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Potential of vermicomposting technology in soil and waste management

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Abstract
Waste management is the best way for vermicomposting technology which is an eco-friendly process to environment. Waste management has been problem in around many countries. Vermicomposting technology also used in reduction of pollution. Especially the animal waste produced worldwide produces pollution in high range. Livestock waste producing every year is increasing day by day. Nutrients present in animal waste can produce nutrient rich vermicompost which is also used in soil management. Application of vermicompost to plants affects its plant growth and also EC, pH of its soil. Water soluble nutrients present in vermicompost plays excellent role in plant growth. Long term usage of inorganic fertilizers results in reduction of soil fertility. Through vermicompost technology soil management is also possible, which is a part of sustainable agriculture.

Keywords: Vermicompost, production, proper utilization of sources, soil EC, pH, waste management

Introduction
In agriculture the produced waste can be used for other purposes through different technologies. Vermicomposting technology is one of them. Vermicomposting is the process by which earthworms are used to convert bio-degradable waste materials into organic fertilizers. Waste generated from the livestock is more through excreta. In cattle dung percentage of nitrogen 3%, phosphorous 2%, potassium 1% which are essential nutrients required to plants.

Table 1: Waste produced from livestock

Animal species	Population in million	Daily average excreta animal Wet weight (kg)
Cow	190	11.6
Buffalo	109	12.2
Horse	0.1	-
Donkey	0.1	-
Sheep	74.3	0.76
Goat	148.9	0.70
Camel	0.3	-

Source: Department of animal husbandry and dairying ministry of fisheries 2019.

It was found that when compared to compost vermicomposting is rich in nutrients. Vermicompost can affect soil physically, chemically, biologically. Physically includes its bulk density, porosity, aeration, water retention. chemically through its pH, organic matter, electrical conductivity. Vermicompost should be applied in limited quantity to avoid high concentration of soluble salts in vermicompost Gutberlet, J., & Uddin, S.M.N. (2017) [4].
Vermicomposting is a cheaper and eco-friendly composting process to degrade waste. The vermicomposting technology is very useful and cost effective to recycle waste.it increases soil fertility, soil texture, high and crop production (Arya, N., & Kala, S). The biological activity in the soil is increased by vermicompost which helps in germination of seeds. Earthworm gut has micro-organisms which can produce exoenzymes that help to degrade organic matter into the fertilizer. The earthworms need feed stock to survive. Food is provided in different materials such as cow dung, poultry waste, sheep/goat excreta, agricultural waste etc. which are mentioned below with which earthworm is suitable for it. Breeding and propagating earthworms, using their castings for trash recycling, and vermicomposting as a new technique have all contributed to this development.

Utilizing species like *Eisenia foetida* and *Eudrilus euginiae*, organic wastes (including domestic and agricultural waste) have been transformed into vermicompost Das, A.K *et al.*, (2017) [2]. In FRI, the division of Ecology and Environment has started a project on vermicomposting using the earthworm species *Eisenia foetida.* They have found that vermicomposting would be the best sustainable way to recycle the waste materials produced every year in different countries.

Benefits of Vermicompost

1. More Nutrient Availability

Vermicompost has a higher nutritious value than any other organic fertilizers i.e., it contains high amounts of N, P, K and other micronutrients required for the optimum performance of the crops. Nitrogen -(1-3)% potassium (1.85-2.25)% and phosphorus = (1.55-2.25)%.

2. No Leaching

Chemical fertilizers get easily leached out. They create pollution and are expensive. But, Organic fertilizers like vermicompost don't leach out and are very good for agricultural use.

3. No Pollution

Vermicompost is organic, so it doesn't have any side effects on our health as well as it doesn't create any pollution of soil and water. Moreover, It doesn't have a residual effect. Some chemical fertilizers like urea have an acidic residual effect which destroys the soil productivity.

4. Improve Soil Properties

It improves the physical, biological and chemical properties of soil like Soil aggregation, Porosity, Water holding capacity, buffering capacity, Nutrient retention and increases the microorganisms population which all contribute to our agriculture Production.

5. Contains PGR and Enzymes

There is a rare availability of plant growth hormones in other fertilizers. Vermicompost on the other hand contains a decent amount of Auxin, Gibberellin, Vitamins and Enzymes.

6. Vermicompost Tea

It is a liquid fertilizer that is extracted from vermicompost. This is beneficial for garden plants as it can be directly sprayed to plant leaves and shoots. It shows the results pretty fast.

7. Requires Less Space

When we traditional farming methods. Composting needs a large area. People who don't have much area weren't able to make adequate compost. However, Vermicompost can be made in less space. You can even make it on your terrace. It doesn't have a foul smell. There is availability of Vermi bags and bins for Vermicomposting.

8. Employment and Money

Vermicomposting is emerging as a business. Many youths are doing entrepreneurship in this field. It has also created employment opportunities and many people are able to earn good money from it.

9. Better Use Waste

Organic wastes are regularly produced in our kitchen. By giving this waste to earthworms, we can convert it into vermicompost.

Soil management: Vermicompost can enhance the size, richness, and activity of the microbial community in soil in addition to providing a source of organic matter and nutrients. Furthermore, vermicompost can impact the soil's structure, nitrogen cycling, and a variety of other characteristics. As inorganic fertilizers are applied over an extended period of time without organic supplements, the use of organic manures is becoming more and more common in sustainable crop and soil nutrient management. Over a 10-year period, the only use of mineral fertilizer increased the soil's residual nitrate concentration, raising the danger of leaching. demonstrated consistent, long-term treatment of balanced inorganic fertilizers enhanced soil water-holding capacity, overall porosity, and lowered soil bulk density. Additionally, inorganic fertilizer boosted the straw and grain yields of both maize and wheat as well as soil aggregation in deeper soil layers. Vermicompost has a considerable positive impact on plant development. Additionally, adding earthworms to the healthy soil may result in a significant influence on the soil's physical and chemical characteristics as well as the activities of other creatures living there. Vermicompost technology relating to soil and waste management –

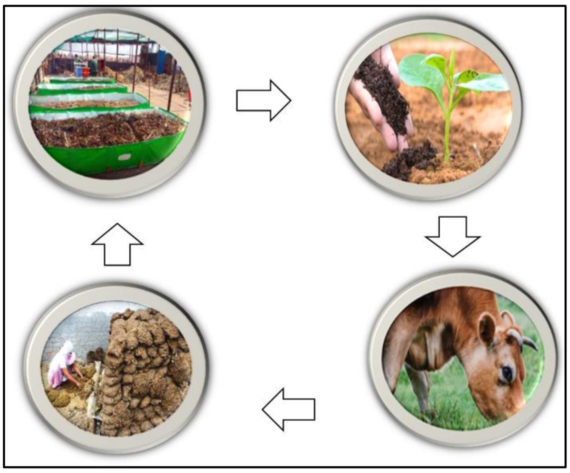


Fig 1: Cycle of vermicompost

Table 2: Different Waste Feed Stock for Worm

Worm feed	Advantages	Earthworm species
Cow dung	A nutrient rich organic fertilizer made from cow dung using earthworms.	*Eudrilus eugeniae*
Poultry	Poultry litter has higher protein content and phosphoric acid.	*Eisenia foetida*
Sheep/ goat excreta	Good nutrition	*Eisenia foetida*
Agriculture waste	Higher N content makes these good feed as well as reasonable bedding	*Eudrilus eugeniae*
Pre consumer vegetable waste	Worms prefer this substance due to its great product and higher N content.	*Eudrilus eugeniae, Eisenia foetida*
Paper waste	High in micronutrients and producing superior products, good nutrition	*Lumbricus rubellus, Eisenia foetida*
Municipal solid waste	Good nutrition is high in micronutrients and results in improved products.	*Eisenia foetida, Eudrilus eugeniae*

When an earthworm consumes organic waste, the substrate travels through its stomach and is broken down in the worm's intestine by helpful bacteria. Mucus or chemical secretion, enzyme, and bacteria aid in the digestion of substrate in the digestive system to produce vermicompost, a finely split peat-like substance that is easily accessible to plants. As a result, vermicompost can be used to improve soil or as a medium for growing plants. By giving plants nutrients, lowering the c to n ratio, enhancing soil texture, raising soil porosity, and boosting soil water holding capacity, vermicompost may operate as a soil conditioner, reducing the need for tillage and irrigation. There are two stages in the mesophilic phase of vermicomposting. Earthworms and helpful microorganisms work together during the active phase, which is the first stage, to start breaking down organic substrate through metabolic processes that change the physical and biological activity of the soil. After the earthworm advances to a new layer of undigested wastes, the maturation phase is the next step that requires microorganism activity to complete the decomposition process. The amount of organic waste that earthworms can eat each day is equal to their body weight, and the time it takes for them to start breaking down organic substances through their metabolic processes (digestion, absorption, and assimilation) varies depending on the species and density of the earthworms.

Table 3: Representing the different nutrient content

Waste	Nutrient management		
	Nitrogen	Phosphorous	Potassium
Cow dung	3%	2%	1%
poultry	5.46%	2.82%	2.32%
Sheep/goat excreta	3%	1%	2%
Agricultural waste	1.4%	1%	1.4%
Vegetable waste	2.11%	1.22%	1.4%

How animal waste can be recycled?

Waste produced from animal generally causes water, soil, air pollution. Excreta can be regenerated into fertilizers and used as feed stuffs. when compare to use this as fertilizer to use it as feed stuffs would be more beneficial. For ruminants and nonruminants poultry litter can be used as good source as feed stuffs. Animal excreta can also help in producing bio gas. Through vermicomposting and composting animal waste can be converted. recycling waste into manure can provides the essential nutrients in proper way by protecting natural environment. Recycling also reduces the amount of waste going to landfills. If action not taken to recycle the waste many diseases can be transferred from Faeces matter to human and animals.

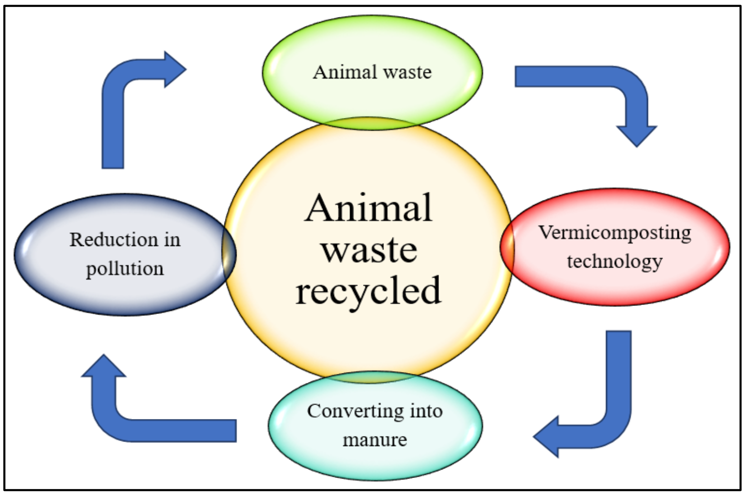


Fig 2: Representing the Animal waste recycled

India and China are two leading countries to produce more waste. In case of China, a young man named Ye Kaifang observed that if raw pig waste is directly applied to the farm, it may spoil the soil due to compounds like ammonia (Gupta, C *et al.*, 2019) [3]. In China generally each household raises pigs and poultry. This produces a large amount of waste in country. In this case vermicomposting technology can play a key role in reusing waste in a natural way. The most pollution caused by animal waste is the production of methane. methane is produced from dung of ruminating animals. These have methanogens in their gut. Production of methane from these animals being biggest problem for the environment. So, through vermicomposting technology we can use this dung and produce enriched compost also known as black gold.

How can livestock waste causes pollution

Animal composted manure have long been recognised as adva ntageous organic soil additions that are rich in nutrients. Rich and preserve the soil's physical characteristics, including its structure and capacity to hold rainwater. By stabilising soil aggregates, manure helps to enhancesoil quality and water retention, minimising erosion, and perhaps even addressing drainage issues in wet places. The interaction between soil and its water and air components is connected to the major effect of nutrient overloaded soils. While air pollution results from complicated processes like nitrification and denitrification as well as the breakdown and conversion of organic material in soils, water pollution is mostly caused by the discharge of nitrates provided in abundance of plant absorption.

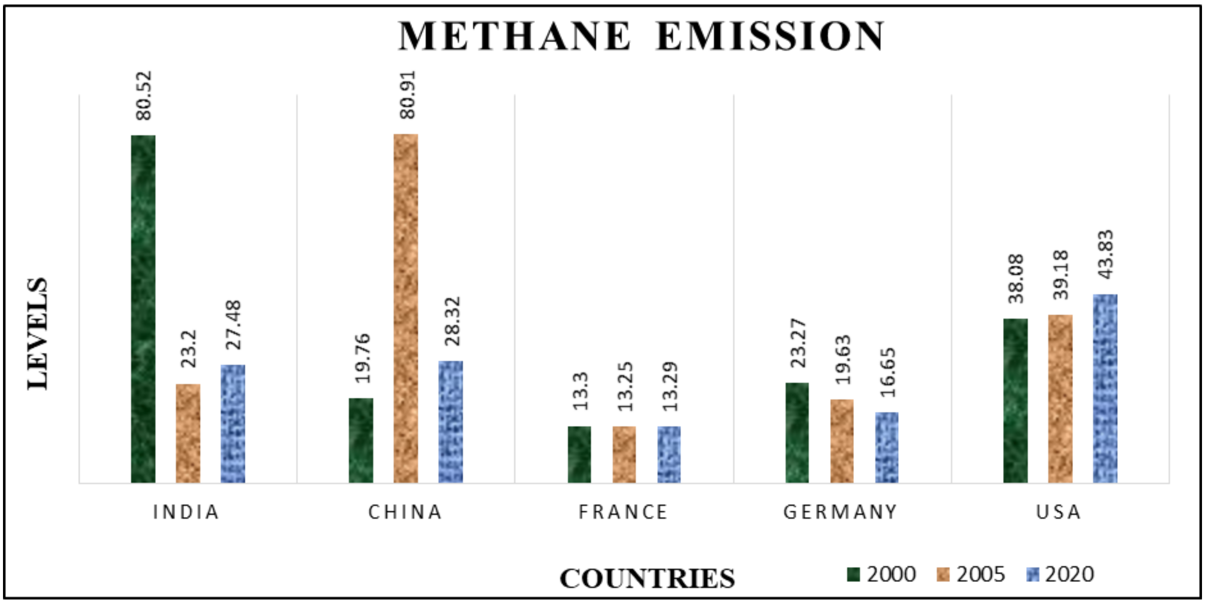
Pollution caused to water

The leach and runoff of nutrients from the soils or the direct dumping of manure into watercourses are two common ways that animal production contributes to water pollution. Nutrients from animal dung that crops cannot use build up and even saturated soils. Nutrient loss occurs upon saturation, either to surface waters or ground waters. The two nutrients of particular agricultural relevance with the highest potential to pollute water are nitrogen and phosphorus. Potassium (K), while not a problem right now, will become one in the near future since the application of organic manure based on plants' absorption of P often results in the excess application of this mineral. Because it is hazardous to many fish species, free ammonia has a bigger effect on water systems than ammonium salt. For instance, 5 mg/L of ammonia has an impact on salmon, an ammonium sensitive fish. particularly illustrated the issue while describing the water quality issues in livestock areas and came to the conclusion that there is an overall transducing of nutrient cycles and problems with nutrient enrichment are either brief immediate losses or lengthy, related to aggregated nutrient excess supply.

Air pollution caused by waste

Animal agriculture has been noted as a significant source of air pollution. More than a hundred gaseous chemicals are present in the air in cattle housing thanks to the ventilation system. From an environmental standpoint, odorous chemicals, particularly ammonia, have been the principal concerns among these gases. The majority of the gases resulting from animal husbandry are created by microbial activity from recently descended or previously stored faeces and urine.

An estimated 54 million tonnes of ammonia (NH_3) were emitted globally in 1990, of which 43 million tonnes (or 80%) were from human sources. The two main anthropogenic sources are the usage of synthetic Nitrogen fertilizer (25%) and the excrement of domestic animals (50%) in homes. Western Europe's annual anthropogenic ammonia emissions were estimated to be between 2.8 and 5.2 million tonnes of NH_3-N in 1990. The main source was farm animal manure, and its emissions were harming the environment by causing eutrophication and soil acidification. These emissions also represent a significant loss of expensive N fertilizer Jain, N. (2016) [5]. Animal habitation, manure storage areas, and the use of manure to land all cause ammonia to be lost to the atmosphere. The shelter and slurry storage are responsible for around 50% of the methane emission from swine production, while the other 50% are released after land application. The concentration of nitrate ions in the sludge, the emission surfaces, the pH of the sludge, the air speed over the slurry, and the slurry temperature are the main parameters affecting ammonia emissions. Since prolonged exposure to NH_3 in combination with dust can result in serious respiratory disorders, animal houses represent a health concern to both people and animals. Additionally, a high NH_3 concentration may impair animal performance. Because prolonged exposure to NH_3 in combination with dust can result in serious lung disorders, it poses a health concern to both animals and people living in animal houses. Additionally, a high NH_3 concentration may impair animal performance. Ammonia emissions have caused long-term harm to delicate natural and semi-natural ecosystems in Europe during the past ten years due to high rates of deposition on land and over surface waters. Ammonia is a concern on both a national and worldwide scale since it may travel great distances in the atmosphere. European Union members have ratified international accords to control pollution.



Methane emission from livestock waste (million tons) causes pollution

Climate change and methane and nitrogen oxide emissions. One scenario in the best estimates of climatic disruption brought on by human activity suggests a potential temp growth of up to 4 °C within next 40–65 years. In terms of agriculture, such a climate shift would cause currently fruitful huge land areas to dry up. The northern hemisphere's tundra and other cold places won't always be suited for growing crops. More particular, there is no justification to believe that agriculture would be able to adjust to any climatic change brought on by the trend of global "warming" soon enough. Major greenhouse gases linked to the global warming phenomena include methane and nitrous oxide.

Table 4: Different countries having different waste product in million tons

Country name	Agriculture Waste (Million tons)	Dung (Million tons)	Paper waste (Million tons)	Municipal waste (Million tons)	Kitchen waste (Million tons)
India	350 million tons	562 million tons (2022)	85 million tons (no country specification)	42 million tons	68.7 million tons
China	900 million tons (2017)	700 million tons (2020)	54.93 million tons (?)	210 million tons (2017)	35 million tons (2021)
US	103 million tons (2020)	--	21 million tons (2018)	292.4 million tons (2018)	--
Russia	--	--	15 million tons	55-60 million tons	17 million tons (2020)
Japan	--	89 million tons	--	--	27.59 million tons (2020)
Europe	--	--	23 million tons	61 million tons (2020)	88 million tons (2020)
Canada	--	177.5 million tons	--	34 million tons (2020)	--

Source: Environmental protection agency (USA)
*(--) (data not available)

How Vermicompost Effects On Soil

Soil physical properties effected by vermicompost as Vermicompost has the potential to enhance the soil's physical properties, such as porosity, aeration, drainage, corrosion resistance, and infiltration, resulting in a better environment for root development.

Vermicompost enhanced the soil's physical qualities, which further boosted bean growth, yield, and quality. Vermicompost appears to be loaded with polysaccharides, according to earlier studies. For enhanced aeration, water retention, drainage, and aerobic conditions, the soil structure was created and maintained in the presence of polysaccharide, which served as a cementing agent and produced aggregate stability. The growth of roots and the availability of nutrients to the plants are both greatly aided by the preservation of soil structure. The soil's aggregation stability is improved by the inclusion of mucus secreted from the earth worm's gut and bacteria in the gut Kumar, A *et al.*, (2022) [6]. The absorbent organic material in Vermicompost, which only stores the appropriate quantity of water required by the plant roots, increases the soil's ability to retain water. Decrease in the density of the treated soil with vermicompost. The increased bacterial community and activity, which caused aggregate formation and improved soil porosity, was the primary cause of decreases in particle & bulk densities. The natural resources used for vermicomposting affect the electrical conductivity (EC) of the compost as well as how concentrated their ions are in those materials. Ragi and cowpea are produced on soils that had had vermicompost treatment. The stability of the natural resources may be to blame for the decrease in EC. Similar to this, noted a drop in EC at the conclusion of the growth research, demonstrating that the large saline concentrations in vermicompost made from pig dung were successfully leached. When vermicompost was added to the soil, the exchangeable Ca^{2+} concentration rose. This enhanced Na^+ - Ca^{2+} exchange at the soil's cation exchange sites allowed for greater exchanged Na^+ leaching and, as a result, a decrease in the soil's electrical conductivity (EC).

Vermicompost is reported to show hormone-like activity, and this has been hypothesized to result in greater root initiation, root biomass, plant growth and development, as well as morphology changes in plants grown in vermicompost - amended media. There is some likelihood that the enhanced plant growth is due to the presence of plant hormone-like activity produced by microflora during vermicomposting, and also the presence of metabolites as a result of secondary metabolism. Vermicompost contains plant growth hormones such as auxins, gibberellins and cytokinin produced by microorganisms during the process of vermicomposting Wardianto, D., *et al.*, (2020) [7]. These substances may be partially responsible for the increases in germination, growth and yield of plants. Since there is clear evidence from greenhouse trials that they could. Vermicompost also aids in increasing the soil's porosity and penetration rate, which promotes salt leaching. According to vermicompost with EC values less than 1.5 (stabilized material) and 4.0 ds m1 is appropriate for use as organic soil amendments and growth media, respectively.

Conclusions

Vermicomposting had always been the best option for recycling the waste in natural way.

- To make greater use of both its input and products, livestock production should be better integrated with other agri-food and agricultural operations. The necessary rise in animal output that will be needed cannot be achieved by substantial increases in "average daily gain" or animal genetic improvement. Additionally, the production of animals will face increasing competition from the economic and human strain on grains. We may anticipate that in the approach, co- or through from agro - based operations will gradually replace the cereals to use for animal feeding, allowing the cost of animal feeding to be reduced and the creation of systems for recycling previously discarded goods.
- It is also obvious that new waste management strategies must be developed for the outputs in order to safeguard the environment and enable manure management to return to a recycling perspective of manure handling. Early liquid-solid separation in livestock homes may be of special relevance among these novel strategies since it lowers emission levels in the structures and produces water and solids that may be handled separately.
- It is important to create methods for recycling nutrients from wastes, particularly phosphorus, as well as any methods that have a positive economic and environmental impact, such as improving manure's agronomic value or producing biogas from it.
- The ideal scenario would be to simultaneously focus on the inputs, outputs, and integration of livestock production in its "region" or geographical elements. To do this, however, we must take into account all treatment factors, including economic factors like the cost of livestock buildings, the development and depletion of fuel, phosphorus, and maybe low-priced grains, in addition to any environmental or hygienic limits.

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