Saravannan, S., T.Meenambal, R.N.Uma "Study On Biodegradation Of Fruit Waste Aerobic Composting" in Martin J. Bunch, V. Madha Suresh and T. Vasantha Kumaran, eds., *Proceedings of the Third International Conference on Environment and Health, Chennai, India, 15-17 December, 2003*. Chennai: Department of Geography, University of Madras and Faculty of Environmental Studies, York University. Pages 441 – 450.

STUDY ON BIODEGRADATION OF FRUIT WASTE AEROBIC COMPOSTING

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Abstract

A study was convened to assess the biodegradability of fruit wastes by using In-Vessel Non Flow Reactor type Aerobic Composting. The study was enunciated by studying the characteristics of the selected fruit waste. The composting process was executed under forced aeration at a rate of 1 litre/kg/min in four reactors with the C/N ratio of the fruit wastes. The wastes were initially allowed to remain undisturbed in the reactor for 6 days to avoid thermal instability. The samples were then analyzed once in four days for studying the various physical, chemical and biological characteristics. After 26 days the compost of desired quality was obtained. From the study, it is inferred that the fruit wastes have good biodegradable characteristics that are well exploited by the In Vessel Non flow aerobic composting technique to produce a quality compost material in a quick pace. The optimum C/N Ratio to be present in the fruit wastes for achieving high quality compost are also identified in this study.

1. INTRODUCTION

One of the major environmental concerns in urban areas today is the issue of Solid Waste Management. In India, the collection, transportation and disposal of solid waste is normally done in an unscientific and chaotic manner. Uncontrolled dumping of wastes on outskirts of towns and cities has created overflowing landfills, which are not only impossible to reclaim because of the haphazard manner of dumping, but also have serious environmental implications in terms of ground water pollution and contribution to global warming. An effective system of solid waste management is the need of the hour and should be environmentally and economically sustainable. Composting is the simplest yet best process for solid waste management for our condition. It is basically a special form of Waste Stabilization that requires special conditions of moisture and aeration to produce stable compost which can be used as a low grade manure and soil conditioner.

2. COMPOSTING

Composting is the biological decomposition and stabilization of organic substrates under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens and plant seeds, and can be beneficially applied to land. Composting has a wide range of agricultural, economic and environmental benefits. Based on the oxygen status in the process; the composting can be broadly classified into aerobic and anaerobic composting. Experiences from the past elucidates that aerobic composting is highly beneficial compared to anaerobic. Off all the Aerobic Composting techniques, In Vessel Non Flow Reactor composting technique is a simple and efficient technique and the most suitable for bench scale studies.

2.1 In Vessel Non Flow Aerobic Composting

Systems that use reactors are popularly termed "mechanical" "enclosed" or "in-vessel", while those that do not are often termed "open systems". Reactor Systems of In-Vessel type are those in which composting material is placed for the process. Generally In–Vessel systems prove advantageous because of (i) rapid rate of decomposition (ii) precise control of moisture, aeration and temperature (iii) quicker odor removal (iv) lesser area requirements (v) lesser personnel requirements and (vi) pest control. The principle behind these non flow techniques is to use batch operated compost boxes that are now available in the market. In the process, the wastes are loaded at the start of the cycle and typically remain in the box reactor for 7 to 14 days. Aeration is usually controlled. Curing is conducted in windrows for several months. The above technique is the best solution for lab scale studies.

3. WASTE SELECTION

It is clear that source segregation of waste and its systematic aerobic composting is a viable and a beneficial solution to our vital problem of Solid Waste Management. The major component of MSW is food waste, and fruit wastes occupy a prominent position in the food wastes. Fruit wastes can also be easily segregated and they also have a good biodegrading capacity. Thus the component was chosen for experimental study.

4. PROJECT METHODOLOGY

4.1 Waste Preparation

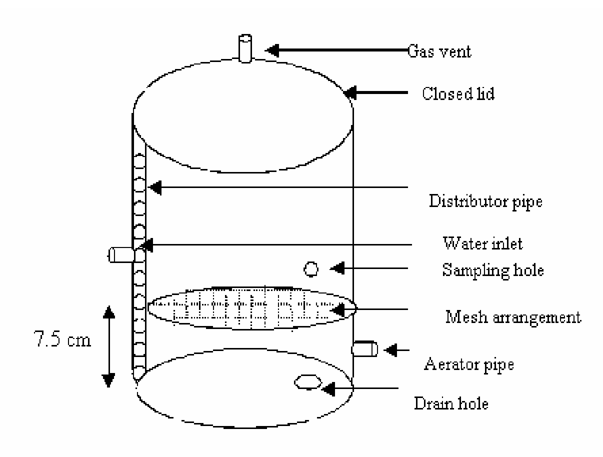
The first step in the experimental study was the collection of the chosen fruit wastes. The collection stations were Gandhipuram Pazhamudir Nilayam, a departmental store exclusively for fruits and vegetables and Ukkadam Fruit Market, Coimbatore and samples of required quantity were taken. The fruit wastes were collected after the peeling and crushing operations, after which they lose their utility. Rotten fruits were also included in the collection. Before preparation of the composite sample, hand sorting was emphasized to segregate unwanted materials like straw, plastic covers, packaging materials etc. Then a composite sample was prepared and allowed to dry for one week to adjust the moisture content to the desired levels. The dried samples were shredded manually into pieces between sizes 2 and 3 cms. The shredding was done to have good uniformity in heating and to provide greater surface area for microbial attack. The shredded sample was then analyzed for various physical, chemical and biological characteristics to get a rough idea about the biodegradability of the sample.

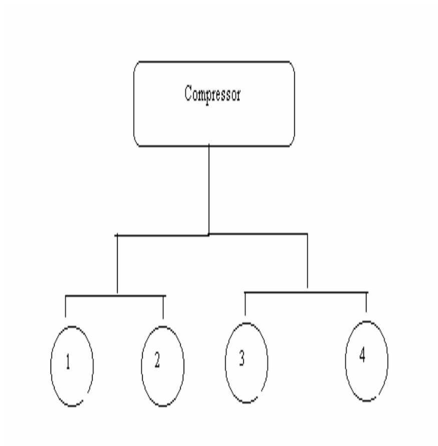
Table No.1 Initial Characteristics of Fruit Waste and Additional Agents

PARAMETER	UNITS	FRUIT WASTE	COIR PITH	YEAST SLUDGE	POULTRY YARD WASTE
Carbon	%	5.71	29.3	31.8	6.0
Nitrogen	%	1.25	0.175	1.82	1.25
Phosphorus	%	0.25	0.17	0.98	0.225
pH	-	5.14	7.41	6.24	7.38
Electrical conductivity	mmhos/cm	1.02	0.519	0.804	0.532
Total Solids	%	86.9	22	28	-
Volatile Solids	%	89.8	30.4	48	-
Ash Content	%	10.12	69.6	52	-
Moisture Content	%	13.1	78	4.14	-
C.O.D (Chemical oxygen demand)	mg/g	840	460	304	320

4.2 Reactor

For this study bench scale reactor to compost given quantity of solid waste and to maintain optimum environmental conditions was designed. To accommodate the solid waste weighing 8 kg and having a density of 400 kg / m^3, the vessel (Reactor) of height 38 cm and diameter 28 cm (based on mass-volume calculations) was chosen for use. The reactor consists of a single compartment unit, made of tin with anti-corrosive coatings. The sampling port and the mesh arrangement (7.5 cm from the bottom) were provided for uniform air distribution. The reactor was secured tightly at the top with lids providing gas vent and all the reactors are connected to the compressor for aeration. The reactors were also provided with water distribution pipes to uniformly distribute the water and thereby maintain uniform moisture condition. The reactor was equipped with baffles in the inner periphery to maintain uniform mixing of waste during turning operations. A drain hole to remove excess water inside the reactor and a sampling port to collect the samples periodically were arranged in the reactor. Four such reactors were set up and they were all connected to the compressor for forced aeration.





4.3 Proportioning

With reference to the research requirements, the prepared waste was divided into four different mixtures, with varying C/N ratios. To achieve the above stated variations, the bulking agent coir pith and nitrogen feeder matter poultry waste were employed. To enhance the rate of bio degradation, required quantity of yeast sludge (microbial source) and pleurotosis (decomposition culture) were also added. Four different mixtures of the wastes with varying constituents were taken for composting process. The mixtures were obtained by fixing a ratio between coir pith and the remaining constituents and accordingly mixtures of 1:2, 1:3, 1:4 and 1:5 (coir pith: remaining constituents) were prepared. The detailed mixture specifications are given in the following page.

Table No.2COMPOSITION OF DIFFERENT MIXTURES

MIXTURE / CONSTITUENTS	1:2	1:3	1:4	1:5
FRUIT WASTE (kg)	1.6	1.875	2	2.083
COIR PITH (kg)	1.5	1.125	0.9	0.75
YEAST SLUDGE (kg)	1	1.125	1.2	1.25
POULTRY WASTE (grams)	0.33	0.375	0.4	0.412
PLEUROTOSIS(grams)	20	20	20	20

4.4 Loading and Mixing

The mixtures were loaded into the specified reactors with great care and attention. Before the waste was allowed to degrade, it was well mixed manually. During the period of study, mixing was done by turning the materials in the mixing unit ensuring proper distribution of the materials in the reactors. The temperature is an important indicator for identifying the process stage during composting. Typically, the temperature of composting material rises during the initial days and stays at an elevated temperature for some days (Thermophilic conditions i.e. above 45^oC) before dropping gradually. In this study, the wastes were not disturbed for six days and the temperature shooted to thermophilic condition (47^oC).

4.5 Aeration

Air is required during aerobic composting mainly for the three purposes (i) supplying oxygen for biological decomposition (stochiometric demand) (ii) removing moisture from the composting mass (drying demand), and (iii) removing heat to control process temperature (heat removal demand). For this study of aerobic composting, forced aeration was provided to all the four reactors at a rate of 1litre/kg/minute each with help of rotometer. The aeration was done through compressor arrangements.

4.6 Moisture Adjustments

The moisture content of the waste in the reactor is a critical parameter towards the success of the composting process. If the moisture content falls below 30%, the microbial activities are limited. On the other hand, if the moisture content is too high the oxygen access to the system is reduced. Keeping that in mind, the moisture content was maintained at an optimal level of 40% to 55% throughout the period of study. In case of forced aeration the moisture losses are inevitable and great care was taken to overcome this moisture loss by adding water to the reactors and subsequent thorough mixing.

4.7 Process Monitoring and Sampling

The process of composting was monitored with great attention. The compost was turned as and when required to ensure uniform mixing and proper aeration. The sampling was done once in four days and the samples were analyzed for nutrient values, physical, chemical and biological characteristics. The nutrient analysis was carried out for the initial waste and the final compost. The collected samples were oven dried, grinded, fine sieved before analysis. The analysis was done for a score of physical and chemical parameters like pH, moisture content, TS, C/N Ratio, COD etc.

5. RESULTS AND DISCUSSIONS

5.1 BIO-DEGRADATION OF MIXTURE 1:2

For the waste mixture, 1:2 the bio degradation was studied by analyzing various parameters of the composted samples once in four days.

Table No.3 BIO-DEGRADATION OF MIXTURE 1:2

Day/ Parameter	Unit	1	6	10	14	18	22	26
Ambient Temperature	^{o}C	30	27	27	27	28	28	25
Temperature	^{o}C	27	44	35	28	28	28	27
Moisture Content	%	48	50	55	49	46.3	44	41
pH	-	5.74	6.89	7.2	7.64	7.70	7.81	7.90
Electrical Conductivity	mhos/cm	2.17	2.18	2.48	2.51	2.58	2.54	1.95
C.O.D	mg/g	776	720	592	576	512	496	580
Total Solids	%	52	50	45	51	53.7	56	59
Volatile Solids	%	75	66	68	51	48.1	48.2	42.37
Ash Content	%	25	34	32	49	51.9	51.8	57.63

1.2 BIO-DEGRADATION OF MIXTURE 1:3

For the waste mixture, 1:3 the bio degradation was studied by analyzing various parameters of the composted samples once in four days.

Table No.4 BIO-DEGRADATION OF MIXTURE 1:3

Day/ Parameter	Unit	1	6	10	14	18	22	26
Ambient Temperature	^{o}C	30	27	27	27	28	28	25
Temperature	^{o}C	26	41	35	29	30	29	27
Moisture Content	%	45	52	56	50	48	44	40
pH	-	6.10	6.87	7.52	7.64	7.70	7.81	7.92
Electrical Conductivity	mhos/cm	2.22	2.71	2.8	2.53	2.31	2.25	1.92
C.O.D	mg/g	792	680	648	616	580	552	498
Total Solids	%	55	48	44	50	52	56	60
Volatile Solids	%	76.36	62.5	59	58	51.9	48.21	41.66

Ash Content	%	23.64	37.5	41	42	48.1	51.79	58.34

5.3 BIO-DEGRADATION OF MIXTURE 1:4

For the waste mixture, 1:4 the bio degradation was studied by analyzing various parameters of the composted samples once in four days.

Table No.5 BIO-DEGRADATION OF MIXTURE 1:4

Day/ Parameter	Unit	1	6	10	14	18	22	26
Ambient Temperature	^oC	30	27	27	27	28	28	25
Temperature	^oC	26	45	35	30	29	29	26
Moisture Content	%	50	52	49	53	48	45	42
pH	-	5.95	6.67	7.17	7.33	7.56	7.60	7.82
Electrical Conductivity	mhos/cm	2.18	2.58	2.57	2.79	2.56	2.30	1.9
C.O.D	mg/g	808	712	688	584	526	480	456
Total Solids	%	50	48	51	47	52	55	58
Volatile Solids	%	74	66.66	64.7	65.95	59.61	54.54	48.27
Ash Content	%	26	33.34	35.3	34.05	40.39	45.46	51.73

1.3 BIO-DEGRADATION OF MIXTURE 1:5

For the waste mixture, 1:5 the bio degradation was studied by analyzing various parameters of the composted samples once in four days.

Table No.6 BIO-DEGRADATION OF MIXTURE 1:5

Day/ Parameter	Unit	1	6	10	14	18	22	26
Ambient Temperature	^oC	30	27	27	28	28	29	25
Temperature	^oC	26	48	36	30	29	28	27
Moisture Content	%	52	54	48	55	49	45	41
pH	-	5.84	6.79	7.21	7.30	7.35	7.46	7.65
Electrical Conductivity	mhos/cm	2.36	2.61	2.78	2.75	2.4	2.37	2.27
C.O.D	mg/g	688	680	632	568	524	472	408

Total Solids	%	48	46	52	45	51	55	59
Volatile Solids	%	75	71.73	69.23	64.44	60.78	58.18	49.15
Ash Content	%	25	28.27	30.77	35.66	39.22	41.82	50.85

5.6 NUTRIENT VALUES OF WASTE – BEFORE AND AFTER COMPOSTING

The nutrient values of the chosen fruit waste before (waste) and after composting (compost) for different mixtures in different reactors were analyzed and are the values are provided below

Table No.7 NUTRIENT VALUES OF WASTE BEFORE COMPOSTING

Mixture	Carbon	Nitrogen	Phosphorous	C/N Ratio
1:2	**28.68**	**0.30**	**0.13**	**95.6**
1:3	**28.29**	**0.35**	**0.12**	**80.8**
1:4	**26.68**	**0.38**	**0.4**	**70.2**
1:5	**26.50**	**0.38**	**0.38**	**69.7**

Table No.8 NUTRIENT VALUES OF THE FRUIT WASTE AFTER COMPOSTING.

Mixture	Carbon	Nitrogen	Phosphorous	C/N Ratio
1:2	**23.4**	**0.63**	**0.14**	**37.14**
1:3	**23.16**	**0.75**	**0.38**	**30.88**
1:4	**19.8**	**0.81**	**0.47**	**24.44**
1:5	**18.7**	**0.95**	**0.66**	**19.6**

6. CONCLUSION:

The Experimental study of biodegradation of fruit wastes using techniques of aerobic composting has established the following significant details.

In the bio-degradation of fruit waste by In-vessel Non flow Reactor Type the process of composting is significantly affected by constituents like C/N ratio, moisture content, COD, pH, electrical conductivity, total solids and temperature. The Composting process proceeds at a fairly quick rate (26 Days) with forced aeration of 1 lit/kg/min. From the analysis of C/N ratio, the reduction was great for mixtures 1:3 and 1:4, which implies that addition of excessive carbon content, is not encouraged. Moreover the final C/N ratio for the mix 1:5 (19.6) is indicative of the completion of composting in 26 days.

All the same, if easily viable the aerobic composting of fruit wastes by the suggested methods may prove a handy solution for the society.

REACTOR

MIXING UNIT

EXPERIMENTAL SETUP FOR FORCED AERATION

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