VERMICOMPOSTING OF LEAF LITTER AND PAPER

NOREENAWATI NORDIN

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DECLARATION

I declare that this thesis is my original work except for the quotations and summary that has been cited in references.

Noreenawati bt. Nordin

BS07110371

11th May 2010

AUTHENTICATION

1. Supervisor

Assoc. Prof. Dr. Piakong bin Mohd. Tuah

2. Examiner

Dr. Harry Chong Lye Hin

3. Examiner

Miss Siti Aishah Binti Mohd. Ali

4. Dean

Prof. Dr. Mohd. Harun bin Abdullah

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VERMIKOMPOS KERTAS DAN SISA-SISA DAUN

ABSTRAK

Kajian ini menumpukan kepada proses vermikompos dalam mengkompos kertas terpakai dan daun-daun kering. Kajian ini dijalankan dengan menggunakan cacing tanah (American Night crawler) sebagai pembolehubah tidak bersandar. Manakala kertas dan dedaun kering sebagai pembolehubah bersandar. Kajian ini dijalankan selama 5 minggu. Keupayaan vermikompos dalam mengkompos kertas terpakai dan dedaun kering dari segi suhu adalah dalam lingkungan 25°C hingga 28°C, pH 7.8 hingga pH 5.7, dan kandungan air adalah 61.36% hingga 89.98%. Dari aspek populasi mikroorganisma, fungi menunjukkan polpulasi mikrob yang tertinggi iaitu $1.4x10^5$, diikuti oleh actinomycetes $1.3x10^5$ seterusnya bakteria iaitu $0.2x10^5$ mencatatkan populasi mikrob terendah. Kandungan nutrien seperti nitrat nitrogen, ammonia nitrogen dan analitikal urea adalah masing-masing adalah 3.5 hingga 6.6 per 20g sampel, 2.2 hingga 2.4 per 20g sampel, 115.66 to 135.4 per 20g sampel. Manakala, nisbah karbon kepada nitrogen di dalam vermikompos dalam mengkompos kertas adalah 1:20 hingga 1:24. Nilai setiap nutrien dan nisbah karbon nitrogen adalah dipengaruhi oleh jenis bahan yang dikompos.

ABSTRACT

This study is focused on the process of vermicompost in composting leaf litter and paper. This study carried out by using earthworm (American Night Crawler) as the independence variable. Meanwhile, paper and leaf litter are dependence variable. It s carried out in 5 weeks. The vermicomposting performance in temperature, pH and moisture content shows that the range of optimum temperature is between 25ºC to 28ºC, pH were observed to be neutral to slightly acidic (pH 7.8 to pH 5.7) and moisture content were observed to be high ranging from 61.36% to 89.98%. In microbial population, fungi shows highest microbial population ($1.4x10^5$), followed by actinomycetes ($1.3x10^5$) and bacteria ($0.2x10^5$) presence in the vermicompost materials. The nutrients in vermicompost of leaf litter and paper are respectively, nitrate nitrogen ranging from 3.5 to 6.6 per 20g sample, analytical urea ranging from 115.66 to 135.4 per 20g sample, and ammonial nitrogen is ranging from 2.2 to 2.4 per 20g sample. Meanwhile, for C:N ratio is 1:20 to 1:24. The value of each nutrients and C:N ratio is influenced by types of treatment applied.

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LIST OF SYMBOLS AND UNITS

°C	Degree celcius
g	Gram
%	Percent
μ	Specific growth rate (h^{-1})
% v/v	Percent volume per volume
M	Molarity

LIST OF ABBREVATIONS

MSW	Municipal Solid Waste
rpm	Revolution per minute
T_1	Treatment 1
T_2	Treatment 2
C	Control

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Municipal solid waste (MSW) can be defined as the useless and unwanted product in the solid state derived from the activities and discarded by society. Currently, over 23,000 tonnes of waste is produced each day in Malaysia. However, this amount is expected to rise to 30,000 tonnes by the year 2020. The amount of waste generated continues to increase due to the increasing population and development, and only less than 5% of the waste is being recycled (GEC Malaysia, 2009).

The largest constituents of MSW are household waste which made of 45% and followed by industrial and commercial waste which made up of. The example of household waste is organic and industrial and commercial waste such as plastic and paper. Approximately, 46% has made the organic waste and the other15% and 14% made up the plastic and paper respectively. Since there are large number organic wastes, study indicated that composting can be incorporated in all the landfills in the country along with an integrated system of recycling. This newly construct integrated system would permit the reduction and reuse of waste programs, which is a realistic possibility to improve the MSW management in the country (Fauziah *et al.*, 2004)

In Malaysia, there is approximately 98% of the total Municipal Solid Waste (MSW) is sent to landfills. Landfilling is a popular way in disposing solid waste in many developed country as it is known for cost effective. However, since this is the major method practices and very few recycling method used, the current disposal method of landfilling have decrease the landfill`s life span and increase the problem of land scarcity.

Due to the rapid developments and industrialization, it is necessary to have a better and more efficient waste management system. In order to treat the abundance of MSW having alternatives method such recycling method, biocomposting method and vermicomposting method is necessary to be practiced.

1.1 Objectives

The aim of this research is to determine the performance of worms to biocompose organic and degradable municipal solid waste. Specific objectives are listed below:

i) To monitor the performances of (temperature, pH and moisture content) in vermicomposting of leaf litter and paper.

ii) To determine and compare microbial population (fungi. Actinomycetes and bacteria) in the vermicompost material.

iii) To determine the nutrients (nitrate nitrogen, ammonia nitrogen and analytical urea) and C:N ratio of the vermicompost material.

CHAPTER 2

LITERATURE REVIEW

2.1 Degradable municipal waste

If looking into a state in Malaysia, alone, waste generated in Selangor in 1997 was over 3000t/day. This amount of waste is expected to rise up to 5700t/day in the year 2017 (Muhd Noor, 2000). Assuming that all state in Malaysia undergoing the same situation in which, increasing of MSW with limited available landfill, will consequently contribute to many environmental issues. For instance, study showed that 19% of wastes apart from total waste thrown to landfill will end up into drains, which will cause flash floods and drainage blockage. This situation has been and will be reducing environmental capacity to sustain life (GEC Malaysia, 2009).

Despite the massive amount and complexity of waste produced, the standards of waste management in Malaysia are still poor. These include outdated and poor documentation of waste generation rates and its composition, inefficient storage and collection systems, disposal of municipal wastes with toxic and hazardous waste, indiscriminate disposal or dumping of wastes and inefficient utilization of disposal site space.

2.2 Vermicomposting

Vermicomposting is a method to biocompose organic material into more valuable product in low temperature by using earthworms.

In conducting vermicomposting, there are two ways which is the traditional open systems or the modern stacked rack system and batch reactor. The traditional open system of vermicomposting is based on beds (bedding or vermicast) on the ground containing degradable materials up to 18 inches deep. Meanwhile, the stacked rack system, it is conducted in a vessel or larger container that have racked inside. The batch reactor system has containers raised on legs above the ground. These allow input material to be added at the top from modified spreaders or mobile gantries and collected mechanically at the bottom through mesh floors using breaker bars.

The traditional system requires large areas of land for large scale production and requires labor intensive, even when machinery is used for adding materials to the beds. More importantly, this type of systems process organic wastes slowly. The modern system also has its limitation when conducted in large scale of production of fertilizers. They require considerable handling and lifting machinery, and also have problems in adding water and additional layers of material inputs. Batch reactor in the other hand, apart from using manual loading and collection, this system are able to fully process three feet deep layers of suitable organic wastes in less than 30 days (Yelm earthworm & casting farm, 2009).

2.2.1 Types of annelids

Red Worms *(Eisenia foetida or Lumbricus rubellus)* or Red Wigglers, are among the common species used in vermicomposting. Each species has its preferences or adaptation to the bedding materials. For example, Red Wigglers are ideal for composting kitchen waste. This species thrive in the confinement of a composting bin. They require a moist, dark, well-drained and well-aerated environment (MSU, 2009).

According to Capistrn *et al.* (2001) cited in Earthwormdigest.org, (2008), the most widely used earthworm due to its efficiency in composting process are *Eisenia foetida* (tiger earthworm), *Eudrilus eugeniae* (African earthworm), *Perionyx excavatus* (oriental earthworm), and *Eisenia andrie* (red earthworm of California).

2.2.2 Advantages in vermicomposting

In regards of total nitrogen, the net content is gradually decreased. In the beginning of vermicompost process, the reduction of nitrogen may not be clearly significance as the worms are not yet matured. However, in the final stage of the process as the worms are being matured, the activity was higher. This resulting to the clear reducing of total nitrogen content and also high nitrification rate were observed in. The nitrification was 50 to 65 percent higher in the earthworm treatments than in the controls (Yelm earthworm & casting farm, 2009).

2.3 Microbial processes

In vermicomposting, there are part where composting by microbes occurs. These microbes are found within the herbivore animal`s manure. Composting is an accelerated biooxidation of organic matter undergoing thermophilic stage (45 to 65°C) where microorganisms (mainly bacteria, fungi and actinomycetes) liberate heat, carbon dioxide and water. The complex organic material is transformed into a homogeneous and stabilized humus through turning or aeration. Indeed that the temperature is quite high, but the microbes presence in the animals manure merely act as a decaying agent. Plus, the proportion of manure mixed in the bedding material are considerably low as the manure only act as an inducement to the decaying organic materials. Which in turns the component is degrade by the worm itself. In Vermicomposting, it involves the joint action of earthworms and microorganisms and does not involve a thermophilic stage. The earthworms are the agents of turning, fragmentation and aeration (Earthwormdigest.org, 2008).The composting process is carried out by three classes of microbes:

Psychrophiles - low temperature microbes
Mesophiles - medium temperature microbes
Thermophiles - high temperature microbes

Generally, composting begins at mesophilic temperatures and progresses into the thermophilic range. In later stages other organisms including Actinomycetes, Fungi and Earthworms assist in the process.

2.4 Vermicomposting processes

The red worm ingests all forms of organic matter through its mouth as it burrows through the soil. On the surface, it will ingest plant matter in any form of decomposition and other surface residues. This ingested material travels through the digestive track, going through the crop, the gizzard and then the intestinal tract. Finally, waste material is passed out through the anus.

In the digestive pathway, the ingested material is mixed with digestive enzymes. This enzyem are purposely secretes to release critical nutrients from the ingested material. Nutrients such as sugars, amino acids, and smaller organic organisms such as protozoa, bacteria, fungi, nematodes, and other microorganisms are 'extracted'. These smaller molecules are then absorbed by the intestines. Any matter not used by the body is excreted out through the anus.

Organic wastes are broken down by earthworms, resulting in a stable nontoxic material. This final material posse's good structure which has a potentially high economic value as soil conditioner for plant growth. Vermicompost has the properties of excellent structure, porosity, aeration, drainage and moisture-holding capacity, possess suitable mineral balance, and improves nutrient availability and function as complex-fertilizer granules. In the composting process, vermicomposting play an important role to great reduction of waste bulk density. However, this may takes longer time.

It is claimed that through vermicomposting process, great reduction in populations of pathogenic microorganisms and decrease of bioavailable heavy metals occurs. Generally, the thermophilic stage during the composting process eliminates the pathogen organisms. But, as an aerobic process, composting leads to a nitrogen mineralization and this nitrogen mineralization rate is increased by the help of earthworm's for vermicomposting.

2.5 Parameter monitoring & quality control

2.5.1 Temperature

Within the composting system, temperature plays are direct influence towards the biological activity. When metabolic rate of the microbes accelerates, the temperature within the system also increases. Conversely, as the metabolic rate of the microbes decreases, the system temperature decreases. For example, Maintaining a temperature of 130F or more for 3 to 4 days favors the destruction of weed seeds, fly larvae and plant pathogens. However, higher temperature manipulation in vermicomposting are not really significance as in common composting, as the reduction of pathogen are done by the worm itself. However, it is best to keep the temperature low in order to ensure the worms to survive. (Ecochem, 2009)

2.5.2 C:N ratio

In composting process, nitrogen and carbon are being used by the microbes and the worms as the source of energy and protein synthesis respectively. The proportion are about 30 parts carbon to 1 part nitrogen. Accordingly, the ideal ratio of Carbon to Nitrogen (C:N) is 30 to 1 (measured on a dry weight basis). Most organic materials do not have this ratio and, to accelerate the composting process, it may be necessary to balance the numbers. The C:N ratio of materials can be calculated by using table 1 below.

For example,

Two bags of cow manure (C:N = 20:1) and,

One bag of corn stalks (C:N = 60:1)

C:N ration of (20:1 + 20:1 + 60:1)/3 = (100:1)/3 = 33:1

Table 1 List of Carbon/Nitrogen Ratios of Some Common Organic Materials (Source: Ecochem, 2009)

Material	C:N ratio
Vegetables waste	12-20:1
Alfalfa hay	13:1
Cow manure	20:1
Apple pomace	21:1
Leaves	40-80:1
Corn stalks	60:1
Oat straw	74:1
Wheat straw	80:1
Paper	150-200:1
Sawdust	100-500:1
Grass clippings	12-25:1
Coffee grounds	20:1
Bark	100-130:1
Fruit wastes	35:1
Poultry manure (fresh)	10:1
Horse manure	25:1
Newspaper	50-200:1
Pine needles	60-110:1
Rotted manure	20:1

2.5.3 Moisture

Moisture content, oxygen availability, and microbial activity all influence temperature. Composting microorganisms thrive in moist conditions. For optimum performance, moisture content within the composting environment should be maintained at 45%. Too much water can cause the compost pile to go anaerobic and emit obnoxious odors. Too little water will prevent the microorganisms from propagating (Ecochem, 2009).

CHAPTER 3

METHODOLOGY

3.1 Experimental Design

Figure 3.1 shows the experimental design that conducted in determining vermicomposting of leaf litter and paper.

3.2 Vermireactor

In this study, the experiment are done in a specifically design reactor called the vermireactor. It is design in terms of to ensure the suitability of study conducted in a lab scale experiment. The design and structural function of the vermireactor are shown in figure 3.2, 3.3 and 3.4.

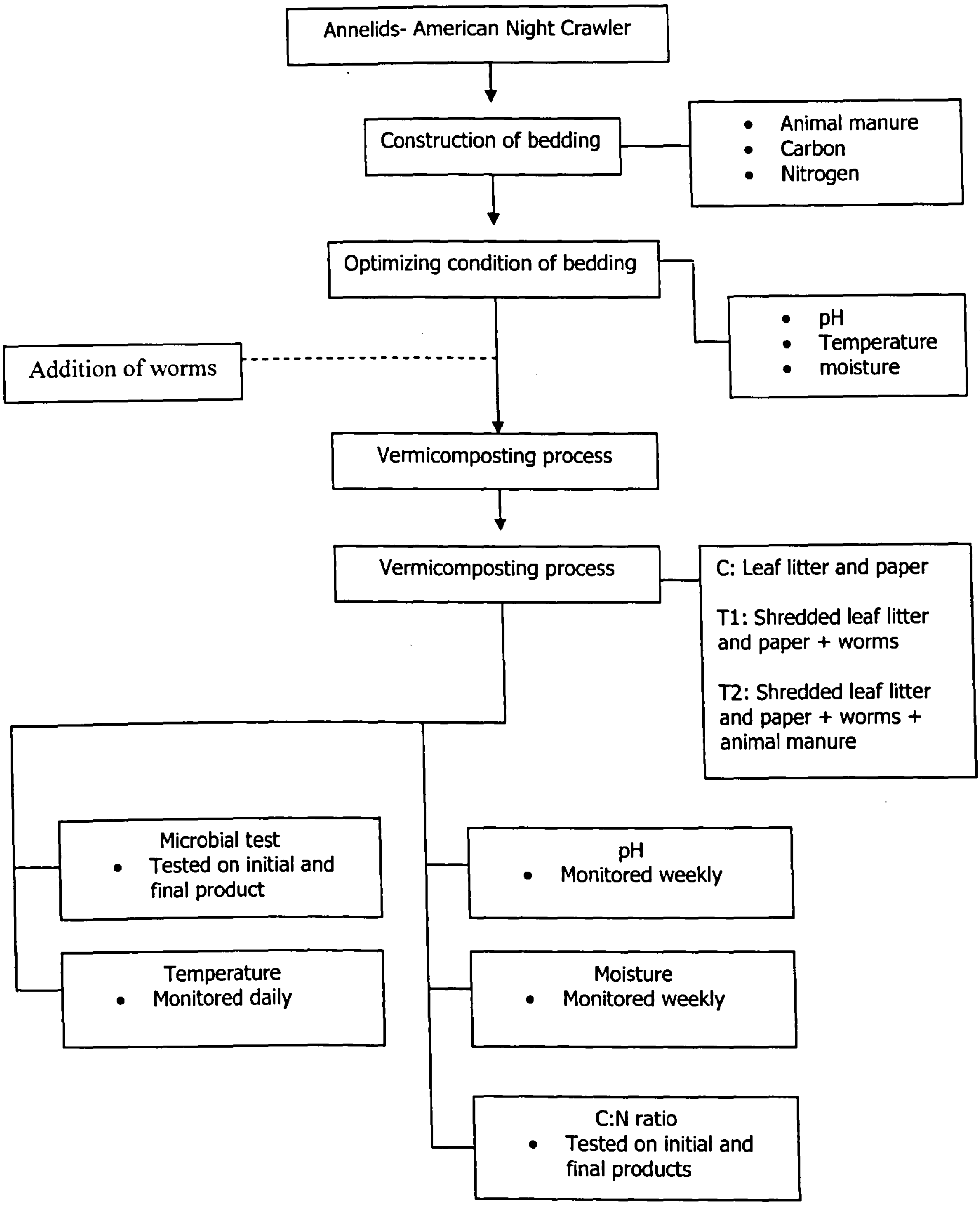

Figure 3.1 The summarized experimental design for this study

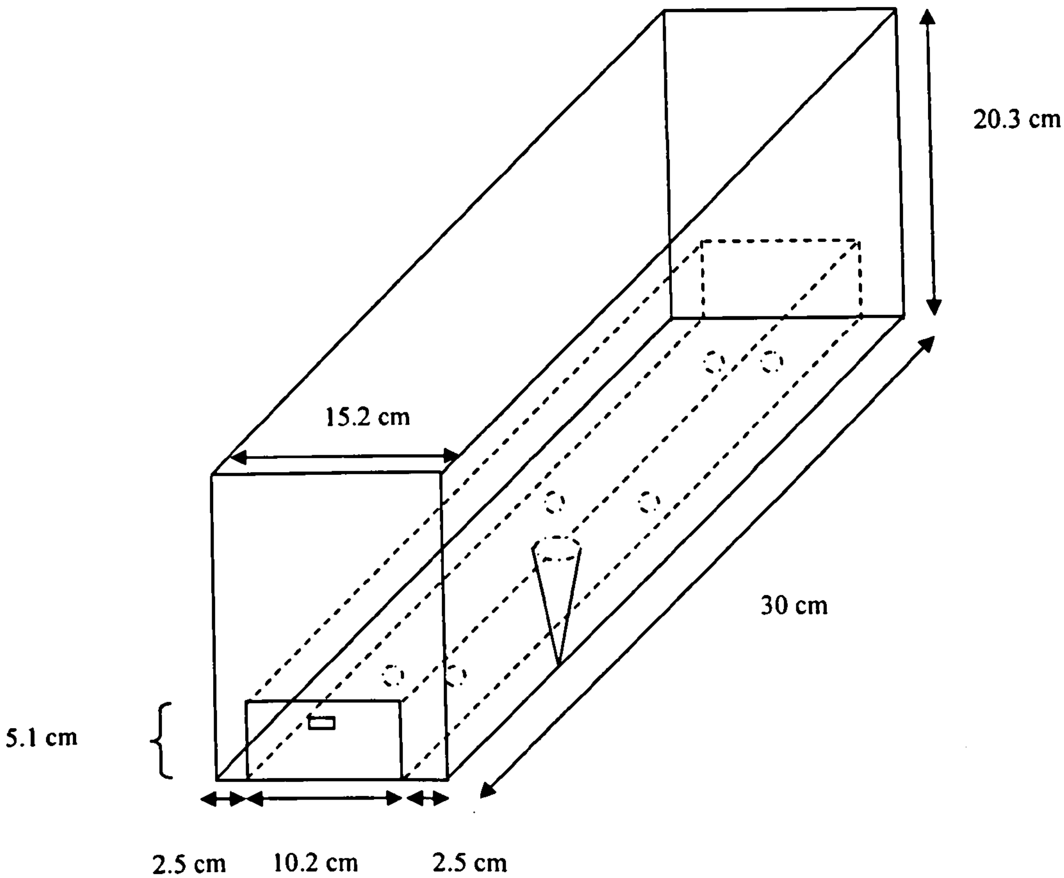

Figure 3.2 Measurement design of vermireactor

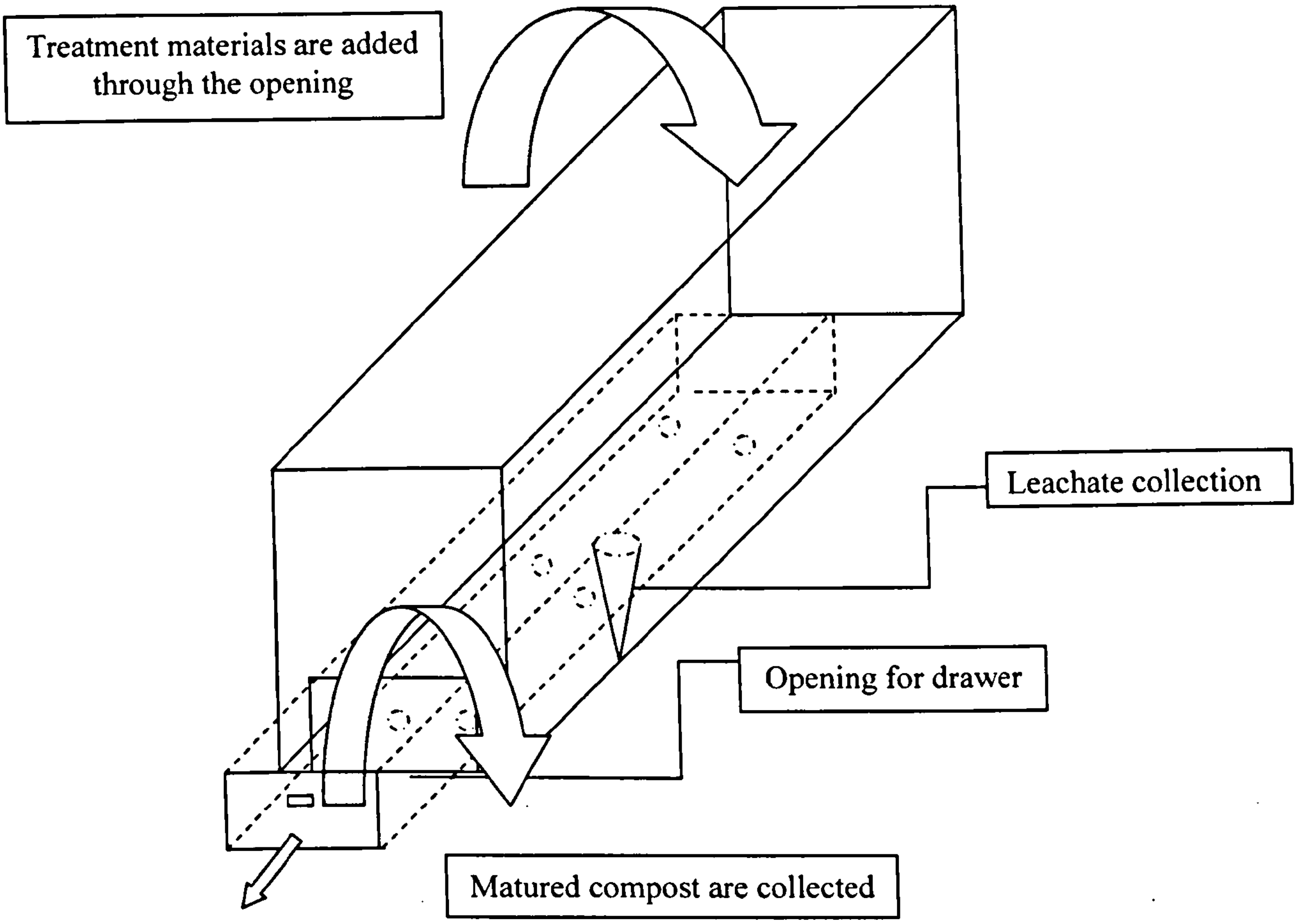

Figure 3.4 Structural function of vermireactor

3.3 Preparation of treatment

The bedding material is leave decayed for a week before the worm is allocated. This is to ensure to provide the worms to have its habitat throughout the experiment. Unsuitable condition for the worm will lead to worm's death or inactiveness which may result to the unsuccesibility of the experiments. There are three vermireactor made for this study, which, each to allocate control sample, treatment 1 (T1) and treatment 2 (T2).

This reactor function as the bedding material is topped up with treatment, it will gradually piled up. The bottom materials is the matured compost. The second compartment act as a drawer. While the unmatured material are been adding up, the matured compost are collected by only harvesting the bottom 2" of the compost. The

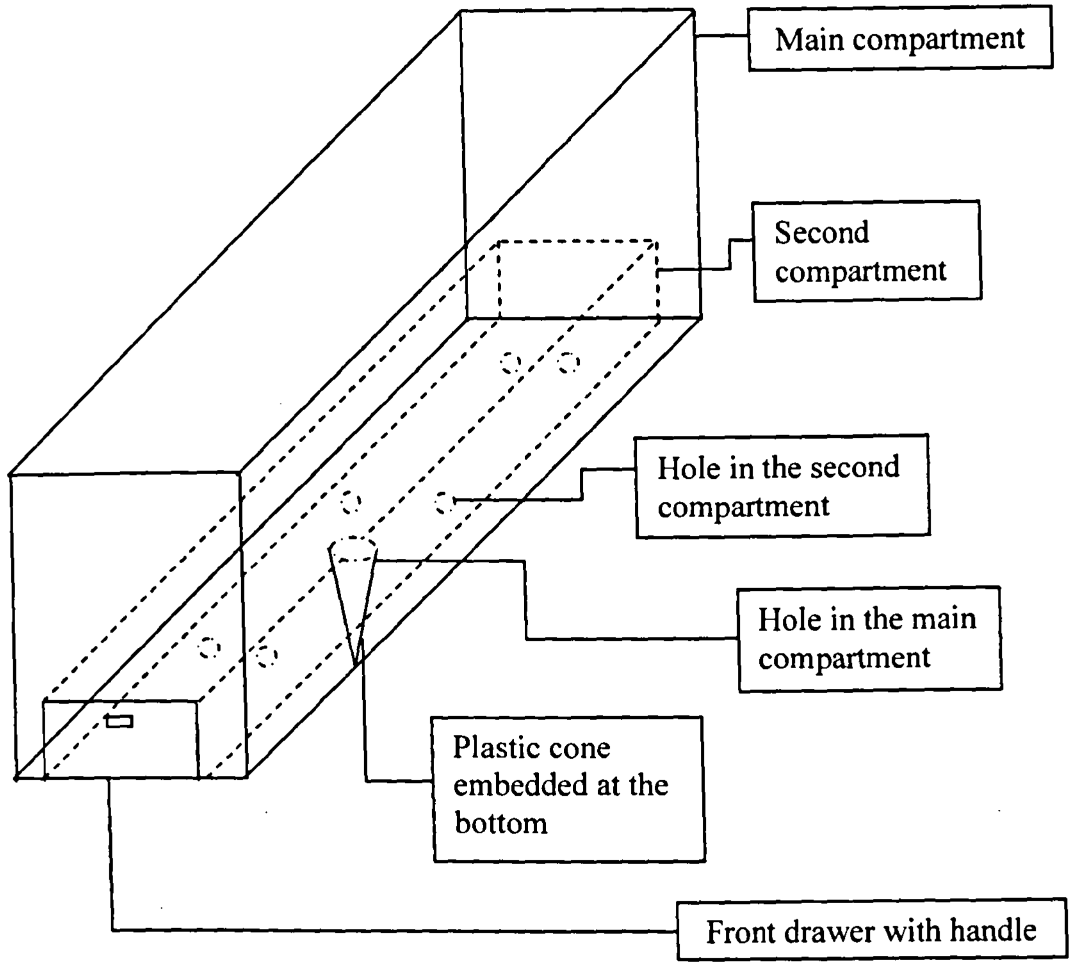

Figure 3.3 Design of vermireactor

Referring to diagram 3.3 there is 2 compartments in this design. The main compartment is to contain the second compartment. In which the second compartment will allocate the bedding material, worms and treatment material. If there is an excessive treatment material added, it will contained by main compartment. The holes in the second compartment function are to allow discharge of leachate. This leachate is then collected by a universal bottle through the hole in the main compartment.

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