**Effect of different crop residues mixture, weed biomass and vegetable waste on quality of vermiwash**

**Abstract**

A field experiment was conducted at the Centre for Organic Agriculture Research and Training (COART) Farm, Department of Agronomy, Dr. PDKV. Akola. The chemical and biological properties like pH, EC, N, P, K, Carbon content, Ca, Mg, Na, Cl, SO4, ESP, micronutrient analysis and microbial population were used for analysis quality of vermiwash. It was revealed that, treatment T3 i.e. vegetable waste (70%) + cow dung slurry (30%) was found to be higher in pH (7.78), EC (1.06 dS m-1), carbon content (0.073%) and micro nutrient like Na (79.75 ppm) than the rest of the treatment. Treatment (T1) soybean straw 20% + cow dung slurry 30% recorded significantly highest in NPK content (192.78, 26.78 and 176.72 ppm), Fe (2.35 ppm), Mn (0.64 ppm), Zn (0.74 ppm), Cu (0.44 ppm), Ca (212 ppm), Mg (176.75 ppm), S (176.75 ppm), Cl (20.75 ppm), ESP (49.70), microbial population like fungi, bacteria & actinomycetes (8.50, 230, 3.00 x 104 CFU g-1), GMR (₹ 13639), NMR (₹ 1792) and B:C ratio (1.15) than rest of the treatment, but it was at par with treatment T3 i.e. vegetable waste (70%) + cow dung slurry (30%).

**Key word:** cow dung slurry, ESP, microbial population, Vermiwash

**1 Introduction**

The Green Revolution, initiated in the mid-sixties, marked a significant turning point in India's agricultural landscape. It introduced intensive technologies in seeds, fertilizers, plant protection, irrigation, and other allied areas, leading India towards self-sufficiency in food production. However, in recent decades, the productivity gains from these technologies have stagnated. The indiscriminate and unscientific use of chemical inputs has deteriorated soil health and triggered various negative environmental consequences. Modern agriculture has increasingly relied on inorganic chemical fertilizers in recent years. However, there have been numerous reports detailing the adverse effects of these fertilizers on soil, the environment, and plant health. Earthworms are integral to soil biology, as they have the ability to consume large quantities of organic matter, equivalent to their body weight, each day. This process results in the production of worm castings, commonly known as vermicompost. In India, studies have identified 509 species of earthworms belonging to 67 genera and 10 families (Kale, 1991). These earthworms consume various organic materials such as leaves, kitchen waste, and vegetable scraps, thereby contributing to the decomposition process. Vermiculture, the practice of raising earthworms, is being explored for the treatment of agricultural, sugar, and food processing wastes (Kale, 2000). Vermicomposting, which involves the natural conversion of biodegradable waste into high-quality manure with the assistance of earthworms, is an important aspect of sustainable waste management and agricultural practices. Vermiwash is a liquid extract obtained from vermicomposts, extracted in the presence of a thriving population of earthworms. It contains various enzymes, plant growth hormones, vitamins, as well as major and minor nutrients (Shield and Earl, 1982), which contribute to improving crop resistance against diseases and enhancing growth and productivity. Vermiwash serves as an environmentally friendly alternative to chemical fertilizers.In vermiwash, nitrogen exists in the form of mucus, nitrogenous excretory substances, growth-stimulating hormones, and enzymes (Tripathi and Bhardwaj, 2004). It is rich in dissolved nutrients and amino acids, readily accessible to plants. Vermiwash is non-toxic and eco-friendly, inhibiting bacterial growth and forming a protective layer for plant survival and growth. It acts as a plant tonic, reducing the presence of various plant pathogenic fungi and increasing the rate of photosynthesis. Additionally, it enhances the population of soil microorganisms, aiding in the decomposition of organic matter. Vermiwash can be applied as a foliar spray or soil application, serving as a pesticide and natural fertilizer in sustainable agriculture practices. It aligns with Good Agriculture Practices (GAP).

**2. Materials and methods**

The experiment was conducted in the compost unit at the Centre for Organic Agriculture Research and Training (COART) Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.The experiment was laid out in a random block design with five treatments and four replication. Treatments where, T1: Soybean straw (70%) + cow dung slurry (30%), T2: weed biomass (70%) + cow dung slurry (30%), T3: vegetable waste (70%) + cow dung slurry (30%), T4: leaf biomass (70%) + cow dung slurry (30%), T5: millets Straw (70%) + cow dung slurry (30%). Crop residues of Soyabean (*Glycine max)*, Weed Straw, Vegetable Straw, Leaf Litters, and Millet’s straw were used for the experiment. Cement tanks of length 0.90 m, width 0.45 m and height 0.30 m were used for decomposition of crop residues for vermiwash preparation. For the purpose of vermicomposting, cow dung from healthy animals was collected from the Dairy Farm, Department of Animal Husbandry and Dairy Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola. At the bottom of tank layer of 2 cm soil is spread evenly to hold water at bottom of the tank then a 5cm layer of crop residues was added ad it is then sprinkled with dung slurry sufficient to wet the desired layer. Again, the layer of crop residues added and similar procedure is carried out till the tank gets filled. About six layers were required to fill the tank, after the final layer one kg soil is added in dung slurry to plaster the layer to prevent heat and gaseous exchange. These tanks were kept 21 days for partial decomposition. *Eisenia foetida*species of earthworm was used for this experiment.After the partial decomposition turning is given to partial decomposed material, water is sprinkled to remove excess heat for the convenience of earthworms.A sufficiently large container made of concrete or plastic bucket is to be selected. A hole is drilled at the base of the container to fix a tap to it. A base layer of gravel or broken small pieces of bricks is placed upto the height of 10-15 cm. On the coarse sand layer, place 40-45 cm pre-decomposed organic wastes and moisten the different layers with water. Introduce earthworms into the container. To get vermiwash continuously suspend a mud pot or a small bucket with some holes. Cotton wicks or bamboo sticks are placed in the holes so that water can trickle down. Fill the container with 4-5 litres of water every day. The unit starts yielding good quality vermiwash after ten days and about 3-4 litres of vermiwash can be collected every day. The tap should be kept open to collect the washings. The vermiwash is coppery brown in colour. It should be stored in a cool dry place. The data on pH, EC,N, P, K, carbon content, Ca, Mg, Na, Cl, So4, micronutrient analysis, ESP and microbial population (fungi, bacteria & actinomycetes) were recorded from five vermiwash tanks randomly selected from all treatment at the time of observation.The data on pH, EC,N, P, K, carbon content, Ca, Mg, Na,Cl,So4, micronutrient analysis, ESP and microbial population (fungi, bacteria & actinomycetes) were analysed statistically using ANOVA.

**3. Result and discussion**

**3.1 pH**

At Initial days, treatment T3 (vegetables waste (70%) + cow dung slurry (30%)) recorded highest pH of 7.88 which was found to be significantly superior over the T2 (weed biomass (70%) + cow dung slurry (30%) and it was at par with treatments T1 (soybean straw 70%) + cow dung slurry (30%)), T4 (leaf litters (70%) + cow dung slurry (30%)) and T5 (millets straw (70%) + cow dung slurry (30%)). At maturity, treatment T3 (vegetables waste (70%) + cow dung slurry (30%))has recorded maximum pH of 7.78 which is found to be significantly superior over the treatment T2 (weed biomass (70%) +cow dung slurry (30%)) and at par with treatments T1 (soybean straw 70%) + cow dung slurry (30%)), T4 (leaf litters (70%) + cow dung slurry (30%)) and T5 (millets straw (70%) + cow dung slurry (30%)), respectively. The shift in pH during the study could be due to microbial decomposition of residues during the process of vermicomposting. According to Garg *et al.* (2006) the mineralization of nitrogen into nitrate/ nitrite and phosphate into orthophosphate responsible for transferring of pH from basic to acidic or neutral condition.

**3.2 Electrical Conductivity (EC) (dS m-1)**

The EC of vermiwash was found significantly highest (0.80 dS m-1) at initial days with treatment T3 (vegetable waste+ cow dung slurry (30%)), except T1 (soybean straw + cow dung slurry (30%)) and T4 (leaf litters + cow dung slurry (30%)) which was at par. However, the lowest (0.78 dS m-1) EC observed with treatment T2 (weed biomass + cow dung slurry (30%)). At maturity, EC in vermiwash of T3 (vegetable waste (70%) + cow dung slurry (30%)) was found significantly higher than all treatments except T1 (soybean straw 70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. However, the lowest EC was recorded in treatment T2 (weed biomass (70%) + cow dung slurry (30%)). The increase in EC. might have been due to loss of weight of organic matter and release of different mineral salts in available forms (Kaviraj and Sharma, 2003) also noticed nearly about same values.

**3.3 Total organic carbon (%)**

At initial days, regarding the different organic residue, it was observed that the maximum organic carbon (53.55%) was in treatment T1 *i.e*. soybean straw (70%) + cow dung slurry (30%) while minimum organic carbon (48.26%) was found in treatment T5 *i.e*. millets straw (70%) + cow dung slurry (30%). At maturity, the maximum organic carbon (0.072%) was observed in treatment T1 *i.e.* soybean straw (70%) + cow dung slurry (30%) while minimum organic carbon (0.068%) was found in treatment T2 *i.e.* weed biomass (70%) + cow dung slurry (30%). Treatment T1 containing soybean straw (70%) + cow dung slurry (30%) was found significantly superior over the rest of the treatments. Nath *et al.* (2009) reported significant decreased in total organic carbon of vermiwash obtained from composting of animal, agro and kitchen wastes in different combinations.

**3.4 Total Nitrogen content (N)**

At initial, total nitrogen content in residue of T1 (soybean straw (70%) + cow dung slurry (30%)) was found significantly higher (0.0108 ppm) than all treatments except T2 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. However, the lowest total nitrogen content (0.0090 ppm) was recorded in treatment T3 (vegetable west (70%) + cow dung slurry (30%)). At maturity, total nitrogen content in the vermiwash of T1 (soybean straw (70%) + cow dung slurry (30%)) was notably higher (192.78 ppm) than that in all other treatments, except T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. On the other hand, the treatment with the lowest total nitrogen content (171.02 ppm) was T5 (millets straw (70%) + cow dung slurry (30%)). According to Crawford (1983), the final N content obtained in vermiwash samples was largely dependent on the initial N present in waste material and their extend of decomposition.

**3.5 Total Phosphorous content (P)**

At initial, total phosphorous content in residue of T1 (soybean straw (70%) + cow dung slurry (30%)) was found significantly higher (0.0013 ppm) than all treatments except T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. However, the lowest total phosphorous content was recorded (0.0011 ppm) in treatment T5 (millets straw (70%) + cow dung slurry (30%)). At maturity, total phosphorous content in the vermiwash of T1 (soybean straw (70%) + cow dung slurry (30%)) was notably higher (26.78 ppm) than that in all other treatments, except T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. On the other hand, the treatment with the lowest total phosphorous content (23.01 ppm) was T5 (millets straw (70%) + cow dung slurry (30%)). Khwairakpam and Bhargava (2007) observed a decrease in P and attributed it to the mineralization of organic phosphorus and consumption by microbes. The passage of organic matter through the gut of worm results in phosphorus being converted to more bio-available forms. This is done by both worm’s gut enzyme ‘phosphatases’ and by the phosphate solubilizing microorganisms in the worm cast Nath *et al.* (2009) and Degefe *et al*. (2012) Increasing trend of total phosphorous content with time interval is supported by Hatti *et al*. (2010), Murali *et al.* (2010) Abdullah and Kumar (2010).

**3.6 Total Potassium Content (K)**

At initial, total potassium content in residue of T1 (soybean straw (70%) + cow dung slurry (30%)) was found significantly higher (0.0133 ppm) than all treatments except T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. However, the lowest total potassium content (0.0115 ppm) was recorded in treatment T5 (millets straw (70%) + cow dung slurry (30%)). At maturity, total potassium content in the vermiwash of T1 (soybean straw (70%) + cow dung slurry (30%)) was notably higher (176.72 ppm) than that in all other treatments, except T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. On the other hand, the treatment with the lowest total potassium content (151.83 ppm) was T5 (millets straw (70%) + cow dung slurry (30%)). The increased potassium content in vermiwash is due to large number of symbiotic microflora present in the gut and the cast of earthworms in collaboration with secreted mucus and water. This might increase the degradation of ingested organic matter and the release of assailable metabolites. These metabolites enhanced the enrichment of the vermiwash with exchangeable potassium. The microorganisms during vermicomposting produce soluble potassium. Those of Hatti *et al*. (2010), Kaviraj and Sharma (2003) report similar results. Similar findings corroborate with the Murali *et al.* (2010) and Abdullah and Kumar (2010).

**3.7 Micronutrients of vermiwash**

The total iron content of vermiwash collected from treatment of T1 (soybean straw (70%) + cow dung slurry (30%)) was found significantly higher (2.35 ppm) than all treatments except T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. However, the lowest total iron content (2.03 ppm) was recorded in treatment T5 (millets straw (70%) + cow dung slurry (30%)). Mall *et al.* (2005) reported that the presence of enzymes and co-factors in the gut of earthworms resulted in increase in total iron (Fe) content of vermiwash. The total manganese content of vermiwash of treatment of T1 (soybean straw (70%) + cow dung slurry (30%)) was found significantly higher (0.64 ppm) than all treatments except T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. However, the lowest total manganese content was recorded (0.53 ppm) in treatment T5 (millets straw (70%) + cow dung slurry (30%)). According to Vasanthi and Kumaraswami (1999), the activities of earthworms enhancing the mineralization rate on Mn due to microbial and enzymatic activities of earthworm’s intestines which were resulted in increased in manganese content of vermiwash. The total zinc content of vermiwash of treatment of T1 (soybean straw (70%) + cow dung slurry (30%)) was found significantly higher (0.74 ppm) than all treatments except T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. However, the lowest total zinc content (0.64 ppm) was recorded in treatment T5 (millets straw (70%) + cow dung slurry (30%)). The total copper content of vermiwash of treatment of T1 (soybean straw (70%) + cow dung slurry (30%)) was found significantly higher (0.44 ppm) than all treatments except T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. However, the lowest total copper content was recorded (0.38 ppm) in treatment T5 (millets straw (70%) + cow dung slurry (30%)). Increase in copper (Cu) content of vermiwash might be due to various copper containing oxidizing enzymes. (Lee, 1991). The data Regarding the total sodium content of vermiwash having different organic residues was significant throughout the period of composting. At maturity, total sodium content in the vermiwash of T3 (vegetable waste (70%) + cow dung slurry (30%)) was notably higher (79.75 ppm) than that in all other treatments, except, T1 (vegetables waste (70%) + cow dung slurry (30%)) which was at par. On the other hand, the treatment with the lowest total sodium (75.75 ppm) content was T2 (weed biomass (70%) +cow dung slurry (30%)). The data Regarding the total chlorine content of vermiwash having different organic residues was significant throughout the period of composting. At maturity, total chlorine content in the vermiwash of T1 (soybean straw (70%) + cow dung slurry (30%)) was notably higher than (20.75 ppm) that in all other treatments, except T2 (weed biomass (70%) +cow dung slurry (30%)), T3 (vegetables waste (70%) + cow dung slurry (30%)) and T5 (millets straw (70%) + cow dung slurry (30%)) which was at par. On the other hand, the treatment with the lowest total chlorine content (18.75 ppm) was T4 (leaf litters (70%) + cow dung slurry (30%)).

**3.8 Macronutrients of vermiwash**

The data Regarding the total calcium content of vermiwash having different organic residues was significant throughout the period of composting. At maturity, total calcium content in the vermiwash of T1 (soybean straw (70%) + cow dung slurry (30%)) was notably higher (212.00 ppm) than that in all other treatments, except T2 (weed biomass (70%) +cow dung slurry (30%)), T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. On the other hand, the treatment with the lowest total calcium content (182.00 ppm) was T5 (millets straw (70%) + cow dung slurry (30%)). The data Regarding the total magnesium content of vermiwash having different organic residues was significant throughout the period of composting. At maturity, total magnesium content in the vermiwash of T1 (soybean straw (70%) + cow dung slurry (30%)) was notably higher (176.75 ppm) than that in all other treatments, except T2 (weed biomass (70%) +cow dung slurry (30%)), T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. On the other hand, the treatment with the lowest total magnesium content (152.00 ppm) was T5 (millets straw (70%) + cow dung slurry (30%)). The data Regarding the total sulphate content of vermiwash having different organic residues was significant throughout the period of composting. At maturity, total sulphate content in the vermiwash of T1 (soybean straw (70%) + cow dung slurry (30%)) was notably higher (176.75 ppm) than that in all other treatments, except, T3 (vegetables waste (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) which was at par. On the other hand, the treatment with the lowest total sulphate content (152.00 ppm) was T5 (millets straw (70%) + cow dung slurry (30%)), similar findings were observed by Katakula *et al*., 2021.

**3.9 Total Exchangeable Sodium Percentage (ESP)**

The data Regarding the Exchangeable Sodium Percentage (ESP) of vermiwash having different organic residues was significant throughout the period of composting. At maturity, Exchangeable Sodium Percentage (ESP) in the vermiwash of T1 (soybean straw (70%) + cow dung slurry (30%)) was notably higher (49.70 %) than that in all other treatments, except T2 (weed biomass (70%) +cow dung slurry (30%)), T4 (leaf litters (70%) + cow dung slurry (30%)) and T5 (millets straw (70%) + cow dung slurry (30%)) which was at par. On the other hand, the treatment with the lowest ESP (46.00 %) was T3 (vegetables waste (70%) + cow dung slurry (30%).

**4.10 Microbial population**

Data concerned to fungi count significant differentiation was evident among crop residues mixtures of vermiwash during the vermicompost experimentation. Fungi population increased significantly throughout the decomposition process of crop residue mixtures. It again showed increase in population count at maturity in all crop residue mixtures. T1 (soybean straw (70%) + cow dung slurry (30%)) vermiwash recorded statistically highest bacterial count (8.50 x 104 CFU g-1)at maturity followed by T2 (weed biomass (70%) + cow dung slurry (30%)), T3 (vegetables waste (70%) + cow dung slurry (30%)) and T5 (millets straw (70%) + cow dung slurry (30%)). T4 (leaf litters (70%) + cow dung slurry (30%)) vermiwash recorded lowest increase in bacterial count (7.00 x 104 CFU g-1)at maturity. In present investigation highest fungal population at maturity was observed in T1 (soybean straw (70%) + cow dung slurry (30%)) due to availability of nutrient rich organic waste caused by the mechanical action of earthworm’s gizzards for the proliferation of microbes. Similar results were reported by Esakkiammal *et al.* (2015), Meenatchi *et al.* (2009) and Pawar *et al.* (2017). Data concerned to bacterial count significant differentiation was evident among crop residues mixtures of vermiwash during the vermicompost experimentation. Bacterial population increased significantly throughout the decomposition process of crop residue mixtures. It again showed increase in population count at maturity in all crop residue mixtures. T1 (soybean straw (70%) + cow dung slurry (30%)) vermiwash recorded statistically highest bacterial count (230 x 106 CFU g-1)at maturity followed by T2 (weed biomass (70%) +cow dung slurry (30%)), T3 (vegetables waste (70%) + cow dung slurry (30%)) and T5 (millets straw (70%) + cow dung slurry (30%)). T4 (leaf litters (70%) + cow dung slurry (30%)) vermiwash recorded lowest increase in bacterial count (205.25 x 106 CFU g-1)at maturity. Data concerned to actinomycetes count significant differentiation was evident among crop residues mixtures of vermiwash during the vermicompost experimentation. Actinomycetes population increased significantly throughout the decomposition process of crop residue mixtures. It again showed increase in population count at maturity in all crop residue mixtures. T1 (soybean straw (70%) + cow dung slurry (30%)) vermiwash recorded statistically highest bacterial count (3 x 104 CFU g-1)at maturity followed by T2 (weed biomass (70%) +cow dung slurry (30%)), T3 (vegetables waste (70%) + cow dung slurry (30%)) and T5 (millets straw (70%) + cow dung slurry (30%)). T4 (leaf litters (70%) + cow dung slurry (30%)) vermiwash recorded lowest increase in actinomycetes count (2 x 104 CFU g-1)at maturity. In present investigation highest actinomycetes population at maturity was observed in T1 (soybean straw (70%) + cow dung slurry (30%)) however the lowest was observed in T4 (leaf litters (70%) + cow dung slurry (30%)). The increase in actinomycetes count might be due to availability of nutrient rich organic waste caused by the mechanical action of earthworm’s gizzards for the proliferation of microbes. Similar results were reported by Meenatchi *et al.* (2009), Esakkiammal *et al.* (2015) and Pawar *et al.* (2017).

**4.11** **Economics studies**

In the assessment of various vermiwash treatments, it was evident that the vermiwash treatment T1, consisting of soybean straw (70%) and cow dung slurry (30%), achieved the significantly highest gross monetary returns, amounting to (13639 ₹ tonne-1). Conversely, the vermiwash treatment T2, incorporating weed biomass (70%), and cow dung slurry (30%), recorded the lowest gross monetary returns at (12782 ₹ tonne-1). The economic analysis was varied according to inputs used as per the treatments *viz.* crop residue, dung, earthworm culture and labour. The cost of production of compost is given in Appendix-I. The highest cost of production (11883 ₹ tonne-1) recorded in the treatment T5 (millets straw (70%) + cow dung slurry (30%)). The lowest cost of production recorded for T1 (soybean straw (70%) + cow dung slurry (30%)) and T4 (leaf litters (70%) + cow dung slurry (30%)) due to less price of crop residue and lesser watering charges as it matures early than other treatments. The net monetary returns per tonne was obtained significantly highest (1792 ₹ tonne-1) in treatment T1 (soybean straw (70%) + cow dung slurry (30%)). However, lowest (917 ₹ tonne-1) net monetary returns were recorded in treatment T2 (weed biomass (70%) + cow dung slurry (30%)). In the vermiwash treatments, the highest Benefit: Cost (B:C) ratio, reaching (1.15), was documented in T1, where the composition included soybean straw (70%), and cow dung slurry (30%). Conversely, the lowest B:C ratio, recording (1.07), was noted in weed biomass (70%), and cow dung slurry (30%) in the vermiwash.

**Conclusion**

soybean straw 20% + cow dung slurry 30% (T1) recorded significantly highest in NPK content Iron, Manganese, Zinc, Copper, Calcium, Magnesium, Sulphur, Chlorine, ESP (49.70), microbial population like fungi, bacteria & actinomycetes, GMR, NMR and B:C ratio. In Ph, EC, and OC significantly higher in treatment T3 - Vegetable waste (70%) + cow dung slurry (30%) as compared to other treatment.

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**Reference**

Abdullah A. A., and Kumar Sukhraj. 2010. Effect of vermiwash and vermicompost on soil parameters and productivity of okra (Abelmoschus esculentus) in guyana. African J. Agri. Res., 5 (14): 1794-1798.

Degefe, G., M. Seyoum and J. Dominguez. 2012. Vermicomposting as a sustainable practice to manage coffee husk, enset waste (enset ventricosum), khat waste (Catha edulis) and vegetable waste amended with cow dung using an epigeic earthworm eisenia andrei. International Journal of PharmaTech Research 4(1): 15-24.

Esakkiammal, B. and LakshmiBai, L. 2013. Antimicrobial activity of vermicompost and vermiwash of earthworm, Eudriluseugeniae(Kinberg). International Journal of Biological Technology 4(1): 7-9**.**

Garg V. K., Yadav Y. K., Sheoran A, Chand S. and Kausik P. (2006). Livestock excreta management through vermicomposting using epigeic earthworm Eisenia fetida. Environmentalist. 26: 269–76.

Hatti, S.S., Londonkar, R.L., Patil, S.B., Gangawane, A.K., Patil, C.S., 2010. Effect of Perionyx excavatus vermiwash on the growth of plants. J. Crop Sci. 1(1), 1-5.

Kale, R. (1991). Vermiculture: Scope for New Biotechnology. Calcutta: Zoological Survey of India. 101: 336-344

Kale, R.D. (2000). An evaluation of the vermitechnology process forthe treatment of agro, sugar and food processing wastes. In: Technology Appreciation Programme on Evalution of Biotechnological Approaches to Waste Management held in 26th October 2000. Industrial Association-Ship of IIT, Madras, 15–17.

Katakula AA, Handura B, Gawanab W, Itanna F, Mupambwa HA. Optimized vermicomposting of a goat manure-vegetable food waste mixture for enhanced nutrient release. Scientific African. 2021 Jul 1;12: e00727

Kaviraj and Sharma (2003) Municipal solid waste management through vermicomposting employing exotic and local species of earthworms. Bioresour Technol., **90**, pp .169-173.

Khwairakpam and Bhargava (2009) Vermitechnology for sewage sludge recycling. J. Hazard Mater., **161** (2-3), pp-948-954.

Lee K. E. (1991) Soil Fauna and Soil Structure. Australian Journal of Soil Research. **29** : 749-776.

Mall A. K., Dubey A and Prasad S. (2005) Vermicompost: An inevitable tool of organic farming for sustainable Agriculture, Agrobios Newsletter; **3**: 10-11.

Meenatchi, R., Giraddi, R. S., Awaknavar, J. S. and Biradar, D. P. 2009. Effect of food substrates and earthworm species on microbial activity in vermicompost and vermiwash. Karnataka Journal of Agricultural sciences **22** (5): 1020-1022.

Murali, M. Bharathiraja. A. and Neelanarayanan. P., (2011). Conversion of coir Wastes (Cocos nucifera L.) into vermicompost by utilizing Eudrilus eugeniae and Its Nutritive Values. Indian Journal of Fundamental and Applied Life Sciences. **1**(3): 80-83.

Nath G., Singh K., and Singh D. K. (2009) Chemical Analysis of Vermicompost/vermiwash of different Combination of Animal, Agro and Kitchen Waste. Australian Journal of Basic and Applied Sciences, **3**(4): 3671-3676, ISSN; 1991-8178.

Pawar PS, Datkhile RV, Bhite BR. Use of organic manures in sweet orange (Citrus sinensis Osbeck) cv. Mosambi. J. of Trends in Biosci. 2017; 10(14):2483- 2486.

Shield Earl B. 1982. Raising Earthworms for Profit. Shields Publication. P.O. Box 669 Eagle River Wisconsin 128p.

Tripathi, G. and Bhardwaj, P. (2004). Decomposition of kitchen waste amended with cow manure using an epigeic species (*Eisenia foetida*) and an anecic species (*Lampito mauritii*). AU: *Bioresource-Technology*. 92 (2): 215-218.

Vasanthi D. and Kumaraswami K. (1999) Efficacy of Vermicompost to improve soil fertility and rice yield, Journal of the Indian Society of Soil Science; **47**: 268-272.

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| **Treatment details** | **Initial (residue)** | | | **Maturity (vermiwash)** | | | **Initial (residue)** | | | **Maturity (vermiwash)** | | |
| **pH** | **EC**  **(dS m-1)** | **OC (%)** | **pH** | **EC (dSm-1)** | **OC** | **N**  **(%)** | **P**  **(%)** | **K**  **(%)** | **N**  **(ppm)** | **P**  **(ppm)** | **K**  **(ppm)** |
| **T1** - Soyabean straw (70%) + cow dung slurry (30%) | 7.88 | 0.79 | 53.55 | 7.68 | 1.05 | 0.072 | 0.0108 | 0.0013 | 0.0133 | 192.78 | 26.78 | 176.72 |
| **T2** - Weed biomass (70%) + cow dung slurry (30%) | 7.48 | 0.75 | 48.33 | 7.28 | 1.01 | 0.068 | 0.0108 | 0.0012 | 0.0120 | 173.99 | 24.17 | 159.49 |
| **T3** - Vegetable waste (70%) + cow dung slurry (30%) | 7.98 | 0.80 | 51.45 | 7.78 | 1.06 | 0.073 | 0.0090 | 0.0012 | 0.0128 | 185.23 | 25.73 | 169.79 |
| **T4** - Leaf biomass (70%) + cow dung slurry (30%) | 7.78 | 0.78 | 50.37 | 7.58 | 1.04 | 0.071 | 0.0102 | 0.0014 | 0.0125 | 181.33 | 25.19 | 166.22 |
| **T5** - Millets Straw (70%) + cow dung slurry (30%) | 7.58 | 0.76 | 48.26 | 7.38 | 1.02 | 0.069 | 0.010 | 0.0011 | 0.0115 | 171.02 | 23.01 | 151.83 |
| SE (m) ± | 0.09 | 0.09 | 1.53 | 0.09 | 0.01 | 0.0009 | 0.0009 | 0.000041 | 0.00048 | 5.57 | 0.82 | 5.42 |
| CD at 5% | 0.27 | 0.27 | 4.71 | 0.27 | 0.03 | 0.0027 | 0.0027 | 0.000127 | 0.00145 | 17.16 | 2.53 | 16.70 |
| GM | 7.74 | 7.74 | 50.39 | 7.54 | 0.77 | 0.07 | 0.07 | 0.00125 | 0.0132 | 0.07 | 24.97 | 164.81 |

**Table 1. pH, EC (dS m-1), carbon content (%) and NPK content of vermiwash as influenced by different treatments.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** |  | **Total micronutrient content (ppm)** | | | | | | | | **ESP (%)** |
| **Fe** | **Mn** | **Zn** | **Cu** | **Na** | **Cl** | **Ca** | **Mg** | **S** |
| **T1** - Soyabean straw (70%) + cow dung slurry (30%) | 2.35 | 0.64 | 0.74 | 0.44 | 78.75 | 20.75 | 212.00 | 176.75 | 176.75 | 49.70 |
| **T2** - Weed biomass (70%) + cow dung slurry (30%) | 2.12 | 0.57 | 0.66 | 0.40 | 74.75 | 18.75 | 196.50 | 159.50 | 159.50 | 49.25 |
| **T3** - Vegetable waste (70%) + cow dung slurry (30%) | 2.26 | 0.62 | 0.71 | 0.42 | 79.75 | 20.50 | 203.75 | 169.75 | 169.75 | 46.00 |
| **T4** - Leaf biomass (70%) + cow dung slurry (30%) | 2.21 | 0.61 | 0.69 | 0.41 | 77.75 | 18.25 | 199.50 | 166.50 | 166.50 | 47.75 |
| **T5** - Millets Straw (70%) + cow dung slurry (30%) | 2.03 | 0.53 | 0.64 | 0.38 | 75.75 | 18.75 | 182.00 | 152.00 | 152.00 | 49.50 |
| SE (m) ± | 0.07 | 0.02 | 0.02 | 0.02 | 0.88 | 0.89 | 4.25 | 5.37 | 5.42 | 0.92 |
| CD at 5% | 0.22 | 0.07 | 0.07 | 0.07 | 2.70 | 2.73 | 13.08 | 16.55 | 16.69 | 2.82 |
| GM | 2.19 | 0.59 | 0.59 | 0.59 | 77.35 | 19.40 | 164.00 | 198.75 | 164.90 | 48.40 |

**Table 2. Total micronutrient content (ppm) and ESP (%) of vermiwash as influenced by different treatments**

**Table 3. Microbial population (x 104CFU g-1) and economics of vermiwash at maturity as influenced by different treatments**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment details** | **Microbial population** | | | **₹ (tonnes-1)** | | | |
| Fungi | Bacteria | Actinomycetes | Total  Cost | GMR | NMR | B:C  ratio |
| **T1** - Soyabean straw (70%) + cow dung slurry (30%) | 8.50 | 230.00 | 3.00 | 11847 | 13639 | 1792 | 1.15 |
| **T2** - Weed biomass (70%) + cow dung slurry (30%) | 7.25 | 207.25 | 2.10 | 11865 | 12782 | 917 | 1.07 |
| **T3** - Vegetable waste (70%) + cow dung slurry (30%) | 8.25 | 225.25 | 2.25 | 11865 | 13160 | 1295 | 1.11 |
| **T4** - Leaf biomass (70%) + cow dung slurry (30%) | 7.00 | 200.00 | 2.00 | 11847 | 12962 | 1115 | 1.09 |
| **T5** - Millets Straw (70%) + cow dung slurry (30%) | 8.25 | 205.25 | 2.25 | 11883 | 12832 | 949 | 1.08 |
| SE (m) ± | 0.46 | 9.78 | 0.57 | - | 86.87 | 89.17 | - |
| CD at 5% | 1.43 | 30.13 | 1.76 | - | 267.68 | 274.76 | - |
| GM | 7.85 | 213.55 | 2.30 | - | 3268.75 | 303.40 | - |