A Study on Recycling of Timber Waste and Fertilizer Production using Solar Powered Forced Air Supply

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Abstract
The maximum amount of air pollution was obtained in India from diesel engine vehicles operation and open burning of saw dust waste in saw mills. Indoor air pollution in a house or working place environment would produce health-related problems. The air pollution produced diseases in human beings were asthma, Lung cancer, and skin irritant. It affected particular age groups in more numbers. They were the age group of children and aged peoples. This study of saw dust recycling came under the Indoor air quality Engineering. This paper would give a chance to study indoor air pollution in deep and solve air pollution problems. The saw mills produced more amount of saw dust per year and dumped in open ground. In general, the saw dust was disposed of in the open ground firing method. The air pollution was increased by this type of activity done by the saw mill owners. Due to urbanization and population growth, the living people occupied nearby areas of saw mills would lead to health-related problems. The present study highly focused on the saw dust recycling process with forced air circulation driven by the solar-powered unit and reduction in composting time. The conversion of saw dust into a natural fertilizer (N-fertilizer) was highly possible and served as a natural gift to each farmer. This fertilizer was completely replaced the existing large scale usage of chemical fertilizer in the agricultural lands. This process was an eco-friendly, low cost, and high root absorption rate in agricultural cultivation. The continuous usage of natural fertilizer in a land practice would produce an increased yield up to 20-30% in all cultivation crops. The main benefit of natural fertilizer utilization would maintain the NPK in the soil for a long time.

Keywords: Future cultivation, N-Fertilizer, Open firing, Saw powder, Soil save, Timber waste, Yield rich and Zero pollution

Introduction

India and other developing countries faced many problems in the disposal of solid waste and its associate problems. India had large forest resources from the Himalaya forest to western guard. From the forest resources, the paint, paper, and furniture utilized in houses and offices were getting from it at a cheap rate and good in appearance (Judd H. Michael et al., 2004). The timber Industries already had advanced machinery in saw mill and wood processing Industries in the 21st century. The safety of working peoples in saw mill was ensured by the saw mill owner (Qutubuddin et al., 2013). The timber waste of saw dust was the end product produced by a saw mill. The saw dust waste produced in the saw mill in India was continuously increased by (10-20)% per annum. In general, the saw dust was disposed of through an open ground burning method. The air pollution increased in cities in India was an environmental health threat (Kan et al., 2009; Wong et al., 2008; McCarthy et al., 2007). Few cities in India, the air pollution standard, were below average (Pallav purohit et al., 2019; Pat-Mbano Edith 2012; Bhavin Soni, 2020). It is reflected in the local air pollution, which consists of particle sizes as $PM_{2.5}$ and PM_{10}. (Ogunbode et al., 2017; Okedere, 2017; Wardoyo, Morawska, Ristovski & Marsh, 2006; WHO report, 2016).

The air pollution impact on human health-related problems was seen in the form of skin diseases and heart problems(Gauderman et al., 2007; Jaishankar et al., 2015; Jomova et al., 2011; Valko et al., 2016; Wallenborn et al., 2009). The saw dust could be used in the following areas to obtain a better result.

1. Mushroom production
2. Food processing
3. Building product
4. Animal husbandry
5. Environmental protection

The weather report was released daily by the meteorological department Chennai by mentioned the place name and GPS location (Old Batalgundu longitude and latitude were 77°45' 33.8'E and 10°9' 49.3'N). It was elevated around 320m above sea level. This rural area had more number of agricultural lands with channel water cultivation. The rain water gained in this area was at a medium level. Due to urbanization in these areas, most of the coconut trees were cut down by local peoples for their survivals. The saw mill in this area was around ten in numbers. So far, no study was not done in this area about the recycling of saw dust into natural fertilizer (up to 2020) on forced air saw dust composting method.

The end product of saw dust was used in the energy sector in Indian and foreign countries for a long period (Sakthivel et al., 2017; Rominiyi OL et al., 2017). The vermi composting was one of the methods to convert the saw dust into fertilizer with the help of the earth warm and minimizing the environmental impact (Shankar Adhikari et al., 2018). The saw dust was converted into plywood by application of pressure and heat treatment. This is utilized in doors and furniture's for houses/office/industry (Jacob et al., 2016; N. Subramanian et al., 2019).

The aim of this study was done to analyze the conversion process and how the forced air circulation and turning process helped in reducing the composting time. The parameters taken for the analysis were temp, p^H, C: N ratio, and moisture during the composting process. The solar power generation used for pumping of water forced air circulation and air blower operation.

For this study, the aerobic method and anaerobic method of composting were implemented in two different pits. This method was a pure converting process of saw dust waste into natural fertilizer in a short period. In aerobic composting technique, the supply of oxygen was increased to increase the bacteria for quick decomposition (Lakshmi priya Thyagarajan et al., 2010). In the anaerobic composting technique, the decomposition was occurred by microbes without any oxygen supply from outside. In the aerobic method the decomposing would be completed with 30-35 days, which was highly suitable for diary firms. The conventional method of composting normally would take more composting time (4-6 months). The saw dust from a saw mill dust was dumped in one place was shown in the Figure 1.

Figure 1: The saw dust storage in a Saw mill

Methodology

Study Area description

The selected area for this study was Old Batagundu, which was an urban area located in Dindigul District. The average temperature available in this area was around 23°C. In this area, the ground nut husk, cow dung, rice straw, banana waste, Coconut waste, and saw dusts were easily available for this study.

Material and Methods

Materials

Saw dust, Cow dung, rice straw, banana tree waste, river sand, air blower, solar panel-power supply, and earth auger m/c.

Measuring Instruments Required

Long stem compost thermometer, moisture measuring instrument, p^H meter, and pressure gauge (air) for blower

Collection of Resource Material

The raw materials required for composting were sawed dust, cow dung, banana tree waste, and rice straw. The Saw dust purchased from a Saw mill (Rs. 5/- per kg) was collected nearby the Old Batalagundu urban area, which was the selected area of place for this study. The entire agricultural waste was collected from a nearby agricultural firm. The raw material was collected on a weight basis. The collected items in kilograms were 2000 kg cow dung, 1000 kg rice straw, 1000 kg banana tree waste, and 1000 kg saw dust. The river sand of weight 400 kg was collected from the river - "Manjalar." The water collected from the well and stored in a (2x1000) liter plastic tank installed nearby pits with a plastic hose of 10-15 meters in length (Rs.12/- per feet). The earth auger with moving attachments setup, air supply blower attachment, and a shed were established over the pits.

Method Used

There several types of composting techniques were available. The selection of the method was used for this study was the aerobic composting method (pit-2) and anaerobic composting method (pit-1). By using these methods, data were collected from the experimental setup made in pit-1 and pit-2. Based on these data analysis, the comparison was made to identify the pit which had the lowest time taken to complete the degradation process.

Temperature

The temperature maintained in each pit was very important for this study. If the temperature in the pits were below the minimum temperature, then the group of microorganism reduces their metabolic activities. The temperature around 55°C may be maintained for 15 days, and then the pathogen destruction was found in the composting system completely in these pits. A long stem compost temperature meter was used to measure temperature in a pit (pile).

Moisture

Moisture was essential for the microorganism living in a compost pit. The moisture maintained inside the pits were around in the range of (50-60)%, for the better decomposing process. If the moisture content were lower than 50% then, more water would be added to maintain the moisture inside the pits. The long stem moisture meter was used to measure the moisture in a pit. An oven was used to heat samples up to 100°C. The sample weight was taken before the drying process was Y1. The heating process is taken for 10 min. Then cool the sample for some time. The weight was taken after cooling was Y2. This procedure was repeated to get a constant value. The moisture calculation was done with the help of the following formula:

$$\%MC = [(Y1-Y2)/Y1] \times 100\%$$

where Y1 = weight of the sample before drying
Y2 = weight of the sample after drying

p^H

The p^H was one of the very important factors for a waste materials composting method. The microorganism's metabolic activity may be affected by low or high p^H value. For composting, the p^H range lies between 6 and 8. If the p^H value below 6, then the addition of lime is needed to increase its value. If the p^H value greater than 8, then the addition of Sulphur is needed to reduce the p^H value. A p^H meter with a long stem is used to measure the p^H value directly.

C/N Ratio

For best composting, the C: N ratio should within the range of 30:1 to 40:1. For this study, the C: N ratio taken would be 32:1 for pit-2 and 35:1 for pit-1. The C: N ratio was calculated either in a volumetric basis or weight basis. The composting method maintained a C: N ratio within its range. The starting and ending C/N ratios were noted for this analysis and further study in deep. The brown color materials contained more amount of carbon. They are tree leaves (35), saw dust (135), dry plant stem (76-78), and rice straw (80). The green color materials contained more amount of Nitrogen. They are Cow manure, green vegetable, and fruit waste. The addition of more carbon/nitrogen content would be done to maintain the C: N ratio within the limit. The following volumetric approach (parts) of composting was followed for a better result.

pit-2 = [135+35+80+90(cow dung)]/4 = 85;
[85+75(cow dung)]/5=32

pit-1 = [135+35+80+90(cow dung)]/4 = 85;
[85+90(cow dung)]/5 = 35

Special-Compost Turning Arrangement

The turning of compost was not done on the first day. After composting begun, the turning of compost would be done on alternate days. During the turning process, the water and feedstock were added if it is necessary. The main aim of this turning process would be given the moisture and air would spread uniformly in a pit. Also, it gave a cool environment inside the pit constantly to increase the microbial activity. The hand-operated earth auger with 12” bit (automatic SCEA-68E earth auger) was used for turning and agitation purposes.

Experimental Procedures

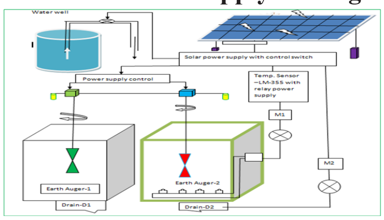
The required cow dung (2000 kg), banana tree waste (1000 kg), rice straw (1000 kg), and saw dust (1000 kg), and river sand (400 kg) were dumped near the pits. The (banana tree waste and rice straw) were cut into sizes of 1” for pit-2 and 3” for pit-1 with the help of a wood cutting machine. The two numbers of pits were created /dug in the same sizes of (7X3X3)m^3. Each pit was filled with cow dung; saw dust, banana tree waste, and rice straw were taken in the ratio of 3:1:.1:1 in different layers. The first layer of bed was formed with soft soil in (1/4)’feet height. The second layer was filled with cow dung at a height of (1/2)’feet. The third layer was filled with (3” banana waste + 3” straw waste) in the height of (1/2)’feet. The fourth layer was filled with (soft soil+ river sand) in the height of (1/4)’feet. The (1-4) layer was called as 1-set of filling of a pattern. It was repeated to layer (5-8) as a second set. The same procedure was extended if any of the items was reminded. The last layer was filled with soft soil (mud) as a cover. An additional plastic cover is used to avoid the penetration of rain water and sun radiation directly. A tin sheeted shed required to save the pit/pile turning arrangement setup for a long time. A bar arrangement was created to operate the earth auger horizontally with the help of a ball bearing rolling arrangement fitting. The bar fitting was made with G.I pipe bar (4” dia), common to both pit-1 and pit-2. The same type of filling procedure was carried out in the pit-2 also. The only difference was the pit-2 had a facility of forced air circulation with the help of solar-powered air blower with controlled temperature operation. The air circulation was supplied in the bottom side and side way. The pit-2 was treated in the Aerobic composing method with forced air circulation. The pit-1 was treated in Anaerobic composting without air circulation. The compost turning facility was given in pit-2 by an earth auger with a special arrangement. The earth auger could move vertically up to 3’ feet deep, turning of compost material. The turning of compost was done on alternate days. The water was sprayed from a 1000 liter capacity tank with a sprayer arrangement. The water sprayed one or two times to increase the moisture in the manure. The maximum of (8-10) times of turning would be carried out in pit-2. The increase of moisture would be very much helpful to multiply the micro organism in large numbers. The increased microbe leads to quick decompose of saw dust and cow dung mixture. Initially, the pit-1 was started with the aerobic condition (anaerobic method) and ended with the anaerobic condition. The pit-2 was started with the aerobic conditions and ended with aerobic conditions. All the parameters (temp, p^H, moisture, C:N ratio, No. of days) were noted at regular interval. If there was no odor and constant temperature are an indication of composting process completion. All the final parameters were noted at the end of the day (temp, p^H, moisture, C: N ratio, No. of days)

Result and Discussion

Data Observation and Analysis in pit-1 and pit-2

The arrangement was made in pit-1 was an anaerobic method of composting. The pit-2 was made with aerobic forced air circulation method. Both pits were of the same size and were treated with a different method of composting. The details of data collected for pit-1 and pit-2 were tabulated for comparison purposes. The experimental setup was shown in the figure 2.

Figure 2: The Composting Pit with Solar Powered Forced Air Supply Arrangement



The Following Results were Observed in pit-1

The initial temperature was noted 25°C (meter reading) before starting the process. The initial value displayed by moisture meter in the pit-1 was noted as 60%, and the C.N ratio was maintained in the pit/pile-1 was 35:1. The P^H meter shown the initial value as 6.2 was noted. The method of degradation in pit-1 was the anaerobic composting method. The particle size used here was 3" inch in length was maintained. The turning of compost would be done on alternate days. The (1) numbers of turning would be done in the whole composting process. The temperature, p^H, C: N ratio, and moisture readings were recorded in the intermediate periods. The final parameter values of temperature, p^H, C:N ration, and moisture were noted to end the process. They are (26°C, 7.9, 22:1 C:N ratio and 28% moisture) content. The odor of pit-1 and constant temperature readings indicated completion of composting process in that pile. Finally, the compost would be obtained after 45 days in pit-1. The conventional method with a few turning of compost would give a reduced period by ten days was observed.

The Following Results were Observed in pit-2

The initial temperature was noted 26°C (meter reading) before starting the process. The initial value displayed by the moisture meter in the pit-2 was noted as 50%, and the C.N ratio maintained in the pile-1 was 32:1. The p^H meter shown the initial value as 6.5 was noted. The method of degradation in pit-2 was the Aerobic composting method. The particle size used here was 1" inch in length was maintained. The turning of compost would be done on alternate days. The (8-10) number of the turning of composting would be done in the whole composting process. The temperature, p^H, C: N ratio, and moisture readings were recorded in the intermediate period. The final parameter values of temperature, p^H, C: N ration, and moisture were noted to end the process. They are (28°C, 7.8, 21:1 C: N ratio, and 25% moisture content. The odors of pit-2 and constant temperature readings indicated the completion of composting process in that pile. Finally, the compost would be obtained after 32 days in pit-2. The more turning of the pile would give better results and reduced the composting period by half was observed.

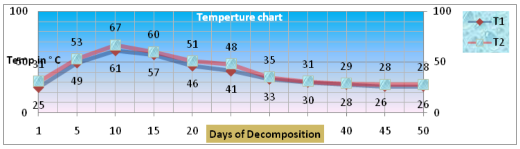
The collected data's in pit-1 and pit-2 were analyzed by the comparison method. From this experimental study, a conclusion was made that pit-2 had a lower composting period than pit-1. The time taken for the aerobic forced air circulation composting method was only 32 days and the time taken for anaerobic composting was 47 days was observed. The size of the particle was taken (banana tree waste and rice straw) was reduced in length by 1" inch would lead to very short decomposing time as compared with 3" in length was observed. Further, it was proved that forced air circulation and more turning of composting thoroughly would lead to reduce in composting time. The monitored parameters values in the composting method were temperature, moisture, p^H, and C: N ratio, in pit-1 and pit-2, were tabulated in Table 1.

Table 1: List of parameters monitored during composting

Parameter Tested	Method used in pit-1	Method used in pit-2
Type of method used in pit-1	-	Anaerobic method used
Type of method used in pit-2	Aerobic method used	-
Starting Temperature of pit	25° C	26° C
Ending temperature in pit	26° C	28° C
Ending Max temperature in pit	61° C	67° C
Initial Moisture	60%	50%
Final Moisture	28%	25%
Initial p^H value	6.2	6.5
Final p^H value	7.9	7.8
Initial C:N ratio	35:1	32:1
Final C:N ratio	22:1	21:1
No. of days completed pit-1	1-day	47 days
No. of days completed pit-2	1-day	32 days

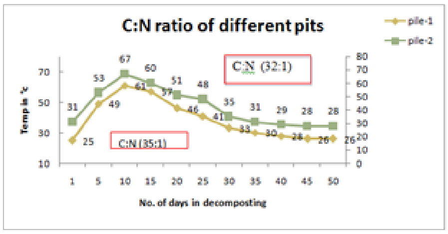
The temperature values obtained in different days of composting were noted and displayed in a graph 1.

Graph 1: Temperature Curve Drawn for pit-1 and pit-2 in Different Days



The benefit of the C: N ratio in pit-1(high) and pit-2(low) were observed and displayed in the graph 2.

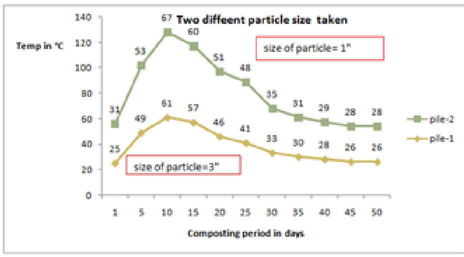
Graph 2: C:N Ratio Effects on Composting C:N



Particle Size Effects on Composting

The 3" particle size was used in compost pit-1, and 1" particle size was used in pit-2 during the composting process were noted. The maximum temperature would be obtained by the pit-2 as compared with pit-1. Their effect of particle size on composting would be shown in graph 3.

Graph 3: Particle Size Effect on Composting



The earth auger used in the composting process for turning purposes was shown in the figure 3

Figure 3: Earth Auger with 8-inch bit Attachment

Conclusion

It was observed that the Saw mill produced saw dust per year was increased and produced a solid waste disposal problem. By the composting method, these were completely convert into (100%) natural fertilizer by controlling the compost parameters such as P^H, temperature, moisture, forced air circulation and C:N ratio. If the C:N ratio not in the range of (30:1 to 40:1) then, the composting period would be taken more time to complete the conversion process. Early-stage of agitation and turning of compost above (8-12) times would leads to better result. The study observed that, the final compost product would be obtained within (32) days in forced air supply method (-aerobic method) and (47) days in conventional method with few turns of compost (anaerobic method). It was a complete replacement for chemical fertilizers used in an agricultural land. By using the natural fertilizer in a field, the cultivation was not affected by insects and diseases (50%-60%) and a increased cultivation production up to (20-30)%. This natural fertilizer would suitable for all types of lands. All soil nutrients were saved in the land for long time. The study concluded that the saw dust natural fertilizer was produced within 32 days by using forced air circulation arrangements. It was applicable to all types of lands and cultivation crops. Further, the air pollution is completely reduced because there was no open ground burning of saw dust and banana waste. Also, the study observed that motivation required among the farmers in utilization of this saw dust natural fertilizer was less focused in numbers should be increased in near future. To obtain a great goal, each farmer should motivate more and more by the Government agencies in India. Future expansion of this method would be applied to a Diary firm for the conversion of cow dung into natural fertilizer production for further study.

Recommendations

In general, Rice straw, banana tree waste, and saw dust were burned in open ground. This type of activity is seen in more states of India. Every year, some cities are more affected by air pollution in a particular seasonal period (January and March). In year January 2020, Delhi city was more affected by rice/wheat straw burning in open ground from

Punjab and U.P. state after cultivation was over. So, the Central Government/State Government agencies motivate the farmers to avoid the open burning of agricultural waste in the near future and adopt the quick composting methods. This leads to the amount of air pollution in local area will be reduced and human health will be improved. The Natural fertilizer usage gives a chance to recharge the soil again and again. Also, it reduces the air pollution in certain percentage in India.

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