RESEARCH ARTICLE

Effects of vermiconversion on coffee husk, paper waste and vegetable waste using red worm (*Eisenia fetida*) in Begi district, Ethiopia

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Vermicomposting is the bioconversion of organic waste into a bio-fertilizer due to earthworms' activity and it is operated in mesophilic conditions. PH and moisture content levels shall be optimized. The vermicomposting process takes place in vermin-reactors. In the vermicomposting method microorganisms begin the process, but it is the red worm that plays the largest role in converting organic matter. In this study, vermicomposting process was conducted to evaluate performance of epigamic earth worm species of *Eisenia fetida* in 60 days to change on the three biodegradable wastes (Coffee husk, paper waste and vegetable wastes) in Begi town. Two of the wastes (coffee husk and paper wastes) were mixed with cow dung 3:1 ratio and vegetable wastes without cow slurry treated with *Eisenia fetida* (tiger worm). Thirty (30) numbers of matured earth worms were inoculated on the three substrates and monitored for 60 days. Each waste was observed three times at intervals of 0 day, 30 days and 60 days. Characterization results showed that there is a change of pH, EC, OM, OC, TN, C:N, AP, EK, ash from initial day to final day, 0 and 60 day (pH 7.51-7.03, EC 1.91 mS/cm-1.24 mS/cm, OM 47.06-29.21%, OC 27.3-16.93%, TN 1.38-2.199%, C:N 21.39-8.63, AP 11.17-20.85 ppm and EK 2.26-4.43 mg/k) were found. The finding from the study showed that, the vermicomposting produced have matured and have quality when compared with WHO and ISIRI standards. The obtained vermicompost had an excellent nutrient status confirmed by the chemical analyses and contained essential nutrients. Vermicomposting could good option to recover biodegradable wastes from the town and simultaneously produces organic fertilizer.

Key Words: Bioconversion; Biodegradable wastes; Earthworms; *Eisenia fetida*; Vermicomposting; Vermitechonology

Abbreviations: ANOVA: Analysis of Variance; AARI: Asossa Agricultural Research Institute; AP: Available Phosphorous; CSA: Central Statistical Agency; C:N: Carbon to Nitrogen ratio; CH: Coffee Husk; CD: Cow Dung; EC: Electric Conductivity; EK: Exchangeable Potassium; OC: Organic Carbon; OM: Organic Matter; PW: Paper Waste; TN: Total Nitrogen; TOC: Total Organic Carbon

INTRODUCTION

Rapid expansion of urbanization, industrialization and population increase have led to generation of huge amounts of wastes over the whole world. Managing these wastes is one of the most serious environmental problems confronting urban areas in developing countries [1]. Vermicomposting technology is globally becoming a popular organic waste management technique. Vermicomposting is the bioconversion of organic waste into a bio-fertilizer due to earthworm activity. Vermicomposting technology is a fast growing one with its pollution free, cost effective and efficient nature. It defines the exciting potential for waste diminution, fertilizer production, as well as an assortment of possible uses for the future. According to Achsahand and Lakshmi, the vermicomposting process is a massive process and operating conditions such as temperatures, pH, electrical conductivity and moisture content levels must be optimized [2]. Normally, the vermicomposting process takes place in vermi-reactors which include plastic, earthed pots and wood worm bins.

In the vermicompost method microorganisms begin the process, but it is the red worm that plays the largest role in converting Organic Matter (OM) subjected to preliminary decomposition processes (e.g. hydrolysis or fermentation). When the organic material passes through the gut of the earth worm it again increases the surface area of the material so that the microorganisms can break it down further. According to Rakish, et al. during vermicomposting earthworms act as mechanical blenders and by commuting the OM, they modify its biological, physical and chemical status, gradually reducing its C:N ratio, increasing the surface area exposed to microorganisms and making it much more favourable for microbial activity and further decomposition [3]. Traditionally, vermicompost has been generated with animal manure as the substrate and has been recognized as a good soil conditioner and fertilizer; while in recent years, other organic substrates or biodegradable wastes materials like human and animal waste, plant product, wood, paper, food waste, leave grass, chicken waste like vegetable and fruit wastes have also been vermicomposted and the products have been found to be as good as the manure based vermicompost.

According to Suthar and Singh, the waste in many developing nations would supposedly be ideal for reduction through composting, having a much higher composition of organic material than in industrialized countries, the average town's municipal waste stream more than 50% are OM [4]. Vincent S and Chandrashekar stated that, the huge amounts of biodegradable organic wastes that generate every day in urban and agriculture areas creating disposal problems on the environmental, gas emissions, public health, economic and social levels especially in developing countries [5]. These huge amounts of organic wastes could be a renewable source for agriculture sectors and the wastes can be converted into valuable compost by applying vermicomposting technology. The approach reduces pollution and provides a valuable substitute for chemical fertilizers [6]. Since the conventional approaches to organic waste management are capital intensive and costly there is a need for somewhat more low technology approach to reduction of organic waste and biodegradable waste material is the sustainable source for organic manure production for improving the livelihood of any farming community.

Akin to many developing countries, rapid population growth in relation with natural growth, high rural to urban and urban-urban migration poses many environmental problems in general and solid waste (organic and inorganic) in particular for urban areas of Ethiopia. So, inadequate management of organic solid waste has resulted in accumulation of waste on open land, drainage, roads and living areas of many people in Ethiopia. Uncollected and poorly managed organic solid wastes affect health and environmental hazard to the residents, especially to the urban poor who live near informal and often illegal waste dumps. The disposal of waste has

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proved to be a major public health issue and a vital factor affecting the quality of the environment and especially in Ethiopian cities has become one of the most intractable environmental problems today. The main problem that facing the city is open and random dumping off refuses.

The growth of urban populations and economic activities have resulted accumulation of biodegradable wastes which is characterized by high organic content while the municipality has no allocation of budget to collect, transport and disposing waste from Begi town which resulted in disposing of organic wastes to open disposal sites. These open dumping and burning of the wastes causes health and environmental problem of the residential community of the town. Since the vermitechonology is not well known in enormous parts of the country; thus, it is now time for the Ethiopian city, especially Begi town to think about the biological waste treatment system like vermitechonology with the intervention of appropriate biological organisms. Thus, vermicompost is an efficient and eco-friendly way to convert any biodegradable wastes into quality manure within relatively shorter period of time utilizing earthworm species. Composting through earthworm is advantageous in preventing the loss of nutrients, beneficial micro-flora and vitamins, as strong heat does not generate during the process.

Several epigeics (*Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavatus*) have been identified as potential candidates to decompose organic waste materials. The red worm *Eisenia fetida* is widely considered as the best species at converting organic matter into compost; what is more, it feeds intensively and breeds most quickly and characterized by long life cycle, high fertility and high tolerance to changing environmental factors. Vermitechonology is not well known in enormous parts of the country; thus, it is now time for the Ethiopian cities, especially Begi town to think about the biological waste treatment system like vermitechnology with the intervention of appropriate biological organisms. Therefore, the main objective of this study was to evaluate the conversion of biodegradable waste into compost on the bio-conversion of coffee husk, paper wastes and vegetable wastes through the process of vermicompost, employing earthworm *Eisenia fetida* with organic wastes like cow dung to stabilize the nutrient requirements and hasten the decompose of substrates with specifically intended to assess the physico-chemical properties of biodegradable wastes after vermicomposting and compare the obtained vermicompost quality with standards.

MATERIALS AND METHODS

Description of the study area

The study site is located in Oromia regional state, west Wollega zone, Begi town. According to Begi district Agriculture office, agro ecology of the area was semi humid and annual rain fall of Begi town falls between 2000-1800 mm/year and mean annual temperature is 20°C-28°C. The area was located at 662 km of west Addis Ababa that lie within 3 km radius of 9°26'N latitude and 34°32'E longitude with altitude range of 1650-2000 m.a.s.l while the total area coverage of the town is 834 hectares (Google map). The total the current population of the town is male 14,381 females 13,707 total 28,088 (projection from CSA 2007) (Figure 1).

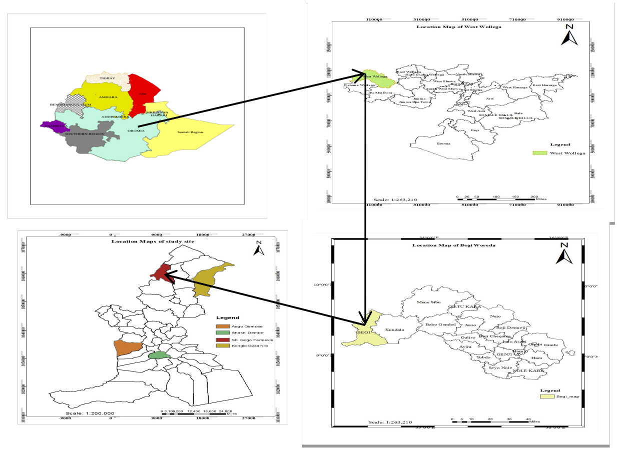

Figure 1) *Geographical location of the study area*

Data collection

Collection of wastes: The biodegradable wastes such as coffee husk, paper waste, vegetable waste and cow dung were collected from Begi town. Coffee husk were taken from dry coffee processing machine of the town while paper waste was collected from government institutions in additionally vegetable waste were from market site and cow dung were collected from individual's households. After collection of wastes, segregation process was done. Segregation is important process for distinguish of biodegradable wastes from non-biodegradables waste materials. After segregation the collected wastes were sheared, cut and dried in order to make them having uniformity size.

Procurements of earthworms: Epigeic earthworm's species type of *Eisenia fetida* was obtained from vermiculturing center, located in Benishangul Gumuz regional state, Asossa Agricultural Research Institute (AARI), Asossa. Matured and adult earth worms were taken from AARI stock culture for experimental purpose (Figure 2).

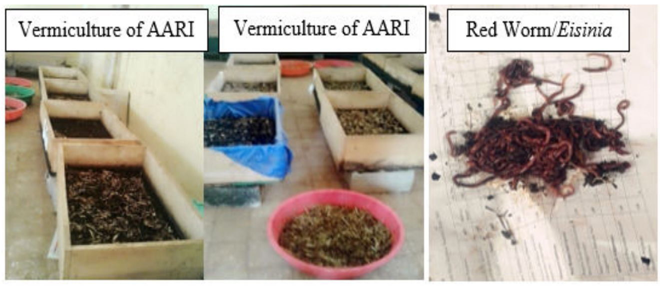

Figure 2) *Matured and adult earth worms taken from AARI*

Experimental setup

Pre-decomposition experiment: A three plastic tank of 45 cm × 35 cm × 15 cm sized, 5-6 small holes (0.5 cm for diameter) were drilled at the side of the plastic reactor for ventilation and bottom of the tank for draining and humidity control at the same time as each of the plastic reactor were filled with three kilogram (3 kg) pre decomposed coffee husk and cow dung, paper waste and cow dung of 3:1 ratio respectively that mean 2.25 kg of coffee husk and 2.25 kg paper wastes were mixed with 0.75 kg of cow dung and 3 kg of vegetable waste without cow dung were prepared and mixed carefully. The cow dung was used as the bulking agent to enhance the efficiency of vermicomposting process.

The substrates were also daily sprinkled with water so that it gets decomposed. This experiment was continued for 10 days, and the wastes were procedure accordingly and, turned up and down for proper aeration and decomposition. The experimental set up was accomplished in Begi agricultural nursery site under prepared shade (Figure 3).

Figure 3) *Shows pre-decomposition experiment of the three treatments*

Composting experiment: The first part of pre-decomposition experiment in plastic tank of 45 cm × 35 cm × 15 cm sized each experimental unit were filled with a mixture (3 kg) of coffee husk and cow dung, paper waste and cow dung, and vegetable waste without cow dung. After 10 days, pre-decomposition process thirty (30) numbers of red worms (*Eisenia foetida*) adult, matured, and clitelled worms were uniformly released on the top of each experimental containers that was taken from Asossa Agricultural Research Institute (AARI) stock culture. The experiments were conducted inside the shade located in Begi agricultural nursery site to protect against birds, termites, ants and rats. The containers were covered by mesh like materials made from plastic and it was observed daily in order to check the various parameters necessary for the survival and number of earth worm during the study.

The experiments were maintained for 60 days till the finely granular vermicompost was prepared. During the experiments of composting process the material was analysed for different physico-chemical characteristics such as PH, electrical conductivity, organic matter, organic carbon, total nitrogen, C:N ratio, available Phosphorus, exchangeable potassium and ash, by using conventional methods as well as for number of earthworm, cocoon production and weight loss of organic materials. During this research experiments, the samples were examined at periodic intervals at initial 0/day and after 30 and 60 days of vermicomposting.

Data analysis

Compost analysis: Chemical analyses were applied in the soil laboratory. The pH value of a solution is the negative logarism of hydrogen ion concentration pH-H_2O using a pH meter; Electrical Conductivity (EC in mS/cm) using a conductivity meter; total organic carbon in % by using the Walkley-Black method; total nitrogen (N in %) using the Kjeldahl method; C:N; Available phosphorus; two methods are described for the determination of available phosphorus [7]. Exchangeable potassium content of the manure sample was determined by flame photometric method and the sample is extracted with Morgan's solution and K in the extract is measured by flame photometer. Ash determined by drying method placed in furnace and heated at 550°C for 5 hours then cooled and dissolved in 10 ml of 6 N HCl.

Statistical analysis

All statistical analyses were carried out using the SAS program, version 9, (SAS system 2004) and Microsoft office excel. The treatments considered as independent variables, the results of the analysis were subjected to analysis of variance ANOVA at ($p<0.05$) throughout the study and statistical analysis of data was determined by using one-way ANOVA. Finally, obtained results were presented in tables and descriptive graphs and compared with related standards (Institute of Standards and Industrial Research of Iran).

RESULTS AND DISCUSSION

Characterization of physico-chemical properties of wastes

Characterization of waste materials before the vermicomposting process is critically important in understanding the properties of each substrate at the original level and helps to demonstrate their difference due to vermicomposting (Figure 4).

Figure 4) *Collected and semi processed wastes*

The above figure illustrates characterization of waste materials before vermicomposting process in three different treatments of coffee husk with mixture of cow dung (CH+CD) at 3:1 ratio, paper waste and cow dung (PW +CD) with referred ratio as well as vegetable wastes without supplementary of cow slurry were examined. From Figure 5, coffee husk and paper wastes were characterized with high PH values and organic matter, while the strongly acidic rating was observed in vegetable wastes. Coffee husk and paper wastes with cow dung materials characterized by high values of pH, OM, organic carbon and high C:N ratio, while in vegetable wastes low values of pH and organic carbons were registered.

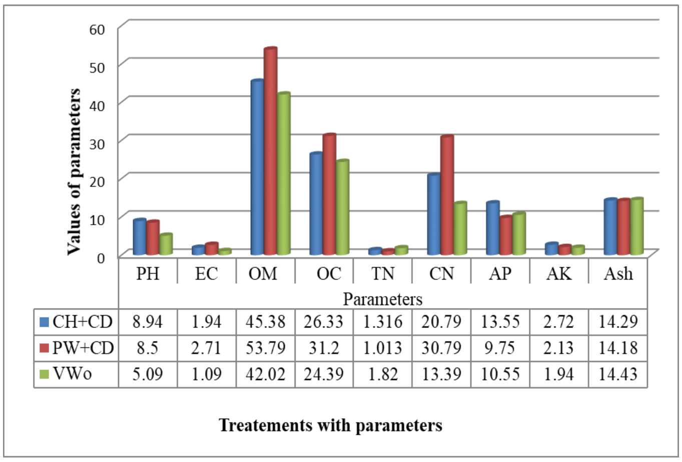

Figure 5) *Shows physicochemical characterization of the three substrates before composting*

Paper waste contains high organic matter relatively when compared with both coffee husk and vegetable wastes and high C:N was found on paper wastes at initial day. In other hands, nutrients like total nitrogen, available phosphorous and potassium recorded comparatively in fewer amounts in paper wastes inversely high results in vegetable wastes. High values of EC (2.71 mS/cm) recorded in paper waste. The recorded value of available phosphorous in coffee husk with cow dung slurry was (13.55 ppm), in coffee husk (9.71 ppm) and in vegetable wastes (10.25 ppm) and exchangeable potassium in coffee husk, paper waste and vegetable wastes were 2.72, 2.13 and 1.94 mg/k respectively. The impacts of earth worms on the waste materials during vermicomposting process with time intervals are shown in Table 1. The table indicates that the effects of vermicomposting on different parameters results OM, OC, TN, C:N, AP, EK and ash. It shows the results of each parameters measured in day intervals of their significance level at ($p<0.05$) from 0 days 30 days and 60 days (Table 1).

TABLE 1

Effects of vermicomposting on different parameters in time intervals

Parameters	Duration of vermicomposting			Mean value	C.V. (%)	LSD (5%)	P value
	0 days	30 days	60 days				
pH-H_2O	7.51[a]	7.24[a]	7.03[a]	7.2633	12.16	NS	0.1922
EC-mS/cm	1.91[a]	1.38[a]	1.24[a]	1.51	26.89	NS	0.2285
OM%	47.063[a]	39.06[b]	29.207[b]	38.44	4.016	4.401	0.0006**
OC%	27.3[a]	22.65[b]	16.93[c]	22.29	2.311	2.33	0.0006**
TN%	1.383[b]	1.76[a]	2.1993[a]	1.78	14.45	0.58	0.0323*
C:N	21.397[a]	13.99[b]	8.63[c]	14.67	15.2	5.056	0.0038*
AP-ppm	11.17[a]	17.93[b]	20.85[b]	16.48	9.22	3.481	0.002*
EK-mg/k	2.263[a]	3.54[b]	4.43[b]	3.41	7.21	0.5573	0.0177*
Ash %	14.29	42.86	47.62	34.92	2.776	36.61	0.2353

Note: *: Significance at 5%, mean value of parameters was taken; NS: Non Significance; [a]: Means with different letter at rows are significantly different; [b]: Means with the same letter at rows are not are significantly different.

During vermicomposting there was a change within parameters due to earth worms' activities the mean value of pH 7.51 at 0 day, 7.24 at 30 days and 7.03 at final days of the experiments. It shows reduction trends. The electrical conductivities fluctuated in each days of observance comparatively from 0 days observation which is 1.91 mS/cm to 1.24 mS/mc at final days but no significance change was observed at ($p<0.05$). There is a change in pH and EC during vermicomposting however, are not significantly different. The Electrical Conductivities (EC) also show decrement with respect to pH falls.

The total nitrogen during vermicomposting was observed at initial day 1.38 was recorded while at the end of the experiment 2.199 was achieved; the available phosphorous has grown up from 11.17 to 20.85 ppm. Exchangeable potassium from 2.263 to 4.43 and ash moved from 14.29 to 47.62. In the case of the OM, there was a great significance difference between before vermicomposting and after vermicomposting mean initial value 47.063% fall down 22.29% at 60 days and organic carbon also shows a significance difference during vermicomposting it decreases from 21.39 to 8.63 while total nitrogen, available phosphorous, exchangeable potassium and ash shows incremental trends during vermicomposting. The total nitrogen shows increment trends while values of organic matter reduced from (47%, 39%, and 29.2%) shows reduction as time increase. The organic carbon also follows this trend (27.3, 22.65, and 16.9) in percent which is significantly different (Figure 6).

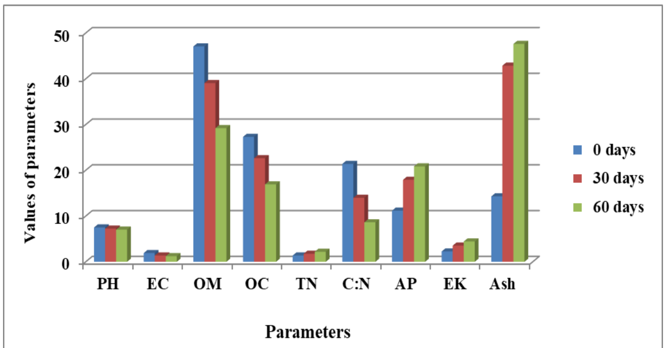

Figure 6) *Changes on parameters during vermicomposting*

Since C:N is the results of organic carbon and total nitrogen shows decreasing trends. Due to earth worms significance change was observed in all parameters from initial point of the substrate pH shows decrement by 6.4%, EC reduced by 35%, organic matter and organic carbon decreased by 37.94 % and 37.98% respectively.

The available phosphorous and exchangeable potassium shows significant change at ($p<0.05$). Total nitrogen shows an increment from 1.38 to 2.198%, available phosphorous from 11.17 to 20.85 p.m. and exchangeable potassium from 2.63 to 4.43 mg/kg/soil. Total nitrogen was increased by 59% than at initial day, while C:N ratio was decreased by 59.36%. Available phosphorous, exchangeable potassium and in ash highly pronounced percentage of differences was observed. Available phosphorous increased by 86.6%, EK by 95.76% and on ash scored results was exceeded three times of its original content.

Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents, which provides a measure of the total amount of minerals within substrates. Dry ashing is the decomposition of plant tissues using high temperature. It is not recommended for plant materials high in silicon content. This is used for the determination of P, K, Na, Ca Mg, and the micronutrient such as Fe, Mn, Zn and Cu. For this study, ash contents of the samples were putted in percent. The physic-chemical properties and nutrient status of the three wastes that was used as growing media in this study are given in Table 2. From the result observed, high pH was observed during the process in CH +CD and PW+CD, while the pH value very low in vegetable waste treatment.

Comparatively high electrical conductivity observed on paper wastes and coffee husk with cow slurry. Paper wastes contain high organic matters 47.1%, while coffee husk and vegetable wastes contain 35.85% and 32.2% respectively. The organic carbon also scores high values in paper wastes+ cow dung. From ANOVA results OM and OC show highly significant differences in three wastes at ($p<0.05$).

Relatively the highest TN was observed in vegetable wastes than coffee husk and paper wastes. The high C:N was found in paper waste with cow dung slurry. Coffee husk contains high AP (20.4 ppm) and EK (4.087 g/kg/so) was scored while least ash contents were registered in coffee husk. From the observed results the amount of ash produced during vermicomposting was increased which contradicts with the result of Patyal who reported the passing of organic residue along the earth worms gut unavailable form of phosphorous in organic matter which was converted to available form of plants, there are some conducted reports claimed that in vermicomposting a dry ash gradual reduction was observed in the amount of AP after 60 days (Table 2).

TABLE 2

Effects of vermicomposting on the physic-chemical properties of three wastes

Treatments	Mean value parameters								
	pH H_2O	CEC (mS/mc)	OM (%)	OC (%)	TN (%)	CN	AP (ppm)	EK mg/k	Ash (%)
CH+CD	8^a	1.54^a	35.85^b	20.8^b	1.902^a	12.65^b	20.49^a	4.087^a	28.57^a
PW+CD	7.8^a	1.85^a	47.16^a	27.35^a	1.28^a	22.33^a	13.28^b	3.08^b	33.33^a
VWo	5.96^b	1.5^a	32.3^b	18.73^b	2.126^b	9.57^b	15.27^b	3.065^b	42.86^b
LSD (5%)	2.021	0.9232	4.401	2.33	0.583	5.057	3.841	0.5573	36.61
C.V. %	2.002	26.89	4.016	2.3311	0.5836	5.057	5.057	0.5573	0.235

Note: a: Means with different letter at column are significantly different; b: Means with the same letter at column are not being significantly different.

The Table 2 shows trends of physico-chemical properties of vermicompost of different parameters in the three waste materials illustrated and fluctuation of parameters were observed among the treatment comparatively high organic matter, organic carbon and carbon nitrogen ratio was scored in PW +CD while TN least than in the two substrates. The least organic matter found in vegetable wastes and high available phosphorous was taken place.

Discussion on observed parameters during vermicomposting

The result shows that the duration of vermicomposting preparation was in proper time and effective in changing physico-chemical properties of the substrates. The results revealed that the quality of the mature vermicomposting was dependable with the determinant standards for evaluating parameters in order to improve soil fertility.

pH: The results of vermicomposting found that the pH value paper waste and coffee husk a significantly falls from its initial 0 days however, pH shows an increment in vegetable wastes. The mean pH values of CH+CD, PW+CD and VWo is 8.0, 7.8 and 5.96 respectively the values in vegetable wastes significantly different from the value of coffee husk and paper wastes. The mean pH values at an initial day of the three wastes were 7.51 while after 30 days and 60 days value pH become 7.24 and 7.03 respectively and compares the lower value recorded in the 60 days. The result found is within the acceptable ranges of pH for vermicomposting, 6.0-7.5. Table 3 point out that, the higher pH value was in the initial sample compared to the final sample. The change in pH from alkaline range to acidic range was due to the activity of fungi and other mesophilic organisms and also due to the formation of organic acids. Henok contradicts the above ideas that, higher pH value was registered during the examination might be due to ammonia production through the crash of organic nitrogen by microorganisms or might also as a result of discharge of basic cations from the mineralization of organic matter [8].

In agreement with the current findings obtained regarding vermicomposting from fruit, vegetable waste and cow dung, Gunadi and Edwards have been reported similar results [9]. Raphael stated that, vermicomposting might be due to the production of CO_2 and organic acid by microbial metabolism during the decomposition of different substrates in the feeding mixture. The pH shift toward acidic condition is resulted from higher mineralization of nitrogen and phosphorous into nitrites and nitrates and the orthophosphates respectively. The pH shifts also are attributes to bioconversion of organic material into other various intermediate species of organic acid. According to other researcher the neutral pH of vermicomposting may be also attributed by the secretion of $NH4^+$ ions that reduce the pool of H+ ions. Neutral pH helpful for effective decomposition due to the mixing of inoculants increases their pH value.

Electric Conductivity (EC): The electrical conductivity of all the treatments considerably decreased during the vermicomposting process. The reduction of EC was observed in coffee husk and paper waste while it shows increment in vegetable wastes; which indicates the reduction of salinity (mineral salt) considerably. The lower level of salinity is the essential character of good bio compost which is better for crop growth. From original mean EC values of all treatments at 0 day was 1.91 mS/cm, 1.38 mS/cm at 30 days and 1.24 mS/cm at 60 days, while the variation in EC with respect treatments were 1.5 mS/cm in vegetable wastes, 1.85 mS/cm in paper wastes and 1.54 mS/cm in coffee husk.

The low value of electrical conductivity shows the greater the decomposition rate. A decrease in the electrical conductivity values in vermicomposting may be due to the presence of exchangeable Ca, Mg, and K. From the Tables 1 and 2, the vermin casts have been reported with a higher base exchange capacity and are rich in total organic matter, phosphorus and potassium with a reduced electrical conductivity. In opposite of this, Ansari reported increments in EC during the process [10]. The increase in EC in the vermicompost could be due to the loss of weight of organic matter and the release of different mineral salts in available forms [11]. Electrical conductivity of vermicompost was higher, which may be due to the presence of more salts in the feed of cattle.

Organic matter: The mean value of organic matter content of the wastes before and after vermicomposting was identified and results at 0 day is 46.063% while after vermicomposting of 30 days 39.06% present finally it was reduced to 29.21%. The mean percentage loss of organic matter from the initial day was reduced by 15% at 30 days and 40.46 at 60 days of the experiment. The three wastes (coffee husk+cow dung, paper waste+cow dung and vegetable waste) were separated from the set up and loss percentage is calculated from the final weight attained on the 60^{th} day. Impacts of *Eisenia fetida* on the loss of organic wastes during vermicomposting was illustrated in the blow graphs.

The vermicompost was much darker in color, had no bad odour and procedure into a uniform mixture following earthworm activity. The weight loss percentage of organic substrate during vermicomposting was estimated by finding the difference between the final weight of the organic substrate and the initial weight of the organic substrate [12]. Weight loss in coffee husk with cow dung was observed from 3000 gm reduced to 930 gm; while in paper waste with cow dung reduced from to 1050 gm and vegetable wastes declining to 870 gm. The total amount of waste blend was reduced in 69% in coffee husk and cow dung while in paper waste it was reduced 65% and high reduction of organic matter was observed in vegetable waste 71% after vermicomposting.

This clearly indicated that the vermicomposting process significantly helps in abatement of organic matter pollution load in the environment. Generally, the organic matter contents at different composting time decreases from 42.9% to 31.41%. Similar to this study, it was also confirmed that reduction of organic matter content based on parent materials and as composting process progresses. Thus, the loss of organic matter clearly indicates that vermitechnology reduces the amount of waste and also improves the nutrient content of the product (vermicompost) to be used as a bio-fertilizer in agricultural practices.

Organic carbon: Organic carbon found to reduce significantly from initial value and declining trends as decomposition progressed. The compost treated with *Eisenia fetida* significantly different from their corresponding original substrates ($p<0.05$). The change is highly pronounced in vegetable wastes and coffee husk with cow dung supplementary than paper wastes. The results found were illustrated in graph 3 which is CH+CD 64.29%, PW+CD 54.26% and VWo 69.47%. According to Suthar, mineralization of organic matter in sludge with red worms leads to considerable decrease in total organic carbon contents [13].

The reduction of organic carbon in process of vermicomposting due to the results of mineralization of organic matter primarily by microorganism and earth worms since vermicomposting is a combine action of earthworms and microorganisms, earth through their fragmenting action modifies the substrates condition which consequently the surface area for microbial action [14]. Thus, promote carbon loss through respiration and in similar pattern the oxidation of organic matter within vermicompost enhance by red worms numbers in the vermicomposting unit. Other author cited that, the excreta and body fluids of earth worms like mucus promote microbial reproduction which in turn enhances speed of respiration that reduces the carbon status of substrates.

Total nitrogen: Compared to their initial levels, total nitrogen in all vermin reactor were treated by *Eisenia fetida*, showed significance change from Table 2. The increasing trend of TN in the vermicompost produced by the earthworm species in the present study agreed with the earlier reports. The enhancement of N in vermicompost was probably due to mineralization of the organic matter containing proteins and conversion of ammonium nitrogen into nitrate [15]. Earthworms can boost the nitrogen levels of the substrate during digestion in their gut adding their nitrogenous excretory products, mucus, body fluid, enzymes, and even through the decaying dead tissues of worms in vermicomposting subsystem.

From the current study, similar results were found out that after six months of vermicomposting, the nitrogen content in the end product was high. The increase in nitrogen, phosphorus and potassium in the vermicompost confirms the enhanced mineralization of these elements due to enhanced microbial and enzyme activity in the guts of worms. Opposite to the finding the nitrogen content decreases at different composting time. This might be due to decrease of nitrogen by volatilization of gaseous ammonia as composting process progresses/proceeds. According to Niyazi, et al. the reason for disagreement of experimental in total nitrogen dissimilarity in vermicomposting of different wastes is the fact that the quality of substrate in feeding the earthworms together with their physical structure and chemical composition affects mineralization of nitrogenous organic compounds and the amount of nitrogen from the compounds [16]. The enhancement of N in vermicompost was probably due to mineralization of the organic matter and increased rates of conversion of ammonium into nitrate. Similar findings in vermicompost produced by different feed substrates have been recorded earlier by [17]. Moreover, *Eisenia fetida*, treatment of which produced maximum nitrogen content, might be due to its individual capability and better adaptability to the local temperate conditions.

Available Phosphorous (AP): The vermicomposting obtained from all three wastes treated by *Eisinia fetida* was significantly higher than respective initial waste substrate wastes as well as controlled ($p<0.05$). This is agreed with other finding who reported that vermicomposted from vegetable waste contains more phosphorous than untreated vegetable wastes. It has been reported that higher content of potassium found in a vermicompost. The rise AP might be due to the action of earth worms, phosphates and phosphorous solubilizing microorganisms in the vermicompost.

In supporting to the above ideas Patyal reported the organic matter that passes through the worms gut changes phosphorous in available forms which plants can absorb it easily. The earthworms responsible for increase in phosphorous in soils. The increase in total phosphorus content reveals that the vermicomposting process is in order. The phosphorus content at 0 days was 11.17 ppm while after 60 days it grown up to 20.85 ppm, the total change observed in vermicomposting process is accounts 86% increments. The release of phosphorous in available form is performed partly by earthworm gut phosphates, and further release of P might be attributed to the P-solubilizing microorganisms present in worm casts.

Low level of available phosphorous after six weeks of vermicomposting was observed which is similar with Negdawa, et al. [18]. Vermicompost contains an average of 1.5%-2.2% N, 1.8%-2.2% P and 1.0%-1.5% K. The organic carbon is ranging from 9.15 to 17.98 and contains micronutrients like Sodium, Calcium, Zinc, Sulphur, Magnesium and Iron [19]. From various studies it is also, evident that vermicomposting provides all nutrients in readily available form and enhances uptake of nutrients by plants. Similarly, the uptake of nitrogen, phosphorus, potassium and magnesium by rice (*Oryza sativa*) plant was highest when fertilizer was applied in combination with vermicompost.

Exchangeable Potassium (EK): There is consecutive increment in EK in all wastes acted by *Eisinia fetida* as vermicomposted process shown from Table 1 statistically its significance was observed at ($p<0.05$) and results from observances significantly increased than initial day. The finding was similar with other finding reported the total potassium increased between 23.6-43.6% which resulted from vermicomposting treated with *Eisenia anderies* species of earth worms. Dominiguez found that the amount of potassium increases gradually in vermicomposting which also depend on the amount of raw organic waste used. The escalating of content of total potassium confirms that the composting is taking place in well order. It was suggested that earthworm processed waste material contains higher concentration of exchangeable potassium due to enhanced microbial activity during the vermicomposting process, which consequently enhances the rate of mineralization.

In coffee husk significant changes observed was due to the large amount of symbiotic micro flora exist in the gut and the casts of earth worms in collaboration with secrete mucus and water might be increase the degradation of ingested organic matter and release of assailable metabolites. Dominiguez found that the amount of potassium increases gradually in vermicomposting which also depend on the amount of raw organic waste used. The escalating of content of total Potassium confirms that the composting is taking place in well order.

The total potassium value after 60 days is 4.43 these indicate that the direct effects of *Esinia foetida* produce changes in microbial populations that can influence the overall dynamics of organic-matter degradation. In contrast to above finding some researchers have been reported lower level of potassium in vermicomposting than initial substrates. This is because of high decomposition of raw composting material. Similar results study on composting of coffee byproduct indicated that the increase in K content in compost from coffee husk was due to decomposition. This might be due high decomposition of raw composting material at final.

From the experiments results higher exchangeable potassium content was recorded in coffee husk and paper wastes at 60 days. Makuria convince that potassium in completed compost is much more available for plant uptake than nitrogen and phosphorus since potassium is not incorporated into organic matter and the increase of K concentration during composting process might correspond to the parent materials, enrichment of nutrients and potassium releasing fungus species. The concentration of potassium showed an increasing trend from initial to final compost through all treatments.

Evaluation of vermicomposting based on WHO and ISIRI standards

Vermicomposting quality will vary depending on many factors including worm species, raw materials used, and age of the compost. Vermicompost are generally of finer structure, contain more nutrients, and have higher microbial activity than other types of compost. Worms facilitate two sets of processes: Gut associated processes and cast associated processes. The ratio of carbon to nitrogen in compost is probably the best known objective indicator of compost quality. A primary measure of vermicomposts physical composition is its organic-matter content. In actuality, this measure provides only a very basic indication of the overall stability of the material.

However, the portion of the organic matter that is not completely stabilized (*i.e.,* the biodegradable organic matter) does represent an important property, since it provides the energy sources for biological activity in the soil and is the source of potentially mineralizable nutrients. In a finished vermicompost, the organic-matter content should be greater than 20-25%. The result shown in Table 3 represents the mean values of all the samples and parameters were arranged according to WHO and ISIRI standards. Organic matter scores 38.44% and it is reduced by 1.56 from WHO standards and exceeds in 3.44 grade 1 ISRI standard and 13.44 of grade 2 standards. The mean value of total carbon achieved 22.29% and total Nitrogen is 1.78% in present.

The total carbon shows beyond the both standards while total nitrogen shows reduction by 0.22 comparatively with WHO and exceeds ISIRI standards with 0.23 to 0.78 of grade 1 and grade 2. Carbon nitrogen ratio 14.67 which shows negative (-5.33) from WHO standards while it accounts positive 0.03 to 4.66 on ISIRI standards. The mean value of registered available phosphorous was (16.65) highly significance difference from both standards. Electrical conductivity accounts -2.49 mS/mc reduction with WHO standard while it exceeds than both grade of ISIRI standards by 0.11 to 1.99. The pH values of vermicomposted material fit the assigned standards in all ranges (Table 3).

TABLE 3
WHO standard and ISIRI standard about mature and quality vermicomposting

Parameters	Number of samples	Mean ± SD	Comparison with WHO standard	Comparison with ISIRI standard	
				Grade 1	Grade 2
OM	9	38.44 ± 1.77	-1.56	3.44	13.44
Total C	9	22.297 ± 1.028	14.29	2.71	7.29
Total N	9	1.78 ± 0.257	-0.22	0.23 to 0.12	0.78 to 0.28
C/N ratio	9	14.67 ± 2.23	-5.33	0.03	4.67 to 0.03
Available P	9	16.65 ± 1.535	16.63-16.63	15.65 to 12.88	16.62 to 12.85
Ec (mS/cm)	9	1.51 ± .0470	-2.49	0.01	1.99
PH	9	7.26 ± 0.883	1.26 ± 74	1.26 to 0.74	1.26 to 0.74
Ash	9	34.92 ± 20.19	-15.08	15.08	15.08

The C:N ratio is one of the most widely used and potentially useful indicators of the stability of organic materials such as composts and vermicomposts. Material that has been sufficiently stabilized will typically have C:N ratio below 20-22. C:N ratio was much higher than this may indicate the presence of bio available carbon and therefore material that is not completely stabilized. In many U.S. states, it is necessary to state the minimum contents of N, P (as phosphate), and K (as potash) on the label to be able to market vermicomposts as organic fertilizers or soil amendments and P contents of more than 0.5% are desirable [20]. Vermicompost has high porosity, aeration, drainage, and water-holding capacity. Nutrients such as nitrates, phosphates, and exchangeable calcium and soluble potassium in plant-available forms are present in vermicompost.

Generally, from the Table 3 researcher concluded that the vermicompost produced from the three wastes have a good quality when compared with standards of WHO and ISIRI. The mean value achieved in all aspects exceed than ISIRI grade1 standards except Ash and OM but in case of ISIRI grade 2 produced vermicompost exceed the standards. The above Table 3 illustrates the differences and explains ISIRI standards with mean value of measured parameters. Thus, the produced vermicompost has a good quality and vermitechonology is good optional in eliminating coffee husk with cow dung, paper waste with cow dung and vegetable wastes if treated with *Eisenia fetida*.

CONCLUSION

Vermicomposting technology involves harnessing earthworms as adaptable natural bioreactors playing a vital role in the decomposition of organic matter. The researcher concluded that vermicomposting is a valuable means to handle biodegradable wastes like coffee husk, paper waste and vegetable wastes. The selection of the correct earthworm species for particular vermiculture application is important. *Eisenia fetida* most common species of earthworms had a wider range of tolerance to the environmental condition. In this study *Eisenia fetida* was used and has shown significant change during vermicomposting on coffee husk, paper waste and vegetable wastes.

Subsequent to present study shows that the good quality of organic compost was gained. The results showed that, there was a significant change between all the evaluated parameters in original waste and final results, at 0 days, 30 days and 60 days vermicompost in a way that the increased of the indicator such as organic matter, total nitrogen, pH, electrical conductivity, and phosphorous in percent, exchangeable potassium, dry ash the compost production was observed. The study also revealed that there was a decreasing tends in PH, electrical conductivity, OM, OC and C:N ratio but there was increments in TN, AP, EK and ash percent.

Generally, the earth worm *Eisenia fetida* has potential to treat the coffee husk with cow dung and paper waste with cow dung at 3:1 ratio and alone of vegetable wastes. Quality vermicompost was produced thus; properly utilization of biodegradable waste is possible with assist of *Eisenia fetida* in the town. A currently environmental problem has been escalating from time to time due to anthropogenic action lying on it and we can defeat it especially organic wastes those generated in enormous amount from each household and marketable area. The results show that vermitechonology has potential to treat organic wastes. As a result it minimizes the impacts on the environment and maximizes the potential carrying capacity of ecosystem through degrading wastes hence, ensures sustainable development of ecosystem service with human environments. The vermicompost contains essential plant nutrients like nitrogen, phosphorous and potassium results improve soil fertility status simultaneously minimize costs of chemical fertilizers. Thus, vermitechonology is one of the optional in treating the biodegradable waste and solving environmental problem. The slogan" waste is waste!" claimed by the author that "waste is not waste" if properly handled and utilized!

RECOMMENDATIONS

Finally, the study recommended that vermicomposting is easiest and simplest technology and the best assimilator of organic wastes, thus the study area's government body and other concerned bodies should encourage and thought their communities and spreading the vermitechnology, supplementary lessons and investigation on the technology and development of vermin-projects is critically important.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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AUTHOR'S CONTRIBUTIONS

Z.T. developed the concept of this experiment works, provided the lab facilities. Y.Sh. carried out the experimental woks and statistical analysis. Both Z.T. and Y.Sh. wrote the main manuscript.

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