VERMICOMPOSTING

CENTRE FOR ENVIRONMENTAL STUDIES
Forest, Environment & Climate Change Department
Government of Odisha, Bhubaneswar

ISBN No.978-81-978159-5-9

VERMICOMPOSTING

CENTRE FOR ENVIRONMENTAL STUDIES
Forest, Environment & Climate Change Department
Government of Odisha, Bhubaneswar

VERMICOMPOSTING

Dr. Sasanka Lenka
Sr. Scientist and Head
Krishi Vigyan Kendra, Nabarangpur

Pravat Mohan Dash
Programme Officer
Centre for Environmental Studies

Swagatika Mishra
Project Officer
Centre for Environmental Studies

Published by:
Centre for Environmental Studies
Forest, Environment & Climate Change Department
Government of Odisha, Bhubaneswar

Supported by:
Environment Education Division
Ministry of Environment, Forest & Climate Change
Government of India, New Delhi

Published on:
March-2025

Printed at :
Ankita Graphics, Bhubaneswar
9437077337/saroj77337@gmail.com

ISBN No.978-81-978159-5-9

Dr. K. Murugesan, IFS
Director
Centre for Environmental Studies
Forest, Environment & C.C. Department
Government of Odisha

PREFACE

Vermicomposting, the process of using earthworms to convert organic waste into nutrient-rich compost, is a sustainable and eco-friendly practice that has gained significant attention in recent years. This booklet, Vermicomposting, compiled by the Centre for Environmental Studies (CES), aims to provide a comprehensive guide to understanding and implementing vermicomposting practices.

This guide is designed to serve as a practical resource and covers a wide range of topics, from the basics of earthworm biology and the benefits of vermicompost to the step-by-step process of setting up a vermicomposting unit.

Under the guidance of Dr. Sasanka Lenka, this resource has evolved into a comprehensive and scientifically robust tool, thanks to his meticulous attention to detail and expert knowledge.

The Centre for Environmental Studies (CES) promotes environmental education and sustainability. This guide supports mission LiFE to conserve natural resources and promote organic waste management. Let's reconnect with nature and create a greener future through vermicomposting.

I would like to thank Ministry of Environment, Forest & Climate Change (MoEF&CC), Govt. of India for giving opportunity to compile this book under Environment Education Programme (EEP).

(Dr. K. Murugesan)

CONTENT

Sl. No.	Topic	Page
1.0	Backdrop	05
2.0	About the Earthworms	09
3.0	Earthworms Good Friends of Farmers	14
4.0	Vermicast Effects on Soils	16
5.0	Importance of Vermicompost	17
6.0	Advantages and Disadvantages of Vermicompost	20
7.0	Components of a Commercial Unit	22
8.0	Materials Required for Vermicomposting	31
9.0	Method of Preparation of Vermicompost	31
10.0	Vermiculture Techniques	36
11.0	Impact of vermicomposting	39
12.0	Conclusion	47

VERMICOMPOSTING

1.0 Backdrop

The Egyptians were one of the first cultures to recognise the soil-amending properties of the earthworm. Under Cleopatra's rule, removing earthworms from Egypt was a crime that could have been killed. Worms have been observed by such scholars as Aristotle and Charles Darwin as organisms that decompose organic matter into rich humus or compost. However, the actual practice of vermiculture is about a century old. Charles Darwin (1809-1882) who studied earthworms for 40 years, estimated that an acre of British farmland contained 50,000 worms, producing about 18 tons of worm-casts per year.

The first serious experiments on vermiculture were conducted in Holland in 1970 and subsequently in England and Canada. It is believed that vermiculture was first introduced in the year 1970s by a biology teacher, Mary Appelhof. She developed the idea of using red earthworm (*Eisenia fetida*) to convert kitchen waste to worm compost in indoor and outdoor systems. As a Michigan (U.S.A.) biology teacher, Appelhof wanted to continue composting in winter months even though she lived in a northern climate. She ordered worms from a


bait shop nearby and set up one of the first indoor composting systems. She found her composting system to be a great success. She published two brochures titled “Basement Worm Bins Produce Potting Soil and Reduce Garbage” in 1973 and “Composting your Garbage with Worms” in 1979. Her work was featured in a New York Times titled “Urban Composting: A New Can of Worms”. Finally, in 1982 she published a book entitled “Worms Eat My Garbage”. This inspired many people to partake in vermiculture, especially urban apartment dwellers. The American Earthworm Technology Company started a vermicomposting farm in 1978-79 with 5000 tons per month of vermicompost production. Earthworm has around 7,000 species, out of which 150 species are widely distributed around the world. These are the peregrine or cosmopolitan earthworms. More than 509 species of earthworms have been reported by various workers till now but the most abundant species are few ones.

Beginning in 1905, Sir **Albert Howard** worked as an agronomist in India conducting research on farming practices and composting on the Indian sub-continent. **Sultan Ahmed Ismail** (born 9 October 1951) is an Indian soil biologist and ecologist. His work has centred on techniques for recycling biodegradable waste into fertilizer using local varieties of earthworms, and on soil bioremediation. The University of Agricultural Sciences, Bangalore initiated vermiculture in India and propagated the knowledge to the farming community by releasing a press note in the year 1984. M.R. Morarka-GDC, Rural Research Foundation in Rajasthan has been the most entrepreneurship organization for vermicomposting technology in India so far. Vermicomposting having 100 tons per day has been operated in Pune, Bangalore and several other cities in India. Now, it has gained popularity in all the corners of the state. Odisha and Uttar Pradesh states were recorded as mega-diversity regions for earthworms.

Vermicompost is becoming popular as a major component of organic farming systems. Using Vermicompost can fulfil the requirements for organically grown products. Earthworms and microorganisms convert organic materials to beneficial soil amendments. Vermicomposting is a process that relies on earthworms and microorganisms to help stabilize active organic materials and convert them to a valuable soil amendment and source of plant nutrients. Earthworms will consume most organic materials, including food preparation residuals and leftovers, scrap paper, animal manure, agricultural crop residues, industry by-products, and yard trimmings. Vermicomposting is the scientific method of making compost by using earthworms. They are commonly found in the soil, feeding on biomass and excreting it in a digested form. Vermicomposting is a natural process whereby earthworms convert waste material with rigid structures into compost. The compost produced in this green process is traditionally and popularly used as a natural fertilizer for enhancing plant growth. Earthworms belong to the phylum Annelida, subclass Oligochaeta. Vermicompost (vermicompost) is the product of the decomposition process using various species of worms, usually, red earthworms, white worms, and other earthworms, to create a mixture of decomposing vegetable or food waste, bedding materials, and vermicast. This process is called vermicomposting, with the rearing of worms for this purpose is called vermiculture.

Vermiculture is a technique based on utilizing some species of earthworms to convert organic waste into vermicompost which is again, the product of decomposition by various worms. It is a practice of harvesting worms that take part in decomposing organic waste and turning it into nutrient-rich fertilizer. The worms consume the decomposing organic material and flush it out of their system, which is referred to as worm manure. Vermiculture and Vermi

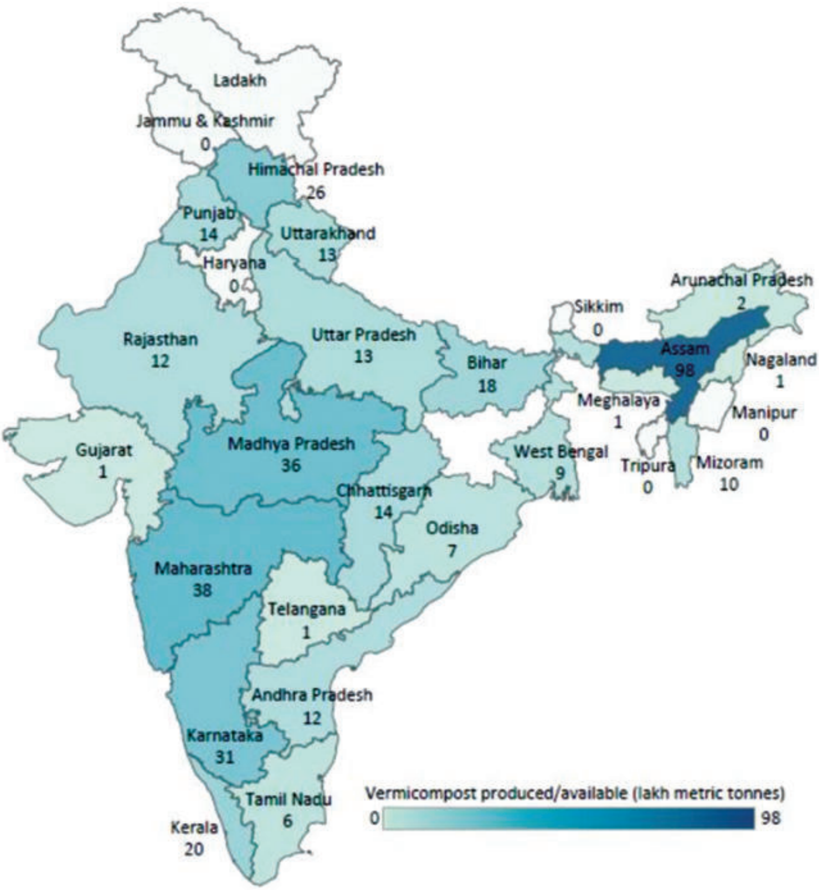


Fig 1, Geographical coverage of states producing vermicompost composting are the cultivation of earthworms and the use of earthworms to decompose organic wastes into nutrient-rich fertiliser. Earthworms are commonly used in vermiculture. According to the National Centre of Organic Farming (NCOF), the total agricultural land where vermicompost is practised is around 3.5 million hectares, covering 19 states.

The importance of vermicomposting extends far beyond waste reduction and soil enrichment. It represents a shift towards sustainable agriculture, reducing dependence on chemical fertilizers, minimizing soil and water pollution, and improving crop yields in an environmentally responsible manner. Vermicomposting enhances soil structure, increases its water-holding capacity, and facilitates better root development, making it a vital tool for farmers, gardeners, and environmental enthusiasts alike.

2.0 About the Earthworms

About 350 species of earthworms in India with various food and burrowing habits, *Eisenia fetida, Eudrilus eugeniae, Perionyx excavatius* are some of the important species for rearing to convert organic wastes into manure. The worms feed on any biodegradable matter ranging from coir waste to kitchen garbage and vermicomposting units are ideally suited to locations/units with generation of considerable quantities of organic wastes. One earthworm reaching reproductive age of about six weeks lays one egg capsule (containing 7 embryos) every 7-10 days. Three to seven worms emerge out of each capsule. Thus, the multiplication of worms under optimum growth conditions is very fast. The worms live for about 2 years. Fully grown worms could be separated and dried in an oven to make a 'worm meal' which is a rich source of protein (70%) for use in animal feed.

India's earthworm fauna is well-reported compared to other Asian Countries. The most diverse families of earthworm species in India are Megascolecidae comprises 153 species (119 native) of 15 genera; Octochaetidae with 130 species (129 native) of 29 genera and Moniligastridae with 83 species (all native) of 3 genera. Especially diverse earthworm genera of India belong to Moniligastridae Drawida (71 species); the Megascolecidae Perionyx (56 species) and Megascolex (33 species); the Acanthodrilidae Plutellus (23 species); the Octochaetidae Eutyphoeus (23 species), Hoplochaetella (19 species) and Octochaetona (15 species).

Earthworms are broadly classified into three categories:

- **Anecic** (Greek for "out of the earth") – these are burrowing worms that come to the surface at night to drag food down into their permanent burrows deep within the mineral layers of the soil. Example: the Canadian Night crawler.
- **Endogeic** (Greek for "within the earth") – these are also burrowing worms but their burrows are typically more shallow and they feed on the organic matter already in the soil, so they come to the surface only rarely.
- **Epigeic** (Greek for "upon the earth") – these worms live in the surface litter and feed on decaying organic matter. They do not have permanent burrows. These "decomposers" are the type of worm used in vermicomposting.

2.1 Eisenia fetida/Eisenia andreii:

Fig-2. *Eisenia fetida*

(common name, Red Worm) Eisenia fetida/Eisenia andreii are the worm species identified as the most useful in vermicomposting systems and are the easiest to grow in high-density culture because they tolerate the widest range of environmental conditions and fluctuations, and handling and disruption to their environment of all species identified for this purpose.

E. fetida/E. andreii are also common to virtually every landmass on Earth, meaning there is no concern over importing potentially alien species to an environment where they might cause damage.

2.2 Eudrilus eugeniae:

This species is used in some vermicomposting systems around the Mediterranean region and some areas of eastern Asia.

Fig-3.*Eudrilus eugeniae*

- Temperature range: Minimum; 45° F, maximum; 90° F, ideal range; 70° F-80° F.
- Reproductive rate: Approximately 7 young per worm per week under ideal conditions. Average number of young per cocoon: Approximately 2.
- Time to emerge from the cocoon: Approximately days under ideal conditions.
- Time to sexual maturity: Approximately days under ideal conditions.

2.3 Perionyx excavates (Indian Blue worm)

- The Perionyx excavatus lacks the alternate light & dark banding of the E. fetida.

Fig-4. *Perionyx excavates*

- P. excavatus tends to have a pale-coloured clitellum that covers segments 13-17 and, for those inclined to look, has a single dorsal pore visible using a hand lens on segment 14, paired sperm pores at the juncture of segments 7/8 and 8/9, a pair of slit-like pores on segment 18, and paired rows of excretory pores on each segment along the side of the worm body. Per Kelly Slocum.
- The Perionyx excavatus has an irridescent blue sheen.
- The Perionyx excavatus is much thinner than the E. fetida, thus making the P. excavatus much more difficult to use as a bait worm.

2.4 Sourcing Earthworms:

- Purchase worms from reputable suppliers, nurseries, or online vendors specializing in vermicomposting. Alternatively, collect worms from existing composting setups or community compost projects.
- Ensure the worms are healthy, active, and acclimated to the local climate

3.0 Earthworms Good Friends of Farmers

Earthworms are farmers' friends because they improve the quality of the soil like water holding capacity, moisture, and nutrient content by burrowing into the soil. The soil becomes loose and porous. Also, the worm castings improve the distribution of organic matter in the soil. Earthworms make burrows in the soil and make the soil porous, which helps in respiration and penetration of developing plant roots. Earthworms are known as farmers' best friends as they help increase the fertility of the soil and thus increase the yield of the crops grown. Earthworms can eat and mix a large amount of soil and organic matter and deposit it in the form of casts. They also enhance the incorporation and decomposition of organic matter, increase soil aggregate stability, improve porosity and water infiltration, and increase microbial activity.

Below the surface, an earthworm's diet centers on dead plant matter, and scientists have finally figured out how these important decomposers, or detritivores, do it. Their guts produce a unique compound that counters the effects of plant


Utility of Vermicompost
Safe Food
Healthy Soil
Superior Crop Growth
Clean Environment
Sustainable Production
Increase Carbon Sequestration
Better mineralization and uptake

defences, enabling the digestion of otherwise toxic material. Earthworms improve the health of the soil and plant, too; that's why earthworms are called farmer's friends.

4.0 Vermicast Effects on Soils

New approaches to agriculture have the potential to improve crop production, human health, and the environment. Three new primary practices that promote soil health have emerged-all of them directly opposed to the decades-old farming practices that relied on use of synthetic fertilizers, herbicides, and pesticides.

Instead of disturbing the soil with tillage, no-till practices are being adopted. In place of planting the same crop over and over, rotational cropping is being encouraged to increase soil fertility and reduce soil erosion. Instead of leaving soil bare between rows or after harvest, farmers are planting legumes, vegetables, or grasses to cover the soil, thus returning nutrients to the soil, reducing erosion, and supporting biodiversity.

Vermicomposting, too, can play an important role in the remediation of soil. Research studies have shown that vermicast improves soil aeration, porosity, and water retention. The reason vermicast improves the physical structure of soil has to do with its enhanced microbial populations and activity, absorbent organic matter, polysaccharides, and mucus secretions that help cement soil particles together, causing aggregate stability.

4.1 Enhancing Soil Fertility:

- Vermicompost is rich in essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), and micronutrients like zinc, copper, and manganese. These nutrients are readily available for plant uptake.

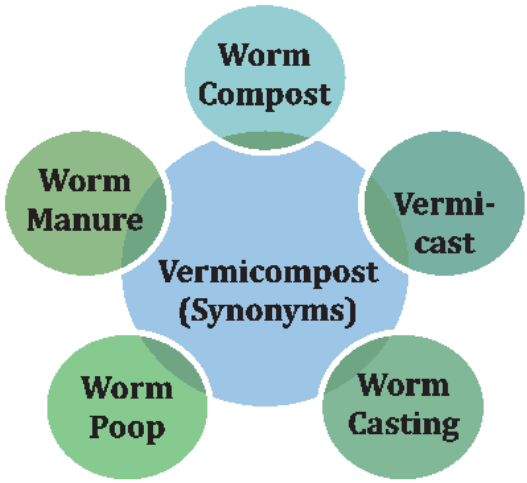
- Regular application improves soil organic matter content, leading to better soil structure and aeration.

5.0 Importance of Vermicompost

Indiscriminate use of chemical fertilizers and pesticides leads to environmental hazards and has imposed a serious threat globally resulting in low productivity in most crops.

The environmental degradation is evidenced by changes in rainfall patterns and a rise in day and night temperature. The greatest natural resources soil and water are still polluted due to the continuous use of chemical fertilizers and pesticides. Besides pollution in natural resources, the food consumption by human beings is also intoxicated due to this excess use of chemicals. Therefore, it is time to think about eco-friendly, sustainable food production in nature's cycle through vermicomposting for a safe environment.

Over the years agricultural practices have changed. In the changing scenario, bullocks are being replaced by tractors and power tillers, thus the population of dung-producing animals is regularly decreasing. Mainly, dung, cow urine, foodstuffs waste and farm waste are the major components of farmyard manure, that are not available to meet the demands of the production system. Hence, Vermicomposting is the only viable method to restore the problem. Vermicomposting is an effective means of safeguarding the environment, and it turns biodegradable waste into useful manure. Vermicompost is a term, that denotes the preparation of compost with the help of earthworms, that has been recognised as a friend of agriculture from time immemorial. Vermicompost can be prepared in rural and urban areas in a wooden model plastic model or a pit.



Vermicompost is
Vermicomposting is a method of preparing enriched compost with the use of earthworms. It is one of the easiest methods to recycle agricultural wastes and to produce quality compost. Earthworms consume biomass and excrete it in a digested form called worm casts. Worm casts are popularly called as Black gold. The casts are rich in nutrients, growth-promoting substances, and beneficial soil microflora and have the properties of inhibiting pathogenic microbes.

Vermicompost is stable, fine granular organic manure, which enriches soil quality by improving its physicochemical and biological properties. It is highly useful in raising seedlings and for crop production. Vermicompost can enhance soil fertility physically, chemically and biologically. Physically, vermicompost-treated soil has better aeration, porosity, bulk density and water retention. Chemical properties such as pH, electrical conductivity and organic matter content are also improved for better crop yield. Vermicomposting is a unique process that occurs in earthworms' guts to convert organic wastes into organic fertilizer or vermicompost by using the joint action of earthworms and microorganisms. Likewise, conventional composting, vermicomposting is an aerobic process that requires the presence of oxygen. Vermicompost has many synonyms, these are worm compost, vermicast, worm castings, worm-poop and worm manure.

Vermicompost has been emerging as an important source in supplementing and substituting chemical fertilizers in agriculture. Vermicompost, also known as 'farmers' friend' is used for general crops and plantation crops. It is a valuable input for sustainable agriculture and wasteland development. It is a growth promoter and helpful in providing hormones required for plant growth. Some important and common terminology used for vermicompost are:

- **Vermiculture** - the culture of worms
- **Vermicomposting** - the use of worms for composting organic materials.
- **Vermicompost** - the product of vermicomposting containing worm castings, bedding materials as well as organic matter in various stages of decomposition.


- **Vermicasts -** excreta of worms Vermicast (also called worm casting, worm humus, worm poop, worm manure, or worm faeces) is the end-product of the breakdown of organic matter by earthworms. These excreta have been shown to contain reduced levels of contaminants and a higher saturation of nutrients than the organic materials before vermicomposting.
- **Vermiculturist** - the Worm Man or a person who farms, breeds and cares for WORMS. A professional WORM farmer is called a Vermiculturist.
- **Vermiwash -** Vermicompost contains water-soluble nutrients which may be extracted as vermiwash and is an excellent, nutrient-rich organic fertilizer and soil conditioner. It is used in gardening and sustainable, organic farming.

6.0 Advantages and Disadvantages of Vermicompost

The major benefits of vermicomposting are:

1. Adds organic matter
2. Helps soil to absorb and retain water
3. Breaks up clay soils
4. Improves soil structure
5. Increases cation exchange capacity
6. Eases cultivation
7. Helps form soil aggregates

8. Enhances soil fertility
9. Reduces bulk density
10. Improves soil aeration
11. Increases soil microbial populations
12. Reduces soil compaction
13. Diminishes soil erosion
14. Reduces pH
15. Lowers electrical conductivity
16. Helps prevent soil crusting
17. Provides micro- and macronutrients and increases their availability
18. Helps to develop the roots of the plants.
19. Improves the physical structure of the soil.
20. Vermi protein use as a food for human, fishery, poultry and piggery.
21. Helps in germination, plant growth, and crop yield.
22. Nurtures soil with plant growth hormones such as auxins, gibberellic acid, etc.
23. The vermicomposting process generates an internal heat. The heat kills the pests and pathogens. It also destroys the seeds of weeds that may be found in the organic wastes.
24. Nitrogen oxides from chemical fertilizers might deplete the Ozone layer which may consequently cause- more skin cancer, more eye cataracts, loss of immunity, harm to the phytoplankton and crop damage affecting entire food chain but Vermicompost will help the minimization of these consequences.

The following are the important disadvantages of vermi-composting:

1. It is a time-consuming process and takes as long as six months to convert the organic matter into usable forms.
2. It releases a very foul odour.
3. Vermicomposting is high maintenance. The feed has to be added periodically and care should be taken that the worms are not flooded with too much to eat.
4. The bin should not be too dry or too wet. The moisture levels need to be monitored periodically.
5. They nurture the growth of pests and pathogens such as fruit flies, centipedes and flies.

Vermicomposting turns kitchen waste and other green waste into dark, nutrient-rich soil. Due to the presence of microorganisms, it maintains healthy soil. Vermicomposting is an eco-friendly process that recycles organic waste into compost and produces valuable nutrients.

7.0 Components of a Commercial Unit

7.1 Sheds

For a vermicomposting unit, whether small or big, this is an essential item and is required for having vermi beds. They could be of a thatched roof supported by bamboo rafters and purlins, wooden trusses and stone pillars. If the size is so chosen as to prevent wetting of beds due to rain on a windy day, they could be open sheds. While designing the sheds adequate room has to be left around the beds for easy movement of the labour attending to the filling and harvesting of the beds.

Excessive sunlight can lead to dehydration, stress, and even death of the worms. Ideal shaded locations include areas under dense tree canopies, shaded courtyards, semi-open sheds, or designated areas with artificial coverings such as tarpaulins, shade nets, or roofing materials.

7.2 Vermi-beds

Normally the beds are 75 cm - 90 cm thick depending on the provision of a filter for the drainage of excess water. The entire bed area could be above the ground. Care should be taken to make the bed with uniform height over the entire width to the extent possible to avoid low production owing to low bed volumes. The bed width should not be more than 1.5 m to allow easy access to the centre of the bed.

7.3 Land

About 0.5-1 acre of land will be needed to set up a vermiculture production cum extension centre. The centre will have at least 8-10 sheds each of about 180-200 sq. ft. It should also have a bore well, and pump set or watering arrangement and other equipment as described in the scheme economics. The land can be taken on lease for at least 10-15 years. Even sub-marginal land also will serve the purpose.

7.4 Buildings

When the activity is taken up on a large scale on commercial lines, a considerable amount may have to be spent on buildings to house the office, store the raw material and finished product, and provide minimum accommodation to the Manager and workers. The cost of the buildings along with the electrification of these buildings and the vermi-sheds may be included under this item.

7.5 Seed Stock

This is an important item requiring considerable investment. Though the worms multiply fast to give the required numbers over 6 months to a year, it may not be wise to wait till such a time having invested in the infrastructure. Thus, worms @ 350 worms per m^3 of bed space should be adequate to start with and to build up the required population in about two cycles or three without unduly affecting the estimated production.

7.6 Fencing and Roads/Paths

The site area needs development for the construction of structures and the development of roads and pathways for easy movement of hand-drawn trolleys/wheelbarrows for conveying the raw material and the finished products to and from the vermi-sheds. The entire area has to be fenced to prevent trespass by animals and other unwanted elements. These could be estimated based on the length of the periphery of the farm and the length and type of roads/paths required. The costs of fencing and the formation of roads should be kept low as these investments are essential for a production unit, yet would not lead to an increase in production.

7.7 Water Supply System

As the beds have always to be kept moist with about 50% moisture content, there is a need to plan for a water source, lifting mechanism and a system of conveying and applying the water to the vermi-beds. Drippers with round the clock flow arrangement would be quite handy for continuous supply and saving on water. Such a water supply/ application system requires considerable initial investment, however, reduces the operational costs of hand watering and proves economical in the long run. The cost of these items depends on the capacity of the unit and the type of water supply chosen.

7.8 Machinery

Farm machinery and implements are required for cutting (shredding) the raw material in small pieces, conveying shredded raw material to the vermi-sheds, loading, unloading, collection of compost, loosening of beds for aeration, shifting of the compost before packing and for air drying of the compost, automatic packing and stitching for the efficient running of the unit. The costs of providing necessary implements and machinery have to be included in the project cost.

7.9 Transport

For any vermicomposting unit transport arrangement is a must. When the source of raw material is away from the production unit, off-site transport becomes a major item of investment. A large-sized unit with about 1000 tonnes per annum capacity may require a 3-tonne capacity mini-truck. With small units particularly with the availability of raw materials near the site, expanding on transport facility may become infructuous. On-site transport facilities like manually drawn trolleys to convey raw materials and finished products between the storage point and the vermicompost sheds could also be included in the project cost.

7.10 Furniture

A reasonable amount could also be considered for furnishing the office-cum-stores including the storage racks and other office equipment. These enhance the efficiency of operations.

7.11 Operational Costs

To operate the unit, expenditure on some items has to be incurred regularly. These items include salaries of the staff, wages to the labourers, cost of raw material, fuel cost on the transport of raw materials and finished goods, packing material cost, repairs and maintenance, power, insurance, etc. The number of office personnel and labourers has to be decided breaking each activity into several sub-activities and for each sub-activity estimating the work involved and the capacity of the labour to finish the work in a given time. The number of persons should be so chosen to keep them engaged throughout by providing enough persons at various work

points like stores, vermi-beds and equipping them with an adequate number of implements to avoid undue waiting.

Estimate for construction of a temporary shed for setting up 200 TPA (Tonnes per annum) Vermicompost unit (Size 8 m x 15m x 5.4 m).

Sl. No	Particulars	Quantity	Rate (Rs.)	Amount (Rs.)
1	Wooden ballies (3 m long)	472	25	7800
2	Wooden ballies (3.6 m long)	48	30	1440
3	Bamboo (3 m long)	800	15	12000
4	Bamboo (6 m long)	240	20	4800
5	Bamboo mats for roof covering	720	25	18000
6	Coir rope 6 mm dia	200 kg	15	3000
7	Binding wire for tying bamboos & mats	100 kg	25	2500
8	Labour charges for the erection of sheds	LS		20000
9	Miscellaneous			2460
	Total			**72000**

200 TPA vermicompost unit-Implements and machinery

S.N.	Particulars of item	Amount (Rs.)
1	Shovels, spades, crowbars, iron baskets, dung forks, buckets,bamboo baskets, trowel, wire mesh sieves (3 mm and 6 mm)	2800
2	Plumbing and fitting tools	1000
3	Power operated shredder	20000
4	Sieving machine with 3 wire mesh sieves 0.6 m x 0.9 m size - power operated without motor	35000
5	Weighing scale (100 kg capacity)	1500
6	Weighing machine (platform type)	5000
7	Bag closer	3000
8	Empty barrels (200 L capacity) 4 Nos.	1600
9	Culture trays (plastic) (35 cm x 45 cm) - 4 Nos	200
10	Wheelbarrows - 2 Nos.	10000
	Total	**80100**

Total operational cost for one cycle of 75 days
Bed volume 330 m3 Recovery percent: 30%

Sl. No	Particulars	Unit	Rate (Rs.)	Amount (Rs.)
1	Agricultural waster @ 320 kg per m3	105.6 ton	100	10560
2	Cow dung @ 80 kg/m3	26.4 ton	150	3960
3	Worms @ 350 per m3 500 worms per kg	231 kg	50	11550
4	Formation of vermibed with agro-waste, cow dung and worms	330 m3	46	15180
5	Harvesting, sieving, packing, etc., including the cost of bags	40 ton	0.45	18000
6	Electrical charges for the pump, machinery, lighting etc.	-	-	4800
7	Repair and maintenance	-	-	7950
	Total			72000
	Cost for 5 cycles			360000
	Rent on lease @Rs 8000/year			8000
	Total operating cost			**368000**

* Operational cost for two cycles is capitalized in the first year

200 TPA vermicomposting unit - Financial Analysis

(Rs.in lakhs)

Particulars		Years	
1	**COSTS**	**I**	**II to IX**
A	Capital Cost		
i)	Buildings	1.32	-
ii)	Machinery/tools	0.8	-
iii)	Water supply system	0.6	-
iv)	NADEP tanks	0.05	-
B	Operational cost	3.68	3.68
Total Cost		**6.45**	**3.68**
2	**BENEFITS**		
i)	Sale of vermicompost	3.00	4.50
ii)	Sale of worms		0.45
iii)	Consultancy and extension services		0.10
Total benefit		**3.000**	**5.05**
3	**Net benefit**	*0.792	1.37
	Discounting Rate 15%		
	NPV 2.35		
	IRR 36%		
	NPV of benefits	22.31	
	NPV of costs	19.97	
	BCR	1.12	

8.0 Materials Required for Vermicomposting

- Crop residues
- Vegetable waste
- Farm Yard Manure/ Cattle dung
- Dried leaves
- Waste from agro-industries
- A suitable container
- Shed
- Pits- Cement concrete structure/ Well rings with bottom plate/Vermi bags
- Water supply
- Rose cane
- Earthworms

9.0 Method of Preparation of Vermicompost

Vermicomposting can be done indoors and outdoors, thus allowing year-round composting. Wooden plastic containers either built or bought, or something like an old dresser drawer, trunk or discarded barrel may be used for vermicomposting. Wooden containers preferably should be used because it is more absorbent and a better insulator for the worms. In plastic containers, compost tends to get quite wet. Containers should not be very large and heavy for easier lifting and moving. Depending on the size of the container drill 8 to 12 semi-circular holes of ½ inches in the bottom for aeration and drainage. A plastic bin needs more drainage holes. Raise the container on bricks or wooden blocks and place a tray underneath to capture excess liquid, which can be used as liquid plant fertilizer.

The container needs a cover to conserve moisture and provide darkness for the worms. If the container is indoors, a sheet of dark plastic placed loosely on top of the bedding is sufficient as a cover. For outdoor containers, a solid lid should be preferred, to keep away unwanted scavengers and rain. Worms need air to live, so be sure to have been sufficiently ventilated.

It is necessary to provide damp bedding for the worms to live in and to bury food waste in. Suitable bedding materials are cow dung slurry, shredded newspaper and cardboard, shredded fall leaves, chopped-up straw and other dead plants, seaweed, sawdust, compost and aged manure. It is very important to moisten the dry bedding materials before putting them in the container. Do not use large-size worms found in soil and compost, as they are not likely to survive. It is advisable not to compost meats, dairy products, oily foods and grains because of problems with smells, flies and rodents. No glass, plastic or tin foil should be present in the composting materials. Containers should be kept out of hot sun and heavy rain. If the temperature drops below 40^{0}F, containers should be replaced indoors or well-insulated outdoors. It is estimated that 1000 tonnes of sludge organic waste could be converted into 400 tonnes of organic fertilizer through vermicomposting. The production cost of vermicompost works out of Rs. 750 – 1000/- per tonne. A flow chart for the preparation of Vermicompost is given herewith.

The process consists of constructing brick-lined beds generally of 0.9 to 1.5 m width and 0.25 to 0.3 m height constructed inside a shed open from all sides. For commercial production, the beds can be prepared with 15 m length, 1.5 m width and 0.6 m height spread equally below and above the ground. The method used by farmers to multiply earthworms is by mixing high amounts of farm waste, organic wastes, including plant materials, and cattle dung in a proportion of 1:1. Once the substrate medium has been made, around 40-50 earthworm species are released into the medium and it is protected from various environmental factors. Regular maintenance is important for the growth of earthworms. The temperature should be between 15 to 25 degrees centigrade and the moisture level should be at 80-90%. Within one to two months, the earthworms can multiply up to 300 times relying on this process and factors affecting the process, and then they can be harvested. The different ways we can fill the vermicompost structures based on the requirement and availability of waste materials with 50 per cent FYM (Farm yard Manure) for better composition of NPK. The details in Fig 6.

The method used by farmers to multiply earthworms is by mixing high amounts of farm waste, organic wastes, including plant materials, and cattle dung in a proportion of 1:1. Once the substrate medium has been made, around 40-50 earthworm species are released into the medium and it is protected from various environmental factors. Regular maintenance is important for the growth of earthworms. The temperature should be between 15 to 25 degrees centigrade and the moisture level should be at 80-90%. Within one to two months, the earthworms can multiply up to 300 times relying on this process and factors affecting the process, and then they can be harvested.

Fig 6, Vermicompost structure with various layers with worm's *other species of Earthworms*

Other Methods of Preparation of Vermicomposting

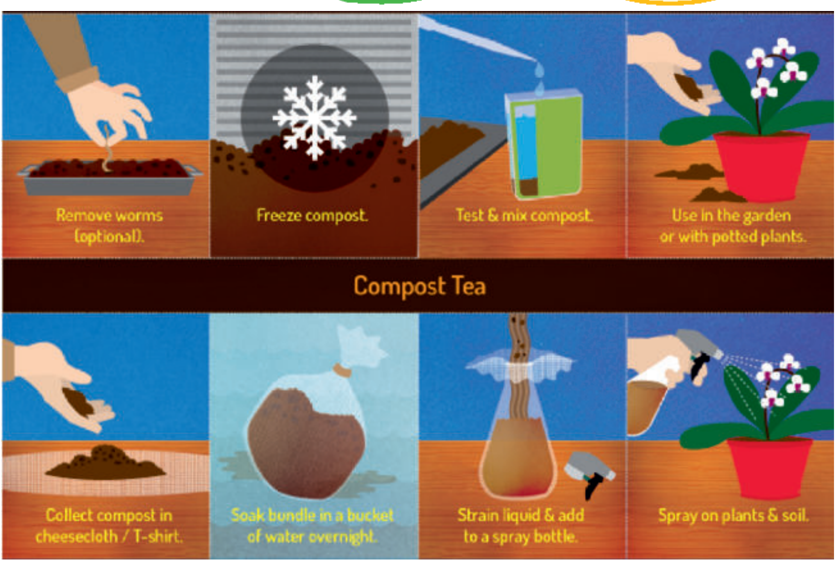
- A container with suitable dimensions is chosen and a worm bed I made at the pit of the container. This worm bed consists of old papers, sugar cane trash, paddy husk, and coir waste. A thin layer of soil is spread over this mixture and the humidity is maintained at 40-45%.

- A mix of organic waste, slurry from a biogas plant and cattle dung is spread over the bed and it is kept for half digestion for two weeks. During this time, the temperature of the bedding will rise to 50-55 degrees centigrade. A 5-10% neem cake is added to eliminate harmful microorganisms.
- After the temperature is cooled down to 30 degrees, the earthworms are introduced. Around 500 earthworms are introduced for 100 kgs of organic material.
- The bed is covered with straw and jute clothes to protect the worms. The temperature is maintained at 20-30 degrees centigrade and the moisture content is kept at 45-50%. (pH: 6.5-7)
- The compost will be ready in around 60 days and

after it is ready the worms are separated by spreading the Vermicompost on a plastic sheet in a heap under sunlight. As earthworms are sensitive to sunlight, they will move to the bottom of the heap and the top layer of the compost can be removed.

10.0 Vermiculture Techniques

Worms cannot tolerate direct light, worms left in this compost will move away from the light, toward the bottom of each pile. There are three major techniques in vermiculture for harvesting worms. These are:



Harvesting & Using of Vermicompost

10.1 Manual Method of Harvesting

This method is generally used by farmers for small-scale businesses selling worms. The worms are harvested from the soil directly by using hands. The organic material which contains earthworms is kept on a flat surface and exposed to sunlight. It should be noted that earthworms are sensitive to light, so once they are exposed to sunlight they dive below the surface. The harvester will then remove the organic layer above and once the worms are seen they are harvested.

10.2 Migration Method of Harvesting

This method takes advantage of the earthworm's tendency to migrate to a new location for food and for this reason, onion bags and screens are used for harvesting. At the bottom surface of the screen, a box will be constructed where the worms will be collected. The migration method is carried out in two ways.

The downward migration method is where the worms are forced to move downwards in the organic material with the use of light. They will go through the screen mesh and be collected in the container box below which is filled with peat moss. The process is repeated until the required quantity of worms has been achieved. It is a time-saving process and can be seen in multiple locations.

In the upward migration method, the mesh bottom of the box would be replaced by a worm bed. The box will be filled with peat moss and food which attracts the worms. Generally, coffee grounds and manure from fresh cattle are used as food for worms and they will move towards it and be collected in the box.

10.3 Mechanical Method of Harvesting

In this method, a mechanical harvester is used to collect worms. It is a trammel screen which is called a rotary screen that is used to separate materials. It is around 11ft long and

4ft in diameter and has a cylindrical shape. The walls of the cylinder are made of screening materials with different-sized meshes. The cylinder is powered by an electric motor. The device would be set at an angle at the top side of the trammel. After that, the castings and the worm beds are added. When the rotation starts the castings of the worms will drop through the screen and the worms will move across the trammel device and enter into the wheelbarrow.

11.0 Impact of vermicomposting

Vermicomposting has three impacts namely economic, social, and environmental.

11.1 Economic Impact

1. Yields

There is widespread consensus in India on the positive role of vermicompost in crop productivity. Various case studies from across the country show that yield changes compared to conventional cultivation depend on the quality and quantity of vermicompost and the combinations applied. There is also

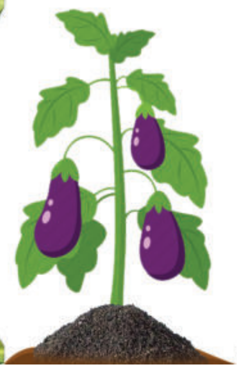
 

evidence that a few crops gave higher yields when enriched vermicompost1 was applied rather than standard vermicompost alone or in combination with chemical fertilizers.

According to several case studies, it is evident that when vermicompost is applied with vermicast (worm castings) it can increase yields significantly compared to conventional fertilizers. For instance, one study shows yield growth of more than 40 percent when applied to wheat. Whereas the integrated approach of using half vermicompost and fertilizers did improve yields over the balanced nutrient management approach,2 the rate was lower - ranging from 2 percent to 16 percent for various crops. Even fruits such as strawberries and grapes show interesting yield increases (32.7 percent and 23 percent) when vermicompost is applied alone. The combination of vermicompost, fertilizer, and biofertilizer gave medium rates of yield growth in rice.

2. Income

The practice of producing vermicompost is said to be an economical enterprise compared to chemical fertilizers. Generally, there is direct marketing of vermicompost from producer to consumer which is the strongest channel for marketing the product, but marketing is also done through cooperatives and traders. Vermicomposting used as an alternative to chemicals can significantly reduce input costs.




Estimates show that applying only 6 tonnes per hectare of vermicompost instead of the recommended dose of N, P, K for cereal crop production, can reduce the cost of fertilizer by up to Rs. 4,000 per hectare and the cost of pesticides by 40 percent in the subsequent three to four years. Farmers can also fetch Rs. 5-30 per kg in the wholesale market in India. These are estimated prices for vermicompost, not earthworms, which sell at INR 300-500 per kg.

Income and livelihood opportunities arising from the sale of the vermicompost itself, as well as increased agriculture productivity, make vermicomposting an attractive proposition. However, the process of making vermicomposting is labour intensive which can raise input costs for farmers.

11.2 Social Impact

1. Human health

Relevant literature on the health impact of vermicompost is scarce, other than those that suggest human and environmental health benefits by reducing chemical use in food production. However, these studies have not probed deeper into the subject. Vermicompost is considered an alternative to industrial farming methods involving heavy fertilizer and pesticide use, but there is a lack of systematic studies.

2. Gender

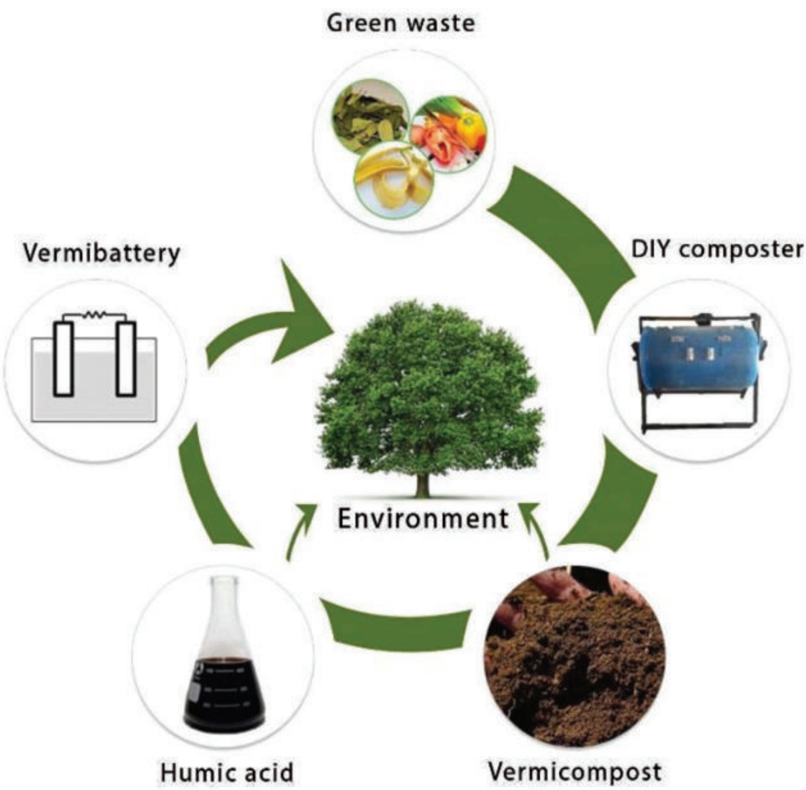
Vermicomposting is an essential activity for generating employment and income for women, especially women SHGs, many of which have benefitted from participatory vermicomposting activities. Several case studies highlight how vermicomposting has impacted women's groups by facilitating rural finance to 'women groups for vermicompost production, which helped to raise their economic status. Vermicompost training programs improved women's livelihoods, together with imparting peer-to-peer knowledge to help women's SHG initiatives expand in the region.

The women SHGs collect and prepare vermicompost from the community, which is then purchased by the government. However, the evidence suggests that women in eastern India have lesser participation in vermicomposting activities due to the fear of untouchability, diseases, and the foul-smelling nature of vermicomposting sheds. As most of these impacts were reported in case studies and articles, efforts need to be made to conduct experimental studies that capture the impact on women more comprehensively.

11.3 Environmental Impacts

1. Soil and nutrients

The practice has gained prominence due to its prime role in converting a variety of waste materials (agricultural waste, household waste) into rich nutrients that can increase agricultural productivity. Earthworms, the core element of the



practice, essentially live in the soil and turn organic debris into worm casts through vermicomposting. These worm casts are vital as they add fertility to the soil and invigorate soil health. They are known to have more than 5 times the available nitrogen, seven times more potash, and one and a half times more calcium than generally found in topsoil. Especially NPK (nitrogen, potassium, phosphorus) is known to be higher in vermicompost than other composts (farmyard manure, bacterial compost).

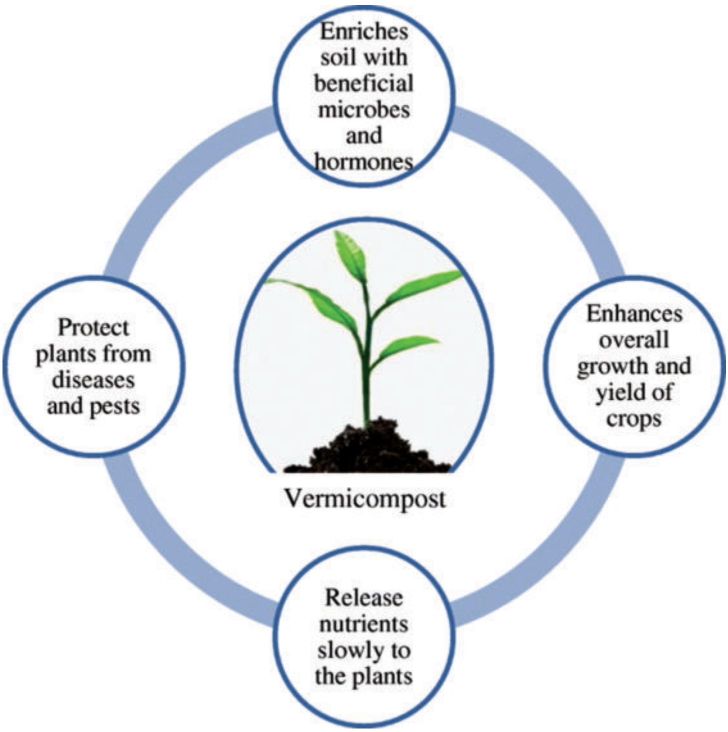
Mounting evidence also suggests that the earthworm casts have certain features that complement soil health as they aerate the soil (8-30 %) and have a high moisture-holding capacity, maintain soil temperature conditions, and increase oxygen availability. Even the nutrient content of vermicompost varies depending on the waste materials used for compost making, as a wider variety of waste materials gives a diverse nutrient profile. However, compost worms are subject to predation by certain animals and insects and to a disease known as "sour crop" caused by environmental conditions which could pose a challenge to cultivators.

2. Water

Water is a very important medium for vermicomposting as it not only sustains the earthworms which are the core of the practice, but it is needed to dissolve the organic waste created by the earthworms into water-soluble substances. Vermicompost also makes the soil more aerated, with a high moisture-holding capacity (nearly 40-60 %) that can save water and reduce irrigation costs.

3. Energy and emissions

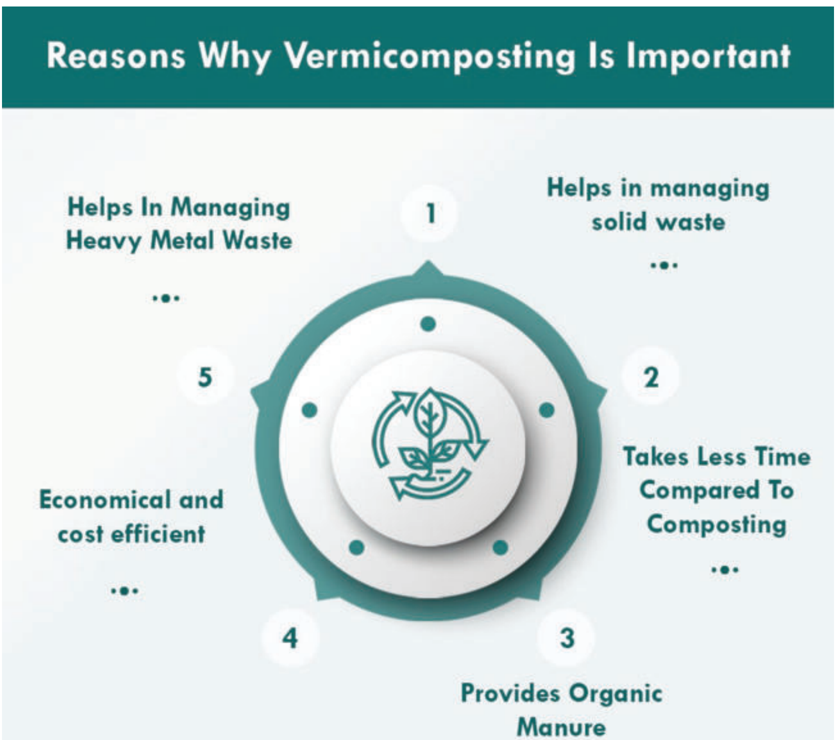
Vermicompost is produced using low-energy inputs, thus making it a cost-effective and efficient method for recycling waste products.[35] Another vital use of vermicompost is its use in producing biogas energy, as it is used as a raw material along with cow dung for generating gas and slurry from biogas plants.



Vermicompost finds relevance in the context of climate change mitigation and emissions in two ways. Firstly, the use of vermicompost reduces the need to apply nitrogenous fertilizers which are responsible for emitting GHG gases like nitrous oxide (N_2O) and ammonia (NH_3). Secondly, when waste materials decompose through vermicomposting it reduces the waste which is generally left unattended in landfills, and which is a source of harmful methane emissions. One study found that vermicomposting of waste released less N_2O and had a higher potential for reducing GHGs than centralized composting and anaerobic digestion facilities, landfilling, incineration, etc. More efforts are needed to understand the impact of emissions and carbon sequestration.

4. Biodiversity

The practice usually enhances activity beneath the soil, increasing the soil microbial diversity. Vermicompost is usually richer in microbial populations and diversity, particularly fungi, bacteria, and actinomycetes than conventional composts,



directly enhancing soil biodiversity and plant growth. "While these are mentioned in limited studies, the linkages are not very profound, thus more investigative studies are required to understand its genuine impact on biodiversity.

5. Analysis Assessment

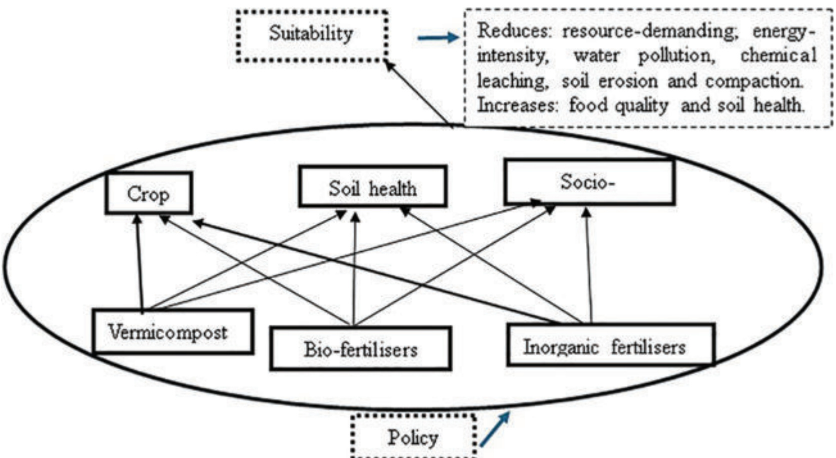
Apply your own vermicompost harvested from your own worm composting bin in your gardens to analyse the effect of vermicompost on plant growth rate in different types of plants.

6. Opportunities

By leveraging these benefits and opportunities, cities can promote sustainable waste management, urban agriculture, and eco-friendly practices while generating income and promoting economic growth.

12.0 Conclusion

Vermiculture is the culture of earthworms. It is a beneficial way of improving the fertility of the plant and soil. Vermiculture mainly focuses on the breeding of worms to increase their population. Vermicompost is then prepared to promote the growth and development of crops. This greatly reduces the need for chemical fertilizers and encourages organic matter. Vermicomposting is considered a climate-resilient practice as it sustainably manages soils and crops with fewer chemicals and improves soil health and crop productivity. It also minimizes fertilizer use and related emissions. Vermicomposting is one of the best methods to recycle agricultural and domestic waste, allowing for the safe disposal of garbage and preventing environmental pollution that could pollute landfills. Vermicompost enhances soil biodiversity by promoting beneficial microbes, enhancing plant growth directly by producing plant growth-regulating hormones and enzymes, and indirectly controlling plant pathogens, nematodes, and other pests. Vermicomposting is one of the best methods to recycle agricultural and domestic waste, allowing for the safe disposal of garbage and preventing environmental pollution that could pollute landfills. Several vermicompost micro-enterprises run by women's Self-Help Groups (SHG) and farmers have improved their economic and social status, empowering them in the process.



ISBN No.978-81-978159-5-9

Published by:

CENTRE FOR ENVIRONMENTAL STUDIES (CES)

Department of Forest, Environment & Climate Change, Govt. of Odisha

CRP-Ekamrakanan Road, IRC Village, Nayapalli, Bhubaneswar-751015

0674-2551853 www.cesodisha.org cesodisha@gmail.com /CESOdishaGovt

Printed at : Ankita Graphics, Bhubaneswar, Cell: 9437077337