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Effect of earth worms on solid waste to get nutrient rich vermicompost for plants

Arun Karnwal, Ravi Kumar

Bhojia Institute of Life Sciences, Bhud (Baddi), District Solan, H.P. 173205, India.
Corresponding author: A. Karnwal, arunkarnwal@gmail.com

Abstract. In present time, environmental protection becomes very essential to minimizing environmental stress by developing effective technologies for use in recycling various organic wastes. Landfills and incineration are the most common means of solid waste disposal. This can also be solved by combination of effective technologies like Biodung composting and Vermitech (incorporating earthworms for the production of vermicompost). In the present study an effort has been made to assess the efficacy of earth worms in utilizing the food waste and medical waste to analyze the waste decomposition process assessed with earthworm activity. The results indicated that the organic waste and medical waste were successfully processed through vermicomposting during the period of 45 days. Treatment CS-1 was shown very good nutrient contents after 45 days of vermicomposting (phosphate .0055mg/l, organic content 152.93 mg/g, organic carbon 18.64%, chloride 56.8 mg/100g, sulphate 13 mg/100g and calcium 0.10%) while treatment CS-2 was shown effective nutrient levels in organic carbon 12.14%, chloride 41.18 mg/100g in comparison to CS-3. Treatment CS-3 shown higher nutrient content for phosphate .0074mg/l, organic content 73.83 mg/g, sulphate 9 mg/100g and calcium 0.13% in compare to CS-2.
Key Words: cow dung, *Eudrilus eugeniae*, solid waste, medical waste disposal, vermibed.

Introduction. Earthworms are considered 'ecological engineers', organisms that create physical structures and modify the availability or accessibility of resources for other organisms (Jones et al 1994). Soils with vermicasts have roughly 100 times more bacteria than soil without worms. Composting is the biological conversion of solid organic waste into usable end products such as fertilizers, substrates for mushroom production and biogas. Moreover, their high organic matter content and biological activity make composts effective in a variety of applications, including erosion control, re-vegetation, bio-filtration and bioremediation (Alexander 1999; Rasse & Rumpel 2005; García & Hernandez 1991).

Vermicomposting is an eco-biotechnological process that transforms energy-rich and complex organic substances into stabilized humus-like product vermicompost. Different type of domestic wastes i.e. Cattle dung and/or plant-derived wastes can be used as substrate material with P. excavates for vermicomposting (Kale & Bano 1982; Subler & Edwards 1998; Manna & Jha 2003; Suthar 2006; Suthar 2007).

At the end of vermicomposting, vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, water-holding capacity (Edwards & Burrows 1988). It is rich in Ca, Mg, K, N, useful microorganisms (bacteria, fungi, actinomycetes and protozoa), hormones, enzymes and vitamins and certain micronutrients needed for plant growth (Lee 1985; Bansal & Kapoor 2000). They have greatly increased surface areas, providing more microsites for microbial decomposing organisms, and strong adsorption and retention of nutrients (Shi-wei & Fu-zhen 1991).

The main objectives of the present study were to access the effects of earthworm on the type of solid waste for the production of rich nutrient vermicompost.

Material and Methods. Soil for preparing vermibed was collected from Bhojia Institute of Life Sciences (BILS) garden. Earthworms belong to phylum Annelida, sub class-Oligochaeta. They are invertebrate in nature. In the present studies the well-known species of earthworm used was *Eudrilus eugeniae*. For present study, earthworms were collected from Palampur University, H.P., India.

Solid waste. Paper waste for present study was collected from BILS and Bhojia Dental College. While medical wastes (bandages and cotton) was collected from Bhojia General Hospital and ESI, Baddi. Medical waste was sterilized before use.

Vermicomposting container/pots/tubs. For vermicomposting plastic tubs of radius 33 cm and of 10 kg capacity were used.

Preparation of vermibed. Three different types of vermibed were prepared by adding different types of solid-waste products. One soil bed was prepared without any solid waste and earthworms, which was work as control (CS-4).

First treatment (CS-1). First bed was constructed by adding solid waste materials in different layers. First layer was prepared by adding garden soil (2 cm of depth), second layer of paper waste slurry (2cm of depth), third layer of soil (8 cm of depth) and fourth layer of cow dung slurry (6 cm of depth) and then a thin layer of soil. After this, 250 gm of earthworm was introduced in constructed bed.

Second treatment (CS-2). Second bed was prepared by adding 100 gm sterilized medical bandages in second layer, and garden soil in third layer (8 cm of depth) while first layer was prepared by adding garden soil (3 cm of depth). After this, 250 gm of earthworm was introduced in constructed bed.

Third treatment (CS-3). Third bed was constructed by adding 250gm of sterilized medical waste and 500ml of bacterial culture of *Bacillus subtilis* (108 cells C.F.U.) in second layer and garden soil in third layer (8 cm of depth). After this, 250 gm of earthworm was introduced in constructed bed.

Moisture content was maintained regularly by adding sterilized water. After 45 days chemical estimation (soil analysis) of vermicompost soil of each treatment against control was done.

Soil analysis

pH. A 10% (w/v) suspension of air dried soil was prepared in distilled water. It was then allowed to settle for one hour and filtered through Whatman filter paper no. 42. pH for all the soil filtrates was checked using a calibrated pH meter.

Moisture content. 10gm of soil was weighed (w1) and dried at 1000C in a hot air oven for 24 hours. The final weight (w2) of samples was determined by using an electronic weighing balance and the moisture content (w1-w2) was estimated as mg of moisture/g soil.

Inorganic phosphate contents. A 0.5% (w/v) suspension of air dried soil was prepared in 0.002N sulphuric acid in a 500ml conical flask and mixed for 30 minutes using magnetic stirrer. The suspension was filtered through Whatman filter paper no. 42 and the soil extract was processed further for Inorganic phosphate.

To 5ml of soil extract, 0.2ml ammonium molybdate solution and one drop of stannous chloride solution were added. After 10 minutes absorbance at 690nm was recorded to observe the concentration of the developed blue colour on U.V.-VIS. Spectrophotometer. Deionized water blank was also run in similar manner. Inorganic phosphate contents in the sample was determined using a curve of KH_2PO_4 (P, 0-1 mgl-1) at 690nm wavelength.

Inorganic phosphate was estimated as

PO_4-3-P (mg/l) = PS X V/1000XW

Where,

PS = PO_4-3-P estimated in suspension (mg/l).

V = total volume of suspension (ml).

W = Mass of air dry soil taken (g).

Standard curve for inorganic phosphate contents

A standard curve was plotted between increasing concentration of phosphate vs. the corresponding absorbance at 690nm. The phosphate contents in the samples to be analyzed were determined with the help of this curve.

Total organic content. To 250 mg of air dried soil in a 250 ml conical flask, 5 ml of 1N potassium dichromate solution was added sequentially. Gradually 10 ml of conc. Sulphuric acid was added and incubated for 30 min at room temperature. To the contents of flask, 100 ml of deionized water, 5 ml conc. phosphoric acid, 0.1 g of dry sodium fluoride and 0.5ml of diphenylamine indicator were added sequentially. The contents of flask were titrated against 0.5 N ferrous ammonium sulfate. The end point was noted as dull green through turbid blue to brilliant green. A distilled was also run simultaneously, and the total organic matter was calculated as;

Total organic matter (mg/g soil) =6.791/W X (1-T1/T2) X 10

Where,

W =Mass of soil (g)

T1 =Volume of titrant used against sample (ml)

T2 =Volume of titrant used against dislilled water blank (ml)

Chloride test. 1:5 soil suspension was prepared by adding 100 ml of distilled water to 20 g of soil in each samples. Stir mechanically for about one hour at regular intervals. Filter the suspension through Whatman No.50 filter paper using funnel. 50 ml of sample was taken in an Erlenmeyer flask and 2 ml of K_2CrO_4 solution was added. Then titrate the contents against 0.02N $AgNO_3$ until, a persistent red ring appear.

% Chloride = (ml x N) of $AgNO_3$ x1000x35.5/ml soil solution x 2

To convert the values in mg/100g, multiply the values in % with 1000.

Organic carbon by wet digestion (modified weakly-black procedure). Grind about 5g of 2-mm soil using a mortar and pestle. Took 0.50g of grind soil in a Erlenmeyer flask. Also took two blanks to standardize FeSO4. Added 10 ml dichromate solution and swirl flask gently. Rapidly added 20 ml concentrated H_2SO_4 by directing steam into the suspension. Immediately mix by gentle rotation for one minute. Mixing should be done carefully to avoid throwing soil up into the wall of the flask, out of the contact with the reagent. Allowed flask to stand for 30 minute at room temperature. Added 30 ml distilled water and 3-4 drops of the o-phenanthroline indicator. Then from a manual burette, added ferrous sulfate solution rapidly at the beginning. Initially the colour was dark brown (colour depend on organic matter content of the sample). Then the solution colour changes to greenish and then changes to dark green or greenish blue. At that point, added titrant dropwise. At the end point it flashes quickly from greenish blue to reddish brown. Check by adding a drop of dichromate solution. Colour should change back to greenish blue.

Carbon in soil (%) = M x V1-V2 / weight of soil sample (g) x .39

Where,

M = molarity of the $FeSO_4$ solution.

V1 = volume of FeSO4 required for the blank (ml).

V2 = volume of FeSO4 required for the sample (ml).

0.39 =3 x 10-3 x100 x 1.3, where 3 is equivalent weight of C and 1.3 is the factor explained below.

The factor of 1.3 was based on the assumption that their was77% recovery.

Calcium carbonate test. Weighed 5g of soil, crush in small particals. Added 100 ml of 1M HCl /l solution. Agitate into 250ml flask, left the contact overnight. Transfer the material into 100 ml centrifuge tubes. Centrifuged at 2000g for 10 minutes, then pipette 10 ml of supernatant liquid into a 100 ml conical flask. Added 25 ml of water and 2 drops of phenolphthalein indicator. Titrate using 0.5MNaOH L-1 solution. Under the same condition treated to blanks.

CaCO3 % =50N x a-b/S

Where,

a = ml NaOH used for blank b = ml NaOH used for soil samples.

S = weight of dried soil samples. N = concentration of soda /solution mol/l.

2.4.8 Sulphate test

1:5 soil suspension was prepared by adding 100 ml of distilled water to 20 g of soil in each sample. Stir mechanically for about one hour at regular intervals. Filter the suspension through Whatman No.50 filter paper using funnel. The final soil solution should be free of any turbidity for which it can also be centrifuged. 100 ml of sample or a suitable aliquot diluted to 100 ml in 250 ml Erlenmeyer flask and 5 ml of conditioning reagent. Stirrer the sample on a magnetic stirrer and during stirring added a spoonful of Bacl2 crystals. Gently mix only for a minute after addition of $BaCl_2$ crystals. Absorbance was recorded at 420 nm. Exactly after 4 minutes. Concentration of sulphate was recorded from the standard curve at 420 nm wavelength. Standard curve of sulphate was prepared with different concentration (0.0-40.0 mg/l at the interval of 5 mg/l).

Turbidimetric method: % SO_4 = SO_4 mg/l soil solution/2000

To convert values in mg/100g, multiply the results in % with 1000.

Standard curve for Sulphate contents

A standard was plotted between increasing concentration of sulphate vs the corresponding absorbance at 420 nm. The sulphur contents in the samples to be analyzed were determined with the help of this calibration.

Results. For soil analysis, various parameters such as pH, moisture contents, inorganic phosphate contents, total organic contents, carbon, chloride, sulphate, and calcium carbonate test was used to determine the fertility of treated and non-treated soil samples. The results for various parameters for different vermibeds are given in the Table 1.

Table 1

Description of Soil Analysis for Various Parameters after 20 days of vermicomposting

Treatments	*Soil Parameters*							
	pH	*Moisture Content (mg/g)*	*Inorganic PO_4^{-3} (mg/ml)*	*Total organic contents (mg/g)*	*Organic carbon (%)*	*Chloride (mg/100g)*	*Sulphate (mg/100g)*	*Calcium Carbonate (%)*
CS-1	8.27	2.9	0.55	152.93	18.65	56.8	13	0.10
CS-2	8.10	1.8	0.50	42.19	12.14	41.18	7	0.085
CS-3	8.20	2.2	0.74	73.83	11.70	39.0	9	0.13
CS-4	6.84	0.8	0.48	21.095	9.54	36.0	6.5	0.075

pH. Of the various compost samples, minimum pH of 6.84 was observed in the case of CS-4 and maximum of 8.27 (CS-1, Table 1, Figure 1). It showed that simple soil had acidic and after treatment with earthworm and other waste product, the pH increased to certain extent i.e. it becomes basic, which indicates large amount of nutrients was available in composts.

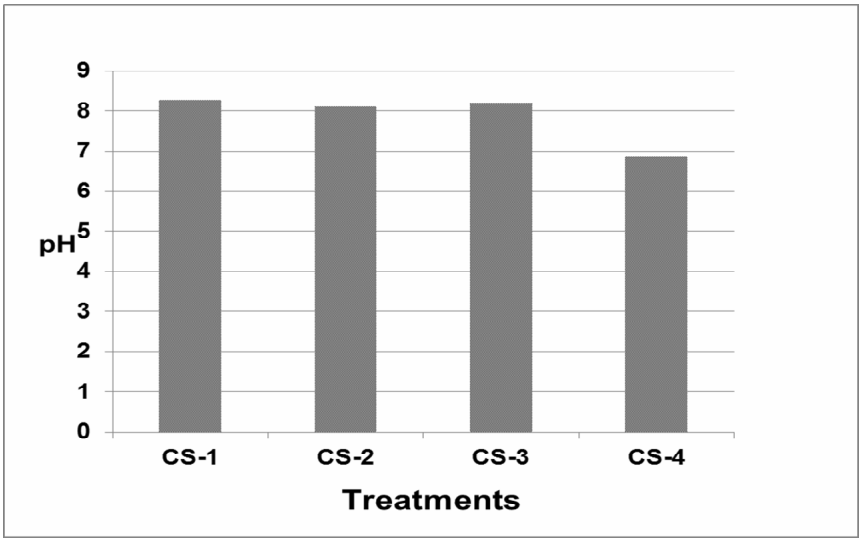

Figure 1. pH of different treatments after 20 days of compositing.

Moisture contents. Minimum moisture content of 0.8g was recorded in the CS-4 treatment (control) and maximum of 2.9g (CS-1). It showed that in simple soil had less moisture contents and after treatment with earthworm and other waste product, the moisture contents was increased, by which the decomposition of waste product was occurred rapidly as shown in Table 2.

Table 2

Net moisture content in different samples

Treatments	*Initial weight of soil samples (w_1)*	*Dry Weight of soil at 100^0C (w_2)*	*Moisture contents of samples (w_1- w_2)*	*Net moisture contents*
CS-1	10g	7.10g	10-7-10g	2.9g
CS-2	10g	8.2	10- 8.2g	1.8g
CS-3	10g	7.8	10- 7.8g	2.2g
CS-4	10g	9.2	10- 9.2g	0.8g

Inorganic phosphate contents. Of the various compost samples, minimum inorganic phosphate is 0.48 mg/ml (CS-4), while maximum is 0.74 mg/ml (CS-3). It showed that earthworm along with microorganism (bacteria) decomposed the waste product (CS-3) rapidly as compared to the other treatments (CS-1 0.55mg/ml and CS-2 0.50 mg/ml) and simple soil (CS-4) as shown in Table 3.

Table 3

Inorganic phosphate concentration in various samples and standard after 20 days of vermicomposting

Samples	*Absorbance at 690nm*	*Inorganic phosphate concentration (mg/ml)*
CS-1	0.184	0.55
CS-2	0.173	0.50
CS-3	0.244	0.74
CS-4	0.17	0.48

Total organic content. In all treatments it were observed that control have minimum total organic contents 21.095 mg/g (CS-4), while others shows a good level of organic content from 42.19 to 152.93 mg/g in soil. Maximum total organic content was 152.93 mg/g recorded in CS-1. It showed that earthworm decomposed the waste product (CS-1) rapidly as compared to the other compost sample (Figure 2).

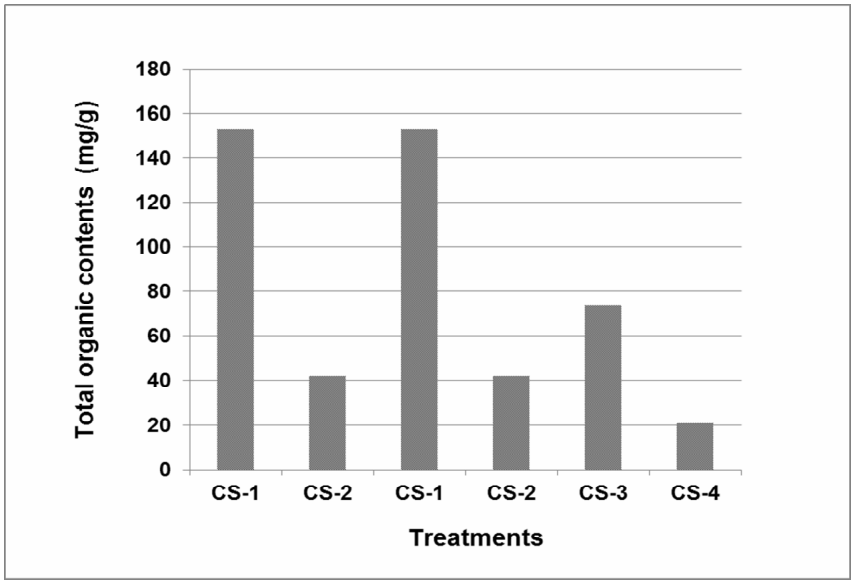

Figure 2. Level of total organic content in different composts after 20days.

Chloride test. Of the various compost samples, minimum chloride content was noticed in CS-4 treatment (36.0mg/g). Maximum level of chloride content is recorded in compost CS-1 (56.8 mg/g) while other two composts also have good level of chloride from 39.0 (CS-3) to 49.19 (CS-2) mg/g as shown in Figure 3.

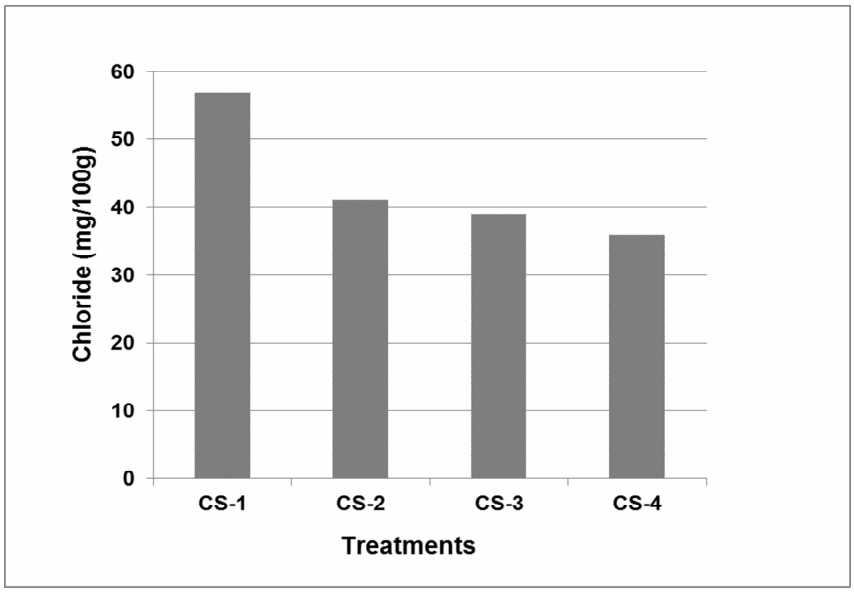

Figure 3. Effect of vermicomposting on chloride levels in treatments after 20 days.

Organic carbon by wet digestion. A significant difference in organic content was recorded in different waste material based composts. In various compost samples, maximum level of organic carbon content was observed in treatment CS-1 (18.65%) while CS-2 and CS-3 shown 12.14 and 11.70%. minimum organic carbon was recorded in CS-4 sample as shown in Table 1. It showed that earthworm decomposed the waste product (CS-1) rapidly as compared to the other compost sample and it was clear that carbon contents in simple soil are very low because of absence of microbes and earthworm.

Calcium carbonate test. Of the various compost samples, minimum calcium carbonate was 0.075% (CS-4), while maximum was 0.13 % (CS-3) as shown in Table 1.

Sulphate test. All treatments shown a significant increase in the level of sulphate content in final compost. As from Table 4, it is observed that CS-1 has the maximum level of sulphate in comparison to other treatments, while control has the leas level of sulphate (5.5mg/100gm).

Table 4

Sulphate concentration in different samples after vermicomposting

Samples	*Sulphate concentration (mg/100gm)*
CS-1	13
CS-2	7
CS-3	9.5
CS-4	5.5

Discussions. It is evident from the data presented in Table 1 that simple soil (control, CS-4) characterized with pH (6.84), moisture content (0.8 mg/g), organic carbon (9.54 %), organic matter (21.095 mg/g), chloride (36 mg/100g) and sulphate (6.5 mg/100g). However, other nutrients such as inorganic phosphate (0.48 mg/ml) and available calcium carbonate (0.075%) were found in very trace amounts. The vermicomposting activity significantly modified the physical and chemical properties of simple soil

supplemented with different solid wastes material that can be an important tool for organic farming.

It is indicated in Table 1 that after the vermicomposting the pH of all treatments shifted to alkaline in comparison to control (CS-4). It is also observed that treatment CS-1 shows highest organic content (152.93 mg/g) level while treatment CS-3 shows a little high organic content (73.83mg/g) level in comparison to treatment CS-2 (42.19 mg/g), it show the effect of inoculated bacterial culture in treatment. These data are also supported by Elvira et al (1998) and Manna et al (2003). Same result also recorded in the case of organic carbon, chloride and sulphate content after vermicomposting as shown in Table 1.

Treatment CS-1 shows very good result in comparison to other solid waste management but still other treatment have a good waste management in compare to control, which shows the positive effect of vermicomposting in these solid waste management.

It is clearly evident from the result of Table 1 that the values of different nutrients in soil increased over 20 days of vermicomposting. Lowest values of available phosphorus (0.0048mg/l) and calcium (0.075%) were found in control. Moreover, as the time period increases during vermicomposting, these parameters also increases and their maximum values i.e. phosphorus (0.0074mg/l) and calcium (0.13%) in treatment CS-3 were obtained after 20 days of vermicomposting. Gunadi & Edward (2002) and Villar & Beloso (1993) also demonstrate that after vermicomposting nutrient value in the end product was high.

Biotechnology greatly reduces the waste amount, besides improving the nutrient pool status of converted biomass for its utilization for one or the other purposes in agricultural production. From the present study, it can be concluded that vermicomposting is the one more economic, ecofriendly waste management technology and resulting in the bioconversion from waste to wealth.

Conclusions. The waste disposal needs immediate attention and strict monitoring. The results obtained prove the potential of vermi-technology for degradation of vegetable waste amended with cattle manure. The earthworms have enriched the end product with many fold increases in other essential plant nutrients in the end product. Vermi-technology is a system harnessing earthworms for bio- conversion of organic waste into vermicompost which has extensive application in waste management and sustainable organic farming and has proved to be one of the efficient methods of managing organic wastes with least complexity and economic viability.

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Authors:

Arun Karnwal, Bhojia Institute of Life Sciences, Bhud (Baddi), District Solan, H. P. 173205, India, e-mail: arunkarnwal@gmail.com.

Ravi Kumar, Bhojia Institute of Life Sciences, Bhud (Baddi), District Solan, H. P. 173205, India

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