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Design and Development of Compost Bin for Indian Kitchen

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Abstract

Composting is the decomposition of organic waste by microorganisms under controlled conditions. Organic waste, which forms a significant part of municipal solid waste, has caused increasing environmental concerns. It is estimated that around 50 percent it can be composted. Instead, most of it is landfilled and incinerated. By composting organic waste, we can preserve resources and produce a valuable by-product that can be used as locally produced fertilizer. The existing compost bins have few challenges which are difficult to handle such as messy and smelly compost, time-consuming process (30-45 days), prone to insects and rodents and hard to clean. In addition, some of them release greenhouse gases. Cost issues are there with few automatic and high-end compost bins. This project aims at designing a compost bin for Indian household kitchen, which is easy to use, odor free, ergonomic in nature and visually appealing. Designed Compost bin consists of a separate chamber for compost starter, composting chamber consisting of a mixing blade (runs with help of a DC motor and rechargeable batteries), air filter setup and a compost collection tray. Rechargeable batteries used in the product makes it portable. The air filter contains pellets made out of Azadirachta Indica (neem) and Gomaya (Cow dung) which are used to keep away bad odor and acts as a disinfectant. Simple mechanism allows the user to maintain cleanliness. A video was made of the working of the compost bin for user feedback. Users appreciated the product for its colour, aesthetics, easy mechanism, odour free, easy handling, easy maintenance etc.

Keywords: Composting; Ergonomic; Indian household kitchen; Organic waste; Solid waste management

Introduction

Relevance to design practice

The designed Compost bin aims at reducing the municipal solid wastes generated at houses and it helps the users to make their own natural fertilizer (Compost) for the plants they grow at home, which is easy to use, ergonomic, odor free and can compost quickly.

What seems natural to us is probably just something familiar in a long tradition that has forgotten the unfamiliar source from which it arose. Yet this unfamiliar source once struck man as strange and caused him to think and to wonder. (Heidegger, 2001, p. 24).

Today solid waste management is one of the biggest problems in the world. Around 50% of the waste in the world is organic waste. India is second largest populated country in the world; it produces more than 100 tons of solid waste a day. It is the mixture of both organic food waste and inorganic waste. Around 78% is food waste, which can be recycled. Some of them is land filled but it is not segregated properly and it mixes organic and inorganic waste, which produces bad odor, and it will spoil the soil. To manage the solid waste, it should be properly segregated at the source (houses). The organic and inorganic waste needs to be separated, the organic waste can be treated to make compost, and inorganic waste can be segregated and given for garbage collection. There are many companies who take in the waste and segregate and convert the organic waste into compost but as the waste is very high; they are unable to achieve all the targets so it is better to compost at home [1-5].

Compost is organic matter decomposed as fertilizer. Compost is the key in organic farming. The process of composting requires wet organic matter known as green waste (leaves, food waste) and waiting to break down into humus for a certain period. Modern methodical composting is multi-step, closely monitored process with measured inputs of water, air, carbon and nitrogen-rich materials. The decomposition process is carried out by shredding the plant matter, adding right amount of water and ensuring proper aeration by regularly turning the mixture. Compost is rich in nutrients. It is used in small gardens, agriculture, rooftop farming etc. The compost itself is beneficial for the land in many ways, such as soil conditioner, fertilizer, addition of vital nutrients to soil and as a natural pesticide/insecticide for soil. In ecosystems, compost is useful for controlling soil erosion, land and stream reclamation, wetland construction and as landfill cover. Compost is commonly known as Black gold by gardeners. Anaerobic compost results in black color of the soil due to presence of methane. Aerobic composting results in dark brown color/ chocolate color of the soil after composting [6-10].

Methodology

To review literature survey of existing compost bins (household and Industrial), various composting process, identifying drawbacks in the existing compost bins and processes. Carrying out an ethnographic research focusing on product study, market study and user study wherein interview will be conducted with user to understand the drawbacks of the existing compost bin. Based on the data collected in literature survey and ethnography research, Quality Function Deployment (QFD) chart is defined and based on the QFD and literature survey, ethnography data, Product Design Specifications (PDS) is designed. To generate concepts, develop 3D models based on the product design specifications, and choose the final concept based on the weight ranking method. To develop a full-scale working prototype using suitable materials of compost bin for Indian Kitchen. To carry out user validation of the compost bin to identify the success rate of

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product and collect the suggestion of the users.

Design criteria

Frequency of use: The vegetable waste is input every day. Research shows due to the busy urban lifestyle, the output compost would be taken out once a week.

Product handling: The output compost should be in a form to avoid any inconvenience to the people handling it. It should be collected in a tray and can be used easily for home gardening.

Product location: The home composter to be placed in either balconies or kitchens of urban houses without causing any issues in kitchen.

Product size: The dimensions of the Home Composter would be ergonomic in nature and it will maintain the standard modular kitchen dimensions followed in Indian kitchens.

Visual permeability: The psychological desire to not encounter waste within one's kitchen or household helps define the visual permeability parameter of the Home Composter. The actual process of composting would be visually invisible while the interface will provide all the required information in an easy to comprehend manner to the user.

Odour free: The home composter would not give out any bad odour.

Low noise: The home composter's noise limit shall be well within the limits of a kitchen appliance.

Easy process: The home composter to be operable by everyone in the house.

Portable: The home composter to be easily movable inside the kitchen.

Aesthetics: As an integral part of an urban household, the design language of the Home Composter would be at par with the other kitchen appliances.

Figure 1 shows the market study data of Solid waste management in India and around the world. In both rich countries and poor countries, 59% of the collected solid waste is land filled and only 1% is only composted. In rich countries, 13% of waste is dumped in streets and in poor countries, 33% is dumped in streets. Around 64% of the waste generated is Organic waste and 5% is paper waste. Others are Inorganic waste of 31%, which can be recycled if properly separated. Majority of the solid waste is generated in houses; it accounts to around half the total waste collected. Among them food waste accounts to 21% of total waste and plastics accounts to 18% which can be recycled. Around 78% of the waste generated is food waste. Other 18% of the waste is inorganic waste. Overall, if the organic waste collected from the houses can be avoided, around 50% of the total solid waste can be avoided landfilled and incinerated.

Ethnography research

Ethnography research is a part of literature survey. It is the study of the people and the product in their environment and how they use certain products. It involves observational research and face-to-face interview. Figure 2 shows the images of the ethnography research done on the BBMP workers and how the sewage is being collected from home and how it is being dumped in the dumping yard for segregation. It shows that the BBMP workers dump tons of waste in which some part will be taken by NGO and is composted or recycled and most part of the waste is land filled which produces lot of smell and gives diseases to nearby people (Figure 2).

Quality function deployment (QFD)

Quality function deployment is a tool used to transform user demands into technical voices for delivering better design. This is mainly done using Quality Function Deployment matrix. QFD has a major role in deciding the product design specification as the importance of features will be decided in this. Features to be incorporated are decided based on priorities. Floor space area, Compartments, Portable, Ease of use, Attractive, Less cost, Maintenance, Lightweight, Durable are the major customer requirements plotted. These were marked against technical voices like Mechanism, Weight, Performance, Material, Ergonomics, Feature, Shape, Size, Aesthetics and Capacity. Customer rated Ease of use as the important requirement. The technical requirement, which is important, is weight, ergonomics and mechanism (Figure 3).

Product design specification

Product design specification is made according to the results of quality function deployment and the analysis results of the primary and secondary research. Product design specification helps to understand the basic dimensions of a product. Below is the Product design specification of the Compost Bin for Indian Kitchen. All the details pertaining to the product is given (Table 1).

Compost bin model design

The compost bin consists of three parts mainly. The top unit is compost-starter storage part. The second unit is the composting bin part. The third unit is the compost collection tray. One-half of top unit, compost-starter storage part consists of a cap is connected to a hinge

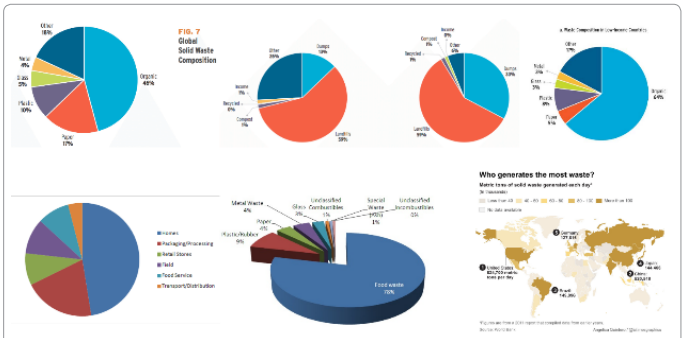

Figure 1: Market research.

Figure 2: Ethnography research.

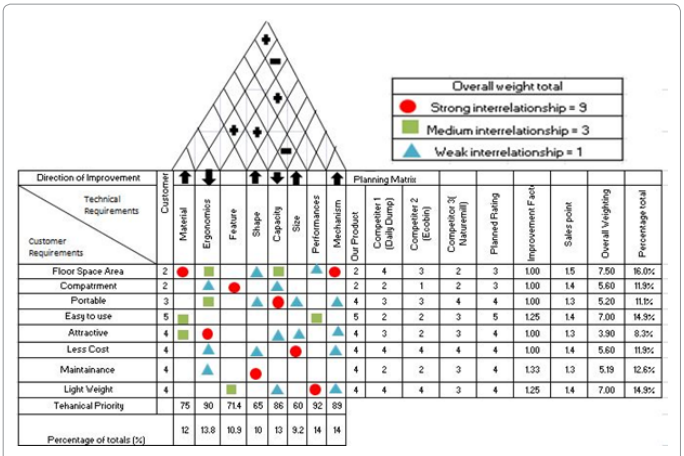

Figure 3: Quality function deployment.

S. NO	Factors	Specifications
1	Area of Usage	Indian Household Kitchen
2	Target Customer	Indian Kitchen Users
3	Target Country	India
4	Competitors	Daily dump, Eco bin
5	Shape	Organic
6	Size	300 × 300 × 650 mm
7	Weight	4-5 kg
8	Materials	Bio-plastic(Cellulose, starch)
9	Process	Injection molding, coloring, fabrication
10	Texture	Smooth texture
11	Color	Brown, White, Green
12	Aesthetics/Style	Modern
13	Expected lifespan	8 Years
14	Maintainance	Once a month
15	Performance	Semi-automatic
16	Quality and manufacture	Mass production
17	Ergonomic Aspect	Easy to access to all points of area
18	Cost	2000-3000 INR
19	Type	Portable
20	Safety	Safe and smooth operation

Table 1: Product design specification.

which can be refilled with the compost starter and other mixtures. The compost starter can be added to the composting area for mixing with vegetable waste with the help of a simple mechanism. The other half of the top unit, which consists of stainless steel blade setup consisting of blades arranged horizontal and vertical to each other. A plate is used to press the vegetable waste against the blade setup so that it can be finely chopped, which in turn increases the area of decomposition. The middle unit consists of a bio-plastic mixing blade, rechargeable batteries, a low powered DC motor, air filter setup and a switch. This unit can hold up to 10 kgs of vegetable waste and the compost starter mixture. This unit has a housing for a DC motor, which is attached to the mixing blade. The mixing blade is designed such that it scoops down the bottom most part of the bin and mixes the vegetable waste and compost starter mixture continuously and a switch turns it on. It is powered with two rechargeable batteries of 5800mAH. The air filter contains pellets made out of Azadirachta Indica (neem) and Gomaya (Cow dung) which are used to keep away bad odor and acts as a disinfectant. The bottom unit is a collection tray for compost collection. It takes around a week for composting the vegetable waste and it depends on the time the mixing blade is turned on (Figures 4-6).

Compost bin working flowchart

This explains the working of the designed compost bin for Indian kitchen. It explains the parts present in the Compost bin and explains the working flowchart. This flowchart explains how the compost bin works. The process starts with addition of vegetable waste onto the vegetable cutting setup part. When the plate is pressed, the vegetable waste is cut into small piece and it falls into composting bin part. The compost starter part is filled with the compost starter and a knob is pulled so that right amount of compost starter along with accelerator and calcium oxide is put into composting bin part. Then the switch is switched on and the mixing blade starts rotating which is connected to a DC motor and rechargeable batteries. After some time, the switch is turned off and checked for compost. It generally takes 3 to 4 days to get the composted output with daily rotating the mixing blade for some duration of time. The Air filter is filled with right amount of pellets of cow dung and neem to avoid foul smell and insects while composting. After the composting process is completed, it can be removed by pulling a knob and collecting at the bottom bucket part, which can be removed and used for plants (Figure 7) [11-17].

Figure 8 shows the parts used in compost bin. A DC motor is used with 10 kg torque and 50 rpm. It can rotate at 50 rpm and a maximum load of 10 kg. Two rechargeable Ultra fire batteries are used with each of 5800 mAH power, which means it can run straight for 10 to 12 hours on a single charge. Springs are used for easy motion of knobs, which helps in dumping of compost starter powder and final composted output.

Figure 9 shows the parts used in compost bin. The blade setup is used which is made of strips of stainless steel arranged in horizontal and vertical across a wood stand. The blade setup is used to cut the vegetable waste into less than 1.5 square centimeters of length. The next part is the Natural Air filter part, which uses Indian idea of avoiding bad smell, and avoid insects, as cow dung is anti-insecticide, pesticide and anti-odor. Neem is also used as anti-insecticide. Pellets are made with a mixture of cow dung and neem powder and is filled regularly to avoid bad smell [18] (Figure 10).

Composting process

Figure 11 shows the composting process used in the compost bin designed for Indian kitchen. The process goes as follows:

- Vegetable waste is chopped finely to increase the area of decomposition with the help of cutting blade setup.
- Addition of compost starter consisting of microbes which starts the composting process.
- Continuous mixture of the vegetable waste and the compost starter powder for effective composting with the help of mixing setup consists of dc motor.
- Use of a natural air filter (mixture of cow dung and neem powder tablets) for avoiding the foul smell and to avoid insects.
- Use of calcium oxide with the compost starter mixture to maintain the initial heat and to start the composting process.

Thereby following these above five process steps, the composting process is simple, odour free, less time for composting, less work while using compost bin and can be kept inside the kitchen without any issues.

Figure 4: Working physical prototype of compost bin.

Figure 5: Compost collection tray, blade setup and compost-starter unit.

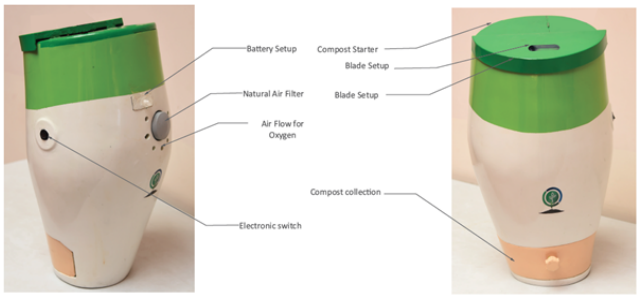

Figure 6: Compost bin parts.

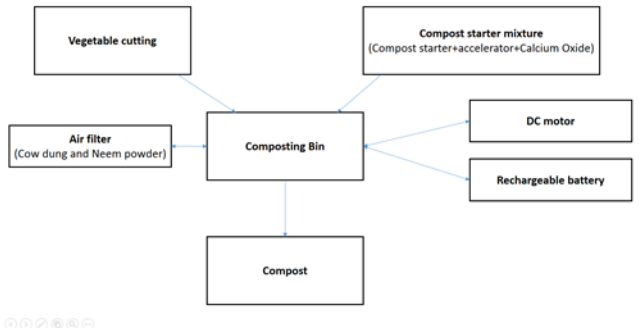

Figure 7: Working flowchart.

Results and Discussion

The steps involved in composting of the working prototype are as follows: Mixture of Compost starter, accelerator and the Calcium oxide is added to the storage unit. The Storage Unit Cap is covered which is connected to a hinge. Air filter is opened. Air filter cap is opened.

Figure 8: Components.

Figure 9: Compost bin parts.

Figure 10: Compost bin operating process.

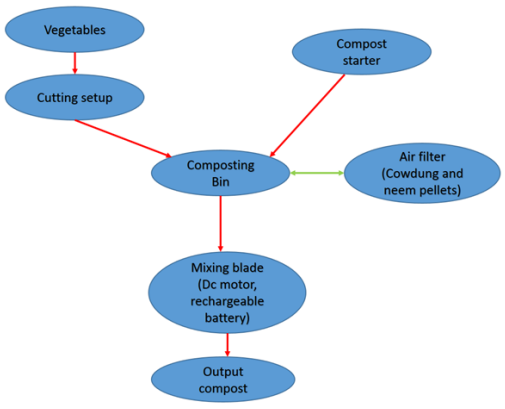

Figure 11: Composting process.

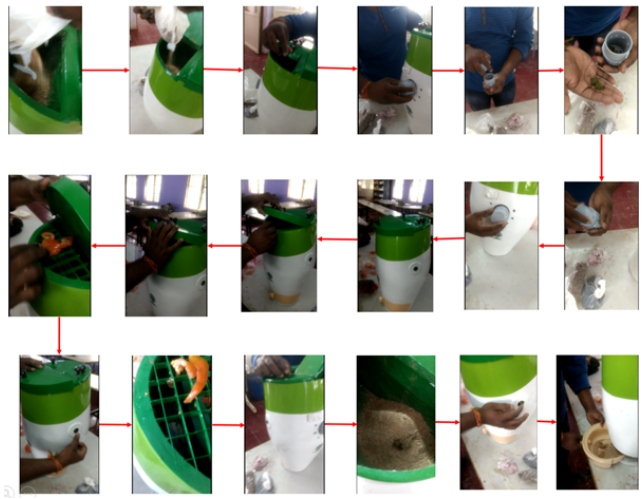

Figure 12: Results.

Mixture of Cow dung and Neem powder pellets are filled in the Air filter. Air filter cap is closed. Air filter is placed in its position. Cutting setup plate is opened. Vegetable scrap is placed on top of blade setup. Plate is pressed. Check whether vegetable waste is cut and put it inside the Composting Bin. Pull the knob to add the compost starter mixture to the composting unit. Power on the switch. Check whether mixing blade is rotating. Wait for some time for the mixture to mix. Power off the switch. Pull the knob for adding the compost from composting unit to compost storage unit. Remove the below compost storage unit with the finished compost (Figure 12).

Conclusion

Compost Bins play a major role in solid waste management in India in the future by eliminating the organic waste dumping at the source and instead only dumping inorganic waste. As the compost bin is easy to use and is cost effective, many people can buy and use it. It is easy to use and is simple. It has 2 rechargeable batteries which can be recharged once a day or 2. Composting have great potential to contribute to material recovery, reduction of landfill, use of renewable resources and helps in Solid waste management. The new design of the compost bin is aesthetically good looking can be kept inside kitchen, non-messy, no odor, keeps insects, flies away from compost pile, and keeps the plants in the home healthy.

Future Work

Based on few of the suggestions suggested by the users for future improvements of the compost bins, below are some of the future scope of the compost bin. They are:

- Wheels can be added at the base so that it is easily transportable.
- Blade setup can be made with multiple size for thick and thin vegetables.
- Blade setup can be removable.
- Composting area to be transparent.
- Proper handle for movement of compost bin.
- Mechanism for addition of compost starter and final output compost removal.

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