Vermicomposting of Yard Waste and Shredded Paper Using *Eisenia Foetida*

by

Syazana binti Mustapha

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Department
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Approved by,

(Assoc. Prof. Dr. Shamsul Rahman Mohamed Kutty)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

SYAZANA BINTI MUSTAPHA

ABSTRACT

Yard waste comprises an estimated 6.3% of the total waste generated by residential area in Kuala Lumpur in 2002. It should not be land filled because it is relatively a clean and biodegradable material that can be recycled for soil improvement and other agricultural uses. Paper comprises 6.7% of total residential waste in Kuala Lumpur in 2002. In the past, paper was collected with other Municipal Solid Waste and sent to landfills or incinerators for final disposal. As fewer incinerators have been under construction in recent years, paper disposal has become a serious problem in many cities. Vermicomposting is an alternative for waste management of using earthworms to accelerate the decomposition and stabilization of biodegradable matter into usable end product called vermicompost. The project was focused on the efficiency of *Eisenia Foetida* in vermicomposting of yard waste and shredded paper generated by Universiti Teknologi Petronas. The study was conducted for 10 weeks by measuring the changes in Total Organic Carbon, Total Kjeldahl Nitrogen, Potassium, Phosphorus and pH in homogenized sample which collected at every 2 weeks of the experimental duration. 20 reactors having five Carbon to Nitrogen ratio (C/N=30, 35, 40, 45 and 50) and four variation initial numbers of earthworms (N_0=0, 20, 30 and 40) were tested. The moisture level of substrate was maintained around 70-90% throughout the study period. The maximum reduction of TOC was in R3 at C/N=50 (22.26%). The highest increment of TKN occurred in R3 at C/N=50 (247.53%). The highest increment of K was in R3 at C/N=50 (290.00%). Available P increased greatest in R3 at C/N=50 (728.90 %). The maximum reduction of pH was observed in R2 at C/N=30 (7.40%). However, the change of pH in vermicomposting was not affected by N_0. The maximum reduction of weight of substrate after 10 weeks of vermicomposting was in R3 at C/N=45 (44.62%). The experimental data had provided that C/N=50 and N_0=40 was the most efficient condition for optimum vermicomposting of yard waste and shredded paper.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Yard waste is defined as the leaves or leaf fall, grass clippings or grass trimmings and woody waste found in the Municipal Solid Waste (MSW) stream. A study conducted by Local Government Department Ministry of Housing & Local Government (DMHLG) in 2002 shows that yard waste comprises an estimated 6.3% of the total waste generated by residential area in Kuala Lumpur. Yard waste should not be land filled because it is relatively a clean and biodegradable material that can be recycled for soil improvement and other agricultural uses. A further advantage of recycling yard wastes is that they are easy to separate from the rest of the MSW stream at their point of origin (Evanylo *et al.*, 2003).

Paper comprises 6.7% of total residential waste in Kuala Lumpur in 2002 as in Figure 1.1. In the past, paper was collected with other MSW and sent to landfills or incinerators for final disposal. As fewer incinerators have been under construction in recent years, paper disposal has become a serious problem in many cities (Kaviraj and Sharma, 2003). Moreover, the practice of burning waste in the incinerator could cause environmental problems such as production of hazardous gas (methane) during emission and burning process.

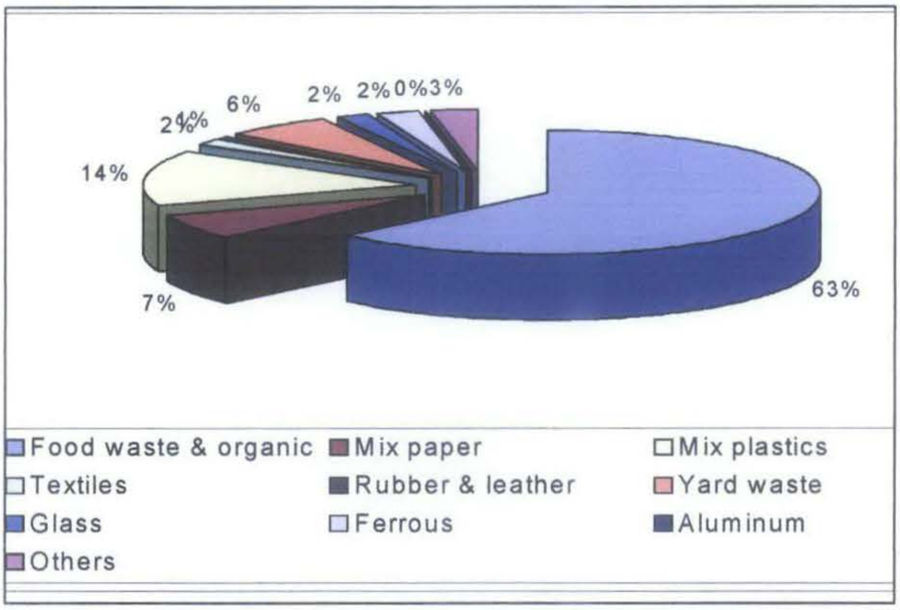


Figure 1.1: Composition of residential waste generated in Kuala Lumpur in 2002 (DMHLG, 2003)

As reported by The Solid Waste Management Board of West Virginia (SWMB), vermicomposting of yard waste and paper is an attractive disposal option for many communities who wish to recycle plant nutrients, save landfill space and comply with safety laws prohibiting yard waste disposal in sanitary landfills. Vermicomposting can be a cost-effective and environmentally sound method to reuse a community's yard waste and paper. Landfill space is conserved, disposal costs reduced and a useful end product is produced with vermicomposting. It is a controlled process requiring advanced planning and ongoing management.

1.2 Problem Statement

Yard waste and paper were usually collected and burned into the incinerator or dumped at the landfill. This operation not only consumed high amount of money but also caused major environmental and disposal problem.

1.3 Objectives

The purpose of this project is to dispose the yard waste and paper generated from UTP by vermicomposting employing exotic species of earthworm (*Eisenia Foetida*). It is not only reduces the amount of yard waste and used paper going to the landfill but also converts them into usable plant fertilizer.

1.4 Scope of Study

The scopes of study of this project were as follows.

1. Studied the composting process of yard waste and shredded paper generated by UTP with the absence and presence of *Eisenia Foetida*.
2. Monitored the effects of various C/N ratios and initial numbers of earthworm in vermicomposting.
3. Measured the changes in chemical and physical properties (Total Organic Carbon, Total Kjeldahl Nitrogen, Potassium, Phosphorus and pH) of substrate during vermicomposting study.

CHAPTER 2

LITERATURE REVIEW

2.1 Vermicomposting

Vermicomposting is a method of using earthworms to feed on the organics and convert material into casting rich in plant nutrients (Kaviraj and Sharma, 2003). It has been reported to be a viable, cost effective and rapid technique for the efficient management of the organic MSW (Garg *et al.*, 2004). During vermicomposting earthworms ingest, grind and digest organic waste and convert it into a stable and homogeneous material. The generated product or compost is a valuable, marketable and superior plant growth medium. This process will convert nutrients present in the waste which are important to plant such as nitrogen, phosphorus, potassium and carbon into the forms that are much more soluble and available to plants than parent substrate (Gupta and Garg, 2007). The use of *Eisenia Foetida* in vermicomposting has been proven and proposed globally as potential method to stabilize wastes such as sewage sludge, industrial sludge, plant-derived waste and animal dung (Kaushik and Garg, 2003). Yard waste and paper contain high amount of organic in nature, so vermicomposting has become an alternative for safe and effective disposal of it (Kaviraj and Sharma, 2003).

Yard waste which traditionally includes grass clippings, leaves and light brush, can easily be composted in the back yard or in centralized composting operations. A waste quantification and characterization study conducted for the SWMB indicates that yard waste makes up about 6% of the waste stream (William, 1991). It should be noted that this survey was conducted in November 1990. United States Environmental Protection Agency 1 (USEPA) estimates that approximately 19% of the waste stream is yard waste. This indicates vermicomposting may reduce the volume of waste going into landfills in West Virginia. If one includes other organic waste (paper, food waste, and other wood waste) the volume of material which can be composted jumps to over 50% of the waste stream.

A study of decomposition efficiency of *Perionyx Sansibaricus* for vermicomposting by using a variety of wastes such as agriculture waste, farm yard manure and urban solid waste was done by Suthar in 2006. After 150 days of experiment, the vermicomposting resulted in significant increase in total nitrogen (80.8–142.3%), phosphorous (33.1–114.6%) and potassium (26.3–125.2%), whereas decrease in organic C (14.0–37.0%) as well as C/N ratio (52.4–69.8%) in different experimental beddings. The increased level of plant metabolites in end product (vermicompost) and growth patterns of *Perionyx Sansibaricus* in different organic waste resources demonstrated the candidature of this species for wastes recycle operations at low-input basis.

In 2004, Parvaresh *et al.* have studied the stabilization of municipal wastewater sludge with and without earthworms (*Eisenia Foetida*) in a pilot study. The earthworms were fed at the optimum level of 0.75 kg-feed/kg-worm/day. Decomposition and stabilization of wastewater sludge occurred both in the presence and in the absence of earthworms during 9 weeks but the process was accelerated in their presence. Phosphorus content increased in the sludge with earthworms but decreased in it without them. Nitrogen content in the resulting vermicompost showed no difference with its quantity in the original substrate while it increased in the control treatment.

Frederickson *et al.* have showed that vermicomposting for 8 weeks produced a material with a significantly lower volatile solids content compared to composting for a similar period ($P < 0.01$). A combined composting and vermicomposting system was investigated by extracting partially-composted samples from the compost windrow every 2 weeks and feeding these to *Eisenia Andrei*. Growth and reproduction were found to be positively correlated to the volatile solids content of the waste ($P < 0.01$). For a further 6 weeks, vermicomposting reduced volatile solids content significantly more than for composting fresh waste for 8 weeks ($P < 0.001$). It is concluded that *Eisenia Andrei* containing good rates of growth and reproduction in fresh green waste and that vermicomposting can result in a more stable material (lower volatile solids content) compared to composting. Combining vermicomposting with existing composting operations can also accelerate stabilisation compared to composting alone.

2.2 Earthworms Categories

Edwards and Bohlen (1996) have done a study which can categorize earthworms into three categories which are epigeic, anecic, and endogeic. These groupings generally reflect morpho-ecological distinctions between species adapted to different habitats. The epigeic group is generally surface dwelling species that inhabit and feed on decomposing litter on the soil surface, rarely ingesting soil. They have rapid mobility, relatively short-lived, small to medium in size, grow and reproduce quickly. The earthworm species that have evolved with these characteristics are predominantly used in vermicomposting. The anecic group is burrowing earthworms that construct large, permanent and vertical burrows and feed on decomposing litter at the soil surface or pull it into their burrows. They have a rapid withdrawal response, large in size, relatively long-lived and have a longer growth and reproduction time than epigeic species. Anecic species may be used in vermicomposting but usually in combination with epigeic species. The endogeic group of earthworms lives in extensive horizontal burrows and feed on mineral soil and rich organic matter. These species are never used in vermicomposting purposes.

2.3 Common Compost Worm Species

A survey has been done in Australia to determine the range of worm species most commonly found in compost piles and vermicomposting facilities (Baker and Barrett, 1994). It has been identified that the common compost worm species are mostly of European origin, which include *Eisenia Andrei* (red tiger worm, commonly sold as red or red wriggler), *Eisenia Foetida* (tiger worm), *Eudrilus Eugeniae* (African night crawler), *Lumbricus Rubellus* (red worm), *Perionyx Excavatus* (Indian blue worm), *Fletcherodrilus* species (native to Australia) and *Heteroporodrilus* species (native).

The *Eudrilus Eugeniae* and *Perionyx Excavatus* are of tropical origin and are best suited to indoor or temperature controlled environments but *Perionyx Excavatus* has been cultivated successfully in cooler conditions (Murphy, 1993). *Eisenia Foetida* are the dominant commercial compost worm for temperate areas including Malaysia. There are several reasons why they are preferred for composting, which are their rapid consumption of food, capacity to inhabit, consume and breed in a high nutrient environment and their ability to suit to a broad range of climates and environmental conditions.

This study focused on *Eisenia Foetida* as the compost worm species due to its ability in composting and availability in the market.

2.4 Anatomy of Compost Worm

The earthworm has a long and rounded body with a pointed head and slightly flattened posterior. Rings that surround the moist and soft body allow the earthworm to twist and turn, especially since it has no backbone. With no true legs, bristles on the body move back and forth, allowing the earthworm to crawl. Food is ingested through the worm's mouth (Figure 2.1) into the stomach. They have no teeth to chew the food and use saliva to soften the food. Later the food passes through the esophagus to the gizzard where it is ground up by ingested stones. After passing through the intestine for digestion, what is left is eliminated (Appelhof, 2008).

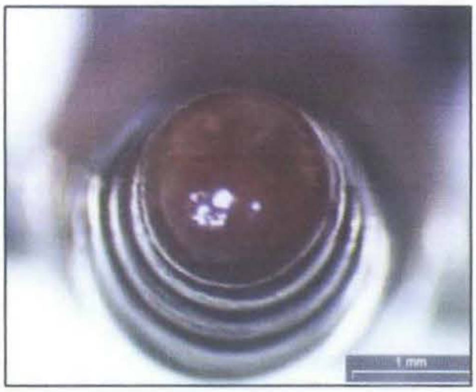


Figure 2.1: The worm's mouth (Jais, 2008)

Earthworm breathes through its wet skin. Oxygen taken by the worm will passes through the capillary of the worm's body but excessive moisture of composting place will cause the worm to die due to anaerobic condition (Murphey, 2003). The earthworm does not have ear or eyes but they are very sensitive to vibration, disturbance and sunlight. An hour exposure to direct sunlight will temporarily numb the worm while a few hours of exposure will kill the worm (Murphey, 2003).

2.5 Lifecycle and Production Rate of Compost Worm

Earthworms are hermaphrodites, which mean they have both male and female sex organs but they require another earthworm to mate (Murphey, 2003). The wide band (clitellum) that surrounds a mature breeding earthworm secretes mucus (albumin) after mating (Figure 2.2). Sperm from another worm is stored in sacs. As the mucus slides over the worm, it encases the sperm and eggs inside. After slipping free from the worm, both ends seal and forming a lemon-shape cocoon approximately 1/8 inch long (Figure 2.3 (a)). Two or more baby worms will hatch from one end of the cocoon in approximately three weeks. Baby worms are whitish to almost transparent and are 1/2 to 1 inch long. Earthworm takes 60 to 90 days to become sexually mature (Appelhof, 2008).

Figure 2.2: Clitellum at a matured worm's body (Jais, 2008)

(a)

(b)

(c)

Figure 2.3: (a) Worm after 1 day, (b) 1 week and (c) maturity (Jais, 2008)

2.6 Environmental Requirements for Vermicomposting

The optimum favorable environmental conditions for vermicomposting have been well researched and they are fairly similar for all composting species (Edwards, 1995). The parameters which are important in vermicomposting are as below.

2.6.1 Temperature

Temperatures referred to relate to temperature of substrate or bedding mass, not to ambient air temperature. The decomposition of organic matter will heat up a system from the metabolic processes of microorganisms. Earthworms aid and abet the increase of heat to foster microorganism activity and further increasing this activity with the exponential increase of microorganism populations in their castings (Edwards and Bohlen, 1996). Earthworm activity can also enable a system to aerate and release heat (up to a maximum bedding depth). It has been observed for *Perionyx Excavatus* that as the vermicomposting system approaches 30°C, growth and sexual maturity accelerate, cocoon incubation times shorten and hatching success increases, although reproduction is highest at 25°C. A balanced vermicomposting system is usually 15-25°C. The optimum temperature for *Eisenia Foetida* is generally regarded as 20°C although, *Eisenia Foetida* has the broadest temperature tolerance (Edward, 1995). Constant temperatures above 30°C are deadly for all species of composting earthworms. Earthworm activity will increase up to 30°C and *Eisenia Foetida* has been observed to survive for short periods up to 45°C (Edwards, 1995) but from this temperature and above thermophilic composting is optimised.

Surface area to volume ratio will also play a role in heating up a system. The larger the system, the lower is the surface area to volume ratio to allow the microbial heat to dissipate (Edward, 1995). This is one of the advantages of continuous flow and tray systems because they have a larger surface area to allow heat to dissipate. The literature suggests optimum temperatures for bedding mass in on-site vermiculture systems will vary within the 20°C – 30°C range depending upon the species or variety of compost worm species employed.

2.6.2 Moisture

Compost worms require a moist environment to move through substrates and prevent dehydration. Excess moisture may cause the system to become anaerobic and too little may cause dehydration of compost worm stock. Compost worms can function in moisture as low as 40%. The optimum range of moisture for *Eisenia Andrei* is 80-90% and best growth is achieved at 85% (Dominguez and Edwards, 1997), *Eisenia Foetida* is 70-80% and *Perionyx Excavatus* is 76-83% (Hallatt et al, 1990). The literature suggests 80% moisture level is recommended as the optimum moisture levels for systems of mixed worm stock appropriate for temperate environments.

2.6.3 pH

The pH of most waste streams decreases to the acidic range as microorganisms decompose organic residues. All earthworm species have a fairly broad range of tolerance to pH levels between a pH of 4.5 and a pH of 9. Earthworms will operation the entire range. Edwards recommends that compost earthworms will function best in a substrate with a pH of 5.9. Hallatt *et al.* (1990) claim a pH of 7 (neutral) is optimal for *Perionyx Excavatus*. Murphy (1993) recommends a pH of 6.5 as suitable for compost worms.

Vermicomposting units will normally shift towards a pH of 7 because earthworm castings are usually pH neutral. It has been observed that cocoon survival is more likely to be achieved in castings than the surrounding organic matter which in some substrates is completely toxic to cocoons (Edwards, 1995).

2.6.4 Carbon to Nitrogen (C/N) ratio

To ensure efficient vermicomposting, the nitrogen rich materials should be blended with complementary carbonaceous materials to achieve a C/N ratio of 20 – 50 parts carbon to every one part of nitrogen on a dry matter basis. Nitrogen is a crucial component of the protein, nucleic acid and amino acid that necessary for cell growth and function. Carbon provides energy source and a basic cellular building block for the worm growth. These carbon rich materials are often referred to as bulking agents, as they provide structural stability to the mix, allowing air exchange and continued aerobic conditions. Such conditions are critical for optimal worm activity and worm survival (Edwards, 1995).

Carbon rich materials that could be considered as bulking agents may include shredded paper, shredded cardboard, shredded leaves, compost, coconut fibre (coir), straw, wood chips or rotted manure (Appelhof, 2008). Paper and cardboard products are common waste products of the MSW and provide a useful on-site source of carbonaceous bulking agents.

Low C/N ratio will cause undesirable odor to the reactor due to loss of excessive nitrogen as ammonia gas. Too high C/N ratio will cause the composition process to run at slower rate.

CHAPTER 3

METHODOLOGY

3.1 Reactor Setup

3.1.1 Collection of Project Material

The study was carried out by using yard waste collected from UTP and used paper collected from Civil Engineering Department of UTP. The yard waste was first oven dried at 105°C for 24 hours before grinded into smaller and finer pieces. The grinder machine used is located at the concrete laboratory of UTP with the blade size of 0.25µm. The used paper was shredded by using shredder at Civil Engineering Department.

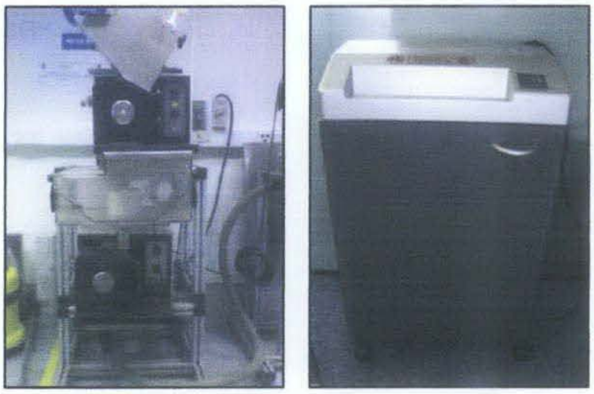


Figure 3.1: Grinder and shredder

Figure 3.2: Grinded yard waste and shredded paper

The earthworm used for this study was *Eisenia Foetida.* 1 kg of adult earthworm was bought on 13th March 2008 from a worm farm, ESI Agrotech in Kajang.

Figure 3.3: Author and En Kamarul (owner of ESI Agrotech)

Figure 3.4: *Eisenia Foetida*

3.1.2 Determination of Percentage of Yard Waste and Shredded Paper

To determine the percentage in weight of yard waste and shredded paper to be used, carbon (C) and kjeldahl nitrogen (N) of raw yard waste and shredded paper was determined from the chemical analysis. Then the percentage was calculated by using the mass balance equation as follow.

$$\frac{C}{N} = (25 \sim 50) = \frac{C \text{ in } 1kg \text{ } Yardwaste + x(C \text{ in } 1kg \text{ of } Paper)}{N \text{ in } 1kg \text{ } Yardwaste + x(N \text{ in } 1kg \text{ of } Paper)} \text{ .... (1)}$$

3.1.3 Experimental Setup

The experimental setup was done by first mixing the shredded paper and yard waste according to the percentage of weight calculated. Yard waste and moistened shredded paper (substrate) were weighted and mixed inside a square metal container for easier mixing. Total of 5 C/N ratios (C/N=30, 35, 40, 45 and 50) and 3 variations of initial numbers of earthworms (N_0=0, 20, 30 and 40) were used in this study. The experimental setup is shown as follow.

Table 3.1: Experimental setup

	Reactor			Control
C/N ratio	R1 (N_0=20)	R2 (N_0=30)	R3 (N_0=40)	(N_0=0)
30	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture
35	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture
40	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture
45	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture
50	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture	TOC, TKN, P, K, pH, Moisture

The reactors used in this study were plastic reactors as it was the most economical reactor which was available. The dimension for each reactor is 32 length x 25 width x 11 depth. Sag bag is trimmed to fit into the reactor to prevent substrates from falling out of the reactor.

Moisture content of the substrate was maintained by spraying adequate quantity of water every 24 hours. The reactors were placed under a shaded area behind Building 13 of Civil Engineering Department in UTP to ensure minimum exposure of sunlight (Figure 3.5)

For chemical and physical analysis, homogenized sample (free from hatchlings, cocoons and earthworms) was drawn once in each 2 weeks for 10 weeks of vermicomposting study.

(a)

(b)

(c)

Figure 3.5: (a) Weighted yard waste and shredded paper, (b) Mixed yard waste and shredded paper and (c) Reactor setup

3.2 Chemical and Physical Analysis

Table 3.2: Chemical and physical analysis

Analysis	Method	Reference
Total Organic Carbon	TOC Analyzer	-
Total Kjeldahl Nitrogen	Sulfuric acid digestion with	ASTM for Soil and Peat (D

	alkali distillation.	4972 – 95a)
Potassium	Atomic Absorption Spectrophotometer (AAS) with Sulfuric Acid-Nitric Acid Digestion	Modified Standard Methods for the Examination of Water and Wastewater (4500-P B)
Phosphorus	Spectrophotometer with Sulfuric Acid-Nitric Acid Digestion	Modified Standard Methods for the Examination of Water and Wastewater (4500-P B)
pH	Electrometric measurement	ASTM for Soil and Peat (D 2974 – 87)
Moisture Content	Hydrogen Moisture Analyzer	-

3.2.1 Measurement of Total Organic Carbon (TOC)

TOC was done to measure the organic carbon contain in the sample. First the sample was dried in the oven for 24 hours at 150 °C to ensure the sample is free from moisture. Next 50mg of dried sample was weighted using the weighting machine and placed inside the vial. The sample was then measured for TOC by using the TOC Analyzer. This method was based on the combustion of organic compound and further detection of CO_2 released with non-dispersive infrared analysis. The result was given in percentage.

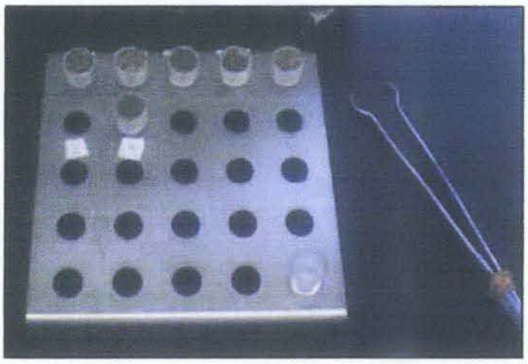


Figure 3.6: Preparation of sample for TOC measurement

3.2.2 Measurement of Total Kjeldahl Nitrogen (TKN)

Approximately 0.5g of dried sample was prepared and placed in a 600ml Kjeldahl flask. 0.25g of selenium and 20ml of concentrated sulfuric acid were added into the flask. The mixture was digested on the digestion rack until all the sulfur gas evaporated for 40 minutes and continued for 30 minutes to ensure complete digestion. The solution was then allowed to cool for 10-15 minutes before 125ml of distilled water was added.

50ml of 4% boric acid was placed in a 500ml Erlenmeyer flask. The flask was placed on the distillation rack so that the end of receiver tube of distillation apparatus was under the surface of the boric acid in the flask. Kjeldahl flask was held at 45° angle and 100ml of sodium hydroxide was added to it. The flask was connected without mixing to a trap which was connected to the distillation column. The solution was heated until 150ml of distillate had been collected in the collection flask.

The boric acid solution changed from bluish purple to bluish green with the introduction of ammonia. The solution was titrated using titrator with 0.02 N of sulfuric acid.

TKN was calculated using the formula below.

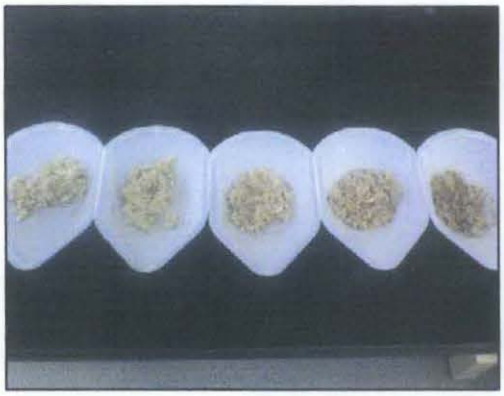
$$TKN(\%) = \frac{(A-B)}{C} \times 280 \times 0.0001 \qquad (2)$$

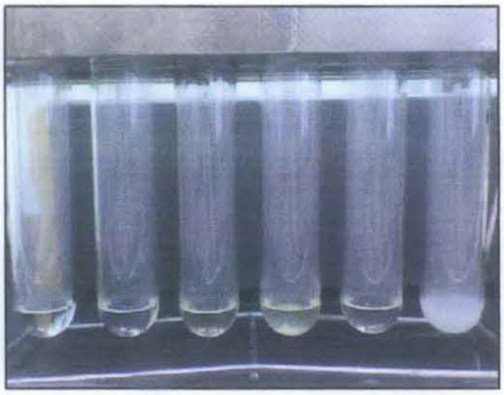
Where,

A = volume titrated for sample (ml)

B = volume titrated for blank (ml)

C = Weight of sample (g)





(a) Weighing the sample (b) Digested sample with NaOH

(c) Distillation machine (d) Titration with 0.2 N NaOH

Figure 3.7: Total Kjeldahl Nitrogen Measurement

3.2.3 Measurement of Potassium (K)

Approximately 0.6g of 1ml of concentrated sulfuric acid and 5ml of concentrated nitric acid were added in a 600ml Kjeldahl flask. The sample was digested for about 30 minutes and continued until the solution becomes colorless to remove nitric acid. It was then cooled and 20ml of distilled water, 0.05ml phenolphthalein indicator and 1 N of NaOH solution were added as required to produce a faint pink tinge. 10ml of digested sample was filtered and transferred into 100ml volumetric flask. The volume of sample was adjusted to 100ml with distilled water.

The digested sample was taken for Atomic Absorption Spectrophotometer (AAS) for further Potassium analysis.

Figure 3.8: Atomic Adsorption Spectrophotometer equipment

3.2.4 Measurement of Phosphorus (P)

Approximately 0.6g of 1ml of concentrated sulfuric acid and 5ml of concentrated nitric acid were added in a 600ml Kjeldahl flask. The sample was digested for about 30 minutes and continued until the solution becomes colorless to remove nitric acid. It was then cooled and 20ml of distilled water, 0.05ml phenolphthalein indicator and 1 N of NaOH solution were added as required to produce a faint pink tinge. 10ml of digested sample was filtered and transferred into 100ml volumetric flask. The volume of sample was adjusted to 100ml with distilled water.

10ml of digested sample was filled into a 100ml conical flask and distilled water was added to adjust to 100ml. 5ml of diluted sample was filled into a vial and Potassium Persulfate Powder Pillow was added. Then the vial was capped tightly and mixed for 30 minutes to allow it to dissolve and digest. After cooling down to room temperature, a Tensette pipette was used to add 2ml of 1.54 N Sodium Hydroxide Standard Solution into the vial. Then the vial surface was wiped with a clean cloth and inserted into a 16mm cell holder DRB 2500 device for zeroing purpose. Next Phosver 3 Powder Pillow was added into the vial and was mixed for 2 minutes. The vial was inserted into the 16mm cell holder again and the reading was taken.

Figure 3.9: Sample after digestion

Figure 3.10: Spectrophotometer

3.2.5 Measurement of pH

pH was measured by first placing 0.1g sample into a 100ml beaker. 100ml of distilled water was added into the beaker and the sample was stirred for 1 hour. The sample was then allowed to sit for 30 minutes to permit the sample and water to equilibrate. The pH meter was standardized with buffer solution at pH 4.0 and the pH of the sample was measured. After each determination, the electrode was washed clean with distilled water and the excess water blotted from the electrode tip was wiped with Kimwipes.

Figure 3.11: Measuring the pH

3.2.6 Measurement of Moisture Content

Moisture content was measured by using Halogen Moisture Analyzer. A weight of sample is added onto an aluminum container of the equipment and the moisture of the sample will be measured by the equipment. The result was given in percentage.

Figure 3.12: Halogen Moisture Analyzer

3.4 Hazard Analysis

Hazard analysis is the process of identifying anything that can cause harm such as hazardous chemical and noise to prevent accident, properties damage and loss event. The study involved dealing with hazardous chemicals and equipments in the Environmental, Concrete and Chemical Laboratory in UTP. Each laboratory has different precaution in order to prevent or reduce the risk of hazard. Below are the list of hazard which may occur in the laboratory, the effects of hazard and its precaution.

Table 3.3: Hazard analysis

Area of Workplace	Hazard	Effects	Precaution
Concrete Laboratory	Noise and dust	Irritation nose, throat and ear	Using earplug and dust mask
Environmental and Chemical Laboratory	Hazardous chemical splashes (e.g. Sulphuric Acid)	Bronchitis, dental erosion, skin burn	Wear hand glove and lab coat all the time. Flush with a lot of water if contact

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Raw Yard Waste and Shredded Paper Characteristics

Yard waste and shredded paper collected from UTP were investigated to determine the characteristics. Two parameters were analyzed from the raw yard waste and shredded paper which are TOC and TKN to determine the C/N ratio. The result is tabulated in the table below.

Table 4.1: Characteristics of raw yard waste and shredded paper

Parameter	Yard Waste	Shredded Paper
TOC (%)	37.31	32.67
TKN (%)	1.44	0.03
C/N	25.91	1089

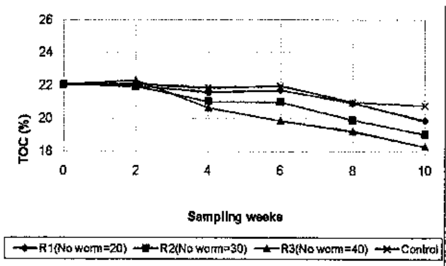
The total dry weight of yard waste and shredded paper is approximately 1 kg. Below is the calculated percentage in weight (kg) of yard waste and shredded paper for different C/N ratios.

Table 4.2: Dry weight of raw yard waste and shredded paper

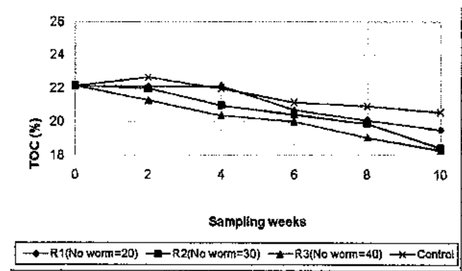
C/N ratio	Dry weight (kg)	
	Yard Waste	Shredded Paper
30	0.812	0.146
35	0.681	0.273
40	0.586	0.365
45	0.513	0.435
50	0.456	0.490

4.2 Effects of Various C/N Ratios with Fixed Initial Number of Earthworms (N_0)

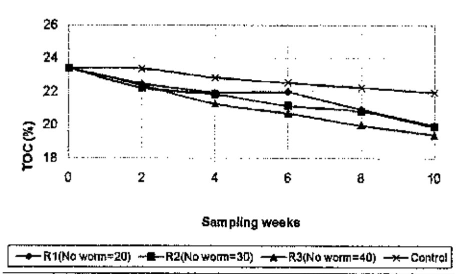
4.2.1 TOC vs Sampling Weeks for R1 (N_0=20), R2 (N_0=30), R3 (N_0=40) and Control (N_0=0) containing Various C/N Ratios



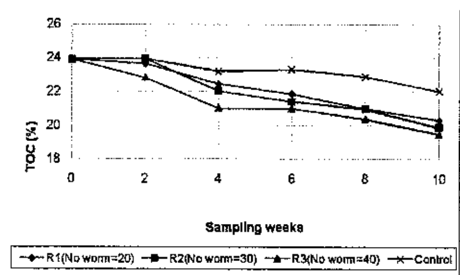
(a) C/N=30



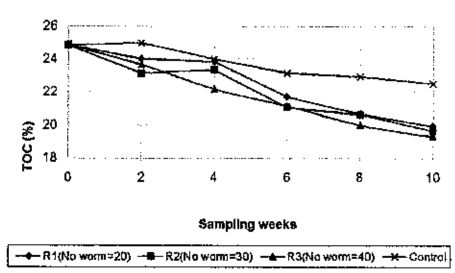
(b) C/N=35



(c) C/N=40



(d) C/N=45



(e) C/N=50

Figure 4.1: TOC vs sampling weeks for R1, R2, R3 and control

From Figure 4.1(a), until Week 10, the maximum reduction of TOC at C/N=30 was in R3 (17.09%) followed by R2 (13.74%), R1 (9.97%) and control (5.80%). From statistical analysis, the difference in initial number of earthworms (N_0) at C/N=30 for TOC reduction was not statistically significant.

Figure 4.1(b) shows the reduction of TOC at C/N=35. The highest TOC reduction until Week 10 was in R3 (17.43%) followed by R2 (16.84%), R1 (11.87%) and control (7.18%). Statistical analysis showed that there was no significant differences in N_0 for TOC reduction at C/N=35.

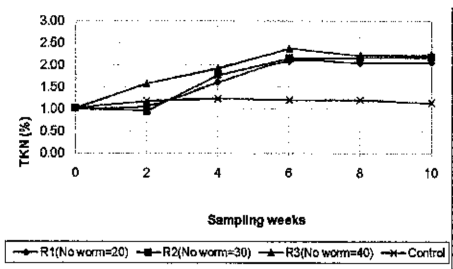
From Figure 4.1(c), the highest reduction of TOC at C/N=40 was in R3 (17.04%) followed by R2 (14.95%), R1 (14.52%) and control (6.15%). From statistical analysis, the TOC reduction at C/N=40 was not significantly affected by R1 (N_0=20) and R2 (N_0=30) but significantly affected by R3 (N_0=40).

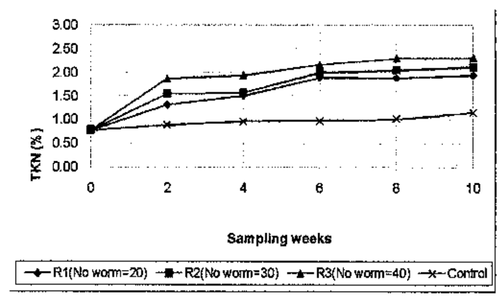
Figure 4.1(d) shows the highest reduction of TOC at C/N=45 was in R3 (18.53%) followed by R2 (16.81%), R1 (15.01%) and control (7.90%). Statistical analysis showed that the TOC reduction at C/N=45 was not significantly affected by R1 and R2 but significantly affected by R3.

The highest reduction if TOC at C/N 50 from Figure 4.1(e) was in R3 (22.26%) followed by R2 (20.89%), R1 (19.77%) and control (9.34%). Statistical analysis showed that there was no significant difference in N_0 for TOC reduction at C/N=50.

It was observed that until week 10, the highest reduction of TOC during vermicomposting was in R3 at C/N=50 with percentage reduction of 22.26%. The result was supported by Kaviraj and Sharma (2003) who observed 20-42% loss of carbon as CO_2 at the end of vermicomposting period. At 5% level of significance, it was indicated that the reduction of TOC was not significantly affected by N_0 at C/N=30, 35 and 50. At C/N=40 and 45, the TOC reduction was not significantly affected by R1 and R2. However, the TOC reduction at C/N= 40 and 45 was significantly affected by R3.

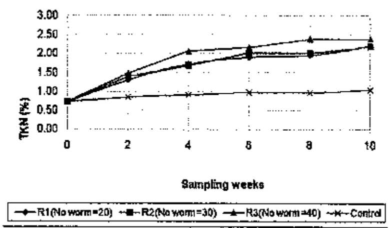
4.2.2 TKN vs Sampling Weeks for R1 (N_0=20), R2 (N_0=30), R3 (N_0=40) and Control (N_0=0) containing Various C/N Ratios

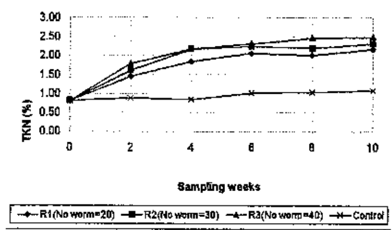




(a) C/N=30

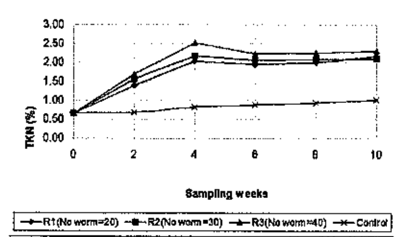
(b) C/N=35





(c) C/N=40

(d) C/N=45



(e) C/N=50

Figure 4.2: TKN vs sampling weeks for R1, R2, R3 and control

Figure 4.2(a) shows the highest increment of TKN at C/N=30 until Week 10 was observed in R3 (116.19%) followed by R2 (112.08%), R1 (100.02%) and control (10.32%). Statistical analysis showed that the increment of TKN at C/N=30 was significantly affected by N_0.

Figure 4.2(b) shows the highest TKN increment at C/N=35 was in R3 (194.23%) followed by R2 (169.45%), R1 (147.41%) and control (47.12%). Statistical analysis showed that the increment of TKN at C/N=35 was significantly affected by N_0.

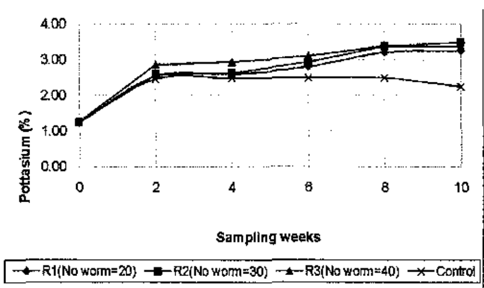
Figure 4.2(c) shows the highest increment of TKN at C/N=40 was observed at R3 (223.52%) followed by R1 (200.43%), R2 (196.46%) and control (43.34%). Statistical analysis showed that the increment of TKN at C/N=40 was significantly affected by N_0.

Figure 4.2(d) shows the highest increment of TKN at C/N=45 was in R3 (202.38%) followed by R2 (180.35%), R1 (163.85%) and control (32.64%). Statistical analysis showed that the increment of TKN at C/N=45 was significantly affected by N_0.

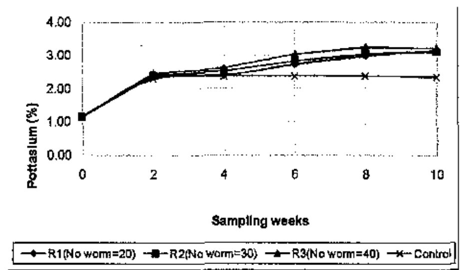
Figure 4.2(e) shows the highest increment of TKN at C/N=50 was in R3 (247.53%) followed by R1 (225.66%), R2 (217.31%) and control (53.94%). Statistical analysis showed that the increment of TKN at C/N=50 was significantly affected by N_0.

From Figure 4.2, it was observed that the highest increment of TKN occurred in R3 at C/N=50 (247.53%). The TKN content increased as result of carbon loss with significant differences between C/N ratio and N_0. The loss of dry mass (organic carbon) in terms of CO_2 as well as water loss by evaporation during mineralization of organic matter might have determined the relative increase in nitrogen (Garg, 2004). Based on the statistical analysis performed at 5% level of significance, the increment of TKN at C/N=30, 35, 40, 45 and 50 was significantly affected by N_0.

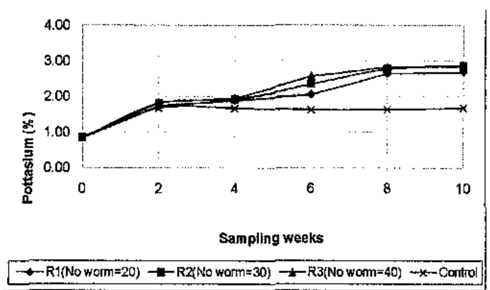
4.2.3 K vs Sampling Weeks for R1 (N_0=20), R2 (N_0=30), R3 (N_0=40) and Control (N_0=0) containing Various C/N Ratios



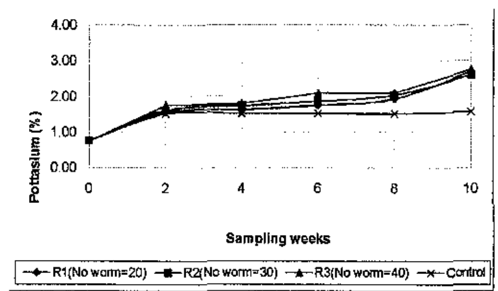
(a) C/N=30



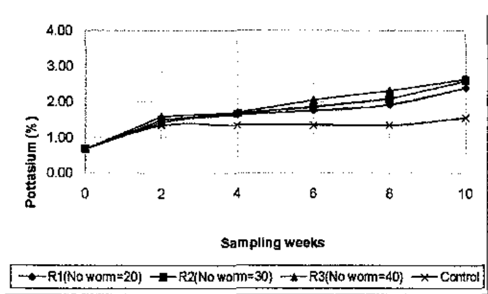
(b) C/N=35



(c) C/N=40



(d) C/N=45



(e) C/N=50

Figure 4.3: K vs sampling weeks for R1, R2, R3 and control

Figure 4.3(a) shows the increment of K at C/N=30 was in R2 (179.48%) followed by R3 (169.24%), R1 (160.22%) and control (80.58%). Statistical analysis showed that the increment of K at C/N=30 was not significantly affected by N_0.

Figure 4.3(b) shows the highest increment of K at C/N=35 was in R3 (178.47%) followed by R1 (173.54%), R2 (169.92%) and control (103.51%). Statistical analysis showed that the increment of K at C/N=35 was not significantly affected by N_0.

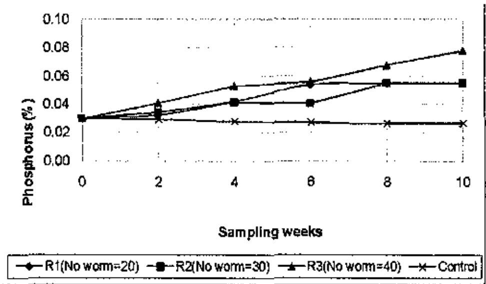
Figure 4.4(c) shows the highest increment of K at C/N=40 was observed in R3 (236.21%) followed by R2 (233.74%), R1 (215.12%) and control (97.03%). Statistical analysis showed that the increment of K at C/N=40 was not significantly affected by N_0.

Figure 4.4(d) shows the highest K increment at C/N=45 was at R3 (260.85%) followed by R1 (253.2%), R2 (240.46%) and control (106.37%). Statistical analysis showed that the increment of K at C/N=40 was not significantly affected by N_0.

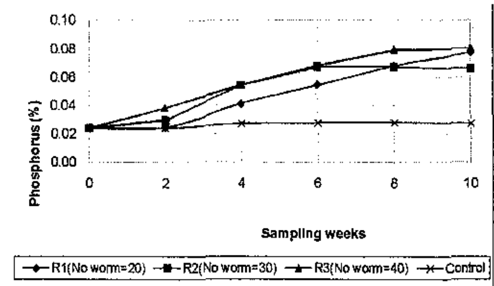
Figure 4.4(e) shows the highest increment of K at C/N=50 occurred in R3 (290.00%) followed by R2 (284.22%), R1 (254.25%) and control (126.91%). Statistical analysis showed that the increment of K at C/N=35 was not significantly affected by N_0.

From Figure 4.4, it was observed that total K increased significantly in all the substrates with worm inoculated waste than in control. The highest increment of K was in R3 at C/N=50 (290.00%). *Garg et al.* (2004) observed that K content was higher in final product than in the initial feed substrates indicating that the microbial flora also influences the level of available K. The enhanced number of microflora present in the gut of earthworms in the case of vermicomposting might have played an important role in this process and increased K_2O over the control (Kaviraj and Sharma, 2003). Statistical analysis at 5% level of significance showed that there was no effect of N_0 to the increment of K at C/N=30, 35, 40, 45 and 50.

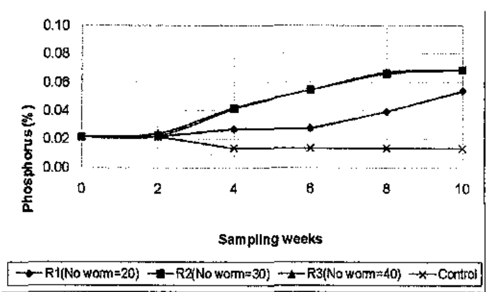
4.2.4 P vs Sampling Weeks for R1 (N_0=20), R2 (N_0=30), R3 (N_0=40) and Control (N_0=0) containing Various C/N Ratios



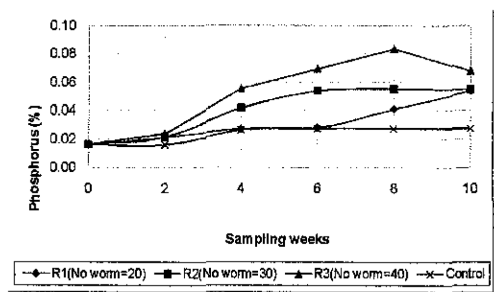
(a) C/N=30



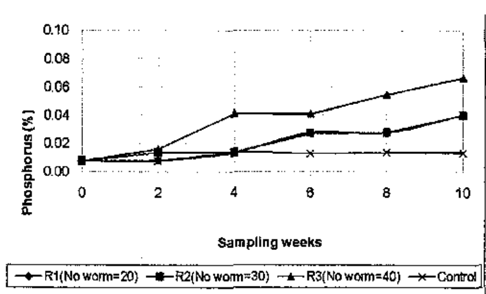
(b) C/N=35



(c) C/N=40



(d) C/N=45



(e) C/N=50

Figure 4.4: P vs sampling weeks for R1, R2, R3 and control

Figure 4.4(a) shows the highest increment of P at C/N=30 occurred in R3 (160.66%) followed by R2 (84.28%), R1 (83.17%) and control (11.31%). Statistical analysis showed that the increment of P at C/N=30 was significantly affected by N_0.

Figure 4.4(b) shows the highest increment of P at C/N=35 was in R3 (234.93%) followed by R1 (221.50%), R2 (174.43%) and control (13.96%). Statistical analysis showed that the increment of P at C/N=35 was significantly affected by N_0.

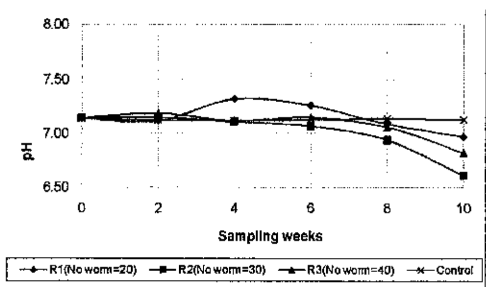
Figure 4.4(c) shows the highest P increment at C/N=40 was in R2 (218.63%) followed by R3 (218.38%), R1 (149.09%) and control (37.60%). Statistical analysis showed that the increment of P at C/N=40 was significantly affected by N_0.

Figure 4.4(d) shows the highest increment of P at C/N=45 occurred in R3 (316.83%) followed R2 (235.42%), R1 (230.32%) and control (68.04%). Statistical analysis showed that the P increment at C/N=45 was not significantly affected by R1 but significantly affected by R2 and R3.

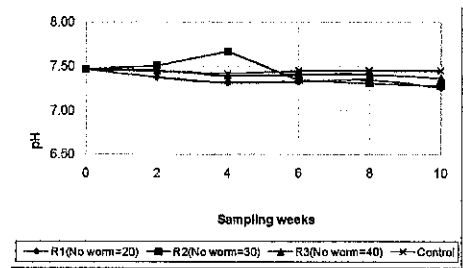
Figure 4.4(e) shows the highest increment of P at C/N=50 was in R3 (728.90%) followed by R1 (402.69%), R2 (400.00%) and control (67.76%). Statistical analysis showed that the P increment at C/N=50 was not significantly affected by R1 and R2 but significantly affected by and R3.

From Figure 4.4, it was observed that available P increased greatest in R3 at C/N=50 (728.90 %). Mansell *et al.* (1981) observed that plant litter was found to contain more available P after ingested by earthworms, which may be due to the physical breakdown of the plant material by worms. Edwards and Bohlen (1996) also found that increase in total P during vermicomposting is probably due to mineralization and mobilization of P as a result of bacterial and faecal phosphatase activity of earthworms. At 5% level of significance, it was indicated that the increment of P was significantly affected by N_0 at C/N=30, 35 and 40. At C/N=45, the P increment was not significantly affected by R1 but significantly affected by R2 and R3. However, the P increment at C/N= 50 was not significantly affected by R1 and R2 but significantly affected by and R3.

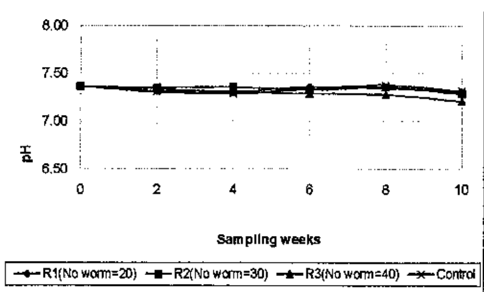
4.2.5 pH vs Sampling Weeks for R1 (N_0=20), R2 (N_0=30), R3 (N_0=40) and Control (N_0=0) containing Various C/N Ratios



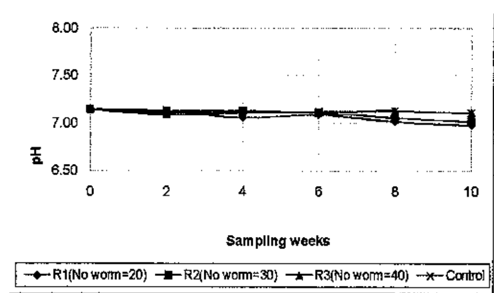
(a) C/N=30



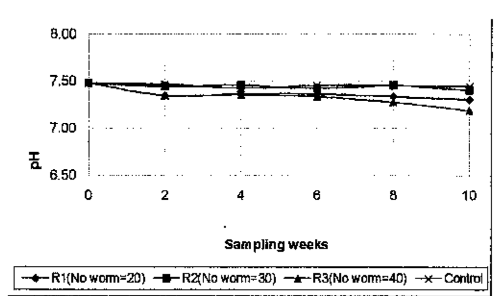
(b) C/N=35



(c) C/N=40



(d) C/N=45



(e) C/N=50

Figure 4.5: pH vs sampling weeks for R1, R2, R3 and control

Figure 4.5(a) shows the highest reduction of pH at C/N=30 was in R2 (7.49%) followed by R3 (4.55%), R1 (2.45%) and control (0.21%). %). Statistical analysis showed that the changes of pH at C/N=30 was not significantly affected by N_0.

Figure 4.5(b) shows the highest reduction of pH at C/N=35 was in R1 (2.83%) followed by R2 (2.54%), R3 (1.36%) and control (0.29%). Statistical analysis showed that the pH changes at C/N=35 was not significantly affected by R1 but significantly affected by R2 and R3.

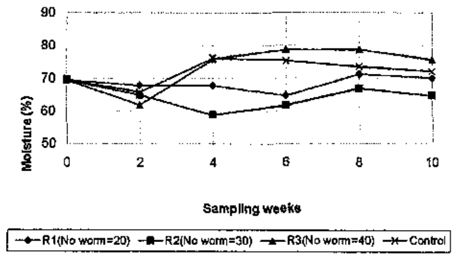
Figure 4.5(c) shows the highest reduction of pH at C/N=40 was in R3 (2.09%) followed by R2 (1.00%), R1 (0.73%) and control (0.59%). Statistical analysis showed that the changes of pH at C/N=40 was not significantly affected by N_0.

Figure 4.5(d) shows the highest reduction of pH at C/N=45 was in R1 (2.30%) followed by R2 (1.74%), R1 (0.48%) and control (0.48%). Statistical analysis showed that the changes of pH at C/N=45 was not significantly affected by N_0.

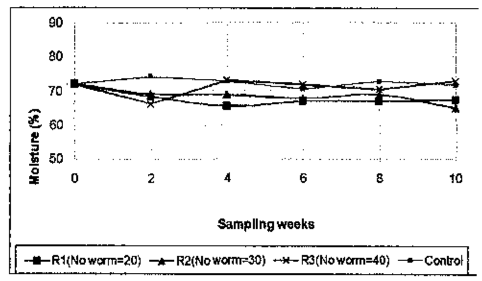
Figure 4.5(e) shows the highest reduction of pH at C/N=50 was at R3 (3.92%) followed by R1 (2.31%), R2 (0.98%) and control (0.44%). Statistical analysis showed that the pH changes at C/N=50 was not significantly affected by R1 and R3 but significantly affected by R2.

From Figure 4.5, it was observed that the maximum reduction of pH until Week 10 of vermicomposting was in R2 at C/N=30 (7.40%). At 5% level of significance, it was indicated that the increment of pH was not significantly affected by N_0 at C/N=30, 35, 40 and 45. At C/N=50, the increment of pH was not significantly affected by R1 and R3 but significantly affected by R2. However, it can be concluded that the changes of pH in vermicomposting of yard waste and shredded paper was not affected by N_0.

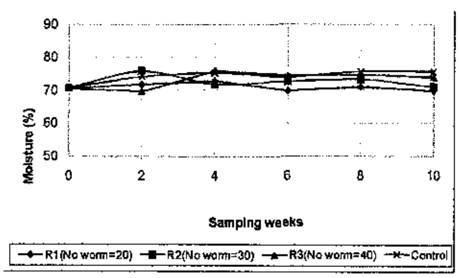
4.2.6 Moisture Content vs Sampling Weeks for R1 (N_0=20), R2 (N_0=30), R3 (N_0=40) and Control (N_0=0) containing Various C/N Ratios



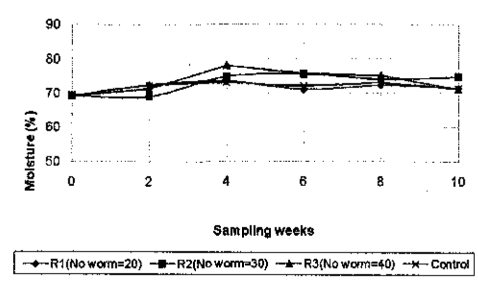
(a) C/N=30



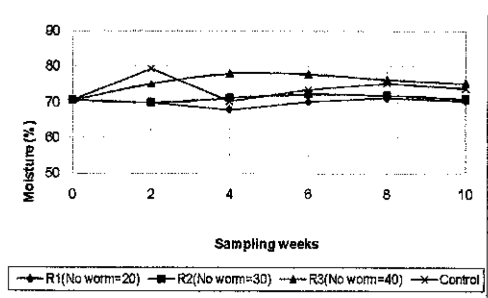
(b) C/N=35



(c) C/N=40



(d) C/N=45



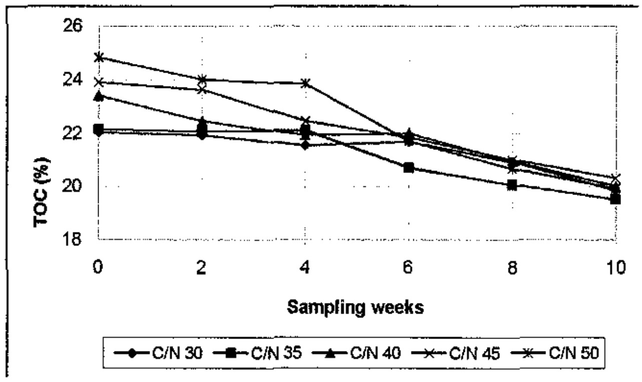
(e) C/N=50

Figure 4.6: Moisture content vs sampling weeks for R1, R2, R3 and control

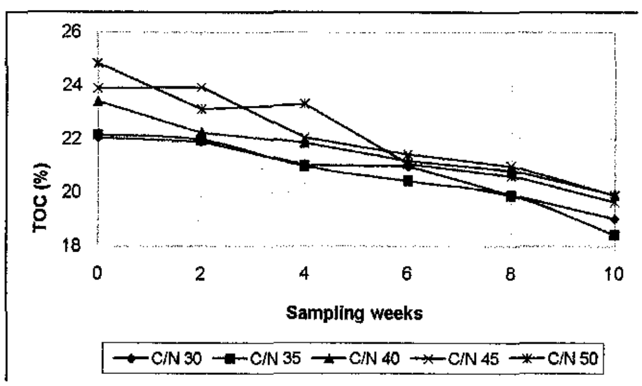
Moisture content for all reactors (R1, R2, R3 and control) having various C/N ratios were kept between 70-90% by spraying adequate quantity of water every 24 hours.

4.3 Effects of Various Initial Number of Earthworms (N_0) with Fixed C/N Ratios

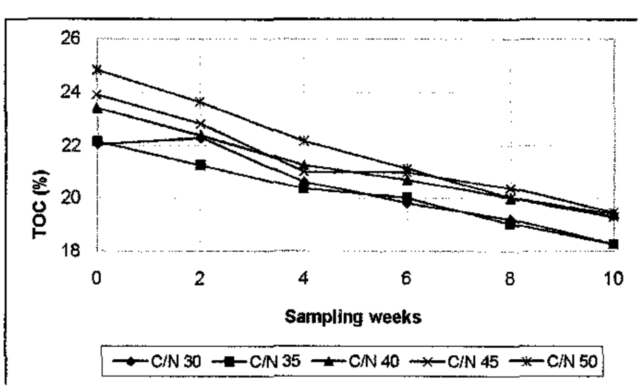
4.3.1 TOC vs Sampling Weeks for C/N=30, 35, 40, 45 and 50 containing Various Initial Number of Earthworms (N_0)



(a) R1 (N_0=20)



(b) R2 (N_0=30)



(c) R3 (N_0=40)

Figure 4.7: TOC vs sampling weeks for C/N=30, 35, 40, 45 and 50

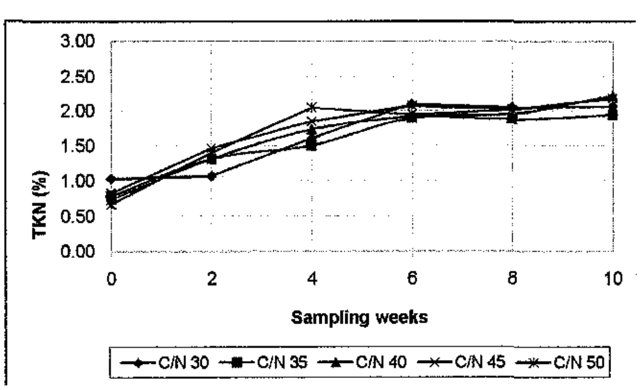
Figure 4.7(a) shows the highest reduction of TOC in R1 was at C/N=50 (19.77%) followed by C/N=45 (15.01%), C/N=40 (14.52%), C/N=35 (11.87%) and C/N=30 (9.97%). Based on statistical analysis, the reduction of TOC in R1 was not significantly affected by C/N at 5% level of significance.

Figure 4.7(b) shows the highest TOC reduction in R2 was at C/N=50 (20.89%) followed by C/N=35 (16.84%), C/N=45 (16.81%), C/N=40 (14.95%) and C/N=30 (13.74%). Statistical analysis showed that at 5% level of significance, the reduction of TOC in R2 was not significantly affected by C/N.

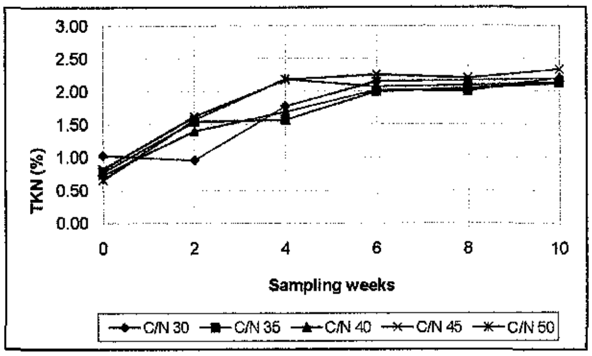
Figure 4.7(c) shows the highest TOC reduction in R3 was at C/N=50 (22.26%) followed by C/N=45 (18.53%), C/N=35 (17.43%), C/N=30 (17.09%) and C/N=40 (17.04%). Statistical analysis showed that at 5% level of significance, the reduction of TOC in R3 was not significantly affected by C/N.

From Figure 4.7, the maximum reduction of TOC was in R3 at C/N=50 (22.26%). Statistical analysis showed that the reduction of TOC in vermicomposting of yard waste and shredded paper was not significantly affected by C/N ratio.

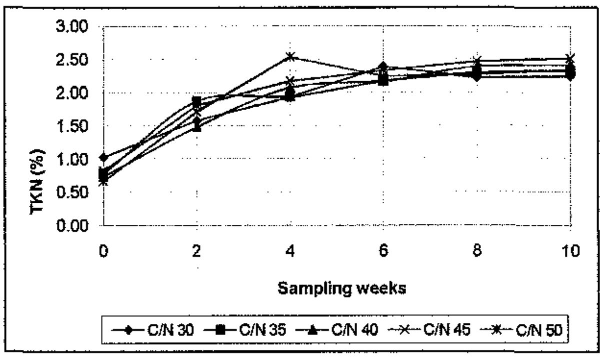
4.3.2 TKN vs Sampling Weeks for C/N=30, 35, 40, 45 and 50 containing Various Initial Number of Earthworms (N_0)



(a) R1 (N_0=20)



(b) R2 (N_0=30)



(c) R3 (N_0=40)

Figure 4.8: TKN vs sampling weeks for C/N=30, 35, 40, 45 and 50

Figure 4.8(a) shows the highest TKN increment in R1 was at C/N=50 (225.66%) followed by C/N=40 (200.43%), C/N=45 (163.85%), C/N=35 (147.41%) and C/N=30 (100.02%). Based on statistical analysis, at 5% level of significance, the increment of TKN in R1 was not significantly affected by C/N.

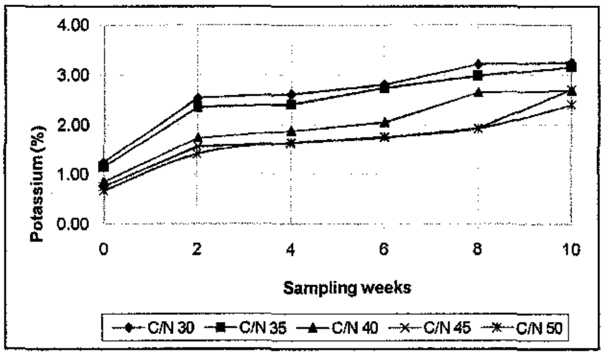
Figure 4.8(b) shows the highest TKN increment in R2 was at C/N=50 (217.31%) followed by C/N=40 (196.46%), C/N=45 (180.35%), C/N=35 (169.45%) and C/N=30 (112.08%). Based on statistical analysis, at 5% level of significance, the increment of TKN in R2 was not significantly affected by C/N.

Figure 4.8(c) shows the highest TKN increment in R3 was at C/N=50 (247.53%) followed by C/N=40 (223.52%), C/N=45 (202.38%), C/N=35 (194.23%) and C/N=30

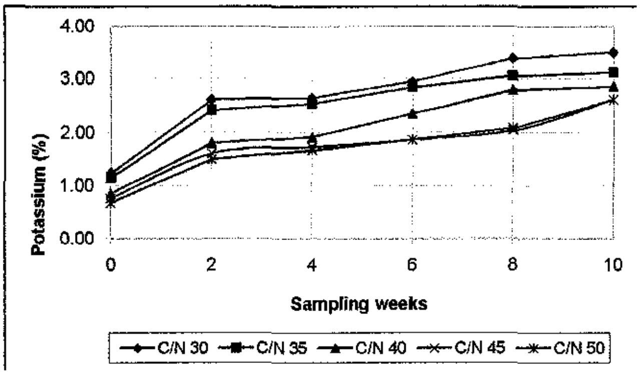
(116.19%). Based on statistical analysis, at 5% level of significance, the increment of TKN in R3 was not significantly affected by C/N.

From Figure 4.8, the maximum increment of TKN was in R3 at C/N=50 (247.53%). Analysis on variance conducted on substrates from R1, R2 and R3 showed that the increment of TKN was not significantly different at 5% level of significance. It can be concluded that C/N used did not have any significant impact on the result.

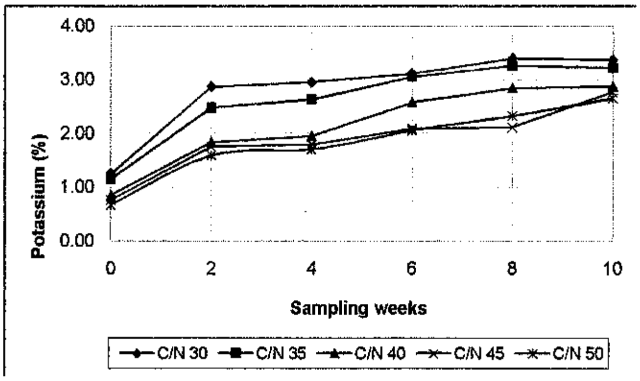
4.3.3 K vs Sampling Weeks for C/N=30, 35, 40, 45 and 50 containing Various Initial Number of Earthworms (N_0)



(a) R1 (N_0=20)



(b) R2 (N_0=30)



(c) R3 (N_0=40)

Figure 4.9: K vs sampling weeks for C/N=30, 35, 40, 45 and 50

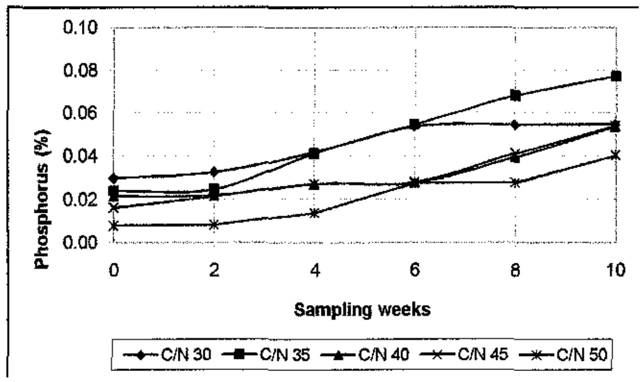
Figure 4.9(a) shows the highest K increment in R1 was at C/N=50 (254.25%) followed by C/N=45 (253.22%), C/N=40 (215.12%), C/N=35 (173.54%) and C/N=30 (160.22%). Statistical analysis showed that the increment of K in R1 was not significantly affected by C/N=35 and 40 but significantly affected by C/N=45 and 50.

Figure 4.9(b) shows the highest K increment in R2 was at C/N=50 (284.22%) followed by C/N=45 (240.46%), C/N=40 (233.74%), C/N=35 (179.48%) and C/N=30 (169.92%). Statistical analysis showed that the increment of K in R2 was not significantly affected by C/N=35 and 40 but significantly affected by C/N=45 and 50.

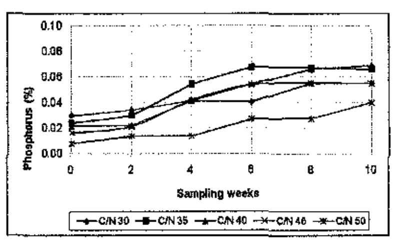
Figure 4.9(c) shows the highest K increment in R3 was at C/N=50 (290.00%) followed by C/N=45 (260.85%), C/N=40 (236.21%), C/N=35 (178.47%) and C/N=30 (169.24%). Statistical analysis showed that the increment of K in R3 was not significantly affected by C/N=35 and 40 but significantly affected by C/N=45 and 50.

From Figure 4.9, the maximum increment of K was in R3 at C/N=50 (290.00%). Based on statistical analysis, it can be concluded that the increment of K was not significantly affected by C/N=35 and 40 but significantly affected by C/N=45 and 50.

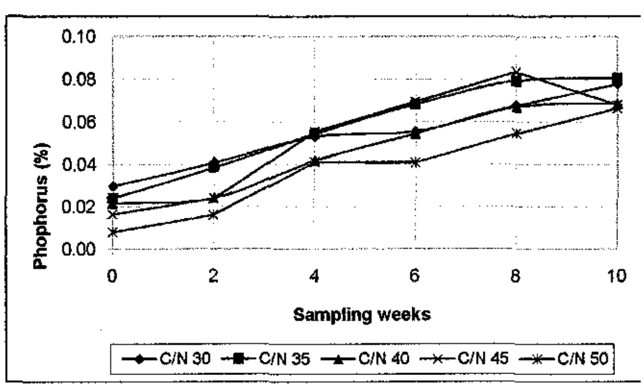
4.3.4 P vs Sampling Weeks for C/N=30, 35, 40, 45 and 50 containing Various Initial Number of Earthworms (N_0)



(a) R1 (N_0=20)



(b) R2 (N_0=30)



(c) R3 (N_0=40)

Figure 4.10: P vs sampling weeks for C/N=30, 35, 40, 45 and 50

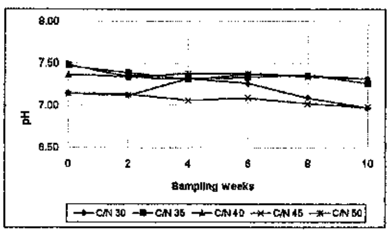
Figure 4.10(a) shows the highest P increment in R1 was at C/N=50 (402.69%) followed by C/N=45 (230.32%), C/N=35 (221.50%), C/N=40 (149.09%) and C/N=30 (83.17%). Statistical analysis showed that the increment of P in R1 was not significantly affected by C/N=35, 40 and 45 but significantly affected by C/N=50.

Figure 4.10(b) shows the highest P increment in R2 was at C/N=50 (400.00%) followed by C/N=45 (235.42%), C/N=35 (218.63%), C/N=40 (174.43%) and C/N=30 (84.28%). Statistical analysis showed that the increment of P in R2 was not significantly affected by C/N=35, 40 and 45 but significantly affected by C/N=50.

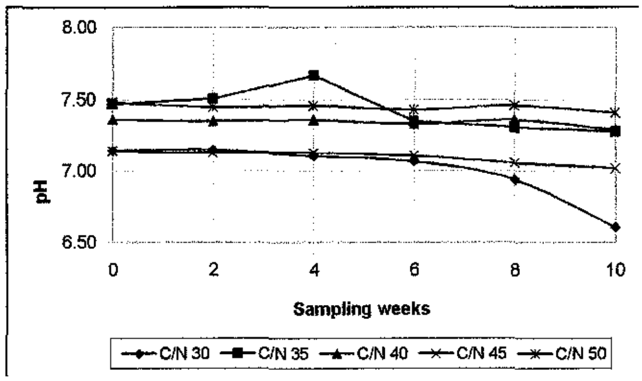
Figure 4.10(c) shows the highest P increment in R3 was at C/N=50 (728.90%) followed by C/N=45 (316.83%), C/N=35 (234.93%), C/N=40 (218.38%) and C/N=30 (160.66%). Statistical analysis showed that the increment of P in R3 was not significantly affected by C/N ratio.

From Figure 4.10, the maximum increment of P was in R3 at C/N=50 (718.90%). Statistical analysis showed that the increment of P in R1 and R2 was not significantly affected by C/N=35, 40 and 45 but significantly affected by C/N=50. However, the increment of P in R3 was not significantly affected by C/N ratio.

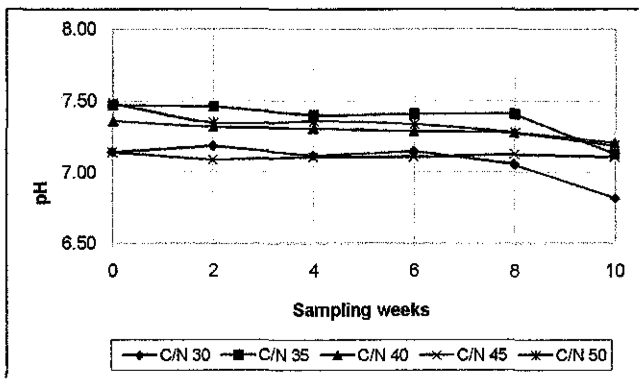
4.3.5 pH vs Sampling Weeks for C/N=30, 35, 40, 45 and 50 containing Various Initial Number of Earthworms (N_0)



(a) R1 (N_0=20)



(b) R2 (N_0=30)



(c) R3 (N_0=40)

Figure 4.11: pH vs sampling weeks for C/N=30, 35, 40, 45 and 50

Figure 4.11(a) shows the highest pH increment in R1 was at C/N=35 (2.83%) followed by C/N=30 (2.45%), C/N=50 (2.31%), C/N=45 (2.30%) and C/N=40 (0.73%). Statistical analysis showed that the increment of pH in R1 was not significantly affected by C/N=45 but significantly affected by C/N=35, 40 and 50.

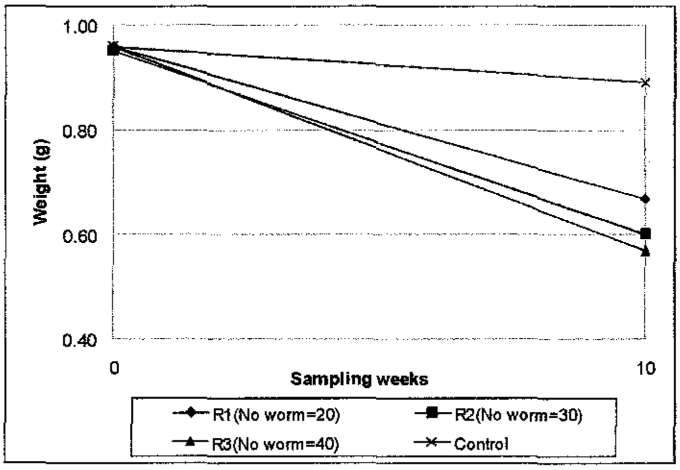
Figure 4.11(b) shows the highest pH increment in R2 for was at C/N=30 (7.49%) followed by C/N=35 (2.57%), C/N=45 (1.74%), C/N=40 (1.00%) and C/N=50 (0.98%). Statistical analysis showed that the increment of pH in R2 was not significantly affected by C/N=45 but significantly affected by C/N=35, 40 and 50.

Figure 4.11(c) shows the highest pH increment in R3 was at C/N=35 (4.57%) followed by C/N=30 (4.55%), C/N=50 (3.92%), C/N=40 (2.09%) and C/N=45 (0.48%).

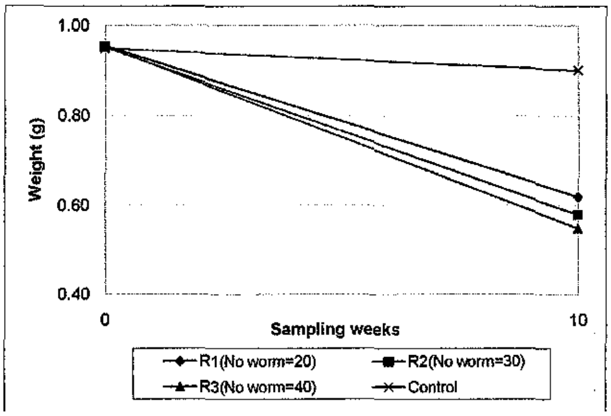
Statistical analysis showed that the increment of pH in R3 was not significantly affected by C/N=45 but significantly affected by C/N=35, 40 and 50.

From Figure 4.11, the maximum increment of pH was in R2 at C/N=30 (7.49%). Statistical analysied shows that the increment of pH was not significantly affected by C/N=45 but significantly affected by C/N=35, 40 and 50.

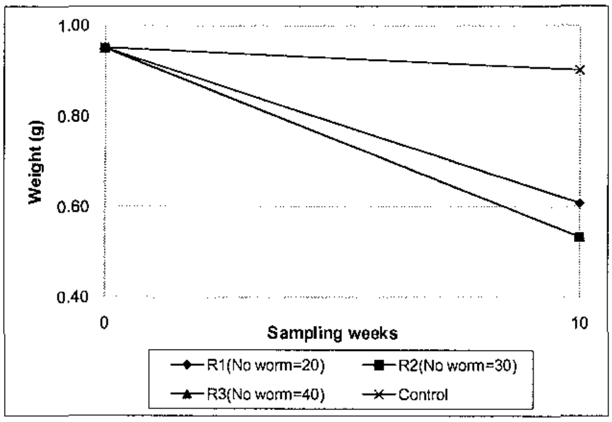
4.4 Reduction of Weight of Substrate after Vermicomposting



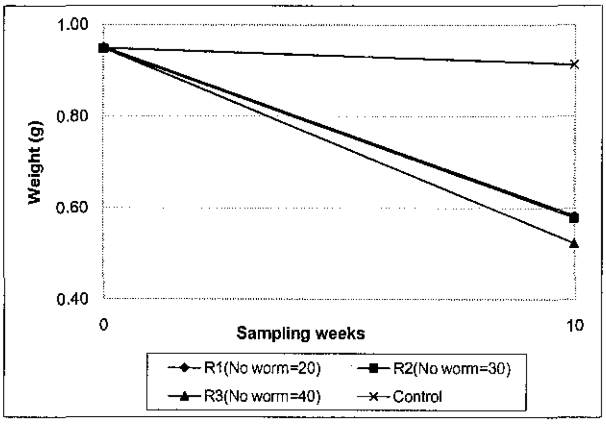
(a) C/N=30



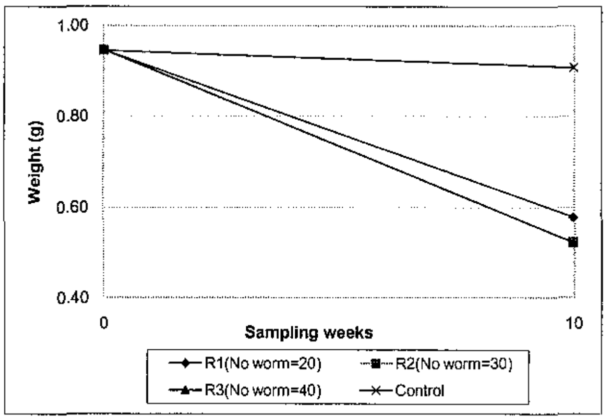
(b) C/N=35



(c) C/N=40



(d) C/N=45



(e) C/N=50

Figure 4.12: Weight of substrate vs sampling weeks for R1, R2, R3 and control

Figure 4.12(a) shows the maximum reduction of weight of substrate at C/N=30 was in R3 (40.53%) followed by R2 (36.84%), R1 (30.06%) and control (6.90%).

Figure 4.12(b) shows the maximum reduction of weight of substrate at C/N=35 was in R3 (42.35%) followed by R2 (39.08%), R1 (35.01%) and control (5.06%).

Figure 4.12(c) shows the highest reduction of weight of substrate at C/N=40 was in R3 (43.79%) followed by R2 (43.68%), R1 (35.86%) and control (5.04%).

Figure 4.12(d) shows the highest reduction of weight of substrate at C/N=45 was in R3 (44.62%) followed by R2 (38.82%), R1 (38.49%) and control (3.58%).

Figure 4.12(e) shows the highest reduction of weight of substrate at C/N=50 was in R3 (44.56%) followed by R2 (44.50%), R1 (38.69%) and control (3.81%).

From Figure 4.12, the maximum reduction of weight of substrate in vermicomposting of yard waste and shredded paper was in R3 at C/N=45 (44.62%). The loss of weight of the substrate was due to conversion of substrate to vermicompost by earthworms during vermicomposting process (Suthar, 2006).

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

From the results discussed in Chapter 4, it was observed that until week 10 vermicomposting has significantly modified the chemical properties of yard waste and shredded paper.

The maximum reduction of TOC was in R3 at C/N=50 (22.26%). At 5% level of significance, it was indicated that the reduction of TOC was not significantly affected by N_0 at C/N=30, 35 and 50. At C/N=40 and 45, the TOC reduction was not significantly affected by R1 and R2. However, the TOC reduction at C/N= 40 and 45 was significantly affected by R3.

The highest increment of TKN occurred in R3 at C/N=50 (247.53%). Based on the statistical analysis performed at 5% level of significance, the increment of TKN at C/N=30, 35, 40, 45 and 50 was significantly affected by N_0.

The highest increment of K was in R3 at C/N=50 (290.00%). Statistical analysis at 5% level of significance shows that there was no effect of N_0 to the increment of K at C/N=30, 35, 40, 45 and 50.

Available P increased greatest in R3 at C/N=50 (728.90 %). At 5% level of significance, it was indicated that the increment of P was significantly affected by N_0 at C/N=30, 35 and 40. At C/N=45, the P increment was not significantly affected by R1 but significantly affected by R2 and R3. However, the P increment at C/N= 50 was not significantly affected by R1 and R2 but significantly affected by and R3.

The maximum reduction of pH until Week 10 of vermicomposting was in R2 at C/N=30 (7.40%). At 5% level of significance, it was indicated that the increment of pH was not significantly affected by N_0 at C/N=30, 35, 40 and 45. At C/N=50, the increment of pH was not significantly affected by R1 and R3 but significantly affected by R2. However, it can be concluded that the changes of pH in vermicomposting of yard waste and shredded paper was not affected by N_0.

The maximum reduction of weight of substrate after 10 weeks of vermicomposting was in R3 at C/N=45 (44.62%).

From the results, it can be concluded that reactor with larger N_0 performed better degradation that reactor with less N_0. The presence of earthworm in the system had further enhanced the efficiency of composting process of the substrate. Higher C/N ratio indicated better efficiency for vermicomposting of the substrate. As a conclusion, the experimental data had provided that C/N=50 and N_0=40 was the most efficient condition for optimum vermicomposting of yard waste and shredded paper.

5.2 Recommendation

For further study, it is recommended that the vermicompost needs to be taken for further chemical analysis to ensure the compost is suitable to be used as plant fertilizer.

REFERENCES

1. Local Government Department Ministry Of Housing & Local Government (2003) "Overview Of Solid Waste Management In Malaysia".
2. Appelhof Mary (2008) "Worms Eat My Garbage".
3. Baker, G. and Barrett, V. (1994) "Earthworm Identifier" CSIRO Publications: East Melbourne.
4. Dominguez, J. and Edwards, C.A. (1997) "Effects of stocking rate and moisture content on the growth and maturation of *Eisenia andrei* (Oligochaeta) in pig manure." Soil Biology and Biochemistry, 29 (3/4): 743-746.
5. Edwards, C.A. and Bohlen, P.J. (1996) "Biology and Ecology of Earthworms." 3rd Edn. Chapman & Hall: London.
6. Edwards, C.A. (1995) "Historical overview of vermicomposting." BioCycle, 36 (6): 56-58.
7. Environmental Protection Agency (EPA). Fact sheet on Municipal Solid Waste (2002) (http://www.epa.gov/epaoswer/nonhw/muncpl/facts.htm).
8. Gupta R. and Garg V.K. (21 Sept 2007) "Stabilization of primary sewage sludge during vermicomposting".
9. Hallatt, L., Reinecke, A.J. and Viljoen, S.A. (1990) "Life cycle of the oriental compost worm *Perionyx excavatus* (Oligochaeta)." South African Journal of Zoology, 25 (1): 41- 45.
10. Jais, H. (2008) "Teknologi vermikultur dalam pelupusan sisa dapur dan penghasilan baja organic".
11. Frederickson J., Kevin R., Richard M. and Daniel C. (1997) "Combining vermiculture with traditional green waste composting systems".
12. Kaushik P. and Garg V.K. (2003) "Vermicomposting of mixed solid textile mill sludge and cow dung with epigeic earthworm *Eisenia foetida*" Biosour. Technol. 90(2003), pp. 311-316.

13. Kaviraj and S. Sharma (2003) "Municipal solid waste management through vermicomposting employing exotic and local species of earthworms".

14. Mansell *et al.* (1981) "Plant availability of phosphorus in dead herbage ingested by surface-casting earthworms" Soil Biol. Biochem. 13, 163-167.

15. Murphy, D. (1993) "Earthworms in Australia: a blueprint for a better environment." Hyland House: South Melbourne.

16. Parvaresh et al. (2004) "Vermistabilization of Municipal Wastewater Sludge with *Eisenia foetida*".

17. Garg P. et al. (2004) "Vermicomposting of different types of waste using *Eisenia Foetida*: A comparative study".

18. Suthar S. (2006) "Vermicomposting potential of *Perionyx sansibaricus* (Perrier) in different waste materials".

19. The Solid Waste Management Board (2008) "Program For Handling Yard Waste In West Virginia".

20. William F. Cosulich Associates, LTD. (1991) "Preliminary Feasibility Study of Alternative Project Concepts for Processing and Materials Recovery of Solid Wastes Generated Within Waste Shed "H"".

APPENDICES

Appendix A – Formula for Potassium and Phosphorus

$$Potassium(\%) = \frac{1.4 \times A \times 0.1}{B}$$

$A = potassium(mg/L)$

$B = weightofsample(g)$

$$Phosphorus(\%) = \frac{1.4 \times A \times 0.1}{B}$$

$A = phosphorus(mg/L)$

$B = weightofsample(g)$

Appendix B – Sample calculation for Total Kjeldahl Nitrogen, Potassium and Phosphorus

1) Sample calculation for TKN

Week 0

Sample	Weight (g)	Remaining volume (mL)	Volume titrated (mL)	A	B	Nitrogen (%)	mg/kg	g/g (%)
30	0.5162	124	3.17	20.35	1.34	0.001031	10311.94	1.03
35	0.5243	132	2.37	16.03	1.34	0.000785	7846.602	0.78
40	0.5195	135	2.186	15.07	1.34	0.000740	7400.654	0.74
45	0.5144	150	2.194	16.54	1.34	0.000828	8275.707	0.83
50	0.5233	151	1.826	13.84	1.34	0.000669	6692.69	0.67

Week 2

C/N	Reactor	Weight (g)	Remaining volume (mL)	Volume titrated (mL)	A	B	Nitrogen (%)	mg/kg	g/g (%)
30	R1(N_o worm=20)	0.5161	130	3.103	20.72	0.97	0.001071	10713.74	1.07
	R2(N_o worm=30)	0.5303	131	2.851	19.16	0.97	0.000960	9603.286	0.96
	R3(N_o worm=40)	0.5152	143	4.150	30.03	0.97	0.001579	15794.81	1.58
	Control	0.5239	150	3.060	23.07	0.97	0.001181	11809.76	1.18
35	R1(N_o worm=20)	0.5104	126	3.841	24.98	0.97	0.001317	13173.52	1.32
	R2(N_o worm=30)	0.5166	120	4.728	29.53	0.97	0.001548	15480.24	1.55
	R3(N_o worm=40)	0.5092	120	5.596	34.95	0.97	0.001869	18686.48	1.87
	Control	0.5781	120	3.102	19.38	0.97	0.000891	8914.272	0.89
40	R1(N_o worm=20)	0.514	160	3.161	25.19	0.97	0.001319	13193.75	1.32
	R2(N_o worm=30)	0.5037	155	3.382	26.22	0.97	0.001404	14037.65	1.40
	R3(N_o worm=40)	0.5252	125	4.460	28.82	0.97	0.001485	14846.44	1.48
	Control	0.5147	131	2.487	16.71	0.97	0.000856	8563.669	0.86
45	R1(N_o worm=20)	0.5245	184	3.168	28.52	0.97	0.001471	14707.86	1.47
	R2(N_o worm=30)	0.52	194	3.296	31.09	0.97	0.001622	16220.17	1.62
	R3(N_o worm=40)	0.5275	183	3.906	35.00	0.97	0.001806	18061.71	1.81
	Control	0.5247	149	2.369	17.76	0.97	0.000896	8957.537	0.90
50	R1(N_o worm=20)	0.5024	131	3.912	26.29	0.97	0.001411	14110.27	1.41
	R2(N_o worm=30)	0.5048	155	3.786	29.36	0.97	0.001574	15744.61	1.57
	R3(N_o worm=40)	0.5234	140	4.636	32.95	0.97	0.001711	17108.4	1.71
	Control	0.5395	126	2.199	14.30	0.97	0.000692	6919.746	0.69

Week 4

C/N	Reactor	Weight (g)	Remaining volume (mL)	Volume titrated (mL)	A	B	Nitrogen (%)	mg/kg	g/g (%)
30	R1(N_o worm=20)	0.5005	132	4.402	29.77	0.97	0.001611	16112.48	1.61
	R2(N_o worm=30)	0.5055	124	5.154	33.08	0.97	0.001779	17786.37	1.78
	R3(N_o worm=40)	0.5259	138	5.302	37.23	0.97	0.001930	19304.61	1.93
	Control	0.5027	120	3.698	23.10	0.97	0.001233	12325.28	1.23
35	R1(N_o worm=20)	0.5094	131	4.226	28.40	0.97	0.001508	15076.64	1.51
	R2(N_o worm=30)	0.5156	121	4.758	29.92	0.97	0.001572	15723.75	1.57
	R3(N_o worm=40)	0.5129	159	4.598	36.44	0.97	0.001937	19366.05	1.94
	Control	0.5148	115	3.102	18.71	0.97	0.0009647	9647.407	0.96
40	R1(N_o worm=20)	0.5148	138	4.678	32.85	0.97	0.0017338	17337.79	1.73
	R2(N_o worm=30)	0.5069	124	4.928	31.63	0.97	0.0016936	16935.98	1.69
	R3(N_o worm=40)	0.5007	130	5.692	38.01	0.97	0.0020711	20710.63	2.07
	Control	0.5122	117	2.906	17.78	0.97	0.0009187	9187.071	0.92
45	R1(N_o worm=20)	0.5127	125	5.396	34.87	0.97	0.0018512	18511.82	1.85
	R2(N_o worm=30)	0.502	119	6.456	40.05	0.97	0.0021796	21795.97	2.18
	R3(N_o worm=40)	0.503	116	6.598	40.08	0.97	0.0021768	21768.32	2.18
	Control	0.5301	113	2.887	17.16	0.97	0.0008553	8552.706	0.86
50	R1(N_o worm=20)	0.5043	127	5.781	37.85	0.97	0.0020478	20477.93	2.05
	R2(N_o worm=30)	0.5072	135	5.893	40.62	0.97	0.0021887	21886.8	2.19
	R3(N_o worm=40)	0.5076	124	7.309	46.91	0.97	0.0025343	25342.61	2.53
	Control	0.5084	110	2.763	16.07	0.97	0.0008315	8315.134	0.83

Week 6

C/N	Reactor	Weight (g)	Remaining volume (mL)	Volume titrated (mL)	A	B	Nitrogen (%)	mg/kg	g/g (%)
30	R1(N_o worm=20)	0.5209	125	6.187	39.98	0.97	0.002	20967.35	2.10
	R2(N_o worm=30)	0.5198	117	6.703	41.00	0.97	0.002	21563.42	2.16
	R3(N_o worm=40)	0.5023	125	6.772	43.76	0.97	0.002	23850.87	2.39
	Control	0.5149	120	3.697	23.09	0.97	0.001	12029.42	1.20
35	R1(N_o worm=20)	0.5128	128	5.408	35.64	0.97	0.002	18931.72	1.89
	R2(N_o worm=30)	0.5198	142	5.301	38.13	0.97	0.002	20018.97	2.00
	R3(N_o worm=40)	0.5127	130	6.086	40.64	0.97	0.002	21662.17	2.17
	Control	0.5077	125	2.907	18.78	0.97	0.001	9823.941	0.98
40	R1(N_o worm=20)	0.5041	120	5.688	35.53	0.97	0.002	19194.71	1.92
	R2(N_o worm=30)	0.5131	125	5.901	38.13	0.97	0.002	20277.63	2.03
	R3(N_o worm=40)	0.5129	130	6.103	40.75	0.97	0.002	21715.68	2.17
	Control	0.5123	126	2.908	18.92	0.97	0.001	9807.728	0.98
45	R1(N_o worm=20)	0.5003	130	5.691	38.00	0.97	0.002	20723.02	2.07
	R2(N_o worm=30)	0.5198	128	6.496	42.81	0.97	0.002	22539.44	2.25
	R3(N_o worm=40)	0.5031	135	6.209	42.79	0.97	0.002	23276.88	2.33
	Control	0.5102	115	3.283	19.80	0.97	0.001	10333.02	1.03
50	R1(N_o worm=20)	0.5074	121	5.771	36.30	0.97	0.002	19493.15	1.95
	R2(N_o worm=30)	0.5126	126	5.992	38.98	0.97	0.002	20759.59	2.08
	R3(N_o worm=40)	0.5134	124	6.573	42.19	0.97	0.002	22479.5	2.25
	Control	0.5381	121	2.898	18.23	0.97	0.001	8978.841	0.90

Week 8

C/N	Reactor	Weight (g)	Remaining volume (mL)	Volume titrated (mL)	A	B	Nitrogen (%)	mg/kg	g/g (%)
30	R1(N_o worm=20)	0.5129	123	6.039	38.50	0.97	0.002	20488.3	2.05
	R2(N_o worm=30)	0.5087	125	6.246	40.36	0.97	0.002	21680.04	2.17
	R3(N_o worm=40)	0.5172	126	6.461	42.03	0.97	0.002	22226.51	2.22
	Control	0.5298	129	3.578	23.74	0.97	0.001	12031.4	1.20
35	R1(N_o worm=20)	0.5145	128	5.387	35.50	0.97	0.002	18793.85	1.88
	R2(N_o worm=30)	0.5207	128	5.926	39.06	0.97	0.002	20480.34	2.05
	R3(N_o worm=40)	0.5299	132	6.564	44.39	0.97	0.002	22944.28	2.29
	Control	0.5022	121	3.062	19.26	0.97	0.001	10195.77	1.02
40	R1(N_o worm=20)	0.5319	120	6.112	38.18	0.97	0.002	19585.63	1.96
	R2(N_o worm=30)	0.5296	123	6.123	39.04	0.97	0.002	20125.37	2.01
	R3(N_o worm=40)	0.5215	130	6.797	45.38	0.97	0.002	23845.51	2.38
	Control	0.5127	125	2.928	18.92	0.97	0.001	9802.241	0.98
45	R1(N_o worm=20)	0.5098	128	5.728	37.75	0.97	0.002	20201.49	2.02
	R2(N_o worm=30)	0.5064	130	6.119	40.86	0.97	0.002	22053.49	2.21
	R3(N_o worm=40)	0.5034	135	6.582	45.37	0.97	0.002	24692.95	2.47
	Control	0.5101	120	3.213	20.07	0.97	0.001	10483.18	1.05
50	R1(N_o worm=20)	0.5041	118	6.042	37.22	0.97	0.002	20133.75	2.01
	R2(N_o worm=30)	0.5035	127	5.905	38.66	0.97	0.002	20961.54	2.10
	R3(N_o worm=40)	0.5121	130	6.376	42.57	0.97	0.002	22746.26	2.27
	Control	0.5142	117	3.014	18.44	0.97	0.001	9510.647	0.95

Week 10

C/N	Reactor	Weight (g)	Remaining volume (mL)	Volume titrated (mL)	A	B	Nitrogen (%)	mg/kg	g/g (%)
30	R1(N_o worm=20)	0.5124	121	6.156	38.72	0.97	0.002	20626.08	2.06
	R2(N_o worm=30)	0.5093	120	6.524	40.75	0.97	0.002	21869.54	2.19
	R3(N_o worm=40)	0.5401	124	6.851	43.97	0.97	0.002	22293.26	2.23
	Control	0.5291	120	3.597	22.47	0.97	0.001	11376.03	1.14
35	R1(N_o worm=20)	0.5436	121	6.147	38.66	0.97	0.002	19413.09	1.94
	R2(N_o worm=30)	0.5307	125	6.352	41.04	0.97	0.002	21142.67	2.11
	R3(N_o worm=40)	0.5218	129	6.632	44.00	0.97	0.002	23087.33	2.31
	Control	0.5112	127	3.367	22.05	0.97	0.001	11543.59	1.15
40	R1(N_o worm=20)	0.5214	120	6.784	42.37	0.97	0.002	22234.13	2.22
	R2(N_o worm=30)	0.5095	120	6.547	40.89	0.97	0.002	21939.9	2.19
	R3(N_o worm=40)	0.5099	121	7.087	44.57	0.97	0.002	23942.5	2.39
	Control	0.5203	125	3.201	20.68	0.97	0.001	10608.36	1.06
45	R1(N_o worm=20)	0.5191	123	6.502	41.45	0.97	0.002	21835.78	2.18
	R2(N_o worm=30)	0.5112	119	6.985	43.33	0.97	0.002	23200.62	2.32
	R3(N_o worm=40)	0.5142	131	6.983	46.93	0.97	0.003	25024.1	2.50
	Control	0.5102	127	3.203	20.97	0.97	0.001	10976.9	1.10
50	R1(N_o worm=20)	0.5205	126	6.378	41.49	0.97	0.002	21795.17	2.18
	R2(N_o worm=30)	0.5233	121	6.465	40.66	0.97	0.002	21236.28	2.12
	R3(N_o worm=40)	0.5261	120	7.152	44.67	0.97	0.002	23258.85	2.33
	Control	0.5199	120	3.218	20.10	0.97	0.001	10302.4	1.03

2) Sample calculation for P and K

Week 0

Sample	Weight (g)	K (ppm)	K (%)	P (mg/L)	P (%)
30	0.5162	9.2332	1.2521	0.11	0.0298
35	0.5243	8.6634	1.1567	0.09	0.0240
40	0.5195	6.3395	0.8542	0.08	0.0216
45	0.5144	5.6334	0.7666	0.06	0.0163
50	0.5233	5.0830	0.6799	0.03	0.0080

Week 2

C/N	Reactor	Weight (g)	K (ppm)	K (%)	P (mg/L)	P (%)
30	R1(N_o worm=20)	0.5161	9.3786	2.5441	0.12	0.0326
	R2(N_o worm=30)	0.5303	9.8786	2.6080	0.13	0.0343
	R3(N_o worm=40)	0.5152	10.5511	2.8671	0.15	0.0408
	Control	0.5239	9.2567	2.4736	0.11	0.0294
35	R1(N_o worm=20)	0.5104	8.6188	2.3641	0.09	0.0247
	R2(N_o worm=30)	0.5166	8.9182	2.4169	0.11	0.0298
	R3(N_o worm=40)	0.5092	8.9982	2.4740	0.14	0.0385
	Control	0.5781	9.5081	2.3026	0.10	0.0242
40	R1(N_o worm=20)	0.514	6.3957	1.7420	0.08	0.0218
	R2(N_o worm=30)	0.5037	6.5011	1.8069	0.08	0.0222
	R3(N_o worm=40)	0.5252	6.8907	1.8368	0.09	0.0240
	Control	0.5147	6.1907	1.6839	0.08	0.0218
45	R1(N_o worm=20)	0.5245	5.8690	1.5666	0.08	0.0214
	R2(N_o worm=30)	0.52	5.9906	1.6129	0.08	0.0215
	R3(N_o worm=40)	0.5275	6.6083	1.7539	0.09	0.0239
	Control	0.5247	5.7124	1.5242	0.06	0.0160
50	R1(N_o worm=20)	0.5024	5.1059	1.4228	0.03	0.0084
	R2(N_o worm=30)	0.5048	5.4168	1.5023	0.05	0.0139
	R3(N_o worm=40)	0.5234	5.9370	1.5880	0.06	0.0160
	Control	0.5395	5.2060	1.3510	0.03	0.0078

Week 4

C/N	Reactor	Weight (g)	K (ppm)	K (%)	P (mg/L)	P (%)
30	R1(N_o worm=20)	0.5005	1.869	2.6140	0.03	0.0420
	R2(N_o worm=30)	0.5055	1.907	2.6408	0.03	0.0415
	R3(N_o worm=40)	0.5259	2.215	2.9483	0.04	0.0532
	Control	0.5027	1.796	2.5009	0.02	0.0278
35	R1(N_o worm=20)	0.5094	1.758	2.4158	0.03	0.0412
	R2(N_o worm=30)	0.5156	1.876	2.5469	0.04	0.0543

	R3(N_o worm=40)	0.5129	1.925	2.6272	0.04	0.0546
	Control	0.5148	1.753	2.3836	0.02	0.0272
40	R1(N_o worm=20)	0.5148	1.386	1.8846	0.02	0.0272
	R2(N_o worm=30)	0.5069	1.391	1.9209	0.03	0.0414
	R3(N_o worm=40)	0.5007	1.398	1.9545	0.03	0.0419
	Control	0.5122	1.227	1.6769	0.01	0.0137
45	R1(N_o worm=20)	0.5127	1.198	1.6357	0.02	0.0273
	R2(N_o worm=30)	0.502	1.243	1.7333	0.03	0.0418
	R3(N_o worm=40)	0.503	1.293	1.7994	0.04	0.0557
	Control	0.5301	1.151	1.5199	0.02	0.0264
50	R1(N_o worm=20)	0.5043	1.185	1.6449	0.01	0.0139
	R2(N_o worm=30)	0.5072	1.216	1.6782	0.01	0.0138
	R3(N_o worm=40)	0.5076	1.235	1.7031	0.03	0.0414
	Control	0.5084	0.983	1.3535	0.01	0.0138

Week 6

C/N	Reactor	Weight (g)	K (ppm)	K (%)	P (mg/L)	P (%)
30	R1(N_o worm=20)	0.5209	2.0891	2.8074	0.04	0.0538
	R2(N_o worm=30)	0.5198	2.1876	2.9460	0.03	0.0404
	R3(N_o worm=40)	0.5023	2.2341	3.1134	0.04	0.0557
	Control	0.5149	1.8402	2.5017	0.02	0.0272
35	R1(N_o worm=20)	0.5128	2.006	2.7383	0.04	0.0546
	R2(N_o worm=30)	0.5198	2.1053	2.8351	0.05	0.0673
	R3(N_o worm=40)	0.5127	2.2348	3.0512	0.05	0.0683
	Control	0.5077	1.7312	2.3869	0.02	0.0276
40	R1(N_o worm=20)	0.5041	1.4831	2.0595	0.02	0.0278
	R2(N_o worm=30)	0.5131	1.7258	2.3544	0.04	0.0546
	R3(N_o worm=40)	0.5129	1.8874	2.5759	0.04	0.0546
	Control	0.5123	1.1946	1.6323	0.01	0.0137
45	R1(N_o worm=20)	0.5003	1.2503	1.7494	0.02	0.0280
	R2(N_o worm=30)	0.5198	1.3871	1.8680	0.04	0.0539
	R3(N_o worm=40)	0.5031	1.5012	2.0887	0.05	0.0696
	Control	0.5102	1.1125	1.5264	0.02	0.0274
50	R1(N_o worm=20)	0.5074	1.2783	1.7635	0.02	0.0276
	R2(N_o worm=30)	0.5126	1.3671	1.8669	0.02	0.0273
	R3(N_o worm=40)	0.5134	1.5073	2.0551	0.03	0.0409
	Control	0.5381	1.0417	1.3551	0.01	0.0130

Week 8

C/N	Reactor	Weight (g)	K (ppm)	K (%)	P (mg/L)	P (%)
30	R1(N_o worm=20)	0.5129	2.3562	3.2157	0.04	0.0546

	R2(N_o worm=30)	0.5087	2.4617	3.3874	0.04	0.0550
	R3(N_o worm=40)	0.5172	2.5116	3.3993	0.05	0.0677
	Control	0.5298	1.8935	2.5018	0.02	0.0264
35	R1(N_o worm=20)	0.5145	2.1968	2.9888	0.05	0.0680
	R2(N_o worm=30)	0.5207	2.2736	3.0565	0.05	0.0672
	R3(N_o worm=40)	0.5299	2.4705	3.2635	0.06	0.0793
	Control	0.5022	1.7131	2.3878	0.02	0.0279
40	R1(N_o worm=20)	0.5319	2.0118	2.6476	0.03	0.0395
	R2(N_o worm=30)	0.5296	2.1052	2.7826	0.05	0.0661
	R3(N_o worm=40)	0.5215	2.1181	2.8431	0.05	0.0671
	Control	0.5127	1.2023	1.6415	0.01	0.0137
45	R1(N_o worm=20)	0.5098	1.4096	1.9355	0.03	0.0412
	R2(N_o worm=30)	0.5064	1.4817	2.0482	0.04	0.0553
	R3(N_o worm=40)	0.5034	1.5197	2.1132	0.06	0.0834
	Control	0.5101	1.1092	1.5221	0.02	0.0274
50	R1(N_o worm=20)	0.5041	1.3918	1.9327	0.02	0.0278
	R2(N_o worm=30)	0.5035	1.5016	2.0876	0.02	0.0278
	R3(N_o worm=40)	0.5121	1.7037	2.3288	0.04	0.0547
	Control	0.5142	0.9936	1.3526	0.01	0.0136

Week 10

C/N	Reactor	Weight (g)	K (ppm)	K (%)	P (mg/L)	P (%)
30	R1(N_o worm=20)	0.5124	2.385	3.2582	0.04	0.0546
	R2(N_o worm=30)	0.5093	2.546	3.4993	0.04	0.0550
	R3(N_o worm=40)	0.5401	2.601	3.3710	0.06	0.0778
	Control	0.5291	1.709	2.2610	0.02	0.0265
35	R1(N_o worm=20)	0.5436	2.457	3.1639	0.06	0.0773
	R2(N_o worm=30)	0.5307	2.367	3.1221	0.05	0.0660
	R3(N_o worm=40)	0.5218	2.401	3.2210	0.06	0.0805
	Control	0.5112	1.719	2.3539	0.02	0.0274
40	R1(N_o worm=20)	0.5214	2.005	2.6918	0.04	0.0537
	R2(N_o worm=30)	0.5095	2.075	2.8508	0.05	0.0687
	R3(N_o worm=40)	0.5099	2.092	2.8719	0.05	0.0686
	Control	0.5203	1.251	1.6831	0.01	0.0135
45	R1(N_o worm=20)	0.5191	2.008	2.7078	0.04	0.0539
	R2(N_o worm=30)	0.5112	1.906	2.6099	0.04	0.0548
	R3(N_o worm=40)	0.5142	2.032	2.7662	0.05	0.0681
	Control	0.5102	1.1531	1.5821	0.02	0.0274
50	R1(N_o worm=20)	0.5205	1.791	2.4086	0.03	0.0403
	R2(N_o worm=30)	0.5233	1.953	2.6125	0.03	0.0401
	R3(N_o worm=40)	0.5261	1.993	2.6518	0.05	0.0665
	Control	0.5199	1.156	1.5565	0.01	0.0135

Appendix C – Summary of Results for TOC, TKN, P, K, pH and Moisture Content from Week 0 to Week 10

Total Organic Carbon, TOC (%)

C/N	Reactor	0	2	4	6	8	10
30	R1(N_o worm=20)	22.06	21.95	21.56	21.69	20.94	19.86
	R2(N_o worm=30)	22.06	21.91	21.03	20.99	19.91	19.03
	R3(N_o worm=40)	22.06	22.31	20.65	19.84	19.21	18.29
	Control	22.06	22.08	21.85	21.95	20.98	20.78
35	R1(N_o worm=20)	22.15	22.09	22.12	20.71	20.08	19.52
	R2(N_o worm=30)	22.15	21.97	20.99	20.43	19.89	18.42
	R3(N_o worm=40)	22.15	21.28	20.37	20.01	19.05	18.29
	Control	22.15	22.65	21.97	21.16	20.94	20.56
40	R1(N_o worm=20)	23.41	22.46	21.94	22.01	20.96	20.01
	R2(N_o worm=30)	23.41	22.24	21.86	21.18	20.84	19.91
	R3(N_o worm=40)	23.41	22.39	21.29	20.72	20.01	19.42
	Control	23.41	23.39	22.86	22.54	22.26	21.97
45	R1(N_o worm=20)	23.91	23.65	22.45	21.87	21.01	20.32
	R2(N_o worm=30)	23.91	23.95	22.04	21.42	20.99	19.89
	R3(N_o worm=40)	23.91	22.83	21.04	21.01	20.39	19.48
	Control	23.91	23.95	23.20	23.31	22.89	22.02
50	R1(N_o worm=20)	24.84	24.01	23.85	21.72	20.69	19.93
	R2(N_o worm=30)	24.84	23.12	23.32	21.08	20.62	19.65
	R3(N_o worm=40)	24.84	23.65	22.18	21.15	20.01	19.31
	Control	24.84	24.98	23.99	23.14	22.92	22.52

Total Kjeldahl Nitrogen, TKN (%)

C/N	Reactor	0	2	4	6	8	10
30	R1(N_o worm=20)	1.03	1.07	1.61	2.10	2.05	2.06
	R2(N_o worm=30)	1.03	0.96	1.78	2.16	2.17	2.19
	R3(N_o worm=40)	1.03	1.58	1.93	2.39	2.22	2.23
	Control	1.03	1.18	1.23	1.20	1.20	1.14
35	R1(N_o worm=20)	0.78	1.32	1.51	1.89	1.88	1.94
	R2(N_o worm=30)	0.78	1.55	1.57	2.00	2.05	2.11
	R3(N_o worm=40)	0.78	1.87	1.94	2.17	2.29	2.31
	Control	0.78	0.89	0.96	0.98	1.02	1.15
40	R1(N_o worm=20)	0.74	1.32	1.73	1.92	1.96	2.22
	R2(N_o worm=30)	0.74	1.40	1.69	2.03	2.01	2.19
	R3(N_o worm=40)	0.74	1.48	2.07	2.17	2.38	2.39
	Control	0.74	0.86	0.92	0.98	0.98	1.06

45	R1(N_o worm=20)	0.83	1.47	1.85	2.07	2.02	2.18
	R2(N_o worm=30)	0.83	1.62	2.18	2.25	2.21	2.32
	R3(N_o worm=40)	0.83	1.81	2.18	2.33	2.47	2.50
	Control	0.83	0.90	0.86	1.03	1.05	1.10
50	R1(N_o worm=20)	0.67	1.41	2.05	1.95	2.01	2.18
	R2(N_o worm=30)	0.67	1.57	2.19	2.08	2.10	2.12
	R3(N_o worm=40)	0.67	1.71	2.53	2.25	2.27	2.33
	Control	0.67	0.69	0.83	0.90	0.95	1.03

Potassium, K (%)

C/N	Reactor	0	2	4	6	8	10
30	R1(N_o worm=20)	1.25	2.54	2.61	2.81	3.22	3.26
	R2(N_o worm=30)	1.25	2.61	2.64	2.95	3.39	3.50
	R3(N_o worm=40)	1.25	2.87	2.95	3.11	3.40	3.37
	Control	1.25	2.47	2.50	2.50	2.50	2.26
35	R1(N_o worm=20)	1.16	2.36	2.42	2.74	2.99	3.16
	R2(N_o worm=30)	1.16	2.42	2.55	2.84	3.06	3.12
	R3(N_o worm=40)	1.16	2.47	2.63	3.05	3.26	3.22
	Control	1.16	2.30	2.38	2.39	2.39	2.35
40	R1(N_o worm=20)	0.85	1.74	1.88	2.05	2.65	2.69
	R2(N_o worm=30)	0.85	1.81	1.92	2.35	2.78	2.85
	R3(N_o worm=40)	0.85	1.84	1.95	2.58	2.84	2.87
	Control	0.85	1.68	1.68	1.63	1.64	1.68
45	R1(N_o worm=20)	0.77	1.57	1.64	1.75	1.94	2.71
	R2(N_o worm=30)	0.77	1.61	1.73	1.87	2.05	2.61
	R3(N_o worm=40)	0.77	1.75	1.80	2.09	2.11	2.77
	Control	0.77	1.52	1.52	1.53	1.52	1.58
50	R1(N_o worm=20)	0.68	1.42	1.64	1.76	1.93	2.41
	R2(N_o worm=30)	0.68	1.50	1.68	1.87	2.09	2.61
	R3(N_o worm=40)	0.68	1.59	1.70	2.06	2.33	2.65
	Control	0.68	1.35	1.35	1.36	1.35	1.56

Phosphorus, P (%)

C/N	Reactor	0	2	4	6	8	10
30	R1(N_o worm=20)	0.03	0.03	0.04	0.05	0.05	0.05
	R2(N_o worm=30)	0.03	0.03	0.04	0.04	0.06	0.05
	R3(N_o worm=40)	0.03	0.04	0.05	0.06	0.07	0.08
	Control	0.03	0.03	0.03	0.03	0.03	0.03
35	R1(N_o worm=20)	0.02	0.02	0.04	0.05	0.07	0.08
	R2(N_o worm=30)	0.02	0.03	0.06	0.07	0.07	0.07
	R3(N_o worm=40)	0.02	0.04	0.05	0.07	0.08	0.08

	Control	0.02	0.02	0.03	0.03	0.03	0.03
40	R1(No worm=20)	0.02	0.02	0.03	0.03	0.04	0.05
	R2(No worm=30)	0.02	0.02	0.04	0.05	0.07	0.07
	R3(No worm=40)	0.02	0.02	0.04	0.05	0.07	0.07
	Control	0.02	0.02	0.01	0.01	0.01	0.01
45	R1(No worm=20)	0.02	0.02	0.03	0.03	0.04	0.05
	R2(No worm=30)	0.02	0.02	0.04	0.05	0.06	0.05
	R3(No worm=40)	0.02	0.02	0.06	0.07	0.08	0.07
	Control	0.02	0.02	0.03	0.03	0.03	0.03
50	R1(No worm=20)	0.01	0.01	0.01	0.03	0.03	0.04
	R2(No worm=30)	0.01	0.01	0.01	0.03	0.03	0.04
	R3(No worm=40)	0.01	0.02	0.04	0.04	0.05	0.07
	Control	0.01	0.01	0.01	0.01	0.01	0.01

pH

C/N	Reactor	0	2	4	6	8	10
30	R1(No worm=20)	7.15	7.12	7.32	7.26	7.09	6.97
	R2(No worm=30)	7.15	7.15	7.11	7.07	6.94	6.61
	R3(No worm=40)	7.15	7.19	7.12	7.15	7.06	6.82
	Control	7.15	7.13	7.12	7.13	7.14	7.13
35	R1(No worm=20)	7.47	7.38	7.32	7.33	7.35	7.26
	R2(No worm=30)	7.47	7.51	7.67	7.35	7.31	7.28
	R3(No worm=40)	7.47	7.46	7.40	7.41	7.41	7.37
	Control	7.47	7.45	7.42	7.45	7.45	7.45
40	R1(No worm=20)	7.36	7.34	7.31	7.36	7.35	7.31
	R2(No worm=30)	7.36	7.35	7.36	7.33	7.36	7.29
	R3(No worm=40)	7.36	7.32	7.31	7.29	7.28	7.21
	Control	7.36	7.31	7.29	7.34	7.38	7.32
45	R1(No worm=20)	7.14	7.13	7.06	7.09	7.02	6.98
	R2(No worm=30)	7.14	7.13	7.13	7.11	7.06	7.02
	R3(No worm=40)	7.14	7.09	7.11	7.11	7.13	7.11
	Control	7.14	7.11	7.11	7.12	7.13	7.11
50	R1(No worm=20)	7.48	7.35	7.37	7.37	7.34	7.31
	R2(No worm=30)	7.48	7.45	7.46	7.43	7.46	7.41
	R3(No worm=40)	7.48	7.35	7.36	7.34	7.28	7.19
	Control	7.48	7.47	7.43	7.46	7.46	7.45

Moisture Content (%)

C/N	Reactor	0	2	4	6	8	10
30	R1(No worm=20)	69.63	67.91	67.90	65.07	71.56	70.42
	R2(No worm=30)	69.63	65.02	59.01	62.11	67.34	65.08

	R3(N_o worm=40)	69.63	61.93	75.92	78.94	79.07	75.92
	Control	69.63	65.91	76.12	75.62	73.91	72.41
35	*R1(N_o worm=20)*	*71.94*	*68.29*	*65.59*	*67.01*	*67.03*	*67.52*
	R2(N_o worm=30)	71.94	69.01	68.91	67.92	68.99	65.08
	R3(N_o worm=40)	71.94	66.06	73.18	71.87	70.55	72.87
	Control	71.94	74.12	72.94	70.65	72.77	71.87
40	R1(N_o worm=20)	70.81	71.91	72.99	70.18	71.43	70.21
	R2(N_o worm=30)	*70.81*	*75.94*	*72.05*	*73.09*	*73.74*	*71.41*
	R3(N_o worm=40)	70.81	69.71	76.02	74.82	75.24	74.32
	Control	70.81	74.31	75.39	74.44	76.09	75.98
45	R1(N_o worm=20)	68.99	72.09	73.48	71.08	72.33	71.35
	R2(N_o worm=30)	68.99	68.80	74.87	75.67	74.12	74.81
	R3(N_o worm=40)	*68.99*	*70.98*	*78.01*	*75.67*	*75.22*	*71.07*
	Control	68.99	71.99	73.01	72.09	72.98	71.24
50	R1(N_o worm=20)	70.65	69.96	68	70.18	71.34	70.45
	R2(N_o worm=30)	70.65	69.97	71.28	72.36	71.98	71.02
	R3(N_o worm=40)	70.65	75.21	78.09	77.89	76.39	75.34
	Control	70.65	79.41	70.38	73.56	75.41	74.01

Appendix D – % Difference of TOC, TKN, P, K, pH , Weight of Substrate and C/N Ratio between Week 0 and Week 10

TOC Difference (%)

C/N	Reactor	Week 0	Week 10	% difference
30	R1(No worm=20)		19.86	9.97
	R2(No worm=30)		19.03	13.74
	R3(No worm=40)		18.29	17.09
	Control	22.06	20.78	5.80
35	R1(No worm=20)		19.52	11.87
	R2(No worm=30)		18.42	16.84
	R3(No worm=40)		18.29	17.43
	Control	22.15	20.56	7.18
40	R1(No worm=20)		20.01	14.52
	R2(No worm=30)		19.91	14.95
	R3(No worm=40)		19.42	17.04
	Control	23.41	21.97	6.15
45	R1(No worm=20)		20.32	15.01
	R2(No worm=30)		19.89	16.81
	R3(No worm=40)		19.48	18.53
	Control	23.91	22.02	7.90
50	R1(No worm=20)		19.93	19.77
	R2(No worm=30)		19.65	20.89
	R3(No worm=40)		19.31	22.26
	Control	24.84	22.52	9.34

TKN Difference (%)

C/N	Reactor	Week 0	Week 10	% difference
30	R1(No worm=20)		2.06	-100.02
	R2(No worm=30)		2.19	-112.08
	R3(No worm=40)		2.23	-116.19
	Control	1.03	1.14	-10.32
35	R1(No worm=20)		1.94	-147.41
	R2(No worm=30)		2.11	-169.45
	R3(No worm=40)		2.31	-194.23
	Control	0.78	1.15	-47.12
40	R1(No worm=20)		2.22	-200.43
	R2(No worm=30)		2.19	-196.46
	R3(No worm=40)		2.39	-223.52
	Control	0.74	1.06	-43.34
45	R1(No worm=20)		2.18	-163.85
	R2(No worm=30)		2.32	-180.35

	R3(N_o worm=40)		2.50	-202.38
	Control	0.83	1.10	-32.64
50	*R1(N_o worm=20)*		*2.18*	*-225.66*
	R2(N_o worm=30)		2.12	-217.31
	R3(N_o worm=40)		2.33	-247.53
	Control	0.67	1.03	-53.94

K Difference (%)

C/N	Reactor	Week 0	Week 10	% difference
30	R1(N_o worm=20)		3.26	-160.22
	R2(N_o worm=30)		3.50	-179.48
	R3(N_o worm=40)		3.37	-169.24
	Control	1.25	2.26	-80.58
35	R1(N_o worm=20)		3.16	-173.54
	R2(N_o worm=30)		3.12	-169.92
	R3(N_o worm=40)		3.22	-178.47
	Control	1.16	2.35	-103.51
40	R1(N_o worm=20)		2.69	-215.12
	R2(N_o worm=30)		2.85	-233.74
	R3(N_o worm=40)		2.87	-236.21
	Control	0.85	1.68	-97.03
45	R1(N_o worm=20)		2.71	-253.22
	R2(N_o worm=30)		2.61	-240.46
	R3(N_o worm=40)		2.77	-260.85
	Control	0.77	1.58	-106.37
50	R1(N_o worm=20)		2.41	-254.25
	R2(N_o worm=30)		2.61	-284.22
	R3(N_o worm=40)		2.65	-290.00
	Control	0.68	1.56	-128.91

P Difference (%)

C/N	Reactor	Week 0	Week 10	% difference
30	R1(N_o worm=20)		0.05	-83.17
	R2(N_o worm=30)		0.05	-84.28
	R3(N_o worm=40)		0.08	-160.66
	Control	0.03	0.03	11.31
35	R1(N_o worm=20)		0.08	-221.50
	R2(N_o worm=30)		0.07	-174.43
	R3(N_o worm=40)		0.08	-234.93
	Control	0.02	0.03	-13.96
40	R1(N_o worm=20)		0.05	-149.09

	R2(N_o worm=30)		0.07	-218.63
	R3(N_o worm=40)		0.07	-218.38
	Control	*0.02*	*0.01*	*37.60*
45	R1(N_o worm=20)		0.05	-230.32
	R2(N_o worm=30)		0.05	-235.42
	R3(N_o worm=40)		0.07	-316.83
	Control	0.02	0.03	-68.04
50	*R1(N_o worm=20)*		*0.04*	*-402.69*
	R2(N_o worm=30)		0.04	-400.00
	R3(N_o worm=40)		0.07	-728.90
	Control	0.01	0.01	-67.76

pH Difference (%)

C/N	Reactor	Week 0	Week 10	% difference
30	R1(N_o worm=20)		6.97	2.45
	R2(N_o worm=30)		6.61	7.49
	R3(N_o worm=40)		6.82	4.55
	Control	7.15	7.13	0.21
35	R1(N_o worm=20)		7.26	2.83
	R2(N_o worm=30)		7.28	2.57
	R3(N_o worm=40)		7.37	1.36
	Control	7.47	7.45	0.29
40	R1(N_o worm=20)		7.31	0.73
	R2(N_o worm=30)		7.29	1.00
	R3(N_o worm=40)		7.21	2.09
	Control	7.36	7.32	0.59
45	R1(N_o worm=20)		6.98	2.30
	R2(N_o worm=30)		7.02	1.74
	R3(N_o worm=40)		7.11	0.48
	Control	7.14	7.11	0.48
50	R1(N_o worm=20)		7.31	2.31
	R2(N_o worm=30)		7.41	0.98
	R3(N_o worm=40)		7.19	3.92
	Control	7.48	7.45	0.44

Weight of Substrate Difference (%)

		Weight (g)		
C/N	Reactor	Week 0	Week 10	% difference
30	R1(N_o worm=20)	0.958	0.670	30.06
	R2(N_o worm=30)	0.950	0.600	36.84
	R3(N_o worm=40)	0.959	0.570	40.53

	Control	0.958	0.892	6.90
35	R1(No worm=20)	0.954	0.620	3.01
	R2(No worm=30)	0.952	0.580	39.08
	R3(No worm=40)	0.954	0.550	42.35
	Control	0.949	0.901	5.06
40	R1(No worm=20)	0.951	0.610	35.86
	R2(No worm=30)	0.950	0.535	43.68
	R3(No worm=40)	0.951	0.535	43.74
	Control	0.952	0.904	5.04
45	R1(No worm=20)	0.951	0.585	38.49
	R2(No worm=30)	0.948	0.580	38.82
	R3(No worm=40)	0.948	0.525	44.62
	Control	0.949	0.915	3.58
50	R1(No worm=20)	0.946	0.580	38.69
	R2(No worm=30)	0.946	0.525	44.50
	R3(No worm=40)	0.947	0.525	44.56
	Control	0.945	0.909	3.81

C/N ratio Difference (%)

C/N	Reactor	Week 0	Week 10	% difference
C/N 30	R1(No worm=20)		9.63	54.99
	R2(No worm=30)		8.70	59.32
	R3(No worm=40)		8.20	61.65
	Control	21.39	18.27	14.61
C/N 35	R1(No worm=20)		10.06	64.38
	R2(No worm=30)		8.71	69.14
	R3(No worm=40)		7.92	71.94
	Control	28.23	17.81	36.91
C/N 40	R1(No worm=20)		9.00	71.55
	R2(No worm=30)		9.07	71.31
	R3(No worm=40)		8.11	74.36
	Control	31.63	20.71	34.53
C/N 45	R1(No worm=20)		9.31	67.79
	R2(No worm=30)		8.57	70.33
	R3(No worm=40)		7.78	73.06
	Control	28.89	20.06	30.57
C/N 50	R1(No worm=20)		9.14	75.36
	R2(No worm=30)		9.25	75.07
	R3(No worm=40)		8.30	77.63
	Control	37.12	21.86	41.10

Appendix E – Statistical Analysis

Effects of Various C/N Ratios with Fixed Initial Numbers of Earthworm (N_0)

TOC

1) C/N 30

Control	22.06	22.08	21.85	21.95	20.98	20.78
R1(No worm=20)	22.06	21.95	21.56	21.69	20.94	19.86

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.61666667	21.34333333
Variance	0.336426667	0.682346667
Observations	6	6
Pooled Variance	0.509386667	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.663329693	
P(T<=t) one-tail	0.261058147	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.522116295	
t Critical two-tail	2.228138842	

Control	22.06	22.08	21.85	21.95	20.98	20.78
R2(No worm=30)	22.06	21.91	21.03	20.99	19.91	19.03

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.61666667	20.82166667
Variance	0.336426667	1.366176667
Observations	6	6
Pooled Variance	0.851301667	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.492402659	
P(T<=t) one-tail	0.08322687	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.166453741	
t Critical two-tail	2.228138842	

Control	22.06	22.08	21.85	21.95	20.98	20.78
R3(No worm=40)	22.06	22.31	20.65	19.84	19.21	18.29

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.61666667	20.39333333
Variance	0.336426667	2.529546667
Observations	6	6
Pooled Variance	1.432986667	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.770045222	
P(T<=t) one-tail	0.053572297	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.107144595	
t Critical two-tail	2.228138842	

2) C/N 35

Control	22.15	22.65	21.97	21.16	20.94	20.56
R1(No worm=20)	22.15	22.09	22.12	20.71	20.08	19.52

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.57166667	21.11166667
Variance	0.649576667	1.362216667
Observations	6	6
Pooled Variance	1.005896667	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.794404644	
P(T<=t) one-tail	0.222701605	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.44540321	
t Critical two-tail	2.228138842	

Control	22.15	22.65	21.97	21.16	20.94	20.56
R2(No worm=30)	22.15	21.97	20.99	20.43	19.89	18.42

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.57166667	20.64166667
Variance	0.649576667	1.941296667
Observations	6	6
Pooled Variance	1.295436667	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.415257559	
P(T<=t) one-tail	0.093686007	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.187372013	
t Critical two-tail	2.228138842	

Control	22.15	22.65	21.97	21.16	20.94	20.56
R3(No worm=40)	22.15	21.28	20.37	20.01	19.05	18.29

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.57166667	20.19166667
Variance	0.649576667	2.000816667
Observations	6	6
Pooled Variance	1.325196667	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.076345143	
P(T<=t) one-tail	0.032296351	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.064592702	
t Critical two-tail	2.228138842	

3) C/N 40

Control	23.41	23.39	22.86	22.54	22.26	21.97
R1(No worm=20)	23.41	22.46	21.94	22.01	20.96	20.01

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	22.73833333	21.79833333
Variance	0.349816667	1.400216667
Observations	6	6
Pooled Variance	0.875016667	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.740525211	
P(T<=t) one-tail	0.05619461	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.112389219	
t Critical two-tail	2.228138842	

Control	23.41	23.39	22.86	22.54	22.26	21.97
R2(No worm=30)	23.41	22.24	21.86	21.18	20.84	19.91

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	22.73833333	21.57333333
Variance	0.349816667	1.471826667
Observations	6	6
Pooled Variance	0.910821667	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.114315902	
P(T<=t) one-tail	0.030300277	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.060600554	
t Critical two-tail	2.228138842	

Control	23.41	23.39	22.86	22.54	22.26	21.97
R3(No worm=40)	23.41	22.39	21.29	20.72	20.01	19.42

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	22.73833333	21.20666667
Variance	0.349816667	2.224586667
Observations	6	6
Pooled Variance	1.287201667	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.338307333	
P(T<=t) one-tail	0.020729511	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.041459022	
t Critical two-tail	2.228138842	

4) C/N 45

Control	23.91	23.95	23.2	23.31	22.89	22.02
R1(No worm=20)	23.91	23.65	22.45	21.87	21.01	20.32

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	23.21333333	22.20166667
Variance	0.513226667	2.029696667
Observations	6	6
Pooled Variance	1.271461667	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.553983605	
P(T<=t) one-tail	0.075619685	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.15123937	
t Critical two-tail	2.228138842	

Control	23.91	23.95	23.2	23.31	22.89	22.02
R2(No worm=30)	23.91	23.95	22.04	21.42	20.99	19.89

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	23.21333333	22.03333333
Variance	0.513226667	2.650826667
Observations	6	6
Pooled Variance	1.582026667	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.624934033	
P(T<=t) one-tail	0.067619228	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.135238455	
t Critical two-tail	2.228138842	

Control	23.91	23.95	23.2	23.31	22.89	22.02
R3(No worm=40)	23.91	22.83	21.04	21.01	20.39	19.48

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	23.21333333	21.44333333
Variance	0.513226667	2.664386667
Observations	6	6
Pooled Variance	1.588806667	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.432194864	
P(T<=t) one-tail	0.017658684	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.035317367	
t Critical two-tail	2.228138842	

5) C/N 50

Control	24.84	24.98	23.99	23.14	22.92	22.52
R1(No worm=20)	24.84	24.01	23.85	21.72	20.69	19.93

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	23.73166667	22.50666667
Variance	1.066096667	4.013466667
Observations	6	6
Pooled Variance	2.539781667	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.331369256	
P(T<=t) one-tail	0.106310174	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.212620348	
t Critical two-tail	2.228138842	

Control	24.84	24.98	23.99	23.14	22.92	22.52
R2(No worm=30)	24.84	23.12	23.32	21.08	20.62	19.65

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	23.73166667	22.105
Variance	1.066096667	3.85391
Observations	6	6
Pooled Variance	2.460003333	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.796351607	
P(T<=t) one-tail	0.051330191	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.102660382	
t Critical two-tail	2.228138842	

Control	24.84	24.98	23.99	23.14	22.92	22.52
R3(No worm=40)	24.84	23.65	22.18	21.15	20.01	19.31

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	23.73166667	21.85666667
Variance	1.066096667	4.523186667
Observations	6	6
Pooled Variance	2.794641667	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.942669109	
P(T<=t) one-tail	0.040361614	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.080723229	
t Critical two-tail	2.228138842	

TKN

1) C/N 30

Control	1.03	1.18	1.23	1.20	1.20	1.14
R1(No worm=20)	1.03	1.07	1.61	2.10	2.05	2.06

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.164730474	1.653664652
Variance	0.005272753	0.249606604
Observations	6	6
Pooled Variance	0.127439679	
Hypothesized Mean Difference	0	
df	10	
t Stat	-2.372240358	
P(T<=t) one-tail	0.019563662	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.039127325	
t Critical two-tail	2.228138842	

Control	1.03	1.18	1.23	1.20	1.20	1.14
R2(No worm=30)	1.03	0.96	1.78	2.16	2.17	2.19

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.164730474	1.71357658
Variance	0.005272753	0.33277866
Observations	6	6
Pooled Variance	0.169025707	
Hypothesized Mean Difference	0	
df	10	
t Stat	-2.312250244	
P(T<=t) one-tail	0.021670513	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.043341025	
t Critical two-tail	2.228138842	

Control	1.03	1.18	1.23	1.20	1.20	1.14
R3(No worm=40)	1.03	1.58	1.93	2.39	2.22	2.23

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.164730474	1.896366567
Variance	0.005272753	0.261254755
Observations	6	6
Pooled Variance	0.133263754	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.471360585	
P(T<=t) one-tail	0.003003705	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.006007409	
t Critical two-tail	2.228138842	

2) C/N 35

Control	0.78	0.89	0.96	0.98	1.02	1.15
R1(No worm=20)	0.78	1.32	1.51	1.89	1.88	1.94

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.966193061	1.553923678
Variance	0.015412997	0.204190766
Observations	6	6
Pooled Variance	0.109801882	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.072090823	
P(T<=t) one-tail	0.005899342	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.011798683	
t Critical two-tail	2.228138842	

Control	0.78	0.89	0.96	0.98	1.02	1.15
R2(No worm=30)	0.78	1.55	1.57	2.00	2.05	2.11

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.966193061	1.67820951
Variance	0.015412997	0.251653963
Observations	6	6
Pooled Variance	0.13353348	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.374858517	
P(T<=t) one-tail	0.00353172	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.00706344	
t Critical two-tail	2.228138842	

Control	0.78	0.89	0.96	0.98	1.02	1.15
R3(No worm=40)	0.78	1.87	1.94	2.17	2.29	2.31

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.966193061	1.893215144
Variance	0.015412997	0.327907389
Observations	6	6
Pooled Variance	0.171660193	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.875394418	
P(T<=t) one-tail	0.00154098	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.00308196	
t Critical two-tail	2.228138842	

3) C/N 40

Control	0.74	0.86	0.92	0.98	0.98	1.06
R1(No worm=20)	0.74	1.32	1.73	1.92	1.96	2.22

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.922828688	1.649111147
Variance	0.012706865	0.288187346
Observations	6	6
Pooled Variance	0.150447105	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.243203987	
P(T<=t) one-tail	0.00441071	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.008821419	
t Critical two-tail	2.228138842	

Control	0.74	0.86	0.92	0.98	0.98	1.06
R2(No worm=30)	0.74	1.40	1.69	2.03	2.01	2.19

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.922828688	1.678619786
Variance	0.012706865	0.291132489
Observations	6	6
Pooled Variance	0.151919677	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.358577593	
P(T<=t) one-tail	0.003629845	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.00725969	
t Critical two-tail	2.228138842	

Control	0.74	0.86	0.92	0.98	0.98	1.06
R3(No worm=40)	0.74	1.48	2.07	2.17	2.38	2.39

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.922828688	1.874356948
Variance	0.012706865	0.419221621
Observations	6	6
Pooled Variance	0.215964243	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.546430012	
P(T<=t) one-tail	0.002649834	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.005299667	
t Critical two-tail	2.228138842	

4) C/N 45

Control	0.83	0.90	0.86	1.03	1.05	1.10
R1(No worm=20)	0.83	1.47	1.85	2.07	2.02	2.18

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.959650782	1.737594403
Variance	0.012952874	0.260599864
Observations	6	6
Pooled Variance	0.136776369	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.643369481	
P(T<=t) one-tail	0.002255773	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.004511546	
t Critical two-tail	2.228138842	

Control	0.83	0.90	0.86	1.03	1.05	1.10
R2(No worm=30)	0.83	1.62	2.18	2.25	2.21	2.32

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.959650782	1.901423351
Variance	0.012952874	0.340101633
Observations	6	6
Pooled Variance	0.176527254	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.882404497	
P(T<=t) one-tail	0.001523492	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.003046983	
t Critical two-tail	2.228138842	

Control	0.83	0.90	0.86	1.03	1.05	1.10
R3(No worm=40)	0.83	1.81	2.18	2.33	2.47	2.50

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.959650782	2.01832778
Variance	0.012952874	0.404289378
Observations	6	6
Pooled Variance	0.208621126	
Hypothesized Mean Difference	0	
df	10	
t Stat	-4.014624791	
P(T<=t) one-tail	0.001229827	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.002459655	
t Critical two-tail	2.228138842	

5) C/N 50

Control	0.67	0.69	0.83	0.90	0.95	1.03
R1(No worm=20)	0.67	1.41	2.05	1.95	2.01	2.18

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.84532425	1.711715848
Variance	0.020567915	0.331269129
Observations	6	6
Pooled Variance	0.175918522	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.577824845	
P(T<=t) one-tail	0.00251493	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.005029859	
t Critical two-tail	2.228138842	

Control	0.67	0.69	0.83	0.90	0.95	1.03
R2(No worm=30)	0.67	1.57	2.19	2.08	2.10	2.12

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.84532425	1.788025109
Variance	0.020567915	0.349645536
Observations	6	6
Pooled Variance	0.185106725	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.795101811	
P(T<=t) one-tail	0.001756943	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.003513887	
t Critical two-tail	2.228138842	

Control	0.67	0.69	0.83	0.90	0.95	1.03
R3(No worm=40)	0.67	1.71	2.53	2.25	2.27	2.33

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.84532425	1.960471672
Variance	0.020567915	0.4747236
Observations	6	6
Pooled Variance	0.247645757	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.881302268	
P(T<=t) one-tail	0.001526228	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.003052455	
t Critical two-tail	2.228138842	

Potassium

1) C/N 30

Control	1.2521	2.4736	2.5009	2.5017	2.5018	2.2610
R1(No worm=20)	1.2521	2.5441	2.6140	2.8074	3.2157	3.2582

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.248523804	2.615242883
Variance	0.247135965	0.534830557
Observations	6	6
Pooled Variance	0.390983261	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.015816002	
P(T<=t) one-tail	0.166831944	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.333663888	
t Critical two-tail	2.228138842	

Control	1.2521	2.4736	2.5009	2.5017	2.5018	2.2610
R2(No worm=30)	1.2521	2.6080	2.6408	2.9460	3.3874	3.4993

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.248523804	2.722254699
Variance	0.247135965	0.655491644
Observations	6	6
Pooled Variance	0.451313804	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.221386252	
P(T<=t) one-tail	0.124976299	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.249952598	
t Critical two-tail	2.228138842	

Control	1.2521	2.4736	2.5009	2.5017	2.5018	2.2610
R3(No worm=40)	1.2521	2.8671	2.9483	3.1134	3.3993	3.3710

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.248523804	2.825211848
Variance	0.247135965	0.640444345
Observations	6	6
Pooled Variance	0.443790155	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.499383554	
P(T<=t) one-tail	0.082332259	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.164664517	
t Critical two-tail	2.228138842	

2) C/N 35

Control	1.1567	2.3026	2.3836	2.3869	2.3878	2.3539
R1(No worm=20)	1.1567	2.3641	2.4158	2.7383	2.9888	3.1639

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.161922693	2.471264459
Variance	0.243600946	0.512338661
Observations	6	6
Pooled Variance	0.377969803	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.87150651	
P(T<=t) one-tail	0.201957798	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.403915596	
t Critical two-tail	2.228138842	

Control	1.1567	2.3026	2.3836	2.3869	2.3878	2.3539
R2(No worm=30)	1.1567	2.4169	2.5469	2.8351	3.0565	3.1221

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.161922693	2.522367679
Variance	0.243600946	0.523939964
Observations	6	6
Pooled Variance	0.383770455	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.00777562	
P(T<=t) one-tail	0.168662319	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.337324639	
t Critical two-tail	2.228138842	

Control	1.1567	2.3026	2.3836	2.3869	2.3878	2.3539
R3(No worm=40)	1.1567	2.4740	2.6272	3.0512	3.2635	3.2210

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.161922693	2.632263346
Variance	0.243600946	0.624616906
Observations	6	6
Pooled Variance	0.434108926	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.236442109	
P(T<=t) one-tail	0.122273481	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.244546962	
t Critical two-tail	2.228138842	

3) C/N 40

Control	0.8542	1.6839	1.6769	1.6323	1.6415	1.6831
R1(No worm=20)	0.8542	1.7420	1.8846	2.0595	2.6476	2.6918

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.528644626	1.979949531
Variance	0.109652079	0.458355351
Observations	6	6
Pooled Variance	0.284003715	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.466792466	
P(T<=t) one-tail	0.086581406	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.173162812	
t Critical two-tail	2.228138842	

Control	0.8542	1.6839	1.6769	1.6323	1.6415	1.6831
R2(No worm=30)	0.8542	1.8069	1.9209	2.3544	2.7826	2.8508

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.528644626	2.094977468
Variance	0.109652079	0.552832051
Observations	6	6
Pooled Variance	0.331242065	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.704353329	
P(T<=t) one-tail	0.059566717	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.119133434	
t Critical two-tail	2.228138842	

Control	0.8542	1.6839	1.6769	1.6323	1.6415	1.6831
R3(No worm=40)	0.8542	1.8368	1.9545	2.5759	2.8431	2.8719

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.528644626	2.15607071
Variance	0.109652079	0.599621085
Observations	6	6
Pooled Variance	0.354636582	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.824867895	
P(T<=t) one-tail	0.048997239	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.097994479	
t Critical two-tail	2.228138842	

4) C/N 45

Control	0.7666	1.5242	1.5199	1.5264	1.5221	1.5821
R1(No worm=20)	0.7666	1.5666	1.6357	1.7494	1.9355	2.7078

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.406873082	1.726908153
Variance	0.098948614	0.392465754
Observations	6	6
Pooled Variance	0.245707184	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.118276693	
P(T<=t) one-tail	0.144796403	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.289592807	
t Critical two-tail	2.228138842	

Control	0.7666	1.5242	1.5199	1.5264	1.5221	1.5821
R2(No worm=30)	0.7666	1.6129	1.7333	1.8680	2.0482	2.6099

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.406873082	1.773131353
Variance	0.098948614	0.365053722
Observations	6	6
Pooled Variance	0.232001168	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.317052182	
P(T<=t) one-tail	0.10860105	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.217202099	
t Critical two-tail	2.228138842	

Control	0.7666	1.5242	1.5199	1.5264	1.5221	1.5821
R3(No worm=40)	0.7666	1.7539	1.7994	2.0887	2.1132	2.7662

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.406873082	1.881333386
Variance	0.098948614	0.429083
Observations	6	6
Pooled Variance	0.264015807	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.599357478	
P(T<=t) one-tail	0.070412279	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.140824557	
t Critical two-tail	2.228138842	

5) C/N 50

Control	0.6799	1.3510	1.3535	1.3551	1.3526	1.5565
R1(No worm=20)	0.6799	1.4228	1.6449	1.7635	1.9327	2.4086

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.274758321	1.642074877
Variance	0.091537623	0.332123729
Observations	6	6
Pooled Variance	0.211830676	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.382313995	
P(T<=t) one-tail	0.098483549	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.196967099	
t Critical two-tail	2.228138842	

Control	0.6799	1.3510	1.3535	1.3551	1.3526	1.5565
R2(No worm=30)	0.6799	1.5023	1.6782	1.8669	2.0876	2.6125

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.274758321	1.737905138
Variance	0.091537623	0.416433627
Observations	6	6
Pooled Variance	0.253985625	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.591749576	
P(T<=t) one-tail	0.071262629	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.142525257	
t Critical two-tail	2.228138842	

Control	0.6799	1.3510	1.3535	1.3551	1.3526	1.5565
R3(No worm=40)	0.6799	1.5880	1.7031	2.0551	2.3288	2.6518

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.274758321	1.834471561
Variance	0.091537623	0.474401066
Observations	6	6
Pooled Variance	0.282969345	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.822453742	
P(T<=t) one-tail	0.049190896	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.098381793	
t Critical two-tail	2.228138842	

Phosphorus

1) C/N 30

Control	0.0298	0.0294	0.0278	0.0272	0.0264	0.0265
R1(No worm=20)	0.0298	0.0326	0.0420	0.0538	0.0546	0.0546

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.027858795	0.044555456
Variance	2.14372E-06	0.000130938
Observations	6	6
Pooled Variance	6.65406E-05	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.545249893	
P(T<=t) one-tail	0.002655049	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.005310097	
t Critical two-tail	2.228138842	

Control	0.0298	0.0294	0.0278	0.0272	0.0264	0.0265
R2(No worm=30)	0.0298	0.0343	0.0415	0.0404	0.0550	0.0550

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.027858795	0.042686077
Variance	2.14372E-06	0.000109093
Observations	6	6
Pooled Variance	5.56182E-05	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.443606627	
P(T<=t) one-tail	0.003146624	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.006293249	
t Critical two-tail	2.228138842	

Control	0.0298	0.0294	0.0278	0.0272	0.0264	0.0265
R3(No worm=40)	0.0298	0.0408	0.0532	0.0557	0.0677	0.0778

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.027858795	0.054169228
Variance	2.14372E-06	0.000302873
Observations	6	6
Pooled Variance	0.000152508	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.690130065	
P(T<=t) one-tail	0.002087974	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.004175949	
t Critical two-tail	2.228138842	

2) C/N 35

Control	0.0240	0.0242	0.0272	0.0276	0.0279	0.0274
R1(No worm=20)	0.0240	0.0247	0.0412	0.0546	0.0680	0.0773

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.026380592	0.048305937
Variance	3.10772E-06	0.000492861
Observations	6	6
Pooled Variance	0.000247984	
Hypothesized Mean Difference	0	
df	10	
t Stat	-2.411542945	
P(T<=t) one-tail	0.018293376	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.036586752	
t Critical two-tail	2.228138842	

Control	0.0240	0.0242	0.0272	0.0276	0.0279	0.0274
R2(No worm=30)	0.0240	0.0298	0.0543	0.0673	0.0672	0.0660

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.026380592	0.051441572
Variance	3.10772E-06	0.000387867
Observations	6	6
Pooled Variance	0.000195488	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.104553207	
P(T<=t) one-tail	0.005581873	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.011163747	
t Critical two-tail	2.228138842	

Control	0.0240	0.0242	0.0272	0.0276	0.0279	0.0274
R3(No worm=40)	0.0240	0.0385	0.0546	0.0683	0.0793	0.0805

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.026380592	0.057522037
Variance	3.10772E-06	0.000521572
Observations	6	6
Pooled Variance	0.00026234	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.330177932	
P(T<=t) one-tail	0.00380779	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.007615581	
t Critical two-tail	2.228138842	

3) C/N 40

Control	0.0216	0.0218	0.0137	0.0137	0.0137	0.0135
R1(No worm=20)	0.0216	0.0218	0.0272	0.0278	0.0395	0.0537

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.016292805	0.031916508
Variance	1.72928E-05	0.00015622
Observations	6	6
Pooled Variance	8.67566E-05	
Hypothesized Mean Difference	0	
df	10	
t Stat	-2.905316172	
P(T<=t) one-tail	0.007845041	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.015690082	
t Critical two-tail	2.228138842	

Control	0.0216	0.0218	0.0137	0.0137	0.0137	0.0135
R2(No worm=30)	0.0216	0.0222	0.0414	0.0546	0.0661	0.0687

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.016292805	0.045762602
Variance	1.72928E-05	0.000434937
Observations	6	6
Pooled Variance	0.000226115	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.394479874	
P(T<=t) one-tail	0.003417089	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.006834177	
t Critical two-tail	2.228138842	

Control	0.0216	0.0218	0.0137	0.0137	0.0137	0.0135
R3(No worm=40)	0.0216	0.0240	0.0419	0.0546	0.0671	0.0686

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.016292805	0.046306313
Variance	1.72928E-05	0.000425979
Observations	6	6
Pooled Variance	0.000221636	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.491863449	
P(T<=t) one-tail	0.00290245	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.0058049	
t Critical two-tail	2.228138842	

4) C/N 45

Control	0.0163	0.0160	0.0264	0.0274	0.0274	0.0274
R1(No worm=20)	0.0163	0.0214	0.0273	0.0280	0.0412	0.0539

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.0235125	0.031350856
Variance	3.25224E-05	0.000192077
Observations	6	6
Pooled Variance	0.0001123	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.281139049	
P(T<=t) one-tail	0.114528169	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.229056338	
t Critical two-tail	2.228138842	

Control	0.0163	0.0160	0.0264	0.0274	0.0274	0.0274
R2(No worm=30)	0.0163	0.0215	0.0418	0.0539	0.0553	0.0548

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.0235125	0.040605508
Variance	3.25224E-05	0.000309331
Observations	6	6
Pooled Variance	0.000170927	
Hypothesized Mean Difference	0	
df	10	
t Stat	-2.264507848	
P(T<=t) one-tail	0.023503592	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.047007185	
t Critical two-tail	2.228138842	

Control	0.0163	0.0160	0.0264	0.0274	0.0274	0.0274
R3(No worm=40)	0.0163	0.0239	0.0557	0.0696	0.0834	0.0681

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.0235125	0.052825033
Variance	3.25224E-05	0.000725385
Observations	6	6
Pooled Variance	0.000378954	
Hypothesized Mean Difference	0	
df	10	
t Stat	-2.608080283	
P(T<=t) one-tail	0.01306336	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.026126719	
t Critical two-tail	2.228138842	

5) C/N 50

Control	0.0080	0.0078	0.0138	0.0130	0.0136	0.0135
R1(No worm=20)	0.0080	0.0084	0.0139	0.0276	0.0278	0.0403

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.011610984	0.020996037
Variance	8.30871E-06	0.000168471
Observations	6	6
Pooled Variance	8.83901E-05	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.729002262	
P(T<=t) one-tail	0.057249537	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.114499073	
t Critical two-tail	2.228138842	

Control	0.0080	0.0078	0.0138	0.0130	0.0136	0.0135
R2(No worm=30)	0.0080	0.0139	0.0138	0.0273	0.0278	0.0401

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.011610984	0.02182353
Variance	8.30871E-06	0.000143813
Observations	6	6
Pooled Variance	7.60608E-05	
Hypothesized Mean Difference	0	
df	10	
t Stat	-2.028215463	
P(T<=t) one-tail	0.035006524	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.070013047	
t Critical two-tail	2.228138842	

Control	0.0080	0.0078	0.0138	0.0130	0.0136	0.0135
R3(No worm=40)	0.0080	0.0160	0.0414	0.0409	0.0547	0.0665

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.011610984	0.037925656
Variance	8.30871E-06	0.000498395
Observations	6	6
Pooled Variance	0.000253352	
Hypothesized Mean Difference	0	
df	10	
t Stat	-2.863494616	
P(T<=t) one-tail	0.008427816	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.016855631	
t Critical two-tail	2.228138842	

pH

1) C/N 30

Control	7.15	7.13	7.12	7.13	7.14	7.13
R1(No worm=20)	7.15	7.12	7.32	7.26	7.09	6.97

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.131722167	7.150722167
Variance	8.84611E-05	0.01559593
Observations	6	6
Pooled Variance	0.007842196	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.371616843	
P(T<=t) one-tail	0.358965547	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.717931094	
t Critical two-tail	2.228138842	

Control	7.15	7.13	7.12	7.13	7.14	7.13
R2(No worm=30)	7.15	7.15	7.11	7.07	6.94	6.61

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.131722167	7.004222167
Variance	8.84611E-05	0.043242944
Observations	6	6
Pooled Variance	0.021665703	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.500321811	
P(T<=t) one-tail	0.082212659	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.164425318	
t Critical two-tail	2.228138842	

Control	7.15	7.13	7.12	7.13	7.14	7.13
R3(No worm=40)	7.15	7.19	7.12	7.15	7.06	6.82

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.131722167	7.0805555
Variance	8.84611E-05	0.01808611
Observations	6	6
Pooled Variance	0.009087286	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.929673958	
P(T<=t) one-tail	0.187218632	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.374437264	
t Critical two-tail	2.228138842	

2) C/N 35

Control	7.47	7.45	7.42	7.45	7.45	7.45
R1(No worm=20)	7.47	7.38	7.32	7.33	7.35	7.26

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.448611167	7.352166667
Variance	0.000271577	0.00503129
Observations	6	6
Pooled Variance	0.002651433	
Hypothesized Mean Difference	0	
df	10	
t Stat	3.244126084	
P(T<=t) one-tail	0.004403828	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.008807655	
t Critical two-tail	2.228138842	

Control	7.47	7.45	7.42	7.45	7.45	7.45
R2(No worm=30)	7.47	7.51	7.67	7.35	7.31	7.28

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.448611167	7.4319445
Variance	0.000271577	0.02180269
Observations	6	6
Pooled Variance	0.011037134	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.274777535	
P(T<=t) one-tail	0.394540237	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.789080475	
t Critical two-tail	2.228138842	

Control	7.47	7.45	7.42	7.45	7.45	7.45
R3(No worm=40)	7.47	7.46	7.40	7.41	7.41	7.37

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.448611167	7.420277833
Variance	0.000271577	0.001473803
Observations	6	6
Pooled Variance	0.00087269	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.661224248	
P(T<=t) one-tail	0.063825809	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.127651619	
t Critical two-tail	2.228138842	

3) C/N 40

Control	7.36	7.31	7.29	7.34	7.38	7.32
R1(No worm=20)	7.36	7.34	7.31	7.36	7.35	7.31

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.3339445	7.3389445
Variance	0.001148022	0.000570688
Observations	6	6
Pooled Variance	0.000859355	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.295422933	
P(T<=t) one-tail	0.386856905	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.773713811	
t Critical two-tail	2.228138842	

Control	7.36	7.31	7.29	7.34	7.38	7.32
R2(No worm=30)	7.36	7.35	7.36	7.33	7.36	7.29

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.3339445	7.342277833
Variance	0.001148022	0.000805799
Observations	6	6
Pooled Variance	0.000976911	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.461797867	
P(T<=t) one-tail	0.327054521	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.654109042	
t Critical two-tail	2.228138842	

Control	7.36	7.31	7.29	7.34	7.38	7.32
R3(No worm=40)	7.36	7.32	7.31	7.29	7.28	7.21

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.3339445	7.295611167
Variance	0.001148022	0.002607583
Observations	6	6
Pooled Variance	0.001877803	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.532188577	
P(T<=t) one-tail	0.078239441	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.156478882	
t Critical two-tail	2.228138842	

4) C/N 45

Control	7.14	7.11	7.11	7.12	7.13	7.11
R1(No worm=20)	7.14	7.13	7.06	7.09	7.02	6.98

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.120666667	7.070666667
Variance	0.000194667	0.004034667
Observations	6	6
Pooled Variance	0.002114667	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.883257354	
P(T<=t) one-tail	0.044522557	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.089045114	
t Critical two-tail	2.228138842	

Control	7.14	7.11	7.11	7.12	7.13	7.11
R2(No worm=30)	7.14	7.13	7.13	7.11	7.06	7.02

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.120666667	7.099
Variance	0.000194667	0.002366
Observations	6	6
Pooled Variance	0.001280333	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.048796436	
P(T<=t) one-tail	0.159479064	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.318958128	
t Critical two-tail	2.228138842	

Control	7.14	7.11	7.11	7.12	7.13	7.11
R3(No worm=40)	7.14	7.09	7.11	7.11	7.13	7.11

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.120666667	7.115666667
Variance	0.000194667	0.000352667
Observations	6	6
Pooled Variance	0.000273667	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.52350361	
P(T<=t) one-tail	0.306013618	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.612027237	
t Critical two-tail	2.228138842	

5) C/N 50

Control	7.48	7.47	7.43	7.46	7.46	7.45
R1(No worm=20)	7.48	7.35	7.37	7.37	7.34	7.31

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.458833333	7.3705
Variance	0.000324167	0.0035335
Observations	6	6
Pooled Variance	0.001928833	
Hypothesized Mean Difference	0	
df	10	
t Stat	3.483677112	
P(T<=t) one-tail	0.002942448	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.005884897	
t Critical two-tail	2.228138842	

Control	7.48	7.47	7.43	7.46	7.46	7.45
R2(No worm=30)	7.48	7.45	7.46	7.43	7.46	7.41

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.458833333	7.448833333
Variance	0.000324167	0.000656167
Observations	6	6
Pooled Variance	0.000490167	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.782327759	
P(T<=t) one-tail	0.226074462	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.452148924	
t Critical two-tail	2.228138842	

Control	7.48	7.47	7.43	7.46	7.46	7.45
R3(No worm=40)	7.48	7.35	7.36	7.34	7.28	7.19

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.458833333	7.333833333
Variance	0.000324167	0.009364167
Observations	6	6
Pooled Variance	0.004844167	
Hypothesized Mean Difference	0	
df	10	
t Stat	3.110721293	
P(T<=t) one-tail	0.005523552	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.011047104	
t Critical two-tail	2.228138842	

Effects of Various Initial Numbers of Earthworms (N_0) with Fixed C/N ratio

TOC

1) R1 (No worm=20)

C/N 30	22.06	21.95	21.56	21.69	20.94	19.86
C/N 35	22.15	22.09	22.12	20.71	20.08	19.52

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.34333	21.11167
Variance	0.682347	1.362217
Observations	6	6
Pooled Variance	1.022282	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.396861	
P(T<=t) one-tail	0.349904	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.699807	
t Critical two-tail	2.228139	

C/N 30	22.06	21.95	21.56	21.69	20.94	19.86
C/N 40	23.41	22.46	21.94	22.01	20.96	20.01

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.34333	21.79833
Variance	0.682347	1.400217
Observations	6	6
Pooled Variance	1.041282	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.7723	
P(T<=t) one-tail	0.228899	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.457799	
t Critical two-tail	2.228139	

C/N 30	22.06	21.95	21.56	21.69	20.94	19.86
C/N 45	23.91	23.65	22.45	21.87	21.01	20.32

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.34333	22.20167
Variance	0.682347	2.029697
Observations	6	6
Pooled Variance	1.356022	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.27668	
P(T<=t) one-tail	0.115282	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.230563	
t Critical two-tail	2.228139	

C/N 30	22.06	21.95	21.56	21.69	20.94	19.86
C/N 50	24.84	24.01	23.85	21.72	20.69	19.93

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	21.34333	22.50667
Variance	0.682347	4.013467
Observations	6	6
Pooled Variance	2.347907	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.315	
P(T<=t) one-tail	0.108933	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.217867	
t Critical two-tail	2.228139	

2) R2 (No worm=30)

C/N 30	22.06	21.91	21.03	20.99	19.91	19.03
C/N 35	22.15	21.97	20.99	20.43	19.89	18.42

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	20.82167	20.64167
Variance	1.366177	1.941297
Observations	6	6
Pooled Variance	1.653737	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.242438	
P(T<=t) one-tail	0.40667	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.813341	
t Critical two-tail	2.228139	

C/N 30	22.06	21.91	21.03	20.99	19.91	19.03
C/N 40	23.41	22.24	21.86	21.18	20.84	19.91

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	20.82167	21.57333
Variance	1.366177	1.471827
Observations	6	6
Pooled Variance	1.419002	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.09294	
P(T<=t) one-tail	0.150026	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.300051	
t Critical two-tail	2.228139	

C/N 30	22.06	21.91	21.03	20.99	19.91	19.03
C/N 45	23.91	23.95	22.04	21.42	20.99	19.89

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	20.82167	22.03333
Variance	1.366177	2.650827
Observations	6	6
Pooled Variance	2.008502	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.48084	
P(T<=t) one-tail	0.084727	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.169455	
t Critical two-tail	2.228139	

C/N 30	22.06	21.91	21.03	20.99	19.91	19.03
C/N 50	24.84	23.12	23.32	21.08	20.62	19.65

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	20.82167	22.105
Variance	1.366177	3.85391
Observations	6	6
Pooled Variance	2.610043	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.37587	
P(T<=t) one-tail	0.099446	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.198893	
t Critical two-tail	2.228139	

3) R3 (No worm=40)

C/N 30	22.06	22.31	20.65	19.84	19.21	18.29
C/N 35	22.15	21.28	20.37	20.01	19.05	18.29

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	20.39333	20.19167
Variance	2.529547	2.000817
Observations	6	6
Pooled Variance	2.265182	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.232083	
P(T<=t) one-tail	0.410577	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.821154	
t Critical two-tail	2.228139	

C/N 30	22.06	22.31	20.65	19.84	19.21	18.29
C/N 40	23.41	22.39	21.29	20.72	20.01	19.42

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	20.39333	21.20667
Variance	2.529547	2.224587
Observations	6	6
Pooled Variance	2.377067	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.91371	
P(T<=t) one-tail	0.191185	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.382371	
t Critical two-tail	2.228139	

C/N 30	22.06	22.31	20.65	19.84	19.21	18.29
C/N 45	23.91	22.83	21.04	21.01	20.39	19.48

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	20.39333	21.44333
Variance	2.529547	2.664387
Observations	6	6
Pooled Variance	2.596967	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.12854	
P(T<=t) one-tail	0.142719	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.285439	
t Critical two-tail	2.228139	

C/N 30	22.06	22.31	20.65	19.84	19.21	18.29
C/N 50	24.84	23.65	22.18	21.15	20.01	19.31

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	20.39333	21.85667
Variance	2.529547	4.523187
Observations	6	6
Pooled Variance	3.526367	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.34971	
P(T<=t) one-tail	0.103435	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.206869	
t Critical two-tail	2.228139	

TKN

1) R1 (No worm=20)

C/N 30	1.03	1.07	1.61	2.10	2.05	2.06
C/N 35	0.78	1.32	1.51	1.89	1.88	1.94

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.653665	1.553924
Variance	0.249607	0.204191
Observations	6	6
Pooled Variance	0.226899	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.362676	
P(T<=t) one-tail	0.362198	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.724395	
t Critical two-tail	2.228139	

C/N 30	1.03	1.07	1.61	2.10	2.05	2.06
C/N 40	0.74	1.32	1.73	1.92	1.96	2.22

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.653665	1.649111
Variance	0.249607	0.288187
Observations	6	6
Pooled Variance	0.268897	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.015209	
P(T<=t) one-tail	0.494082	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.988164	
t Critical two-tail	2.228139	

C/N 30	1.03	1.07	1.61	2.10	2.05	2.06
C/N 45	0.83	1.47	1.85	2.07	2.02	2.18

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.653665	1.737594
Variance	0.249607	0.2606
Observations	6	6
Pooled Variance	0.255103	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.28782	
P(T<=t) one-tail	0.389681	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.779362	
t Critical two-tail	2.228139	

C/N 30	1.03	1.07	1.61	2.10	2.05	2.06
C/N 50	0.67	1.41	2.05	1.95	2.01	2.18

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.653665	1.711716
Variance	0.249607	0.331269
Observations	6	6
Pooled Variance	0.290438	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.18657	
P(T<=t) one-tail	0.427864	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.855727	
t Critical two-tail	2.228139	

2) R2 (No worm=30)

C/N 30	1.03	0.96	1.78	2.16	2.17	2.19
C/N 35	0.78	1.55	1.57	2.00	2.05	2.11

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.713378	1.677433
Variance	0.333105	0.253323
Observations	6	6
Pooled Variance	0.293214	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.114975	
P(T<=t) one-tail	0.45537	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.910741	
t Critical two-tail	2.228139	

C/N 30	1.03	0.96	1.78	2.16	2.17	2.19
C/N 40	0.78	1.40	1.69	2.03	2.01	2.19

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.713378	1.685276
Variance	0.333105	0.276406
Observations	6	6
Pooled Variance	0.304755	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.08817	
P(T<=t) one-tail	0.465741	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.931482	
t Critical two-tail	2.228139	

C/N 30	1.03	0.96	1.78	2.16	2.17	2.19
C/N 45	0.83	1.62	2.18	2.25	2.21	2.32

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	Variable 2
Mean	1.713378	1.901828
Variance	0.333105	0.339059
Observations	6	6
Pooled Variance	0.336082	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.56304	
P(T<=t) one-tail	0.292906	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.585812	
t Critical two-tail	2.228139	

C/N 30	1.03	0.96	1.78	2.16	2.17	2.19
C/N 50	0.67	1.57	2.19	2.08	2.10	2.12

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	Variable 2
Mean	1.713378	1.788147
Variance	0.333105	0.349319
Observations	6	6
Pooled Variance	0.341212	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.2217	
P(T<=t) one-tail	0.414503	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.829007	
t Critical two-tail	2.228139	

3) R3 (No worm=40)

C/N 30	1.03	1.58	1.93	2.39	2.22	2.23
C/N 35	0.78	1.87	1.94	2.17	2.29	2.31

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.896168	1.892438
Variance	0.261668	0.329977
Observations	6	6
Pooled Variance	0.295823	
Hypothesized Mean *Difference*	0	
df	10	
t Stat	0.011876	
P(T<=t) one-tail	0.495379	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.990758	
t Critical two-tail	2.228139	

C/N 30	1.03	1.58	1.93	2.39	2.22	2.23
C/N 40	0.74	1.48	2.07	2.17	2.38	2.39

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.896168	1.874346
Variance	0.261668	0.419251
Observations	6	6
Pooled Variance	0.34046	
Hypothesized Mean *Difference*	0	
df	10	
t Stat	0.064776	
P(T<=t) one-tail	0.474815	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.949629	
t Critical two-tail	2.228139	

C/N 30	1.03	1.58	1.93	2.39	2.22	2.23
C/N 45	0.83	1.81	2.18	2.33	2.47	2.50

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.896168	2.018733
Variance	0.261668	0.403133
Observations	6	6
Pooled Variance	0.332401	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.36821	
P(T<=t) one-tail	0.360195	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.720391	
t Critical two-tail	2.228139	

C/N 30	1.03	1.58	1.93	2.39	2.22	2.23
C/N 50	0.67	1.71	2.53	2.25	2.27	2.33

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	1.896168	1.960594
Variance	0.261668	0.474346
Observations	6	6
Pooled Variance	0.368007	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.18395	
P(T<=t) one-tail	0.428866	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.857731	
t Critical two-tail	2.228139	

Potassium

1) R1 (No worm=20)

C/N 30	1.25	2.54	2.61	2.81	3.22	3.26
C/N 35	1.16	2.36	2.42	2.74	2.99	3.16

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.615243	2.471264
Variance	0.534831	0.512339
Observations	6	6
Pooled Variance	0.523585	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.344639	
P(T<=t) one-tail	0.368752	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.737504	
t Critical two-tail	2.228139	

C/N 30	1.25	2.54	2.61	2.81	3.22	3.26
C/N 40	0.85	1.74	1.88	2.06	2.65	2.69

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.615243	1.97995
Variance	0.534831	0.458355
Observations	6	6
Pooled Variance	0.496593	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.561474	
P(T<=t) one-tail	0.074737	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.149475	
t Critical two-tail	2.228139	

C/N 30	1.25	2.54	2.61	2.81	3.22	3.26
C/N 45	0.77	1.57	1.64	1.75	1.94	2.71

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.615243	1.726908
Variance	0.534831	0.392466
Observations	6	6
Pooled Variance	0.463648	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.259659	
P(T<=t) one-tail	0.023698	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.047396	
t Critical two-tail	2.228139	

C/N 30	1.25	2.54	2.61	2.81	3.22	3.26
C/N 50	0.68	1.42	1.64	1.76	1.93	2.41

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.615243	1.642075
Variance	0.534831	0.332124
Observations	6	6
Pooled Variance	0.433477	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.56015	
P(T<=t) one-tail	0.014183	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.028366	
t Critical two-tail	2.228139	

2) R2 (No worm=30)

C/N 30	1.25	2.61	2.64	2.95	3.39	3.50
C/N 35	1.16	2.42	2.55	2.84	3.06	3.12

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.721908	2.522924
Variance	0.656716	0.522118
Observations	6	6
Pooled Variance	0.589417	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.448918	
P(T<=t) one-tail	0.331531	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.663062	
t Critical two-tail	2.228139	

C/N 30	1.25	2.61	2.64	2.95	3.39	3.50
C/N 40	0.85	1.81	1.92	2.35	2.78	2.85

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.721908	2.094275
Variance	0.656716	0.554927
Observations	6	6
Pooled Variance	0.605822	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.396671	
P(T<=t) one-tail	0.096368	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.192736	
t Critical two-tail	2.228139	

C/N 30	1.25	2.61	2.64	2.95	3.39	3.50
C/N 45	0.77	1.61	1.73	1.87	2.05	2.61

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.721908	1.773698
Variance	0.656716	0.363686
Observations	6	6
Pooled Variance	0.510201	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.299293	
P(T<=t) one-tail	0.022154	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.044308	
t Critical two-tail	2.228139	

C/N 30	1.25	2.61	2.64	2.95	3.39	3.50
C/N 50	0.68	1.50	1.68	1.87	2.09	2.61

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.721908	1.737916
Variance	0.656716	0.416406
Observations	6	6
Pooled Variance	0.536561	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.326712	
P(T<=t) one-tail	0.021143	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.042286	
t Critical two-tail	2.228139	

3) R3 (No worm=40)

C/N 30	1.25	2.87	2.95	3.11	3.40	3.37
C/N 35	1.16	2.47	2.63	3.05	3.26	3.22

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.824865	2.63282
Variance	0.641754	0.622649
Observations	6	6
Pooled Variance	0.632201	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.418347	
P(T<=t) one-tail	0.342268	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.684536	
t Critical two-tail	2.228139	

C/N 30	1.25	2.87	2.95	3.11	3.40	3.37
C/N 40	0.85	1.84	1.95	2.58	2.84	2.87

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.824865	2.155368
Variance	0.641754	0.601819
Observations	6	6
Pooled Variance	0.621787	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.470579	
P(T<=t) one-tail	0.086078	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.172156	
t Critical two-tail	2.228139	

C/N 30	1.25	2.87	2.95	3.11	3.40	3.37
C/N 45	0.77	1.75	1.80	2.09	2.11	2.77

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.824865	1.8819
Variance	0.641754	0.427568
Observations	6	6
Pooled Variance	0.534661	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.233658	
P(T<=t) one-tail	0.024767	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.049534	
t Critical two-tail	2.228139	

C/N 30	1.25	2.87	2.95	3.11	3.40	3.37
C/N 50	0.68	1.59	1.70	2.06	2.33	2.65

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	2.824865	1.834482
Variance	0.641754	0.474371
Observations	6	6
Pooled Variance	0.558063	
Hypothesized Mean Difference	0	
df	10	
t Stat	2.296266	
P(T<=t) one-tail	0.022268	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.044536	
t Critical two-tail	2.228139	

Phosphorus

1) R1 (No worm=20)

C/N 30	0.02983	0.03255	0.04196	0.05375	0.05459	0.05464
C/N 35	0.02403	0.02469	0.04122	0.05460	0.06803	0.07726

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.044555	0.048306
Variance	0.000131	0.000493
Observations	6	6
Pooled Variance	0.000312	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.36782	
P(T<=t) one-tail	0.360335	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.72067	
t Critical two-tail	2.228139	

C/N 30	0.02983	0.03255	0.04196	0.05375	0.05459	0.05464
C/N 40	0.02156	0.02179	0.02720	0.02777	0.03948	0.05370

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.044555	0.031917
Variance	0.000131	0.000156
Observations	6	6
Pooled Variance	0.000144	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.826948	
P(T<=t) one-tail	0.048831	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.097662	
t Critical two-tail	2.228139	

C/N 30	0.02983	0.03255	0.04196	0.05375	0.05459	0.05464
C/N 45	0.01633	0.02135	0.02731	0.02798	0.04119	0.05394

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.044555	0.031351
Variance	0.000131	0.000192
Observations	6	6
Pooled Variance	0.000162	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.799658	
P(T<=t) one-tail	0.051055	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.102109	
t Critical two-tail	2.228139	

C/N 30	0.02983	0.03255	0.04196	0.05375	0.05459	0.05464
C/N 50	0.00803	0.00836	0.01388	0.02759	0.02777	0.04035

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.044555	0.020996
Variance	0.000131	0.000168
Observations	6	6
Pooled Variance	0.00015	
Hypothesized Mean Difference	0	
df	10	
t Stat	3.335092	
P(T<=t) one-tail	0.003776	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.007553	
t Critical two-tail	2.228139	

2) R2 (No worm=30)

C/N 30	0.02983	0.03432	0.04154	0.04040	0.05504	0.05498
C/N 35	0.02403	0.02981	0.05431	0.06733	0.06722	0.06595

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.042686	0.051441
Variance	0.000109	0.000388
Observations	6	6
Pooled Variance	0.000249	
Hypothesized Mean *Difference*	0	
df	10	
t Stat	-0.96203	
P(T<=t) one-tail	0.179359	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.358719	
t Critical two-tail	2.228139	

C/N 30	0.02983	0.03432	0.04154	0.04040	0.05504	0.05498
C/N 40	0.02156	0.02224	0.04143	0.05457	0.06609	0.06869

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.042686	0.045763
Variance	0.000109	0.000435
Observations	6	6
Pooled Variance	0.000272	
Hypothesized Mean *Difference*	0	
df	10	
t Stat	-0.32316	
P(T<=t) one-tail	0.376614	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.753229	
t Critical two-tail	2.228139	

C/N 30	0.02983	0.03432	0.04154	0.04040	0.05504	0.05498
C/N 45	0.01633	0.02154	0.04183	0.05387	0.05529	0.05477

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.042686	0.040606
Variance	0.000109	0.000309
Observations	6	6
Pooled Variance	0.000209	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.249065	
P(T<=t) one-tail	0.404176	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.808351	
t Critical two-tail	2.228139	

C/N 30	0.02983	0.03432	0.04154	0.04040	0.05504	0.05498
C/N 50	0.00803	0.01387	0.01380	0.02731	0.02781	0.04013

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.042686	0.021824
Variance	0.000109	0.000144
Observations	6	6
Pooled Variance	0.000126	
Hypothesized Mean Difference	0	
df	10	
t Stat	3.213231	
P(T<=t) one-tail	0.004641	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.009281	
t Critical two-tail	2.228139	

3) R3 (No worm=40)

C/N 30	0.02983	0.04076	0.05324	0.05574	0.06767	0.07776
C/N 35	0.02403	0.03849	0.05459	0.06827	0.07926	0.08049

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.054169	0.057522
Variance	0.000303	0.000522
Observations	6	6
Pooled Variance	0.000412	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.28603	
P(T<=t) one-tail	0.390345	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.78069	
t Critical two-tail	2.228139	

C/N 30	0.02983	0.04076	0.05324	0.05574	0.06767	0.07776
C/N 40	0.02156	0.02399	0.04194	0.05459	0.06711	0.06864

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.054169	0.046306
Variance	0.000303	0.000426
Observations	6	6
Pooled Variance	0.000364	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.713335	
P(T<=t) one-tail	0.245975	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.49195	
t Critical two-tail	2.228139	

C/N 30	0.02983	0.04076	0.05324	0.05574	0.06767	0.07776
C/N 45	0.01633	0.02389	0.05567	0.06957	0.08343	0.06807

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.054169	0.052825
Variance	0.000303	0.000725
Observations	6	6
Pooled Variance	0.000514	
Hypothesized Mean Difference	0	
df	10	
t Stat	0.102632	
P(T<=t) one-tail	0.460142	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.920284	
t Critical two-tail	2.228139	

C/N 30	0.02983	0.04076	0.05324	0.05574	0.06767	0.07776
C/N 50	0.00803	0.01605	0.04137	0.04090	0.05468	0.06653

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.054169	0.037926
Variance	0.000303	0.000498
Observations	6	6
Pooled Variance	0.000401	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.405527	
P(T<=t) one-tail	0.095082	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.190164	
t Critical two-tail	2.228139	

pH

1) R1 (No worm=20)

C/N 30	7.15	7.12	7.32	7.26	7.09	6.97
C/N 35	7.47	7.38	7.32	7.33	7.35	7.26

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.150722	7.352167
Variance	0.015596	0.005031
Observations	6	6
Pooled Variance	0.010314	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.43566	
P(T<=t) one-tail	0.003189	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.006378	
t Critical two-tail	2.228139	

C/N 30	7.15	7.12	7.32	7.26	7.09	6.97
C/N 40	7.36	7.34	7.31	7.36	7.35	7.31

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.150722	7.338945
Variance	0.015596	0.000571
Observations	6	6
Pooled Variance	0.008083	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.62608	
P(T<=t) one-tail	0.002321	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.004643	
t Critical two-tail	2.228139	

C/N 30	7.15	7.12	7.32	7.26	7.09	6.97
C/N 45	7.14	7.13	7.06	7.09	7.02	6.98

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.150722	7.070667
Variance	0.015596	0.004035
Observations	6	6
Pooled Variance	0.009815	
Hypothesized Mean Difference	0	
df	10	
t Stat	1.399587	
P(T<=t) one-tail	0.095943	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.191885	
t Critical two-tail	2.228139	

C/N 30	7.15	7.12	7.32	7.26	7.09	6.97
C/N 50	7.48	7.35	7.37	7.37	7.34	7.31

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.150722	7.3705
Variance	0.015596	0.003534
Observations	6	6
Pooled Variance	0.009565	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.89232	
P(T<=t) one-tail	0.001499	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.002998	
t Critical two-tail	2.228139	

2) R2 (No worm=30)

C/N 30	7.15	7.15	7.11	7.07	6.94	6.61
C/N 35	7.47	7.51	7.67	7.35	7.31	7.28

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.005	7.431667
Variance	0.04351	0.021777
Observations	6	6
Pooled Variance	0.032643	
Hypothesized Mean Difference	0	
df	10	
t Stat	-4.09027	
P(T<=t) one-tail	0.001089	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.002178	
t Critical two-tail	2.228139	

C/N 30	7.15	7.15	7.11	7.07	6.94	6.61
C/N 40	7.36	7.35	7.36	7.33	7.36	7.29

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.005	7.341667
Variance	0.04351	0.000777
Observations	6	6
Pooled Variance	0.022143	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.91868	
P(T<=t) one-tail	0.001436	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.002873	
t Critical two-tail	2.228139	

C/N 30	7.15	7.15	7.11	7.07	6.94	6.61
C/N 45	7.14	7.13	7.13	7.11	7.06	7.02

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.005	7.098333
Variance	0.04351	0.002297
Observations	6	6
Pooled Variance	0.022903	
Hypothesized Mean Difference	0	
df	10	
t Stat	-1.06819	
P(T<=t) one-tail	0.155271	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.310543	
t Critical two-tail	2.228139	

C/N 30	7.15	7.15	7.11	7.07	6.94	6.61
C/N 50	7.48	7.45	7.46	7.43	7.46	7.41

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.005	7.448333
Variance	0.04351	0.000617
Observations	6	6
Pooled Variance	0.022063	
Hypothesized Mean Difference	0	
df	10	
t Stat	-5.16958	
P(T<=t) one-tail	0.00021	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.000419	
t Critical two-tail	2.228139	

3) R3 (No worm=40)

C/N 30	7.15	7.19	7.12	7.15	7.06	6.82
C/N 35	7.47	7.46	7.40	7.41	7.41	7.37

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.081333	7.42
Variance	0.018211	0.00144
Observations	6	6
Pooled Variance	0.009825	
Hypothesized Mean Difference	0	
df	10	
t Stat	-5.91779	
P(T<=t) one-tail	7.37E-05	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.000147	
t Critical two-tail	2.228139	

C/N 30	7.15	7.19	7.12	7.15	7.06	6.82
C/N 40	7.36	7.32	7.31	7.29	7.28	7.21

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.081333	7.295
Variance	0.018211	0.00251
Observations	6	6
Pooled Variance	0.01036	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.63589	
P(T<=t) one-tail	0.002284	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.004568	
t Critical two-tail	2.228139	

C/N 30	7.15	7.19	7.12	7.15	7.06	6.82
C/N 45	7.14	7.09	7.11	7.11	7.13	7.11

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.081333	7.115
Variance	0.018211	0.00031
Observations	6	6
Pooled Variance	0.00926	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.60596	
P(T<=t) one-tail	0.279021	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.558041	
t Critical two-tail	2.228139	

C/N 30	7.15	7.19	7.12	7.15	7.06	6.82
C/N 50	7.48	7.35	7.36	7.34	7.28	7.19

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.081333	7.333333
Variance	0.018211	0.009187
Observations	6	6
Pooled Variance	0.013699	
Hypothesized Mean Difference	0	
df	10	
t Stat	-3.72925	
P(T<=t) one-tail	0.001958	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.003915	
t Critical two-tail	2.228139	