VERMICOMPOSTING

Introduction

Soil fauna play a prominent role in regulating soil processes and among these the termites and the earthworms play a vital role in maintaining soil quality and managing efficient nutrient cycling. In organic farming practices the soil is considered to be a living component with physical, chemical and biological characteristics. For much of the past decade, homeowners, farmers and solid waste managers have looked with greater interest at the potential of worms to transform wastes into beneficial resources such as compost. This compost is generally called as **Vermicompost or** wormi-compost in which controlled degradation or composting of organic wastes primarily occurs due to earthworms. Hence it is a method of making compost with the use of earthworms, which generally live in soil, eat bio-mass and excrete it in digested form.

Organic wastes can be broken down and fragmented rapidly by earthworms, resulting in a stable nontoxic material with good structure which has a potentially high economic value as soil conditioner for plant growth. Vermicompost is finely divided peat like material with excellent structure, porosity, aeration, drainage and moisture-holding capacity. Low, medium and high technology systems are available. Vermicomposting involves great reduction in populations of pathogenic microorganisms, thus not differing composting from this point of view. Even low, medium and high technology systems are available to increase quality of the vermicompost.

Finished vermicompost should have a rich, earthly smell if properly processed by worms. Vermicompost can be used in potting soil mixes for house plants and as a top dressing for lawns. Screened vermicompost combined with potting soil mixes make an excellent medium for starting young seedlings. Vermicompost also makes an excellent mulch and soil conditioner for the home garden.

The best natural means of converting waste is vermicomposting and let us understand this in details in this episode in the following headings

1. **Organic wastes use for vermicomposting**
2. **Earthworms used in vermicomposting**
3. **Gut microflora of earthworms**
4. **Process of Vermicomposting**
5. **Advantages and disadvantages of vermicomposting**

- **ORGANIC WASTES USED FOR VERMICOMPOSTING**

The biologically degradable and decomposable organic wastes commonly used as composting materials in vermiculture and vermicomposting are: animal dung, agricultural waste, forestry wastes, city leaf litter, waste paper, cotton cloth, city refuge, biogas slurry, and industrial wastes. Utilizable wastes for vermicomposting can also be generated from different sources like house hold waste, industrial wastes etc. (Table 1).

Earthworms can be fed all forms of food waste, yard and garden waste, paper and cardboard, etc. Yard wastes, such as leaves, grass clippings, straw, and non woody plant trimmings can be composted. Leaves are the dominant organic waste in most backyard compost piles. If grass clippings are used, it is advisable to mix them with other yard waste; otherwise the clippings may compact and restrict airflow. Branches and twigs greater than 1/4th inch in diameter should be put through a shredder/chipper. Kitchen wastes such as vegetables scrape, coffee grounds, and eggshells may also be added. Sawdust may be added in moderate amounts if additional nitrogen is applied. Wood ashes act as a lime source and if used should only be added in small amounts (5 Kg per ton of waste).

Source of waste generation	**Utilizable waste for vermicomposting**
Agricultural waste	
Agricultural fields	Stubbles, weeds, husk, straw and farmyard manure.
Plantations and gardens	Stems, leaf matter, fruit rinds, stubbles, grass clippings.
Animal waste	Dung, urine and biogas slurry.
Urban solid waste	Kitchen waste from households and restaurants, waste from market yards and places of worship and sludge from sewage treatment plants.
Agro industry waste	
Food processing units	Peels, rinds and unused pulp of fruits and vegetables
Vegetable oil refineries	Pressmud and seed husk
Sugar factories	Pressmud, fine bagasse and boiler ash
Breweries and distilleries	Spent wash, barley waste and yeast sludge
Seed processing units	Core of fruits, paper and seeds after expiry date

Aromatic oil extraction units Coir industry Tissue culture units	Stems, leaves and flowers after extraction of oil Coir pith Paper, agar wasted plantlets

Table 1: Utilizable wastes from different sources.

- **EARTHWORMS EMPLOYED IN VERMICOMPOSTING**

Earthworms have 600 million years of experience as waste and environmental managers managing bio-waste including human waste, soil and land on earth. Aristotle called them as 'intestine of earth' meaning that they can digest a wide variety of waste materials from earth. About 4,400 different species of earthworms have been identified, and quite a few of them are versatile waste eaters and bio-degraders and feed on variety of organic wastes. It promotes the growth of 'beneficial decomposer bacteria' in waste biomass and acts as an aerator, grinder, crusher, chemical degrader and a biological stimulator.

Earthworms affect ecosystem structure and function directly by ingesting, altering and mixing organic residues and mineral soil. Through these actions, they change the structure, chemistry and biology of soil. Earthworms are classified into three ecological groups based on their distinct feeding and burrowing habits. Stable isotope analysis has confirmed and refined conventional ecological classification systems. Epigeic earthworms live above mineral soil, rarely form burrows and feed preferentially on plant litter. Endogeic earthworms forage below the surface soil, ingest large quantities of mineral soils and humified material, and they build ramified, predominantly horizontal, burrows. Anecic earthworms build permanent, vertical burrows deep into the mineral soil layer, and they come to the surface to feed on partially decomposed plant litter, manure and other organic residues. The ecological groups of some common, but not all earthworm species are clearly established. For example, *Aporrectodea caliginosa* is an endogeic and both *Lumbricus terrestris* and *L. friendi* are anecic species.

The various species of earthworms have different environmental requirements which are necessary for their propagation and continued health. These requirements will inevitably dictate whether one particular “family” of worms will be suitable for culture in any given circumstance. For instance, though many people may be interested in the possibility of raising *Lumbricus terrestris* (The nightcrawler, or Dew worm) in the house as a source of fishing bait, this is simply not very plausible when we consider that this particular worm prefers temperatures in the area of 5-10°C.

On the other hand, the two most commonly-used worms for vermicomposting, *Eisenia foetida* and *Lumbricus rubellus*, are the most popular precisely because of the ease replicating in the environmental conditions they prefer. Perfectly suited to an indoor existence, the culturing of these animals presents next to no problem, requiring only a minimum of effort, and presenting no hardship for those of us who share their place of residence. The fact is, in the absence of the normal hazards these worms usually face in their outdoor habitats, they are found to grow faster, stay healthier, live longer, and reproduce at an increased rate indoors. Thus, indoor culture turns out to be heaven for them, and a great benefit to the "landlord" who will have a great new way to convert his organic waste materials into a wonderful "food" for his plants, lawn, and garden.

Major requirements for the vermiculture are aeration, moisture content and temperature. Earthworms need to breath, just like most other living creatures. The process of osmosis makes a worm rather different than those of us with lungs, but the end results is pretty much the same. Gradually, the available oxygen is used up and replaced with carbon dioxide and other miscellaneous waste gases. Moisture content should be maintained within range, rainfall must not be allowed to enter the bin and also bin must not be dried out during summer. Temperature requirement for optimal results is 20-30°C, earthworms can survive at the range of low temperatures to 48°C maximum.

Earthworm will need little help for feeding bigger sized waste materials. If it is chopped into small pieces it will be easier to the earthworms to feed. Usually 2Kg of earthworms will recycle 1Kg of organic waste in 24hours. In absolutely ideal conditions of comfort and ground up, moist food, the heard will recycle their own weight in wastes every 24hours.

- **GUT MICROFLORA OF EARTHWORMS**

Differences in earthworm digestion and assimilation processes suggest the possible existence of ecological group-specific gut microbiota. Although the microbial profile of the gut content is of the same kind to that of soil and feed resources, it is not a coincidental combination of the microorganisms present in soil. The evolutionary relationship between earthworm burrowing and feeding habits and the gut microbial community has not been defined. However, based on studies conducted on insects and faunal gut-associated microbial communities, we can expect the microbial profile of the gut to be an important determinant of earthworm metabolism.

Diet, host anatomy and phylogeny have been shown to influence the composition of microbiota within the gut of carnivores, herbivores and omnivores, including humans and primates. However, there is no information available regarding the comparative microbial community composition in different earthworm ecological groups or the association between gut microbiota biodiversity and ecological groups. Recent studies are highlighting the importance of gut microflora and their influence on the host physiology.

Earthworms are the most important soil invertebrates in the soil ecosystem in terms of biomass and activity, being often considered as ecosystem engineers. Moreover, soil contains a large diversity of microorganisms. Earthworms are important drivers of soil biogeochemical processes as they modify soil physicochemical properties and microbial communities by feeding, burrowing and casting activities. Decomposition and humification of biodegradable organic waste materials is predominantly carried out by microorganisms in the soil but earthworms too have roles in humification. The composition of microflora in the earthworm gut varies depending on the species of earthworm, season and feeding regime of the earthworm. The number of microorganisms present in the gut of earthworm depended on the substrate that the earthworm fed on soil, and either no changes or higher numbers in earthworms fed on decomposed leaves, than in earthworms fed on inert substrate.

Interactions between earthworms and microorganisms seem to be complex. Earthworms are reported to have association with such free living soil bacteria and constitute the drilosphere. In this way, it is known that microbial biomass and activity are usually enhanced in the drilosphere, with greater numbers of microbial colony forming units (CFUs) in the burrow walls and earthworm casts than in the parent soil. The aerobic bacterial counts in midgut of the earthworm, *Libyodrillus violaceous* was higher than that of foregut whereas the hindgut region recorded maximum. This incorporates with the findings of the researchers proving that earthworms include microorganisms in their substrates as a food source and can digest them selectively.

- **PROCESS OF VERMICOMPOSTING**

Process of vermicomposting will starts from the construction of bins, these can be made of wood or plastics, or from recycled materials or concrete tanks may also be used. The length and width of the bin will depend on whether it is to be stationary or portable. The shape and size of the vermicomposting container depend on the requirement that is quantity of the waste to be composted and number of live earthworms required for culturing. On an average, 2000 adult earthworms can be maintained in containers of $1m^2$ dimension. These with appropriate conditioning of composting material would convert approximately 200 Kgs wastes every month. Interestingly, roughly in a container of 2.23 X 2.23 m. about 10 Kgs of earthworms can convert approximately 1 ton per month.

- Vermicomposting will start from the process of preparing the vermicomposting bin.
- Vermibed is cleaned and disinfected properly.
- A layer of broken bricks or pebbles are added to the vermibed.
- A layer of coarse sand was added.
- Loamy soil was filled up to $3/4^{th}$ of the vermicomposting bin.
- Above this a layer of epigeic and anecic earthworms were added.
- A layer of cattle dung and hay was added on the top of the vermicomposting bin.
- Finally on the top of vermicomposting bin a net was covered.

The lower most layer of earthworm feed substrate that is required to be vermicomposted is called as bedding material. The bedding material for startup and future restarts can be any biodegradable matter like banana stem peels, coir pith, coconut and other leaves, sugarcane trash, stems of crops, grasses or husk, etc. Any moistened organic materials can be used for bedding.

Ideal conditions for earthworms are like temperature between 55 to 70°F, humidity should be maintained at 55% and keep the earthworms out of rain. p^H of the bed should be maintained at 6.0 to 7.0. Ingredient mixture or bedding material will play a major role in vermicomposting; these ingredients are broadly grouped into two classes that are browns and greens. Browns are dry and dead plant materials such as straw, dry brown weeds, autumn leaves, and wood chips or sawdust. These are mostly made of chemicals that are just long chains of sugar molecules linked together. These browns must need to be wetted before they are put into compost system. Greens are fresh plant materials such as green weeds from the garden, kitchen fruit and vegetable scraps, green leaves, horse manure, etc. compared to browns; greens have more nitrogen in them. Good mix of browns and greens is the best nutritional balance for the gut microflora of earthworms in 1:1 ratios of greens and browns, or two parts of brown to one part of greens will be a good nutritional balance for composting.

Particle size of the waste material should be smaller in nature, because smaller the size of organic wastes, the faster the compost will be ready for use. Smaller particles have much more surface area that can be attacked by the gut microflora. Larger wastes are chopped off to smaller size and then it can be used for composting systems as mentioned earlier.

5. ADVANTAGES AND DISADVANTAGES OF VERMICOMPOST

Problems in Production of Vermicmposting

There are many problems that will directly or indirectly affect the vermicomposting process. Earthworms are the key players in the vermicomposting process, as all the organisms have their own predators in the natural system. The major earthworm predator is the mole. This voracious insect predator loves to dine on white and any earthworms it can find.

Tilling the soil does reduce the earthworm population. Not because it kills or disturbs them, but because tilling aerates the soil, and this oxygen quickly reduces the organic matter that the earthworm use as food. Mulching with green matter will help provide food to earthworms to replenish what is lost in tilling.

Earthworms come out of their burrows during rain to avoid drowning. Worms have no lungs they take their oxygen directly through the skin, either from air or from water. In fact, rather than fear water, they love it. Its drying out they fear and dry soils kill them.

The excess food wastes must be maintained in a proper storing facility otherwise this food wastes will be spoiled by the fruit flies. They lay their eggs on the waste foods and spoil the texture and cannot be used as a composting material. Too much of food wastes are loaded on to the bin then earthworms will get stressed and they will die.

Even too wet condition or too dry conditions have influence on survival of earthworms or they will try to escape. If the bedding material was used up by the earthworms, bin should be harvested and fresh bedding material should be added or then also these earthworms will try to escape. If the bin started smelling very bad, then the lid has to be taken off for some time and more ventilation must be provided, this is because the bin is too wet, too much of food was loaded or there was not enough air present. If fruit flies were started growing then it is because of food wastes exposed to the air and it must be buried inside the bed.

Advantages

Vermitechnology is the combination of vermiculture and vermicomposting, thus it is the application of earthworm in the following areas:

- For development of arable soils, turnover of soils, breakdown of plant organic matter, aeration and drainage.

- For production of useful products like vermifertilizer, worm tissue for animal feed.
- For maintenance of environmental quality and monitoring of the environment for soil fertility organic and heavy metal, non-biodegradable toxic material pollution etc.

The money making potential of vermiculture is so attractive that it is rapidly becoming a growth industry. There are three key components of commercial vermiculture which explain its present appeal and future potential:

- First, earthworms are capable of transforming huge amounts of waste which is growing concern in our society. For those who are raising worms for profit, the feedstock is generally plentiful and free.
- Second, after acquiring an initial inventory as breeding stock the worm population can double in 2 to 4 months.
- Third, the production of castings (worm manure) is a highly-prized soil amendment, sought by landscapers, gardeners, and horticulturists.

Vermicomposting, will enables easy management of the organic wastes. Huge quantities of domestic, agricultural, and rural industrial organic wastes can be recycled for various usages. This also reduces pollution. Vermicastings are effective Biofertilizers containing beneficial soil-microflora and earthworm cocoons. When covered with a layer of mulch in the soil, they produce an earthworm population of one lakh per acre in 3months. Activation of soil biology in this way is an essential component of natural farming.

The other applications of vermicompost, it can be effectively utilized as a carrier medium for *Azospirillum*, *Rhizobium* and phosphate solubilizers. These are also providing very good association for enhancing their interactions with plant roots.

Conclusion

In the past 50 years, mankind has destroyed the worm habitat in an effort to improve agricultural efficiency. The use of chemical fertilizers has increased the salinity of the soil, making it unpalatable to our own worm friends. Pesticides, in turn, kill indiscriminately, destroying the good with the bad. As if that wasn’t enough, over-tillage of the soil destroys the worm tunnels that are vital their efforts. The art of vermicomposting need to be practiced to add values to principles of environment and ecofriendly management of wastes generated from different sources including food industry.