INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 22, No. 1, p. 45-52, 2023

RESEARCH PAPER OPEN ACCESS

Design and Modification of Compost Bin with a Chopper for 3R (Reduce, Reuse, Recycle) Temporary Shelter (TPS 3R) in Banjar Regency South Kalimantan

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Key words: Chopper, Compost, Compost bin design, Organic waste

http://dx.doi.org/10.12692/ijb/22.1.45-52 Article published on January 03, 2023

Abstract

Composting is an effective method of managing organic waste from decomposition by microorganisms. This research using composting technique with a modification compost bin with additional chopper on the top of the bin. The composter was designed using an HDPE drum with a height of 100 cm and a diameter of 50 cm with the addition of a chopper and a manual compost mixer as well as a lower cross-section. This research aimed to calculate the amount and composition of waste in TPS 3R Sekumpul and to design modification of a compost bin to handle the problem of organic waste in TPS 3R Sekumpul. The average waste generation in TPS 3R Sekumpul is 66,875 kg/day with the composition of the waste generated including compostable (organic) at 4.28%, resaleable waste at 93.85%, and residual waste at 1.87%. The manual chopper is designed with 7 blades with a slope of 45° which are placed on an iron plate connected to a handle to rotate the chopper. The rotate is in the form of a spiral attached to the rotate handle and connected to the drum cover and the bottom section is a rectangular metal structure having 4 wheels on each side. All of the tools that are designed and made can work smoothly without being constrained during the testing of the tool. The composter drum can accommodate up to 25 kg of compost and leachate in the lower part of the compost bin partition. Assessment of the performance of the compost bin with a chopper is seen from the results of the chopped organic waste produced from the chopper. In the knife chopper test using 5 kg of organic waste, the chopped waste results were obtained with an average size is between 0.5 cm - 1 cm. Compost bin with chopper are designed so that they are easy to operate for households and regional scales. It is expected that the use of the compost bin can facilitate the user so that compost is produced with good quality, large quantity and fast composting time.

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Introduction

Composting activity is an alternative choice in organic waste management using a composter with a decomposition process. With the help of microorganisms on biodegradable organic waste with the final result in the form of humus (Gonawala & Jardosh, 2018). There are two composting methods, namely aerobic and anaerobic processes. The use of a drum composter in the composting method is included in aerobic composting. The use of a drum that has been modified into a composter tool and used in organic waste composting activities in an area will help significantly reduce the amount of waste in a landfill (Manu *et al.*, 2016). In utilizing organic waste in Banjar Regency, the composting method is an alternative that can be applied to convert organic waste into compost.

Indonesia, which is a developing country, is recorded to produce twice the amount of organic waste generation (food waste), which is 50 - 80% of the total municipal waste generation. Compared to the current three developed countries, Japan produces the highest organic waste generation, which is only 40%, followed by the European Union at 34%, and the USA at 24% organic waste generation from the total waste generation (Dalankopoulos *et al.*, 1998)). For this reason, an organic waste management effort is needed which starts with micro-scale management at various points in the territory of the country of Indonesia to help reduce and deal with the problem of organic waste generation in Indonesia.

The discussion regarding Waste Management and TPS Facilities is contained in Law no. 18/2008, 3R (Reduce, Reuse, Recycle) Temporary Shelter (TPS 3R) is a place where activities to collect, sort, reuse, and recycle waste on a regional scale (Nurlela, 2017). Waste that is generated will go into the first processing site, namely the Temporary Shelter – Tempat Penampungan Sementara (TPS). TPS is a place where waste is transported before it is moved to either the recycling site, processing site, Integrated Waste Processing Site – Tempat Pemrosesan Sampah Terpadu (TPST), or 3R Waste Management (TPS 3R) site. Composting municipal waste allows the organic material contained in the waste to be returned to the soil so that the level of soil fertility is maintained because of the addition of organic material as a substitute for material absorbed by cultivated plants. Household-scale composting technology with several considerations such as placement can be done indoors and outdoors, resistant to heat and rain, has a longer shelf life, does not need to replace supporting materials (cardboard), and is easier get the composter container (Wahyono *et al.*, 2016). Some of the obstacles in composting include still using the manual method (Antu & Djamalu, 2019). In addition, there are obstacles in the long composting time due to the large size of the organic waste. The smaller the size of the organic waste, the faster the decomposition will be. Designing a composter with a manual chopper can be a solution to simplify household and communal scale composting such as TPS 3R.

In this design, the development and improvement of the compost bin design was carried out in the three previous studies, namely by adding a compost mixer and improvements to the designs of Purba (2021) and Akhmad (2020) by making a bottom section of the composter bin as in the design of Tjahjani *et al.* (2008). The addition of a compost mixer in the compost bin is to help the mixing of the compost easier. Improvements to the chopper tool from Purba's research (2021) were also carried out because there were still many deficiencies, the majority of the chopped organic waste results were still not up to standard.

This research will develop the design of Compost Bin that have made in 2021 (Mahyudin *et al.*, 2022) in order to produce tools that are easier to operate. The communal composter will process organic waste from several households to be composted. This composter is designed in such a way that it is easy to operate on a regional scale. Furthermore, testing the performance of the composter will be carried out so that later a variation will be produced that can produce compost with good quality, large quantity and fast composting time.

The urgency of this research lies in the innovative development of Compost Bin design with a chopper which is easier to operate on a regional scale and produces good quality compost that can be used or sold. This research was conducted for identifying the amount and composition of the waste that entering TPS 3R; also to designing a developed Compost Bin with a modification of the chopping knife to process organic waste into compost?

Material and methods

The location of this research is in TPS 3R Sekumpul, Banjar Regency, South Kalimantan, Indonesia. Located on Jalan Pendidikan, Gang Berkat Tawakal 2, RT 006 RW 03.

Preparation of tools and materials for measuring waste generation and composition, namely hanging scales, meters, gloves, masks, trash bags. The equipment needed in the design of compost bins is Autocad applications, electric drills, grinders, tape measure, sandpaper, rulers, and markers. In the design of this chopping composter bin, materials are used, namely, High Density Polyethylene (HDPE) Drum, ¾ and ½ inch PVC pipes, ¾ inch T joints, door slots, door hinges, ring reservoirs, water faucet 1 ½ inch, pipe glue, drum scraps, pipe seal tape. This research was conducted by calculating waste generation and composition at TPS 3R Sekumpul. Generation data and composition of waste are used as the basis for calculating the compost bin design. Waste samples from TPS 3R Sekumpul were tested for water content for the purpose of designing the composter bin for the leachate compartment. After all the data is obtained, the design of the compost bin with a chopper is carried out using the AutoCAD software. Compost bin that has been assembled is then tested by monitoring several parameters.

Parameters observed were chopped particle size, organic waste capacity and chopping time.

Result and discussion

Result

The amount and composition of the waste that entering TPS 3R

TPS 3R Sekumpul is a cooperative legal entity in collaboration with the Banjar Regency Government and the local community. The purpose of establishing TPS 3R Sekumpul is as a forum to foster, train, accompany as well as buy and market the results of waste management activities from sources of waste generation originating from the Banjar Regency community in the context of reducing waste in TPA and empowering the community's economy by carrying out the 3R program (reduce, reuse, recycle).

Table 1. Description of Composter Bin Components.

No	Component	Description
1	Pusher Tool	Used to push the trash that is inserted into the mouth of the chopper so that it gets to the chopping blade.
2	Chopper cover	Function to coat the metal plate and the chopping knife (blade) so that during the counting process the waste does not spread around.
3	Waste Chopper Handle	Function to rotate or move the metal plate and chopping knife so that the trash can be chopped
4	Bottom Section Tool	Function to facilitate the process of moving the enumerator composter barrel and maintain the stability of the composter barrel when used.
5	Chopping Knife (Blade)	Has the most important or vital function, which is to chop the waste into smaller parts.
6	Chopper's Iron Plate	Serves as a container or place to place 7 chopping blades, placed horizontally and connected to the chopping lever.
7	Inlet	Serves as the first place for the path to enter garbage before heading to the chopper section with the help of a trash pusher.
8	HDPE Drum	Used to accommodate the results of chopped shredder.
9	Composter bin door	Used to take the results of solid compost that has been ripe in the chopper composter bin.

Measurement of waste generation carried out at TPS 3R Sekumpul was carried out for 8 consecutive days in accordance with SNI 19 – 3964 – 1994 concerning Methods for Taking and Measuring Sample Generation and Composition of Municipal Waste, which aims to determine the amount of waste generated by residents' activities per day and to find out the type of waste generated.

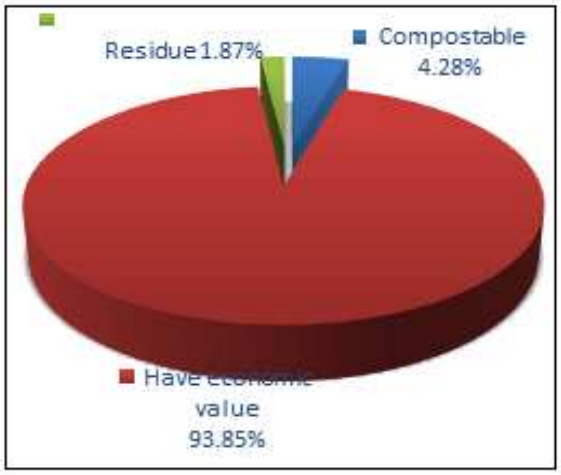

Fig. 1. Percentage of Composition of Waste that goes to TPS3R Sekumpul.

The average weight of waste that enters TPS 3R Sekumpul is 66.875 kg/day. The average volume from the results of waste sampling for 8 consecutive days is 252.1 L/day. The types of waste that are most often generated are cardboard, duplex, and glass bottles. After carrying out the waste sorting process, there were three groups of types of waste obtained, namely 4.28% compostable (organic) waste, 93.85% marketable waste and 1.87% residual waste.

The partition design of compost bin

Based on the results of testing the water content of the TPS 3R Sekumpul waste sample, the water content value was 23.52%. According to Tchobanoglous *et al.* (1993) the range of the physical characteristics of the waste for testing the moisture content is 15 - 40%. Based on this, the results of the waste physical characteristic test for water content in the Sekumpul TPS 3R organic waste sample showed that the water content in Sekumpul TPS 3R was within the specified value range.

The placement of the partitions is carried out based on the calculation of the previous water content test so that the partitions made are able to accommodate the leachate produced. In testing the water content obtained a value of 23.52%, then:

HDPE drum height = 100 cm,

Moisture Content of Organic Waste = 23.52%,

Heigth of leachate compartment= 23.52 % x 100 cm = 23.52 cm (± 25 cm).

In the design carried out, the partition partition is placed 25 cm high to ensure that all the leachate produced is able to be accommodated in the leachate compartment of composter bin.

Discussion

The designed composter is a composter used for aerobic composting techniques. Equipped with an organic waste counter, rotate and bottom section. Inside the composter there is also a partition between the compost and the leachate. The first compartment is a chopper containing an iron plate equipped with seven blades for chopping organic waste, in which the plate is connected to a pillow with a stirring handle to rotate the iron plate containing seven blades. The results of the chopped organic waste obtained an average size of 0.5 cm - 1 cm.

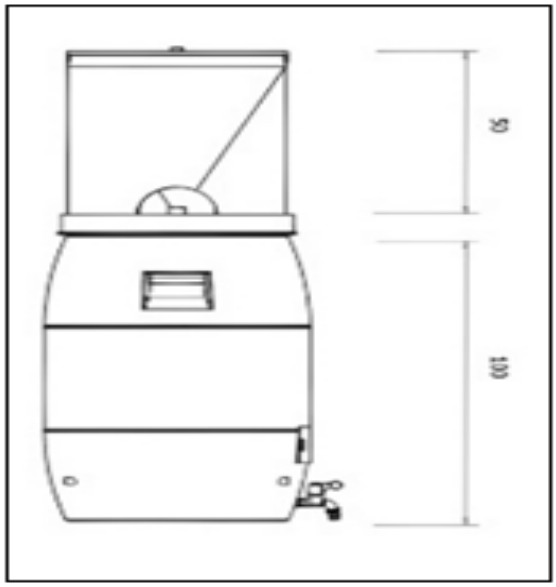

Fig. 2. Compost Bin Partition Design.

Assessment of the performance of the composter (chopper) is seen from the results of the chopped organic waste produced from the chopper. Assessment of the performance of the composter (chopper) seen from the results of chopped organic waste produced from the chopping knife.

The desired chopped results are in accordance with SNI 19-7030-2004 concerning the specifications for compost from domestic organic waste with the criteria for a good material particle size for compost is 0.55 – 25 mm or with a maximum size of 2.5 cm.

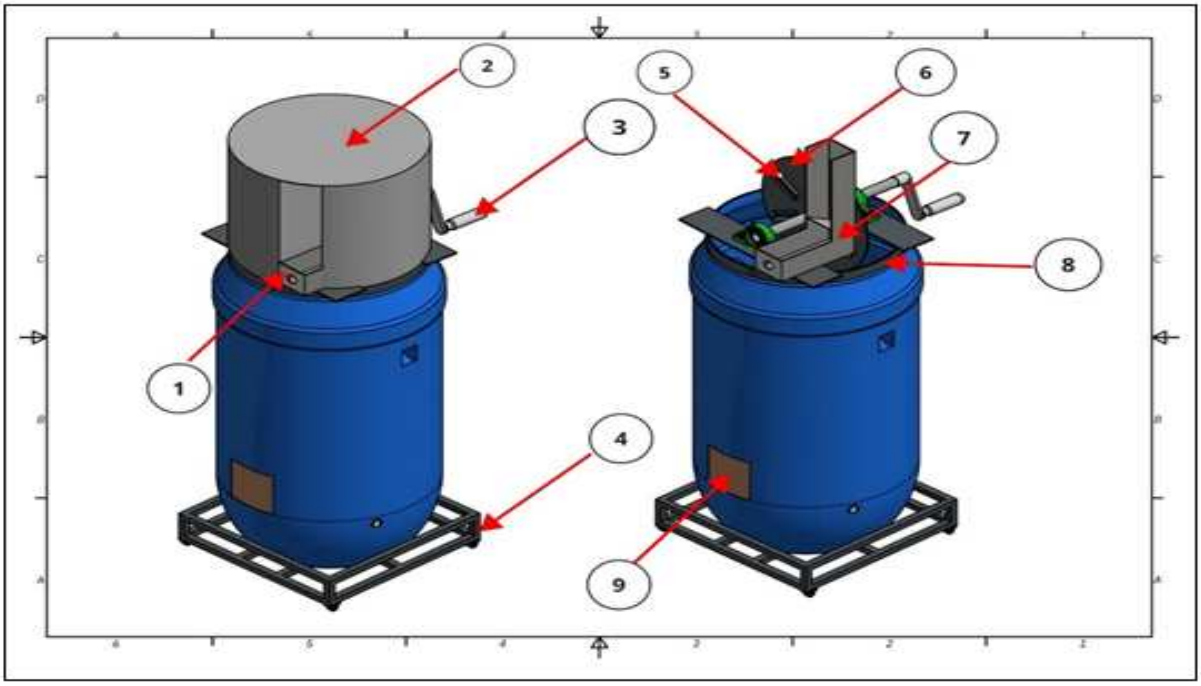

Fig. 3. Compost Bin Design.

The chopped results were obtained with an average particle size of 0.5–1 cm, these results met the particle size criteria compost raw materials.

Fig. 4. Compost Bin with a Chopper.

This is due to the modification of the chopper system which is designed with an inlet for organic waste with a chopper blade 0.5 cm apart with a total of 7 blades, making the organic waste chopped properly to the desired size because the contact that occurs between the blade and the organic waste occurs automatically continuous.

The effectiveness of the chopped results was measured using 1 kg of waste sample organic waste, around 804.42 grams of shredded waste according to the desired size while 195.58 grams of the remaining organic waste was not chopped properly. This is due to the fact that some waste is still able to pass through the chopper, especially vegetable waste because the texture is slightly elastic and soft, so it cannot be processed optimally.

In the following, a comparison of the chopped results is presented between organic waste with a rather soft texture (vegetables) and organic waste with a rather hard texture (fruit peels) (Fig. 5). Compared with the results of the study by Sunge *et al.* (2019) who chopped organic waste with a vertical cutter equipped with a blade with a slope of 45° used electrical energy, this research obtained chopped results ranging from 2 – 5 mm.

Fig. 5. The results of chopped organic waste using modification compost bin with a chopper; (a) vegetables; (b) fruit peels.

The use of a chopper that utilizes electrical energy gives better and more efficient results compared to a chopper that utilizes human energy (manually). But the manual chopper system has the advantage of making it easier for users to process organic waste anytime and anywhere without depending on electricity. The time required for the chopping process of 1 kg of waste samples is 19 minutes (18 minutes 53 seconds). One compost bin can accommodate as much as 24 kg of waste, so the time needed to fill one compost bin in 1 process is 456 minutes or about 8 hours.

Therefore this tool is recommended for continuous or repeated composting techniques every day when there is waste that can be processed, not for one-time composting activities. Furthermore, the compost bin is equipped with a stirrer to make the waste decomposition process run well. This stirrer consists of a stir stick connected to the cover of the HDPE drum and connected to the stirrer inside the composter bin (Fig. 6).

Assessment of the compost mixer can be seen from whether or not the tool works smoothly or rotates. The rotate is designed to be integrated with the lid of the composter bin, this is because the mixing process is carried out after the chopping process is complete, so that during the mixing process the compost can be stored immediately because the rotate is already attached to the lid of the HDPE drum.

Fig. 6. Compost Stirrer Tool.

The lowest part of the planned compost bin is the bottom cross-section of the composter, which is made of a series of square-shaped mild steel and is equipped with small wheels on each side of the bottom section.

Fig. 7. Bottom part of Compost Bin.

Conclusion

Based on the results from field observations in TPS 3R Sekumpul, it was found that the average waste generation at TPS 3R Sekumpul was 66.875 kg/day. The average waste volume generated is 252,100 L/day. The most dominant waste composition is marketable waste 93.85%, compostable (organic) waste 4.28% and residue waste 1.87%. The design of the chopping blade on the top of compost bin consists of 7 blades connected to a rotate handle, then a compost stirrer connected to the HDPE drum cover, a bottom part of compost bin equipped with wheels on each side. Assessment of the performance of the composter chopper is seen from the results of the chopped organic waste produced from the chopper. The chopped results were obtained with an average particle size of 0.5–1 cm, these results met the particle size criteria compost raw materials according to SNI 19-7030-2004.

Recommendation (S)

Suggestions that can be given in the design of this chopping composter bin are to replace the system with a trash pusher that is connected directly to the inlet, so that the mobility of the pusher will be better and more effective.

Acknowledgement

This research supported by LPPM PNBP of Lambung Mangkurat University Indonesia contract number 023.17.2.677518/2022 November 17, 2021.

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