iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VIII **Month of publication:** August 2019

DOI: http://doi.org/10.22214/ijraset.2019.8089

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VIII, Aug 2019- Available at www.ijraset.com

Accelerated Biocomposting: For Ecological Agriculture Good Practices and Biodynamic Livelihoods Prosperity in terms of Climate Smart Extension Education by Odisha Livelihoods Mission

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I. INTRODUCTION

A chemical fertilizer is a substance applied to soils or directly onto plants to provide nutrients optimal for their growth and development. The essential nutrients contained in these fertilizers are nitrogen, phosphorous, and potassium (NPK), as well as other nutritional substances in smaller amounts—all presented in a form that can easily be absorbed and metabolized by plants. Chemical fertilizers have become a staple in many yards and gardens, and can be a key component of a healthy lawn care routine. One of the biggest advantages of synthetic fertilizer is that it will provide immediate nourishment, particularly when compared with its organic counterparts, which release nutrients much more slowly. This makes it the most effective solution for plants that are struggling and in need of immediate help. And because they've been specifically formulated, you have access to the specific nutritional content of these types of fertilizers, allowing you to better gauge what you are feeding your plants.

Many of these types of fertilizers are highly acidic, which in turn often increases the acidity of the soil, thereby reducing beneficial organisms and stunting plant growth. By upsetting this natural ecosystem, long-term use of synthetic fertilizer can eventually lead to a chemical imbalance in the recipient plants. Chemical fertilizer must also be applied in moderation, as too much can easily "burn" the plants and sometimes even kill them. From a green standpoint, they contribute to groundwater pollution when they accompany natural runoff from your yard or garden, and the process of manufacturing them releases greenhouse gases and other pollutants into the environment as well.

On the other hand , organic fertilizers are quite reliable as they donot have any environmental impacts. The only disadvantage being they take time to work. Moreover , their production takes time. If we can use a method , which can be economical and also produce organic fertilizers comparatively faster , it can be used in daily household and also environment can be protected.

Composting is nature's way of recycling. Composting biodegrades organic waste. i.e. food waste, manure, leaves, grass trimmings, paper, wood, feathers, crop residue etc., and turns it into a valuable organic fertilizer.

Composting is a natural biological process, carried out under controlled aerobic conditions (requires oxygen). In this process, various microorganisms, including bacteria and fungi, break down organic matter into simpler substances. The effectiveness of the composting process is dependent upon the environmental conditions present within the composting system i.e. oxygen, temperature, moisture, material disturbance, organic matter and the size and activity of microbial populations. Composting is not a mysterious or complicated process. Natural recycling (composting) occurs on a continuous basis in the natural environment. Organic matter is metabolized by microorganisms and consumed by invertebrates. The resulting nutrients are returned to the soil to support plant growth.

Composting is relatively simple to manage and can be carried out on a wide range of scales in almost any indoor or outdoor environment and in almost any geographic location. It has the potential to manage most of the organic material in the waste stream including restaurant waste, leaves and yard wastes, farm waste, animal manure, animal carcasses, paper products, sewage sludge, wood etc. and can be easily incorporated into any waste management plan. Since approximately 45 - 55% of the waste stream is organic matter, composting can play a significant role in diverting waste from landfills thereby conserving landfill space and reducing the production of leachate and methane gas. In addition, an effective composting program can produce a high quality soil amendment with a variety of end uses.

The essential elements required by the composting microorganisms are carbon, nitrogen, oxygen and moisture. If any of these elements are lacking, or if they are not provided in the proper proportion, the microorganisms will not flourish and will not provide adequate heat. A composting process that operates at optimum performance will convert organic matter into stable compost that is odour and pathogen free, and a poor breeding substrate for flies and other insects. In addition, it will significantly reduce the volume and weight of organic waste as the composting process converts much of the biodegradable component to gaseous carbon dioxide.

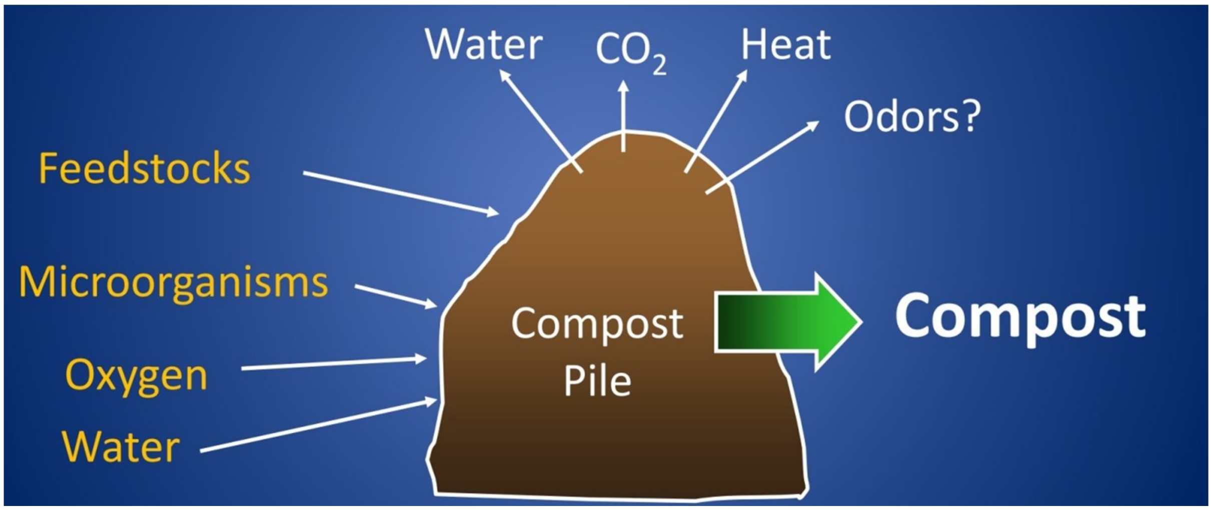

FIG:-1 , Composting Process

Microbes consume feed stocks to obtain energy and nutrients. Their activity creates heat which is released and is ultimately trapped which further accelerates the composting process.

A. The Needs Of Composting Organisms Are Same As That Of Living Organisms

1) Food
2) Water
3) Nutrients
4) Oxygen
5) Hospitable Environment
a) Temperature
b) pH(Neutral Conditions)

Composting as a recognized practice dates to at least the early Roman Empire, and was mentioned as early as Cato the Elder's 160 BCE piece De AgriCultura. Traditionally, composting involved piling organic materials until the next planting season, at which time the materials would have decayed enough to be ready for use in the soil. The advantage of this method is that little working time or effort is required from the composter and it fits in naturally with agricultural practices in temperate climates. Disadvantages (from the modern perspective) are that space is used for a whole year, some nutrients might be leached due to exposure to rainfall, and disease-producing organisms and insects may not be adequately controlled.

Composting was somewhat modernized beginning in the 1920s in Europe as a tool for organic farming. The first industrial station for the transformation of urban organic materials into compost was set up in Wels, Austria in the year 1921. Early frequent citations for propounding composting within farming are for the German-speaking world Rudolf Steiner, founder of a farming method called biodynamics, and Annie Francé-Harrar, who was appointed on behalf of the government in Mexicoand supported the country 1950–1958 to set up a large humus organization in the fight against erosion and soil degradation.

Composting is a natural biological process, carried out under controlled aerobic conditions (requires oxygen). In this process, various microorganisms, including bacteria and fungi, break down organic matter into simpler substances. The effectiveness of the composting process is dependent upon the environmental conditions present within the composting system i.e. oxygen, temperature, moisture, material disturbance, organic matter and the size and activity of microbial populations. Composting is not a mysterious or complicated process. Natural recycling (composting) occurs on a continuous basis in the natural environment. Organic matter is metabolized by microorganisms and consumed by invertebrates. The resulting nutrients are returned to the soil to support plant growth.

There is a huge difference between a backyard humanure composter and a municipal composter. Municipal composters handle large batches of organic materials all at once, while backyard composters continuously produce a small amount of organic material every day. Municipal composters, therefore, are batch composters, while backyard composters tend to be continuous composters. When organic material is composted in a batch, four stages of the composting process are apparent. Although the same phases occur during continuous composting, they are not as apparent as they are in a batch, and, in fact, they may be occurring concurrently rather than sequentially.

The four phases include: 1) the mesophilic phase; 2) the thermophilic phase; 3) the cooling phase; and 4) the curing phase.

Compost bacteria combine carbon with oxygen to produce carbon dioxide and energy. Some of the energy is used by the microorganisms for reproduction and growth, the rest is given off as heat. When a pile of organic refuse begins to undergo the composting process, mesophilic bacteria proliferate, raising the temperature of the composting mass up to 44C (111F). This is the first stage of the composting process. These mesophilic bacteria can include E. coli and other bacteria from the human intestinal tract, but these soon become increasingly inhibited by the temperature, as the thermophilic bacteria take over in the transition range of 44C-52C (111F-125.6F).

This begins the second stage of the process, when thermophilic microorganisms are very active and produce a lot of heat. This stage can then continue up to about 70C (158F), although such high temperatures are neither common nor desirable in backyard compost. This heating stage takes place rather quickly and may last only a few days, weeks, or months. It tends to remain localized in the upper portion of a backyard compost bin where the fresh material is being added, whereas in batch compost, the entire composting mass may be thermophilic all at once.

After the thermophilic heating period, the humanure will appear to have been digested, but the coarser organic material will not. This is when the third stage of composting, the cooling phase, takes place. During this phase, the microorganisms that were chased away by the thermophiles migrate back into the compost and get back to work digesting the more resistant organic materials. Fungi and macroorganisms such as earthworms and sowbugs that break the coarser elements down into humus also move back in.

After the thermophilic stage has been completed, only the readily available nutrients in the organic material have been digested. Theres still a lot of food in the pile, and a lot of work to be done by the creatures in the compost. It takes many months to break down some of the more resistant organic material in compost such as lignin which comes from wood materials. Like humans, trees have evolved with a skin that is resistant to bacterial attack, and in a compost pile those lignins resist breakdown by thermophiles. However, other organisms, such as fungi, can break down lignin, given enough time; since they dont like the heat of thermophilic compost, they simply wait for things to cool down before beginning their job.

The final stage of the composting process is called the curing, aging, or maturing stage, and it is a long and important one. Commercial composting professionals often want to make their compost as quickly as possible, usually sacrificing the composts curing time. One municipal compost operator remarked that if he could shorten his compost time to four months, he could make three batches of compost a year instead of only the two he was then making, thereby increasing his output by 50%.

Municipal composters see truckloads of compost coming in to their facilities daily, and they want to make sure they dont get inundated with organic material waiting to be composted.

Therefore, they feel a need to move their material through the composting process as quickly as possible to make room for the new stuff coming in. Household compostersdont have that problem, although there seem to be plenty of backyard composters who are obsessed with making compost as quickly as possible. However, the curing, aging, or maturing of the compost is a critically important stage of the compost-making process. And, as in wine-making, an important element to figure into the equation is patience.

A long curing period (e.g., a year after the thermophilic stage) adds a safety net for pathogen destruction. Many human pathogens only have a limited period of viability in the soil, and the longer they are subjected to the microbiological competition of the compost pile, the more likely they will die a swift death.

Immature compost can be harmful to plants. Uncured compost can produce phytotoxins (substances toxic to plants), can rob the soil of oxygen and nitrogen, and can contain high levels of organic acids. So relax, sit back, put your feet up, and let your compost reach full maturity before you even think about using it.

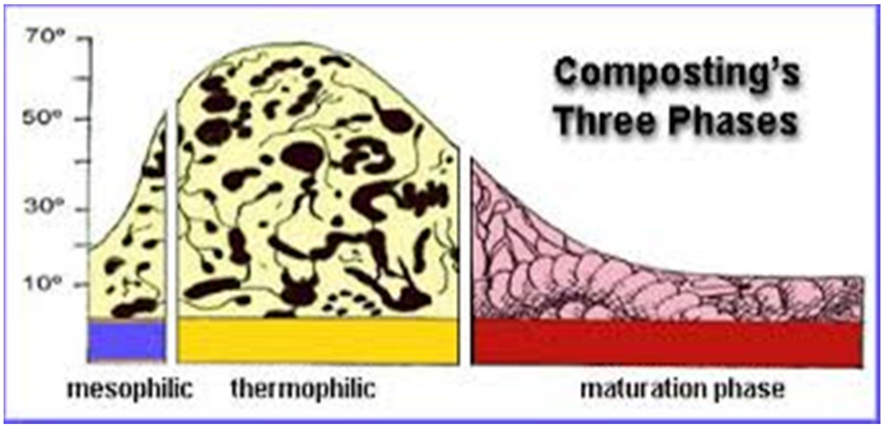

FIG: 2 Phases of Composting

B. There Are Four Types Of Microbes That Are Involved In This Process

1) *Bacteria:* Bacteria are a type of biological cell. They constitute a large domain of prokaryotic microorganisms. Typically a few micrometres in length, bacteria have a number of shapes, ranging from spheres to rods and spirals. Bacteria were among the first life forms to appear on Earth, and are present in most of its habitats. Bacteria inhabit soil, water, acidic hot springs, radioactive waste, and the deep portions of Earth's crust. Bacteria also live in symbiotic and parasitic relationships with plants and animals. Most bacteria have not been characterized, and only about half of the bacterial phyla have species that can be grown in the laboratory. Bacteria are the dominant population of microorganism during all stages of the composting process and are particularly active in the breaking down of the easily degraded organic material. Bacteria require carbon (Browns) and nitrogen (Greens), using carbon as a source of protein and nitrogen as their main source of energy.

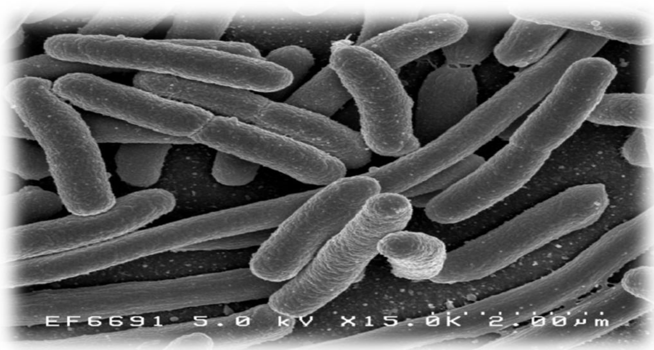

FIG:-3, Rod Shaped Bacteria or Bacillus

Some of the more common compost bacteria include:

a) There are cold-hardy bacteria, known as psychrophiles, which keep working even when temperatures dip below freezing.
b) Mesophiles thrive at warmer temperatures between 70°F. and 90°F. (21 to 32 C.). These bacteria are known as the aerobic powerhouses and do the majority of the work in decomposition.
c) Thermophiles take over after 100°F(37°C). They raise the temperature high enough in the pile to kill weed seeds that may be present.

2) *Fungi:* A fungus (plural: fungi or funguses) is any member of the group of eukaryotic organisms that includes microorganisms such as yeasts and molds, as well as the more familiar mushrooms. These organisms are classified as a kingdom, Fungi, which is separate from the other eukaryotic life kingdoms of plants and animals. Fungi also form threadlike filaments know as hyphae, which spread through the compost heap or bin. Fungi play an essential role, as they are able to breakdown the more resistant organic material e.g. cellulose and lignin. Fungal hyphae aid the aeration and drainage of the compost pile by physically aggregating into small particles. There are between 10,000 -1,000,000, fungal cells per gram of compost. Many fungal hyphae are relatively easily seen by the naked eye being larger than those of actinomycetes Most fungi cannot survive thermophilic stage of hot composting as they do not grow above 50°C and although there are some heat tolerant thermophilic fungi, indeed some start to grow at 60°C e.g. Chaetomium thermophile, some Humicola species Thermoascusaurantiacus and have a role in decomposing cellolose and hemicelloloses. Aspergillus fumigatus can also be active at these temperatures and will continue to function when the compost is reoccupied by mesophilic organisms.

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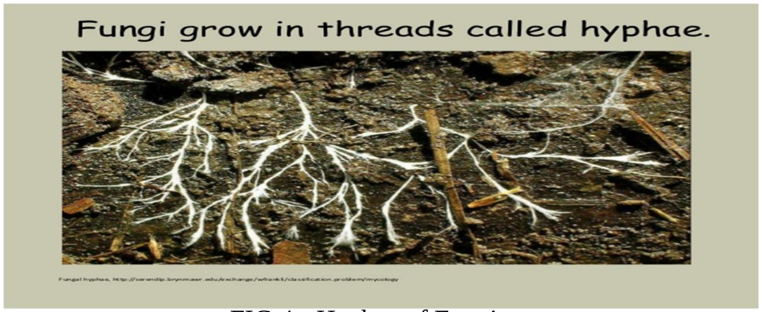

FIG 4:- Hyphae of Fungi

3) *Annelids AS Earthworm:* Composting with worms (a.k.a. vermicomposting) is the proverbial win-win situation. It gives you a convenient way to dispose of organic waste, such as vegetable peelings. It saves space in the county landfill, which is good for the environment. It gives worms a happy home and all the free "eats" that they could want. For those that have gardens or even potted plants, home grown compost is a great way to feed and nurture plants.Vermiculture, which some advocates have dubbed "the organic garbage disposal," recycles food waste into a rich, dark, good-for-your-garden soil conditioner. Thus earthworms , red worms , white worms can be used to decompose vegetable peels to organic manure but they take time.
4) *Actinomycetes:* The Actinomycetes are actually bacteria but in most publications are discussed separately as they play a major role in the decomposition the less easily degraded than that favoured by other bacteria. Actinomycetes can also tolerate dryer conditions than other bacteria and produce a chemical (geosmin) responsible for the typical musty, earthy smell of compost. They are normally found in compost 5-7 days after the start of the process. The Mesophilic actinomycetes operate best in medium temperature areas (20º–50ºC) of the compost normally the edges of the heap or bin and at the end of the process. Thermophilic Actinomyces grow at between 30º–60°C. The optimum temperature for thermophilic fungi is 40–50°C which is also the optimum temperature for lignin degradation in compost. **X** Like fungi, Actinomycetes form threads, filaments, or strands, which spread throughout a compost heap or soil. After bacteria, Actinomycetes are the second most abundant microorganism in the compost heap. There are typically 100,000 -100 million in a gram of compost. They do not respond well to acidic conditions (below pH 5.5) or in the presence of a high moisture conditions.

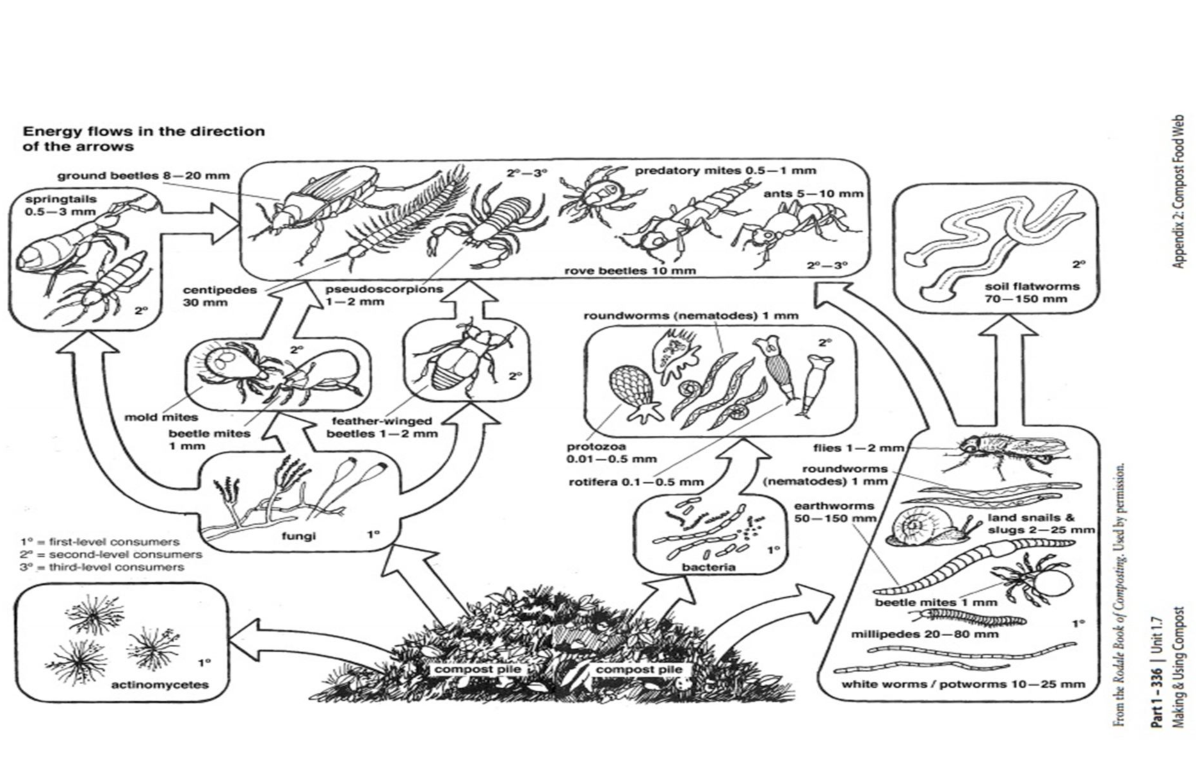

FIG:-5, Compost Food Web

Mesophilic bacteria break down soluble, readily degradable compounds (sugars and starches). Thermophilic bacteria break down proteins, fats; work with actinomycetes to begin breaking down cellulose and hemicelluloses. Actinomycetes and fungi are important during curing phase in attacking most resistant compounds.

C. The Above Diagram Shows The Compost Food Web

1) *Initial Feedstock Mix:* The microorganisms living in our compost and doing the work of decomposition to create soil need a proper balance of carbon, nitrogen, air and water to function optimally. The microorganisms consume carbon for energy, nitrogen for protein for cell structure and water facilitates the biological metabolic functions that allow them to consume food and reproduce. If there is too much carbon, decomposition slows down as available nitrogen gets used up and the microorganism population drops. Some of the organisms use stored nitrogen to form new cell material burning more carbon in the process. In the soil, using organic matter with excess carbon can create problems. To complete the nitrogen cycle and continue decomposition, the microbial cells will draw any available soil nitrogen in the proper proportion to make use of available carbon. This is known as "robbing" the soil of nitrogen, and delays availability of nitrogen as a fertilizer for growing plants until some later season when it is no longer being used in the life-cycles of soil bacteria. When there is not enough carbon needed to fuel the conversion of nitrogen into protein, organisms make full use of what carbon they can get and lose excess nitrogen as ammonia. The release of ammonia into the atmosphere means it's not being stored in the soil and can't be used later by plants. Loss of nitrogen should be kept to minimum if we want to use this compost to feed our gardens. For the purposes of our hot compost system the suggested chemical ratio is 25 to 30 parts carbon to 1 part nitrogen. In real-world terms, this should be about a 2 to 1 ratio of browns to greens added to the compost bin. Organic waste designated for the compost can be separated into two distinct categories based on the elemental properties they bring to the compost. Carbon-rich organic waste materials like newspaper, dead leaves and egg shells are ref Organic vegetable waste, grass clippings and other material high in nitrogen are referred to as "greens". Together with proper aeration and moisture, browns and greens in the right ratios create a well-balanced environment to speed up decomposition and transform organic waste into nutrient-rich soil humus.
2) *Pile Moisture:* It is Required by microbes for life processes, heating and cooling, place to live.

a) Optimum is 45-60% moisture
b) > 65% means pore spaces filled
c) – anaerobic conditions
d) < 40% fungus dominates
e) – difficult to re-wet
f) < 35% dust problems

Adequate amount of water should be given in the beginning.

3) *Pile Aeration:* Aeration supplies oxygen

a) Ambient air is 21% oxygen
b) Consumption increases with temperature
c) Compost organisms can survive 5% oxygen
d) Below 10% oxygen in pile, bacteria can start switching to anaerobic respiration
e) Produces hydrogen sulfide (rotten egg smell)

Maintaining adequate oxygen will reduce odour complaints. Turning increases aeration process. Turning speeds up the decomposition process. As moisture goes up , aeration decreases.

4) *Pile shape and Size:* As decomposition occurs on surface, smaller particles occupy larger surface area than larger particles. Bulk density is the measure of mass(weight) per unit volume. Porosity is the non solid content of the compost. Free air space is the portion of pore space not occupied by liquid. Higher bulk density means lower Porosity and lower Free air space. Starting Porosity and Free air space should be above 50%. refeerred to as "browns".
5) *Pile Temperature:* The suitable temperature for growth of bacteria is around 35-38°C and that of fungi is 28-30°C while annelids like earthworms can grow at normal temperature (17-20°C). Higher Temperature result in faster breakdown and most harmful pathogens are also killed at high temperature. There are different temperature ranges for different phases and different types of bacteria which has already been discussed earlier.

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6) *Compost Retention Time.*

Under normal conditions:-

a) *Mesophilic:* – a few days to 2 weeks
b) *Thermophilic:* – 3 weeks to several months
c) *Curing and Maturation:* – 1 to several months – eliminates inhibitors to seed germination and crop growth

Once the compost turns dark colour , smells earthy , is about 1\2 – 1\3 of its original volume, is less than 10°C , compost is done.

7) *Pile pH:* pH indicates the acidic or basic nature. The most suitable pH range for composting is 6.5-8 as microbes breed and grow the best under neutral conditions.

Table:-1 Necessary Conditions Of Composting

Parameter	OK	Ideal
Moisture	40-65%	45-60%
C:N ratio	20-40:1	25-35:1
Oxygen	>5%	>10%
Temperature	27-47 C	54-60 C
Bulk density	1000 lbs/yc	1000 lbs/yd
pH	5.5-9.0	6.5-8.0

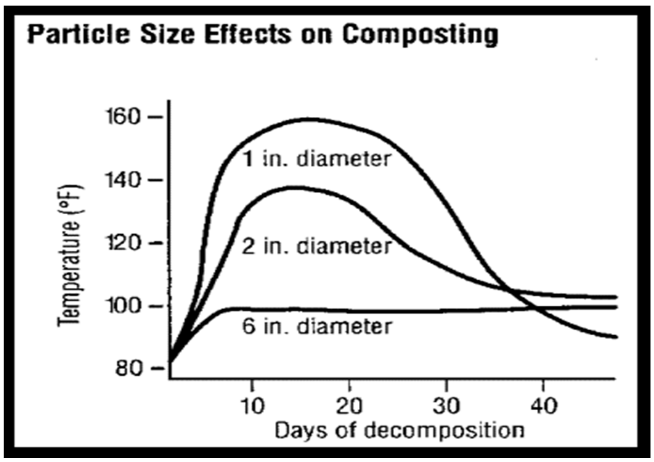


Fig:-6, Particle Size Effect On Composting

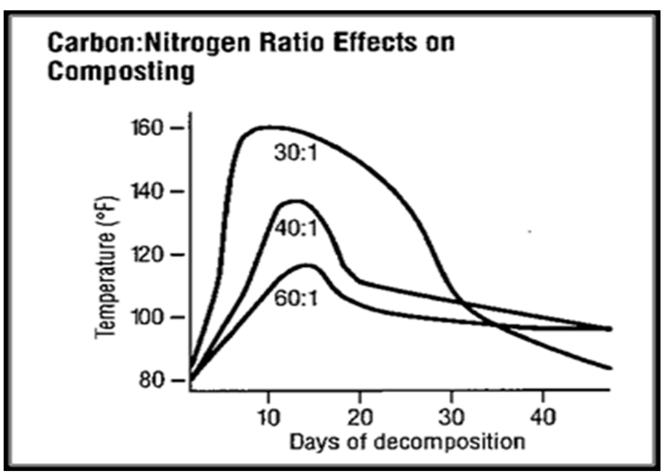
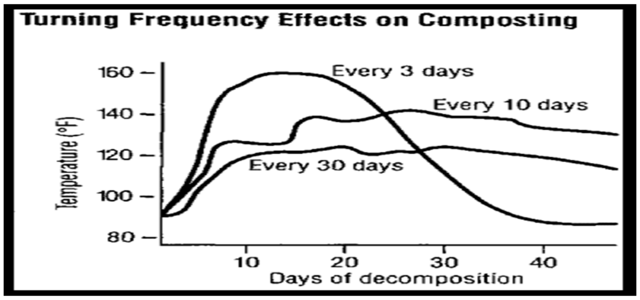


FIG:-7 , C:N Ratio Effect on Composting



Since Composting under normal conditions takes a lot of time , from days to months, to accelerate it , it needs to be performed under certain controlled conditions. If these conditions are maintained properly , then compost formation may happen within a short interval of time.

For the rapid conversion of organic waste to manure ,ie bio composting under commercial scale, certain methods need to be followed :-

a) *Windrowing:* The waste materials should be chopped in small size and formed in windows of 3 meters width and 1.2 meters height, the length according to the availability of the land:
b) *Inoculation:* Mixed population of microorganisms are sprinkled over the windrows at the rate of 4kg/tone of waste materials. In case of liquid 2 litres/tone is enough as the population of fungus and bacteria is 100 times more than solid base inoculum.
c) *Aero Tilling:* The windrow is aero tilled in alternative days by using special type of machine called "Aero tiller" or manual method. It helps for uniform mixing and provides oxygen to the microorganisms.
d) *Application of Spent Wash:* To maintain the optimum moisture of 50-60% and to maintain temperature between 65-700c for high rate composting, the nutrient rich spent wash is sprayed on the windrows, ifit is available. Otherwise, any wash like cow dung wash, vermiwash, kitchen wash, any animal wash etc. can be sprayed.

In household or under controlled conditions at household , the methods to be followed are :-

a) *Chopping:* The waste materials should be chopped in small size , so that they occupy larger surface area and can be decomposed faster.
b) *Inoculation:* Mixed population of microorganisms should be given in right quantity and right sequence.
c) *Turning:* Turning at regular intervals must be done for proper aeration.
d) *Temperature Control:* The appropriate temperature that is needed for growth of micro-organisms should be mainained for effective growth and working of microbes.
e) *Application of Spent Wash:* Any wash like cowdung wash , vermi wash should be added for aggravating the process.

II. SELECTION OF MICROBIAL COMPOSITION:-

There are 5 experimental setups for microbial composition selection.

1) *1st Setup:* 2 different containers are to be taken and in one container bacteria consortium is sprayed and in another container fungi consortium is sprayed . Time taken for both to decompose under similar wastes and similar microbial content at respective temperature is found out. The one consuming lesser time is considered.
2) *2nd Setup:* 2 different containers are to be taken and in one container bacteria consortium is sprayed and in another container earthworm is sprayed . Time taken for both to decompose under similar wastes and similar microbial content at respective temperature is found out. The one consuming lesser time is considered.
3) *3rd Setup:* 2 different containers are to be taken and in one container earthworm is sprayed and in another container fungi consortium is sprayed . Time taken for both to decompose under similar wastes and similar microbial content at respective temperature is found out. The one consuming lesser time is considered.
4) *4th Setup:* 3 different containers are to be taken , in one container earthworm is sprayed and in another container fungi consortium is sprayed and in another container bacteria consortium is sprayed. Time taken for both to decompose under similar wastes and similar microbial content at respective temperature is found out. The one consuming lesser time is considered.
5) *5th Setup:* Only 1 container is taken and at first , bacteria consortium is added, the appropriate temperature is maintained and after few days of decomposition , fungi consortium is added which is also maintained at respective temperature. After certain days again , earthworm and other annelids are added which can decompose organic waste though at a slower rate but can decompose at normal temperature.

Out of these 5 setups , the best setup , on basis of experiment is found to be the 5th one , which uses al three bacteria , fungi , earthworm one after another , consumes least time. So this can be selected for further implementation.

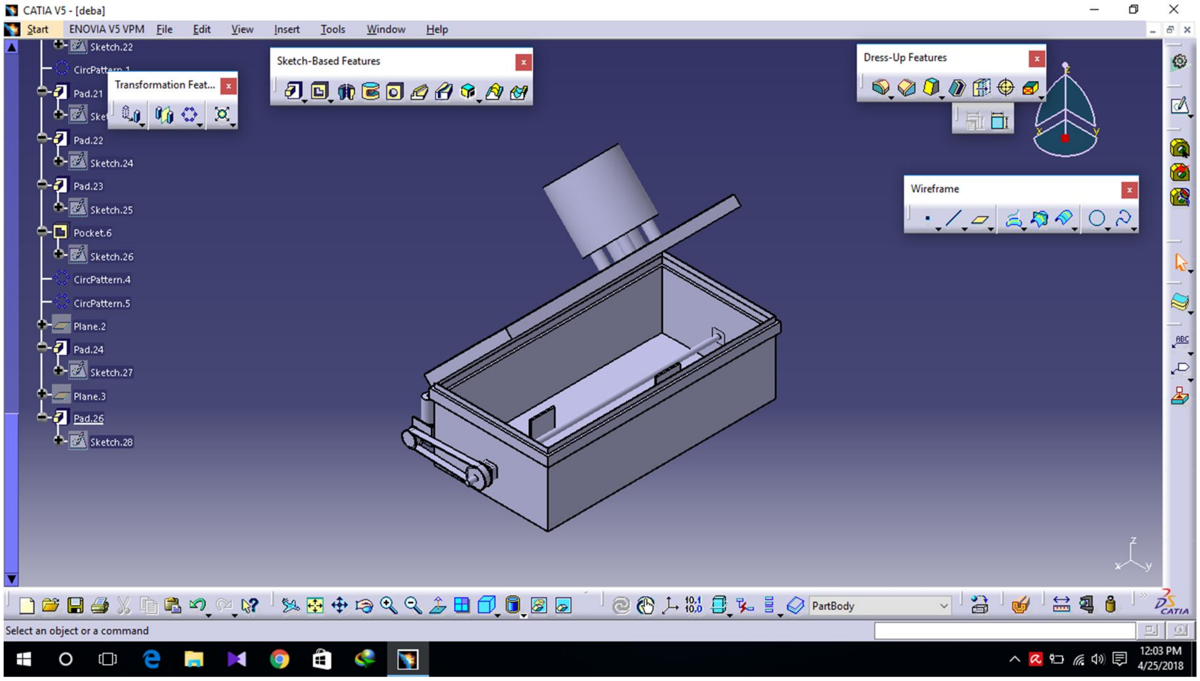


FIG :- 9.1 , CATIA MODEL

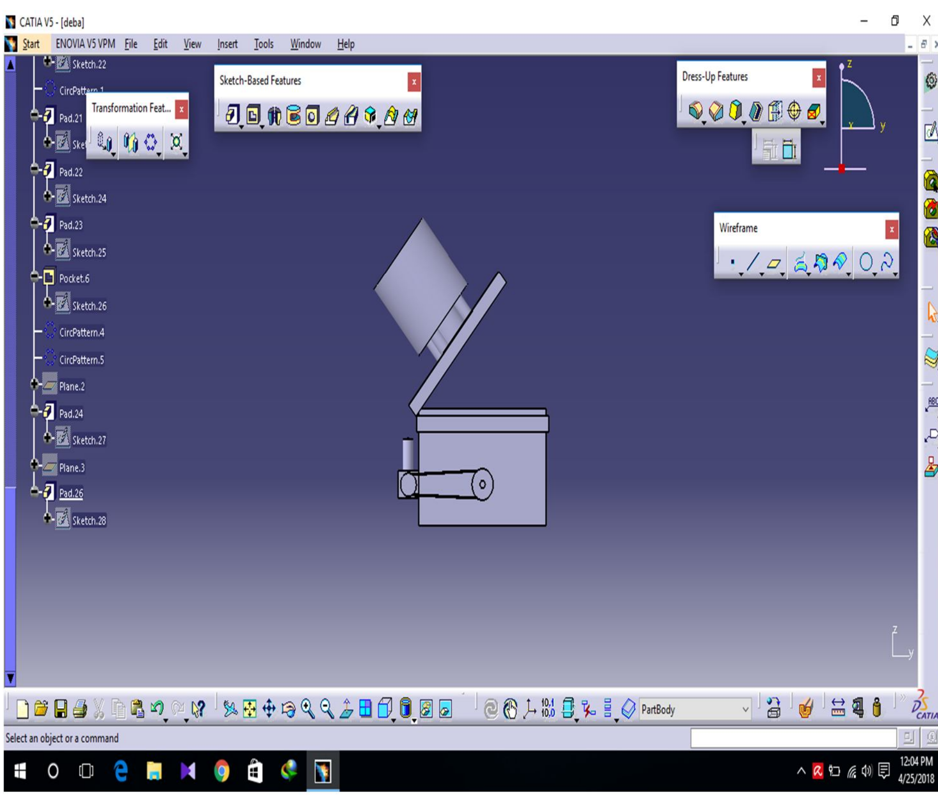


FIG:- 9.2 , Catia Mode

l FIG:-10 , THE Actual Setup OF Composting

As it is evident from the above image , the actual setup consists of 2 chambers . One chamber is for chopping the organic waste and other chamber is for actual composting process to take place.

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The Components are :-

a) Chopper: It consists of a blade and is electrically connected to a 220V AC motor , which rotates it. It rotates at high rpm and chops off all the wastes to small pieces which can be easily decomposed by microorganisms later on. This chamber has holes drilled inside it which transfers the chopped wastes into the combustion chamber.

FIG 11, Chopper Setup

FIG :-12 , Chopper Blade

b) Composting Chamber: It is the place where actual composting takes place. It consists of 2 heaters which supply heat to the chamber. It is surrounded by thermocole on its walls , to provide the insulating effect so that much heat is not lost to the environment. It also contains an arduino and sensor for temperature control. It consists of a shaft attached to blades to act as turner for aeration which is rotated by means of 12V DC motor, connected by chain sprocket mechanism.

FIG:- 13 , Composting Chamber

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ARDUINO

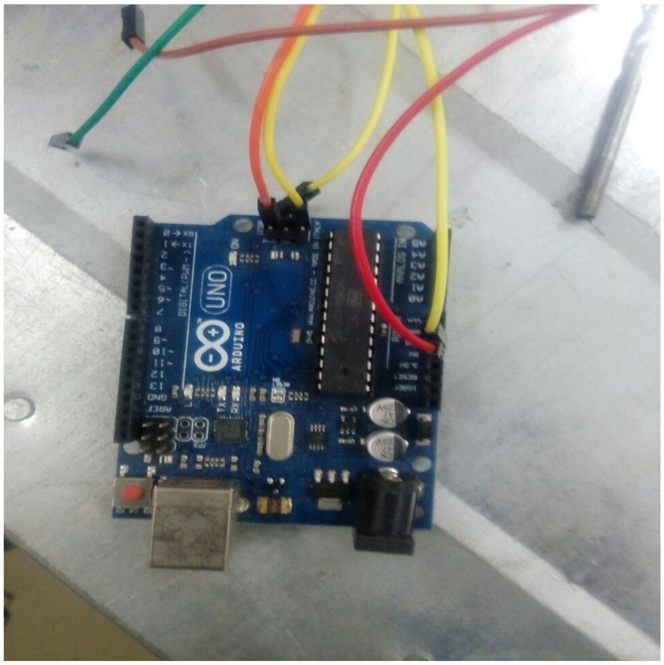

FIG :-14, Arduino Circuit

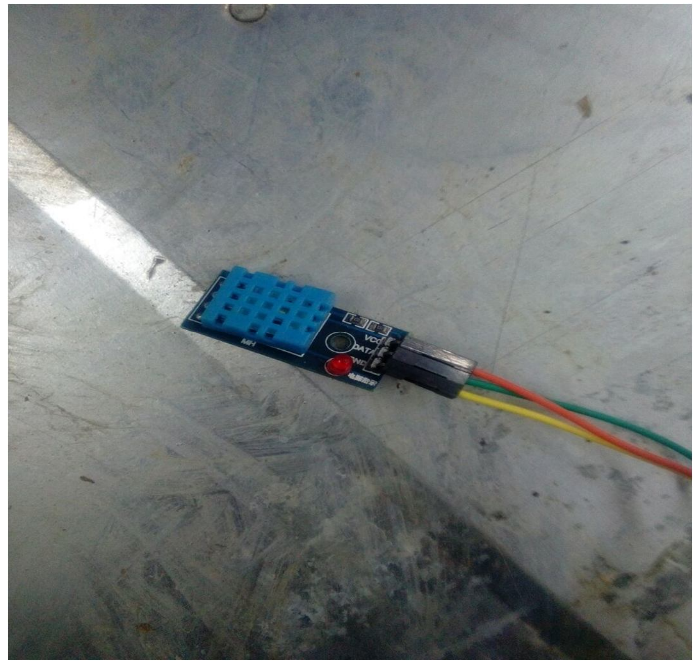

FIG:-15 , Temperature Sensor

c) *Arduino:* Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. Here the arduino circuit maintains the temperature which is required for thegrowth of microbes. Heat is provided. When a temperature of 37°C is reached for bacillus consortium , the arduino detects it with help of temperature sensor and conveys it to relay circuit which switches off the heater. Thus a constant temperature can be maintained.

d) *Temperature Sensor:* A temperature sensor is exactly what it sounds like – a sensor used to measure ambient temperature. This particular sensor has three pins – a positive, a ground, and a signal. This is a linear temperature sensor. A change in temperature of one degree centigrade is equal to a change of 10 millivolts at the sensor output. The Temperature Sensor LM35 series are precision integrated-circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature.

The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾C over a full −55°C to 150°C temperature range.

e) *Relay Circuit:* Relays are electromechanical devices that use an electromagnet to operate a pair of movable contacts from an open position to a closed position. The advantage of relays is that it takes a relatively small amount of power to operate the relay coil, but the relay itself can be used to control motors, heaters, lamps or AC circuits which themselves can draw a lot more electrical power. The electro-mechanical relay is an output device (actuator) which come in a whole host of shapes, sizes and designs, and have many uses and applications in electronic circuits. But while electrical relays can be used to allow low power electronic or computer type circuits to switch relatively high currents or voltages both “ON” or “OFF”, some form of relay switch circuit is required to control it.

Arduino programming:

```
#include<dht.h>
dht DHT;
// if you require to change the pin number, Edit the pin with your arduino pin.
#define DHT11_PIN 3
```

```
void setup() {
pinMode(9,OUTPUT);
pinMode(3,INPUT);
Serial.begin(9600);
void loop() {
intchk = DHT.read11(DHT11_PIN);
Serial.println(" Humidity " );
Serial.println(DHT.humidity, 1);
Serial.println(" Temparature ");
Serial.println(DHT.temperature, 1);
delay(1000);
if(DHT.temperature>=37){
digitalWrite(9,1);  }
if (DHT.temperature<=37){
digitalWrite(9,0);}}
```

f) Bacterias Employed: Bacterial Consortium of *Bacillus Subtilis* and *Bacillus Cereus* and other unindentified bacillus species of bacteria.

Bacillus subtilis are rod-shaped bacteria that are Gram-positive (Perez 2000). The cell wall is a rigid structure outside the cell. It is composed of peptidoglycan, which is a polymer of sugars and amino acids. The peptidoglycan that is found in bacteria is known as murein. Other constituents that extend from the murein are teichoic acids, lipoteichoic acids, and proteins. The cell wall forms the barrier between the environment and the bacterial cell. It is also responsible for maintaining the shape of the cell and withstanding the cell's high internal turgor pressure Bacillus subtilis bacteria have been considered strictly aerobic, meaning that they require oxygen to grow and they cannot undergo fermentation. However, recent studies show that they can indeed grow in anaerobic conditions making them facultative aerobes. The main habitat of endospore forming Bacillus organisms is the soil. Likewise Bacillus subtilis is most commonly found in soil environments and on plant undergrowth. These mesophilic microbes have historically been considered strict aerobes. Thus they are likely to be found in O and A surface soil horizons where the concentration of oxygen is most abundant and temperatures are relatively mild. Consider how this organism functions in s competitive microbial community: when carbon-, nitrogen- and phosphorus-nutrient levels fall below the bacterium's optimal threshold, it produces spores. Scientists have demonstrated that Bacillus subtilis concurrently produces antibiotics and spores. Bacillus subtilis bacteria are non-pathogenic. They can contaminate food, however, they seldom result in food poisoning. The most optimal activity occurs at a temperature of 37 degrees Celsius and a basic pH of 8.

g) Fungi Employed: Fungi consortium of *Aspergillus Fumigatus* and *ApergillusTerreus*

Aspergillus fumigatus is a filamentous fungus that can be found worldwide. It is considered an airborne saprophytic fungi. Because of this, it naturally lives in the soil and is a common mould found among compost and plant surfaces. Here it plays a key role in recycling the carbon and nitrogen from deceased organisms. Aspergillus fumigatus is found predominately in the soil. It is a saprophytic fungi that breaks down carbon and nitrogen from deceased hosts and plays a key role in compost piles..*A. fumigatus* is a fast grower; the colony size can reach 4 ± 1 cm within a week when grown on at 25°C. It is an extremophile that can survive high temperature and survive at pH of 3.7-7.8.

The entire setup was made by assembling the parts. The components have already been discussed before. As all the bacteria grow actively in soil. Soil is utmost necessary for composting process. So, at first clay soil was filled on the surface of the composting chamber. Organic wastes were brought , chopped in the chopper to increase the surface area , so that they can be easily decomposed and were moved into the composting chamber. Vegetable peels are good source of nitrogen. Since microorganisms need both carbon and nitrogen content for their survival , newspaper scrap was also added which are good source of carbon. A requisite carbon : nitrogen of around 20:1 is to be maintained which means 2:1 by weight ratio of carbon wastes(browns) to nitrogen wastes(greens).

Water was added. Initial moisture content should be around 50% of the total wastes and clay soil. Water was added accordingly as moisture is necessary for proper survival of micro-organisms. Now the entire pile was mixed manually and also by the mechanical turner , which is rotated by means of a motor. This is necessary for proper aeration. The mixture is turned at regular intervals for aeration.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VIII, Aug 2019- Available at www.ijraset.com

After this, at first bacteria consortium is added as liquid culture whih contains thousands of bacteria of bacillus ieBacillus Subtilis and Bacillus Cereus. Heat is given by heaters and requisite temperature (37° C) is maintained by the arduino circuit and the temperature sensor. After few days , when mesophilic stage ends , fungi consortium is added containing Aspergillus Fumigatus and Apergillus Terreus, and then again the requisite temperature is maintained. Turning for aeration is regularly done. The compost pile is observed on a regular basis. Thus after few days , organic fertilizer can be found to be formed.

FIG:-16 , Manure Produced

Table: 2, Bill of Material

Component	Quantity	Material
Chopper Chamber	1	Plastic
Composting Chamber	1	GI Sheet
Shaft	1	Mild Steel
Chopper Blade	1	High Carbon Steel
Bearing	2	Stainless Steel
Scoop	2	GI Sheet
Heater	2	
AC Motor	1	
DC Motor	1	
Chain	1	Cast Iron
Sprocket and Hub	2	Cast Iron
Nut and Bolt	18	Carbon Steel

Table: 3, Specification

Component	Capacity	Dimension
Chopper Chamber		28.5 cm
Composting Chamber		36*22*18 inch
Shaft		16 mm
Chopper Blade		25 cm
Bearing		16 mm-inner dia
Heater	25 W	
AC Motor	220 V	
DC Motor	12 V	

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Table 4:- COST ANALYSIS TABLE

Heater	50	100
AC Motor	400	400
Blade	480	480
Alpha Clamp and Adhesive	100	100
Nut and Bolts		280
Drill Bit		120
Bearing	550	1100
Shaft	240	240
Scoop	50	100
DC Motor	500	500
Arduino and Sensor		1200
Chopper Chamber	150	150
Thermocole	100	100
Chain , Sprocket and Hub		260
Miscellaneous		400
Electric Wire		50
Eliminator	250	250
Total Price		**7130**

III. EXPERIMENTAL RESULTS3DAY-5

Fig: 17

Fig:-17.1 Day-1

Fig:-17.2 Day-3

A. Advantages

1) It is economical as the total cost of the project is very less.
2) Since it is performed under controlled conditions , with all process variables and input under control , compost or manure is produced within a very short duration which otherwise takes much time.
3) It is ecofriendly and pollution free as it produces organic fertilizers which don't have any negative impact on the environment.
4) It can be done easily in household from vegetable wastes.

B. Disadvantage

1) Some fungi may be pathogenic in nature and can cause diseases so should be handled with care.
2) Preparing bacteria and fungi consortium culture may not be possible under norml household conditions.
3) This if not done under proper controlled conditions may take time from days to months .
4) It consumes electrical energy , which if not switched to any other renewable source may indirectly cause problem.
5) Mishandling of electrical connections and heater may cause problem.
6) It may not always be possible to maintain the constant temperature.

IV. FUTURE SCOPE

A. If instead of electrical connections , solar power can be used , by installing a solar panel and obtaining energy from it , costs can be further reduced and indirectly environmental pollution effects too.

B. If facultative microbes are used , they can peform under both aerobic and anaerobic conditions , thus the heat loss can be reduced by closing the vents , maintaining constant temperature and reducing heater input.

C. The composting chamber , if can be divided into more than one chamber , then different microbes can act at different time , and wastes can be added at different time , they can flow from one chamber to another , thus efficiency can be increased.

D. pH sensor can be introduced to control pH at various stages according to the need of microbes.

V. CONCLUSION

A. It's a technology for the present and the future because it's environment-friendly, reduces pollution, can be achieved within a very less time,has a low production cost, increases efficiency and is highly customizable and modifiable.

B. In this project, we successfully demonstrated the conversion of organic wastes to manure by microbial action without the use of any chemical within very less time which can be used as organic fertilizer for supplementing plants within affordable price range.

C. Certain modifications can be made and thus organic fertilizer can be obtained in even lesser time and lower cost like solar power for running the motors.

D. With the ever increasing pressure on 5 elements of nature- Fire, Water, Air, Earth and Ether, it is highly the need of the hour to think and work towards developing environment friendly projects.

VI. CONTEXT

Odisha Livelihoods Mission (OLM) has entered into a MoU with Foundation for Ecological Security (FES) for strengthening Natural Resource Management and livelihoods through use of tools and technologies for restoring the commons by strengthening village institutions.

The objective of the MoU is to improve the livelihoods portfolio of the rural poor by efficient and effective village level planning process through combined and complementary actions of both OLM and FES.

Specific objectives of the partnership include securing and restoring commons, improving water governance for livelihood enhancement, creation of livelihood assets using CLART, improving reach of social security schemes and investment planning for improved NRM based livelihoods

1) In order to ensure the same, FES will provide the following as per the MOU;

a) Build Capacities of the OLM empanelled trainers on Crop Water Budgeting and CLART through a double cascading model. The training will highlight the importance of systems approach in livelihoods (inter-linkages of commons, water resources and farming systems). It will also develop understanding on conservation of resources, informed and improved use of water through use of tools and technology.

b) Tools (software and applications) for Crop Water Budgeting and Composite Landscape Assessment and Restoration Tool (CLART) and provide training for the field functionaries of Odisha Livelihoods Mission such as Krushi Mitras and the progressive farmers for using the tool. FES will prepare a training manual in local language.

2) This handbook is compiled for Master Trainers and will be finalised after gathering feedback. The handbook will help in -

a) Highlighting the importance of systems approach in livelihoods (inter-linkages of commons, water resources, and farming systems)

b) Conservation of resources, informed and improved use of water through use of tools and technology