Performance Evaluation of Natural Additives Assisted Vermicomposting

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Abstract - *Vermicomposting is a sustainable and environment friendly method of converting organic waste into a nutrient rich bio-fertilizer by the action of earthworms and microorganisms. The present study evaluates the effectiveness of vermicomposting with natural additives in enhancement of compost quality, nutrient content, rate of decomposition and microbial activity. A field scale vermicomposting model was setup at Govt. College of Engineering, Amravati to study the practical feasibility and efficiency of the process under real environmental conditions with earthworm Eisenia Fetida. The various Natural additives, such as Jeevamrutha, Panchagavya, and neem cake powder were introduced into the garden waste material at different concentrations and their effects on the process of vermicomposting were evaluated. Physico- chemical properties were determined at regular intervals to assess the impact of these additives during the entire duration of the trial. The physico- chemical parameters studied were; pH, temperature, moisture, organic carbon, nitrogen, phosphorus, potassium and carbon: nitrogen ratio. Among all treatment highest nutrient content was observed when the vermicompost unit was added with 4% neem cake powder additive N(2.21%),P(2.19%),K(2.60%) followed by 4% jeevamrytha additive N(1.96%), p(1.56%), k(2.25%), 4% panchagavya additive N(1.85%), P(1.72%), K(2.15%) compared with the NPK values of control unit as N(1.35%), P(1.28%),K(1.35%). The results show that addition of natural additives in vermicomposting will make the process more efficient and ensure production of good quality organic fertilizer.*

Key Words: Vermicomposting, Vermicompost, Earthworm, Eisenia Fetida, Additives, jeevamrutha , panchagavya, neemcake powder

1. INTRODUCTION

The rapid urbanization, population growth and landscaping activities have resulted in a significant increase in the generation of organic solid waste, especially garden waste. Garden waste is mainly comprised of fallen leaves, grass clippings, weeds, twigs, branches and other biodegradable materials from gardens, parks, educational institutions and residential areas. Such waste if improperly disposed by open dumping and burning, causes environmental problems such as air pollution, greenhouse gas emission, foul odour and land degradation [1]. Vermicomposting is an inexpensive process by which earthworms convert organic wastes into nutrient rich organic fertilizer [9]. Vermi compost has many advantages over chemical fertilizers and is beneficial for crops. It supplies nutrients in addition to humic acids and growth promoting hormones. Therefore it is widely used as an organic fertilizer in large scale organic farming [10]. The rise in fertilizer prices and scarcity of organic manures has made recycling of organic waste an important alternative for improving soil fertility[11].There are several additives which can be used along with the cattle dung in vermibed. The use of such additives improves the vermicomposting processes and provides quick degradation of garden wastes.

The experimental research was conducted using natural additives namely jeevamrutha, panchagavya and neem cake powder. Jeevamrutha is a natural plant growth promoter which is rich in beneficial microbes that are key to providing the essential nutrients required to grow and develop plants. The following types of helpful microbes have been found to be present in the dung used in making Jeevamrutha: nitrogen-fixing (azotobacter, acetobacter, azospirillum) and phosphorus solubilizing (pseudomonas) as well as potash solubilizing (bacillus silicus) bacteria [4]. Panchagavya is a biopromoter made from five different cow-derived products - dung, urine, milk, curd and ghee. From the Biochemical composition of Panchagavya (of which macro and micronutrients [N,P,K] and [Fe,Mn,Zn], respectively) are included in its ingredients[5] It can serve as a natural fertilizer to enhance soil fertility, improve earthworm quality and promote crop health [6]. Jeevamrit and Panchgavya are found to increase the microbial communities and earthworm activity significantly which in turn improves the nutrient availability in the soil, resistance mechanisms and crop yields[7]. The neem seed cake powder is a by-product obtained after the extraction of neem seed oil and contains nutrients like nitrogen, phosphorus and potassium with slow release and bioactive compounds that act as a nitrification inhibitor and natural pest suppressant [8].The aim of the study is to evaluate the performance of vermicomposting assisted with natural additives and to study their effects on decomposition rate, quality of compost and nutrient enrichment.

1.1 Vermicomposting Process

Vermicomposting is an organic waste stabilizing biological process where epigeic earthworm species such as Eisenia Fetida eat and digest the organic waste to convert it to nutrient-dense vermicompost (worm castings) using gut digestion and microbial activity. This process involves microbial aerobic decomposition and earthworm metabolic activity, which together create a stable, humus-like material that improves soil quality[12,13].. When the biomass decomposes and is broken down completely to single molecules called monomers, it has been broken down and its nutrients and energy released through the activity of earthworms and their endosymbiotic microorganisms within their gut that secrete hydrolytic digestive enzymes [26]. Furthermore, vermicomposting improves the structure of the soil, increases the amount of water that can be retained, stimulates the activity of microorganisms, increases the yield of crops, and decreases reliance on synthetic fertilisers. Eisenia fetida, Eudrilus eugeniae, and Perionyx excavatus are commonly used earthworm species for vermicomposting because of their ability to break down organic waste at a high rate [27].

2. MATERIAL AND METHODOLOGY

2.1 Collection and Shredding of Garden Waste

The garden care taker collected garden waste from the Government College of Engineering, Amravati campus for the purpose of research. The gathered garden waste involved fallen leaves from many different types of plants, along with small branches and twigs that are high in lignin, cellulose and hemicelluloses, which don't decompose as quickly in the vermicomposting process [2][3]; therefore, to facilitate microbial and earthworm activity, garden waste must be shredded to reduce particle size and increase surface area. A garden waste shredder machine was used to shred the garden waste.

2.2 Experimental setup

The vermibed is a key factor in the success and efficiency of the vermicomposting process. For vermicomposting treatment high density polyethylene bags of size 12ft long, 4ft wide and 2ft deep were selected. These bags are fitted with aeration nets to allow optimum oxygen flow and offer drainage to collect vermiwash. They are a sustainable, reusable alternative to the traditional concrete tank. A thin layer of garden soil (1 inch) at the bottom of the bed which provides natural habitat for earthworms. Well seasoned cow dung of 15 to 20 days old was collected from nearby dairy farm and air dried for 8 days to remove heat and unwanted gases from it which may stress earthworms. The shredded waste and cow dung slurry were placed in alternate layers over the soil layer and water was sprinkled over the bed to keep it moist. The natural additives used in the experimental work are jeevamrutha, panchagavya and neemcake powder. Each additive was added in four different proportions (i.e. 1%, 2%, 3% and 4%). The waste was pre-decomposed for 1 week to stabilize the organic waste, reduce toxicity and temperature and to make it suitable for acclimatization of earthworms and efficient vermicomposting treatment. The experimental work was carried out in nine HDPE bags. Five equal compartments were made in each of the nine bags with a 2.4 ft length . Each compartment was added with a different concentration (1%, 2%, 3% and 4%) additive with one control unit where there was no additive added.

2.3 Physico-Chemical Analysis

Physico-chemical analysis is important for evaluation of the quality, stability and maturity of compost during vermicomposting process. Temperature was measured by 4 in 1 soil tester. The moisture content was determined by using analog moisture meter. For pH and EC analysis, 5 gram of finely ground compost sample was mixed with 50 ml of distilled water and allowed to stand for about 30 minutes. The solution was properly mixed and allowed to settle. The pH and EC of the solution was measured using HANNA pH and EC meter. Using standard laboratory methods, the essential nutrients nitrogen (N), phosphorus (P) and potassium (K), as well organic carbon (OC), were analysed at the Krishi Vigyan Kendra (KVK) Durgapur. All measurements were replicated three times and their average calculated using MS Excel. The alterations in pH, moisture, temperature, electrical conductivity, nitrogen, phosphorus and potassium have been plotted graphically.

2.4 Raw waste characterization

The shredded garden waste was tested to find the initial readings of the chemical parameters, including pH, EC, moisture, OC, NPK, and C/N ratio. The results related with values of chemical parameters of raw waste are tabulated in table 1.

Table -1: Chemical characterization of shredded garden raw waste

Sr. No.	Chemical parameters	Initial Value
1	**Moisture content**	45 %
2	**pH**	6.03
3	**Electric conductivity (EC)**	359.6 µS/cm
4	**Nitrogen (N)**	0.74 %
5	**Phosphorus (P)**	0.69 %
6	**Potassium (P)**	0.71 %
7	**Organic carbon (OC)**	33.08 %
8	**C/N Ratio**	44.70

The shredded garden waste was allowed to decompose through vermin compost unit for the period of 60 days during which the waste characteristics were analyzed. The results obtained are presented in results and discussion.

3. RESULTS AND DISCUSSION

3.1 Analysis of vermin compost assisted with Jeevamrutha

Analysis of vermicomposting plant assisted with jeevamrutha in the ratio of 1%, 2%, 3% and 4% with control unit was carried out. The result obtained during analysis compared to control unit. The 4% Jeevamrutha additive treatment was the most effective among all treatments. It showed a significant improvement in the nutrient content and the overall quality of the compost compared to the control unit. The nitrogen content increased by 45%, phosphorus content increased by 86% and potassium content increased by 30%, slight temperature decrease in jeevamrutha assisted vermin compost (25.80°C) as compared to control (26.18°C), Moisture content increased in jeevamrutha assisted vermin compost (64.86%) as compared to control (60.67%), indicating improved water retention capacity. The electrical conductivity (EC) slightly increased in jeevamrutha assisted vermin compost 1005.7 µS/cm as compared to control 942.6 µS/cm. while the pH decreased in jeevamrutha assisted vermin compost 7.79 as compared to control 7.90. The results of vermicomposting assisted with 4% jeevamrutha and control unit are presented in Table No. 2

Table 2. The results of vermicomposting assisted with 4% jeevamrutha and control unit

Sr. No.	Physico-Chemical Parameter	Control	GW+ 4% Jeevamrutha
1	Temperature	26.18	25.88
2	Moisture content	60.67	64.86
3	pH	7.90	7.79
4	EC (µS/cm)	942.6	1005.7
5	Nitrogen (%)	1.35	1.96
6	Phosphorus (%)	1.20	1.56
7	Potassium (%)	1.21	2.25

Note: The results in the table above are the average of three readings.

3.2 Analysis of vermicompost assisted with Panchagavya

Analysis of vermicomposting plant assisted with panchagavya in the proportion of 1%, 2%, 3%, and 4% along with the control unit was carried out. The result obtained during the analysis is compared with the control unit. Among all treatments, 4% Panchagavya treatment proved to be the most effective in improving the quality and efficiency of vermicompost. Intake of nitrogen from 4% of the Panchagavya treated compost was increased by 40%, phosphorus 60%, and potassium 35% in comparison to the control treatment unit. This decline in temperature from 26.07°C in the control to 25.10°C in the treated unit indicated a stable vermicomposting environment. Moisture content increased in panchagavya treated compost 64.86% as compared to control 60.41%, hence enhancing the activity of earthworms and microbes. Electrical conductivity (EC) of compost treated with Panchagavya recorded a slight increase 920.8 µS/cm as compared to control 890.5 µS/cm, tending towards better mineral availability. There was also a slight decrease in pH in panchagavya treated vermicompost 7.84 as compared to control 7.91, suggesting that conditions were still being established towards a favorable medium for nutrient stabilization. Results of vermicomposting assisted with 4% panchagavya and control unit are presented in Table No. 3

Table 3. The results of vermicomposting assisted with 4% panchagavya and control unit

Sr. No.	Physico-Chemical Parameter	Control	GW+ 4% Panchagavya
1	Temperature	26.07	25.10
2	Moisture content	60.41	64.53
3	pH	7.91	7.84
4	EC (µS/cm)	890.5	920.8
5	Nitrogen (%)	1.34	1.85
6	Phosphorus (%)	1.28	1.72
7	Potassium (%)	1.35	2.15

Note: The results in the table above are the average of three readings.

3.3 Analysis of vermicompost assisted with Neemcake powder

Analysis of vermicomposting plant assisted with neemcake powder in the proportion of 1 %, 2 %, 3 % and 4 % with control unit was carried out. Among all the treatments, application of 4% neemcake powder was found most effective. Nitrogen increased by 68%, phosphorus by 78% and potassium by 91%.Temperature decreased slightly in neemcake powder assisted vermicompost 25.83°C as compared to control 26.86°C, moisture content increased in neemcake powder assisted vermicompost 61.32% as compared to control 56.73% and Electrical conductivity (EC) increased slightly in neemcake powder treated vermicompost 1175.7 µS/cm as compared to control 1034.6 µS/cm. On the other hand, pH decreased slightly in neemcake powder treated vermicompost 7.66 as compared as compared to control 7.93, indicating a shift towards neutral conditions suitable for vermicompost maturity. Results of vermicomposting assisted with 4% neemcake powder and control unit are presented in Table No. 4

Table 4. Final results of vermicomposting assisted with 4% Neemcake Powder and control unit

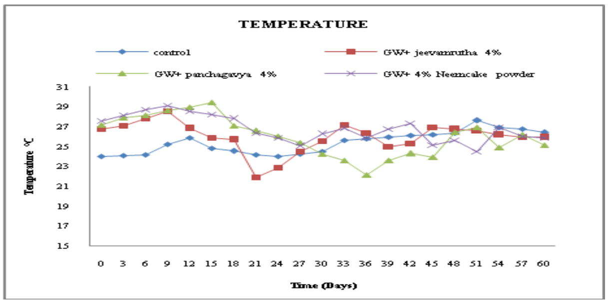
Sr. No.	Physico-Chemical Parameter	Control	GW+ 4% Neemcake powder
1	Temperature	26.86	25.83
2	Moisture content	56.73	61.32
3	pH	7.93	7.66
4	EC (µS/cm)	1034.6	1175.7
5	Nitrogen (%)	1.32	2.21
6	Phosphorus (%)	1.23	2.19
7	Potassium (%)	1.28	2.60

Note: The results in the table above are the average of three readings.

3.4 Change in Temperature during vermicomposting

The temperature increased initially up to 12-15 days in all treatments, this is due to microbial activity and decomposition of readily biodegradable substrates resulting in heat generation. After this phase the temperature gradually decreased or stabilised due to consumption of readily degradable organic substrates reducing microbial respiration and heat production. During vermicomposting, the earthworm activity also helps in cooling and stabilization of the substrate by aeration and conversion of organic matter to stabilized vermin compost. The lowest temperature was recorded in panchagavya (25.10) followed by neemcake powder (25.83), jeevamrutha (25.88) and control (26.83) However, the temperature was in a moderate range of 20–30 °C which was suitable for earthworm survival and efficient vermicomposting [15]. Change in temperature during vermicomposting is shown in Chart 1.

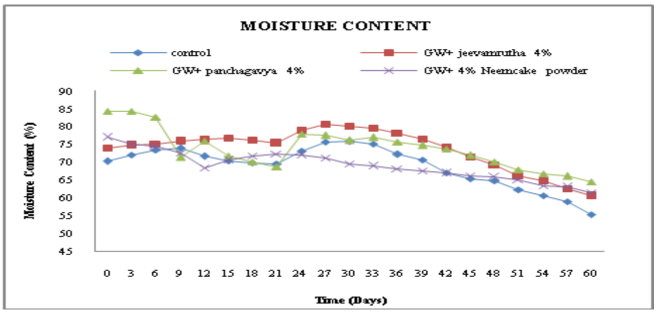
Chart -1: Change in Temperature during vermicomposting



3.5 Change in Moisture Content during vermicomposting

The optimum moisture content is essential for vermicomposting and earthworm activity. Maximum moisture content was observed in jeevamrutha (64.86) followed by panchagavya (64.54), neemcake powder (61.32). The moisture content in the control unit was slightly lower than all additive treatment units. Moisture is important for the optimal activity of earthworms and other microorganisms in the vermicomposting system. There must be enough moisture to maintain their activity. Earthworms breathe through their skin, so the system must be kept at the right moisture level. The desirable moisture content in vermicomposting is 60% - 80% [16]. The earthworms need a moist environment for respiration, locomotion, feeding and reproduction, so that the vermicomposting process is adversely affected by the insufficient moisture contents. An earthworm will experience dehydration due to loss of moisture from its skin when the moisture content of the soil is below optimal levels. As a result of dehydration, the earthworm will have decreased metabolic activity, lower growth rates, fewer cocoons produced, and overall decreased likelihood of survival [17]. The variation in moisture content during vermicomposting is shown in chart 2.

Chart -2: Change in Moisture Content during vermicomposting

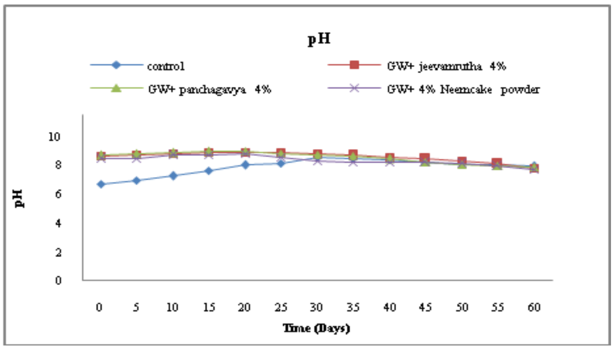


3.6 Change in pH during vermicomposting in additives treatment

The pH of 5 to 9 is suitable for the survival of epigeic worms [13]. All the treatments had pH values in the range acceptable for the growth and survival of Eisenia fetida.

Among the additives, the highest final pH value was recorded in control unit (7.91) followed by 4 % Panchagavya (7.84), 4 % Jeevamrutha (7.79) and 4 % Neemcake powder (7.66). The pH values obtained in all the treatments were near neutral indicating stabilization and maturity of vermicompost. pH Decrease might occur due to mineralization of nitrogen and phosphorus to nitrites/nitrates and orthophosphates and bioconversion of organic matter to intermediate species of organic acids [21]. The variation in pH during vermicomposting is shown in chart 3.

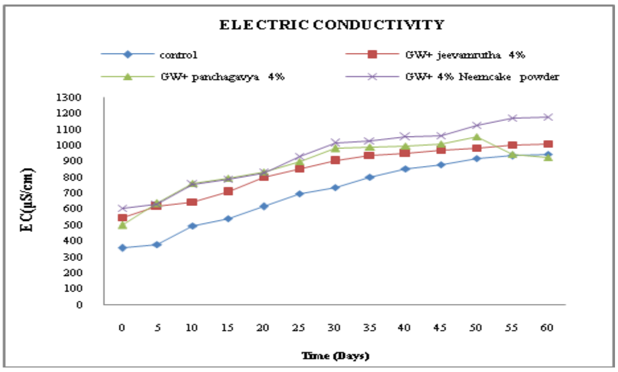
Chart -3: Change in pH during vermicomposting in additives treatment



3.7 Change in Electric Conductivity during vermicomposting

In all three treatments the electrical conductivity (EC) value increased gradually. Maximum value was recorded in 4 per cent neemcake powder (1175.7 µS/cm) followed by jeevamrutha (1005.7 µS/cm), control (942.6 µS/cm) and panchagavya (920.8 µS/cm). The increase in EC (electrical conductivity) during the vermicomposting process was likely due to the degradation of organic matter releasing minerals like exchangeable Ca, Mg, K and P in the available forms, i.e., in the form of cations in the vermicompost [20]. The electrical conductivity values of all treatments were within the upper recommended range of 500–2000 µS/cm [24]. Change in EC During Vermicomposting is shown in Chart 4.

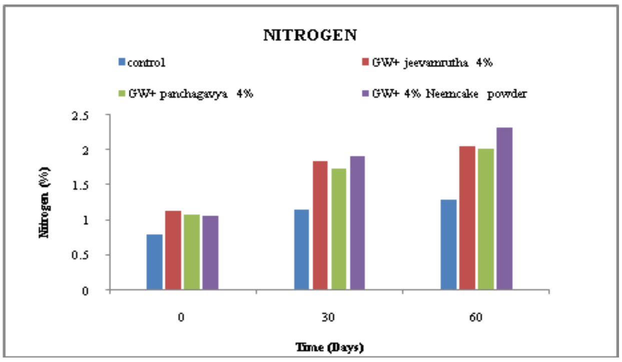
Chart -4: Change in EC During Vermicomposting



3.8 Change in Nitrogen (N) during vermicomposting

Total nitrogen values showed an increasing trend in the vermicomposting period. Maximum value of nitrogen was observed in 4% neemcake powder (2.21%) followed by 4% jeevamrutha (1.96%) and 4% panchagavya (1.85%) among all the treatments. The relative increase in nitrogen content in substrate during vermicomposting may have been determined by the loss of dry organic carbon as CO2 and the loss of water by evaporation during mineralization of organic matter [19]. Change in Nitrogen during vermicomposting is shown in chart 5.

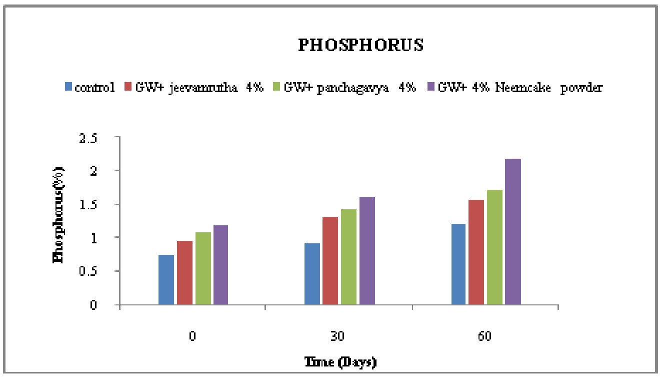
Chart -5: Change in Nitrogen during vermicomposting



3.9 Change in Phosphorus (P) during vermicomposting

High phosphorus in the mature compost is indicative of better plant growth for sustainable crop production. The phosphate mobilization and mineralization is due to gut phosphates of earthworm and the additional release of P by the microbiota associated with earthworm casts. Moreover the fungus has the ability of P solubilization creating a favorable environment to microbes solubilizing P during composting process [25]. Vermicompost prepared with 4% neemcake powder showed highest phosphorous (2.19%) followed by panchagavya (1.72%), jeevamrutha (1.56%) and control unit (1.28%). Change in Phosphorus during vermicomposting is shown in chart 6.

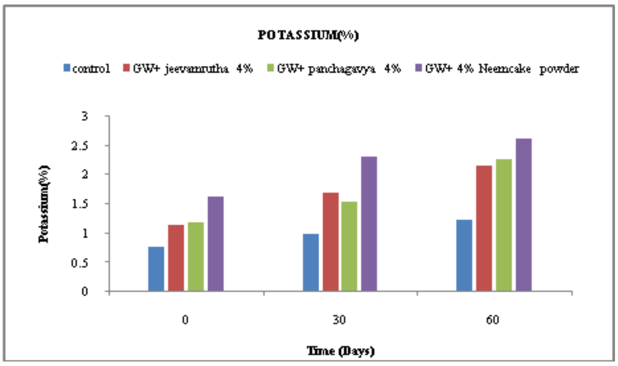
Chart -6: Change in Phosphorus during vermicomposting



3.10 Change in Potassium (K) during vermicomposting

Potassium is an important element for plant growth. Its high presence in ready compost indicates the suitability of prepared compost to crop growth in fields. The different endogenic and exogenic enzymes of the gut of the earthworms convert the non-available organic minerals into available soluble form. Fungal hyphae bind the available potassium with cellulose-rich material due to their absorptive nature and thus contribute to the increase of the Potasium contents in the composting mixtures [25]. 4% neemcake powder among all treatments was the most efficient in increasing potassium content (2.60%) followed by 4% jeevamrutha (2.25%), panchagavya (2.15%) and control (1.35%). Change in Potassium during vermicomposting is shown in chart 7.

Chart -7: Change in Potassium during vermicomposting



3.11 Change in organic carbon and C/N ratio during vermicomposting

The organic carbon content of all treatments of jeevamrutha, panchgavya and neem cake assisted vermicomposting in the range of 25–30 % was within the acceptable limit of mature and good quality vermicompost. The similar ranges of organic carbon have been reported in the previous studies on quality assessment and characterization of vermicompost [23]. The C/N ratio between 12-20 in all treatments of jeevamrutha, panchgavya and neem cake powder indicates the production of stable and mature vermicompost. Previous studies indicated that a C/N ratio lower than 20, especially around 10–20, indicates well stabilized compost and suitable maturity for agricultural application [22]. A C/N ratio less than 20 indicates that the organic waste has reached a sufficient maturity [18].

4. CONCLUSIONS

The present study evaluated the effect of different natural additives like neem cake powder, jeevamrutha and panchgavya on the vermicomposting of garden waste. The results showed that all the additives were effective in vermicomposting process in comparison to control treatment by increasing the rate of decomposition and quality of compost. Among the treatments, 4% neem cake powder was found to be more effective than other treatments followed by 4% jeevamrutha and 4% panchgavya treatments. The use of neem cake powder showed significant effect on physiochemical properties of vermicompost by increasing the nitrogen, phosphorus and potassium (NPK) content. On the other hand Jeevamrutha treatment was found useful for vermicomposting as it contained microorganisms and nutrients which helped in decomposition. Similarly, the panchgavya treatment also helped in the process of vermicomposting. The study concludes that the use of natural additives can play an important role in improving the process of vermicomposting along with the provision of rich organic fertilizer.

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