Vermicomposting with cow dung, banana plant and vegetablewaste

A Dissertation Submitted

In Partial Fulfilment of the Requirements
For the degree of

Master of Technology (M.Tech)
In
Environmental engineering

By

Mohd Anwar Khan (Roll No. 1160470002)

Under the supervision of
Mr. Kamal Nabh Tripathi
(Assistant Professor)

/

Department of Civil Engineering
Babu Banarasi Das University, Lucknow
2019-2020

CERTIFICATE

This is certifying that **Mr. Mohd Anwar Khan** has carried out the research work presented in this thesis entitled **“**vermicomposting with cow dung, banana plant and vegetable waste’’for the award of Master of Technology from Babu Banarasi Das University, Lucknow under my supervision. This thesis embodies result of original work and studies carried out by student himself in the academic session 2019-20.

Date: **Supervisor**

Mr. Kamal Nabh Tripathi

(Assistant Professor)

BBDU Lucknow

CANDIDATE’S DECLARATION

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

Mohd Anwar Khan
Roll no. 1160470002
Department of civil Engineering
Date: _________________

LIST OF FIGURES

CHAPTER 1

CHAPTER 3

CHAPTER 4

LIST OF TABLES

LIST OF GRAPHS

ABSTRACT

Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to convert the organic waste into compost rich in nutrients. Nowadays, farmers mostly use chemical fertilizers for agricultural purposes, which pollute the soil and decrease their fertility and also contaminate the groundwater. Vermicompost has been proposed to be used in the place of chemical fertilizers for overcoming the problems and to utilize organic waste. Vermicompost has better water holding capacity, which also increases the fertility of the soil. Vermicomposting technology can be characterized as environmentally friendly and sustainable. The objective of the topic is to study various techniques adopted by people in the industry as well as in researches and develop vermicompost using organic wastes by optimizing the methods as obtained from the study. To do certain tests in order to check the stability of obtained vermicompost. To compare the vermicompost with some of the available vermicompost and do a comparative study. To use the vermicompost with other organic wastes like sawdust, rice husk, cocopeat, perlite etc. in different combinations and use it as a base material for plantings same species and similar batch of plant saplings and then compare them for their growth in terms of their height, foliage, flowers, etc. The future scope of the work shall be to use the vermicompost to use the vermicompost to bioremediation the polluted water of rivers/ streams in order to remove toxic cum heavy metals from it.

Keywords*: Eisenia Fetida, cow dung, banana plant stem, vegetable waste*

TABLE OF CONTENT

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

Recycling of organic waste through vermicomposting is very popular globally due to its ability to convert the waste to manure as a substitute for chemical fertilizers. Banana is grown in about 120 countries in the world which generates about 86 tonnes of crop waste per hectare. In India, it is cultivated in 4.6 lakhs hectare area with a production of 14.2 t and productivity of 30.5 t/ha. The whole plant (leaves, stem, and rhizome) of banana, after harvesting of the fruits, is left in the field which takes several months to degrade naturally. Such banana plant-derived wastes can also be utilized for recycling through vermicomposting. Earthworms, in vermicomposting, are used to derive a stable compost rich in available plant nutrient elements and plant growth hormones than traditional composting. Among the several epigamic earthworms Eisenia Fetida is most favored for vermicomposting due to its wide range of tolerance towards different environmental variables. In vermicomposting, earthworms have a crucial role, as they influence the activity of microorganism through fragmentation and ingestion of the organic matter. The importance of earthworm microbial communities is well documented in the vermicomposting of lignocellulosic materials.

India is the second-largest producer of fruits and vegetables in the world (next to China) with 221.431 million Metric tonnes. The cumulative wastages are estimated to be 5.8 to 18% of the total produced fruits and vegetables. The total population in India is 1.27 billion representing almost 17.31% of the world's population. With the population growth rate of 1.58%, India is predicted to have more than 1.53 billion people by the end of 2030. Rapid industrialization and population growth in India have led to the migration of people from villages to cities thereby generating thousands of tons of municipal solid waste (MSW) every day throughout the country. City in India is reported to generate about sixty nine million tonnes of MSW per annual with a per capita waste generation rate of 500 g/person/day (Annepu, 2012). The total waste generated included the total tonnage ofwastes from 366 cities representing almost 70% of India's urban population. The composition of MSW in India is completely different when compared to western countries. The MSW is composed of a large amount of organic fraction (40–60%), ash, fine earth (30–40%), paper (3–6%) and plastic, glass, and metals (each less than 1%). The moisture content of urban MSW is 47%, C/N ratio ranges between 20 and 30, and the average calorific value is 7.3 MJ/kg (1745 kcal/kg).Generally, MSW is disposed of in low-lying areas, dumped openly and most of it is landfilled without any operational control and taking proper precautions (Sharholy et al., 2008). The management of MSW is associated with several activities such as generation, storage, collection, Transfer and transport, processing, and disposal (Fig. 1.1). But in India, the practices are compromised with waste generation, collection, transportation, and disposal. Due to the poor management of MSW, improper infrastructure facilities, and maintenance facilities, the practices are becoming more complex and expensive. Since there is no segregation for MSW before disposal, it is leading to more emission of greenhouse gases and leachate production due to large fractions of organic matter (fruit and vegetable peels, food waste) (Suthar et al., 2005). The leachate from these wastes majorly contaminates the groundwater (Pokhrel and Viraraghavan, 2005). Besides, these illegally dumped wastes have adverse effects on human health and the environment (Achankeng, 2003). Moreover, these emissions are mainly due to the result of landfilling and other life cycle activities. With its high biodegradability nature, the organic waste of the vegetable market is causing much nuisance after reaching the landfill (Bouallagui et al., 2004). However, incineration of solid waste generally results in the production of more polluting gases and other toxic solid residues in the land.

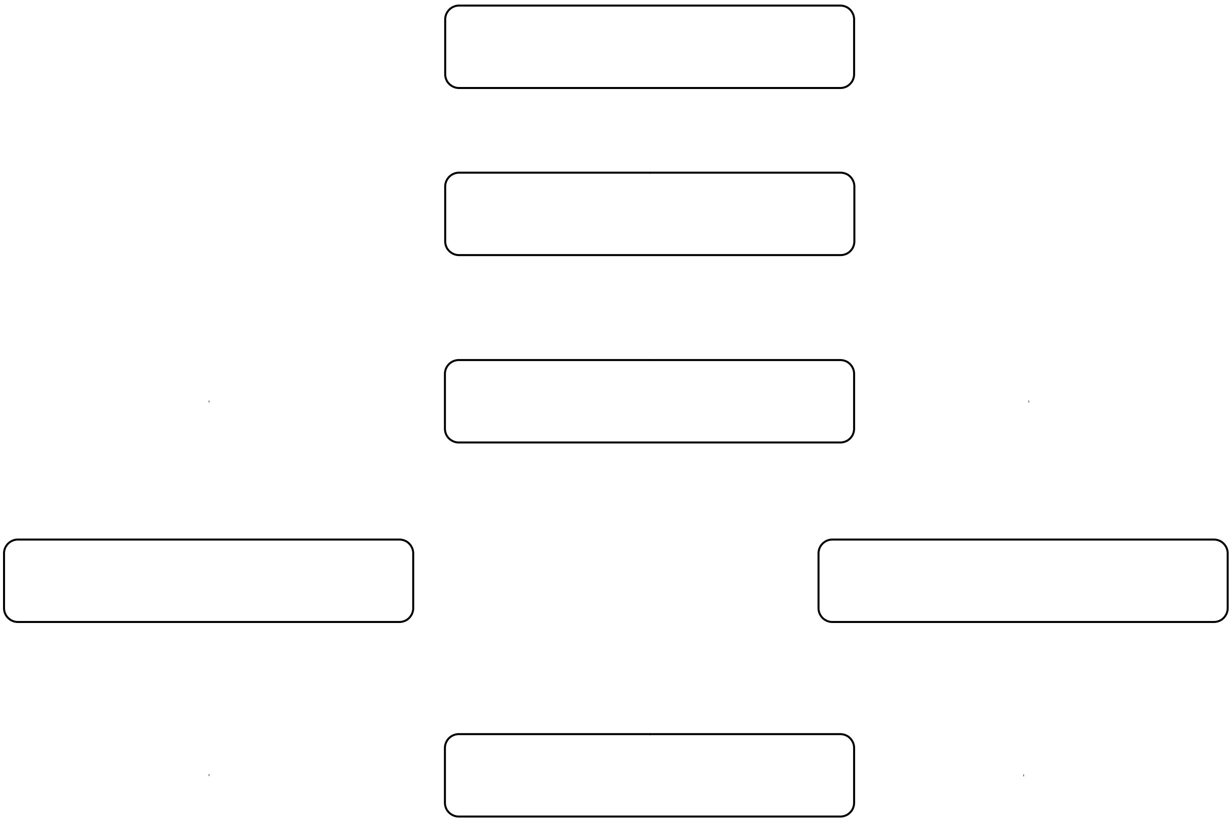

Fig.1.1 Time rotation of municipal solid waste management method

1.2 COMPOSTING

Composting is a microbiological conversion of organic residues of plant and animal origin to manure rich in humus and nutrients by various micro-organisms including bacteria, fungi, and actinomycetes in the presence of oxygen (Fig. 1.2). During the process, it releases by-products such as carbon dioxide, water and heat.

/

Fig.1.2 composting process

1.2.1 Phases in Composting Process

The phases in the composting processes can be distinguished according to temperature patterns as shown in Fig. 1.3. In the mesophilic phase, the microorganisms acclimatize and colonize in the new environment in the compost heap. Growth phase is characterized by the rise of biologically produced temperature to mesophilic level. In thermophilic phase, the temperature rises to the highest level with stabilization of waste and pathogen destruction which are more effective. During maturation phase thetemperature decreases to mesophilic and consequently ambient levels.

/Fig.1.3 Pattern of temperature during composting

In addition, humification takes place in which some of the complex organics are converted into humic colloids that are closely associated with minerals (iron, calcium, nitrogen, etc.) and finally to humus. Oxidation of ammonia to nitrite -) and ultimately nitrate also take place.

1.3 TYPES OF COMPOSTING

Generally, composting systems are of two types: the open process and reactor process. Open composting process are the first types systems originated and practiced from the evolution of composting times, which also includes windrow systems, static and household systems. Reactor systems include tunnel systems, the rotary drum and the reactor systems of various designs. Furthermore, based on the supply of aeration to the composting system they are classified into two; the agitated and the static system. Normally in agitated system the compost materials are mechanically turned using large machines to supply air and to release inner temperature, which also includes mixing of the materials. Whereas in static systems, the compost heaps are made on a series of perforated tubes connected to a blower which is controlled manually or in timer basis to supply air into the system so the temperature is maintained within the system. In the case of reactor operation, there are three major classifications as mentioned in Fig. 1.4. However, In-vessel (rotary drum) system of organic waste and municipal solidwaste composting is the most successful process. An overview of major compostingsystems is discussed below.

/Fig. 1.4 Types of composting methods

1.3.1 Pile/Windrow Composting

Windrow composting involves aerobic bioconversion of organic matter to stable compost with release of heat, water vapor and CO2, in which the pile composting can be used only for small quantities of input materials (Fig. 1.5). However the windrow composting allows large quantities of materials to be composted, having a geometrical shape ranging from two to four meter wide and 2 to 3 meter elevated at starting of composting process.

These types of systems usually acquire a trapezoidal shape, depending on the nature of raw material used for composting. Before forming the windrow, the material is shredded and screened to 3 to 9 cm, with moisture content adjusted to 50-60%. Usually, the windrows are turned twice in a week so that temperature is maintained at 55oC and the process is accomplished in 3-4 weeks. Furthermore for curing, the compost is allowed without turning for another 3-4 weeks for the degradation of residual organics.

/

Fig. 1.5 Windrow/pile composting method

1.3.2 Static (Active/Passive) Composting

Static composting is similar to windrow system in which the raw material is laid in parallel rows, with no restrictions to the size and shape of the compost (Fig. 1.6). But reports state that windrow and static composting are two different processes, in which the material to be composted is agitated manually in the windrow system to introduce oxygen and regulate temperature, whereas in static piles, air is blown through the mass.

Static pile composting (active and passive) is operated by placing them over a network of pipes connected to air blowers that delivers air in and out of the system. The waste material used for the system is mixed all together in one large pile and these piles are suitable only for high organics such as yard trimming and biodegradable MSW (USEPA, 1992). These types of system are effective in substantially reducing the mass and volume of the material being transported to the landfills. The above reports supported the application of aeration system in composting methodologies as they affect the greenhouse gas emissions. This is because during aeration, most of the carbon produced is released as CO_2. Furthermore, it was also reported that the turning frequency in active aeration treatment released higher greenhouse gas emission than passive aeration treatment due to the nitrogen transformation. Passive and active aeration systems produce the same compost quality with similar results (Solano et al., 2001), while the maintenance and operation costs differs with the methodology adopted (Haug, 1993) (Fig. 1.7). Contained pile is a modified variant of static pile in which the materials to be composted are placed between the walls over a perforated floor through which the air is blown. Due to the presence of walls the pumped air is forced to move upward preventing any sideway diffusion, thereby ensuring efficient aeration in the system. Furthermore, the management of leachate from the system is also easier.

/

Fig. 1.6 Windrow/pile composting in passive mode operation

Windrow or pile vermicomposting are of basically two mode that is active mode and passive mode. In active mode organic waste is laid in parallel in row manner and the passive mode operation is in laid in searies.

/

Fig. 1.7 Windrow/pile composting in active aeration mode

1.3.3 In-Vessel Composting

Rotary drum composters are one of the first types of In-vessel composting system design with engineering systems that are completely different from other conventional methods practiced earlier (Fig. 1.8). A common feature of these types of system is that large amount of waste material can be decomposed within an enclosed space in shorter time under controlled process. Therefore, drum composting of vegetable waste is an efficient and promising technique with its decentralized processing of the material, as it provides agitation, aeration and uniform mixing of the compost material to produce a stabilized end product with high quality.

/

Fig. 1.8 In-vessel composting method

1.4 VERMICOMPOSITING

Vermicomposting has been arising as an innovativeecotechnology for the conversion of various types of wastes intovermicompost. Vermicompost is humus like, finely granulated andstabilized material which can be used as a soil conditioner toreintegrate the organic matter to the agricultural soils. Industrialwastes remain largely unutilized and often cause environmentalproblems like ground and surface water pollution, foul odours,occupying vast land areas etc. Non-toxic and organic industrialwastes could be potential raw material for vermitechnology. In thelast two decades, vermitechnology has been applied for themanagement of industrial wastes and sludges and to convert theminto vermicompost for land restoration practices. The success of theprocess depends upon several process parameters like quality of rawmaterial, pH, temperature, moisture, aeration etc., type ofvermicomposting system and earthworm species used.

/

Fig. 1.9 Earthworms during vermicomposting

Vermicomposting is a modified and specialized bio-oxidative process of composting which uses earthworms to convert organic wastes into high quality compost (Fig. 1.9). Unlike other composting process vermicomposting is not an exothermic process. In this process, the organic matter containing major fraction of nutrients are converted into more available forms known as vermicast. Initially the substrate is broken into small fragments for ingestion, thereby it enters into gizzard of earthworms where mincing of the substrate occurs. This mincing helps in increasing the surface area of the substrate and facilitate microbial action (Chan and Griffiths, 1988). During vermicomposting, the earthworm body is reported to act as a bio-filter that can purify and also disinfect and detoxify solid wastes (Rahul and swetha, 2011). Apart from production of compost of high nutrient rich, vermicomposting has also proved to more efficient in removing pathogens, as they are eliminated as soon entering the food chain of earthworms.

1.5 SIGNIFICANCE OF VERMICOMPOSTING

Vermi-composting is biotechnological process in which earthworms employed to convert the organic wastes into humuslike material known as vermicompost. Certain earthworm variety capable of consuming a wide range of organic wastes from sewagesludge, animal wastes, agricultural residues, domestic wastes, toindustrial wastes. Under favourable conditions of temperature andmoisture, earthworms maintain the aerobic conditions in thevermicomposting process ingest organic waste materials and egest ahumus-like substance which is more homogeneous than the organicwastes or raw materials used.

Duringthis process, important plant nutrients such as nitrogen, potassium,phosphorus and calcium present in the waste materials are convertedthrough microbial action into such chemical forms which are muchmore soluble and available to plant life than individuals in close relative substrate.

1.6 MECHANISM OF VERMICOMPOSTING

The transformation of organic wastes into vermicompost is ofdouble interest: on the one hand, a waste is converted into valueadded product, i.e., vermin-compost and, on other; it pedals solidwaste pollution, that is a consequence of increasing population, industrialization, urbanization and intensive agriculture. A new optimistic aspect associated through vermicomposting, it can be done at some extent commencing household vermin-composting of groceries dissipate to community or urban scale vermin-composting. Various steps of waste degradation by earthworms are given below:

- Drinking of organic misuse substance.
- Alleviate of organic dissipate substance by saliva in the mouth of earthworms.

- Alleviate of organic dissipate and neutralization with calcium (excreted by inner walls of oesophagus) and passed on to the gizzard for further action in oesophagus region of young insect body.
- Dissipate is finely ground into small particles in the muscular gizzard.
- Digestion of organic dissipates by a proteolysis enzyme in stomach.
- Breakdown of flesh waste material components by various enzymes including proteases, lipases, amylases, celluloses, etc. secreted in intestine and then the digested matter is absorbed in epithelium of intestine.
- Emission of undigested fare matter from larva castings.

Success of vermin-composting procedure depends on a number ofabiotic and biotic factors. Some of these factors are given below:

1.6.1 Abiotic factors

Most important biotic feature which affect vermin-composting procedure include wetness contented, pH, hotness, aeration, nourish excellence, glow, C:N ratio etc.

Moisture content: Adequate moisture contented single of most important factors necessary for operational of earthworms and bacteria in vermin-composting system. Earthworms breathe from first to last their covering; therefore the system must have adequate moisture comfortable. Ideal moisture range in vermi-composting or vermin-culture process is 60-80% yet substantial and chemical differences in feed supply may source small disparity.

pH: It is an additional important bound which greatly influences the vermin-composting process. Acceptable pH range,suitable for earthworms and micro-organisms activity, is 5.5–8.5.However, optimum pH is neutral or near neutral. During vermin-composting pH values of provide for substrate under goes considerable vary. An initial phase characterized by a low pH is often observed during vermin-composting of feed substrate. This is dueto the formation of carbon dioxide and volatile fatty acids in original. With the subsequent evolution of CO_2 and utilization of volatile fatty acids, the pH begins to rise as the process progresses.

Temperature: The optimum temperature range for earthworms during vermin-composting procedure twelve to twenty eight degree Celsius. Worm activities are significantly influenced by temperature. During winter to remain system active, the temperature should be maintained above ten degree Celsius and in summer the temperature should be maintained below thirty five degree celsius. As temperature decline in the vermin-composting system earthworms are not able to replicate and their metabolic activity also get reduced. At very low temperatures earthworms do not consume food. At higher temperature metabolic action and reproduction of earthworms begins to decline and mortality occurs. Tolerances and preferences intended for temperature vary from species to species.

Air Circulation: As the earthworms are aerobic organisms, air is important for vermin-composting. Oxygen spending is a occupation of microbial and earthworm movement, oxygen levels are also related to substrate heat. In a vermin-composting system excessive moisture could reason poor air circulation and may influence the oxygen supply to worms.

Light: Earthworms are photophobic in nature. So they have to be kept away from light.

C:N ratio: C:N relation of provide for matter affect earthworms' growth and duplicate. Higher C:N relation in provide for material speed up the expansion and imitation of worms. If C:N relation is too elevated or too low, misuse degradation is measured. Plants cannot assimilate granite nitrogen unless the C:N.

1.6.2 Biotic feature

a variety of biotic feature which concern vermin-composting process consist of earthworms reserve thickness, bacteria, enzymes etc.

Earthworms stocking density: Population of earthworms (stocking density) in vermin-composting scheme involve different physiological route, such as respiration speed, imitation pace, nourish pace and burrowing activity. far above the ground inhabitants densities of earthworms in vermin-composting system product in a fast proceeds of new untreated material into earthworm casts. Consequently, when establishing a vermin-composting scheme, it is necessary to preserve best possible earthworm concentration to gain highest population expansion and copy in straight potential time.

Microorganisms: The compostable organic waste materials are naturallyinhabited by microorganisms and these help in the breakdown oforganic wastes under ideal environmental conditions. Thecomposition of the microorganism communities in a vermicompostingsystem depends on the composition of waste components undergoingvermicomposting.

1.7 GROWTH PARAMETERS AND VERMICOMPOST

Vermi-compost is statement to have hormone like movement and this bring on better origin start, greater than before origin biomass, improved stand development and expansion and change the morphology of flora. Subler et al. (1998) report that the amalgamation of tiny quantity of pig fertilizer vermin-compost, into industrial bedcovers stand potting media was adequate to manufacture a important amplify in total biomass of tomato seedling.

Vermi-compost has been establish to have a constructive authority on all provide method limit of yield like wheat, paddy and sugarcane (Ismail, 2005; Garg and Bhardwaj, 2000; Ansari, 2007). Ahmed et al.(2010) state place stature, entirety dried out burden and leaf area significantly increase on request of bio fertilizer. Mohmood etal. (2006) establish that place stature of wheat enlarged by inoculation with Azospirillum sp. several learning have statement approving result of a muck compost on the increase and maturity of flora by use of limitation such as origin, occasion of high point, leaf area, growth and expansion of internode.

Shoot dry weights of marigold plant life better considerably and utmost marigold enlargement was happening in thirty percent compost surround mixture. just some workers have account the enlarged growth of corps grown in media amend with humic acid that were remove from vermin-compost.

1.8 COW DUNG

The amounts of minerals differed in treatment groups, thiscould be attributed to variations in growth and multiplication pace of earthworms in unlike mammal fertilizer, which resulted in discrepancy blueprint of uptake of nutrient for their body mixture and following liberate of residual raw materials in a mineralized form. The carbon pleased of domestic animals fertilizer decreased during vermin-composting representing a senior mineralization of untreated substance. Though, the N contented of domestic animals manure enlarged in the process of vermicomposting. This shows that the increased microbial activity continues outside the gut in the casts and results in amplified mineralization rate of unprocessed N and consequent additional boost in attentiveness of NHþ4.

Earthworm can mineralize cattle dung more easily than other organic wastes because it contains a greater population of decomposing communities, e.g., bacteria, Protozoa, nematodes, fungi, actinomycetes. Dominguez (2004) suggested that vermicomposting is a combined operation of earthworm and microorganisms in which the earthworm fragments and homogenizes the ingested material through muscular action of their foregut and also adds mucus and enzymes to ingested material and thereby increases the surface area for microbial action while, microorganisms perform the biochemical degradation of waste material providing some extra-cellular enzymes required for organic waste decomposition within the worm's gut. Bulking material plays an important role during vermicomposting of organic wastes. The type and proportion of bulking material in vermireactors not only influenced the mineralization rate but at the same time also altered the earthworm biomass production rate. Earlier studies have revealed that mixing of bulking material in some noxious wastes minimizes the concentration of toxic substances in vermireactors and consequently speeds the decomposition process. The importance of bulking material in vermicomposting of waste is as follows: (1) it makes the waste more acceptable for earthworms, (2) lowers the concentration of some unfavorable chemicals, e.g., metals, grease, lignin, polyphenolic substances and cellulose in feedstock, (3) sets the pH within the acceptable limit for earthworms, (4) may enhance the nutritive value of waste and thereby accelerate the decomposition through enzymes production by earthworm itself and associated microflora, (5) enhances the quality of ready product, i.e., vermicompost by adding some important nutrients, and (6) changes the microclimatic conditions of the decomposing waste by promoting microbial colonization in feedstock, although microbes are important part of earthworm diet. However, in this study, the waste mineralization rate was lower in vermibed without bulking material, e.g., VW vermibed, which further supported the hypothesis that bulking agent plays an important role in waste mineralization process during vermicomposting.

CHAPTER 2
LITERATURE SUREY

This chapter covers detail literature on vegetable waste and its problems during disposal, management of vegetable waste through different composting methods. Chapter also deals with detailed composting and vermicomposting process, effect of leachate and bulking agent addition, organic matter transformation, stability and microbial diversity during different composting methodologies.

2.1 SOLID WASTE PRACTICES IN INDIA

In India, the term municipal solid waste refers to solid waste from houses, streets and public places, shops, offices and hospitals (Asnani and Zurbrugg, 2007). Management of these types of waste is most often the responsibility of communal or town neighbouring bodies. Except in metropolitan cities, solid waste management (SWM) is the duty of a fitness administrator who is help out by engineering division in shipping work. The action is chiefly labour rigorous and 2-3 labour is provided per one thousand residents served. The public agencies spend five to twenty five percent of their budget on SWM. A typical waste management system in a short down or middle-income country like India includes the following elements:

- Fritter away invention and storage
- Segregation, reuse, and recycling at the household level
- Primary waste compilation and transport to a relocate station or community bin
- Street comprehensive and cleaning of community places
- Management of transport station or area bin
- Secondary collection and transport to the waste disposal site
- Waste discarding in landfills
- Collections, carry and treatment of recyclables at all aim on solid waste pathway (Collection, storage, transport and disposal)

2.1.1 Adverse Effect of Open Dump

An unlock discarding is defined as a land disposal location at which solid wastes are disposed of in a manner that does not protect the environment, are susceptible to open burning, and are exposed to the elements, vectors and scavengers. Open dumping can include solid waste disposal facilities or practices that pose a reasonable probability of adverse effects on health or the environment. The health risks associated with illegal dumping are significant. Areas used for release dumping may be easily accessible to people, especially children, who are vulnerable to the physical (protruding nails or sharp edges) and chemical (harmful fluids or dust) hazards posed by wastes. Rodents, insects, and other vermin attracted to open dump sites may also pose health risks. Dump sites with scrap tires provide an ideal breeding ground for mosquitoes, which can multiply

100 times faster than normal in the warm stagnant water standing in scrap tire causing several illnesses.

Poisoning and chemical burns results from contact with small amounts of hazardous, chemical waste mixed with general waste during collection and transportation. Burns and other injuries can occur resulting from occupational accidents and methane gas exposure at waste disposal sites. Dust generation occurs from on-site vehicle movements, during placement of waste and materials. The waste in the dumping ground undergoes various anaerobic reactions and produces offensive greenhouse gases such as CO_2, CH_4 etc. These gases are contributing potentially to global warming and climate change phenomenon.

2.2 HISTORY OF COMPOSTING

Even though it is very difficult to attribute the birth of composting, the history of urban waste generation and its management begins with human civilization and urbanization. During the Neolithic period when human beings changed their habitat from essential hunters and gatherers to farmers, they started making pits out of stone for the storage of organic urban waste for the application of agricultural fields (Uhlig, 1976; Martin and Gershuny, 1992). However, the most accurate and technical descriptions of composting had been conducted by the Knights Templar of thirteenth century. These Templar's were a military order during the time of the crusades.

There are references for the usage of manure in agriculture on clay tablets by the ancient Akkadian Empire in the Mesopotamian Valley, thousand years before Moses was born. There are evidences that Romans, Greeks and the Tribes of Israel knew about compost. Even in tenth and twelfth century Arab writings of both Bible and Talmud, have references for using rotted manure straw and organic materials to compost. Many New England farmers' composted 10 parts of muck to 1 part of boneless fish by periodically turning the compost heaps until the disintegration of fish was achieved.

Some of the advances made during the twentieth century include the work of Sir Albert Howard in the year 1933 in India. His work was one of the first documented efforts on the application of composting in the management of organic residues in India ever in the history of modern composting (Howard and Wad, 1935; 1938). Sir Howard in collaboration with few researchers developed the "Indore Process". Initially in Indore process only the animal manure was used for composting. But later readily biodegradable materials such as night soil, garbage, straw, leaves, municipal refuse and stable wastes were also composted on open ground. Indore process included two methods; the heap method and the pit method. In heap method the materials were piled up to height of 1.5 m and in pit method the materials were placed in trenches of 0.6-0.9 m deep. The leachate from the compost material was recirculated to maintain the moisture content and the composting process lasted for 6 months or longer.

Later in 1939, the Indian Council of Agricultural Research at Bangalore developed the “Bangalore Process” with some improvements of Indore method. This process overcame many of the disadvantages of Indore process such as heap protection from adverse weather; nutrient losses due to high winds/strong sun rays, frequent turning requirements and fly nuisance etc. An important modification to the Indore method was increasing the turning frequencies in order to maintain aerobic conditions, thus achieved more rapid degradation and shortened the composting period.

Later, a process that was used in a number of countries and heavily marketed throughout the world is the Dano Process. This is one of the widely known in-vessel systems which uses a large, slowly rotating drum with baffles incorporated inside it that carries the material during the digestion. This process was mainly concerned in the segregation and size reduction of the waste; however the output of this process can be composted by any of the procedures that were available at that time. This process was first developed in Denmark. The Dano Corporation later developed a mechanical silo-type digester known as the Bio-stabilizer (Golueke, 1992). The materials are fed to the stabilizer and maintained in thermophilic conditions for most of the time. The outputs are passed through a 1 mm mesh screen and further composted using windrows system if necessary. Later, Mr. T. van Maanen had started VuilafvoerMaatschappij (VAM) Company to compost city refuse in Netherlands. In the process, the refuse was placed in long and high piles. The piles were sprinkled periodically with the recirculated leachate to maintain the moisture content of the system (Diaz et al., 2007). Overhead cranes were used to turn the piles and the decomposed material was shredded, screened and sold as humus. Stovroff and his associates built an aerobic composting facility in Oakland, California, USA using the windrow method, which is also a modified version of the basic Indore method. This composting methodology was designed to compost 300 tons of mixed waste in an 8 h shift per day or 600 tons on a two shift i.e. 16 h/day basis (Stovroff, 1954a; b). Usually the piles were made in the range of 2 to 3 m in length and it was dependent on the site characteristics.

2.3 LITERATURE REVIEW

Charu Gupta et al. (2019) Vermicomposting technology is an old age practice in India and a well-known technology throughout the world. It represents an attractive, efficient and ecofriendly approach in treatment and management of solid wastes generated from all sources such as industrial, agricultural and domestic. The other added advantage is that in vermicomposting the material is neither landfilled nor burned but recycled. Thus, vermicomposting is a technology that focuses on conservation of resources and their sustainable utilization. Vermicomposting can also be used for the treatment of food-waste, paper, cardboard, manures, and bio-solids. It can be used in soil amendment. In addition, vermicomposting may also help in employment generation. Vermicompost can also be used in greenhouse application, in establishing new plants such as rootstock in vineyards. Vermicomposts can be used for both agricultural and horticultural production. However, there are still many research gaps that need to be addressed such as insufficient scientific study on enhancing the growth rate of earthworms.

Norman Q. Arancon et al. (2019) revolves around the development of vermiculture as an art, a science, and an industry. It traces the early development of vermicomposting, which was used to manage organic wastes that were considered environmentally hazardous when disposed of improperly. It also presents the vermicomposting process, including its basic requirements, technology involved, and product characteristics, both in solid form and as a liquid extract. Research reports from different sources on the performance of the products are also provided. The discussion attempts to elucidate the mechanisms involved in plant growth and yield promotion and the suppression of pests and diseases. Certain limitations and challenges that the technology faces are presented as well.

NatchimuthuKarmegam et al. (2019) The increase in major plant nutrients, TKN, NeNO3 - , TP and TK, decrease in TOC, C/N, C/P and OMC related to that of enzymatic and microbiological activities in vermicompost of PMS, CD and TEP/GLS combinations in this study indicates that green manure plants, TEP and GLS amendment positively supported the enhanced bioconversion of PMS into vermicompost using E. fetida. The worm growth and reproductive activity in PMS, CD and TEP/GLS treatments are in support of the encouraged vermiconversion process.

The PMS generated from paper industries in combination with CD and green manure plants TEP/GLS (50% PMS þ 25% CD þ 25% TEP/GLS, 2:1:1 ratio) can be used for enriched vermicompost production with E. Fetida, which in turn helps sustainable utilization of PMS. The maturity of the vermicompost as indicated by the activities of the enzymes, DEH, UA, SPA and ALP corroborated with the seed germination assay using cowpea and maize highlights that the vermicompost is suitable for agricultural use. The results of the present study signify that the industry generated organic wastes like PMS and organic materials with poor nutrient contents can be utilized for vermicomposting by amending the green manure plants for 'nutrient rich' vermicompost production. Further studies with the amendment of green manure plants in vermiconversion systems may provide possible utilization of different organic materials for nutrient recovery in an eco-friendly manner. However, the changes in the heavy metal contents in PMS amended with CD and green manure plants need to be established.

H. C. Parmar et al. (2019) conducted at the Agriculture Research Station, College of Agriculture, Anand Agricultural University, Jabugam during three consecutive seasons of the years 2015-16 and 2016- 17. This was to evaluate banana Pseudostem and maize fodder waste with and without cow dung and Anubhav biodegradable bacterial consortium (ABBC) for it bi-product in terms of vermicomposting, time required for degradation and the nutritive quality of vermicompost. The experiment consisted of eight treatments and conducted in RBD with three replications. Results shows that, the treatment Banana pseudostem + 5% Cow dung + Anubhav biodegradable bacterial consortium and the treatment Maize fodder waste + 5% Cow dung + Anubhav biodegradable bacterial consortium were significantly higher for N, P, K content during all the three seasons and in pooled analysis with less number of days to harvest and high recovery. While, microbial count were recorded maximum in banana Pseudostem based vermicompost than maize fodder waste. Overall, vermicompost produced from the banana Pseudostem and maize fodder waste by using ABBC @ 1 lit/t and 5 % cow dung provided the major nutrients in more balanced proportion. The main perspectives of this study is to decrease the environmental pollution by making vermicompost from banana pseudostem waste or maize fodder (waste) instead of dumping on road side or burning or left in the field and also reduce the use of chemicals by using vermicompost.

Wenjiao Li et al. (2019) aimed to clarify the effect of excess activated sludge (EAS) on vermicomposting of fruit and vegetable wastes (FVW). For this, a novel vermireactor consists of substrate and bed compartments was used for treating five types of FVW (banana peels, cabbage, lettuce, carrot, and potato) with and without the addition of EAS by earthworms. The EAS promoted the growth and cocoon production of earthworms, and the decomposition efficiency of FVW. The changes of dehydrogenase activity revealed that the EAS enhanced the microbial activity in all treatments except for the carrot. The organic matter content, total carbon and the C/N ratio showed a significant decrease after addition of EAS into FVW. The content of nitrogen and phosphorus was also improved in the final products after vermicomposting. This study suggested that the addition of EAS could be a feasible option to enhance the vermicomposting of FVW.

Naseer Hussain et al. (2018) Vermicomposting is a process in which earthworms are utilized to convert biodegradable organic waste into humus-like vermicast. Past work, mainly on vermicomposting of animal droppings, has shown that vermicompost is an excellent organic fertilizer and is also imbibed with pest-repellent properties. However, there is no clarity whether vermicomposts of organic wastes other than animal droppings are as plant-friendly as the manure-based vermicomposts are believed to be. It is also not clear as to whether the action of a vermicompost as a fertilizer depends on the species of plants being fertilized by it. This raises questions whether vermicomposts are beneficial (or harmful) at all levels of application or if there is a duality in their action which is a function of their rate of application. The present work is an attempt to seek answers to these questions. To that end, all hitherto published reports on the action of vermicomposts of different substrates on different species of plants have been assessed. The study reveals that, in general, vermicomposts of all animal/plant based organic wastes are highly potent fertilizers. They also possess some ability to repel plant pests. The factors that shape these properties have been assessed and the knowledge gaps that need to be bridged have been identified.

Hupenyu Allan Mupambwa et al. (2018) Vermicomposting is a bio-oxidative process that involves the action of mainly epigeic earthworm species and different microorganisms to accelerate the biodegradation and stabilization of organic materials. There has been a growing realization that the process of vermicomposting can be used to greatly improve the fertilizer value of different organic materials, thus, creating an opportunity for their enhanced use as organic fertilizers in agriculture. The link between earthworms and micro-organisms creates a window of opportunity to optimize the vermi-degradation process for effective waste biodegradation, stabilization, and nutrient mineralization. In this review, we look at up-to-date research work that has been done on vermicomposting with the intention of highlighting research gaps on how further research can optimize vermi-degradation. Though several researchers have studied the vermicomposting process, critical parameters that drive this earthworm–microbe-driven process which are C/N and C/P ratios; substrate biodegradation fraction, earthworm species, and stocking density have yet to be adequately optimized. This review highlights that optimizing the vermicomposting process of composts amended with nutrient-rich inorganic materials such as fly ash and rock phosphate and inoculated with microbial inoculants can enable the development of commercially acceptable organic fertilizers, thus, improving their utilization in agriculture.

Joanna Kostecka et al. (2018) Departure from waste storage and maximisation of its utilization is currently the basis of modern waste management. This is favoured by the requirements defined in numerous legal instruments, including both EU directives and local regulations of member states. This also applies to organic waste, especially kitchen waste, which, with adequate education of the public, may constitute waste resources of very good quality to produce e.g. vermicomposts. It is very important, since soils of most European countries require continuous supply of organic matter to replenish humus and nutrients for the plants. The paper describes current trends in the production of kitchen organic waste. Since such waste has been vermicomposted for many years, advantages of this biotechnology have been presented and features of the produced vermicomposts have been characterised.

SiamakShiraniBidabadi et al. (2018) The technology of vermicomposting containing their leachates, teas and other extracts such as vermiwash as a result of earthworm action is widely applied for safe management of agricultural, industrial, domestic and hospital wastes. Remediation of polluted soils, improving crop productivity and inducing the resistance against biotic and abiotic stresses are other advantages of vermicompost derived liquids when used in agriculture. Contrary to the fact that chemical fertilizers are still widely used in agriculture, societies gradually become aware of the negative effects of these fertilizers on their health. Therefore, vermicompost derived liquids contain high amount of valuable plant nutrients which has the potential to be used as liquid fertilizer. This paper reviews the potential of vermicompost derived liquids as as an efficient combination of nutrient source of vermicompost derived liquids contributing to plant growth and acting as a deterrent to biotic and abiotic stresses.

Ranjit Chatterjee et al. (2017) Enormous amount of organic wastes are generated from plant, animals and industrial activities in day to day life. A considerable part of which remains unutilized and are either burnt or dumped nearby sites that create pollution, harbours pathogen for diseases and causes severe problem of disposal. Instead of disposing, it can be used as source of organic wastes and effectively recycled for the production of compost to meet the nutritional requirement of crops. Considering growing deficiency of plant nutrients in crop field, higher cost of synthetic fertilizers and poor efficiency of chemical fertilizers, the organic wastes recycling for plant nutrient supply is becoming more essential for replenishment of plant nutrients, sustaining soil health, reducing the pollution problem and creating employment opportunities. The study was aimed to explore the possibility of bioconversion of different organic wastes to utilize the embedded nutrients for supplying enriched organic manure for better soil health and crop growth, which will not only improve the yield and quality of the produce but also conserve energy, minimize pollution, save foreign exchange and improve the fertilizer use efficiency subsequently that will helps to revitalize and restore the soil fertility and will revive the microbial activities for sustainable crop production.

ThongamIbemchaChanu et al. (2017) Vermicompost is an emerging biotechnological approach towards development of organic farming. In agriculture field the use of vermicompost as organic manure is well documented. However, in aquaculture field it is in its infancy stage. Vermicomposting depend upon the yield and composting structures. In present study we have conducted the pit methods of vermicomposting in cemented tank. A shade was prepared over the cemented tank tomaintain a cool, moist and shady area. Three bedding material viz.egg trays, dried water hyacinth plants and banana stems were used and maintain a bedding layer of 15-20 cm thickness. The product is 3/4th of the materials used. The result showed better yield in egg tray bedding followed by banana stem. This study will give a brief idea of farmyard production of vermicompost and application in aquacultureas organic manure.

Huang, K. et al. (2016) aimed to promote vermicomposting performance for recycling fresh fruit and vegetable wastes (FVWs) and to assess microbial population and community of final products. Five fresh FVWs including banana peels, cabbage, lettuce, potato, and watermelon peels were chosen as earthworms' food. The fate test of earthworms showed that 30 g fresh FVWs/day was the optimal loading and the banana peels was harmful for the survival of Eisenia fetida. The followed vermicomposting test revealed lower contents of total carbon and weaker microbial activity in final vermicomposts, relative to those in compared systems without earthworms worked. The leachate from FVWs carried away great amounts of nutrients from reactors. Additionally, different fresh FVWs displayed dissimilar stabilization process. Molecular biological approaches revealed that earthworms could broaden bacterial diversity in their products, with significant greater populations of actinobacteria and ammonia oxidizing bacteria than in control. This study evidences that vermicomposting efficiency differs with the types and loadings of fresh FVWs and vermicomposts are rich in agricultural probiotics.

Su Lin Lim et al. (2016) shows that composting and vermicomposting are capable of degrading various types of organic waste, thus enabling them to be adopted widely. The present review also reveals that greenhouse gases are emitted during composting and vermicomposting processes. However, introductions of intermittent aeration, bulking agents and earthworm abundance may reduce the greenhouse gases emissions. Economic assessments of composting and vermicomposting technologies show that these technologies are generally viable except in some cases. The differences are due to the wide range in market value for organic fertilizer and differences in cost for the type of composing or vermicomposting system which could affect its economic feasibility. However, if organic fertilizer value increases and carbon offsets are available for nutrient recycling, it will affect the economic feasibility in a positive way.

Rama Lakshmanan et al. (2016) the possible utilization of natural and artificial banana leaf waste which were discharged from Marriage halls were collected and investigated for the enzymatic studies. The Natural and artificial banana leaf waste were mixed with cowdung in the ratio of 1:1 and kept aside in a shed for vermicomposting and composting. The isolated microbes were subjected for qualitative and the quantitative enzyme analysis for the naturaland artificial banana leaf waste. In that the presence of enzymes such as amylase, cellulase , protease and lipase contents in vermicompostand compost were identified. Thus the vermicompost and the compost enriched with enzymes greatly enhance the fertility of the soil. These technologies help in reduction of the organic load on land fill. According to obtained results the left over and old banana leaves processed to as vermicompost and compost may help boost crop yields in terms of economical production and organic farming.

Dr. Rosaline Mary et al. (2016) Vermicomposting is an efficient process by which the solid wastes generated using human activities such as domestic, commercial, and hospital, industrial, agricultural and mining activities. Vermicompost is a finely powdered material, peat like material containing high porosity, good aeration, drainage facility, water holding capacity, microbial activity, and excellent nutrient status and buffering capacity thereby resulting the required physicochemical characters congenial for soil fertility and plant growth. Vermicompost enhances the better quality of composts as compared with those prepared through traditional marks. Hence this present study focuses on the vermicomposting of kitchen wastes usingearthwormPerionyxexcavates and their effect on the growth on Coriander sativum.Due to its physical and chemical characters, Micro and Macro- nutrients vermicompost may be used to promote sustainable agriculture and also for the safe management of agricultural, industrial, domestic wastes which usually possesses serious threat to life and environment.

Neha Singh Chauhan et al. (2016) Biomethanation, by means of which „biogas" is obtained is a renewable, efficient and the good substituent of fossil fuels which are depleting very fast. In this paper we determine the optimal production of Biogas from different mixing ratios of Horticultural waste (HW), Cow dung (CD), and Poultry waste (PW) by the use of gravel filter and also the analysis of wash water and vermincomposting is also been done. The mixing ratios of horticultural waste and cow dung are (HW, CD) 1:1, 1:2, 1:3. The results showed that the co-digestion significantly influenced the biogas production and methane yield. The maximum biogas production is seen to be in the ratio 1:1. Similarly, the mixing ratios of Horticultural waste, cow dung and poultry waste are also been set up so as to analyses the enhancement in the production of biogas. The higher biogas yields were obtained from the ratio 1:1:1 (CD, PW, and HW). Gravel filter has been used and through that, wash water coming out from different ratios of wastes has been collected and analyzed and then vermin composting of the decomposed waste using earthworms is been performed and after that analysis of that vermincompost has also been done.

Balraj Khobragade et al. (2016) Earthworms can be effectively employed for the biodegradation of different types of organic wastes into substances which can be readily utilised by the plants. The nature of organic substrate is a deciding factor of vermicompost quality in cases where the earthworm species used and environmental conditions are kept constant. It can be reaffirmed that the biophysical and biochemical action of earthworm gut microflora on organic substrate renders it into a stabilised product. Apparently, the abundant presence of bacteria in the vermicompost is indicative of their active role in the composting process. The gradual decline in bacterial number in the final phases of composting process points towards the decreasing availability of the nutrients as a result of substrate exhaustion. Although the values of some micronutrients were high in the kitchen waste sample, the values of organic carbon, NPK and the C/N ratio suggest that the leaf litter sample was nutritionally richer than that of kitchen waste sample. Plant growth analysis following the application of vermicompost samples revealed the superiority of leaf litter sample as a fertiliser. Finally, it can be concluded that urban organic wastes can be converted into a valuable biofertiliser by the ecofriendly method of vermicomposting, which has been found to be a safe, hygienic, cost-effective and sustainable way of organic waste management, by many.

V. Sudharsan Varma et al. (2015) The effect of waste carbide sludge (WCS) with higher Ca content and pH buffering capacity was investigated during vermicomposting of agricultural waste. Agricultural waste mixture was prepared by mixing vegetable waste, cow dung, saw dust in (5:4:1) ratio for a total mass of 2.5 kg. In addition, 0.27 kg of dried leaves was added to all of the trials as bulking agent. Finally, the effect of WCS addition was experimented in five different trials of the same ratio of waste combinations but varying WCS concentration as following: 0.5% WCS was added in trial 1, 1% WCS in trial 2, 1.5% WCS in trial 3, 2% of WCS in trial 1 and 2.5% WCS in trial 5 respectively. Appropriate addition of WCS had no negative effects on the growth of biomass, as considerable increase of earthworm population was observed in WCS added trials as compared to the control. A maximum of 43.7% of total organic carbon reduction was observed in trial 3 when compared to all other trials. Higher biomass growth was observed in WCS added trials as compared to the control experiment proving the possibility of WCS effect on biomass growth. Total metal and micronutrient concentration was observed to increase toward the end of process.

Vincent Sequeira et a. (2015) Biodegradable residential solid waste was divided into its constituents like food waste, paper waste, vegetable waste and garden trimmings with grass and leaves. Each of these separately with cow dung slurry and a mixture of biodegradable waste with and without cow dung slurry were used as substrates for vermicomposting, using indigenous Eudrilus species earthworms procured from CPCRI, Kasargod. The vermicomposts obtained were subjected to microbial analysis for general communities and specific communities. The general communities include Bacteria, Fungi and actinomycetes and specific community includes Fluorescent Pseudomonads, P- Solubilizers and N2 Fixers. The study shows that the Eudrilus species was effective in converting residential waste into vermicompost except for food and vegetable wastes. Study highlights the inevitability of cow dung slurry in vermicomposting by using Eudrilus species. The present study not only underscores the feasibility of conversion of biodegradable municipal solid waste into vermicompost but also notes the presence and importance of beneficial and biologically active soil microorganisms in the vermicompost obtained.

S. KARMAKAR et al. (2012) Generation of organic wastes has been increased in an unprecedented rate in India with rapid population expansion, leading to disposal problems. These organic wastes can be converted into valuable wealth by applying vermicomposting technology. Vermicompost which provides macro and micro nutrients to the plants, also reduces pollution by providing a valuable substitute for chemical fertilizers. Present paper deals with vermicomposting of organic wastes from seven different sources and evaluation of nutrient in those vermicomposts following chemical analyses. These seven sources include coconut coir, water hyacinth, mixed materials, cabbage, banana pseudostem, cow dung, and rice husk. Three composting species of earthworms e.g. Eisenia. fetida, Eudrilus. eugeniae, and Perionyx excavatus were chosen for the experiment. Chemical analysis of vermicomposts under study clearly showed that the vermicompost from water hyacinth contained maximum amount of organic C, total N, and total K though the phosphorous content was maximum in vermicompost from mixed materials. Lowest nutrient content was observed in vermicompost of coconut coir. Vermicomposts from mixed materials, cabbage, and banana pseudostem were at per in their chemical properties. It can be concluded that among the seven sources, vermicompost from water hyacinth is best for its nutrient value.

CHAPTER 3
MATERIALS AND METHODS

3.1 Material used

3.1.1 Collection of material: Collection of banana plant stem, cow dung and vegetable waste in the present study, the Banana plant wastes were collected from the village parvatchhaprapadrauna, dist-Kushinagar (U.P) India. Collected materials were chopped into small pieces and allowed to pre-decompose for 40 days. Urine free cow dung was obtained from cattle shed Padraunadist-Kushinagar. Vegetable waste was collected from the vegetable market and different houses. Earthworms were collected from padariKushinagar. The partially decomposed material was mixed with cow dung in three different ratios (Table 1). The experiment was conducted in the bed of size (length 6, width 2 and height 2) ft. The bed was filled with Banana plant stem, cow dung, and vegetable waste according to the different treatments. Healthy, juvenile earthworms of Eisenia Fetida were released in the bed at the rate 40.

Table.1 Description of materials used and their ratio in the experiment.

Sample	**Ratio**
Cow dung	1
Cow dung and banana plant stem	3:2
Cow dung , banana plant stem and vegetable waste	3:1:1
Cow dung and vegetable waste	3:2

/

/

Fig.3.1 mixing of organic waste in different proportion.

3.2 Earthworms

Earthworm are several types which are used in carbon-based composting but the some worms are mostly use for vermicomposting mainly Eisenia Fetida which have high conversion rate about 55-60 days. Efficient epigamic species such as E. Fetida were compared with local earthworm species such as Perionyx sansibaricus, Pontoscolexcorethrurus and Megascolexchinensis for their composting efficiency. The efficiency was assessed in terms of the time taken for vermicomposting, quality of the compost and biomass potential of the earthworms at compost maturity. In this project Eisenia Fetida are use which are high conversion rate.

//

Fig. 3.2 species of earthworm Eisenia Fetida

3.3 Cow dung

Cattle dung offers food for a varied range of animal and mildew species, which pause it down and recycle it into the nutrition chain and into the topsoil. In areas where cows (or other animals with parallel dung) are not native, there are frequently also no native species which can breakdown their dung, and this can lead to infiltrations of pests such as flies and scrounging worms In Australia, slurry beetles from away have been presented to help reprocess the cattle dung rear into the soil. (See the Australian Dung Insect Scheme and Dr. George Bornemissza).[9] Cattle have a usual dislike to feeding round their own dung. This can main to the construction of bigger unglazed patches of extremely manured sward. These environment patches, termed "islets", can be helpful for many parkland arthropods, counting spiders (Araneae) and microbes (Hemiptera). They have an significant function in continuing biodiversity in heavily utilized grasslands.

/

Fig. 3.3 pre decomposition of cow dung

3.4 Banana plant waste

Banana is one of the world's utmost important fruit crops that is broadly cultivated in humid countries for its valued requests in food production. Its enormous by-products are an outstanding foundation of highly valued raw materials for additional industries by reutilizing agricultural waste. This stops an ultimate loss of massive amount of untapped biomass and environmental matters. This analysis discusses widely the advance in the utilization of banana by-products such as peels, leaves, pseudo stem, stalk and inflorescence in several food and non-food applications helping as coagulating agent, skin color and flavor, another source for function and micronutrients, nutraceuticals, cattle feed, normal fibers, and sources of accepted bioactive compounds and bio-fertilizers. Forthcoming prospects and tests are the significant key factors deliberated in suggestion to the sustainability and possibility of applying these by-products. It is significant that entirely available by-products be twisted into highly profitable outputs in instruction to withstand this renewable source and provide other income to small measure farming industries without cooperating its class and care in competing with further commercial crops. Banana is one of the initial crops cultivated in the antiquity of human farming. Banana by-products have remained used for wraps foods, clothes and used in many ceremonial times and the practice expands finished cultural divergence. Modern agriculture usually group's banana into fruit crop or cash crop produces alongside through several other crops such as oil palm, sugarcane, pineapple, mangoes and rice. Similarly, about of these commodities do produce massive amount of cellulostic discarded termed as cultivated waste or biomass. Origination in managing such a huge amount of agricultural waste and biomass is a continuous contest and current trends kindness the consumption of this biomass designed for value additional purposes to satisfy the need in the zones such as renewable dynamism, fiber mixtures and textiles, food replacements and livestock feedstuff. Readings on the cellulosticfibers after other farming wastes such as after the oil palm industries designated the excessive potential of these by-products to develop a viable raw material in creating extremely demanded produces such as paper and fiber compounds

/

Fig.3.4 collection of banana plant waste

Banana is grown in nearly each country in the world mainly in the tropical and subtropical countries where it has been sustainably cultivated and thus contributed to the country's economy. India remains the largest banana producing country in the world, which produce more than 25 % of the world's banana production

3.5 Vegetable waste

Vegetable wastes occur throughout the supply chain and vary widely depending on its processing. Globally, more than 30 % of the loss occurs at the retail and consumer levels, of which the post-harvest and processing level wastages account for the major share. The wastes so generated pose an environmental threat and call for the development of a pollution-free model. Studies on the characterization of unutilized, rotten, and discarded fractions of the vegetable wastes indicate their potential candidature for reprocessing. Generation of renewable dynamism by bioconversion of potato wastes is ahead significance as it has verified to be a capable means of applying the fresh vegetable residues. Researchers and industries are nowadays fully engaged in an amount of projects including the technology of ‘‘waste to fuel’’ with an understanding to overcome the dumping problems. The present item deals through the studies directed on vegetable wastes for manufacture of several types of biofuel.

/

Fig.3.5 collection of vegetable waste

Vegetable and fruit wastes are an unusual group of biomass that wants to be characterized to know its nature for request as raw material and to suggest the best methodology for its suitable utilization. Waste arrangement also effects the complete yield and kinetics of the biologic reaction through digestion.

3.6 Nutrient Enrichment: The manurial value of a compost is determined by its plant nutrient content, while the quality of a compost is determined by the composition of the base material.

3.7 Method for the Faster Multiplication of Earthworms

Accordingly, the present invention provides an efficient method for the faster multiplication of earthworms and production of superior quality vermicompost from the distillation waste of industrial aromatic crops, where said method comprising steps of:

(a) Drying of distillation waste obtained after distillation of herbage for 2-5 hours at 10-40 lbs. Steam pressure in open for 10-72 h,

(b) Chopping the waste into small pieces of at least 15 cm,

(c) Transferring this material of about 20-30 cm layer into compost pits containing about 7-10 cm layer of partially rotten cow dung banana plant and vegetable waste with 40-45 earthworms/bed,

(d) Daily watering of the pits to keep the plant material moist and covering them to check the loss of humidity,

(e) Reloading the pits about 20-30 cm layer with the chopped distilled waste after 30-35 days,

(f) Restricting watering after complete degradation of the added material,

(g) Harvesting of the dried material and shade drying the same for 4-5 days and

(h) Sieving the harvested compost to remove earthworms.

3.8 Methods of Vermicomposting

3.8.1 Bed method: In bed method, the open bed is constructed which are uses 1st class bricks, and the bottom of the bed is fixed to restrict the worms. The bed method is easy to maintain so that is why we used the bed method. Vermicompost was developed in four different ratios that are why four beds are required for sample and size of the bed is (6x2x2) ft. The bed was constructed on the pucca / kachcha flor using 1st class bricks. This size bed is used for small-scale vermicomposting for personal requirements (5-10 tonnes of vermicompost annually). This method is easy to maintain and practice. The tops of the beds were covered with thin mesh, to allow gaseous exchange.

//

Fig 3.6 preparation of open bed

3.8.2 Pits below the ground: Pits made for vermicomposting are 1 m deep and 1.5 m wide. The length varies as required.

3.8.3 Heaping above the ground: The waste material is spread on a polythene sheet placed on the ground and then covered with cattle dung. Sunitha et al. (1997) compared the efficacy of pit and heap methods of preparing vermicompost under field conditions. Considering the biodegradation of wastes as the criterion, the heap method of preparing vermicompost was better than the pit method. Earthworm population was high in the heap method, with a 21-fold increase in Eudriluseugenae as compared to 17-fold increase in the pit method. Biomass production was also higher in the heap method (46-fold increase) than in the pit method (31-fold). Consequent production of vermicompost was also higher in the heap method (51 kg) than in the pit method (40 kg).

3.8.4 Tanks above the ground: Tanks made up of different materials such as normal bricks, hollow bricks, shabaz stones, asbestos sheets and locally available rocks were evaluated for vermicompost preparation. Tanks can be constructed with the dimensions suitable for operations. At ICRISAT, we have evaluated tanks with dimensions of 1.5 m (5 feet) width, 4.5 m (15 feet) length and 0.9 m (3 feet) height. The commercial biodigester contains a partition wall with small holes to facilitate easy movement of earthworms from one tank to the other.

3.8.5 Cement rings: Vermicompost can also be prepared above the ground by using cement rings (ICRISAT and APRLP 2003). The size of the cement ring should be 90 cm in diameter and 30 cm in height. The details of preparing vermicompost by this method have been described in a later section.

3.8.6 Commercial model: The commercial model for vermicomposting developed by ICRISAT consists of four chambers enclosed by a wall (1.5 m width, 4.5 m length and 0.9 m height) (Fig. 2). The walls are made up of different materials such as normal bricks, hollow bricks, shabaz stones, asbestos sheets and locally available rocks. This model contains partition walls with small holes to facilitate easy movement of earthworms from one chamber to another. Providing an outlet at one corner of each chamber with a slight slope facilitates collection of excess water, which is reused later or used as earthworm leachate on crop. The outline of the commercial model is given in Figure 3.7

The four components of a tank are filled with plant residues one after another. The first chamber is filled layer by layer along with cow dung and then earthworms are released. Then the second chamber is filled layer by layer. Once the contents in the first chamber are processed the earthworms move to chamber 2, which is already filled and ready for earthworms. This facilitates harvesting of decomposed material from the first chamber and also saves labor for harvesting and introducing earthworms. This technology reduces labor cost and saves water as well as time

/

Figure 3.7. Diagrammatic representation of the commercial model with chambers for vermicomposting.

3.9 STABILITY ANALYSIS Stability is an important compost quality characteristic, but also one that is difficult tomeasure. A simple respire-metric technique for the assessment of compost stability (SOUR test) was developed, that utilize a dissolved oxygen probe to measure changes in the oxygen concentration in an aqueous compost extract, under conditions ensuring optimum microbial activity and maximum reaction rates.

Instrumentation a schematic diagram of the respirometric system is shown in Fig.3.7.

/

Fig 3.8 Schematic diagram of the experimental setup for the SOUR test

Measuring oxygen consumption of an aqueous compost suspension (SOUR test), instead of a solid matrix, as in most traditional respiration tests, offers certain advantages. These advantages include: the test is not affected by variations in the matric water potential of the samples; there is immediate contact between substrate, microbes and oxygen leading to maximum reaction rates; and the gas±liquid barrier for oxygen diffusion at the surface of the compost particles is omitted.

3.10 Plant growth and development.

Beginning second week after transplanting, the impact of substrate medium on plant growth/development, yield and nutrient uptake in strawberry was studied. Biweekly, the following parameters were measured: the number of runners (stolons), leaf number, fruit number, fruit fresh weight, yield, fruit size, marketability (score 1–4; 1 – extra quality; 2 – good quality; 3 – medium quality; 4 – non marketable).

3.11 PHYSICAL PARAMETERS OF VERMICOMPOST

3.11.1 Determination of pH

It is defined as the negative log to the base 10 of the H+ ion concentration. The pH of the sheet materials was determined Potentiometric method using a digital pH meter. Thirty gm of air-dried sample passed through a 2mm sieve was transferred to a clean 100ml beaker to in which 60ml of distilled water was added. The contents were stirred intermittently and the sample suspension was again stirred just before taking the reading. The electrodes were immersed into the beaker containing sample water suspension and meter readings both in the supernatant solution and suspension were recorded.

3.11.2 Determination of Electrical Conductivity (EC)

Electrical conductivity is the quantity of complete amount of soluble salts existing in the sample and is expressed asmillisimens/cm (mS/cm). To 5 gm of the trial sample, 50 ml of distilled water was added, enthused well and the suspension was permissible to settle for 8 hrs. The electrode of the conductivity cell was deep into the sample solution and the EC was read and expressed in millisimens/cm (mS/cm).

3.12 CHEMICAL PARAMETERS OF VERMICOMPOST

3.12.1 Estimation of Organic Carbon by Empirical Method

The determination of organic carbon was accepted available as per the procedure ofEmpirical Method. Accurately 1 g of finely ground oven dried sample (at 105^{0}C) was placed in a constant mass silica crucible and heated in a muffle furnace at 550^{0}C for 2 h. The crucible was permitted to cool down in a dessicator and over weighed.

Organic Matter=,initial value –final value -initial value..×100

The ratio of carbon content to volatile substance content remains to some extent for a particular type of organic waste. The volatile substance in the sample was determined as for organic matter estimation

Organic Carbon ,%.=,VS-A. = ,Organic Matter(%)-1.724.

Where, A = a constant 1.724 (Walkley and Black, 1934)

VS = Volatile substance percent (organic matter percentage

3.12.2 Estimation of Total Nitrogen (N)

The total nitrogen of the sample was estimated by Kjeldahl method. This method involved two steps (i) digestion of the sample to convert the N compound in the sample to the NH4+ form and (ii) distillation and determination of NH4+ in the digest. (i) To a 100ml Kjeldahl flask 0.5gm of dried sample was transferred. Twenty ml of the sulphuric salicylic acid mixture was added and swirled gently so as to bring the dry sample in contact with the reagents. It was allowed to stand overnight. About 5gm of sodium thiosulphate was added the next day and heated gently for about 5 min. Care was taken to avoid frothing. The contents were cooled to which 10gm of sulphate mixture was added and digested in the Kjeldahl apparatus for 1 hr. Bumping during the digestion can be avoided by adding glass beads. When the digestion was completed, the digest was cooled, diluted and distilled as follows.

(ii) To a vacuum jacket of micro- Kjeldahl distillation apparatus, 10ml of the digest was transferred. In a conical flask, 10ml of 4% boric acid solution was taken containing bromocresol green and methyl red indicators, to which the condenser outlet of the flask was dipped. After adding the aliquot digest, the funnel of the apparatus was washed with 2-3 ml of deionised water and 10ml of boric acid. After completion of distillation, boric acid was titrated against N/200 H2SO4. Blank was also carried out to the same end point as has been followed in the case of the sample.

Weight of the sample = 0.5gm Normality of H2SO4 = N/200

Volume of digestion = 100ml; Aliquot taken = 5ml

Titrant Value (TV) = Sample TV-Blank TV

N,%.=,TV×0.00007×100×100 -0.5×0.5.(1 ml of,N-10H2SO4.+ =0.000014 gm N)

3.12.3 Estimation of Phosphorus

3.12.3.1 Diacid digestion

Using a 9:4 mixture of HNO3 carried out Diacid digestion: HClO4. One gm of ground sample was placed in a 1000ml volumetric flask. To this, 10 ml of acid mixture was added and the contents of the flask were mixed by swirling. The flask was placed on a hot plate at low heat in a digestion chamber. The flask was subsequently heated at higher temperature until the production of red NO2 fumes ceases. The contents were further evaporated until the volume was reduced to about 3- 5 ml but not to dryness. The completion of digestion was confirmed when the liquid becomes colourless. After cooling the flask, 20ml of deionised or glass distilled water was added and the solution was made upto the mark with deionised water. Then it was through Whatman No.1 filter paper

.

3.12.3.2 Determination of Phosphorus (P)

Total phosphorus content of the sample was estimated by colorimetric method. The aliquot from sample digestion was pipetted out to 50ml volumetric flask. Then 10ml of vanadomolybdate reagent was added to each flask. The volume was made up with deionised water and mixed thoroughly (by shaking). Yellow colour was developed in about 30 minutes (The colour is stable for 2-3 weeks). The absorbance / transmittance of the solution was read at 420nm with a spectrophotometer. The phosphorus concentration was determined using the prepared standard curve. *P,%.=Sample conc.,ppm.×,1-weight of sample. ×,100-,A liquid-(ml).. ×,final vol.(ml)-1000.*

3.12.4 Digestion of Sample by Dry acing Method.

For the estimation of K, Ca, Mg, Na, Zn, Fe, Mn and Cu, digestion of manure sample by dry ashing method was followed as shown below. To carry out dry ashing, 1.0 gm of ground, sieved and oven dried (at 1050 C) sample was taken in a silica crucible, placed in a muffle furnace and heated at 5500 C for 5 hrs. The ash was then cooled and dissolved in 10ml of 6N HCl. The solution was filtered through an acid washed filter paper into a 100 ml volumetric standard flask. The filter paper was washed and the solution was made upto the mark with deionised water.

3.12.5 Estimation of Potassium

Total potassium content of the manure sample was determined as per Tandon(1993) by flame photometric method. The unknown sample was atomized in the flame photometric and the readings were recorded. The potassium concentration was determined using the prepared standard curve and multi with dilution factor.

3.12.6 Estimation of Calcium and Magnesium (Ca & Mg)

3.12.6.1 Determination of Calcium

The calcium and Magnesium contents of the sample were determined as per procedure of Tandon (1993). An aliquot of the sample solution containing upto 3mg calcium was pipetted out into a china dish and diluted to 10ml. About 10 droops of each of potassium cyanide, hydroxylaminehydrochloride, and potassium hexacyofarrate and triethanolamine solution were added. Also 2.5 ml NaOH solution and one ml of calcon solution were added. Then, the contents were titrated against 0.01N EDTA until the colour changed from wine red to blue using EBT indicator.

3.12.6.2 Determination of Ca and Mg

An aliquot of sample solution containing upto 3.0mg of Ca and Mg was pipetted out into a China dish and diluted to 10ml. to this 15ml of ammonium chloride, ammonium hydroxide buffer solution, about 10 drops of each of potassium cyanide, hydroxylamine hydrochloride, potassium hexacyofarrate and triethanolamine solution were added. After adding all these reagents, the solution was warmed for 3 min., cooled and 10 drops of Erichrome Black-T (EBT) indicator solution was added. The contents were titrated with EDTA.

3.12.7 Determination of Magnesium

Magnesium content was calculated from the difference between the content Ca+ Mg and the calcium content.For calculation of percentage of calcium and magnesium, the milliequalants of Ca or Mg are to be multiplied by their respective equivalent weights (Meq X Eq. wt/mg). Then 10 to get Ca or Mg percent per gm of sample divided the value.

Ca or ,Ca+Mg.,meq-gm. =,ml. of EDTA consumed ×Normality of EDTA-A liquid taken. ×Vol.

3.12.8 Estimation of Sulphur

Total sulphur content was normally estimated by wet ashing of plants tissue sample (manure) (as described under phosphorous Diacid digestion) and the sulphate turbidimetymethod.Ten ml aliquot from sample Diacid digestion (described as phosphorous) was pipetted out to volumetric flask to which 25ml of salt buffer solution was added. The volume was made up with deionised water upto 50ml and mixed thoroughly. Ten ml each of the above solutions was pipetted into a 50 ml conical flask.One ml of 6N HCl and 1ml of 0.05% gum acacia solutions were added. Swirling and 0.5 gm of barium chloride crystals were dissolved mixed the content. The absorbance or transmission of the solution was read on a spectrophotometer at 420nm. Sulphur concentration was determined using the prepared standard curve.

3.13. Standard value of compost

The standard values of vermicompost given by FCO and this value is compare with the prepared vermicompost. The prepared vermicompost is four different mixed and proportion. All prepared vermicompost test result is lies in between the given standard values by FCO.

Table 2. Quality standards of vermicompost given by FCO.

1. Moisture percent by weight	15.0—25
2. Color	Dark brown to black
3. Odor odor	Absence of foul
4. Particle size should	Minimum 90% material pass through 4.0 mm IS sieve
5. Bulk density (g/cm	0.7—0.9
6. Total organic carbon, percent by weight, and minimum	18.0
7. Total nitrogen (as N), percent by weight, and minimum	1.0
8. Total phosphate (as P2O5), percent by weight, and minimum	0.8
9. Total potassium (as K2O), percent by weight, and minimum	0.8
10. Heavy metal content, (as mg/kg), maximum	
Cadmium (as Cd)	5.0
Chromium (as Cr)	50.00
Nickel (as Ni)	50.00
Lead (as Pb)	100.00

CHAPTER 4

RESULT AND DISCUSSION

4.1 Treatment of vermicompost and result comparison

In this method, efficient epigamic species such as E. Fetida is used and prepared vermicompost were compared with local available vermicompost. The efficiency is assessed in terms of the time taken for vermicomposting, quality of the compost and biomass potential of the earthworms at compost maturity Vermicomposting with different types of organic waste and different ratio mixed prepared sample and conventional composting were conducted using a Completely Randomized Design with five conditions and four replications.

The tests were carried out at the ambient temperature of 28–32^0 C with the moisture maintained at 40% by sprinkling 250 ml water/bed on alternate days. Composting was carried out in open bed of volume 45 cm3 in thatched sheds. 40 adult E. Fetida worms were introduced into 150 kg of pre-treated organic waste. When the compost was ready by its physical appearance, as judged by development of a dark brown to black color with uniformly disintegrated structure, watering was stopped.

One or two days later, the compost was removed from the tank together with the worms, heaped on a paddy waste and kept in the shade. The compost was removed from the top leaving the earthworms in a bundle at the bottom. The total biomass of earthworms was estimated by counting the number of adults, juveniles and cocoons from each replication. Conventional compost, i.e. without earthworms, was also prepared both by sealed and open methods for comparison. The times taken for composting and compost recovery were noted. The ratio of decomposed (2 mm) of the organic waste by weight in the compost was determined by sieving.

Samples of air dried compost were used for fractionation and chemical analysis. Compost samples were analyzed for pH, total organic carbon (C), total nitrogen (N),CNC phosphorous (P), C/N ratio, calcium (Ca), magnesium (Mg), potassium (K), manganese (Mn), zinc (Zn), and copper (Cu). The samples were analysed based on standard analytical procedures for alkali extractable carbon, humic acid, fulvic acid, oxidisable carbon, humic carbon and fulvic carbon. To assess the degree of maturity of the compost, different humification indices were calculated: i.e. Humification ratio (HR) – alkali extractable carbon/ oxidisable carbon, Humfication Index (HI) – humic carbon/oxidisable carbon, Percentage humic acid (Pha) – humic carbon/alkali extractable carbon multiplied by 100.

/

Graph. 4.1. Micronutrient content of different composts in the comparative study to assess the efficiencies of earthworm species for biodegradation of organic wastes.

The SOUR check measures compost stability by calculating the amount of freely degradable organic matter quiet current in the sample, complete its carbonaceous oxygen petition. The potential errors, make known to by nitri®cation during testing are therefore important. However, this problem can be simply addressed by adding a nitri®cation inhibitor to the sample. The essential temperature of the windrows reached 508^{0}C in the ®rst 2±3 d and was continuous at this level for the complete composting period. The deviation of the physical and chemical features of the compost through time has been presented but was generally characteristic of the material and the composting system used. The variation of the planned stability indicator, the SOUR, is presented in below fig.

/

Graph. 4.2. Variation with composting time of the SOUR for two different batches of compost

4.2 Physical and chemical analysis

The properties of the vermicompost samples that is physical and chemical are given in Table 2 and 3. The bulk density (BD) of the test-samples ranged from 0.79—0.81g/cm3, yet around has been significant variance among the samples. However, these additional are within the limits suggested in the Fertilizer Control Order (FCO) standard. Shockingly, the moistness of the testsamples are found to be in height while compared to the FCO standard, the equivalent ranged from 48.62 51.37%. It means that curing of these items has not been complete properly. Electrical conductivity (EC) of the test-samples range from 1.90 to 4.99 ds/m. Sample changes in this respect was found to be extremely significant. Though this parameter is not combined in the FCO standard, the FCO schedule in city vermicompost has been specified to be 4.0 ds/m which corroborates with the three of the 4 test-samples. The pH values of the test samples range between 5.74 and 6.54, which continue a bit lesser than that specified for vermicompost. Differences in pH between the samples tested were set up to be extremely significant. The results show that there rests scope to right to bring the final pH of the making within the neutral range. The whole organic carbon content of the trial samples varied from 17.23 to 19.73% of which the sample S2 ranked below the lowest standard as per FCO requirement. Changes among the samples with deference to entire organic carbon content look like to be statistically substantial. It is here indication commendable that organic carbon plays sure vital roles in successful soil pH, microbial population and soil enzyme actions separately from various others in soil collection mechanism. The chemical properties of the compost samples are existing in Table 3. The mean content of total nitrogen (1.34%) in complete the test samples are fine above the lowest standard, the maximum rank in this honor has been occupied by the sample S4. It is quite shocking that mean total phosphorus content of the test-samples was originate to be pretty high (1.56%), much above the least of FCO standard.

Table 3. Physical properties of theVermicompost

Samples	BD (g/cm^3)	MC (%)	pH	EC Ds/m	TOS (%)
S_1	.79	48.62	5.74	1.90	18.18
S_2	.79	50.99	6.12	4.99	7.43
S_3	.81	51.37	6.54	3.32	20.65
S_4	.80	49.53	6.10	4.05	18.99
Mean	.7975	50.1275	6.125	3.565	16.3125
CD (5%)	.0075	.0075	.005	.005	.0025

S_1= sample 1 cow dung and banana plant

S_2= sample 2 cow dung, banana plant waste and vegetable waste

S_3= sample 3 cow dung

S_4= sample 4 cow dung and vegetable waste

BD= bulk density

MC= moisture content

EC= electrical conductivity

Three of the four samples of vermicompost (0.86 and 1.06%), so far tested, appears to have huge amount of total potassium (above the minimum FCO standard), simply the sample S3 (0.75%) had lesser content of potassium. The mean heavy metal content, mainly cadmium (3.60 mg/kg) and chromium (44.09 mg/kg), of the test-samples is found to keep on within allowable limit as listed in the FCO standard. Sample changes with deference to these 2 heavy metals are set up to be statistically substantial. Variation in deference to nutrient contents strength have been resulted owed to the difference in the kind of raw materials used in the vermicomposting process. Enhancement in the nutrient standing of vermicompost could be complete possible through choosing ideal raw materials (subject to local availability) as testified by other workers. To achieve developed nutrient position of vermicompost, accent has been known to include animal and farmed residues in the raw materials.

Table 4. Chemical properties of the vermicompost

Samples	TN (%)	TP (%)	TK (%)	Cadmium (mg/kg)	Chromium (mg/kg)
S_1	1.15	1.42	.83	3.42	36.76
S_2	1.1	1.70	1.12	3.64	45.83
S_3	1.67	1.54	.80	2.82	46.46
S_4	1.45	1.62	.89	4.53	47.34
Mean	1.34	1.56	.90	3.60	44.09
CD (5%)	.0025	.01	.01	.0025	.0075

In all four sample the chemical property are given in the table 3 in which the total nitrogen in sample 3 is maximum 1.67 in other 3 sample. But in case of total phosphorous the sample 2 is maximum 1.70. And same as potassium the maximum value is 4.53 of sample 2. In cadmium and chromium has maximum value 4.53 and 47.3 respectively of sample 4.

/

/

Fig. 4.1 finished vermicompost after cultivation

Table. 5 NUTRIENTS COMPARISON

Nutrient element	Vermicompost	Local available vermicompost
organic carbon	9.7-13.67	12.1

nitrogen	0.61-1.81	0.75
phosphorus	0.29-1.20	0.30
potassium	0.17-.078	0.50
calcium	1.18-7.91	2.17
magnesium	0.092-0.578	0.51
sodium	0.059-0.168	0.01
Zinc	0.0042-0.110	0.0012
copper	0.0026-0.0048	0.0017
Iron	0.2050-1.33313	1.169
manganese	0.0105-0.2038	0.0414

Nutrients arecompare of prepared vermicompost and locally available vermicompost. In this comparison prepared vermicompost is high value of element of vermicompost which are given in the above table 5.

CHAPTER 5
CONCLUSION AND SCOPE FOR FUTURE STUDIES

5.1 CONCLUSION

1. Eisenia. Fetida reduced the time required for vermicomposting significantly due to a maximum feeding rate. The reproductive potential of 40 Eisenia. Fetida 150kg of vermicompost in 55 days exceeded that for other local earthworms in 60 days. Humiliation indices provided a higher degree of vermicompost maturity for other worm'svermicompost. The enrichment had a major effect on the nutrient at ease of composts, particularly N, P and K. Use of vermicompost as a bio inoculant stimulated the nitrogenize enzyme activity in cow-pea, improved the quality of products in banana cow dung and vegetable waste and stimulated higher tuber establishment in cassava. It increased the availability of N and P and encouraged multiplication of beneficial micro-organisms. By attaching vermitechnolgy, the conversion from chemical nutrition to bio-nutrition can be fast, without an important harm in yield. This helps in the controlling of land without disturbing ecological processes. Thus it can support complete Workable Land Management, the foundation of Sustainable Farming.

2. Vermicomposting involves harnessing the services of epigamic earthworm species which consume the surface litter for the conversion of organic wastes into vermicompost, to produce excellent organic compost.

3. Earthworms consume various types of organic waste mainly cow dung under favorable conditions; these include agriculture waste like banana waste, and vegetable waste.

4. Composting which harnesses these appearingFetida worms is a faster way of organic decomposition than clean vermiculture method using profound burrowing worms.

5. The SOUR test appeared to be proper for the evaluation of process usefulness, as it could differentiate among the two process plans.

6. The present-day findings highlight the assumed to use of organic medium i.e. Sawdust on top of the widely used coco soil as substrate medium in strawberry culture. The presentation of plants grown on Pum-Saw (50-50), followed by the Coc-Saw (50-50) and then by Coc-Pum (50-50) is markedly influenced by the media and the alteration of physicochemical properties (such as porosity, water content and air capacity) of raw material and hence the air and water balance in the root environment. Further research study is necessary for the complete exploitation of the putative use of sawdust in substrate mixtures as pure or composted material and of its ability to improve physicochemical properties as substrate.

Medium, identifying the accurate ratio mixed into substrates as well as appropriate open bed height (to improve water properties of the media), for hydroponically grown of crops.

The prepared vermicompost $s_{1,}$ s_2, s3 and $s_4$all are reach in nutrients but the sample of cow dung and banana plant waste is high and growth of trial planta are excellent.

5.2 Scope for future studies

The future scope of the work shall be to use the vermicompost to use the vermicompost to bioremediation the polluted water of rivers/ streams in order to remove toxic cum heavy metals from it.

5.3 PRACTICAL APPLICATION OF VERMICOMPOST

Compostis used in mostly farming that is in garden, lawn, around trees, in nurseries on farm fields for house plants.

CHAPTER 6

REFERENCE

[1] Gupta, C., Prakash, D., Gupta, S., &Nazareno, M. A. (2019). Role of Vermicomposting in Agricultural Waste Management. In *Sustainable Green*

Technologies for Environmental Management (pp. 283-295). Springer, Singapore.

[2] Arancon, N. Q., &Solarte, Z. (2019). Vermiculture in Greenhouse Plants, Field Crop Production, and Hydroponics. In *Oxford Research Encyclopedia of Environmental Science*.

[3] Karmegam, N., Vijayan, P., Prakash, M., & Paul, J. A. J. (2019). Vermicomposting of paper industry sludge with cowdung and green manure plants using Eisenia fetida: a viable option for cleaner and enriched vermicompost production. *Journal of Cleaner Production*, *228*, 718-728.

[4] Parmar, H. C., Mor, V. B., & Patel, S. R. (2019). Vermicomposting of Banana Pseudostem and Maize Fodder (Waste) Using Eudriluseugeniae. *Current Journal of Applied Science and Technology*, 1-9.

[5] Li, W., Bhat, S. A., Li, J., Cui, G., Wei, Y., Yamada, T., & Li, F. (2020). Effect of excess activated sludge on vermicomposting of fruit and vegetable waste by using novel vermireactor. *Bioresource Technology*, 122816.

[6] Hussain, N., & Abbasi, S. A. (2018). Efficacy of the vermicomposts of different organic wastes as “clean” fertilizers: state-of-the-art. *Sustainability*, *10*(4), 1205.

[7] Mupambwa, H. A., &Mnkeni, P. N. S. (2018). Optimizing the vermicomposting of organic wastes amended with inorganic materials for production of nutrient-rich organic fertilizers: a review. *Environmental Science and Pollution Research*, *25*(11), 10577-10595.

[8] Kostecka, J., Garczyńska, M., Podolak, A., Pączka, G., &Kaniuczak, J. (2018). Kitchen Organic Waste as Material for Vermiculture and Source of Nutrients for Plants. *Journal of Ecological Engineering*, *19*(6).

[9] Bidabadi, S. S. (2018). Waste management using vermicompost derived liquids in sustainable horticulture. *Trends in Horticulture*, *1*(3).

[10] Chatterjee, R., Gajjela, S., &Thirumdasu, R. K. (2017). Recycling of organic wastes for sustainable soil health and crop growth. *International Journal of Waste Resources*, *7*(3), 2-8.

[11] Chanu, T. I., Sharma, A., Ande, M. P., Prasad, J. K., & Patnaik, R. R. S. (2017). Vermicompost Production Technology for Organic Aquaculture. *Aquaculture Times*, 24-28.

[12] Huang, K., Xia, H., Li, F., Wei, Y., Cui, G., Fu, X., & Chen, X. (2016). Optimal growth condition of earthworms and their vermicompost features during recycling of five different fresh fruit and vegetable wastes. *Environmental Science and Pollution Research*, *23*(13), 13569-13575.

[13] Lim, S. L., Lee, L. H., & Wu, T. Y. (2016). Sustainability of using composting and vermicomposting technologies for organic solid waste biotransformation: recent overview, greenhouse gases emissions and economic analysis. *Journal of Cleaner Production*, *111*, 262-278.

[14] Lakshmanan, R., &Muthunarayanan, V. (2016). Enzymatic analysis of Natural and Artificial Banana Leaf waste in Vermi-composting and Composting Technique. *Journal of Advanced Applied Scientific Research*, *1*(6), 50-61.

[15] Mary, R., Kalaimathi, A., & Parthasarathy, N. (2016). COMPARATIVE ANALYSIS OF MIXED VEGETABLE WASTES AND LEAF LITTER VERMICOMPOST USING THE EARTHWORM PERIONYX EXCAVATUS.

[16] Chauhan, N. S., Pandey, R., &Beohar, P. Horticulture Waste Management by Biomethanation and Vermiculture Technology and Analysis of Its Liquid Bio-Fertilizer.

[17] Khobragade, B., Kale, P., & Bale, S. IAssessment of Fertiliser Quality and Plant Growth Dynamics of Vermicomposts obtained from Oligochaete Action on different Organic Wastes.

[18] Varma, V. S., Yadav, J., Das, S., &Kalamdhad, A. S. (2015). Potential of waste carbide sludge addition on earthworm growth and organic matter degradation during vermicomposting of agricultural wastes. *Ecological engineering*, *83*, 90-95.

[19] Sequeira, V., & Chandrashekar, J. S. (2015). Vermicomposting of biodegradable municipal solid waste using indigenous Eudrilus sp. earthworms. *Int. J. Curr. Microbiol. App. Sci*, *4*(4), 356-365.

[20] Karmakar, S., Brahmachari, K., Gangopadhyay, A., & Choudhury, S. R. (2012). Recycling of different available organic wastes through vermicomposting. Journal of Chemistry, 9(2), 801-806.