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# Effects of Epigeic Earthworms, Eisenia fetida on Carbon and Nitrogen during Vermicomposting of Fresh Bio-waste

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**Abstract**

This study was carried out as an experiment using the following procedure: A plastic containers were prepared for vermicomposting, with the control without earthworms and the trials with earthworms (*Eisenia fetida*), within we used four types of beds (leaves, soil, vermiculite, and vermicompost), samples were taken for chemical analysis of total carbon, total nitrogen, ammonium, nitrate, and dissolved organic carbon contents. The results during 100 days of vermicomposting showed an increase of, ammonium, nitrate, and dissolved organic carbon contents, a depletion of total carbon and an increase of total nitrogen. The effect of earthworms on nutrients was significant in some reactors and not significant in others, which implies the effect of vermibed used on the process of decomposition by earthworms.

***Keywords:*** Epigeic earthworms; Eisenia fetida; bio-waste; Decomposition; Vermicomposting.

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## 1. Introduction

Over last few years, the various types of environmental and disposal problem caused by production of large quantities of organic waste all over the world requires sustainable approach in cost effective manner, and he has become a very important issue for maintaining healthy environment [1] However organic waste can be treated by oxygen driven biological process to produce good quality fertilizers thus helping to protect the environment, aerobic composting and vermicomposting are widely used during the recycling of large variety of waste material [2].The composting is biological process which convert heterogeneous organic wastes into humus like substances by mixed microbial population under controlled optimum conditions of moisture temperature and aeration, it is the aspect of control that separate composting from natural rotting or decomposition process which occur in an open dump sanitary landfill, or unmanaged waste pile [3] the composting product are used for fertilization in fields [4], and it can reduce some pathogenic agents from the soil [5,6,7].

Some activators may be added to the treatment of organic matter to accelerate the degradation process is about earthworms. The most important earthworms families is lumbricideae and one of its members *Eisenia fetida* can be used to stabilize organic waste by the process called vermicomposting.

Aristotle named earthworms “territory intestine” but 22 centuries later Charles Darwin showed how earthworms enhance soil fertility by the turning the soil, Darwin estimated that 10 to 18 tons of dry soil passes earthworms guts every on farm land [8] Earthworms fragment the waste substrate and accelerate the rate of decomposition of organic matter, leading to a composting effects through which unstable organic matter becomes stabilized. The vermicompost has more available nutrient par Kilograms weight than the organic substrate from which is produced.

The biological activity of earthworms provides nutrient rich vermicompost for plant growth, this facilitating the transfer of nutrient for plant [9], [1]. However the processing time and quality of the end product vary according to the decomposition of the initial mixture being processed [10].

The various industrial wastes which have been already vermicomposted and turned into nutrients, include animal manure, paper waste [11] agro industrial sludge [12], sewage sludge [13], kitchen wastes [14]

## 2. Materials and methods

Forty plastic containers of 14 L with perforated lids, which in twenty we have put 76 adults’ specimens of *Eisenia fetida*, we used 2, 5 L of four types of vermibeds, as indicated in the Table1. At each sampling date, 5 replicate of each vermireactor were sampled for Measurements of total carbon, total nitrogen, dissolved organic carbon, $N\text{-}NH_4^+$, $N\text{-}NO_3^-$ at days 0,10,30,60,100.

### *2.1. Chemical analysis*

Total carbon and nitrogen were analyzed in LECO CN-2000 analyzer with drayed samples, dissolved organic carbon (DOC) was determined calorimetrically in microplate after moist digestion (K2Cr2O7 and H2SO4)of

aliquot of 0,5 M K2SO4 [15], N-NH3,N-NO3 were determined in 2KCl extract by acid base titration with 0,01 N HCl in BÜCHI distillation unit [16].

### *2.2. Statistical analysis*

A two way analysis of variance (ANOVA) was used to compare variables measurements between each vermireactor with earthworms and the control.

**Table1:** The Experimental design

| **Treatment** | Vermibed type | Vermireactor abbreviation | Incubation time | Weight of the bio waste used | Number of replicates of each vermireactor |
|---|---|---|---|---|---|
| With | Vermiculite | V | | | |
| *Eisenia fetida* | Vermicompost | VC | | | |
| (75 adults) | Soil | S | 100 days | 1500g | 5 |
| | Chest nut leaves | F | | | |
| Without | Vermiculite | $V_{control}$ | | | |
| *Eisenia fetida* | Vermicompost | $VC_{control}$ | | | |
| (control) | soil | $S_{control}$ | 100 days | 1500g | 5 |
| | Chest nut leaves | $F_{control}$ | | | |

## 3. Results and discussion

### *3.1. Total Carbon and Nitrogen*

We observed a significant decrease of total carbon ($C_{tot}$) during time in all vermireactors only in vermireactor "F" without significant changes. The presence of the earthworms had a significant effect on the $C_{tot}$ content which is lower than in the control reactors.

at the final day of process we noticed the lowest value of $C_{tot}$ content was observed in the vermireactor "V" with 3,632% ± 0,626, and the highest is in vermireactor "F" with 47,780 % ± 2,005 (Figure1).

During the vermicomposting total nitrogen ($N_{tot}$) is increased significantly, at the presence of earthworms than in the control, the concentrations of $N_{tot}$ at the end of the process (day 100) were similar in all reactors inoculated with earthworms which exclude the effect of the type vermibed used on total nitrogen.

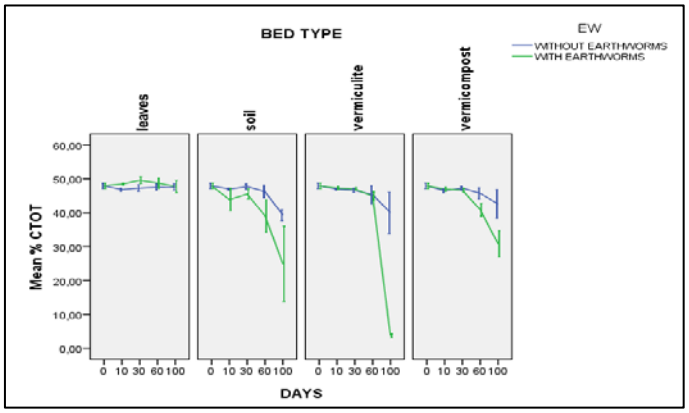


**Figure 1:** Changes in the total carbon throughout the process of vermicomposting, values are means ±SE (n=5)

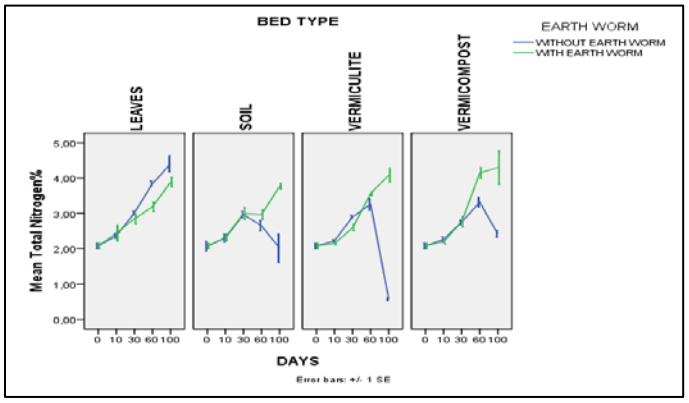


**Figure 2:** Changes in the total nitrogen throughout the process of vermicomposting values are means ±SE (n=5)

According to [17], $C_{tot}$ declines during the decomposition of different types of organic substrates by earthworms, [18] had also noticed that during vermicomposting, earthworms consume organic substrate as their food and reduce C/N rate which in turn leads to relative increase Total Kdjeldhal nitrogen (TKN) content of organic substrates, [1] had also noticed the increase of nitrogen content is due to the earthworms mucus, nitrogenous excretory substances, and also nitrogen from deceased bodies of earthworms [19]

[20] Noticed that earthworms add nitrogen in the form of mucus, nitrogenous excretory substances and enzymes during fragmentation and digestion of organic matter in the vermicomposting matter.

### *3.2. Dissolved organic carbon (DOC)*

Statistical analysis shows significant changes of DOC content during the process, which we observed an rise of DOC content (Table 4), over time the concentrations were higher in the control vermireactors than those in the presence of earthworms (Figure 3), at the final day of the process we noticed the lowest value of DOC in the

vermireactor « VC » with 11931, 8 ± 5654, 46 µg/g of dw, and the highest value was in vermireactor « V » with 39198± 6062, 83 µg/g of dw.

**Table 2:** Results of two way analysis of variance on the effect of incubation time and earthworms On total carbon

| vermireators type | Earthworm | | Incubation time | | Time x Earthworm | |
|---|---|---|---|---|---|---|
| | F | P | F | P | F | P |
| vermireactor « S » | 16,322 | 0,000 | 5,162 | 0,005 | 9,216 | 0,000 |
| vermireactor « V » | 106,637 | 0,000 | 203 ,404 | 0,000 | 111 ,198 | 0,000 |
| vermireactor « F » | 12,851 | 0,000 | 1,097 | 0,365 | 1,291 | 0,294 |
| vermireactor « VC » | 28 ,020 | 0,000 | 36,564 | 0,000 | 12 ,359 | 0,000 |

**Table 3:** Results of two way analysis of variance on the effect of incubation time and earthworms On total nitrogen

| vermireators type | Incubation time | Time x Earthworm | | | |
|---|---|---|---|---|---|
| | F | F | P | F | P |
| vermireactor « S » | 15,867 | 5,162 | 0,005 | 9 ,216 | 0,000 |
| vermireactor « V » | 9,536 | 53,689 | 0,000 | 2,627 | 0,067 |
| vermireactor « F » | 7,305 | 62 ,821 | 0,000 | 2,502 | 0,000 |
| vermireactor « VC » | 60,013 | 53 ,812 | 0,000 | 31,084 | 0,000 |

In some studies like in [21] *Eisenia fetida* in short term increase in labile carbon pool with higher density of earthworms than the control and low density, and high density of earthworms enhance enzymatic capabilities of

Epigeic earthworms to obtain energy from labile carbon and nitrogen [22] Changes in DOC content could be attributed to the microbial utilization of readily available soluble carbon through respiration, in the presence of earthworms which stimulate the microbial activity which accelerate organic carbon mineralization [17]

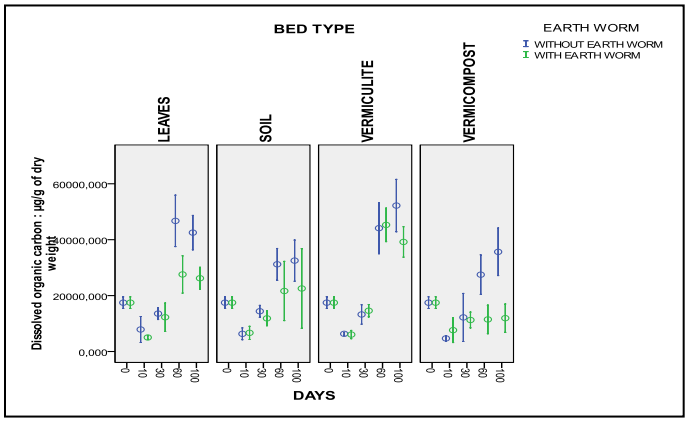


**Figure 3:** Changes in dissolved organic carbon throughout the process of vermicomposting, values are means ±SE (n=5)

**Table 4:** Results of two way analysis of variance on the effect of incubation time and earthworms on DOC

| vermireators type | Earthworm | | Incubation time | | Time x Earthworm | |
|---|---|---|---|---|---|---|
| | F | P | F | P | F | P |
| vermireactor « S » | 4,459 | 0,043 | 15,993 | 0,000 | 1,001 | 0,405 |
| vermireactor « V » | 1,798 | 0,190 | 105,044 | 0,000 | 3,022 | 0,044 |
| vermireactor « F » | 27,18 | 0,000 | 64,781 | 0,000 | 5,725 | 0,003 |
| vermireactor « VC » | 18,771 | 0,000 | 14,683 | 0,000 | 8,585 | 0,000 |

### *3.3. Inorganic nitrogen forms ($N\text{-}NO_3^-$, $N\text{-}NH_4^+$)*

During the process we noticed an elevation of $N\text{-}NH_4^+$ content in all vermireactors accept in vermireactor « V »

With no significant changes (p > 0,413) the effect of earthworms is not significant in all reactors, only in vermireactor « VC » WAS highly significant (p = 0,000) (Table 5).

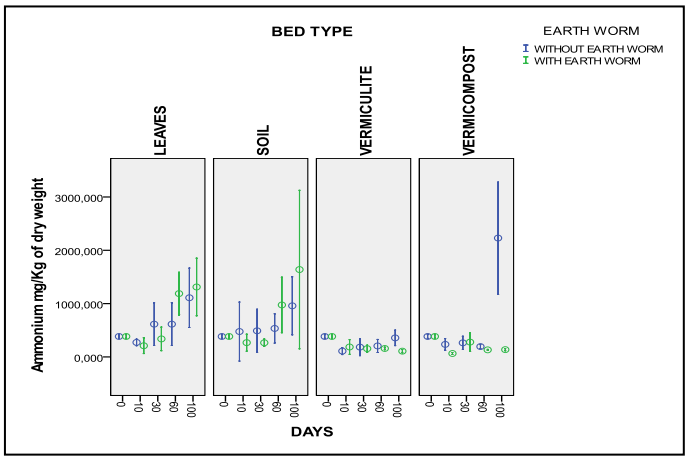


**Figure 4:** Changes in the ammonium throughout the process of vermicomposting, values are means ±SE (n=5)

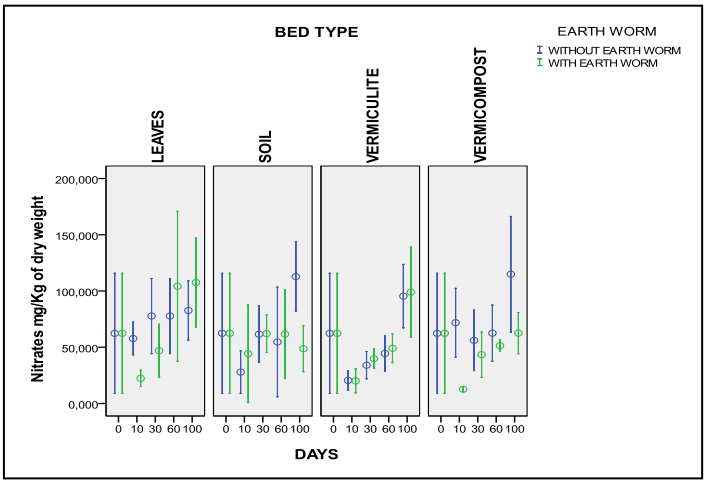


**Figure 5:** Changes in nitrates throughout the process of vermicomposting, values are means ±SE (n=5)

By the end of the process higher concentrations of $N\text{-}NH_4^+$ were measured in vermireactor « F »with 1311,81 ±604,751 mg/Kg of dw the lowest concentration was in vermireactor « V » with 108,31±35,43 mg/Kg of dw.

The release of $N\text{-}NH_4^+$ is due to the mineralization of organic nitrogen by microorganisms colonizing the riche protein wastes used for vermicomposting [14], and also the type of vermibed used may contribute to mineralization of organic nitrogenous compounds by the presence of microorganisms like in soil, vermicompost and leaves reactors, in other hand, earthworms had an effect on $N\text{-}NH_4^+$ content by excretory substances riche in nitrogen, which are easily broken down to mineral compounds. [17], deceased bodies of earthworms is an important source of $N\text{-}NH_4^+$ [19] . The $N\text{-}NO_3^-$ content had also raised in most treatments during time (Table 6), the effect of earthworms is very significant only in vermireactor « VC » ($p < 0,002$) .At the final day of the process we have observed that content of The $N\text{-}NO_3^-$ is higher in the control than in the presence of

earthworms in some reactors like « S » « VC », with 112,88 ± 34,25 mg/kg dw and 114,92 ± 57,46 mg/kg dw respectively, versus 48,62 ± 22,85 mg/kg and 62,56 ± 20,48 mg/kg in the presence of earthworms. The increase may be explained by conversion from $N\text{-}NH_4^+$ to $N\text{-}NO_3^-$ by nitrifying bacteria [23] this conversion may be influenced by earthworms activities, that can increase the nitrification [17],[19], [1].

**Table 5 :** Results of two way analysis of variance of the effect of incubation time and earthworms on $N\text{-}NH_4^+$

| Vermireators type | Earthworm | | Incubation time | | Time x Earthworm | |
|---|---|---|---|---|---|---|
| | F | P | F | P | F | P |
| vermireactor « S » | 0,665 | 0,458 | 3,642 | 0,023 | 1,005 | 0,403 |
| vermireactor « V » | 2,845 | 0,101 | 0,983 | 0,413 | 3,535 | 0,026 |
| vermireactor « F » | 0,656 | 0,424 | 10,341 | 0,000 | 1,850 | 0,158 |
| vermireactor « VC » | 18,411 | 0,000 | 13 ,631 | 0,000 | 14,141 | 0,000 |

**Table 6:** Results of two way analysis of variance of the effect of incubation time and earthworms on $N\text{-}NO_3^-$

| vermireators type | Incubation time | | Time x Earthworm | | |
|---|---|---|---|---|---|
| | F | F | P | F | P |
| vermireactor « S » | 0,810 | 2,773 | 0,058 | 2,752 | 0,059 |
| vermireactor « V » | 0,203 | 20,811 | 0,000 | 0,033 | 0,992 |
| vermireactor « F » | 0,90 | 4 ,399 | 0,011 | 1,899 | 0,150 |
| vermireactor « VC » | 49,73 | 4,450 | 0,009 | 1,715 | 0,184 |

## 4. Conclusion

In this current study, we demonstrated the potential of *Eisenia fetida* to process the bio-waste which is converted Into value added materials after 100 days .vermicompost obtained in the study, was rich in nutrient with low C: N ratio, it could be a good soil conditioner and source of plant nutrient in agriculture, vermicomposting of Kitchen waste is suitable method for solid waste management, and reducing domestic waste at the source.

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