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Investigation of In -Vessel composting Mixed Waste using saw dust as co compost.

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Abstract

The process of composting has been studied using six different types of bins, each simulating different blends for the formation of compost. The composting raw material was a mixture of Bio degradable waste (University Mess), bulking agent (Saw dust, Wood chips and Chopped hay) and Cow dung as compost accelerator Six composting bins were installed with Pilot tests were undertaken in a six 100-L composter. The reactor (length 50 cm, width 40 cm, height 50 cm) was placed horizontally with a slight inclination to permit the collection of leachate. The evaluation studies included the operational indices such as Temperature, pH, Moisture content, compost maturity indices like C/N ratio, Elements, Bulk Density, Microbial survival and the quality of the final compost. Blowers of this system were useful in maintaining aerobic through the entire compost bay. Further Germination studies were performed to ascertain the compost quality. The final compost was satisfactory for its agricultural application based on the results.

Keywords: In-Vessel Composting, C/N ratio,Aeration,Moisture and Germination studies.

1. INTRODUCTION

The collection and disposal of solid waste had been rapidly becoming one of the major unsolved problems of urban areas in India **(Srinath et al).** Composting is defined as the controlled biological decomposition of organic substrates carried out by successive microbial populations combining both mesophilic and thermophilic activities, leading to the production of a final product sufficiently stable for storage and application to land without adverse environmental effects. Two types of composting system have been widely applied: In-vessel systems and Window systems. The technology called In-vessel composting is a system that comprises a number of integrally related components including: materials, amendment, recycle handling, storage mixing, reactor system, odour-control system, aeration system[1-5], exterior curing with storage facilities and marketing of produced compost. This technology offer a highly controlled, enclosed environment for effecting the biological decomposition needed to produce a high quality product and tend be considerably more capital intensive than windrow technologies **(Renkow et al).** In vessel Composting has advantages over the window system: it would require less space and provide better control than windows. It would involve high process efficiency **(J.I. Chang et al).** This study had been conducted to evaluate the performance of a lab-scale In – vessel composting and the evaluations were focused on operational indices such as compost maturity indices and the quality of the final compost. Forced-aeration had been recognized as simple, economical and quick treatment process for organic solid waste. It had also interested operators of other systems because of their low odor emission, which would results from their no-turning operation and an adequate air supply **(Masafumi Tateda).** The study also investigated changes in microbiological and physicochemical parameters during single batch composting of municipal organic waste[6-13]. The inter-relationship between the microbial biomass as well as several physicochemical parameters was also evaluated. In recent years, the In recent years, the development and widespread use of more expensive In-vessel systems for the processing of green bio wastes had been resulted from legislative pressures on the safety of the composting process and the subsequent use of the compost product **(Antizar-Ladislao).** Such systems also allow for more precise control of the composting process, particularly in terms of moisture and temperature. The scope of the study included the design and testing of a household compost reactor working aerobically, which was inoculated with cow dung containing compost accelerating microorganisms and Bulking agents such as saw dust to achieve substantial and rapid volume reduction of the bio waste. The compost from the designed aerobic reactor provided good humus to build up a poor physical soil and some basic plant nutrients. This proved to be an efficient, eco-friendly[14-23], cost-effective and nuisance-free solution for the management of household solid waste **(Srinath et al).**

2. MATERIALS AND METHODS

The process of composting was studied using six different types of reactors, each simulating a different condition for the formation of compost based on the C/N ratio. Bio degradable Solid waste from the Mess in the University was mixed with cow-dung slurry. The cow dung was obtained from the cattle shed in Jeppaiar Milk[24-30]. It was dried to remove odour and then 10 % cow dung slurry was prepared as follows. 100 g of cow dung was mixed with 1000 ml of water. The fibers in the water were filtered using cloth filter. Saw dust from wood mill from the university were mixed with food wastes as bulking agent in the rectangular bin. The saw dust had been sieved using 4.75 mm mesh and the particles retained in them was used as bulking agent and supplemented with grains and minerals. Pilot tests were undertaken in a six 100-L static composter[31-37]. The reactor (length 50 cm, width 40 cm, height 50 cm) was placed horizontally with a slight inclination to permit the collection of leachate. A plastic mesh was fitted at the bottom of the receptacle to support the material and separate it from possible leachates. A 3-cm polyurethane foam layer provided thermal insulation. Several holes were perforated through the walls of the vessel to permit air movement, leachate removal and the insertion of different probes. The loading of the reactor was performed by initially spreading a layer of pebbles of thickness 1 cm. at the top of the under drainage perforated pipes. Then dry leaves were spread and sprinkled with water to impart some moisture within the reactor. A layer of soil was placed over the leaves[38-42]. The reactor was then loaded with waste. A thin iron pipe with a uniform holed loop tail was kept inside the reactor. The mixture (composting source) was fixed on a stainless disc mesh 10 cm above the bottom and aerated through the mesh covered by the loop tail using blowers. A schematic diagram of the pilot-scale in-vessel composting plant evaluated in the study is illustrated in figure 1.

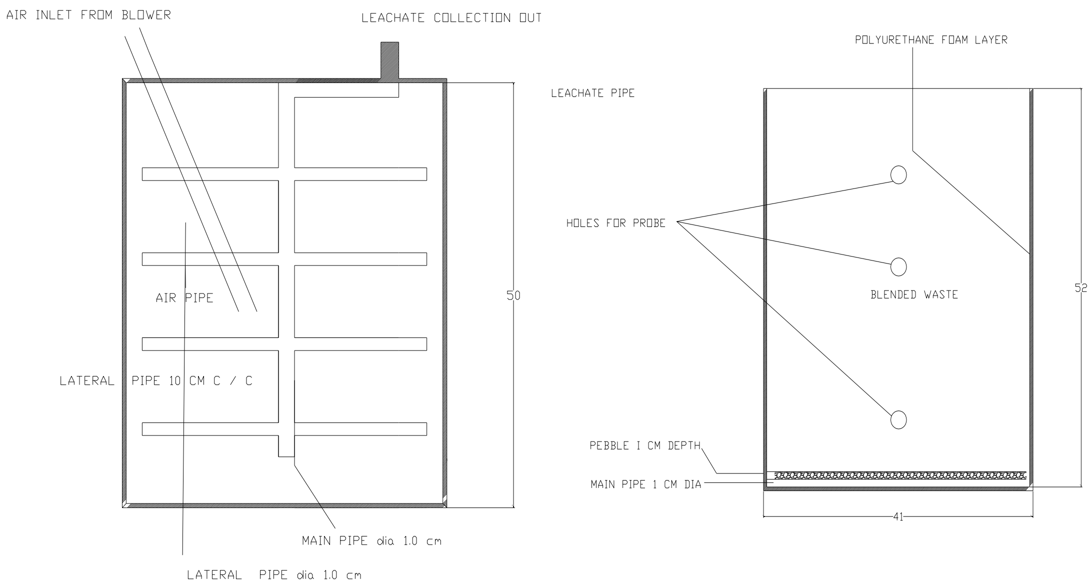

Figure 1 – Plan and front of Rectangular bin used in composting

The mixing ratio of bulking agent to food waste with cow dung had been described in table 1 on a weight basis to adjust the C/N ratio. The compost samples at different decompositions degrees were dried at 60 ^{O}C. In case of the compost samples and mature compost the compost was separated from bulking agents using 4.75 mm sieve[43-46]. It was ground in a coffee grinder to homogenize and powdered, dry samples (7–10 mg) were used for the analysis.

Table 1 Typical Composition of Blends – Saw dust

S. no	MATERIALS	Blend I	Blend II	Blend III	Blend IV	Blend V	Blend VI
1	Cow Dung (g)	550	550	550	550	550	550
2	Food waste (g)	1200	2450	3700	4950	6200	7450
3	Saw dust (g)	8250	7000	5750	4500	3250	2000
		10000	10000	10000	10000	10000	10000

The pH was measured using a pH electrode. 1 g of sample each bin was taken and oven dried for on e hour. It was ground well and mixed with 50 ml of water. (1:50 (w/v)). The Moisture Content (MC) was measured using Hydrometer. The Temperature was measured using Multi Stem Thermometer. The analyzer Vario EL was used for the elemental analysis (Carbon, Nitrogen, Hydrogen and Sulphur) of the samples. Vandate Molybdate method and Flame photometer were used for the determination of Phosphorous and Potassium. The Total Bacterial Count (TBC).was determined as per methods of sampling and microbiological examination of water. The elements include Copper, Zinc, Iron[47-50], Manganese, Cobalt, Chromium and Aluminum was determined using Atomic Absorption Spectrometer following EPA 3050 B. Bulk density was determined using graduate cylinder method. Particle size Distribution was determined using sieve analysis and Water Holding Capacity (WAC) values were determined by soaking the materials in distilled water for 24 h, draining off the gravitational water during another 24 h under cover to limit evaporation, and then drying at 103 ^{O}C for 24 h to determine the final moisture content. Finally the germination study was done by growing seeds in compost obtained from different blends taken in plastic pots. It was spread in layer of about 3 cm height. A trace paper was placed in the top and sprinkled with water.

3. RESULTS AND DISCUSSION

The Central Public Health and Environment Engineering Organization (2000) specify that the Nitrogen, Phosphorous and

Potassium (NPK) contents for compost should be more than 1% each. The nitrogen should be in the form of nitrates for proper utilization by the plants. The C/N ratio should be between 15 and 20. Hence the qualities of the composts produced in the different reactors were compared in the light of the above recommended properties.

3.1 Variation of Carbon (%)

Carbon availability plays a major role in N immobilization. While degrading organic compounds, microbes waste from 60% to 70% of the Carbon as carbon dioxide and incorporate (immobilize) only 30–40% of the Carbon into their body as cellular components **(Suzelle Barrington et al).** Changes in the carbon content during the compost period for saw dust is detailed in Table 2. The content of the carbon decreased gradually as the decomposition period progressed. Initially the contents were around 47. %. It had been drastically reduced in each blend to 34 % to 18 % in each blends respectively. Around 20 % of carbon had been utilized as a source of energy by micro organisms. Decomposition of organic matter is brought about by microorganisms that use the carbon as a source of energy and nitrogen for building cell structure.

Table 2 Variation of Carbon for saw dust (%)

Days	**0**	**15**	**30**	**45**	**60**
Blend 1	47.65	29.80	43.47	38.94	35.21
Blend 2	47.20	19.39	44.13	38.61	32.61
Blend 3	48.65	19.12	38.50	29.90	29.19
Blend 4	48.70	17.54	24.05	35.30	29.30
Blend 5	47.95	31.27	23.10	21.82	14.65
Blend 6	47.10	30.17	20.97	20.61	18.20

3.2 Variation of Nitrogen (%)

The Nitrogen content had increased in the blends in probably by mineralization of organic matter as well as loss of carbon. The increase of nitrogen showed the good quality of bio compost. Nitrogen fixing bacteria would also contribute the increase but in the blends 4, 5 and 6 the Nitrogen content had decreased as shown in table 4. The high temperature and the excessive amount of ammonia would have inhibited the bacterial growth. The stored nitrogen was then used by other organisms to form new cell material. In the process more carbon was used. Thus, the amount of carbon was reduced to a more suitable level while nitrogen is recycled.

Table 3 Variation of Nitrogen for saw dust (%)

Days	0	15	30	45	60
Blend 1	0.67	0.98	1.00	0.95	0.87
Blend 2	0.77	1.21	1.04	1.08	1.20
Blend 3	1.17	1.06	1.27	1.30	1.36
Blend 4	1.57	1.38	1.45	1.20	1.22
Blend 5	1.77	1.36	1.42	1.39	1.18
Blend 6	1.57	1.14	1.17	1.05	1.11

3.3 Variation of C/N Ratio.

C/N ratios in the composting reactors can also be initially within the range 50:1–100:1 while C/N ratios normally encountered in a composting process are around 75:1. **(Alex Godoy-Fa undez et al).** Compost maturity index based on C/N ratio is a very important parameter for compost production and application. Numerous maturity indices have been proposed, but no single method can be universally applied to all composts due to variation in feed stock and composting technology. The compost from the blend 1 reactor would not be suitable for land application since the excess carbon would tend to utilize nitrogen in the soil to build cell protoplasm, consequently resulting in loss of nitrogen in the soil on which it would be applied as in table 5 On the other hand, the low C/N in the compost formed in Blend 6 would not help to improve the soil structure.

Table 4 Variation of C/N ratio for Saw dust

Days	0	15	30	45	60
Blend 1	72.11	40.51	38.32	39.94	35.56
Blend 2	61.70	32.55	32.79	32.69	25.25
Blend 3	40.73	26.53	25.59	25.08	22.04
Blend 4	31.12	25.75	27.62	24.92	21.05
Blend 5	27.17	24.41	23.43	22.89	20.19
Blend 6	25.05	22.19	21.43	17.32	9.18

3.4 Variation of Temperature

Temperature is an important parameter in composting both as a result and as a determining factor for microbial activity. Sanitization of the composting process is achieved by the thermophilic temperatures which kill many of the pathogens that may be initially present in the mixture. Measured temperatures in composting plants usually vary according to aeration mode as well as location of measurement points in the composting mass (**Quazi H. Bari et al**). As in figure the temperature rises gradually due to heat generation from microbial activity and so the composting process experiencing an initial rise in temperature followed by declining, stabilized temperatures. The declining phase result as microbial activity decreases due to lower levels of available organic matter (**Hagerty et al)**. The temperatures were determined in all the six bins of composting mass at a given time. The temperature of the Blend 3 and 4 increased rapidly from 46 to 58 ^{O}C within a period of 5 days and further decreased to 47 ^{O}C at the end of 60 days in the case of saw dust as bulking agent

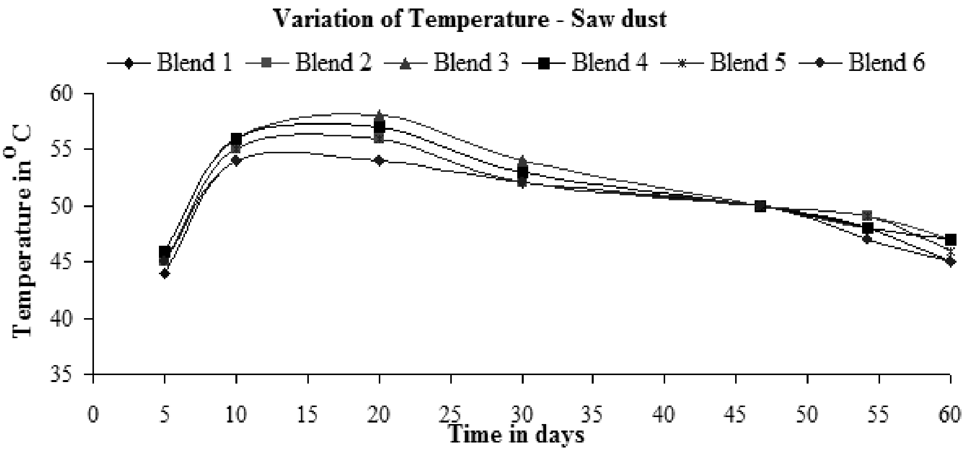

Figure 2 Variation of Temperature for Saw dust

3.5 Variation of Moisture Content (MC)

The moisture level required for effective thermo-composting is between 55% and 65% whereas kitchen waste usually has higher MC and, therefore, adding bulking agents such as saw dust, or shredded paper would help to reduce the moisture level and to develop the thermophilic condition. The heat generated during the degrading process also helps in reducing the moisture content **(Jaya et al).** According to **Finstein et al** .moisture loss during the composting process can be used as an index of the decomposition rate, since the heat generation which accompanies decomposition drives vaporization. The moisture content in the case of saw dust as bulking agents at the start was 62. % and during the whole process, it was in the acceptable range of 50% to 60%. As in figure 3. The moisture content was adequate and would probably not cause any major differences in process performance.

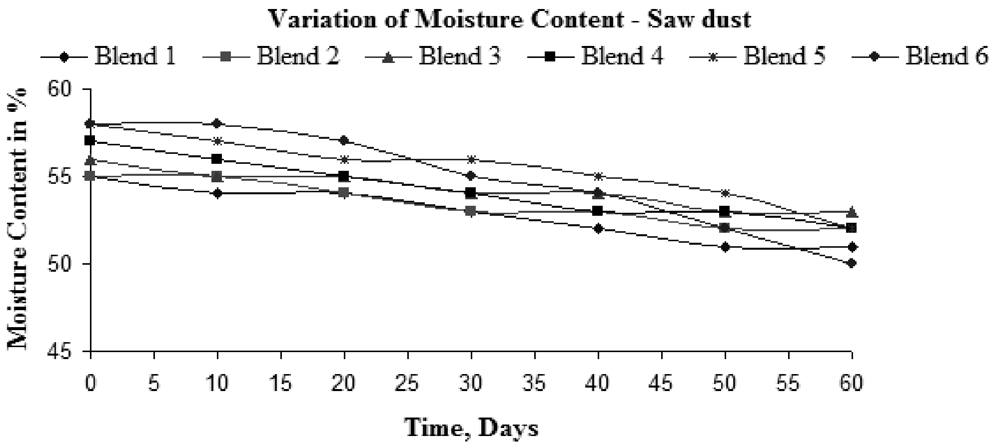

Figure 3 Variation of Moisture Content for Saw dust

3.6 Variation of pH

pH is one of the key factors for microbial metabolism, pH was monitored in the composting substrates every 5 days. In the conditions of excess of nutrients and oxygen, pH values are expected to drop following aerobic microbial degradation. **(Alex Godoy-Fa undez et al).** Before treatment, all reactors presented a pH range close to neutrality (pH 7.0–7.5) and no statistical differences were found between reactors as in figure 4. Once the treatment started, pH changes were observed in the reactors. Significant lower pH values were observed in the reactors with low food waste ratio.

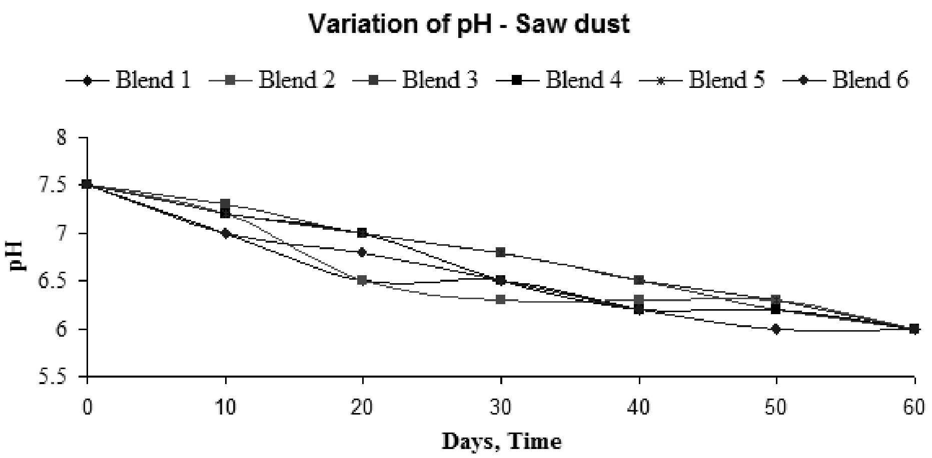

Figure 4 Variation of pH for Saw dust

3.7 Elemental Analysis

Compost also contained trace elements essential for plant growth such as Copper, Zinc, Manganese, and Iron with nutrients such as Potassium and Phosphorous. Results as in table 7 indicated that the compost has a high potential as plant fertilizer with appropriate concentration of nutrients required by the plants **(Terman G. L et al).** Other elements in trace forms would improve the ion exchange capacity of soil. Of all the other parameters, Potassium is the only element that is present in a form that can be easily leached **(Polprasert)** The low potassium content in the compost (0.05–0.167%), compared to the recommended 1% for composts, may be attributed to its draining out in the form of leachate. Effective use of some fibrous material like straw or wood chips, which can absorb relatively large quantities of water and still maintain their structural integrity and porosity, could prevent the loss of potassium from the compost formed. Phosphorous in organic material was released by mineralization process involving micro organisms. The total phosphorus in the compost of each blends showed gradually lower values loss of total phosphorous was probably due to the mineralization of organic phosphorous and consumption by microbes. Table 5 list the % of elements in the blends. Compost application was generally perceived to be beneficial to the soil and crops because of improved soil structure, increased cation exchange and water holding capacity, and the addition of plant nutrients. **(Dick W et al, Kerner et al).**

Table 5 % of Nutrients and Elements in Blends.

Element	Zinc	Copper	Iron	Manganese	Potassium	Phosphorous
Blend 1	0.013	0.0019	0.1065	0.0054	0.122	0.0658
Blend 2	0.012	0.0017	0.1060	0.0050	0.130	0.0660
Blend 3	0.010	0.0017	0.1062	0.0054	0.106	0.0628
Blend 4	0.011	0.0019	0.1065	0.0059	0.110	0.0708
Blend 5	0.009	0.0017	0.1060	Nil	0.118	0.0608
Blend 6	0.010	0.0017	0.1062	0.0050	0.114	0. 080

3.8 Germination Studies

Finally in the study, the seed germination and root elongation of *Lycopersicon esculentum* (tomato) species were used to evaluate quality of compost. . After 5 days of incubation in the dark, the seed germination, root elongation, and germination index (GI),a factor of relative seed germination and relative root elongation) were determined as in table 8. A 5-mm

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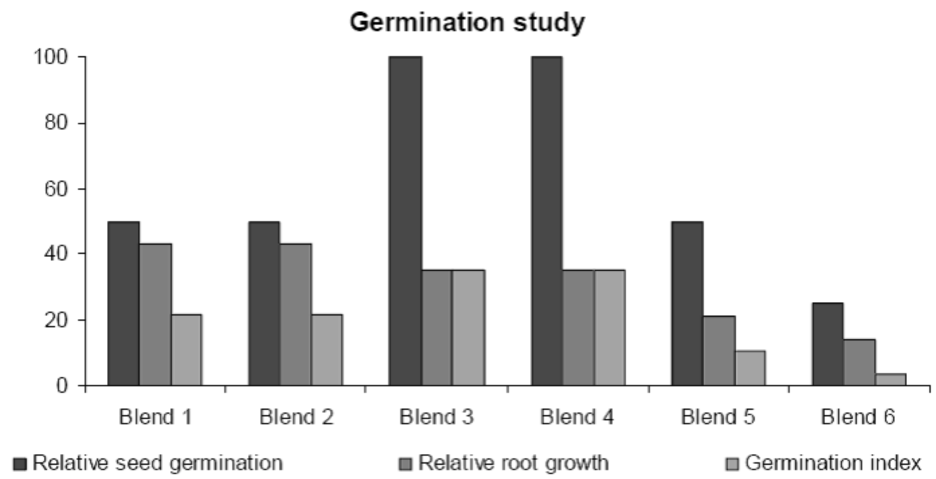
primary root was used as the operational definition of germination **(Tiqua et al)** The percentages of relative seed germination, relative root growth, and GI (figure 6) were calculated **(Tiqua et al)**

Table 6 Seed germination test conditions

1	Test type	static
2	Pre treatment	Soak in distilled water overnight
3	Temperature	22 ± 3°C
4	Light	None
5	Test vessel	10 x 100 mm Petri dish plus Whatman Number 1 paper
6	Number of seeds	10-30 per dish (depending on the size of seeds
7	Replicates	3
9	Test duration	5 days
10	End point	Germination, primary root 2 5 mm
11	Replicates	3

Relative seed germination (%) - number of seeds germinated in litter extract / number of seeds germinated in control x 100 (1)

Relative root growth (%) - Mean root length in litter extract / Mean, root length in control x 100 (2)



GI - (% Seed germination) x (Root growth) 100 (3)

Figure 6 Germination studies for Saw dust

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4. CONCLUSION

Performance of Lab -scale In-vessel composting for Bio degradable solid waste was valuated in this study. The results of the investigations enabled one to prove the usefulness of the In vessel composting method for utilizing bio degradable solid waste. Specific conclusions that can be drawn from this study include the following:

- The operational indices, moisture content, pH, temperature, and C/N ratio were useful in evaluating the composting performance. The levels of indices were relatively stable in the latter part of the composting period and remained constant.

- The final compost produced in this study was satisfactory for its agricultural application in terms of heavy metal contents.

- The test of sprouting proved that the mature compost had a better quality than garden soil that was used for comparison. The time of composting is shorter by at least twice than in classical technology, i.e. composting in piles.

- The Blend 4 and 5 had a C/N ratio around 20 with physical operational indices within specified range proved to be an ideal for agricultural application.

- As bulking agents, saw dust found to offer the best properties, with a high water absorption capacity of over, a neutral pH and a moderately C/N ratio and recycled. It could be introduced in residential areas and the compost used to fertilize plants

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