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ORIGINAL ARTICLE

Vermicomposting of Tea waste mixture with cow dung with the help of earthworm *Eudrilus eugeniae*

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ABSTRACT

Vermicomposting is an environmentally sustainable method of organic waste management that utilizes earthworms to decompose organic materials and produce nutrient-rich vermicompost. This study focuses on the bioconversion of cow dung and tea waste into vermicompost, aiming to explore the potential of utilizing these abundant waste resources for sustainable agriculture. Tea waste (TW) was combined in a 1:1 ratio with cow dung (CD) and then vermicompost for 90 days. Within 45 days of inoculation, earthworm weights increased by 53% in the feed mixture. Physicochemical parameters pH, EC, TOC, and were significantly reduced during vermicomposting, whereas TKN, TP, and TK were significantly elevated in the final product. The presence of tea waste enhanced the microbial activity and decomposition rate, while cow dung provided a rich source of organic matter and essential nutrients. Furthermore, the vermicompost obtained from the bioconversion process exhibited desirable characteristics including a balanced nutrient profile, improved soil structure, and enhanced water-holding capacity. These qualities make it an excellent organic fertilizer for enhancing soil fertility promoting plant growth and reducing the reliance on synthetic fertilizers and harmful agrochemicals.

***Keyword**: Tea waste, vermicompost, cow dung, Eudrilus eugeniae*

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INTRODUCTION

Tea is one of the most widely consumed drinks in the world due to its health benefits. Most tea varieties originate from the same essential plant, Camellia sinensis. The differences in teas are caused by geography, climate, growing conditions, and processing. In 2018, the global per capita intake of tea was around 35 liters, second only to bottled drinking water, and was expected to rise to 37.7 liters by 2021. Tea is extremely popular and growing rapidly in the Asian countries of China and India.[1] The amount of tea consumed in the world was roughly 6.3 million metric tonnes in 2020, and it is predicted to increase to 7.4 million metric tonnes by 2025 (https://www.statista.com; accessed on 06.06.2021 by[2]. The Camellia sinensis plant is native to East Asia, developing in the borderlands of north Burma and southwestern China, but it is now planted in tropical and subtropical places around the world, producing over 3000 types of tea. Tea is classified into six types: black, dark, oolong, yellow, white, and green tea. [3].Tea waste and beverage tea are widely known for their high levels of polyphenols, particularly flavanols and catechins. Catechins are an important component of tea. Catechins are powerful antioxidants because they contain -epigallocatechin-3-gallate (EGCG), -epigallocatechin (EGC), -epicatechin-3-gallate (ECG), -epicatechin (EC), -gallocatechin, and -catechin, which account for roughly 42% of the green tea solids by weight. Tea provides numerous health benefits, including the prevention of cancer cell growth, the reduction of cardiovascular disease, the reduction of cholesterol, and the induction of body weight loss.[3].TW is also released into the environment in huge quantities through regular use, rapid tea extraction, and ready-to-drink teas. In the course of Solid Waste Management, both PMS and TW have produced environmental difficulties. These should be recycled in an environmentally friendly manner. Since Tea Waste is a unique adsorbent, many studies have been conducted in the field of bioremediation for heavy metal removal; however, little research has been conducted on its bioconversion. [4,5].TW is effectively coupled with PMS containing carbonaceous waste for recycling since it has a high lignin concentration and a low amount of organic carbon. Thus, the goal of this study was to recycle TW and CD using vermicomposting. The CD is utilized in vermicomposting as a bulking or amending agent because it is an effective meal for earthworms. (Soobhany et al., 2015) The quality of vermicompost is significantly influenced by the choice of earthworm species (Rajendran and Thivyatharsan, 2014). Most epigeic earthworm species are short-lived, more fertile, and very resistant to a wide range of solid wastes. The majority of epigenic earthworm species have a short lifespan, greater fertility rate, and excellent resistance to a variety of solid wastes. One such epigenic earthworm species that needs enough levels of organic material and a miserable environment for healthy growth and development is *Eudrilus eugeniae* . In the current investigation, CD was added at a consistent rate to TW vermicompost to improve its quality. Vermicomposting is a low-cost method of vermiculture biotechnology that converts organic wastes into fertilizers rich in nutrients that may be applied as a type of soil conditioner for farming. By increasing the surface area for microorganisms and changing the microbial activity for an active breakdown of organic wastes, earthworms fragment the substrate and aerate the entire material. (Ramu et al 2020). It also aids in the stabilization of organic substances inside the earthworm cast and the overall availability of nutrients. Because of the nutrients like N, P, K, and Ca that are easily available to plants, vermicompost is recommended as a well-established option for inorganic fertilizers. As a result of the release of mineral nutrients in earthworm casts, physical, chemical, and microbiological alterations result in overall higher plant development. To the best of our knowledge, the physicochemical shifts associated with the vermiconversion of TW utilizing CD as an amendment have not yet been examined. As a result, the current study seeks to improve and recycle these solid wastes using the earthworm *Eudrilus eugeniae* and to promote the concept of circular economy, which focuses on minimum waste production, less use of existing resources for energy use, maximum by-product utilization, recycling, and reuse of wastes as a whole.

MATERIAL AND METHODS

Collection of samples

Cow dung (CD) was collected from a local cattle farm in Namakkal district, Tamil Nadu, at Navaladipatti. Tea waste (TW) was also collected from the Vivekananda institution canteen at Elayampalayam, Tiruchengode, Namakkal district, Tamil Nadu, India. Earthworms (*Eudrilus eugeniae*) were collected at Periyar Research Organization for Bio-Technique and Eco-system (PROBE) Tamil Nadu, from the Periyar Maniyammai University.

EXPERIMENTAL DESIGN

The studies were carried out in a specifically designed perforated plastic basket (21.5cm in diameter and 11.5cm in depth). Before combining, TW and CD were air-dried and sieved (2.0 mm mesh). For each feed mixture, the studies were repeated three times. TW was combined with cow dung in various combinations. Controls included 100 percent CD and TW, as well as a 1:1 ratio. Cow dung with and without earthworms: tea waste these combinations were manually spun every day for 30 days to eliminate volatile vapours that could be hazardous to earthworms. After 30 days, each vermin reactor received 200 grams of *E. eugeniae.* A periodic sprinkle of water kept the moisture content at 70%. All of the vermireactors were stored in natural condition.

Statistical Analysis

One-way the difference between various feed mixtures was calculated using ANOVA. Tukey's posthoc analysis was used to compare the means (n=3) in order to evaluate test differences between initial and final compost and vermicompost values for various physicochemical parameters. Duncan's multiple range test (DMRT) was used to determine the homogeneous type of treatment for each parameter. The statistical significance of tests was determined using the probability level. $P<.0.05$ Tukey's posthoc test was used to determine the stage of significance for mitotic index and root length. Among the originpro8 software programs, the statistical analysis was performed using SPSS version 16.0. Earthworm growth and reproduction represented and the linear relationship between different concentrations were obtained using regression and correlation study origin software 8.5. The experimental data were presented as means SE.

RESULT AND DISCUSSION

Growth and Reproduction Profiles of Earthworm

The suitability of the tea waste samples for the growth and fecundity of *E.eugeniae* was analyzed through the weight and viability of earthworms, the number of cocoons and hatchlings produced. Since the survival and reproduction rates of earthworms depend on the quality, type of food, and palatability, the CD was mixed with the samples to improve the effectiveness of the tea waste sample. The weight of the worm was observed in the interval day 15, 30, 45,60, and 75-day earthworm weight were reduced on the 45^{th}maximum rate increased 30^{th} day (237.66±6.35) and the minimum rate weight was observed on the 60^{th} (220 ±1.73g) day. The earthworm weight in the current study gradually climbed and declined to begin on the 30th day, just as in the control. Fig 1. A similar observation had previously been reported. [5,7] for *E.eugeniae* and *E. andrei.*

The number of cocoons was observed from the 0^{th} day to the 75^{th} day, and cocoon production started on the 15^{th} day of the experiment. The most cocoons were found on the 60th day 95.00±4.35. From the beginning of the study, cocoons gradually increased. The biochemical quality of the feed mixtures, which was one of the main elements in influencing the commencement of cocoon development, could explain the disparities in cocoon production rates in different vermireactors. [8]. Fig.2 Other variables that lead to increased biomass and earthworm count include increased substrate total porosity, increased water holding capacity, enhanced microbial activity, and abundance of micro and macro-elements. When considering worm repeatability, the incorporation of CD for PMS and TW modification is critical [5]. for *E.eugeniae and E. andrei.* Hatchling development starts on the 15th day. The maximum was increased on the 60^{th} day, and the minimum was decreased on the 30th day. Fig 3. In this study, hatchlings are gradually increased as well as control, and the combination of tea waste and cow dung provides the greatest reproduction. These results suggested that a higher percentage of TW in feed mixtures had a significant impact on the hatchling development per cocoon. Earthworm growth and reproduction are favored by food that provides them with an adequate intake of easily metabolizable organic matter and non-assimilated carbohydrates [9]. According to studies [10] using *E. fetida* to amend cow dung with sugar beet mud 60–100%, the maximum number of hatchlings was observed. This supported the maximum number of hatchlings in V4.

Physio-chemical properties for the final product of composting and vermicompost

Various physico-chemical analyses of the combination of tea waste and cow dung are presented in Table 2.

pH

The pH values are slightly increased in the final product of the vermicompost feed mixture compared to the compost. The pH ranged from acidic to neutral 6.68±0.20to7.20±0.26. respectively Regardless of the original pH of the organic substrates, vermicomposting altered the pH in the direction of neutrality (Table 2). Vermicompost made from non-limed substrates, in general, reported a lower pH value compared to readings from substrates that had been limed, but the difference was not statistically significant ($p = < 0.05$). The initial increase in substrate pH during the vermicomposting process can be attributed to the fact that initially microbes participate in the degradation representing aerobic metabolism. As a result, in the presence of sufficient moisture, basic hydroxides are formed, raising the pH of the substrate during the initial phase of decomposition. As a result, during the log and stabilization phases of microbial action, the conversion of complex compounds into simpler forms results in the formation of weak acids, which become more prevalent than the formation of basic compounds and/or hydroxides. The net effect of more acid and less basic formations was manifested as a slower decrease in substrate pH up to 30 days, after which the substrate pH was almost constant as the substrate tended to acidify.[11]

Electric conductivity EC

Electric conductivity was analyzed for the final product of tea waste and cow dung. Table 2. The electrical conductivity was found to be significantly decreased compared to the initial feed mixture range of 7.90±0.80 to 2.63±0.44 followed by compost 6.75±0.15 to 4.50±0.28. Respectively $p< 0.01$ and $F=0.44$. [12] has been reported since high salinity could result in phytotoxicity, EC is a good indicator of the stability and safety of the vermicompost. With adequate consideration of this, our results showed that lower EC values imply a significant decrease in the concentration of soluble ions. The release of bioavailable mineral salts (PO4-, NH4+) and the precipitation of dissolved salts in the form of non-soluble salts caused by the decomposition of organic matter could also be responsible for the lower EC. The decrease in EC in vermicompost is due to mixture stabilization. [13] There was a decrease in EC in the vermicompost made from the bio sludge beverage industry. [14] Have reported that the EC acceptance limit for plant growth is 4.0 m Scm1, and our results are consistent with this.

Total Organic Carbon (TOC)

The total organic carbon was found to be significantly lower when compared with the initial feed mixtures. The optimum of TOC was observed in vermicompost, where the values are 11.33 to 3.66 respectively. Table 2. $p< 0.01$. These findings show that earthworms and microbes work together to efficiently mineralize organic humic matter, which is a characteristic biochemical change observed during organic matter bio-oxidation.[7] have reported this action is further supported by the relative increase in TKN, specifically in earthworm-treated sludge samples. The decrease in TOC may also be the outcome of microbial respiration leading to the loss of CO_2 and consumption of available C as an energy source by the microbes and worms. Moreover, the decrease in TDS could be corroborated by the statements explaining the decrease in pH and TOC caused by microbial decomposition and mineralization by earthworms. [15,16]

Total Kjeldahl Nitrogen (TKN)

TKN was significantly higher in the compost and vermicompost final products than in the initial feed mixture based on the range of values in 0.05 to 7.33±0.33 and T2 6.29±0.51 to 8.66±0.33$p<0.001$. respectively. Table 2. In the current study, TKN increased as the earthworm population grew while CO2 levels fell. [17]. Previous reports have been found. If earthworms were exposed to organic wastes for longer periods, their bodily secretions (excreta and mucus) would contribute nitrogen to the substrate. Additionally, earthworms modify the microclimate of vermicompost, which favours the microbial populations in charge of nitrogen enrichment [18]. Because of this, in this study, the mixture of organic waste (CD) and polluted soil served as a good source of energy for nitrogen-fixing bacteria that were strengthened by *E. eugeniae*. The increase in nitrogen content may also be due to neutralization of organic substrates and the addition of CD with PMS and other suitable amendments, which is well supported by previous studies on different wastes amended with cow dung.[5].This can be attributed to low nitrogen content in TW and the highest earthworm population in T5 ($P < 0.05$) at the end of the vermicomposting process. The increase in nitrogen content may also be due to the neutralization of organic substrates and the addition of CD with PMS and other suitable amendments, which is well supported by previous studies on different wastes amended with cow dung.

Phosphorus P

P was significantly higher in the compost and vermicompost final products than in the initial feed mixture based on the range of values in 3.85±0.05 to 6.33±0.33 and 4.20±0.20 to 4.93±0.33 respectively. The net P content of vermicomposted material was 87% greater than that of the initial feed mixtures. F2 of the final vermicompost had the highest P content <0.005. Although the concentration of phosphorous in vermicomposted material may reflect the amount of organic phosphorus in TW, the rate of mineralization is directly affected by the nature of the amendment material and the activities of P-mineralizing microflora in decomposing wastes. [19]. Discovered a 25% increase in total P in paper-waste sludge after vermicomposting. In the current study, the P content increased by 87%. This increase could be attributed to the release of P in available forms, which was performed in part by earthworm gut phosphates, and additional P release could be attributed to the P-solubilizing microorganisms present in worm casts, as suggested by [20,21]The findings clearly show that P enrichment is directly related to the material used in the vermireactors.

Potassium K

Potassium content was found in the final compost and vermicompost compared the initial feed mixture. When compared to compost, vermicompost had significantly higher K content $p<.0.01$.The majority of previous reports on vermicompost have indicated a higher K at the end of the experiment. [21]. The main role of microorganisms in solubilizing insoluble potassium is acid production. Introducing earthworms into waste feedstock improves waste mineralization. Organic waste passes through the earthworm gut during the respiration period, and some fraction of minerals are changed into additional available nutrients (i.e. exchangeable forms) due to the work of endogenic and/or exogenic enzymes [20].

C: N ratio C: N ratio was found to decrease significantly in certain sludge samples from 6:21 to 3:70 TW respectively. This is attributed to the increased loss of carbon during microbial respiration in the form of CO_2 as well as the corresponding increase in TKN. These activities have proven to be crucial in enhanced bio-oxidation and stabilization of chemical sludge *E. eugeniae*. The C: N ratio is a good predictor of vermicompost maturity. The C: N ratio of vermicompost material was significantly lower than that of initial substrates in this study. The decrease in the C: N ratio in this study was caused by increased carbon loss through microbial respiration in the form of CO2, as well as an increase in nitrogen and waste stabilization by the action of *E. eugeniae*.[14] discovered similar results. Earlier research indicates that a C: N ratio of less than 20 indicates acceptable maturity, while a ratio of 15 or less is preferred for agronomic use of composts. C: N ratio was found in the vermicompost obtained in this study within the preferred limits described [21].

Table 1. Physico –chemical parameters for initial feed mixture

Parameters	T 1	T 2	T 3	T 4
pH	6.68±0.20	6.68±0.12	7.63±0.15	4.74±0.22
EC	6.75±0.15	7.90±0.80	6.91±0.11	14.69±0.20
TOC %	7.63±0.55	11.66±0.57	5.16±0.69	13.7±0.57
TKN %	4.96±0.05	6.29±0.51	1.91±0.00	7.66±0.57
P %	4.20±0.20	3.85±0.05	1.37±0.13	6.37±0.05
K %	1.61±0.11	1.70±0.51	0.47±0.20	3.49±0.44
C:N ratio	5:8	6:21	5:01	14:8

Values are mean three experiment ± SE T1 Fresh cow dung: tea waste 1:1 ratio
T2 Tea waste and cow dung 1:1 ratio T3 Fresh Cow dung T4 Fresh Tea waste

Table 2. Physico- chemical properties for Tea waste and Cow dung 1:1 ratio in 90th day

Parameters	T1	T2	T3
pH	6.86±0.06	7.20±0.26	6.08±0.30
EC	4.50±0.28	2.63±0.44	3.23±0.28
TOC %	5.76±0.23	3.66±0.33	2.63±0.31
TKN %	7.33±0.33	8.66±0.33	4.66±0.33
P %	4.93±0.33	6.33±0.33	3.00±0.05
K %	3.66±0.37	5.22±0.39	2.36±.31
C:N ratio	4:5	3:70	3:41

Significance level was determined t test p≤0.05 Values are mean three experiment ± error. All values are given in percentage except C/N ratio.T1 tea waste and cow dung without earthworm T2 tea waste and cow dung with earthworm T3 Cow dung and earthworm.

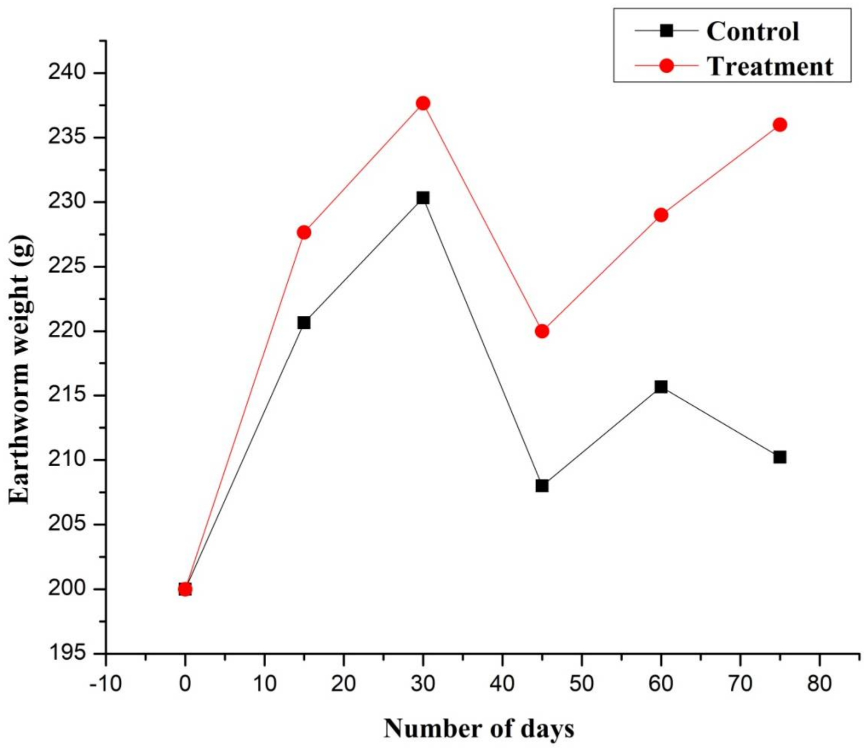

Fig 1. All values are mean (n=3) ± S.E. (p<.0.05 t test) Earthworm weight observed on 0th day to 75th day: Control (Cow dung with earthworm) and Test (Tea waste and cow dung 1:1 ratio)

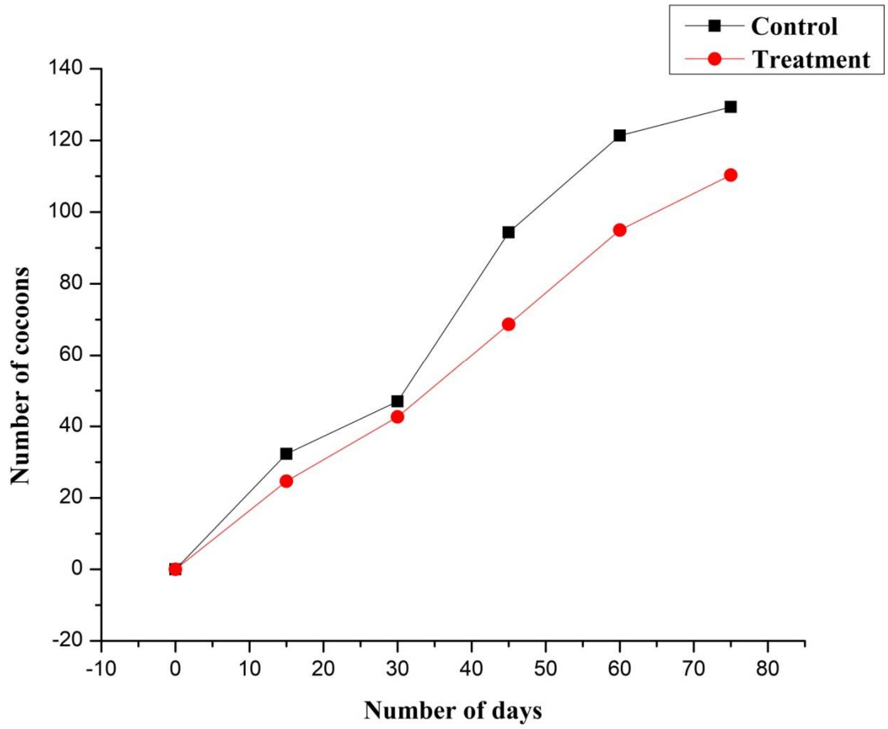

Fig 2. All values are mean (n=3) ± S.E. (p<.0.05) t test: Number of cocoons was observed on 0th day to 75th Control (Cow dung with earthworm) and Test (Tea waste and cow dung 1:1 ratio)

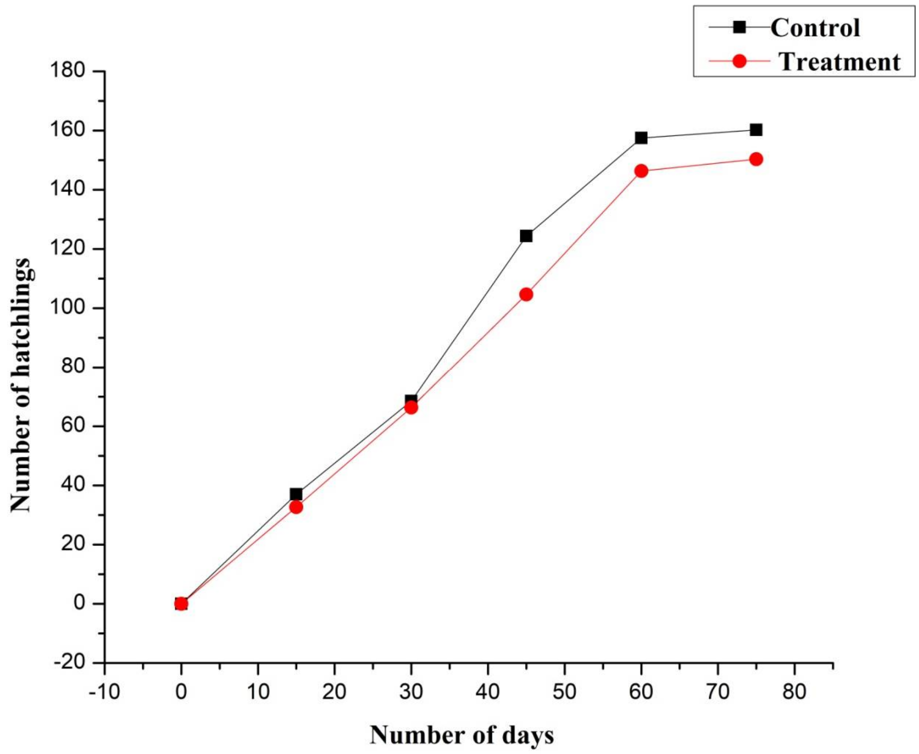

Fig 3. All values are mean (n=3) ± S.E (p<.0.05 t test) Number of hatchlings observed on 0th day to 75th day. Control (Cow dung with earthworm) and Test (Tea waste and cow dung 1:1 ratio)

CONCLUSION

It is concluded that tea waste can be stabilized using vermicomposting in approximately 56 days, as opposed to a longer period for microbial stabilization, but it must be mixed with cow dung. Vermicompost produced by *E. eugeniae* also had lower electric conductivity, lower organic carbon, and increased TKN, K, and P. As a result, it can be used as valuable manure. The study also shows that even a 1:1 ratio feed mixture of tea waste and cow dung can be degraded in this time frame and yield the best quality product or Vermicompost. The current study demonstrated that vermicomposting could be used as an effective technology to convert tea leaf waste into a valuable product.

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