Journal of Advanced Zoology
ISSN: 0253-7214
Volume 45 Issue S-3 Year 2024 Page 169:184

Microbial Loads Of Vermicompost Prepared From Various Medicinal Plants.

C. Sahila Angel[1*] and Dr. A.S Ganga[2]

[1]*Reg.No.19211072192009, Research Scholar, St. John's College, Palayamkottai, Tirunelveli. sahilaangelc@gmail.com
[2]The M.D.T Hindu College, Tirunelveli, Affiliated to Manonmaniam Sundaranar University - Tirunelveli - 627012 asganga2010@gmail.com

***Corresponding Author**: C. Sahila Angel
*Reg.No.19211072192009, Research Scholar, St. John's College, Palayamkottai, Tirunelveli. sahilaangelc@gmail.com

Abstract

Microbes present in the vermicompost plays a major role in exhibiting the beneficiary effect which results in significant plant growth and yield. In this study, we aim to analyze the microbial load present in the vermicompost which is prepared from different medicinal plants including *Phyllanthus emblica, Senna auriculata, Justicia adhatoda, Annona squamosa* at two different ratios of preparation with cow dung. To perform this, microbial load was evaluated before and after vermicompost formation. After completion, it was observed that fungal and actinomycetes loads were significantly higher in vermicompost samples prepared from *Phyllanthus emblica* plant samples. Concerning bacterial load, it was observed that vermicompost samples prepared from *Senna auriculata* showed the maximum load. These data provide us the information about the importance of the vermicompost with different medicinal plants in increasing the microbial load concentration which further enables plant growth and yield. It is also noted that the ratio of 1:2 gave better microbial load results than the 1:1 ratio sample. These datasets provide us with the basic knowledge to improvise the field of the vermicomposting process with the potential usage of medicinal plants.

Keywords: Drinking water quality, waterborne pathogens, fecal contamination, water microbiology, pathogen characterization, physiochemical parameters

INTRODUCTION

Microorganisms are versatile in nature. Different roles were played by them both in beneficial mode and harmful mode. Microorganisms especially play a major role as it completely helps in the process of composting. Some microorganisms are well known worm predators. Major class of beneficial microorganism comprised of different types of aerobic bacteria, fungi and molds Enchytraeids, Millipeds spider and mices springtails, protozoa, grass and their larvae beneficial nematods(Sam Arigma, Michael Noack and Sally Noack October 2011).

Vermicomposting is a well-known process where earthworms are utilized to convert organic stuff into humus-like material known as vermicompost. Many reports and studies have evaluated the significance of vermicompost compared with traditional compost. The involvement of microorganisms in the process of vermicompost is reported in many studies (Amoucei *et al.*, 2017, Satpathy *et al*, 2020). It is always the combination of the earthworm along with different kinds of microorganisms including both bacteria and fungi. Recent reports found the existence of *lactobacillus* species and *acinetobacteria* species. It is also reported that earthworms possess the capacity to promote the growth of fast-growing bacteria such as *y-proteobacteria*, which leads to an increase in the *protobacteria*, *acidobacteria* ratio (Gong *et al.*, 2018). Bacterial count enumeration found that there is a significant increase in the bacterial count. Total bacteria count exceeds $16.97x10^5$ and $28.1x10^5$ in a 1:1 ratio, $19.04x10^5$ and $35.93x10^5$ in a 1:2 ratio and it includes *Nitrobacter*, *azotobacter*, *phosphate solubilizers*, *actinomycetes* and *rhizobium* (Suhane, 2007). The hypothetical reason for the increase in the microbial load might be due to the involvement of microbes present in the digestive tract of earthworms and the consumption of highly nutrient-rich organic wastes which provide energy and act as a substrate for the growth of microorganisms (Tiwari *et al.*, 1989).
Many studies reported that earthworms exhibit significant functions in enhancing the dimensions of the chemical process of the soil and changing the dynamics of the soil by adapting the litter and altering the activity of soil microflora (Peterson and Luxton 1982; Edward and Bohlen 1996). Microorganisms such as bacteria actinomycetes and fungi are the most important microorganisms and play an important role during vermicomposting (Liu *et al.*, 2021). Generally, the earthworms consume microbes that are essential for plant growth including plant growth-promoting rhizospheric bacteria such as *Pseudomonas*, *Rhizobium*, *Bacillus*, *Azospirillum*, *Azotobacter* (Munoz Ucros *et al.*, 2020). It is reported that all these organisms get activated and increased because of the suitable micro-environment of the gut of earthworms. These earthworms excrete significant microbes such as nitrogen-fixing bacteria and decomposer microbes in their excreta along with other essential nutrients (Singltone *et al.*, 2003).

OBJECTIVES

To evaluate the microbial diversity and microbial quantity in the vermicomposting prepared from different medicinal plants.
To compare the efficacy of the prepared vermicompost in different ratio to obtain increasing microbial load.

METHODS

Vermicomposting was done using earthworm *Eudrilus eugeniae* with 8 treatments at 2 different ratios. In 1:1 ratio [T1 – 1 kg cow dung + 1 kg *Phyllyanthus emblica* + cow dung] [T2 – cow dung + *Senna auriculata*] [T3 – 1 kg cow dung + 1 kg *Justicia adhatoda*] [T4 – 1 kg cow dung + 1 kg *Annona squamosa*] 1:2 ratio [T5 – 1 kg cow dung + 2 kg *Phyllanthus emblica*] [T6 – 1 kg cow dung + 2 kg *Senna auriculata*] [T7 – 1 kg cow dung + 2 kg *justicia adhatoda*] [T8 – 1 kg cow dung + 2 kg *Annona Squamosa*] temperature, humidity and pH were measured. The population of earthworms, the production of vermicompost, and the chemical and microbial loads were analysed from the initial day to 60 days. The values are analysed using GraphPad Prism 8.0 software by t-test.

Microbial Culture Conditions

Biochemical Tests

Indole Test:
The pure bacterial culture was grown in sterile tryptophan or peptone broth and incubated for 24-28 hrs. After incubation, 5 drops of Kovac's reagent (isoamyl alcohol, para dimethyl amino benzaldehyde, concentrated hydrochloric acid) were added to the cultured broth. Indication of indole positive will be observed as the formation of red or reddish–violet color in the surface layer of the broth, whereas negative results were observed to be yellow.

Methyl Red Test
MRVP (Polypeprone – 7g; Glucose – 7; Dipotassium phosphate – 5g; Distilled water – 1L; Final pH – 6) broth was prepared in test tubes, the cultures were inoculated with 2 loopful of bacterial culture. Further, the cultures were incubated at 37°C for 48-72 hours. After that few drops of methyl red indicator were added and results were observed as indicated above.

Voges-Proskauer Test
The VP broth (buffered peptone - 7.0 gm; glucose 5.0 gm; dipotassium phosphate 5.0 gm; deionized water – 1L; pH 6.9) was prepared in the test tubes. Pure cultures were inoculated and incubated for 24 hours at 37°C. After incubation, 6 drops of Barritt's reagent A (Alpha-Naphthol, 5% in Absolute Ethanol) were added and stirred well. Further, 2 drops of Barritt's reagent B (Potassium Hydroxide (40% in water) were added to the same tube and stirred well. The results were observed for the formation of red colour.

Citrate Test
Citrate agar plates were prepared using the following composition, Sodium Chloride - 5.0 gm; Sodium Citrate (dehydrate) - 2.0 gm; Ammonium Di hydrogen Phosphate - 1.0 gm; Di Potassium Phosphate - 1.0 gm; Magnesium Sulfate (heptahydrate) - 0.2 gm; Bromothymol Blue - 0.08 gm; Agar - 15.0 gm; Deionised Water - 1000 ml; Final p^H - 69 +/- 0.2 at 25ºC. Above said components were dissolved in deionized water and the p^H was adjusted to 6.9. Further, Bromothymol Blue was added. After preparation, the media appears as deep forest green due to bromothymol blue. The plates were inoculated with the selected organism and incubated aerobically at 35 to 37ºC for up to 4-7 days. The colour change was observed when the organism showed positive results.

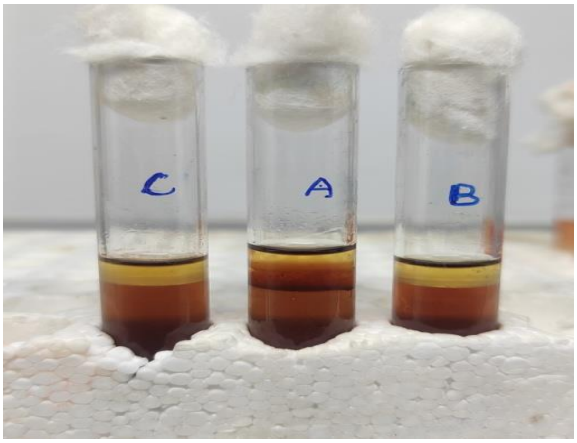
Triple Sugar Iron Test
The triple sugar iron test is used for the presumptive identification of *Enterobacteriaceae* based on the fermentation of glucose, lactose, sucrose, and the production of gas and H_2S. Triple sugar iron Agar is used for the differentiation of gram-negative enteric bacilli based on carbohydrate fermentation and the production of hydrogen sulfide. An Agar slant of special medium with multiple sugars consisting of p^H - sensitive dye (phenol red) 1% alcohol, 1% sucrose, 0.1% glucose as well as sodium thiosulphate and ferrous sulphate or ferrous ammonium sulphate is used for carrying out the test.

Catalase Test
One ml of 3% H_20_2 was directly added to the 24 hr heavily inoculated pure culture which was grown on a nutrient agar slant. Then immediately the tubes were placed against the dark background and observed for the formation of bubbles. If the taken microbes are catalase positive, it is observed with immediate effervescence (bubble formation). No bubble formation (no catalase enzyme to hydrolyze the hydrogen peroxide) was represented by a catalase-negative reaction.

Oxidase Test
The oxidase test is used as a major characteristic for the identification of gram-negative rods that are not in the Entero bacterial family. The oxidase test detects the presence of a cytochrome oxidase system that will catalyse the transport of electrons between election donors in the bacteria and a redox dye-tetramethyl-p-phenylene-diamine. The dye is reduced to deep purple colour. The test is used to assist in the identification of *Pseudomonas*, *Neisseria*, *Aeromonas*, and *Campylobacter Vibrio* all of which produce the enzyme (Begum *et al.*, 2018) were reported that the bacterial strains were gram-positive in nature and rod shape.

1. Biochemical Tests
1.1 Indole Test:

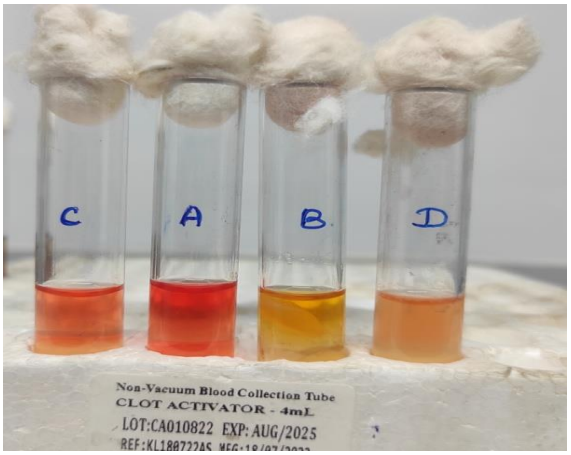
S.No.	Name of the Test	Bacillus subtilis	Vibrio species
1.	Indole test	-	+



C-Control, A-*Vibrio species*, B-*Bacillus subtilis*

1.2 Methyl Red Test:

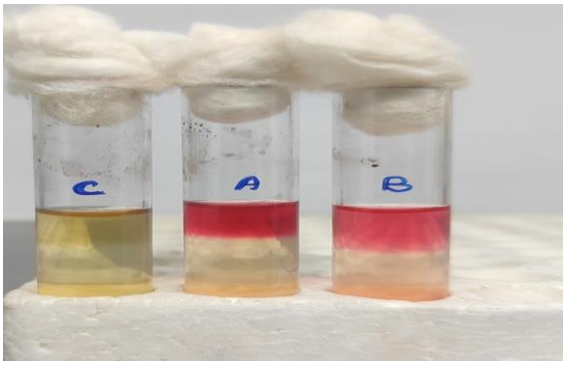
S. No.	Name of the Test	Proteus mirabilis	E.coli	Vibrio species
1.	Methyl Red test	-	+	-



C-Control, A-*E. coli*, B-*Proteus mirabilis*, D-*Vibrio species.*

1.3 VogesProskauerTest:

S.No.	Name of the Test	Klebsiella pneumonia	Enterobacter aerogenes
1.	VogesProskauer test	+	+



C - Control, A - *Klebsiella pneumonia*, B - *Enterobacter aerogenes*

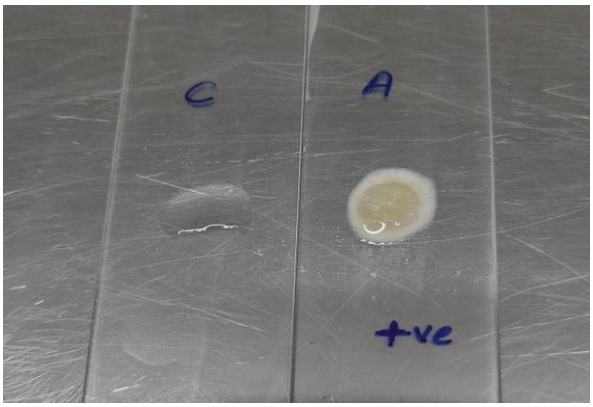
1.4 Citrate Test:

S.No.	Name of the Test	Bacillus cereus
1.	Citrate test	+

C-Control, A-*Bacillus cereus*

1.5 Catalase Test:

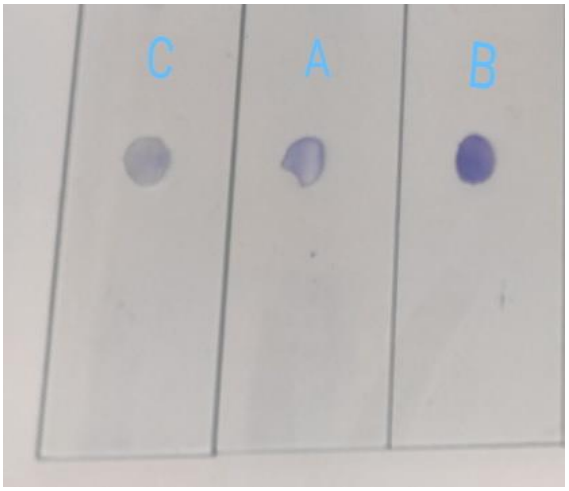
S.No.	Name of the Test	Xanthomonas species
1.	Catalase test	+



C-Control, A-*Xanthomonas species*

1.6 Oxidase Test:

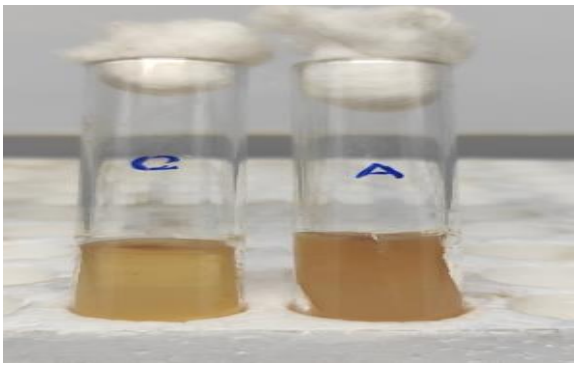
S.No.	Name of the Test	Acinetabacter baumannii	Pseudomonas aeruginosa
1.	Oxidase test	-	+



C - Control, A – *Acinetabacter baumannii* B – *Pseudomonas aeruginosa*

1.7 Motility Test:

S.No.	Name of the Test	Bacillus subtilis
1.	Motility test	+



C - Control, A – Bacillus subtilis

Statistical Analysis

The values are analyzed using GraphPad Prism 8.0 software by t-test. The variations were considered statistically significant if $p \leq 0.05$. All the tests were done in triplicate.

RESULT AND DISCUSSION

Total Microbial Population

The total microbial population analysis was performed for the following categories with specified conditions represented in Table 1. Table 2 describes the biochemical test results obtained for different microbes isolated from vermicompost samples. Table 3 depicts the results obtained about the distribution of microorganisms in 60 days of vermicompost in all 8 treated samples.

Table 1: Treatment No Sample ID and description details

Treatment No.	Description	Cow Dung (% in kg)	Leaf Waste (% in kg)
T0	CD – Cowdung 100%	1	-
T1	CD + Phyllanthus emblica	1	1
T2	CD + Senna auriculata	1	1
T3	CD + Justicia adhatoda	1	1
T4	CD + Annona squamosal	1	1
T5	CD + Phyllanthus emblica	1	2
T6	CD + Senna auriculata	1	2
T7	CD + Justicia adhatoda	1	2
T8	CD + Annona squamosal	1	2

Table 2: Bio-chemical test results of the microbes isolated from vermicompost samples**.**

S. No.	Bacterial Isolate	Gram Stain	Motility	Indole	Methyl Red Test	Voges Proskauer	Citrate	Triple Sugar Iron	Catal-ase	Oxi-dase
1	*Bacillus subtilis*	+	+	-	-	+	+	+	+	Vari-able
2	*Bacillus cereus*	+	+	-	-	+	+	+	+	-
3	*Xanthomonas species*	-	+	-	-	-	+	+	+	-
4	*Pseudomons aeruginosa*	-	+	-	-	-	+	-	+	+
5	*Pseudomonas fluorescens*	-	+	-	-	-	+	-	+	-
6	*Acinetobacter baumannii*	-	-	-	-	-	+	-	+	-
7	*Enterobacter aerogenes*	-	+	-	-	+	+	+	+	-
8	*Klebsiella pheumoniae*	-	-	-	-	+	+	+	+	-

9	*Proteus mirabilis*	-	+	-	+	-	-	+	+	-
10	*Escherichia coli*	-	+	+	+	-	-	+	+	-
11	*Vibrio species*	-	+	+	-	+	+	+	+	+

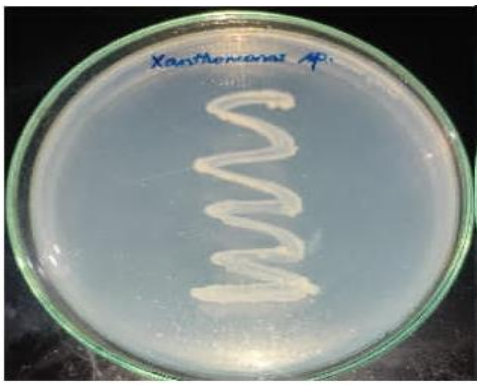
Table 3: Distribution of Microorganisms in 60 days of Vermicompost

S.No.	Bacteria	T0	T1	T2	T3	T4	T5	T6	T7	T8
1	*Bacillus Subtilis*	+	+	+	-	+	+	+	-	+
2	*Bacillus cereus*	-	+	-	+	-	+	-	+	-
3	*Xanthomonas Species*	-	-	+	-	+	-	+	-	+
4	*Pseudomonas aeruginosa*	+	+	-	+	+	+	-	+	+
5	*Pseudomonas fluorescens*	-	+	+	+	-	+	+	+	-
6	*Acienetobacter baumannii*	+	+	+	+	+	+	+	+	+
7	*Enterobacter aerogenes*	-	+	+	-	-	+	+	-	+
8	*Klebsiella pneumoniae*	+	+	+	+	+	+	+	-	+
9	*Proteus mirabilis*	+	+	-	+	+	+	-	+	+
10	*Escherichia coli*	+	+	+	+	+	+	+	+	+
11	*Vibrio species*	+	-	-	+	-	-	-	+	-

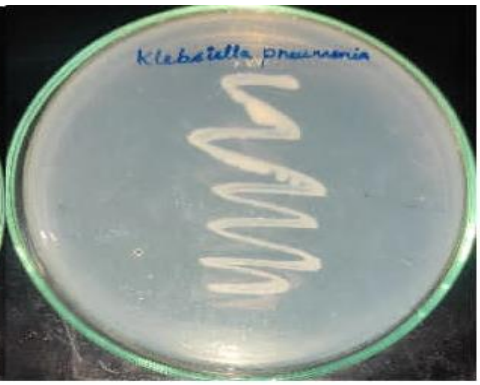
Table 4: Identified bacterial species

S. No.	Identified bacterial species
1.	Bacillus Subtilis Gram + ve
2.	Bacillus cereus Gram + ve
3.	Xanthomonas Species Gram – ve
4.	Pseudomonas aeruginosa Gram - ve
5.	Pseudomonas fluorescens Gram – ve
6.	Acienetobacter baumannii Gram – ve
7.	Enterobacter aerogenes Gram – ve
8.	Klebsiella pneumoniae Gram – ve
9.	Proteus mirabilis Gram – ve
10.	Eschertiehia coli Gram – ve
11.	Vibrio species Gram – ve

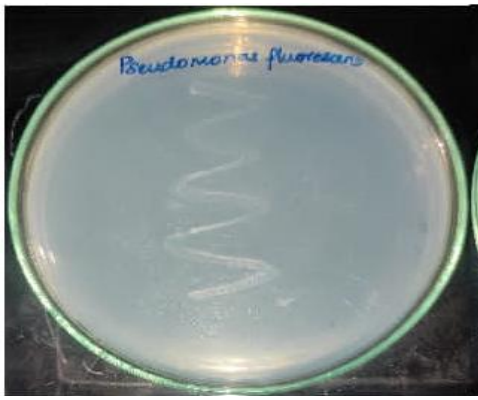
Distribution of bacteria in vermicompost from 2 different ratios (1:1) and (1:2)



Pseudomonas fluoresens



Acinetobacter baumannii



Xanthomonas Species

Klebsiella pneumoniae

Enterobacter aerogenes

Proteus mirabilis

Escherichia coli

Bacillus cereus

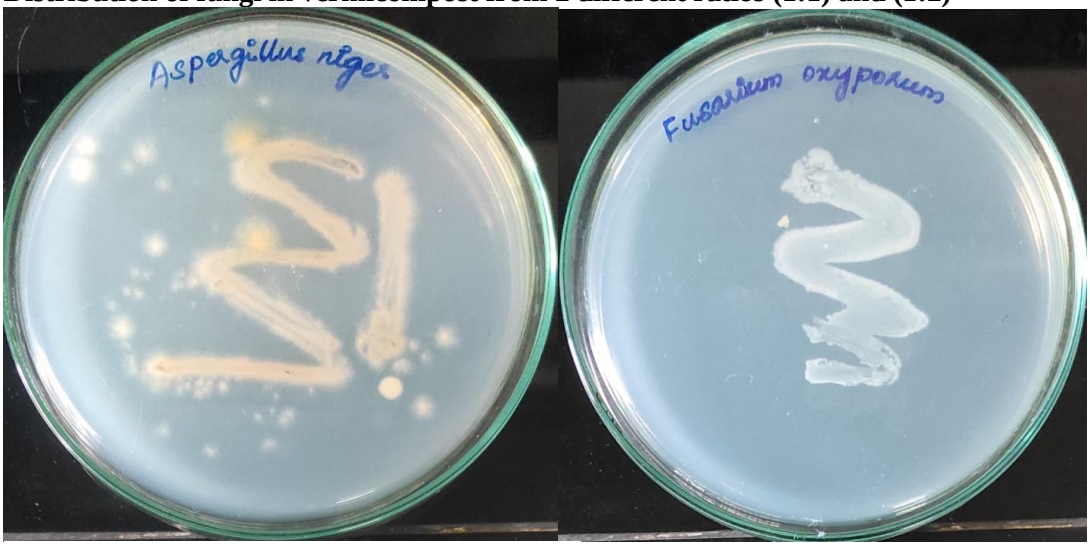
Bacillus subtilis *Vibrio species*

Pseudomonas aeruginosa

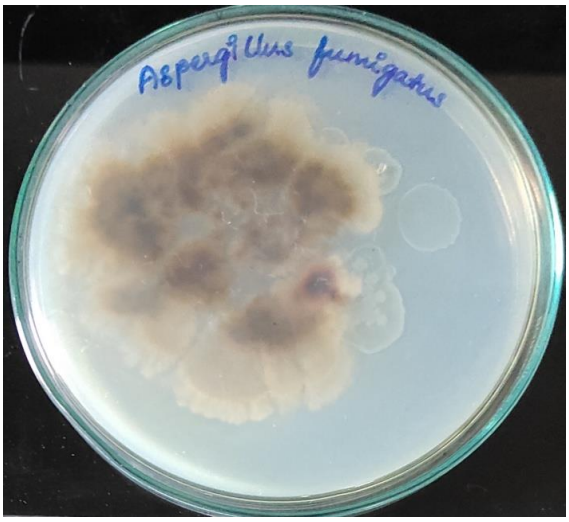
Table 5: Identified fungal species

S.No.	Identified fungal species
1.	Fusarium oxysporum
2.	Aspergillus niger
3.	Aspergillus fumigatus

Distribution of fungi in vermicompost from 2 different ratios (1:1) and (1:2)



Fusarium oxysporum *Aspergillus niger*



Aspergillus fumigatus

The growth range of bacteria was observed from 20.35x10^5/g – 35x10^5/g respectively in all the treatments (T1-T8). The microbial enumeration details before and after the treatment process were documented in Table 4 along with statistical analysis represented as "t" values and mean values. Maximum count was observed in the T6 sample and minimal count was observed in T3.
The growth range of fungus was observed from 4.99 x10^7/g - 8 x 10^7/g respectively in all the treatments (T1-T8). The microbial enumeration details before and after the treatment process were documented in Table 5 along with statistical analysis represented as "t" values and mean values. Maximum count was observed in the T5 sample and minimal count was observed in T1.
The growth range of actinomycetes was observed from 11.23x10^4/g - 25.90x10^4/g respectively in all the treatments (T1-T8). The microbial enumeration details before and after the treatment process were documented in Table 6 along with statistical analysis represented as "t" values and mean values. Maximum count was observed in the T5 sample and minimal count was observed in T3. On the whole comparative analysis, it was observed that all the microbial populations were increased from the initial day to the final day i.e. 60th day of vermicompost.

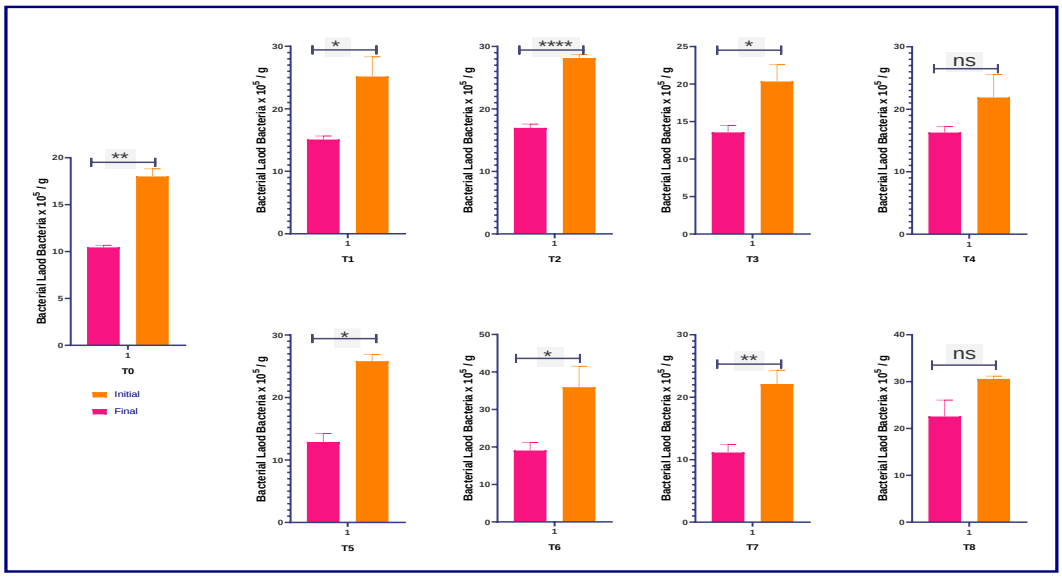


Figure 1: Comparative analysis of bacterial population of 4 medicinal plants treated with Eudrilus eugeniae both 1:1 and 1:2 ratio (3 replication) with statistical analysis.

Figure 1 & 2 depicts the comparative analysis of treated category values with control sample values and initial and final day value comparison for the bacterial load. Figures 3 & 4 depict the comparative analysis of treated category values with control sample values and initial and final day value comparison for the fungal

load. Figures 5 & 6 depict the comparative analysis of treated category values with control sample values and initial and final day value comparison for the actinomycetes load.
The microbial (bacteria, fungi & actinomycetes) load of the samples was increased as the days increased. Compared with the control sample which is only cow dung all the vermicompost-treated samples showed increased microbial growth (Table 4,5,6). This indicates that *E.eugeniae* plays a major role in enhancing microbial growth in the soil samples. These worms utilize the organic matter and enrich them with the impact of beneficial microbes. Other recent studies also reported similar types of data with other vermicomposts (Karmegam and Daniel 2009; M. Prakash *et al*., 2009). Many other reports also observed a significant increase of microbial load along with microbial activity and increased N, P, and K content in the vermicompost which were kept in a condition of 31°C with 70% moisture in the process of vermicomposting using sugar industrial wastes (Parthasarathi 2006).

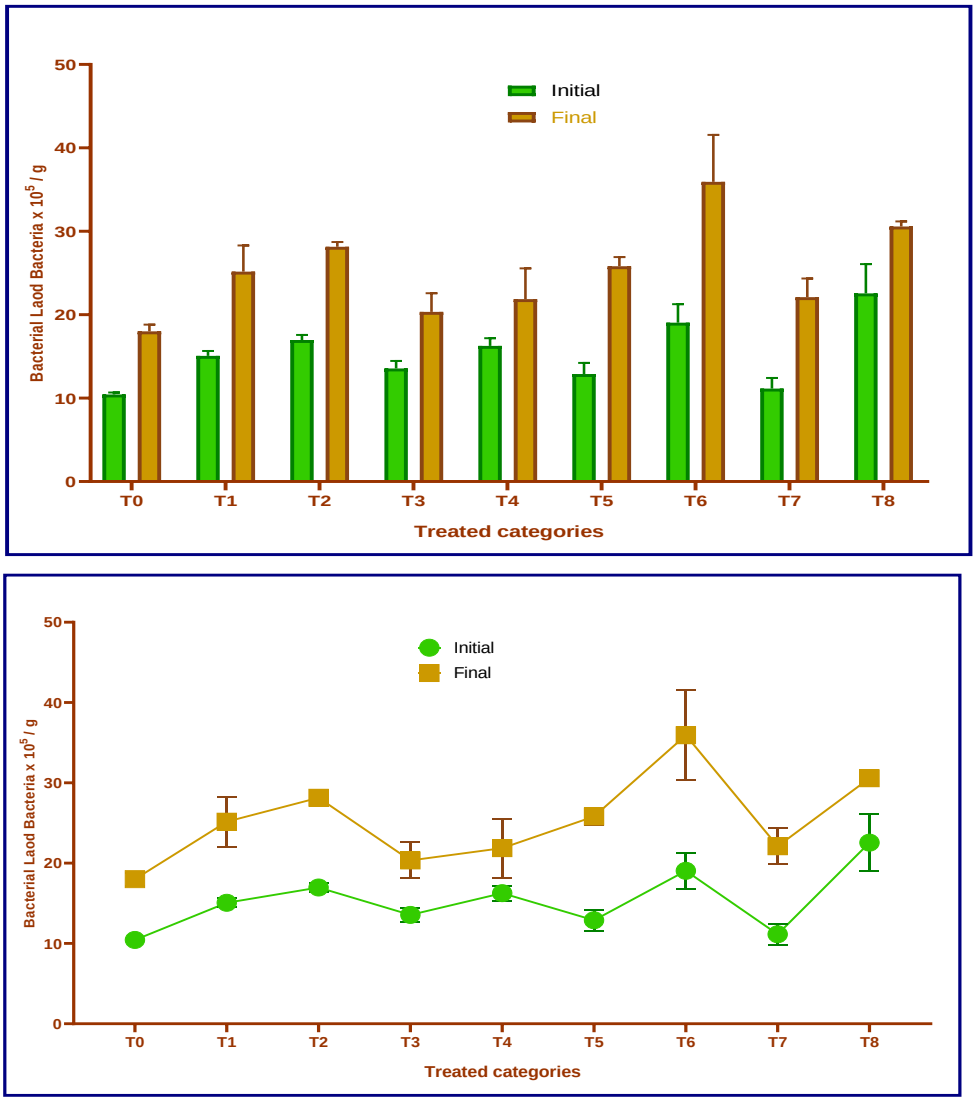


Figure 2: Bacterial population of 4 medicinal plants treated with Eudrilus eugeniae both 1:1 and 1:2 ratio (3 replication) with statistical analysis.

Microbes are the established and significant decomposers of organic matter. The role played by the microbes and their microbial activity in the process of vermicomposting of the earthworms both in the casts and in the soil is very important. Microbes and earthworms stake up the role of degradation of organic waste matter and help in the release of nutrients in a suitable form that can be utilized by plants(Syers *et al*., 1979).
Previous reports describe that the guts of earthworms nurture a specific category of microflora which are significant in the symbiosis process (Lavelle 1983; Wallwork 1983).In the process of vermicomposting, the worm's gut region plays a major role in processing the organic matter. The process includes various kinds of changes physically, chemically, and biochemically and these were due to the symbiotic effects of earthworms and microbes.

In addition to the process of enhancing microbial proliferation by initiating the biodegradation process of organic matter in the gut region, it also helps in the process of stimulation of other free-living aerobic organisms activities in triggering the decomposition process. Any organic matter that is passed through the gut of earthworms is released as vermicast and this further leads to the increased levels of microbial population, microbial activity, microbial respiration, enzyme activity, and NPK enrichment, production of polysaccharide gum by bacteria, the establishment of lignocellulolytic, nitrifying and nitrogen-fixing microorganisms, etc. The increased load of microbial population might be due to the gut transit process in the earthworm. Many studies have discussed about the significant increase in the proliferation of fungi in different types of vermicompost (Scheu 1987; Tiunov and Scheu 2000; Dash *et al*., 1986; Parthasarathi 2006).

In coherence with all these reports, in the present study also we found that there is a significant increase in the fungal proliferation in all the treated samples T1 – T8. The increase in fungal proliferation might be due to the transit process happening through the worm's gut. Various reports found that there is a significant increase in the proliferation of actinomycetes in the vermicomposting earthworms (Pramanik *et al*., 2007). The reason behind this increase might be due to the impact of the gut region which helps in the enrichment of different microbes.

It is reported in many studies about the microbial activity of different microbial communities in decomposing complex organic matter. Mostly nutrient-rich earthworms are a suitable source for enriching microbial growth (Lee 1985). In 1963, Parle observed that the proliferation of actinomycetes and bacteria was happening in the gut region of the earthworm.

(Wang, Ling *et al.*, 2021) revealed that Illumina MiSeq high-throughput sequencing was used to explore the relationship between the incidence of Fusarium wilt of tomato and soil microorganisms in more detail and analyse the contributing factors of changes. (Ezrari, S *et al.*, 2024; Iftikhar, A., *et al.*, 2024) revealed that compared with the control and chemical treatment, vermicompost treatment promoted the growth of *Actinobacteria*, *Chloroflexi*, *Saccharibacteria*, and *Planctomycetes* and inhibited the growth of *Proteobacteria*, *Gemmatimonadetes*, *Firmicutes*, *Verrucomicrobia*, and *Cyanobacteria*. The relative abundance of Ascomycota was negatively related to that of Basidiomycota. The results showed that the incidence of Fusarium wilt of vermicompost treatment was 36.5%~and 73.9% lower than that of the control treatment.

All this literature suggests that the growth of earthworms in proper environmental conditions enhances the growth of microbial population along with nutrients and reduction of organic carbon in the compost (Eriksen-Hamel and Whalen 2007). As indicated in Table 1&2 in the present study the bacterial population was found to be higher in the vermicompost than the control. Among the various treatments, all 8 types of vermicompost showed a significant increase over control.

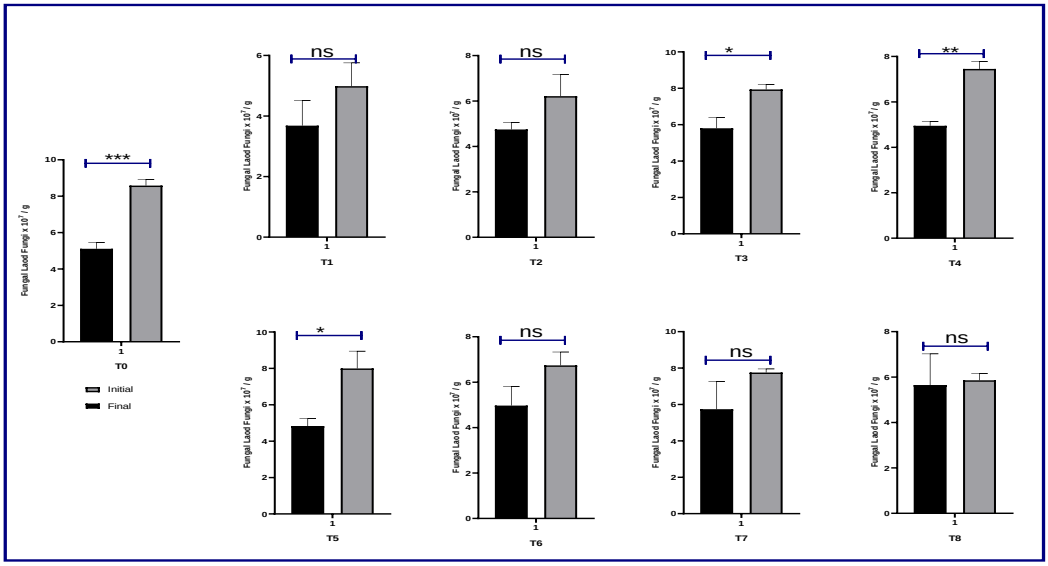


Figure 3: Fungal population of 4 medicinal plants treated with Eudrilus eugeniae both 1:1 and 1:2 ratio (3 replication) with statistical analysis.

Reports validated that the earthworm has the potential to initiate a significant increase in the proliferation of growth-promoting *rhizobacteria* (PGPR) (Sinha *et al*., 2010). This category of microbes has the potential to

enhance the growth of plants by utilizing nutrients (Ayyadurai *et al*., 2006; Naik *et al*., 2008; Pathma and Sakthivel 2012).

Other studies found that significant proliferation was observed in the Eudrilus eugeniae treated in organic wastes mixed with soil. The increased mass of organic wastes eventually leads to an increase in the microbial population.

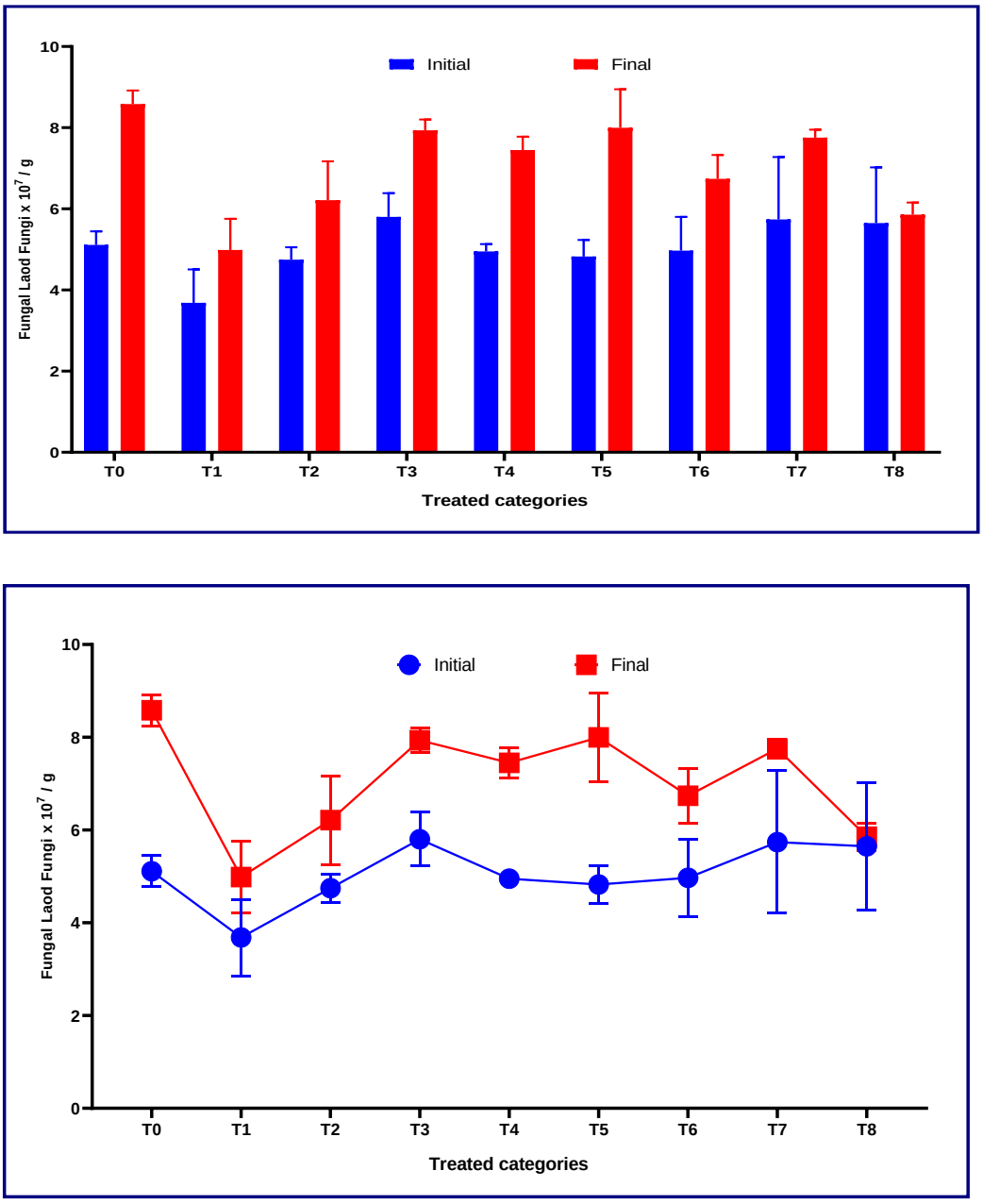


Figure 4: Fungal population of 4 medicinal plants treated with Eudriluseugeniae in both 1:1 and 1: 2 ratio (8 replication) with statistical analysis.

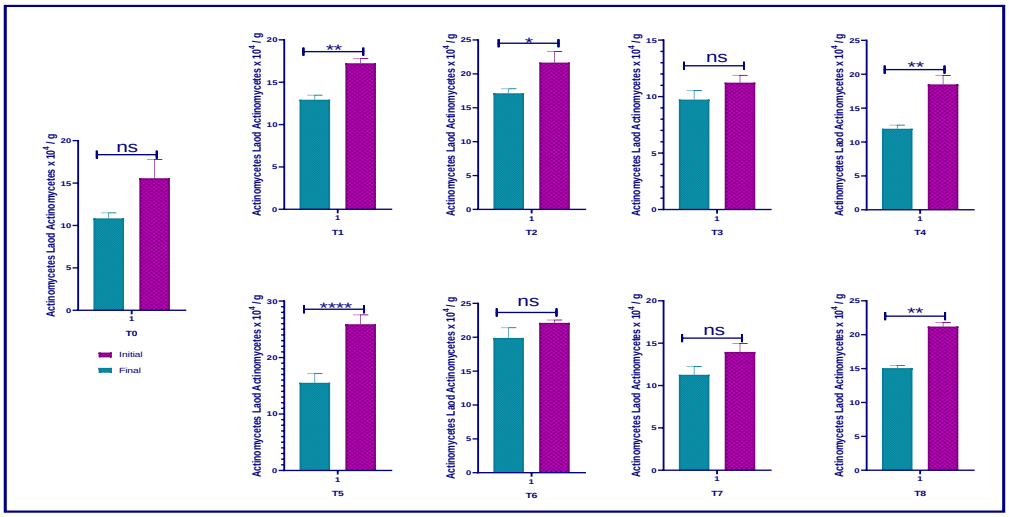
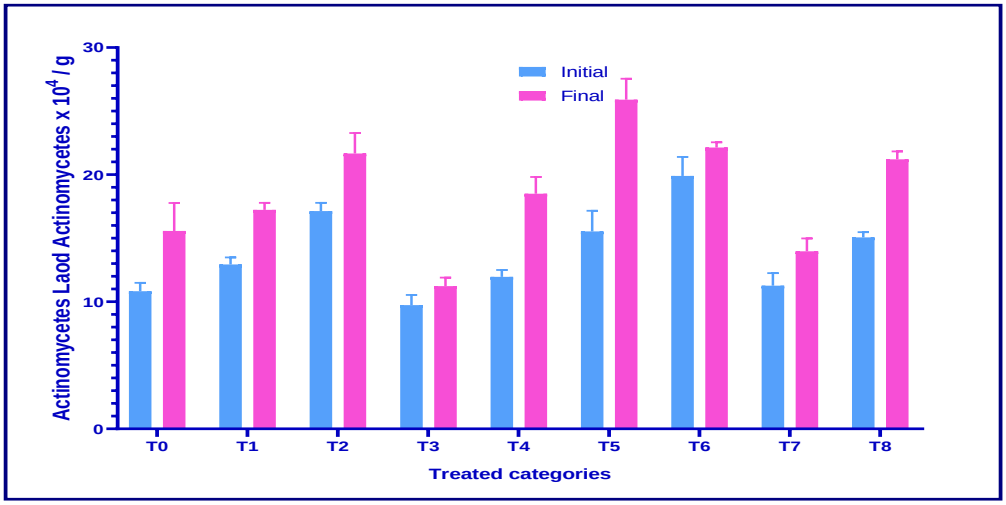


Figure 5: Actinomycetes population of 4 medicinal plants treated with Eudrilus eugeniae both 1:1 and 1:2 ratio (3 replication) with statistical analysis.



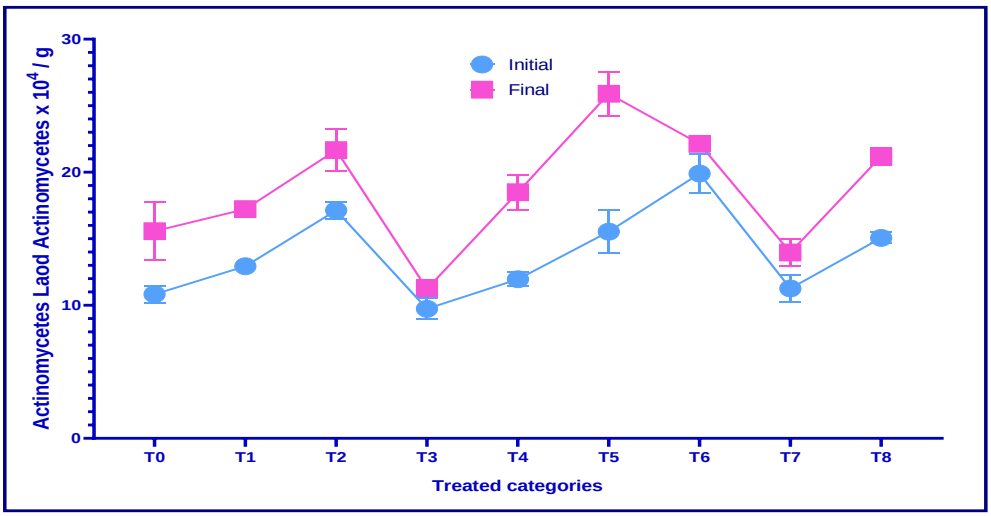


Figure 6: Actinomycetes population of 4 medicinal plants treated with Eudrilus eugeniae both 1:1 and 1:2 ratio (3 replication) with statistical analysis.

The study indicates that the action of earthworm Eudrilus eugeniae could increase the microbial colony forming units during vermicomposting of those organic substrates which in turn can be used for increasing the microbial population of the soil. Generally, earthworms have a strong bond with soil microbes. In addition, the gut region of the earthworms itself has different kinds of microbes and because of this reason,

the area of the surface was increased for microbial decomposition (Gajalakshmi *et al*., 2001). All the vermicompost reports validate that these organisms not only play a role in the in increase the mineralogical fertility factors in the soil but also contribute to the biological fertility factors in the soil. A recent study observed that fly ash vermicompost was involved in the significant increase in microbial mass (Pramanik and Chung 2011).

CONCLUSION

The application of vermicompost provides abundant antagonists and is an ecologically friendly method for the biological control of Fusarium wilt of tomatoes and providing good yield from plants. During vermicomposting the interactions between earthworms and microorganisms modify the biochemical and physical properties of the organic waste and improve the stabilization of organic matter. Vermicomposting amplifies the diversity and population of beneficial microbial communities. In this study, we have isolated and identified a significant set of bacteria like *Bacillus subtilis, Bacillus cereus, Xanthomonas species, Pseudomonas aeruginosa, Pseudomonas fluorescens, Acinetobacter baumannii, Enterobacter aerogenes, Klebsiella pneumoniae, Proteus mirabilis, Escherichia coli, Vibrio species* and three fungal species like *Fusarium oxysporum, Aspergillus niger, Aspergillus fumigatus,* and *Aebinomycetes*. These microbes were isolated from different preparations of samples of vermicompost prepared from the mixture of cow dung and 4 medicinal plants *Phyllanthus emblica, Senna auriculata, Justicia adhatoda, and Annona squamosa* at two different ratios of preparation. Especially The rich microbial diversity in the samples establishes their usefulness as green manure and a safe method of organic waste disposal. Earthworm causes increase in availability of soil organic matter through degradation of dead matters by microbes, leaf litter and porocity of soil. Vermicompost is a non-thermophilic biodegradation process of waste organic material through the action of microorganism with earthworm. Vermicompost is rich in many nutrients including calcium, nitrates, phosphorus and soluble potassium, which are essentially required for plant growth. Different plant growth hormones like gibberellins, auxins and cytokinins are present in vermicompost, which has microbial origin. Nematodes are mostly small, colorless and microscopic organisms which remain under soil, fresh or marine water, plants or animals, and act as parasite in different conditions, while very few have direct effect on human. The nematodes which are parasitic on plants use plant tissues as their food. They have well developed spearing device, like a hypodermic needle called stylet. It is used to penetrate host cell membrane. Management of plant-parasitic-nematodes therefore is necessary and several means are adopted. Of which, use of bio-chemicals and organic compost have shown encouraging results and proved to be potential in suppressing the nematode population. Vermicompost plays an important role of soil fortification on growth characteristics, such as length, weight, root, and shoot branches, number of leaves and metabolism of host plant against nematode infection. Vermicompost fortified plants showed increment in sugar, protein and lipid over untreated control. Increment of these metabolites helps treated plants to metabolically cope up the infection and promotes excessive plant growth. The vermicompost caused the mortality of nematodes by the release of nematicidal substances such as hydrogen sulfate, ammonia, and nitrite apart from promotion of the growth of nematode predatory fungi that attack their cysts. It favours rhizobacteria which produce toxic enzymes and toxins; or indirectly favors population of nematophagous microorganisms, bacteria, and fungi, which serve as food for predatory or omnivorous nematodes, or arthropods such as mites, which are selectively opposed to plant-parasitic nematodes.

REFERENCES

1. Amouci A.I., Yousefi Z., Khosravi T. (2017) Comparison of vermicompost characteristics produced from sewage sludge of wood and paper industry and household solid wastes. *J. Environ. Health Sci. Engin.* 15(1):5. 10.1186/s40201-017-0269-z.
2. Ayyadurai N, Ravindra Naik P, Sreehari Rao M, Sunish Kumar R, Samrat SK, Manohar M, Sakthivel N (2006) Isolation and characterization of a novel banana rhizosphere bacterium as a fungal antagonist and microbial adjuvant in micropropagation of banana. *Journal of Applied Microbiology* 100 (5): 926-937.doi:10.1111/j.1365-2672.2006. 02863.x
3. Dash HK, Beuka BN, Dash MC (1986) Gut load, transit time, gut microflora and turnover of soil, plant and fungal material by some tropical earthworms. *Pedobiologia* 29 (1): 13-20.doi:10.1016/S0031-4056(23)06876-2

4. Eriksen-Hamel NS, Whalen JK (2007) Impacts of earthworms on soil nutrients and plant growth in soybean and maize agroecosystems. *Agriculture, Ecosystems & Environment* 120 (2): 442-448. doi: 10.1016/j.agee.2006.11.004
5. Ezrari, S., Legrifi, I., Taoussi, M., Khadiri, M., Belabess, Z., & Lahlali, R. (2024). Plant–Pathogen Interactions and Global Food Security. In Plant Pathogen Interaction (pp. 11-52). Singapore: Springer Nature Singapore.
6. Gajalakshmi S, Ramasamy EV, Abbasi SA (2001) Assessment of sustainable vermiconversion of water hyacinth at different reactor efficiencies employing Eudrilus eugeniae Kinberg. *Bioresource technology* 80:131-135. Doi:10.1016/S0960-8524(01)00077-3
7. Iftikhar, A., Farooq, R., Akhtar, M., Khalid, H., Hussain, N., Ali, Q., ... & Ali, D. (2024). Ecological and sustainable implications of phosphorous-solubilizing microorganisms in soil. Discover Applied Sciences, 6(2), 33.
8. Karmegam N, Daniel T (2009) Investigating efficiency of Lampito Mauritius (Kinberg) and Perionyx ceylanensis Michaelsen for vermicomposting of different types of organic substrates. *The Environmentalist* 29 (3):287-300. Doi:10.1007/s10669-008-9195-z
9. Lavelle P (1983) The soil fauna of tropical savannas. II. The earthworms. *Ecosystems of the World* 13:485-504
10. Lee KE (1985) Earthworms: their ecology and relationships with soils and land use. Earthworms: their ecology and relationships with soils and land use
11. Liu X.C., Chen L., Li S.Q., Shi Q.H., Wang X.Y. (2021) Effects of vermicompost fertilization on soil, tomato yield and quality in the greenhouse. [Ying Yong Sheng tai xue bao] *J. Appl. Ecol.* 32(2):549-556.10.13287/j.1001-9332.202102.022
12. M.Prakash D, M. Jaikumar, Karmegam N (2009) Vermistabilization of Paper Mill Sludge Using the Earthworm, Perionyx ceylanensis Mich.: Influence on Physico-chemical and Microbiological Status. *Indian Journal of Applied Microbiology* 10:20-25
13. Munoz-Ucros, J., Panke-Buisse, K., Robe, J. (2020). 'Bacterial community composition of vermicompost treated tomato rhizospheres.' *PLoS ONE*, 15(4), e0230577. https://doi.org/10.1371/journal.pone.0230577
14. Naik PR, Raman G, Narayanan KB, Sakthivel N (2008) Assessment of genetic and functional diversity of phosphate solubilizing fluorescent pseudomonads isolated from rhizospheric soil. *BMC Microbiology* 8 (1):1-14. Doi:10.1186/1471-2180-8-230
15. Parthasarathi K (2006) Aging of pressmud vermicasts of Lampito mauritii (Kinberg) and Eudrilus eugeniae (Kinberg) – Reduction in microbial population and activity. *Journal of Environmental Biology* 27
16. Pathma J, Sakthivel N (2012) Microbial diversity of vermicompost bacteria that exhibit useful agricultural traits and waste management potential. *SpringerPlus* 1:26.doi:10.1186/2193-1801-1-26
17. Pramanik P, Chung YR (2011) Changes in the fungal population of fly ash and vinasse mixture during vermicomposting by Eudrilus eugeniae and Eisenia fetida: Documentation of cellulase isozymes in vermicompost. *Waste Management* 31(6):1169-1175.doi:10.1016/j.wasman.2010.12.017
18. Pramanik P, Ghosh GK, Ghosal PK, Banik P (2007) Changes in organic – C, N, P and K and enzyme activities in vermicompost of biodegradable organic wastes under liming and microbial inoculants. *Bioresource Technology* 98 (13):2385-2494.doi:10.1016/j.biortech.2006.09.017
19. Satpathy, O., Saha, M.H., Mishra, A.S., Mishra, S.K. (2020). *'Characterization of Bacterial Isolates in Vermicompost Produced from a Mixture of Cow dung, Straw, Neem leaf and Vegetable Wastes,'*doi:https://doi.org/10.1101/2020.07.01.18346
20. Scheu S (1987) Microbial activity and nutrient dynamics in earthworm casts (Lumbricidae). *Biology and Fertility of Soils* 5 (3):230-234.doi:10.1007/BF00256906
21. Syers JK, Sharpley AN, Keeney DR (1979) Cycling of nitrogen by surface-casting earthworms in a pasture ecosystem. *Soil Biology and Biochemistry* 11 (2):181-185.doi:10.1016/0038-0717(79)90098-1
22. Tiunov AV, Scheu S (2000) Microfungal communities in soil, litter, and casts of Lumbricus terrestris L. (Lumbricidae): a laboratory experiment. *Applied Soil Ecology* 14(1):17-26.doi:10.1016/S0929-1393(99)00050-5
23. Wallwork JA (1983) Earthworm biology. Institute of Biology's studies in biology, vol no.161.E. Arnold, London; Baltimore, MD., U.S.A
24. Wang, Ling & Liu, Jiabin & Nie, Ying & Wang, Daqing & Wang, Hongyan. (2021). Effects of vermicompost on tomato Fusarium wilt and soil microbial community structure. Acta Agriculturae Scandinavica, Section B - Soil & Plant Science. 71. 1-17. 10.1080/09064710.2021.1952301.