COMPARATIVE STUDY OF COPOSTING & VERMICOMPOSTING

Submitted in partial fulfilment of the requirements

for the degree of

Bachelor of Engineering

by

Sayed Sarfaraz (13CE45)

Khan Asifali (14CE21)

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Under the guidance of

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New Panvel, Navi Mumbai-410206

2018

A Project Report on

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CERTIFICATE

This is to certify that the project entitled **"**Comparative study on Composting and Vermicomposting**"** is a bonafide work of Sayed Sarfaraz Parvez (13CE45), Khan AsifAli Azam (14CE21), Patel Shahid Salim (15DCE69), Pathan Manjur Nasir (11CE37) submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of "Bachelor of Engineering" in "Department of Civil Engineering"

Prof. Dhaval Shah

(Guide)

Dr. R. B. Magar	**Dr. Abdul RazakHonnutagi**
(Head of Department)	(Director, AIKTC)

PROJECT REPORT APPROVAL FOR B.E.

This project report entitled **"Comparative Study of Composting and Vermicomposting"** by Sayed Sarfaraz Parvez (13CE45),Khan Asifali Azam (14CE21),Patel Shahid Salim (15DCE69),Pathan Manjur Nasir (11CE37)is approved for the degree of "Bachelor of Engineering" in "Department of Civil Engineering".

Examiners

1. …………………………
2. …………………………

Supervisors:

1. …………………………
2. …………………………

Chairman (Director):

…………………………

DECLARATION

We declare that this written submission represents my ideas in our own words and where others ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that ,we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

The aim of this work was to study the effect of the traditional thermophillic composting thatcommonly adopted for treatment of organic wastes or for production of organic/natural fertilizersthat is introduced to a related technique, called vermicomposting (using earthworms to breakdown the organic wastes). These two techniques have their inherent advantages and disadvantages. The integrated approach suggested in this study borrows pertinent attributes from each of these two processes and combines them to enhance the overall process and improve the products qualities. Two approaches investigated in this study are: pre-composting followed byvermicomposting.Eisenia fetida(red wigglers) species of earthworms used in the vermicomposting processes. The results indicate that, a system thatcombines the two processes not only shortens stabilization time, but also improves the productsquality. Combining the two systems resulted in a product that was more stable and consistent(homogenous), had less potential impact on the environment and for compost. Vermicompostingsystem, the product met the pathogen reduction requirements.

Keywords—Thermophillic, Mesophillic, Vermicompost; Eisenia fetida.

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ABBREVIATION NOTATION AND NOMENCLATURE

COM	Composting
VER	Vermicomposting

Chapter 1

Introduction

1. 1.1 Introduction

Composting is an accelerated biooxidation of organic matter passing through a thermophilic stage where microorganisms (mainly bacteria, fungi and actinomycetes) liberate heat, carbon dioxide and water. The heterogeneous organic material is transformed into a homogeneous and stabilized humus like product through turning or aeration.

Vermicomposting is also a bio-oxidation and stabilization process of organic material that, in contrast to composting, involves the joint action of earthworms and microorganisms and does not involve a thermophilic stage. The earthworms are the agents of turning, fragmentation and aeration.

Application of composting and vermicomposting has often been unsuccessful due to the mythology that these are "natural processes" and need little management. Successful composting and vermicomposting require adequate processing systems and control criteria. Moreover, research in vermicomposting is not developed to the same level as for composting;

it is necessary to know and understand the whole process better in order to make it more efficient.

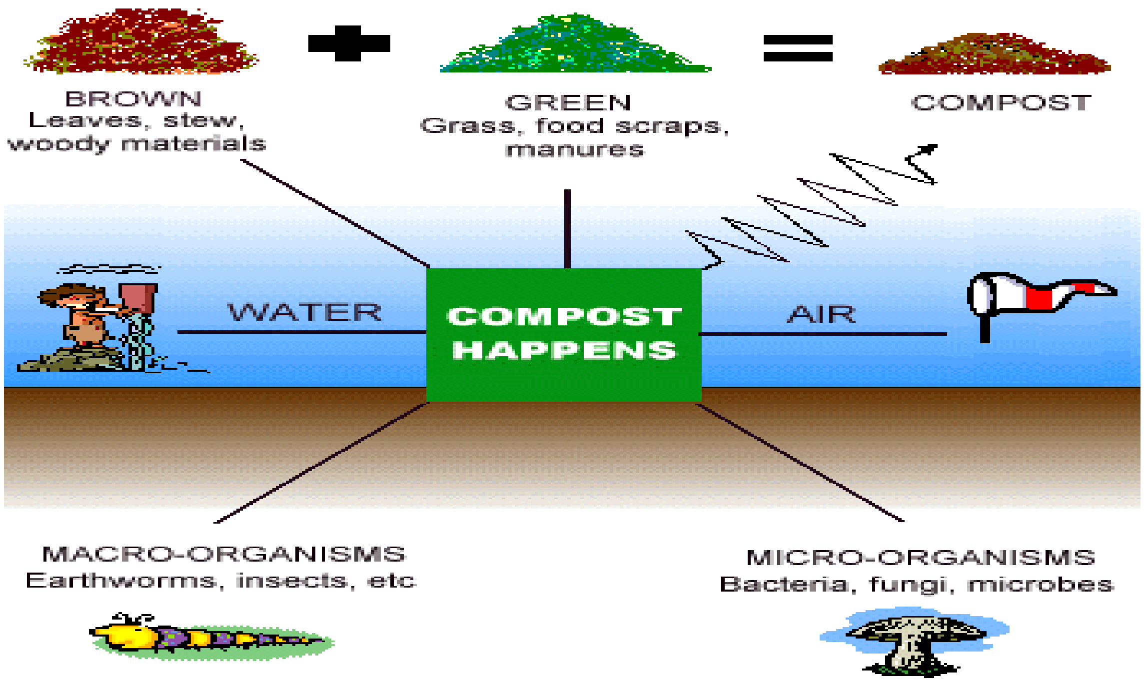

Fig 1.1 Introduction to composting

Anything that is alive or once was alive is “organic.” All plants and animals, anything made from plants or animals, and any wastes generated by plants and animals are organic.

Organic products are an important part of the economy and of everyone’s life. Some of the common organic materials that are used and dis-posed of daily include food, paper products like tissues, and yard waste Organic materials account for much of what is consumed and thrown away every day. Paper products alone make up over 19% of human waste. In total, organics make up 52% of the waste stream.

2. 1.1.2Background

Composting is the most efficient type of recycling. Unlike recycling plastics and other materials,composting does not involve chemicals, huge amounts of energy, or transportation to bringmaterials to recycling plants and then back to product shelves. In fact, if the average personcomposted all their food and garden waste, they would prevent 5kg of methane from beingreleased into the atmosphere every year.Therefore, composting our food waste can be a large part of the solutionto global climate change.

Composting organic matter continues the natural life cycle of organic matter by returning nutrients into the Earth's soil to grow healthy plants and trees. There are even economic benefitsto composting; compost can be used as a natural fertilizer and thus eliminating the need to buyfertilizers, pesticides, and water for one's garden.[5] Additionally, because less matter will need tobe transported to the landfills, collection and landfill costs will be reduced. At the end of theday, composting is ultimately a smarter way to dispose of unwanted food. Next, we will explorehow composting works and how you can be a part of the process.

Vermicomposting uses earthworms todecompose food and is another great way tocreatecompost from food scraps. EitherRed Wigglers or Red Earthworms can beused todecompose food into compost. Abenefit of vermicomposting is that the bincan more easily be placed indoors and caneven be placed in the kitchen or cafeteriaand closer to where food is prepared andeaten. The worms need to be placed in acontainer with a bed of "browns" or yardwaste, and then food scraps can be added.Worms prefer temperatures around 55 to 70 degrees Fahrenheit, which is just aroundroom temperature. But be careful: don't put them outside during winter – they will die.

Worms are able to decompose meat scraps, but adding meat to your compost will attract rodentsand pests, so consider this carefully. As with a regular compost pile, it is important to make surethere are enough carbon materials to prevent bad odors. The worms do the decomposing for you,and after a few weeks you will have fresh, rich compost. The best part of home-grown compostis that it will actually have more nutrients for your soil than traditionally cultured compost

3. Aim of the project

- Aim of the composting is to create an environment where an even decomposition of the constituent materials is achieved with a minimal loss of nutrients and the stimulation of host of beneficial soil organisms.
- The analysis of compost to carry out the comparative study of composting and vermicomposting of organic waste.

4. Objective of the project

- Promote composting as a treatment practice for organic waste.
- Promote the use of compost in agriculture as a fertilizer / substrate / soil broker of organic origin and contribute to a sustainable environmental management.
- Analyze and optimize the composting process in order to improve the quality and quantity of the compound produced
- To understand that our activities on the land affects the quality of the soil.
- Development of terrace garden / planation.

Chapter 2

Literature Review

5. 2.1 General

The organic matter is found to be higher due to the use of fresh and unprocessed vegetables and unprocessed vegetables and has a high moisture contents.

Villar & Alves (2016):-Taken together the structure of microbial community and enzymatic activities provide important info. for monitoring the Composting process and on the stability and maturity of compost. Low enzymatic activity is not indicative of stabilization has observed by the high microbial community. Although waste types subjected to the same composting process, the level of stability and maturity was different and this represented as important factor for designing, processsing and controlling the composting process acccording to waste type.

Arancon & Edward (2006):- Interaction between micro-organism can produce significant quantities of plant growth hormones and humic acids which act as a regulators. Experiment where design to evaluate the effect of humic acid extracted from vermicompost and compare them with the action of commercial humic acid in commbination with a commercial plant growth hormones indole acetic acid.

G. Tripathi *, P. Bhardwajplants (2003):- The conversion of a negative waste into beneficial materials is an important aspect of resource recycling and environmental cleaning. In this regard recycling of utilizable organic wastes is feasible. The recycling of wastes through vermicomposting reduces problems of disposal of agricultural wastes. Vermicomposting is used not only as an alternate source of organic fertilizers but also to provide economical animal feed protein for the fish and poultry industries worldwide Vermiculture has been receiving considerable attention in recent years internationally for its potential role in organic farming and sustainable development . Species identified as potentially useful to break down organic wastes were Eisenia fetida, Dendrobaena veneta and Lumbricus rubellus from temperate areas and Eudrilus eugeniae and Perionyx excavatus from the tropics .

Wei (2017):-Biodegradable material, primarily composed of food waste, accounts for 40–70 wt% of municipal solid waste (MSW) in developing countries. Therefore, to establish a sustainable waste management system, it is essential to separate and recycle biodegradable organic material from the municipal waste stream. Of all the recycling methods, composting is recommended due to its environmental and economic benefits. However, compared with readily recyclable materials (e.g., paper, metals, etc.), recycling/composting biodegradable MSW presents a great challenge to furthering the promotion of waste recycling. The source separated collection and recycling of MSW are crucial processes for establishing sustainable waste management strategies. Composting which has clear benefits from both ecological and economic perspective. By this more high quality raw material will become available, which is pre-requisite for producing high quality compost product.

Tognetti & Hernadez (2005):-The use of the organic fraction of municipal solid waste for agricultural purposes is becoming an established practice worldwide, because it reduces the volume of land filled waste and provides a valuable agronomic resource Composting and vermicomposting are both recommended widely as biological processes for transforming organic wastes into useful soil amendments. Although both are biooxidative processes that stabilize organic matter, there are important differences between them. Composting includes a thermophilic phase (45 to 65°C), during which labile organic matter degradation occurs and pathogens are effectively reduced. Vermicomposting does not involve a thermophilic phase (temperatures above 35°C kill earthworms) and the coupled activities of earthworms and microorganisms stabilize the organic matter .Compost had higher nutrient content then Vermicompost. Vermicompost seems more suitable than Compost has growing media constituent. Comparing the two products derived from same original material, the vermicompost which complied with a thermophilic phase to reduce pathogens, has a better performance than the traditional compost.

Riffaldi,Levi-Minzi,Pera (1986):- Has studied the content of organic matter represents perhaps the most reliable index of soil fertility and productivity. Usually, organic matter levels decline when soils are put under cultivation. Improved aeration, resulting from ploughing and other tillage techniques, may lead to increased microbial activity and consequent loss of organic matter. Under continuous cropping the decrease may progress for many years before a new lower equilibrium level is ultimately attained. Recently, interest has increased in land application of organic wastes, both as a means of recovering organic matter for soils and of reducing disposal costs in comparison with other procedures. However, raw organic materials are phytotoxic and should not be applied to the soil until they have undergone a stabilization process, which may be achieved through a microbial aerobic process (composting) .

Atiyeh et al (2000):- Vermicomposts, which are produced by the fragmentation of organic wastes by earthworms, have a fine particulate structure and contain nutrients in forms that are readily available for plant uptake. vermicomposts should have a great potential in the horticultural and agricultural industries as media for plant growth When the chemical properties of vermicomposts and composts were compared (Table 1), we found that there was a tendency for the vermicomposts to have a slightly lower pH, lower concentrations of ammonium-nitrogen, and higher concentrations of nitrate-nitrogen than many of the composts. However, overall, there was a considerable overlap between both the nutrient content and the form of nutrients in vermicomposts and composts, making it hard to predict the potential plant growth responses to these materials based solely on the results of such chemical analyses. The end product, commonly termed vermicompost and obtained as the organic wastes pass through the earthworm gut, is quite different from the parent waste material. Vermicompost are finally divided into peat like material like high porosity, aeration, drainage, and water holding capacity. They have vast surface area, providing strong absorbability and retention of nutrients. Vermicomposting contains nutrients in form that are readily taken up by plants such as nitrates, exchangeable phosphorous, and soluble potassium

James H. Lenhart (2008):-Compost is used as a soil amendment to promote soil tilth, moisture retention, gasexchange, and as a nutrient source. Applications of compost as an amendment for a growth medium in stormwater applications such as green roofs, swales or infiltration facilities adds new challenges. Properties such as nutrient content, soil moisture holding capacity, metals uptake capacity, shrink/swell, product maturity, pathogen and weed seed content require a high level of scrutiny to insure the appropriate amendments are being

used. There are many feedstock sources of compost and methods of composting which yield very different end products. Feed stock such as mixed yard debris, manure, fallen deciduous leaves offer substantial differences in nutrient content, presence of residual chemicals such as pesticides and herbicides, woody material and relative percent differences in cellulose or lignistic materials. Methods of processing also have a significant impact on the quality of the

compost such as maturity, content of foreign materials, and biological contaminants such

as pathogens, weed seed viability. This paper provides an overview of what designers should be looking for and considering for both design and construction specifications.

Clifford R. Lange and Noemí Méndez-Sánchez (2010):- Biological and abiotic sorptions as well as kinetic experiments were performed to elucidate the mechanism by which color was

being removed from paper mill effluents using anaerobic composting. Experiments were performed using pulp mill upset tank wastewater and E stage filtrate .Color removal experiments using active and gamma sterilized compost showed that the color removal capacity for both wastewaters was nine times higher when using active compost than for those reactors using gamma sterilized compost. Final decolorization for pulp mill upset tank and E stage filtrate was 91 and 83%, respectively, while only 33% decolorization was achieved with gamma sterilized compost. Kinetic tests also showed higher color degradation rates when using active compost compared to sterilized compost. Additional experiments demonstrated that biological color removal appears to be robust with respect to pH and is largely unaffected by pH over a range from pH 5 to 10, typical values for the effluents in paper mills. The effect of aging in sorption were tested and results showed that virgin compost could establish a microbial population in less than 50 days which resulted in a compost with sorption capacity similar to the aged compost.

James I Chang,J.J. Tsai, K.H. Wu (2006):-A laboratory reactor was designed to study the effects of operating parameters (air suction rate, seeding and agitation) on thecomposting process of a synthetic food waste made of dog food. Experimental results showed that the synthetic food waste could be composted within 4 days and the final compost passed the maturity tests. In most cases except those with 32% of seeding, the process involved two major stages of composting. The two peak temperatures between 50 and 60 (occurred at 8–12th hour and 50–65th hour, respectively). Operating parameters that converted the most volatile solids and carbons in the feedstock were as follows: 1.6 l air/kg dry solid-min of air suction rate, 32% of seeding and 50% of agitation time.

S. Suthar, S. Singh (2007):- The composting potential of two epigeic earthworms (P. excavatus and P. sansibaricus) was studied in 2002 to breakdown the domestic waste under laboratory conditions. The experimental container with P. sansibaricus showed maximum mineralization and decomposition rate than that of P. excavatus. Except for exchangeable K (it was higher (P = 0.004) in a container with P. excavatus), the domestic waste processed by P. sansibaricus showed about 6% more total nitrogen (P = 0.002) and about 7% more available P (P = 0.269) at the end than by P. excavatus. As compared with the initial level organic C content as well as C:N ratio showed a considerable reduction that was noted higher in substrate with P. sansibaricus than those by P. excavatus (organic C, t-test: P = 0.870; C:N ratio, t-test: P = 0.002). The growth (biomass increase) and reproduction parameters such as mean individual live weight, maximum individual growth rate (mg wt./worm/day), number of cocoons and reproduction rate (cocoon/worm/day) were higher in bedding with P. sansibaricus. The maximum earthworm mortality was in vermibed having P. sansibaricus (50% higher than by P. excavatus) (t-test: P = 0.423), since both species did not show a drastic difference in waste mineralization rate, but comparatively, P. excavatus exhibited better growth and reproduction performance, which further support the suitability of the species for large scale vermiculture operations.

Dimitris P. Komilis and Robert K. Ham (2004):- This paper presents a life-cycle inventory (LCI) for solid waste composting. Three LCIs were developed for two typicalmunicipal solid waste (MSW) composting facilities (MSWCFs) and one typical yard waste (YW) composting facility (YWCF). Municipal solid waste was assumed to comprise three organic components, food wastes, yard wastes, and mixed paper, as well as various inorganiccomponents. Total costs, combined precombustion, and combustion energy requirements and 29 selected material flows—also referred to as LCI coefficients—were calculated by accounting for both the processes involved in originally producing, refining and transporting a material used in the facility as well as consumption during normal facility operation. Total costs ranged from $15/t to $50/ t and energy requirements from 29 kw h/ t to 167 kw h/ t for a YWCF and a high quality MSW composting facility, respectively. More than 90% of the overall CO2 emissions in all facilities were due to the biological decomposition of the organic substrate, while the rest was due to fossil fuel combustion.

Jorge Domınguez, Manuel Aira, and Maria Gomez-Brandon (2009):- Vermicomposting, a very efficient method of converting solid organicwaste into an environmentally-friendly, useful and valuable resource, is an accelerated process that involves bio-oxidation and stabilization of the waste as a result of the interactions between some species of earthworms and microorganisms. Although microorganisms are the main agents for biochemical decomposition of organic matter, earthworms are critical in the process of vermicomposting. Complex interactions among the organic matter, microorganisms, earthworms and other soil invertebrates result in the fragmentation, bio-oxidation and stabilization of the organic matter.

Paola Campitelli, Silvia Ceppi (2008):- The high variability of some important compost and vermicompost parameters suggests an urgent need for establishing quality assuranceprocedures in order to classify the available materials. The organic amendments prepared from different organic wastes (raw material), with different kind (composting or vermicomposting) and time of process, produce a final product which differs in its quality.

A set of twenty-eight different compost and vermicompost were analyzed through nineteen chemical, physical and biological parameters. The chemometric evaluation was performed by the following multivariate techniques: principal component analysis (PCA) and linear discriminant analysis (LDA). The aim of this paper was to characterize and classify composted and vermicomposted materials by means of multivariate statistical analysis methods, such as PCA and typical classification techniques, LDA, by determining parameters related to their physical, chemical and biological characteristics in order to obtain useful information for both producers and consumers. Results showed a wide variation in some parameters such as total organic carbon (TOC), germination index (GI), pH, total nitrogen (TN), and water soluble carbon (WSC), which depends on the characteristics of each process.

Master Recycler Programme (2018):-Composting can be described as the ultimate in recycling. It mimics the natural cycle of fallen leaves and branches decomposing into humus. To compost, the organic material that has been generated is gathered and treated in a way which hastens its biological decomposition.

Chapter 3

Materials and Methodology

6. 3.1 General

Transform your waste into black gold with four key ingredients to compost.

7.

Fig 3.1 Transform of waste

8. 3.2 Materials

3.2.1Compost Materials

Anything organic--leaves on the ground, a fallen tree will decompose. The more resistant the material is to decay, how-ever, the longer the process will take. Except in some special situations, decomposition is inevitable! A total absence of air, such as in a peat bog, will prevent decomposition. In very dry places, such as within the Antarctic, decomposition may be slowed. But everything organic that is out in the weather will eventually become compost.

Fallen leaves, grass clippings, sod stripped for a garden, weeds, squash vines, watermelon rinds-- even old cotton rags--all come from once-living organisms and can be composted .

A diversity of materials is the key to a first-rate compost. In addition to the major plant nutrients such as nitrogen, phosphorus, and potassium, plants take up a host of minor and trace elements. The more diverse the materials composted, the more likely it is that these elements will be returned to the plants. This does not mean that the materials will compost more quickly or more thoroughly, but that they will feed the plants better.

Glass clippings:

Landscapers are always trying to get rid of them.

Yard Wastes:

Weeds, old plants, wilted flowers.

Leaves:

You'll find these bagged and waiting at neighbors' curbside.

Food scraps:

Except for **bread**, meat, fat, bones, dairy, or oily foods. They must be buried under 8" of soil, composted by earth-worms, or in a hot compost pile.

Wood Chips:

A tree service will deliver a load if you are willing to take a large quantity. Use first on garden paths, then compost it after the initial decay has begun.

Sawdust:

This is best if first used as a livestock litter or allowed to weather, since it takes a lot of nitrogen to break it down.

Seaweed:

Found washed up on some beaches. It's an excellent source of many plant nutrients.

Hair:

Very high in nitrogen. Rescue some from the garbage at barber shops and beauty parlors.

Coffee grounds and filters:

Almost every home and office has coffee grounds. Coffee chaff is a beautiful mulch. Available from coffee roasters.

Manures:

Rabbit, cow, horse and goat manures are the only sterile manures to use. These manures provide useful organisms.

3.2.2 Non-Compostable Organic Materials

Everything that was once alive will compost. However, not everything belongs in a compost pile. Some materials that create problems and should be kept out of home compost systems.

Plants infected with disease or a severe insect attack:

Where eggs could be preserved or where the insects them-selves could survive in spite of the compost pile's heat (examples are apple scab, aphids and tent caterpillars).

Ivy, succulents and certain pernicious weeds:

Such as morning glory and buttercups; and **grasses which spread by rhizomes** such as quack gr ass. These may not be killed by the heat of decomposition and can choke out other plants when compost is used in the garden.

Cat, dog and bird manures:

Which contain pathogens harmful to children. These pathogens are not always killed in the heat of the compost pile.

Meat and fish leftovers, bones, or greasy fatty foods:

Such as oils, butter, and cheeses.

Piles made entirely of waxy leaves:

Such as rhododendron and English Laurel, or pine needles break down very slowly. Try composting small amounts of these mixed with other materials, shred them first or use them as mulch.

3.2.3 Criteria for Selecting a Compost System

There are many ways to make compost. Home compost methods range from mulched paths that are replenished every other year, to turning units that are maintained weekly. Many compost systems can be built with scavenged materials, some require nothing but the soil in a garden.

Composting systems are organized by the type of wastes they process: yard wastes are composted by using them as mulches or in holding and turning units; vegetative kitchen food wastes are composted either through soil incorporation or in worm bins. Turning units also may be used to compost kitchen and yard waste together in a hot pile for those willing to turn the piles regularly. Usually, food wastes should be composted in closed systems separately from yard wastes to keep rodents and other pests from becoming a problem in the open, longer-standing yard waste composting systems. Yard wastes are generally not susceptible to pest problems, so they may be composted in a variety of open systems. The style depends on what materials are to be recycled, how much space is available, when com-post is needed, and what it will be used for. The basic principles and technologies described earlier may be applied to municipal, commercial/industrial and agricultural composting operations. The characteristics of each waste type will dictate the best approach that should be taken for that material. There is no question that organic material, if properly processed can be composted. If composting is to be successful, however, siting and operating conditions must be closely followed.In addition to the Department of Environment's approval, all buildings and structures related to the composting facility shall meet the conditions of all Municipal, Provincial and Federal regulatory agencies responsible for adequacy of design, health, sanitary, safety and water quality requirements. Should composting operations cease, efforts must be made to ensure that no environmental damage will occur.

3.2.4 Composting Yard Wastes

Yard wastes can be composted in simple **holding units** where they will sit undisturbed for slow decomposition, in **turning bins** that produce finished compost in as little as a month, or as **mulches** on paths or around planting until they decompose in a year or two.

Holding units are simple container s used to store yard and garden waste in an organized way until the materials break down. Using a holding unit is the easiest way to compost. It requires no turning or other labour except placing wastes into a pile or bin as they are generated.

Non-woody materials such as grass clippings, garden weeds, crop wastes, and leaves work best in these systems. Decomposition can take from six months to two years. However, the process can be sped up by chopping or shredding wastes, mixing green and brown materials, and maintaining proper moisture.

Since materials are continuously added to holding units, they are at various stages of decomposition. Generally, the more finished compost is at the bottom of the pile, while partially decomposed materials are near the top. Once it is determined that finished compost is at the bottom of a holding bin or pile, the compost is ready to be harvested and used. (Finished compost is somewhat of a personal judgment. It should look like mulch, have a nice earthy smell, and not be changing very much.) To harvest the compost, the holding unit is removed from the compost pile and placed next to it. Yard wastes are then forked from the top of the old pile into the bot-tom of the empty holding unit until rich compost is found. The compost can be used and the holding unit is ready to receive additional yard wastes.

Holding units can be made of light materials so they may be easily taken apart and moved around the garden. Some examples of holding units include circles of snow fencing or hardware cloth, old wooden pallets lashed together, or wire framed in wood. More permanent holding areas can be made by stacking cinder blocks or mortaring bricks or rocks together. It is helpful to have two of these stationary bins, one to use for fresh wastes while the other is curing.

Sod also can be composted in a holding system, with or without a structure. Simply pile freshly stripped sod roots up, grass down. Make sure it is thoroughly wet, and cover with black plastic to keep light out. Sod takes one to three years to decompose completely. Decomposition of sod piles can be shortened to as little as six months by adding a high-nitrogen fertilizer such as cottonseed meal or ammonium sulphate. Covered piles are also an effective way to kill quack grass and some other noxious weeds.

Turning Units are typically a series of bins used for building and turning hot compost piles. An alternative turning system is a horizontally mounted rotation barrel. A turning unit allows wastes to be conveniently mixed for regular aeration. This speeds composting by providing bacteria with the air they need to break down materials. Turning systems require frequent maintenance and involve preparation of the wastes to be composted. These units can be expensive to buy or build. However, the effort and expense is re-warded with large quantities of compost produced in a short time.

Non-woody yard wastes, along with vegetable wastes from the kitchen, may be composted in turning units. Composting in these units is most efficiently done in batches. Materials should be stockpiled until enough are on hand to make a pile that fills a 3 ft. by 3 ft. by 3 ft. bin, or almost fills a barrel composter. (To reduce odours and pests, food wastes should be stored in a sealed container until enough materials are available to make a large pile.)

Gather all the materials needed to make a pile that is at least 3 cubic feet. Use both green and brown materials to approximate the 30:1 carbon to nitrogen balance.

Increase decomposition rate of the materials by running them through a shredder or chop them with a spade or machete on a piece of plywood. Brown leaves may be run over with a rotary lawn mower to break them down.

Start building the pile with a 4- to 6-inch base of brown material. If the pile is going to sit for a few weeks or more, use coarse material (small branches, corn stalks, straw) for this base layer to let air into the pile. Moisten materials.

Next, add a 4to 6-inch layer of green materials. If the greens are not very fresh, sprinkle on a small amount of blood meal or cottonseed meal, poultry manure, or other high-nitrogen source. Fresh grass clippings should be used in thin layers. Mix the green and brown layers together so bacteria can feed on both simultaneously.

These piles should be monitored and turned after temperatures have peaked and begun to fall, in 4 to 7 days; then turned a second time when the temperature peaks again, 4 to 7 days later. Com-post processed this way will be ready in 3 weeks. Rotating barrel units do not need layering; mate-rial can be thrown in and mixed up. If rotating barrel composters are turned every 2 to 4 days, compost will be ready to use in 2 to 3 weeks

A rotating barrel composter may be made from a 55-gallon drum with a loading door cut and hinged. Aeration holes must be cut at the ends or around the barrel. A variety of rotating barrel composters is available commercially. Avoid barrel units made entirely from metal perforated with 1" holes, as they leave materials dry or clumped together. Ideally, barrel units should have flat sides, or "fins" inside to lift and drop materials as the barrel is turned.

Mulches are organic materials spread over the surface of the soil to suppress weeds, keep plant roots cool and moist, and prevent soil from eroding or compacting. Mulches are used around plants in the garden, or as a soft "paving" for paths and play areas. An ideal mulch material is one that costs nothing, is easy to keep in place, and reduces evaporation of soil moisture while permitting rapid penetration of water.

There are a great variety of organic and inorganic materials that can be used for mulching. In this manual, only organic mulches will be discussed. Some common organic materials used for mulch-es include: wood chips, lawn clippings, com-post, sawdust, leaves from deciduous trees and shrubs, manure, and pine needles. It is also possible to mulch with commercial by-products such as coffee chaff and buckwheat hulls, or straw. The focus here will be on using organic wastes that are readily available in and around our homes.

These materials are suitable for surface mulching around trees, shrubs, and other perennial plantings. However, in annual flower and vegetable gardens, it is best to mulch with non-woody materials such as lawn clippings, compost, and other green garden trimmings. Non-woody materials break down quickly and can then be turned under without competing with plants for the nitrogen that bacteria need to break down woody wastes. If woody wastes are used in an annual garden, they should be pulled aside before tilling so that they do not use up nitrogen that plants need. If woody wastes are tilled in, they must be balanced by adding a high-nitrogen source such as blood meal.

The material most commonly used for mulching commercial landscaping is ground bark ("beauty bark”). A more natural looking alternative is the chipped waste from tree pruning and removal operations. This material can often be obtained for free by calling a tree service. If one has tree work done at home, the tree service may be willing to leave the chips. Any leaves left with the branches will decompose in a short time, adding to the beauty of the variegated mulch. Wood chip makes an excellent path and play area mate-rial, as it decomposes slowly and softens the surface

Composting Food

Non-fatty food wastes may be composted by incorporatingthem into the soil where they will break down to fertilize established or future plantings, by placing them in **worm bins** that pro-duce high quality "castings" for use on plants indoors or out, or layering them in **hot piles** along with yard wastes as described in the previous section. Food wastes incorporated into the soil can take from one month to one year to de-compose fully. It takes worms three to six months to transform a bin of wastes into **vermicompost**. Hot piles can compost a mixed load of food and yard wastes in three weeks.

Soil incorporation is the simplest method for composting food waste. A hole is dug one foot deep, and the food wastes are chopped and mixed into the soil, then covered with at least 8 inches of additional soil. (Pet wastes can also be buried in the soil as long and in not vegetable gardens.)

Depending on soil temperature, the number of micro-organisms in the soil, and the carbon contentof the wastes, decomposition will occur in one month to one year. Food wastes such as meat, bones, or fatty foods such as cheese and salad dressing are not recommended for soil in-corporation. These foods have the potential of attracting rodents, dogs, cats, or flies.

Food wastes can be incorporated around the drip line of trees or shrubs by using a post hole digger or shovel. The tree roots actively feed in this zone, and will benefit most from nutrients added there. Food wastes also may be buried in a fallow area of an annual garden, or a trench may be dug and filled with soil as food waste is added.

In English gardens a form of soil incorporation known as **"pit and trench" composting** is practiced (illustrated in *Figure II-5*). This is a simple three-year rotation of soil incorporation of kitchen wastes, growing crops, and path making. In the first season a trench is dug, filled with food wastes and covered. At the same time, another row is used to grow crops and a third is used as a path. In the second year the fertile soil of the former compost trench is used to grow crops, the former crop row is used as a path, and the path is dug as a new trench. After a third year of rotation, the cycle starts over. This form of compost-ing keeps the garden perpetually fertile with a small organizational effort.

Anaerobic composters, can also be used to decompose both food and yard waste. In anaerobic composting, bacteria break down the organic material without the addition of oxygen. This type of composting retains more nitrogen while producing methane but does not reach temperatures high enough to kill weed seeds or pathogens.

Anaerobic systems usually consist of a closed bin or dark plastic bag which is filled with vegetative waste, moistened, closed, and placed in the sun for 10 to 12 weeks. To avoid animal pests it is best to cover the bottom of the composting bin with wire mesh.

Hot compost piles are the only safe way to compost food and yard wastes together without pest problems. They are also the best way to kill soil diseases and weed seeds in compost, and to produce compost in a short period. Not everyone wants or needs to make hot compost piles. Here is a recipe for those who do:

Gather all the materials needed to make a pile that is at least 3 cubic feet. Use both green and brown materials to approximate the 30:1 carbon to nitrogen balance.

- To increase decomposition rate of the materials, run them through a shredder or chop them with a spade or machete on a piece of plywood. Brown leaves may be run over with a rotary lawn mower to break them down.

- Start building the pile with a 4- to 6-inch base of brown material. If the pile is going to sit for a few weeks or more, use coarse material (small branches, corn stalks, straw) for this base layer to let air into the pile. Moisten materials.

- Next, add a 4- to 6-inch layer of green materials. If the greens are not very fresh, sprinkle on a small amount of blood meal or cottonseed meal, poultry manure, or other high-nitrogen source. Fresh grass clippings should be used in thin layers. Mix the green and brown layers together so bacteria can feed on both simultaneously.

- Continue alternating and mixing layers of green and brown materials, adding water and extra green materials as needed, until the pile is 3 to 4 feet high (fill the bin).

- Close bin or cover pile and wait.

- Monitor temperature in the interior of the pile regularly. It should peak between 120o to 160o F in 5 to 10 days.

- When the temperature begins to decrease, turn the pile. Take materials from the outer edges and top off the pile and place them at the base and middle of the new pile. Those from the middle should be on the outside edges and top of the new pile.
- Continue monitoring the temperature in the pile.
- About one week later, the temperature of the pile should peak. Turn the pile again. After another week, the compost should be finished. Piles made this way without food wastes do not need to be turned; they will be finished in 3 to 4 months.

Vermicomposting (worm bin composition) uses redworms in an enclosed container to convert vegetable and fruit scraps into a nutrient-rich soil amendment called worm castings.

Materials needed

- A container
- Bedding
- Red worms
- Kitchen scraps

Container:

The size of the container depends on the amount of waste to be composted. A worm bin can be made by using almost any container that is an appropriate size, prevents light from entering, has air vents, and is covered. Surface area is more important than depth for a worm system. Generally, one square foot of surface is required for every pound of food waste to be composted per week.

Bedding:

Suitable bedding materials include shredded newspaper or cardboard, dry leaves, straw, peat moss, and wood shavings.

Red worms:

The most popular red worm used for vermicomposting is Eisenia fetida. In nature, red worms are surface dwellers that live in the top layer of soil under the organic debris that is their food. By creating suitable living conditions, one can take advantage of the red worm's ability to recycle organic matter.

Worms eat half their weight in food scraps and about an equal amount of bedding each day. A bin that starts with about a 1 pound of worms will need to be fed a handful of food every other day. As worms multiply the food supply should be increased.

Kitchen scraps:

Red worms are capable of eating most kitchen scraps, but some waste is better left out of the bin to avoid odor or pest problems. **Do not compost meats, fish, dairy products, oily foods, or cat and dog waste**.

Foods that can be added to the worm bin include:

- Vegetable scraps
- Fruit peels or pulp
- Coffee and tea grounds and filters
- Breads (without butter or mayonnaise)

Food may be cut up or ground into small pieces to speed up the process. This provides more surface area for the worms to feed on.

Worm bins are fun and an interesting way to compost non-fatty kitchen wastes. In addition, they compost the newsprint, cardboard, or other wastes used as bedding. Worm bins are most efficient if sized and stocked according to the amount of waste to be handled. Mary Appelhof's book “Worms Eat My Garbage” provides information on how to determine what size a worm bin should be, and the amount of bedding and worms required for an efficient system. Another source of information on worms and worm com-posting is the “Worm Digest.”

Compost Uses

Compost is a much needed resource. It is not only useful to the home gardener, but is essential to the restoration of landscapes where topsoil has been removed or destroyed during construction or mining operations. Compost is increasingly being applied to agricultural and forest lands that have been depleted of their organic matter. The most common use of compost today is probably in topsoil mixes used in the landscape industry.

Compost is typically applied:

1. To mulch or "top dress" planted trees.
2. To amend soil prior to planting.
3. To amend potting mixes.

Mulching

Gardeners and landscapers use mulches and top dressings over the surface of the soil to suppress weeds, keep plant roots cool and moist, conserve water, maintain a loose and porous surface, and prevent soil from eroding or compacting. Com-post also gives plantings an attractive, natural appearance. Compost can be used to mulch around flower and vegetable plants, shrubs, trees, and ground covers.

To prepare any area for mulching, first clear away any visible grass or weeds that might grow up through the mulch. Make sure to remove the roots of any weedy plants that spread vegetatively, such as quack grass, ivy, and buttercup. Different types of plants benefit from varying application rates and grades of mulch. Recommended uses of compost as mulch and top dressings.

Soil Amendment

Compost can be used to enrich garden soils be-fore planting annuals, ground covers, shrubs and trees. Many commercial topsoil mixes contain composted yard debris or sewage sludge as a major component. This may be mixed with sand, sandy soil removed from construction sites, peat moss, and/or ground bark.

Soils may be amended by mixing compost top-soil mixes with existing soil. If a rich compost or topsoil mix is laid on top of the existing soil without mixing, the zone where they meet can become a barrier to roots and water. In this condition, plants often develop shallow roots and eventually blow over or suffer from lack of water and nutrients. Recommended applications for different situations.

Potting and Seedling Mixes

Sifted compost can be used to make a rich, loose potting soil for patio planters, house plants, or for starting seedlings in flats. Compost can be used to enrich purchased potting mixes or to make mixes at home.

Plants growing in containers are entirely reliant on the water and nutrients that are provided in the potting mix. Compost is excellent for container growing mixes because it stores moisture effectively and provides a variety of nutrients not typically supplied in commercial fertilizers or soil-free potting mixes. However, because of the limits of the container, it is essential to amend compost-based potting mixes with a “complete” fertilizer to provide an adequate supply of macro nutrients (N-P-K). Simple “recipes” for making your compost mixes

The food web decomposition process includes:

- Level One - primary consumers. Organisms that shred organic matter and the microscopic organisms that eat the shredded organic residues.
- Level Two - secondary consumers. Organ-isms that eat level one organisms.

- Level Three - tertiary consumers. Organisms that eat level two organisms.

All members of the compost food web are very beneficial to a compost pile and should be left alone to do their work. They need each other to survive. If any of the member organisms are re-moved by using insecticides, their natural cycle is disrupted and the compost is contaminated with insecticide residues.

Level One - Primary Consumers

This level is made up of herbivores: bacteria, fungi, actinomycetes, nematodes, mites, snails, slugs, earthworms, millipedes, sowbugs, and worms. Note that some types of mites are carnivores.

The most productive members of a compost pile's food web are the bacteria, which are chemical decomposers. As a group, they can eat near-ly anything. Some are so adaptable that they can use more than a hundred different organic compounds as their source of carbon due to their ability to produce a variety of enzymes. Usually, they can produce the appropriate enzyme to digest whatever material they find themselves on.

Every piece of organic matter placed in the pile is covered with varying amounts of bacteria. As they digest the organic material and break it down into its basic elements, they are also reproducing at an incredible rate. One gram of bacteria can become about 450 grams of bacteria in only three hours.

There are many kinds of specialized bacteria operating in different temperature ranges.

Psychrophilic bacteria work best in temperatures of about 55 degrees F, but can stay on the job even in near freezing conditions. This is why a compost pile sinks in the winter; these bacteria are busy breaking down organic matter. As these cooler bacteria go to work, their activity actually begins to heat up the pile.

The increased temperature creates the ideal conditions for the next type of bacteria to arrive.

Mesophilic bacteria work best in temperatures of about 70 degrees C to 90 degrees C, but can stay on the job in even hotter conditions. The activity of mesophilic bacteria can heat the pile up to temperatures greater than 110 degrees C.

Thermophilic bacteria become active when the temperature reaches between 104 degrees C to 200 degrees C. If a compost pile steams in the morning or on a frosty day, it's because these bacteria are busy at work decomposing the organic waste. These bacteria generally last for up to five days and then the pile begins to cool.

As the psychrophiles eat away at organic matter, they give off a small amount of heat. If conditions are right for rapid growth, this heat will be sufficient to set the stage for the mesophiles. In many compost piles, these efficient mid-range bacteria do most of the work. However, given optimal conditions, they may produce enough heat to kick in the real hot shots–the thermophiles.

Although at first they are the most active decomposers, the bacteria are not alone in all of this work. Other microbes, fungi, and a host of in-vertebrate decomposers also take part. Some are active in the heating cycle, but most other organ-isms prefer the cooler temperatures of later de-composition.

After temperatures go down, the decomposing pile becomes a real zoo. Larger organisms, many of them feeding on the piles' earlier inhabitants, add diversity to the action.

Actinomycetes produce grayish cobwebby growths (molds) throughout the compost that give the pile a pleasing, earthy smell, similar to a rotting log. They are frequently seen in drier parts of the pile and survive a wide range of temperatures.

Fungi send their thin mycelial fiber s out far from their spore-forming reproductive bodies. Molds are actually a form of fungi. The presence of mold and fungi usually implies decay. The most common of these pop up on a cool pile. Fungal decomposition is less efficient than bacterial decay as cold temperatures greatly restrict its growth.

Snails, slugs, millipedes, sow bugs, pill bugs, mites, and earthworms are the larger invertebrates that shred the plant materials, creating more sur-face area for action by the microscopic fungi, bacteria, and actinomycetes, which are in turn eaten by organisms such as mites and springtails. These creatures all excrete "castings" that are very dark and fine, and great for your plants.

Snails are terrestrial mollusks, typically having a spirally coiled shell, broad retractile foot, and distinct head. They generally feed on living plant material but will attack fresh garbage and plant debris.

Slugs are basically snails without the shell. They too feed on living plant material, fresh garbage, and plant debris, and will also show up in the compost heap.

Millipedes are nonpoisonous arthropods with cylindrical bodies of 20 to 100 segments, with two pairs of legs per segment. They feed mainly on decaying plant tissue but will also eat insect carcasses and excrement.

Sow Bugs are fat bodied crustaceans with delicate plate like gills along the lower surface of their abdomens which must be kept moist. They move slowly, and feed on rotting woody materials and highly durable leaf tissues, such as the woody veins. The sow bugs that roll up like armadillos are known as pill bugs.

Pill bugs look similar to sow bugs and also graze on decaying vegetation, but are more flexible They can roll themselves into a ball to protect themselves, which gives them their common nick-name: "rolypolys."

Mites are the second most common invertebrate found in compost. They are transparent-bodied creatures with eight leg-like jointed appendages. Some can be seen with the naked eye and others are microscopic. Some scavenge in leaves, rotten wood, fungi, and other organic debris. Others are predators and feed on nematodes, eggs, insect larvae, and other mites and springtails. Considered pests in fermenting industries such as wineries and cheese factories, they are not pests in the compost pile.

Worms play an important part in breaking down organic materials and forming finished compost. As redworms process organic materials, they coat their wastes with a mucus film that binds small particles together into stable aggregates and prevents nutrients from leaching out with rainwater. These stable aggregates give the soil a loose and well draining structure. Earth-worms pull organic materials into the mineral soil along many burrows. As a result of the worm's well-deserved reputation for being excellent decomposers, many people think that it's a great idea to add extra worms to their compost pile. This is unnecessary. Let the worms find their own way into the pile, when the conditions are right. They prefer the pile when it is cooler, so adding worms could lead to their quick demise in a hot, steamy pile.

Level Two - Secondary Consumers

This level includes both herbivores and carnivores: nematodes, protozoa, rotifers, soil flat-worms, springtails, some types of mites, and feather-winged beetles.

Nematodes, or roundworms, are tiny, cylindrical, and often transparent microscopic worms who are the most abundant invertebrates in the soil. Typically less than one millimeter in length, a handful of decaying compost can contain several million nematodes. Under a magnifying lens, nematodes resemble fine human hair. They can be classified into three categories: 1) those that eat decaying vegetation, 2) those that are predators on other nematodes, bacteria, algae, protozoa, etc., and 3) those that can be serious pests in gardens where they suck the juices of plant roots, especially root vegetables. Though there are pest forms of nematodes, most of those found in soil and compost are beneficial.

Protozoa are the simplest form of animal organism. Even though they are single-celled and microscopic in size, they are larger and have more complex activities than most bacteria. Protozoa obtain their food from organic matter in the same way bacteria do, but because they are present in far fewer numbers than bacteria, they play a much smaller part in the composting process.

Rotifers are minute worms, which usually have one or two groups of vibrating cilia on the head. Their bodies are round and divisible into three parts: a head, trunk, and tail. Many forms are aquatic and are generally found in films of water. The rotifers in compost are found in water that adheres to plant substances where they feed on microorganisms.

Flatworms are, for the most part, general scavengers that graze on a wide variety of things, including animal matter. As their name implies, flatworms are flat and usually quite small in their free-living form. Most flatworms are carnivorous and live in films of water within the com-post structure.

Springtails, along with nematodes and mites, are extremely numerous in compost. They are very small wingless insects and can be distinguished by their ability to jump when disturbed. They run in and around the particles in the compost and have a small spring-like structure under the belly that catapults them into the air when the spring catch is triggered. They feed mainly on fungi, although they also eat nematodes and small bits of organic debris. They are a major population controlling factor on fungi.

Feather-winged beetles are the smallest of all beetles and possibly of all insects. These beetles are distinguished by their feather-like wings. Some are blind and most live under bark in forests and woodland. Not surprisingly they go unnoticed.Most species feed on fungi.

Level Three - Tertiary Consumers

This level is made up of carnivores, or physical decomposers, and includes centipedes, predatory mites, rove beetles, ants, spiders, pseudoscorpions, and earwigs. Most of these creatures function best at medium or mesophilic temperatures, so they will not be in the pile at all times.

Wolf Spiders are truly wolves of the soil and litter micro-communities. They build no webs, merely run freely hunting their prey, which include all sizes of arthropods, from mites to centipedes.

Centipedes are found frequently in soil micro-communities. Centipedes are flattened, segmented worms with 15 or more pairs of legs–one pair per segment. They hatch from eggs laid during the warm months and gradually grow to their adult size. They feed only on living animals, especially insects and spiders.

Mites are related to ticks, spiders, and horseshoe crabs because they have six leg-like jointed appendages. Some mites are small enough to be invisible to the naked eye, while some tropical species are up to half an inch in length. Mites reproduce very rapidly, moving through larval, nymph, adult, and dormant stages. They attack plant matter, but some are also second-level consumers, ingesting nematodes, fly larvae, other mites, and springtails.

Rove Beetles are the most common beetles in compost. While feather-winged beetles feed on fungal spores, the larger rove beetles prey on other insects. Beetles are easily visible insects with two pairs of wings, the more forward-placed of these serving as a cover or shield for the folded and thinner back-set ones that are used for flying. These beetles prey on snails, insects, and other small animals. The black rove beetle is an acknowledged predator of snails and slugs. Some people import them to their gardens when slugs become a garden problem.

Ants feed on a variety of material, including aphid, honeydew, fungi, seeds, sweets, scraps, other insects, and other ants. Compost provides some of these foods, and also provides shelter for nests and hills. Ants will remain only while the pile is relatively cool. Ants prey on first-level consumers, and help benefit the composting process by bringing fungi and other organisms into their nests. The work of ants can make compost richer in phosphorus and potassium by moving minerals from one place to another.

Pseudo scorpions are predators that seize victims with their visible front claws, then inject poison from glands located at the tips of the claws. Pseudo scorpions are so small, their prey include tiny nematode worms mites, larvae, and small earthworms.

Earwigs are large predators, easily seen with the naked eye. They move about quickly. Some are predators, others feed chiefly on decayed vegetation

Unwanted Guests: The Pests of the Pile

Given a comfortable or nourishing environment, pest species will show up to "get in on the action." Rats are probably the least-wanted guests of all. With a hospitable environment and plenty of food, their numbers increase quickly and they may become transmitters of disease. So, it is important to compost food wastes by burying them in the garden, in rodent-proof worm bins, or in hot compost piles. Always keep high-protein and fatty food wastes out of the compost pile (meat and fish scraps, bones, cheeses, butter, and other dairy products).

Many flies, including house flies, can spend their larval phase as maggots in decomposing food wastes. Though they play an important part in the breaking down of all types of organic debris, they are unwanted guests around human house-holds. There are several ways to control their numbers: frequently turn compost piles that contain food (larvae die at high temperatures); cover piles with a dry material that has a high carbon content, such as straw or old grass clippings; or avoiding composting food wastes in yard waste piles.

Carbon-to-Nitrogen Ratios:

"Greens" and "Browns"

All living organisms are made up of large amounts of the element carbon (C) combined with smaller amounts of nitrogen (N). The balance of these elements in a material is called the **carbon-to-nitrogen ratio** (C:N). This ratio is an important factor in determining how easily

The best way to become familiar with this balancing is to be specific about it at first, then relax into an intuitive assessment of what a pile needs. Some people like to think in terms of half brown and half green material when building a compost pile out of kitchen and yard wastes. While this may not give the optimum C:N balance, it is a useful rule of thumb for those new to composting and not familiar with the materials.

It can be thought of like a chef varying the ingredients for a recipe. Be curious, write down the type and quantity of materials used, and take note of the temperature the pile reaches and the quality of the finished compost. After a while, the process becomes no more technical than making a cake.

Actually, building a compost pile is often compared to making a layer cake. Materials can be added in 2- to 6-inch layers. Water and amendments can be added between layers, like frosting. Alternating layers of "greens" and "browns" helps to proportion carbon and nitrogen through-out the pile. After two layers are placed, they should be mixed together. This ensures speedy multiplication of bacteria.

A pile that is too high in carbon will stay cool and sit a long time without breaking down. A pile too high in nitrogen will give off the smell of ammonia gas, and is also likely to get slimy and have a foul odor. The decomposition process is working on everything organic, and with time to wait and space to keep these materials, eventually the reward will be compost.

Surface Area

A melting block of ice is a great analogy for organic materials in compost. When the block is large it melts quite slowly, but when it is broken into smaller pieces the surface area increases, and the melting increases. Similarly, when organic materials are chopped or shredded into smaller pieces, the composting process speeds up. With more surface area exposed, decomposer bacteria have more food easily available so they can reproduce and grow more quickly.

It is not essential to break organic materials into small pieces to compost them, it just speeds the process. Sometimes, such as when using **mulches**, slow decomposition is advantageous. It can certainly be less work!

Mulches are organic materials placed on the soil surface to control weeds, lessen evaporation, and stop soil erosion. Wood chips and sawdust are commonly used as mulches. As they weather and slowly break down, they save water, labor, soil, and money.

If coarse materials are run through a shredder until only small bits remain, much more surface area is exposed for micro-organisms to work on. This allows decomposer organisms to digest more material and multiply faster, generating more heat. Any coarse, woody materials added to compost piles should be chopped, shredded, split, or bruised to speed the rotting process.

Many types of shredders and chippers are available, from large models used by tree services to small hand-cranked types. Some homeowners are finding it appropriate to purchase a small electric model jointly with their neighbors. A rotary lawn mower with its bag removed can be used to shred leaves on a hard surface, such as a driveway. This is managed best by blowing the yard debris against a wall.

If a simpler technology is desired, coarse yard wastes can be chopped with a machete on a piece of plywood. Even some pounding with the back of a hatchet will create entry ways for decomposer organisms.

Moisture and Aeration

All life on earth needs a certain amount of water and air to sustain itself. The compost pile is no different. The amounts of air and water in a compost pile form a delicate balance that must be maintained for rapid decomposition to take place. At less than 40 percent moisture, the bacteria are slowed by the lack of water. At greater than 60 percent moisture, there is not enough air for aerobic decomposition and anaerobic bacteria can take over the pile.

Viewed as a micro-organism farm, the moisture needs of the pile may need to be tended to just as the farmer tends to the irrigation of crops. Fortunately, there is a simple rule of thumb: compost should be about as moist as a wrung-out sponge. It should be obviously moist to the touch, but yield no liquid when squeezed. This level of moisture provides a thin film of water on materials for the decomposer organisms while still al-lowing air into their surroundings.

If the pile is too wet, it should be turned (pulled apart and restacked). This will allow air back into the pile and loosen up the materials for better draining. A pitchfork is the best tool for turning compost piles. Shovels are not very useful for picking up loose, mixed yard waste.

If the pile is too dry, it can be soaked from above with a trickling hose. However, a more effective practice is to turn the pile and re-wet the materials in the process. Once dry, certain materials such as dead leaves, sawdust, hay, straw, and some dried weeds and vegetables will shed water or absorb it only on their surface. These dry materials must be gradually wetted until they glisten with moisture. Then they should be mixed until the water has been absorbed into their fibers.

Volume

A pile should be large enough to hold heat and small enough to admit air to the center. As a rule of thumb, the minimum dimensions of a pile should be 3ft by 3ft to hold heat. The maximum dimensions that will allow air to the center of the pile are 5ft by 5ft by any length.

There are ways around this rule of thumb. By insulating the sides of the pile, higher temperatures can be maintained in a much smaller volume. Although labor-intensive, it works. By turning a pile or using "ventilation stacks" in the center of the pile, dimensions larger than 5 feet wide are possible. However, a pile this large is unnecessary in most backyard situation

Time and Temperature

The hotter the pile, the faster the composting process. Temperature is dependent on many factors: carbon to nitrogen ratios, surface area, moisture content, and aeration. Also, remember that only fresh materials will heat up. With proper consideration of these temperatures, piles can be built and the composting process is quicker.

Fig 3.2.4.1 Bin turning unit

Fig 3.2.4.2 Compost Pit after excavation

Fig 3.2.4.3 During excavation of Pit

Fig 3.2.4.4 Introduction of food waste

3.3 METHODOLOGY

3.3.1 METHODS

- Indore Method
- Bangalore Method
- NADEP Method
- Heap Method
- Pit Method

3.3.2 INDORE Method

Beds/rows of dung and crop residues/leaves, etc. are made about 1 m wide, 75 cm high and with a distance of 75 cm between two rows.

In the beds/rows, crop waste such as leaves, straw etc. is layered alternatively with the dung to thus make a height of about 75 cm. The beds are kept as such for 4-5 days to cool.

Water is sprinkled to let the compostable matter cool down.

Earthworms are put on the top of the manure row/bed. About 1 kg worms in a metre-long manure row are inoculated.

It is left undisturbed for 2-3 days after covering with banana leaves. Covering with jute bags or sacks is not recommended as it heats the manure bed.

The bed is opened after 2-3 days. The upper portion of about 10 cm of manure is loosened with the help of a suitable hand tool.

The bed is covered again. The worms feed on an upper bed of about 10 cm. This portion becomes vermicasted in about 7-10 days.

This portion (vermicasted manure) is removed and collected near the bed. Another upper portion of 10 cm is loosened and covered again with the leaves.

Moisture is maintained in the bed by regular sprinkling of water.

The loosened portion of the manure is vermicasted in another 7-10 days and is removed again.

Thus, in about 40 days, about 60 cm of the bed is converted into vermicompost and is collected on 3-4 occasions.

The remaining bed of about 10 cm in height contains earthworm mixed manure.

Fresh manure mixture/organic residues, etc. are again put on the residual bed containing earthworms of about 10 cm and the composting process is restarted.

The manure collected from the bed is freed of worms through sieving. Uncomposted or foreign matter is also removed in this way.

Chapter 4

Results and Discussions

- Moisture Content Test

1. Indore Composting

Test Sample	Weight of empty pan (W_1) (gram)	Weight of compost+ Empty pan (W_2)(gram)	Weight of Compost after Oven drying +Empty pan (W_3) (gram)	Moisture Content (W_2)-(W_3) / (W_3) ×100 (%)
1	15.82	55.56	38.30	44.28
2	13.81	46.85	32.65	43.49
3	12.65	42.28	29.22	44.69

Table 5.1 Determination of Moisture Content (Indore Composting)

- Moisture Content Test

2. Vermicomposting

Test Sample	Weight of empty pan (W_1) (gram)	Weight of compost+ Empty pan (W_2)(gram)	Weight of Compost after Oven drying +Empty pan (W_3) (gram)	Moisture Content (W_2)-(W_3) / (W_3) ×100 (%)
1	15.82	58.65	38.56	51.84
2	13.81	47.22	30.82	53.21
3	12.65	45.68	29.95	55.85

Table 5.2 Determination of Moisture Content (Vermicomposting)

Fig 5.1 Determination of Moisture Content

- pH Test

Sr. No.	pH Value
Sample 1 (Indore Composting)	7
Sample 2 (Vermicomposting)	8

Table 5.3 pH Test

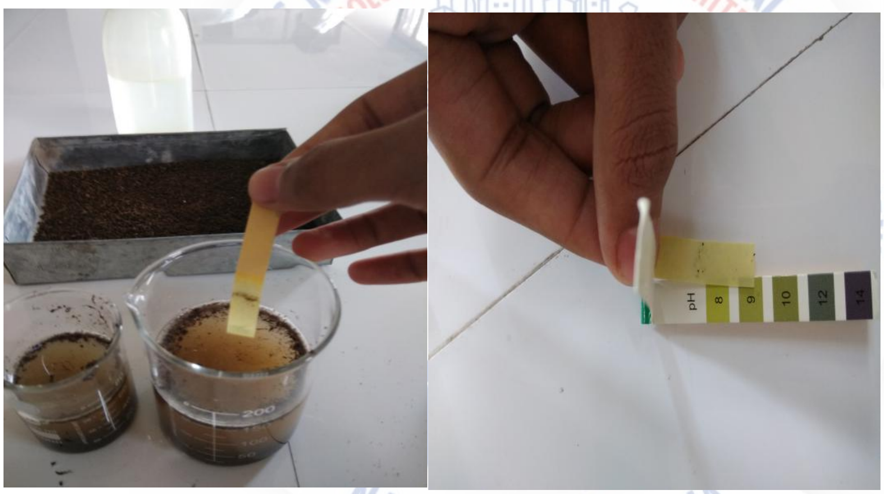

Fig 5.2 Determination of pH Value (by pH paper)

- **Cost Analysis of Materials and Preparing of Compost Pit**

Quantity Analysis

Sr No C	Particular	No	Length (m)	Width (m)	Depth/ Height (m)	Units	Quantity
1.	Excavation	01	2	1.5	0.5	cum	1.5
2.	Timber	02	2	-	1.5	sq-m	6
		02	1	-	1.5	sq-m	3

Total Quantity of excavtation = 1.5m^3

Total Quantity of Timber = 9 m^2

Table 5.4 Quantity Analysis

Cost Analysis

Sr No	Particular	No	Units	Quantity	Rate/Unit	Amount (Rs)
1.	Green Waste	1	Kg	30	10	200
2.	Sawdust	1	Kg	8	9	72
3.	Eisenia Fetida	1	Kg	2	200	400
4.	Buckets	20	No	-	12	240
Total						Rs 912/-

Cost of Epuipment tools

(Shovel,Axe,Trowel,Hoe,Spade,Mattock,Meter Tape) = Rs 400/-

Timber Cost = Rs 150/-

Contingencies = Rs 300/-

Grand Total Rs 1762/-

Cost of Compost pit = Rs1762/-

Chapter 5

Conclusion

Following conclusions have been drawn on the result obtained and from the observation:

- The average daily organic waste generated at the rate of about 15 Kg per day from AIKTC Campus that includes waste from degree as well as diploma canteen.
- The average pH of compost obtained is neutral to slightly alkaline.
- The average chloride content of compost obtained is found to be normal.
- An optimum moisture content of the compost was found.
- It has been found that for composting of organic solid waste generally takes 60-90 days.
- The compost obtained by Vermi-compost was rich in nutrients as compared to composting process.
- It reduces organic solid wastes by upto 70 percentage of the total organic

FUTURE SCOPE OF PROJECT

9. **More efficient methods can be adopted for increasing the quality of the compost .It has been proved that composting and vermicomposting techniques are useful in converting the organic waste, however the composting and vermicomposting setup can be installed for decreasing the overall time and human effort.**

LIST OF PUBLICATIONS

➢ Poster Presentation

1. Comparative Study on Composting and Vermicomposting

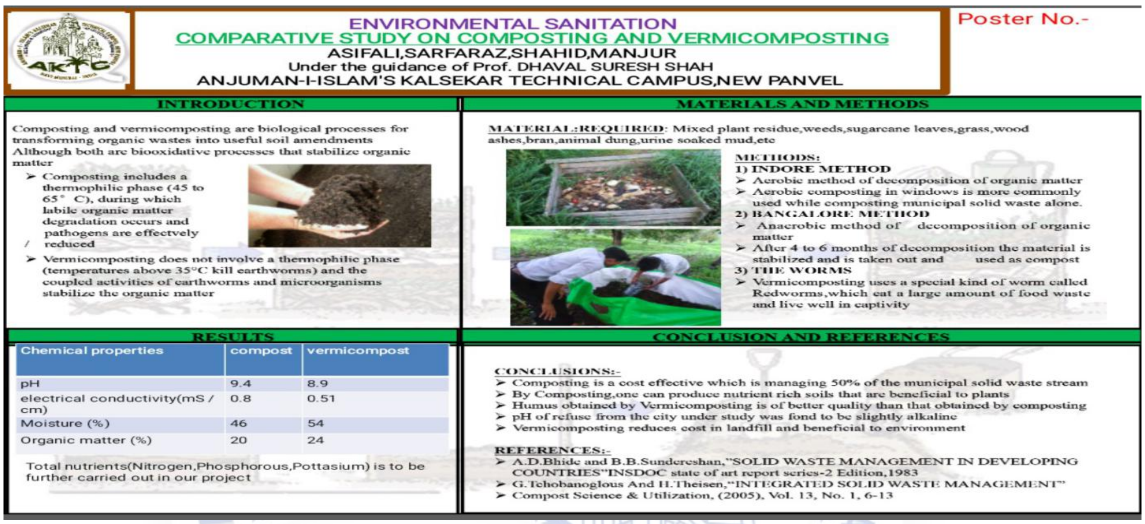

Fig 6 Poster Presentation

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