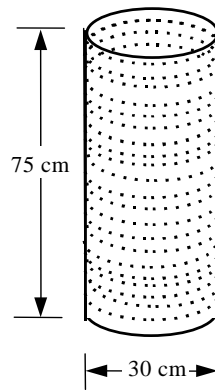


Fig. 1 Basic aluminium holding unit in which kitchen waste turns into compost (not drawn to scale).

### 2.2 Construction of the Wooden Frame required to vertically hold the Basic Aluminium Unit

The aluminium holding unit described in section 2.1 was held vertical with the help of a wooden frame, which was made as described below. Purchased were 04 wooden bars, each having a length of about 85 cm and a cross-section of about 2 inch by 2 inch, and 12 wooden bars, each having a length of about 32 cm and a cross-section of about 2 inch by 1 inch. All the wooden bars cost a total of about Rs 150/= at today's rate. Used engine oil was applied to the wooden bars to protect them from any possible future attack by white ants and other insects. (Wood preservative could also have been used in place of engine oil.) Using the wooden bars, prepare a structure similar to the one shown in Fig. 2.

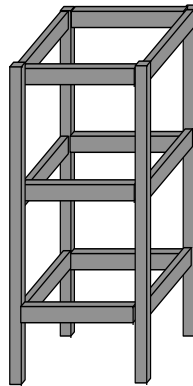


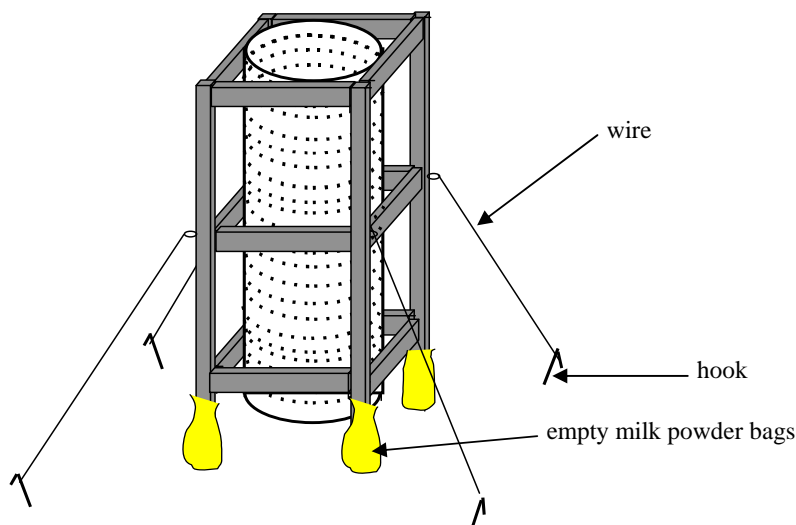
Fig. 2 Wooden frame that would hold the basic aluminium holding unit shown in Fig. 1, vertical (not drawn to scale).

### 2.3 Preparation of the Final Composting Unit

The aluminium cylinder described in section 2.1 was placed erect within the wooden frame described in section 2.2, and the cylinder was nailed to the wooden frame such that the top of the cylinder was

aligned with the top of the wooden frame. The aluminium cylinder was 75 cm high and the wooden frame was 85 cm high. Since the top of the cylinder was aligned with the top of the wooden frame, the cylinder did not touch the ground, and there was about 10 cm gap between the bottom of the cylinder and the surface of the earth. This gap was maintained to facilitate convenient removal of the composted mass from the bottom of the aluminium cylinder.

The foot of each leg of the wooden frame was wrapped with empty milk powder bags (see Fig. 3) in order to secure the legs of the wooden frame from possible decay starting from the bottom. The composting unit was placed on a levelled ground about 9 feet away from the house of the author at a place where there was good air circulation and diffused sun light. (The composting unit could have also been placed under direct sun light.) With the hook and wire arrangement shown in Fig. 3, the composting unit was placed firmly in place.

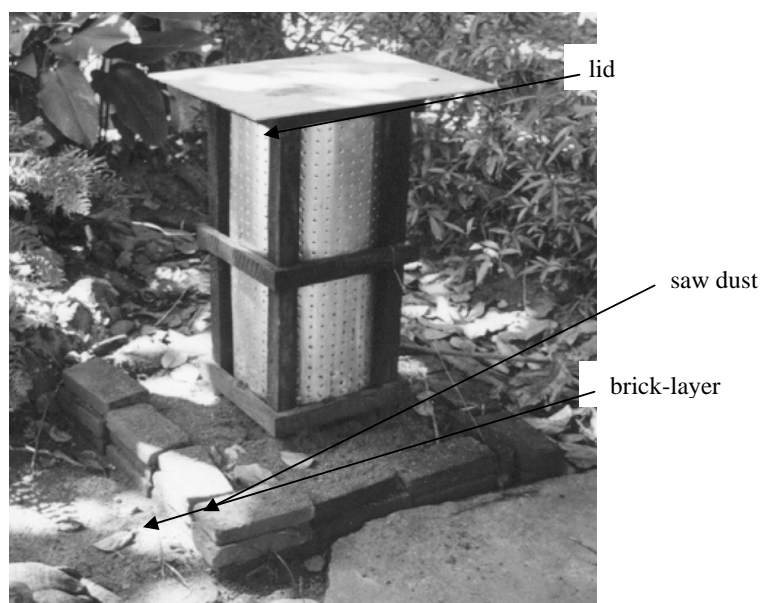


**Fig. 3 Aluminium holding unit was placed in the wooden frame such that the tops of each were aligned. The wooden frame was held firmly in place with a hook-and-wire arrangement shown in the Fig. (not drawn to scale).**

A brick-layer around the bottom of the composting unit, as shown in Fig. 4, was made. The brick-layer served as a barrier to the composting mass that would be added to the aluminium holding unit, and it also improved the appearance of the composting unit set-up. The top of the holding unit was kept covered by a lid, which was 40 cm by 40 cm asbestos sheet, as shown in Fig. 4, to protect the composting mass from rain, flies and other insects, and also to avoid loss of heat that was generated during aerobic composting. (A wide wooden plank wrapped in an aluminium sheet could have also been used as the lid to the composting unit. A small piece of wood nailed to the lid would have facilitated easy handling of the lid.)

### **3 Starting-up and Maintenance of the Aluminium Composting Unit**

Lid of the composting unit was removed, and dry saw dust was fed to the aluminium holding unit such that the 10 cm gap between the ground and the bottom of the aluminium cylinder, and also another 10 cm in and around the aluminium cylinder were filled by the sawdust. The brick-layer boundary at the base of the composting unit helped to contain the sawdust in place (see Fig. 4). Saw dust base for the composting unit was necessary for absorbing the excessive amount of water present in the kitchen waste, and also for preventing rats and other similar creatures from entering the composting mass from the bottom to pull the composting mass out of the aluminium cylinder from below.



**Fig. 4** A photograph of the aluminium composting unit set-up with a brick-layer base filled with saw dust.

A bucket of about 5-litre volume with its lid was maintained in the kitchen to collect the kitchen waste over a day. (We used a bucket in which laundry detergent was sold.) Once a day, during noon hours, the bucket with the kitchen waste was taken to the composting unit, the lid of the composting unit was removed, and the kitchen waste in the bucket was emptied into the composting unit. The lid was replaced on the composting unit, and the 5-litre bucket was washed and placed to dry until the bucket was needed in the kitchen again. No shopping bag or any other plastic material was used to line the bucket in which the kitchen waste was collected

All the unwanted portions of vegetables, fruits and green leaves, egg shells, coconut refuse, leftover and spoiled food, and fish and meat wastes were fed to the composting unit. Shells of wood-apple, 'beli', coconut and the likes were fed to the composting unit only in moderate amounts since they easily filled up the volume of the composting unit, and since they took a very long time to decompose. Paper was fed to the composting unit only if it was torn into small bits. Small amounts of yard waste like leaves and grass clippings were also added now and then. An occasional dead rat that the cat brought home was also added to the composting unit.

Coloured paper, cardboard, batteries, medicines, pesticides and insecticides were not added to the composting unit owing to their toxic nature, which might be fatal to the micro-organisms biodegrading the organic matter in the composting unit. Non-biodegradable wastes such as polythene and plastic items, tin cans, glass bottles, and broken glass and ceramic ware were not added to the composting unit. Water and very wet items were not added to the composting unit since they would make the composting mass soggy giving rise to foul smell.

Since the micro-organisms necessary to start and to maintain the decomposition of kitchen waste in the holding unit come from the kitchen waste itself, no composting aid of any kind was added to the composting mass either at the beginning or during composting.

## **4 Results and Discussion**

### **4.1 Temperatures within the Composting Mass**

Aerobic Composting is a biological decomposition process in which micro-organisms break down organic matter in the presence of oxygen. In this aerobic biodegradation process, organic matter is converted into CO<sub>2</sub> and H<sub>2</sub>O, and hence a great deal of energy is released in the form of heat. If the composting mass is large enough to hold this heat then the temperature of the composting mass will rise. High temperatures in the composting mass are useful in speeding up the composting action and in controlling fly breeding (Gotaas 1956). High temperatures also indicate that good aerobic conditions prevail within the composting unit, and therefore chances of the composting mass giving out foul smelling gases, that are products of anaerobic biodegradation, are very slim.

Performance of the composting unit was therefore assessed by measuring the temperatures of the composting mass within the aluminium holding unit. To measure the temperatures at different levels of the composting mass within the unit, 12 additional holes were made on the aluminium sheet on a vertical line, one above the other as shown in Fig. 5.

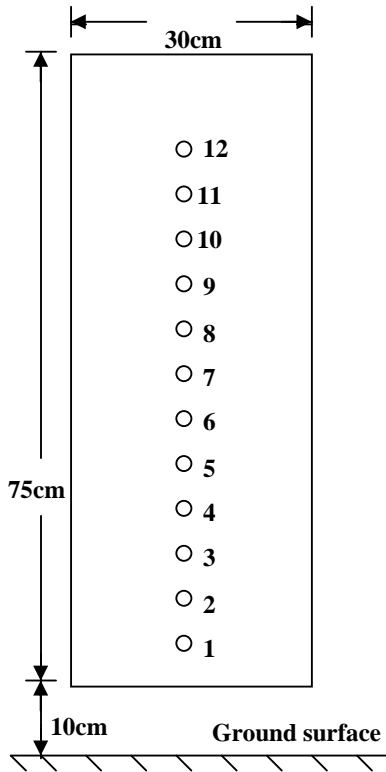


Fig. 5 Front elevation of the aluminium composting unit showing the holes used for temperature measurements (not drawn to scale).

The holes were labelled from 1 to 12 starting from the bottom of the aluminium holding unit. Hole 1 was 6 cm above the bottom of the aluminium 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. 5. Thermometer was inserted into the composting mass through each of these holes until it reached the centre of the composting mass at each level. Thermometer was held in the place of measurement until its temperature reading got stabilised. It took about 3 to 5 minutes per reading.

The values of the temperatures measured at different levels were recorded. Ambient temperature measurements were also recorded. Temperature measurements were recorded starting from the 5<sup>th</sup> day. Fig. 6 shows the recorded maximum temperature within the composting mass and the respective ambient temperatures as functions of the day of the experiment.

#### 4.2 Mass Input to the Composting Unit

Kitchen waste in the 5-litre bucket was weighed together with the bucket, before it was being fed to the holding unit. Subtracting the weight of the bucket gave the mass input to the composting unit. Whenever dried leaves or dried grass clipping were added, they were also weighed in a similar manner. Measurements of mass input were rounded off to the near half a kilogram. The record of the mass input to the composting unit is shown in Fig. 7.

#### 4.3 Height of the Composting Mass

The height of the composting mass within the aluminium unit was recorded as the hole label to which the top surface level of the composting mass was closest. And, the height of the composting mass was

recorded starting from the fifth day, and Fig. 8 shows that information. Fig. 8 also shows the height at which the maximum temperature was recorded.

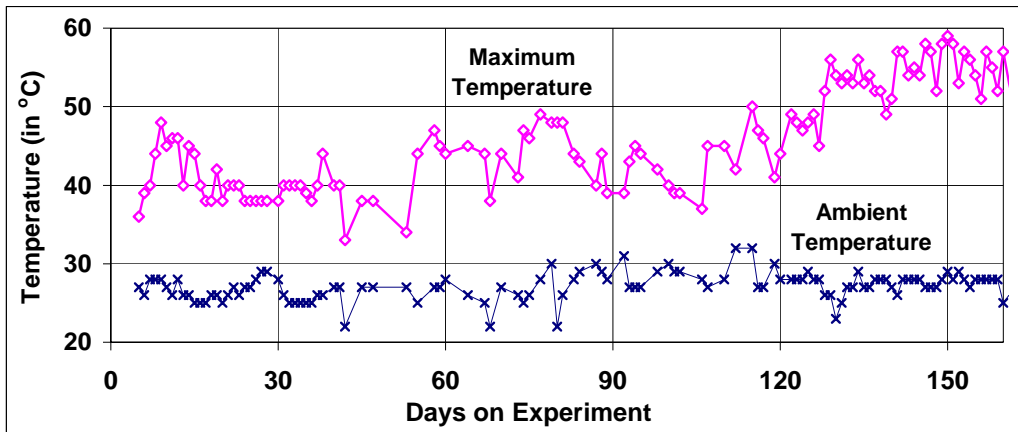


Fig. 6 Recorded maximum temperature within the composting mass, and the respective ambient temperature.

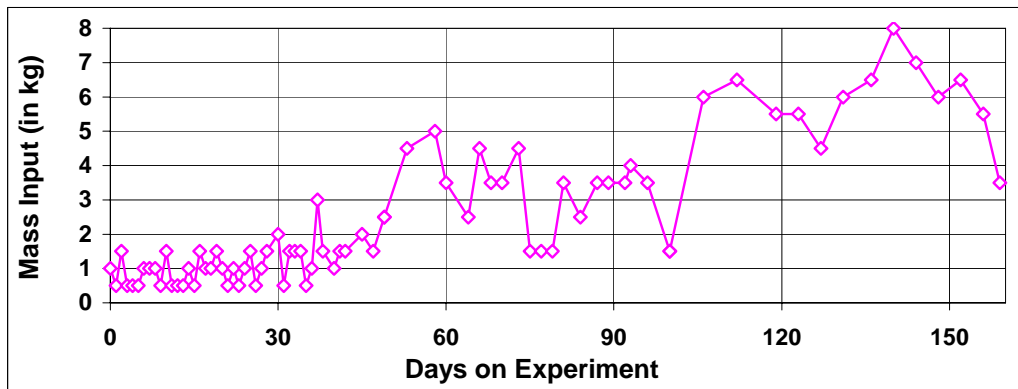


Fig. 7 Recorded mass input to the composting unit.

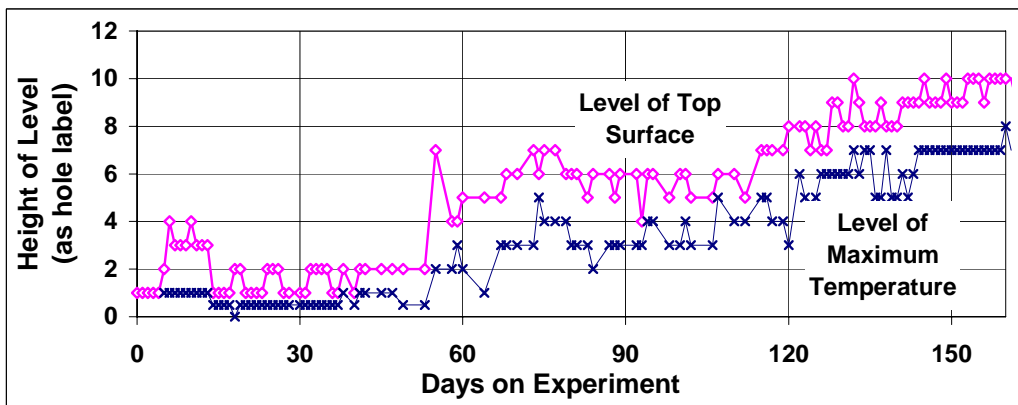


Fig. 8 Recorded height of the level of the top surface of the composting mass, and the level at which the maximum temperature within the composting mass is recorded. The level is measured in hole numbers shown in Fig. 5.

#### 4.4 Performance of the composting mass when the unit was fed on a daily basis

Fig. 7 shows that, initially, kitchen wastes weighing in the range of 0.5 to 1.5 kg were added to the aluminium holding unit on a daily basis. Fig. 6 shows that the maximum temperature profile reached a

maximum of 48°C on the 9<sup>th</sup> day, and dropped to 40°C on the 13<sup>th</sup> day. Fig. 8 shows that this maximum temperature was recorded at level 1 from the 5<sup>th</sup> day to the 13<sup>th</sup> day, and then it moved to a point below level 1. It is of interest to note in Fig. 8 that the height of the composting mass also fell from level 3 on the 13<sup>th</sup> day to level 1 on the 14<sup>th</sup> day. The sudden drop in the top surface level of the composting mass may be attributed to the presence of fly larvae that was first observed on the 10<sup>th</sup> day of composting. The number of larvae of about 1 cm length was considerably high on the 13<sup>th</sup> day and after. The larvae appeared to consume the incoming mass of kitchen wastes at a very high rate, not allowing the top surface level of the composting mass to rise beyond the 2<sup>nd</sup> hole level, as can be seen in Fig. 8.

The daily addition of kitchen waste to the composting unit was continued up until the 49<sup>th</sup> 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 2<sup>nd</sup> hole, which was 21 cm above the ground level. On the 49<sup>th</sup> day, a total of 49 kg of wastes had been added to the composting unit, 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 composting unit 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. The maximum temperature of the composting mass stayed around 40°C between the 13<sup>th</sup> day and the 49<sup>th</sup> day, which was not high enough to effectively disinfect the composting mass, and thereby to control the population of fly larvae present. Nevertheless, birds of several kinds started to flock to the composting unit to feed on the larvae that came out of the composting unit, and thereby maintaining a natural control over the fly population. Within the composting unit, of course, the larvae thrived on the incoming kitchen wastes.

#### **4.5 Performance of the composting mass when the unit was fed at irregular interval of time**

Alternative methods of maintaining the composting unit were experimented for the next 70 days in order to achieve high temperatures of the composting mass, and the following procedure was eventually adapted in maintaining the unit. The composting unit was fed once in four days with about 3.5 to 7 kg of kitchen waste that was accumulated in a closed container over the four days. The composting mass was well turned with a long stick before adding each of the fresh loads of waste. Each addition of the kitchen waste was followed by the addition of 0.5 to 1 kg of dried grass clippings, which topped the kitchen waste in the composting unit. Such maintenance indeed increased the temperature of the composting mass.

Fig. 6 shows that the maximum temperature of the composting mass increased and steadied in the range of 50 to 60°C during the last 30 days. Fig. 8 shows that the height at which the maximum temperature was reached had also steadied at level 7, and that the top surface of the composting mass remained at about level 9, which was 58 cm above ground level. On the 160<sup>th</sup> day, the composting unit had been fed with a total of 177.5 kg of kitchen wastes and 10 kg of dried grass clippings. All these wastes filled only 41 litres volume of the composting unit, which has a total capacity of 60 litres.

#### **4.6 Validation of the Performance of the Composting Unit**

In order to verify the repeatability of the performance of the composting unit reported in section 4.5, the composting unit was emptied of its content and started up once again according to the procedure laid down in section 3. The unit was run for nearly 2 months, and this run was labelled Run 2. The results presented in sections 4.1 to 4.5 belong to Run 1. At the end of Run 2, the unit was emptied of its content and was started all over again. And, this run was labelled Run 3. During Run 2 and Run 3, the unit was topped with dried leaves and dried grass clippings after each addition of the kitchen waste to the unit. The composting mass was well turned before it was being fed with the fresh feed at irregular interval of time. Information on the amounts of mass input to the composting unit during Run 2 and Run 3 are presented in Fig. 9, along with the mass input information of Run 1 during the first 60 days, for comparison's sake. The individual mass inputs are larger during Run 2 and Run 3 than the mass inputs during Run 1 during the first 60 days. However, the cumulative mass inputs were more or less the same in all three runs, as shown in Fig. 10. That is, the unit was being fed with more or less the same cumulative amount of wastes in all three runs. However, individual feeds were less in quantity in Run 1 since the unit was fed on daily basis, and more in quantity in Run 2 and Run 3 as the waste was accumulated and fed at irregular intervals of time.

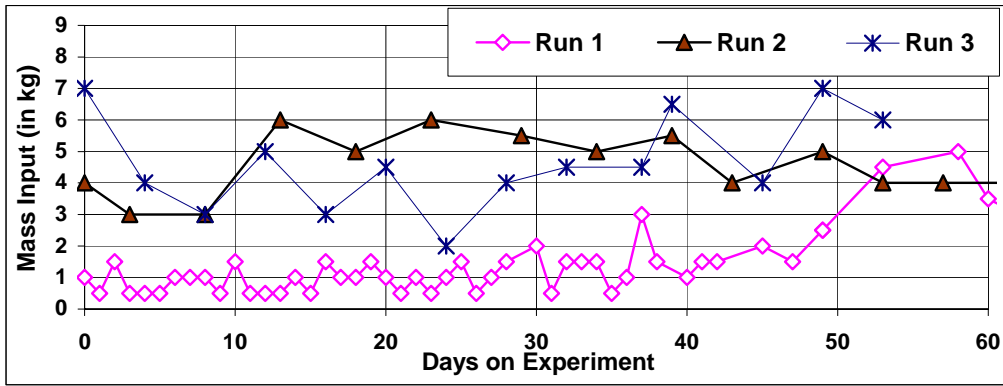


Fig. 9 Mass Input to the composting unit during the three runs.

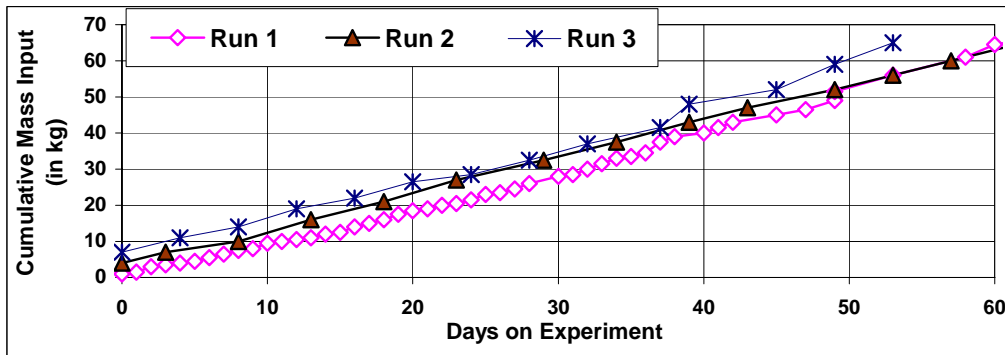


Fig. 10 Cumulative mass input to the composting unit during the three runs.

Maximum temperature profiles recorded during the three runs for a period of 60 days are presented in Fig. 11. It can be observed from Fig. 11 that the maximum temperatures of the composting mass obtained during Run 2 and Run 3, in general, were higher than the maximum temperatures obtained during Run 1. The top surface levels of the composting mass of the three runs are compared with each other in Fig. 12.

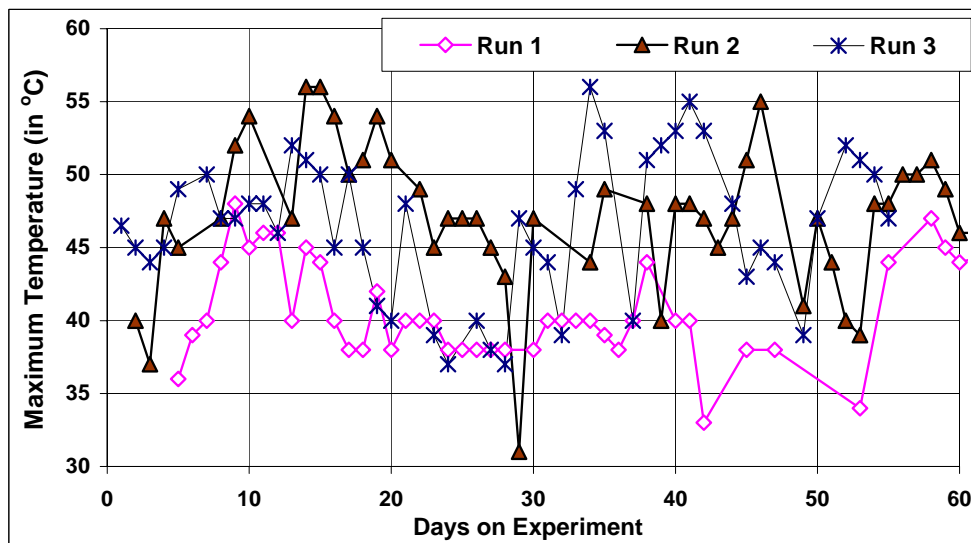


Fig. 11 Maximum temperature profiles during the three runs.

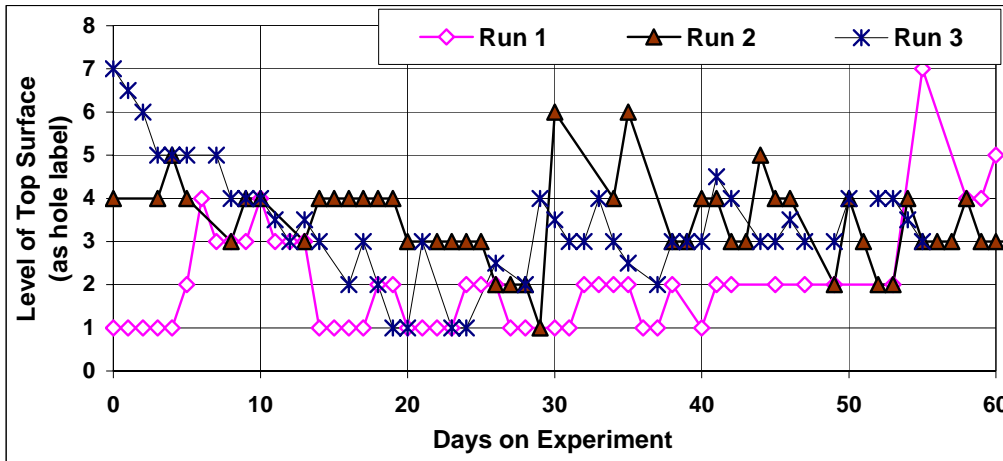


Fig. 12 Top surface levels of the composting mass during the three runs.

As in the case of mass input and maximum temperature profiles, the top surface levels of the composting mass in cases of Run 2 and Run 3 were well above the top surface level of the composting mass in Run 1. Fig. 12 shows that the top surface level of the composting mass at the initial stages is the highest for Run 3, and Fig. 11 shows that the maximum temperature at the initial stages are also the highest for Run 3. Moreover, when the top surface of the composting mass in Run 2 fell to level 1 on the 29<sup>th</sup> day (see Fig. 12), the maximum temperature also fell to very low values (see Fig. 11). This observation shows that the level of the composting mass should be maintained high if high temperatures are to be maintained within the composting mass.

#### 4.7 Discussion

From the results presented in the preceding sections, it could be concluded that larger the mass of a single waste input to the unit, higher was the maximum temperature reached within the unit. This feature could be explained as follows. When a large volume of the waste was fed to the unit, owing to the heat insulating properties of the waste itself, heat generated during composting was retained within the composting mass. Consequently, the temperature of the composting mass rose.

High temperatures within the composting mass help to kill off a considerable number of fly eggs. The result was a reduced larvae population. Since the number of larvae that consumed the incoming waste was considerably reduced, most of the waste added to the unit was retained as waste within the unit. Consequently, the top surface level of the composting mass rose.

Since most of the waste added to the unit now became available for microbial degradation into compost, the amount of heat generated increased, which in turn helped in increasing the temperature of the composting mass killing off more fly eggs. Despite it, the top surface of the composting mass, being cooler than the interior of the composting mass, retained a certain number of larvae, which to a certain degree contributed towards the composting process by breaking down the fresh input of waste to a size suitable for microbial degradation.

High temperatures also helped in evaporating the excess moisture present in the composting mass. During the high temperature period, water vapour rising from the top surface of the composting mass was observed whenever the unit was opened to feed it with fresh waste.

Turning of the composting mass just before feeding the unit with fresh waste, which was exercised towards the end of Run 1, and during Run 2 and Run 3, helped to moderately aerate the composting mass, and also to transfer some amount of the heat contained within 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 the composting mass was therefore very helpful in maintaining good aerobic conditions within the composting unit, which in turn encouraged the 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.

Addition of slowly decomposing dried leaves and dried grass clippings layers between the consecutive kitchen waste feeds to the unit helped to maintain the levels of the composting mass high, and therefore the temperatures of the composting mass were also maintained high.

The dried leaves and dried grass clippings layers also gave an air-cushion effect to the composting mass, that helped to save the composting mass from getting too compressed to have access to the oxygen needed for aerobic decomposition.

Besides, dried leaves and dried grass clippings also 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.

Tomato seeds germinated in the medium of biodegraded mass that was collected from the bottom of the composting unit three months after the unit was started. It indicated that the kitchen and the yard wastes added to the composting unit were ready in three months as matured compost for use in the garden.

## 5 Conclusions

Experimenting with the easy-to-construct aluminium composting unit occupying 2 feet by 2 feet land space, has shown that kitchen waste can be converted into compost by use of a small-volume unit in a convenient manner at one's own home itself. A total of 177.5 kg of kitchen wastes and 10 kg of dried grass clippings fed to the composting unit over 160 days occupied only 41 litres volume of the composting unit, which has a total volume of 60 litres. And, the compost was ready in three months time. Feeding the aluminium composting unit with a larger volume of waste at a time, turning the composting mass well prior to adding the kitchen waste to the unit, and adding a layer of dried leaves and/or dried grass clippings following each addition of the kitchen waste are practices, when followed, ensure a high temperature zone within the composting mass, which enhances the composting performance of the unit.

### Acknowledgement

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