Handbook of Vermicomposting Technology

By

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Dedicated

To

Late Mr.P.K.MOHAMED,
Former Managing Director,
The Western India Plywoods Ltd

&

Late Mr.K.P.KAMALUDDIN,
Former Chief General Manager,
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Preface

This handbook explains a technology which is an alternative option to solid waste management systems, based on the application of earthworms and generally termed as vermicomposting. It also describes the various treatments with earthworms from agro-industrial wastes to domestic wastes. It also highlights the biology of these worms and how to maintain and prepare suitable bedding for this biological treatment of solid waste.

This book also provides basic information and vermicomposting experiences, should one be involved in vermicomposting or breeding of the worms. It is believed that this book would be useful to any person and government agencies involved in vermicomposting; industrial organizations, researchers, teachers as well as to students and other scholars.

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CHAPTER 1

INTRODUCTION

Rapid industrialization, urbanization, and the ever-increasing population generate voluminous solid wastes. In recent years, disposal of organic wastes has caused serious environmental hazards and economic problems. Burning of organic wastes contributes tremendously to environmental pollution thus, leading to polluted air, water and land. This process also releases large amounts of carbon dioxide in the atmosphere, a main contributor to global warming together with dust particles. Burning also destroys the soil organic matter content, kills the microbial population and affects the physical properties of the soil. A substantial portion of this solid organic waste is non-toxic. On one hand tropical soils are deficient in all necessary plant nutrients and on the other hand huge quantities of such nutrients available in solid organic wastes. Treatment of solid organic wastes has therefore become an essential part of the waste management programmes almost all over the world. Existing methods to its treatment and disposal are rather expensive. Vermicomposting technology is one of the best options available at present for the treatment of organic wastes. The term vermicomposting is coined from the Latin word '*Vermis'* meaning the 'worms'. Vermicomposting refers to natural bioconversion of biodegradable garbage into high quality manure with the help of earthworms.

Earthworms play a key role in soil biology; they serve as versatile natural bioreactors to harness energy and destroy soil pathogens by feeding voraciously on all biodegradable refuse. They are nature's way of recycling organic nutrients from dead tissues back to living organisms. They have faithfully done their part to keep this cycle of life continuously moving for more than 20 million years. Ancient civilizations including Greece and Egypt were the pioneers in recognizing the role of these worms played in soil. Earthworms were considered as "sacred" by the Egyptian Pharaoh, Cleopatra who recognized the role played by worms in fertilizing the Nile Valley croplands. The role of earthworms in waste stabilization has been known for many years, especially in Southeast Asian and European countries. Attracted by the nature and activities of burrowing earthworms in soil, Charles Darwin carried out studies on the significance of their activities for over 39 years. He wrote this about these tiny creatures," It may be doubted whether there are many other animals in the world which have played so important a part in the history of the world." He also called them as unheralded soldiers of the land, in his last and final book "*The Formation of Vegetable Mould, Through the Action of Worms, With Observations of their Habits*" which reported how these organisms feed and convert organic materials (Darwin, C.,1881).

From then on, studies have been carried out to find out their role in maintaining the soil fertility and also in the degradation of the organic matter present in the soil. These works also included investigations into the possibility of utilizing earthworms for the break down of organic wastes such as animal wastes, vegetable wastes and municipal solid wastes (MSW). Earthworms convert a portion of the organic matter into worm biomass and respiration products, and expel the remaining partially stabilized matter as discrete material (castings). In this process, earthworms and the microorganisms act symbiotically to accelerate the decomposition of organic matter. The driving forces behind the introduction of vermiculture and other reuse processes, is the global recognition of the need to recover organic material and return this to the natural cycle.

Vermicomposting is generally defined as the aerobic decomposition of organic residues by exploiting the optimum biological activity of earthworms and micro-organisms. The process depends upon the earthworms to fragment, mix and promote microbial activity in the organic waste material. The earthworms ingest organic solids and convert a portion of it into earthworm biomass and respiration products and egest peat like material termed as vermicompost. As compared to the thermal composting, vermicomposting generates a product with lower mass, high humus content, processing time is lower, phytotoxicity is less likely, fertilizer value is usually greater, and an additional product (earthworms) which can have other uses is produced.

Organic waste materials which are biodegradable in nature may be used as substrates for the vermicomposting process, provided that the materials do not contain anything harmful to earthworms. For example, the byproducts of agro-industrial processing offer potential opportunities to be used as substrates for the earthworms and microorganisms. The agro-industrial wastes are huge source of plant nutrients and their disposal means the ultimate loss of the resourceful material. At present, these wastes are either grossly underutilized or completely unutilized due to in situ burning in the fields or land disposal to the surrounding areas. These individually and cumulatively agro-industrial wastes could effectively be tapped for resource recovery through vermicomposting technology for use in sustainable land restoration practices.

Some of the major agro-industrial wastes explored for vermicomposting are shown in Table.1and Fig.1

Table.1: Details of agro-industrial organic wastes for vermicomposting

No.	**Sources**	**Types of wastes generated**
1	Agricultural wastes	Rice husk, cereal residues, wheat bran, millet straw etc.
	Food processing waste	Canning industry waste, breweries waste, dairy industry waste, sugar industry waste press mud and trash, wine industry waste, oil industry waste- non edible oil seed cake, coffee pulp, cotton waste etc.
2	Wood processing waste	Wood chips, wood shavings, saw dust
3	Other industrial wastes	Fermentation waste, paper and cellulosic waste, tannery waste
4	Local organic products	Coco fiber dust, tea wastes, rice hulls etc.
5	Fruits and vegetable processing waste	Peels, rinds and unused pulp of fruits and vegetables

Fig.1: Agro-industrial wastes for vermicomposting

Coir waste

Saw dust

Sugarcane trash

Wood waste

CHAPTER 2

EARTHWORMS

The earthworm is a segmented invertebrate. Its body holds its tube-shape because it is full of a liquid called coelomic fluid found between the body wall and the alimentary canal. Earthworm has a long, cylindrical body with a pointed head (Padashetty,S.&Jadesh,M.,2014)(Fig.2). In some species the posterior end is slightly flattened, while in others the body is cylindrical throughout. Rings that surround the moist, soft body allow the earthworm to twist and turn, especially since it has no backbone. With no true legs, bristles (setae) on the body move back and forth, allowing the earthworm to crawl. Earthworm breathes through its body surface. Food is ingested through the mouth into a bag like structure referred to as crop. In some species a distinct crop is absent. Later the food passes through the gizzard, where ingested stones grind it up. After passing through the intestine for digestion, what’s left is eliminated as castings.

Fig.2: Earthworms

Distribution

Earthworms are found all over the world, except in areas under constant snow and ice, mountain ranges, deserts and areas almost entirely lacking in soil and vegetation. Species which are widely distributed are called peregrine, whereas others termed as endemic do not spread successfully to other areas. (Ansari, A.A. and Ismail,S.A.,2012)

Factors affecting distribution

The distribution of earthworms in soil is affected by physical and chemical characters of the soil, such as temperature, pH, moisture, organic matter and soil texture. (Govindan,1998)

Temperature

The activity, metabolism, growth, respiration and reproduction of earthworms are all influenced greatly by temperature.

pH

pH is a vital factor that determines the distribution of earthworms as they are sensitive to the hydrogen ion concentration. pH and factors related to pH influence the distribution and abundance of earthworms in soil. Several workers have stated that most species of earthworms prefer soils with a neutral pH. There is a significant positive correlation between pH and the seasonal abundance of juveniles and young adults.

Moisture

Prevention of water loss is a major factor in earthworm survival as water constitutes 75-90% of the body weight of earthworms. However, they have considerable ability to survive adverse moisture conditions, either by moving to a region with more moisture or by means of aestivation. Availability of soil moisture determines earthworm activity as earthworm species have different moisture requirements in different regions of the world. Soil moisture also influences the number and biomass of earthworms.

Organic matter

The distribution of earthworms is greatly influenced by the distribution of organic matter. Soils that are poor in organic matter do not usually support large numbers of earthworms. Several workers have reported a strong positive correlation between earthworm number and biomass and the organic matter content of the soil (Ismail,1997).

Soil texture

Soil texture influences earthworm populations due to its effect on other properties, such as soil moisture relationships, nutrient status and cation exchange capacity, all of which have important influences on earthworm populations.

Classification

Earthworm belongs to *Annelida* phylum and to *Oligochaeta* class that comprises more than 1800 species; most of the species belong to *Lumbricidae* family, including the genera: *Dendrobaena*, *Eisenia and Lumbricus*. The classification of one of the species' of this family, *E. fetida* which is known as red worm, brandling worm, red wiggler worm is shown in Table**.**2.

Phylum	Annelida
Class	Oligochaeta
Subclass	Clitelata
Order	Haplotaxia
Suborder	Lumbricina
Super family	Lumbricoidea
Family	Lumbricidae
Subfamily	Lumbricinae
Genus and species	*Eisenia fetida*

Table.2: Taxonomic classification of *Eisenia fetida*

Based on their feeding habits, earthworms are classified into detritivores and geophagous. Detritivores feed near the soil surface. They feed mainly on the plant litter and other plant debris in the soil. These worms comprise the epigeic and the anecic forms. Geophagous worms, feeding deeper beneath the surface ingest large quantities of organically rich soil. These are generally called as humus feeders and comprise of endogeic earthworms.
The morpho-ecological groupings relate to several factors including general size, shape and pigmentation, burrow construction, position in the soil profile, source of food and reproductive potential. The three groups of earthworms are:

1. Litter dwelling earthworms (*Epigeic* species)

There are several deeply pigmented or red species that normally live in the rotting litter or organic matter on the surface of soils. They grow and

reproduce very prolifically compared with true soil dwelling earthworms.
Some of the species commonly used in vermicomposting are *Dendrobaena veneta* (blue nosed worm), *Eisenia fetida* (tiger or brandling worm), *and Eisenia andrei* (red tiger worm) and *Eudrilus eugeniae*.

2. Topsoil dwelling earthworms (*Endogeic* species)
Just below the surface live another group of small earthworms, in the first few centimetres of topsoil. They improve soil structure in the root zone of plants and recycle dead organic matter. One notable species is *Allolobophora chlorotica* (green worm).

3. Deep burrowing earthworms (*Anecic* species)
Anecic species live deeper down in the soil profile in permanent vertical burrows that can be up to two metres long. They help create topsoil by dragging dead organic material from the soil surface down into their burrows, ingesting it along with soil and then egesting the mixture back on the surface as nutrient-rich earthworm casts. Species in this category are highly valued and have been successfully bred for land restoration projects. One beneficial species is *Lumbricus terrestris* (the lob worm).

The Anecic types burrow deep in the soil but come to the surface at night to forage for freshly decaying residues.

Basic Requirements

Earthworms need these basic things for vermicomposting:

1. **Bedding**: Bedding is any material that provides the worms with a relatively stable habitat. This habitat must have the following characteristics: ***High absorbency-*** Worms breathe through their skins and therefore must have a moist environment in which to live. If a worm's skin dries out, it dies. The bedding must be able to absorb and retain water fairly well if the worms are to thrive. ***Good bulking potential-*** If the material is too dense to begin with, or packs too tightly, then the flow of air is reduced or eliminated. Worms require oxygen to live, just as we do. Different materials affect the overall porosity of the bedding through a variety of factors, including the

range of particle size and shape, the texture, and the strength and rigidity of its structure. ***Low protein and/or nitrogen content (high C:N ratio)-*** Although the worms do consume their bedding as it breaks down, it is very important that this be a slow process. High protein/nitrogen levels can result in rapid degradation and its associated heating, creating inhospitable, often fatal, conditions. Heating can occur safely in the food layers of the vermiculture or vermicomposting system, but not in the bedding.

2. Housing: Sheltered culturing of worms is recommended to protect the worms from excessive sunlight and rain. A low cost unit can be arranged in vacant cowsheds, poultry sheds, basements and back yards.

3. Containers: Bricks or cement tanks are to be constructed separated in half by a dividing wall.

4. Environmental conditions: The environmental conditions are vital and may affect the breeding, cocoon production and hatching of young earthworms.

a. Temperature

In vermicomposting, temperatures are kept generally kept below 35^{o}C. Most worm species used in vermicomposting require moderate temperatures from (10-35^{o}C).While tolerances and preferences vary from species to species, temperature requirements are generally similar. In general, earthworms tolerate cold and moist conditions far better than they can hot and dry conditions.

b. Moisture

Earthworm requires plenty of moisture for their growth and survival. They need moisture in the range 60–75 %. The soil should not be too wet else it may create an anaerobic condition and drive the earthworms from the bed (Ronald and Donald, 1977). It is very important to moisten the dry bedding material before putting them in the bin, so that the over all moisture level is well balanced.

c. pH

Earthworms are pH sensitive and generally most of them survive at pH ranging from 4.5 to 9. The alteration of pH in the worm bed is due to the

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