



## **Design and Development of Polycarbonate Dryer Assisted Bio-Composter**

**M. Sriram<sup>1</sup>, R. Pavithiran<sup>1</sup>, M. Tito Anand<sup>1\*</sup> and R. Vidyalakshmi<sup>2</sup>**

<sup>1</sup>Workshop and Fabrication Unit, Indian Institute of Food Processing Technology (IIFPT),  
Ministry of Food Processing Industries, Pudukkottai Road, Thanjavur, 613005, India.

<sup>2</sup>Department of Food Biotechnology, Indian Institute of Food Processing Technology (IIFPT),  
Ministry of Food Processing Industries, Pudukkottai Road, Thanjavur, 613005, India.

### **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors MS and RP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RV guided me during the research and managed the analyses of the study approved the final draft. Author MTA managed the final manuscript. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/CJAST/2020/v39i4831259

#### Editor(s):

(1) Dr. Elena Lanchares Sancho, University of Zaragoza, Spain.

#### Reviewers:

(1) Mateus Alves de Sousa, Federal University of Western Pará, Brazil.

(2) Elaine Cristina dos Santos Araújo, Federal University of Campina Grande, Brazil.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/66116>

**Original Research Article**

**Received 22 October 2020**  
**Accepted 28 December 2020**  
**Published 31 December 2020**

### **ABSTRACT**

Household Food Wastes are causes major environmental problem and health risk problems during dumping into landfilling, sewage and garbage. If household food waste does not short it down in advances, it leads to huge contribution over Municipal Solid Waste. In India, nearly 40% of consumption waste occurs in current status. The present study focused on compost production using household food waste and culture mixed were pour into the fabricated bio-composter bin which can be placed in a polycarbonate dryer to increase the rate of microbial growth concentration, maintain the optimum temperature and make odor free environment. Presented design and fabrication of polycarbonate dryer assisted bio-composter model was done by using Computer-Aided Design (CAD). Further studies, a preliminary design and fabricated design were handled to take different formulation of composting ratio were incorporated and the physio-chemical testing were estimated. According to the composting observation, recovery of compost was higher yield obtained within a short period due to faster degradation with help stable microbes. Especially, this design was well planned, low cost setup approach and reassembled parts used,

\*Corresponding author: E-mail: [tito@iifpt.edu.in](mailto:tito@iifpt.edu.in);

due to customer preference. Comparing to the different trails runs for the preliminary and final fabricated design, R1 and R4 trail runs showed 93% efficiency with minimum digestion loss and the optimized parameter value resulted for plant growth. The overall performance of this composter brings a solution for household seekers to utilize the food waste discard to zero waste success.

*Keywords: Composting; culture; food waste; fabrication; efficiency.*

## 1. INTRODUCTION

Food Waste (FW) disposals are facing critical challenges and increasing attention address to the global. It leads to causes the major climate changes and biodiversity loss [1]. In India, 81,760 tons of FW being generated annually includes food and households kitchen waste, restaurants, caterers and retail premises. It is been expected to reach between 2.78 billion tons and 4.16 billion tons by 2025 in Asia alone [2]. FW main contribution such as logistic chain 52%, consumption level 34% and industrial waste 28% [3]. Now a days, household members are facing the crucial and intermediate challenges of consumption level food waste disposals due to exposure food handling, eating, preparation and provisioning by individual households etc. Another social factors from consumption level such as lack of skills, awareness and knowledge, family-stages, related lifestyle and household type, individual perception, behavior and expectation. FW leads to causes the health risk problem and environmental inconvenience through dumping in garbage, sewage and landfilling.

Currently, Social trends on the phase of food waste management in household to utilize in the proper way to obtain sources for land application and composting is the best and common solution for recycling FW in easy way. Bin-composting technology becomes more popular in urban areas due to social concern by individual. Very few reports were available regarding the utilization of food waste as a biodegradability agent, but the potential use of the household food waste was mostly underrated. Though there a few waste composter for food waste, then seen to be ineffective intense of higher process which are long term composting and high- cost making. It cannot be feasible for practical and commercial utility.

Hence in the present study, the polycarbonate dryer chamber assisted bio-composter was made to incorporate to digest household uneaten or discarded food waste and vegetable waste (without bones, stone, and sand) with inoculum

preparation (culture Actinomycetes; *Streptomyces sp*) to composting production. In order to maintain proper temperature, control moisture content and faster degradation. The salient features of this projects such as Initiate food waste management at domestic level, use of renewable solar energy for accelerated digestion, make an odor free environment by the use of aerobic process, Easy maintenance and Eco-friendly and Endorses the idea of terrace farming and gardens. Based on the above-mentioned features and the pertaining lag the objectives of the present research such as design and fabricate the polycarbonate dryer chamber and bio-composter, study and evaluate the performance of the designed equipment and evaluate the physio-chemical properties of the obtained compost.

## 2. MATERIALS AND METHODS

This present study was undertaken to design and development of polycarbonate dryer assisted bio-composter and evaluate the performance of fabrication, physio-chemical and biological testing to the compost production. The composting experiment was conducted at Indian Institute of Food Processing Technology, IIFPT (Latitude: 10.7311389; Longitude: 79.1045592).

### 2.1 Collection of Food Waste and Culture

The vegetable and food waste include vegetable peels and discarded uneaten parts are substrate which the place collected from the waste dumper in IIFPT boy's hostel by using a from the local laboratory. The substrate of culture includes Dried Cow Dung (DCD), Saw Dust (SD) and Actinomycetes *Streptomyces sp* and prepared culture proportion for SD and DCD in (2:1) ratio. The culture was collected in sterile polyethylene biohazards bags and stored at room temperature to maintain the moisture content. Later, the collected SD substrate was milled and sieved into 2mm for uniform size to maintain MC. The DCD Bind with microbial culture and booster for faster digestion. The source of lab microbial cultured Actinomycetes *Streptomyces sp*. Inoculum 1% added at time culture preparation.

The characterization of each waste substrates was listed in the Table 1.

## 2.2 Preliminary Design Consideration

Proto type design was done by using Poly Vinyl Chloride (PVC) plastic container to make the trail attempt to correct the error and modulate the final fabrication design. This proto type setup was designed with lid of container was drilled with 2cm hole in the center for stirrer action and also three difference place for aeration, filter plate with 0.3cm hole and placed on the height of 4cm from the bottom to box with the help of bolt and nut used to collect the waste from the compost production. Model setup was placed in the solar hybrid dryer for maintaining the stable environment. The model setup specification was showed in the Table 2 and the preliminary design was figured out in Fig. 1.

### 2.2.1 Different trail run

Six different trail runs taken for food waste, vegetable waste and culture were mixed together

in the ratio were taken and poured into the capacity of 1kg model setup showed in the Fig. 3 which placed in the solar hybrid dryer to maintain the moisture content and temperature for microbial degradation. Manual stirrer action takes place on regular interval. The analytical studies and observation were explained in the result and discussion section. The characterization of substrate before composting was listed in the Table 3.

## 2.3 Polycarbonate (Poly-house) Dryer and Bio-composter

Adjustable and flexible poly-house dryer chamber which is made up of polycarbonate sheet. Polycarbonate sheet (PC) is a group of thermoplastic polymers containing carbonate groups in their chemical structures. The polycarbonate used in engineering is strong, tough materials, and some grades are optically transparent. They are easily worked, molded and thermoformed. It maintains good mechanical properties over a wide range of temperatures.

**Table 1. Characterization of waste substrate**

Parameters	Substrate		
	Food & vegetable waste	Dry cow dung	Saw dust
Bulk density (kg m <sup>-3</sup> )	750	620	480
Moisture Content	75.34	57.75	37.5
Water Holding Capacity (%)	38.51	35.33	30.75
Porosity (%)	42.30	52.7	71.57
pH	5.32	7.84	4.57
Electrical Conductivity (mS/cm)	4.13	3.42	1.02
Nitrogen (N) (%)	5.34	3.22	0.27
Phosphorus (P) (%)	3.63	2.44	0.16
Potassium (P) (%)	2.95	1.94	0.36
Hemicellulose (%)	44.37	27.6	18.07
Cellulose (%)	12.45	41.1	29.89

**Table 2. Model setup specification**

Capacity	Condition	Filter plate	Stirrer action
1kg	Open type (Aeration)	Stainless Steel	Manual



**Fig. 1. Preliminary design**

**Table 3. Characterization of substrate before composting**

Parameter	Food & vegetable waste	Mixed culture
Bulk density (kg m <sup>-3</sup> )	750	550
Moisture Content	75.34	47.62
Water Holding Capacity (%)	38.51	33.04
Porosity (%)	42.30	62.13
pH	5.32	5.68
Electrical Conductivity (mS/cm)	4.13	5.62
Nitrogen (N) (%)	5.34	2.50
Phosphorus (P) (%)	3.63	1.30
Potassium (P) (%)	2.95	1.15



**Fig. 2. Different trail run**

The high strength that makes it resistant to impact and fracture. It is non-toxic and can be absolutely transparent up to 2 inches in width. PC also features high electrical and heat resistance. Readily recyclable and cost-effective. The above properties were best suited for choosing polycarbonate sheets. The dimension of the chamber is shown in the Table 1” sq. galvanized pipe structure of 3.25 feet square frame with the front arch opening door. The structure is fully covered with clear UV resistant. 6mm polycarbonate multiwall sheet with proper tension made of aluminum angles fitted with self-tap screw and castor wheels for portable. The dryer chamber (poly-house) consists of bio-composter to digest the household food waste at the optimum temperature which helps for better and faster microbial degradation. The exhaust outlet is used to maintain better temperature control and helps to avoid the water molecule on the surface of the sheet. From the study analysis

of the proto type design, the final fabrication was designed and the dimension of the bin showed in the table. The parts of bio-composter were made up of different material and each part is re-assembled for comfortable and cleaning process.

**2.3.1 Material selection and design consideration**

Materials used for the fabrication of different parts of bio-digester are selected upon heat stability, digestibility and drying. Material selection and dimension of Polycarbonate dryer assisted Bio-digester is given in the Table 4.

**2.3.2 Computer aided design diagram of polycarbonate dryer**

The design of polycarbonate dryer and bio-composter was done as a computer Aided Design (CAD) diagram given in the Fig. 3. After

**Table 4. Material and dimensions of parts of the design**

Parts of the solar-assisted bio-digester	Material selected	Dimension (in cm)
Portable drying chamber	Polycarbonate multiwall sheet	110×110×120
Castor Wheels	Nylon	6
Digester bin	Digester bin Capacity 50L	H= 52.5, OD= 45.7 ID = 31.75
Stem	MS rod	H=75
Stirrer action	MS rod	H=36, Simple paddle = 14×6
Filter plate	Stainless steel	36

fabrication, Designed Equipment of polycarbonate chamber were showed in the Fig. 4.

### 2.3.3 Computer aided design diagram of bio-composter

The design of bio-composter was done as a computer Aided Design (CAD) diagram given in the Fig. 5. After fabrication, Designed Equipment of bio-composter were showed in the Fig. 6.

### 2.4 Physical Analysis of the Composting

The physical properties include bulk density was measured by according to Gabhane et al. [4]. The moisture content was determined by khater [5]. The amount of water holding capacity was determined and followed by the principal of Ahn et al. [6]. Estimation of porosity was followed by Andrew and Leonard [7].

### 2.5 Chemical Analysis of the Composting

The chemical properties include pH value, Electrical Conductivity (mS/cm), Phosphorus (%), Potassium (%), Nitrogen (%) and C/N ratio was estimated and followed by Sriram et al. [8].

## 3. RESULTS AND DISCUSSION

This section explains the result obtained from experiment performed to evaluate the polycarbonate dryer assisted bio-composter. The results were compared with 6 different trail run. The terrace farming attempt and economics of the developed digester is also discussed in this section.

### 3.1 Different Trail Run and Composting Yield for both Preliminary and Fabricated Design

Six different trail run of the composting yield, digestion loss and efficiency for both preliminary and fabricated design were calculated and listed in the Tables 5 and 6.

#### 3.1.1 Data analysis for physical parameter

Data of six different trail run for both preliminary design and fabricated design of the bulk density, moisture content, water holding capacity and porosity were varies and resulted in the Table 7 and 8. In different run, the bulk density value got deviated due to different ratio content of substrate [9]. Moisture content varies due to

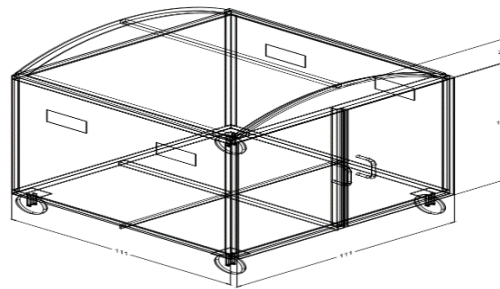


Fig. 3. Computer-aided design diagram of the polycarbonate chamber



Fig. 4. Fabricated polycarbonate chamber

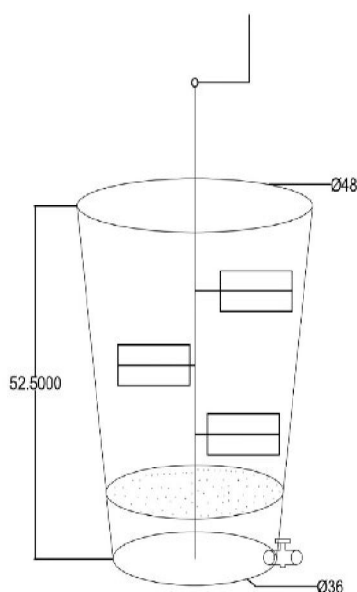


Fig. 5. Computer-aided design diagram of the bio-composter



Fig. 6. Different views of the fabricated bio-digester

Table 5. Yield of composting and digestion loss from preliminary design

Run	Total weight (500 g capacity)	Food waste + Vegetable waste (g)	Culture (g)	Compost yield(g)	Digestion loss (g)	Efficiency (%)
1	(50:25:25)	250 + 125	125	464.92	35.08	93
2	(25:50:25)	125 + 250	125	464.17	34.83	93
3	(25:25:50)	125 + 125	250	461.79	38.21	92
4	(75:12.5:12.5)	300 + 100	100	463.23	36.77	93
5	(12.5:75:12.5)	100 + 300	100	462.12	37.88	92
6	(12.5:12.5:75)	100 + 100	300	459.03	40.97	91
Average	-	166.7 + 166.7	166.7	462.04	37.29	92.33

presence of dry matters. Water holding capacity varies due to particle size and retention capacity of the compost [10]. Porosity depends on the bulk density and moisture content [11].

### 3.1.2 Data analysis for chemical parameter

In data analysis for chemical parameter for both preliminary design and fabricated design value

shows, pH value varies due to formulated substrate concentration of hydrogen ion [12]. The subsequent rise in pH value to run 4 was influenced by nitrogen base organic matter and release of volatile ammonia. Formation of organic acids leads to further decrease in pH value to run 3 after composting. Electrical conductivity varies due to the presence of mineral salt content released during organic

matter decomposition [13]. Release of higher base ions in run 4 resulted increased in EC and reduced in run 3 due to  $\text{NH}_4^+$  evaporation and reduced base ion. Nitrogen content varies due to moisture content of the compost. Run 4 consist of 75 % FW influence to increase in MC and 75 % presence of SD which absorbed the moisture in FW decreased the N %. Phosphorus range rise to run 5 due to nitrogen absorption inferences and gradual decrease to loss of MC and mineral salts. Potassium range value

increased due to the higher concentration of DCD substrate in run 2 and attains lower range to run 6 for presence of dry matter. Based C and N content, C/N ratios were determined. The higher range indicate the higher of dry matter and lowered concludes loss of dry matter and the values were resulted in the Tables 9 and 10. Both preliminary and fabricated design reports that equal value ranges according to the weightage ratio.

**Table 6. Yield of composting and digestion loss from fabricated design**

Run	Total weight (50 kg)	Food waste + Vegetable waste (kg)	Culture (kg)	Compost yield (kg)	Digestion loss (kg)	Efficiency (%)
1	(50:25:25)	25 + 12.5	12.5	49.670	0.330	93
2	(25:50:25)	12.5 + 25	12.5	49.650	0.350	92
3	(25:25:50)	12.5 + 12.5	25	49.612	0.388	92
4	(75:12.5:12.5)	30 + 10	10	49.664	0.336	93
5	(12.5:75:12.5)	10 + 30	10	49.624	0.358	92
6	(12.5:12.5:75)	10 + 10	30	49.597	0.403	91
Average	-	16.7 + 16.7	16.66	49.636	0.360	92.166

**Table 7. Physical parameter after composting from preliminary design**

Run	Bulk density ( $\text{g m}^{-3}$ )	Moisture Content (%)	Water Holding Capacity (g water/g dry sample)	Porosity
1	30	34.83	3.13	60.69
2	30	36.77	3.87	62.53
3	30	38.21	4.37	69.77
4	30	35.08	3.07	63.45
5	30	37.88	3.43	66.59
6	30	40.97	4.89	72.11

**Table 8. Physical parameter after composting from fabricated design**

Run	Bulk density ( $\text{kg m}^{-3}$ )	Moisture Content (%)	Water Holding Capacity (g water/g dry sample)	Porosity
1	665	52	3.28	71.77
2	635	44	3.91	72.17
3	470	35	4.66	75.34
4	670	60	3.38	70.45
5	650	52	3.55	69.59
6	466	28	4.97	80.11

**Table 9. Chemical parameter after composting from preliminary design**

Run	pH value	EC (mS/cm)	N %	P %	K %	C/N %
1	7.2	3.73	4.07	3.14	2.36	17.19
2	7.8	3.56	4.01	3.77	2.10	19.67
3	7.2	2.97	3.88	2.63	0.98	15.77
4	7.7	3.88	4.18	3.54	2.33	20.11
5	7.4	3.02	4.44	3.88	2.54	22.97
6	6.9	2.44	3.17	2.00	0.88	18.17



**Table 10. Chemical parameter after composting from fabricated design**

Run	pH value	EC (mS/cm)	N %	P %	K %	C/N %
1	7.3	3.95	4.13	3.44	2.56	18.19
2	7.6	3.35	4.01	3.83	2.68	20.30
3	6.8	2.46	3.97	2.11	1.03	16.33
4	7.7	3.97	4.56	3.71	2.60	20.18
5	7.6	3.23	4.23	3.97	2.65	23.77
6	6.5	2.77	3.88	2.03	0.97	18.37

**Table 11. Estimation of cost for designed equipment**

Accessories	Quantity	Amount in INR
Poly carbonate sheet roll	2 nos.	
Castor wheel	4 nos.	
Fitting pipe	4 nos.	3,810/-
PVC plastic dustbin	4 nos.	
Filter plate	4 nos.	
Plastic water tap	4 nos.	
Total Amount		3,810/-

### 3.2 Cost Analysis of Designed Polycarbonate Dryer Assisted Bio-composter

The total fixed cost of the polycarbonate dryer and bio-composter is the sum of total material cost and material fabrication cost which is given in the Table 11.

### 4. CONCLUSION

Comparing to the preliminary design and fabricated design, Different trail runs concludes that R1 and R4 remains 93% efficiency with minimum digestion loss, balanced nutrient value, faster degradation capacity and attains faster vegetable growth. Recovery of yield from R3 and R4 remains 91% efficiency with maximum digestion loss due to presence of high dry and organic content. Overall designed equipment declared that low investment and operating cost, domestic level would promote the idea of terrace farming and the house inmate can also make money by selling the obtained manure in the market.

### ACKNOWLEDGEMENTS

We expressed our sincere thanks to Dr. C. Anandharamakrishnan, Director, Indian Institute of Food Processing Technology (IIFPT), Ministry of Food Processing Industries (MOFPI), for motivating and encouraging while carrying out this study in Thanjavur.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

### REFERENCES

- Aschemann-Witzel J, De Hooge I, Amani P, Bech-Larsen T, Oostindjer M. Consumer-Related Food Waste: Causes and Potential for Action. *Sustainability*. 2015;7(6):6457-6477.
- Ren Y, Yu M, Wu C, Wang Q, Gao M, Huang Q et al. A comprehensive review on food waste anaerobic digestion research updates and tendencies. *Bioresource Technology*. 2018;247:1069–1076.
- Palaniswamy D, Ramesh G, Sivasankaran S, Kathiravan N. Optimising biogas from food waste using a neural network model. In *Proceedings of the Institution of Civil Engineers-Municipal Engineer*. 2018; 170(4):221-229.
- Gabhane J, William SP, Bidyadhar R, Bhilawe P, Anand D, Vaidya AN et al. Bioresource technology additives aided composting of green waste: Effects on organic matter degradation, compost maturity, and quality of the finished compost. *Bioresource Technology*. 2012; 114:382–388.
- Khater ESG. Some physical and chemical properties of compost. *International Journal of Waste Resource*. 2015;5(1):1-5.



6. Ahn HK, Richard TL, Glanville TD. Laboratory determination of compost physical parameters for modeling of airflow characteristics. *Waste Management*. 2008; 28(3):660–670.
7. Agnew JM, Leonard JJ. The physical properties of compost. *Compost Science and Utilization*. 2003;11(3):238-264.
8. Sriram M, Pavithiran R, Nikhita B, Janani BM, Vidyalakshmi R, Tito Anand M. Characterization of Physicochemical and Biological Properties of Household Food Waste Composting Using Actinomycetes Genus. 2020.8(4);2582-2845.
9. Celik I, Ortas I, Kilic S. Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a chromoxerert soil. *Soil and Tillage Resource*. 2004;78(1):59–67.
10. Rizki M, Tamai Y, Koda K, Kojima Y, Terazawa M. Wood density variations of tropical wood species: implications to the physical properties of sawdust as substrate for mushroom cultivation. *Wood Resource Journal*. 2010;1(1):34–39.
11. Veeken AHM, Timmermans J, Szanto G, Hamelers HVM. Design of passively aerated compost systems on basis of compaction-porosity-permeability data. In *Proceedings of the 4th International Conference of Orbit Association on Biological Processing of Organics*. Murdoch University. 2003;85-96.
12. Yang F, Li GX, Yang QY, Luo WH. Chemosphere effect of bulking agents on maturity and gaseous emissions during kitchen waste composting. *Chemosphere*. 2013;93(7):1393–1399.
13. Lin C. A negative-pressure aeration system for composting food wastes. *Bioresource Technology*. 2008;99(16): 7651–7656.

© 2020 Sriram et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*  
*The peer review history for this paper can be accessed here:*  
<http://www.sdiarticle4.com/review-history/66116>