DETERMINATION OF BASIC COMPOUND RATE IN VERMICOMPOST PRODUCED WITH DIFFERENT SOLID WASTE

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DETERMINATION OF BASIC COMPOUND RATE IN VERMICOMPOST PRODUCED WITH DIFFERENT SOLID WASTE

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Master Thesis

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I certify that in my opinion the thesis submitted by Samira Salem Omar RADWAN titled "DETERMINATION OF BASIC COMPOUND RATE IN VERMICOMPOST PRODUCED WITH DIFFERENT SOLID WASTE" is fully adequate in scope and in quality as a thesis for the degree of Master of Science.

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The degree of Master of Science by the thesis submitted is approved by the Administrative Board of the Graduate School of Natural and Applied Sciences, Karabük University.

Prof. Dr. Filiz ERSÖZ ....
Head of Graduate School of Natural and Applied Sciences

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"I declare that all the information within this thesis has been gathered and presented in accordance with academic regulations and ethical principles and I have according to the requirements of these regulations and principles cited all those which do not originate in this work as well."

Samira Salem Omar RADWAN

ABSTRACT

M.Sc. Thesis

DETERMINATION OF BASIC COMPOUND RATE IN VERMICOMPOST PRODUCED WITH DIFFERENT SOLID WASTE

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With a number of applications such as waste management, cheap way of soil fertilization, high rate of plant growth, environment-friendly application and advantages over chemical fertilizers; the vermicomposting is an efficient and effective process which can transform the entire dynamics of modern agriculture. In the present study the rates of basic components in the vermicompost have been characterized. Four vermicompost sample were prepared using different organic solid wastes including; natural animal manure, olive oil cake (dry olive cake), cardboard, wheat straw, wheat bran and MDF wood flour with different ratios and compositions. Drying was carried out at 25 and 70 °C to examine the effect of the heat treatment on the composition of the prepared samples. After the end of incubation, XRF elemental analysis and chemical analysis procedures were used to determine the percentage of available Potassium, Calcium, Phosphorus, Total Humic and Fulvic acid, total nitrogen and organic matter. The C / N ratio and the total % N + P_2O_5 + K_2O were calculated as a result of the analyzes. It has been observed that the natural fertilizer prepared with different solid wastes has a visible contribution to the worm reoccurrence.

Key Words : Vermicompost, Eisenia Fetida, Cow Manure, Solid Organic Wastes, Recycling

Science Code: 201.1.004

ÖZET

Yüksek Lisans Tezi

FARKLI KATI ATIKLA ÜRETİLEN DOĞAL GÜBREDE TEMEL BİLEŞİM ORANININ BELİRLENMESİ

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Atık yönetimi, ucuz toprak işleme yöntemi, bitki büyümesinde yüksek hız, çevre dostu uygulama ve kimyasal gübrelere kıyasla avantajları gibi birçok uygulama alanları ile solucan gübresi, modern tarımın tüm dinamiklerini değiştirebilecek etkin ve etkili bir süreçtir. Bu çalışmada, solucan gübresindeki temel bileşenler karakterize edilmiştir. Doğal hayvan gübresi, prina, karton, buğday samanı, buğday kepeği ve MDF olmak üzere değişik organik katı atıklar kullanılarak farklı oran ve bileşimde, dört tane solucan gübresi örneği hazırlanmıştır. Hazırlanan numunelerin bileşimi üzerindeki ısıl işlemin etkisini incelemek amacıyla kurutma işlemi 25 ve 70 °C' larda gerçekleştirilmiştir. İnkübasyon işlemi sonucu XRF elementel analizi ve kimyasal analiz işlemleri sonucu yarayışlı Potasyum, Kalsiyum, Fosfor, toplam Hümik ve Fulvik asit miktarı, toplam azot ve organik madde yüzdesi tespit edilmiştir. Analizler sonucunda C/N oranı ve toplam % N + P_2O_5 + K_2O miktarı hesaplanmıştır. Farklı katı atıklar ile hazırlanan doğal gübrenin, solucan üremesi üzerine gözle görülür katkısı olduğu gözlemlenmiştir.

Anahtar Sözcükler: Solucan gübresi, Kırmızı Kaliforniya Solucanı (Eisenia Fetida), inek gübresi, katı organik atık, geri dönüşüm

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I express my sincere gratitude and appreciation to the person who was my supporter and helper in my alienation that without him I would not reach to my target who is my husband Najey Abdulla Shemas.

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LIST OF SYMBOLS

SYMBOLS	**FULL DESCRIPITION**
^0C:	Degree celciuc
pH:	Degree of the acidity or basicity of an aqueous solution
kg:	Kilo Gram
g:	Gram
N:	Nitrogen
P:	Phosphorus
S:	Sulfur
Na:	Sodium
Ca:	Calcium
Mg:	Magnesium
B:	Boron
K:	Potassium
SO_2:	Sulfur dioxide
H_2SO_4:	sulfuric acid
OC:	organic carbon
$K_2Cr_2O_7$:	potassium dichromate
$Fe(NH_4)_2(SO_4)_2.6H_2O$:	ferrous ammonium sulfate
$NaHCO_3$:	sodium bicarbonate
P_2O_5:	Phosphorus pentaoxide
K_2O:	Potassium oxide
$CaCO_3$:	Calcium Carbonate

LIST OF ABBREVIATIONS

ABBREVIATION	**FULL DESCRIPITION**
ATP	Adenosine tri phosphate
DNA	deoxyribonucleic acid
MDF	Medium Density Fiberboard
NPK	Macro-nutrients are nitrogen (N), phosphorus (P) and potassium (K)
UV	Ultraviolet Radiation
XRF	X-Ray Fluorescence Spectrometer
V	Cow Manure
VC	Cow Manure and Tea Pulp
VP	Cow Manure and Olive oil cake
VM	Cow Manure, Tea Pulp, Olive oil cake, Cardboard, Wheat Straw, Wheat Bran and MDF Wood Flour
HA:	Humic Acids
FA:	Fulvic Acids

CHAPTER 1

INTRODUCTION

Billions of tons of waste are generated worldwide. These wastes are result of activities in our homes, businesses and industries. Safe waste disposal becomes the current global problem with many dimensions (Hoornweg and Bhada-Tata, 2012).

Biological treatment is probably the only eco-friendly way for sustainability. The biodegradable wastes will be subjected to product-oriented processes of bioconversion using advanced technology. The produced biocompost or bio fertilizers of desired quality can be applied as a suitable growing medium or horticultural substrate, soil improvements that influence the physical, chemical and biological properties of the soil (Gajdoš, 1998).

Vermicomposting technology is a promising technology with its potential in certain challenging areas like augmentation of food production, waste recycling, management of solid wastes etc. Vermicomposting is a relatively cheap and eco-friendly technology for the treatment of different organic wastes utilizing different earthworms (Lazcano and Dominguez, 2011). Vermicompost is the product of composting the organic waste using various worms, usually red wigglers, white worms and other earthworms to create a heterogeneous mixture of decomposing vegetable or food waste and bedding materials (Edwards, 2007).

During composting process, worms and microorganisms degrade complex organic compounds into more simple substances along with the production minerals and stabilized organic matter. Earthworms excreta, also called as the vermicast, is also nutrient organic fertilizer rich with micronutrients, humus, NPK, soil microbes such as phosphate solubilizing and nitrogen-fixing bacteria, and growth hormones.

Vermicomposting differs from traditional composting as it is a mesophilic process utilizing microorganisms and earthworms that are active at 10°C to 32°C (Gandhi et al., 1997). As the waste material passes through the earthworm gut, the process is faster than composting; whereby the resulting earthworm castings are rich in microbial activity and plant growth regulators, and fortified with pest repellence attributes as well (Vermi Co., 2001; Crescent, 2003)

Earthworm is a tube-shaped, segmented animal commonly found living in soil and feeding on dead organic matter. About 3000 species of earthworms are found worldwide (Adhikary, 2012). The earthworm digestive system runs along its body (Lee, 1995). When the compost is passing through the worm body, it is enriched with bacteria and microbes. Chaoui et al, reported the more positive effect of worms excrete casts on plant growth when compared with compost or commercial potting mixture amendments (Chaoui et al., 2003).Moreover, movement of earthworms acts as mechanical blenders and increases the surface area exposed to microorganisms, making it much more favorable for microbial activity and further decomposition (Yadav and Garg, 2011).

Vermicomposting process is usually carried out in pits as well as concrete tanks, well rings, sometimes wooden or plastic crates as suited by the situation. When performed in pits, it is favored to choose a composting site in shadow area, on the height or a raised level in order to prevent water stagnation in pits. The place has to be moistened to a certain level that is most efficient for the sustenance of the earthworms. In addition, the pH should be nearly 7. Finally, adequate provision of periodic renewal of organic matter should be ensured after taking out the vermicast.

Vermicompost contains a higher content of macro- and micronutrients compared to ordinary compost (Garg and Kaushik, 2005). It contains 9.8–13.4% organic carbon, 0.51–1.61% nitrogen, 0.19–1.02% phosphorus, and0.15–0.73% potassium. The nutrients present in the vermicompost are in water soluble forms which are easily absorbed by plant (Suthar, 2009; Ndegwa and Thompson, 2001).During the vermicomposting, earthworm consume the organic materials so that it reduces the C:N ratio and retains more N than the traditional methods of preparing composts (Gandhi et al. 1997).

Vermicompost provides a wide range of benefits as an excellent natural fertilizer to the plant alternative to the artificial fertilizers. In addition, the compost is beneficial for the soil as a conditioner, a fertilizer with water-soluble nutrients and vital humus or humic acids (Jenkins, 2005; Coyne and Knutzen, 2008). Application of compost as a soil amendment improves the physical and chemical properties of soil as well as grass quality (Hornick et al., 1984；Angle, 1994; Landschoot and McNitt, 1994).

To improve the environmental quality, reduce the health risk and meet the financial and technology shortages, the present work will focus on the solid organic waste treatment technology. Based on the vermicomposting process, the system is supposed to digest and compost the organic waste and dung.

In order to complete this system, the following objectives have conducted to review the vermicomposting technology, including technology development history, composting facts and parameters introduction, and characters of products. Studying and analyze the available solid organic waste and composting products, including earthworm will be performed.

CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION

Vermicomposting is an earthworm-aided process of the conversion of organic materials such as food waste, agricultural waste, animal remains, etc. into a heterogeneous mixture that is extremely rich in nutrients and can be used as environmentally acceptable manure. This strategy is a cost-effective, practical and convenient method to remove organic waste and convert it to an extremely beneficial substance to treat land devoid of nutrients and therefore, better growth of plants. On the other hand, it is a good replacement to land fillings. The end products also known as castings have been found to contain depleted levels of contaminants present in the mixture and a higher concentration of nutrients as compared to the organic materials before vermicomposting.

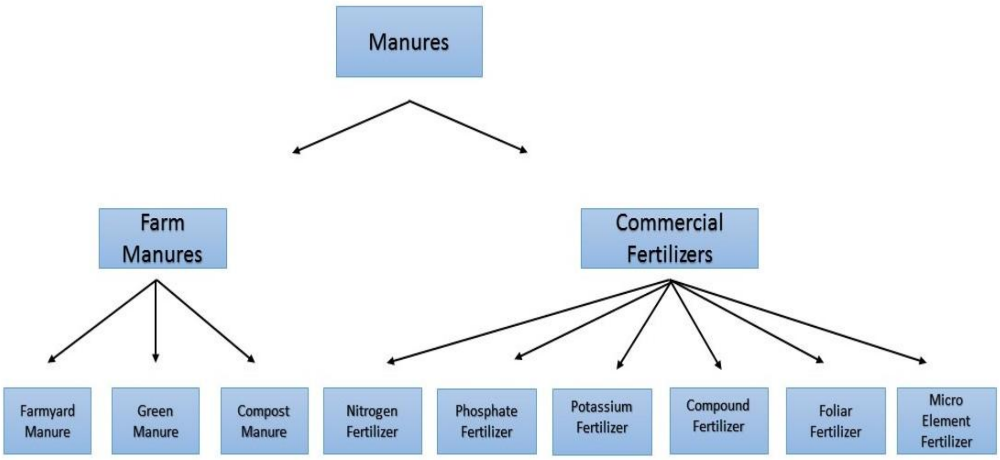

Figure 2.1. Classification of manures in to farm-based and commercial-based fertilizers.

As per Lazcano and Dominguez (2011), vermicomposting is defined as a relatively cheap and nature-friendly technology particularly utilized for the treatment of different types of organic waste. While, the product of the vermicomposting process, called as the vermicompost provides a wide range of benefits as a natural fertilizer to the plant. As per the authors, vermicomposts are an excellent alternative to artificial fertilizers that have different side effects. Further, the author explains the entire numbers of effects of vermicompost are not fully known yet. Though, further research in this field is mandatory to understand the effect of vermicompost, clearly.

Sinha et al. (2013), investigated the nutritional value of different crops which are produced under the application of various agrochemicals. The research has established that due to the large scale usage of artificial fertilizers and agrochemicals, the soil has become rich in certain dangerous minerals and constituents. Especially, the nitrates and free amino acids are present in large amounts in the soil, where agrochemicals are used. The paper explained that the presence of nitrates in the soil could pose different health concerns for the crop consumers. On the other hand, the research also investigated that many of the important nutrients such as calcium, potassium, iron, proteins and vitamins have drastically dropped in the crop samples taken over different decades.

Lazcano and Dominguez discussed the importance of organic farming and vermicomposting on the changing paradigms of the environment (Lazcano and Dominguez, 2011). The authors elaborated different problems of human food safety and depriving nutrient content of the crops. The authors also mentioned the utility of vermicompost produced by the earthworms which provide high productivity and fertility to the soil. As per the research, the vermicompost formed by the earthworms has even better nutrient content than the chemical fertilizers. Moreover, the vermicompost enhances the chemical and physical properties of the soil as it is rich in NPK content, high number of important micronutrients and specific plant enzymes. These plant enzymes contain particular growth hormones which are essential for the proper development of the plant. Moreover, the vermicompost mixed soul can retain nutrients for a long period along with protecting the plant from pests. Another distinguishing factor presented in the paper explained that the vermicompost enhances the water holding capacity of the soil and decreases the necessity of water by nearly 43%.

Waste materials that can be composted include every day organic kitchen waste, discarded materials from the grocery stores such as bread, pastries, fruits, vegetables, milk products, fish, seafood and wide varieties of other frozen products. The idea of recycling waste nutrients and return to the soil where it is available for the plants is the chief underlying concept of this strategy. Composting has been one of the most assuring strategies to treat wastes in a more cost-effective and economical way for many centuries because of its extremely advantageous secondary aspect of recycling organic matter into the soil back again to improve its structure and enhance fertility.

2.2. EARTHWORMS

Vermicompost is an excellent conditioner for soil. Soil microorganisms, such as earthworms have significant potential to boost the decomposition process. Consequently, it reduces the waste volume that results in adding value to the end-product (Kumar, 1994). During composting worms and microorganisms such as bacteria and fungi break down complex organic compounds into simple substances along with the production of water, carbon dioxide, minerals and stabilized organic matter that is called compost. The process is accompanied by the production of heat which destroys pathogens, the disease-causing microorganisms and weed seeds. Earthworms excreta also called as the vermicast is a nutrient rich organic fertilizer loaded with micronutrients, humus, NPK, advantageous soil microbes; phosphate solubilizing and nitrogen-fixing bacteria, actinomycetes and growth hormones such as auxins, gibberlins, and cytokinins. Both the vermicompost and its body liquid also called as the vermiwash, are both growth promoters and protectors for crop plants.

Sinha explained that the vermicomposting done by earthworms had become a major growth promoter for crops, all over the world. Its usage as a soil fertilizer is five times more potent than the normal organic fertilizer (Sinha et al., 2013). When compared to chemical fertilizers, the potential of the vermicompost is 40% higher. Further, the authors explained that vermicompost is highly aerated and has very high water holding capacity. Besides, it also safeguards different plants against different types of pests, soil-borne diseases, thus, increasing the resistance of the plants. While the verminwash secreted by the worm acts as a natural protection against the pests. As per the authors, the vermiwash contains different toxic substances which protect the plant from different types of pests. Therefore, it acts as a great alternative to the chemical pesticides.

Earthworms belong to the class of invertebrates called phylum Annelida and class Oligochaeta. The name comes from their nesting habitats. They are usually terrestrial and burrow into soil rich in moisture and emerge at night for foraging. These organisms are long, soft-bodied, thread-like, elongated, cylindrical creatures with uniform ring-like structures all along the length of their segmented body. The segmentation is not only external but exists internally too. On the ventral surface of each segment lies four pairs of short bristles called setae. The setae provide friction required for locomotion and enable the worms to adhere to their burrows while predators try to pull them out. The food is moistened initially by an alkaline enzymatic secretion that leads to the digestion of starch, and therefore, makes it easier to tear it down to shreds. Leaves may be torn by holding them by the edge of the prostomium and the mouth and pushing the pharynx forward. After passing from across the body of the earthworm, the food comes out in the form of a concentrated and compact mass called as casting. Casting is done by earthworms inside the burrows and sometimes outside too. Earthworm casts can usually be found to contain microorganisms, inorganic minerals, along with organic matter. The castings are formed in a way that is available to plants. Few enzymes are also present in the cast such as lipase, chitinase, protease, amylase, and cellulase which continues to decompose organic matter even the material gets secreted.

2.3. VERMICOMPOSTING

Vermicomposting is done in pits as well as concrete tanks, well rings, sometimes wooden or plastic crates as suited by the situation. When done in pits, it is favored to choose a composting site under a shade, on the height or a raised level in order to prevent water stagnation in pits during rains. An idle set-up for creating vermicompost has certain key attributes. The provision of earthworms should be sufficient so that they can live, feed and breed freely without any limitation on their numbers. The place has to moist to a level that is most efficient for the sustenance of the earthworms. The pH should be nearly 7. The presence of any predators should be checked to prevent harm to the worms. Moreover, adequate provision of periodic renewal of organic matter should be ensured after taking out the vermicast.

The tanks or the containers in which the compost is prepared are called the vermireactors, which are essentially tanks in which earthworms are feed upon animal manure and other biodegradable organic wastes. In order to enhance the benefit from such reactors, it is necessary to lower the reactor volume for a given amount of the vermicast end product (Gajalakshmi, et al., 2001). According to the study conducted by Ismail, a typical vermicomposting unit can be created by initiating with a basal layer of vermi-bed of small pebbles or broken bricks up to 3-4 cm (Ismail, 1997). This layer is followed by a basement of coarse sand up to a thickness of 6-7 cm so that to ensure proper seepage. Finally, a 15cm thick layer of moist soil is placed. It is this layer in which nearly a hundred earthworms are placed forming the inoculums. After the entire setting, water may be sprinkled so that the setup gets moist but not wet. An optimum quantity of water is crucial for the sustenance of the worms since little water can kill them whereas too much of water will repel them away. In some cases the entire setting is at the end covered by broad leaves or old jute bags. The unit is kept under observation for nearly 30 days with a regular check for water. At the end of 30 days, the appearance of young earthworms is taken as a healthy sign. The harvested compost can be piled up in sunlight followed by spreading it to facilitate the worms to move in the upper layers. Specifically, earthworms are utilized for the task of vermicomposting to convert the organic waste into humus. The humus is dark brown in color and highly rich in nutrients, which is required for the proper growth and development of a plant. Vermicomposting can be done on the household wastes to convert them into useful manure for the plants. Many a times, the vermicomposting process is utilized to nullify the pollutants and generate useful products. Although, the process offers a lot of advantages but it needs a precautionary approach for the complete proliferation of the entire vermicomposting process**.**

In a study conducted by Suthar in 2008, vermicomposting was done using vegetable-market solid waste acted upon by *Eiseniafetida* and the impact of the material used on the growth of earthworms and the decomposition of the organic matter (Suthar, 2009). Vegetable waste is released from the market in millions of tones in urban zones which lead to the problem of safe and clean disposal. The vegetable waste was added with wheat straw, cow dung, and biogas slurry in different ratios to produce eight batches with different combinations. These batches were then screened for next 15 weeks. As an observation, by the end of the process, an increment in the concentration of organic Carbon present went from 12.7% to 28% along with the carbon to nitrogen ratio that went to 57.8% from 42.4%. The total nitrogen concentration increased from 50.6% to 75.8%. The concentration of available phosphorous increased from 42.5% to 110.4% whereas the exchangeable potassium increased from 36% to 78.4%. Owing to the following observations, the study concluded that conversion rates as well the humification rates were greater in those batches that contained easily digestible bulky agents that are either Biogas slurry or cow dung. The vermicompost that was obtained from Biogas and vegetable waste compost mixed in 1:2 showed a greater concentration of total amount of Nitrogen present per kilogramme of the compost i.e., 31.3 g kg^{-1}, available Phosphorus, i.e., 8.7 g kg^{-1} and Exchangeable Potassium to be 20.7 g kg^{-1}. A higher ratio of C:N in the vermicompost indicates its agronomic potential. These mixtures were also found to have supported the growth of earthworms and better reproduction rates. The study also concluded that if mixed in proper ratios along with proper additives such as cow dung and biogas slurry, vermicomposting can be an efficient strategy to convert waste to highly useful fertilizers (Suthar, 2009).

Earthworms can be cultured and made to multiply by providing a 1:1 mixture of decaying leaves and cow dung kept in a plastic bucket or a cement tank or wooden box with appropriate effluent facilities. Optimum moisture level should be ensured by a regular sprinkling of water. Worms reproduce to 300 times of their number within 30-60 days and such setups are employed for large-scale composting. In a study by Garg et al., in 2006, the group compared the relative fitness of municipal biosolids, dry olive cake, and cattle manure as additives to the initial mixture for Vermicomposting and examined and concluded that greater masses of newly produced earthworms were achieved in the batch containing dry olive cake as the additive (Garg et al., 2006).

2.4. BENEFITS OF VERMICOMPOST ON CROPS AND PLANTS

There have been studies on the effect of using vermicompost on the growth of many important vegetable crops such as eggplant (*Solanummelangona*), tomato

(*Lycopersicumesculentus*), and okra (*Abelmoschusesculentus*). These crops have been reported to have yielded very good results (Sinha et al., 2009; Webster, 2005; Atiyeh et al., 1999; Gupta et al., 2008) when used upon by vermicompost. Another study by Agarwal et al., in 2010 was conducted to observe the impact of the growth of earthworms with different types of feed materials, cow dung compost, vermicompost, and chemical fertilizers on the healthy growth of okra (*Abelmoschusesculentus*). The study reported that worms and vermicompost served as excellent supporters for growth in the vegetable crop yielding more flowers and development of more fruits. The immensely significant observation was the drastically reduced occurrence of Yellow Vein Mosaic, Color Rot, and Powdery Mildew diseases in plants treated with the worm and vermicompost (Agarwal et al., 2010).

A study conducted by Ansari in 2008 on the effect of the treatment of the productivity of Potato (*Solanumtuberosum*), Spinach (*Spinaciaoleracea*), and Turnip (*Brassica campestris*) with vermicompost in a reclaimed sodic soil in India. The total productivity of potato applied with vermicompost was significantly greater (21.41 tons/hectare) than the vermicompost applied at a rate of 6 tons/hectare when compared to the control which was 4.36 tons/hectare. The alkalinity of the soil was also subdued, and nitrogen contents raised significantly (Ansari, 2008). In supplement to improving plant growth and fertility, vermicompost is also found to increase the nutritional content of many vegetable crops like tomatoes (Gutiérrez-Miceli et al., 2007) , Chinese cabbage (Wang et al., 2010), spinach (Peyvast et al., 2008), strawberries (Singh et al., 2008) and lettuce (Coria-Cayupán, 2009).

Another study was conducted to examine the consequences of usage of organic manure with earthworm vermicast on the growth of garden pea (Pisumsativum) and comparison with chemical fertilizers resulted in higher number of green pods in the plants treated with the vermicast. Moreover, greater green weight per plant, higher number of green pod plants, greater protein and carbohydrates percentage as well as higher green pod yield from 24.8% to 91% when compared to the results of chemical fertilizer was witnessed (Meena et al., 2007).

Studies performed to examine the consequences of vermicompost and chemical fertilizer on the growth of hyacinth beans (Lablab purpureas) found that all parameters used to measure growth and yield such as dry matter production, total chlorophyll content in leaves, appearance of flowers, number of fruits per plant, size and shape of fruits dry mass of hundred seeds, yield of the crop per unit plot size and yield per hectare, were immensely eminent in plots which were supported by vermicompost either along with chemicals or alone. The highest fruit yield that was recorded in plants treated with the vermicompost was observed to be 109 ton/hectares with an input vermicompost injected at a rate of 2.5 tons/hectares (Karmegamand Daniel, 2008).

2.5. HUMIC ACID: A MAJOR COMPONENT OF HUMUS

Humus is the prime component of organic matter. It is produced during the process of biodegradation of organic matter. As water washes the soil, it takes away the humic acids from the humus in the ground. Studies show these acids have proven to be an extremely effective tool for regulating the metals traces in both plants and animals. Humic acid constitutes of many different acids containing carboxyl and phenolate groups. Therefore, the mixture works as a dibasic acid or tribasic acid. These acids are found in the form of colloids due to their association with complex ions present in the soil. Humic acid is chemically insoluble in water at acidic pH. The unique ability of humic acid towards the betterment of plant growth and yield is due to the promotion of specific plant hormones. This leads to regulation of plant development. Humic acids also trigger the removal of free radicals in plants which are formed during stress from drought, UV exposure, heat and herbicides. Free radicals can damage the DNA of the plants with a strong deteriorating effect on lipids and proteins too.

Humic acid is found to have the unusual ability to interact and bind to positively charged ions. Since, the deposits formed from particles of metal such as Magnesium, Calcium, Phosphorus, and Iron are positively charged, humic acid correctly binds to these ions assisting in purification and revitalizing natural balance in human body.

2.6. FULVIC ACID: ANOTHER COMPONENT OF HUMUS

Fulvic acid is another very powerful component of humus that has the least molecular weight. It looks golden in color as compared to the brown color of humic acid. Owing to its small size, its penetration ability is very high. Therefore, it is a great supplement to root sprays and foliar drenches. Another aspect in which Fulvic acids differ from humic acid is that it remains in solution even after extraction of humic acid from humin by acidification. Humic acid and fulvic acid can be differentiated by their acidity, carbon and oxygen contents, the degree of polymerization, and molecular weight.

It is used as an input for crops in any kind of growing environment such as soilless greenhouse facilities. One fulvic molecule can carry over 60 trace elements and minerals so as to boost the process of cation exchange, providing the plants with easier access to nutrients and therefore, exploiting the nutrients present in the soil to the fullest. It incites metabolism in plants and enhances the enzyme activity. It acts as a catalyst in plant respiration too. Adding it to the soil separately improves nutrient intake since it enhances cell permeability to selected beneficial nutrients and improvises cell division and elongation. Adding to its roles, it can also improve the synthesis of chlorophyll in plants and acts as a detoxifying agent against many pollutants. When fulvic acid is added to soil, plants get a uniform supply of food. Another aspect in which Fulvic acids differ from humic acid is that it remains in solution even after extraction of humic acid from humin by acidification.

2.7. MAJOR ELEMENTS REQUIRED FOR PLAT GROWTH

All aspects of a plant's growth is directly dependent on the availability of the nutrients required for its growth and fertility. Carbon, Hydrogen and Oxygen are taken from the atmosphere and water and there is not much a grower should focus on for their availability. Following is the list of elements along with their functions that are of prime importance to plant growth:

2.7.1. Primary Macronutrients:

- ✓ **Nitrogen**

It is the prime nutrient that is required for photosynthesis and vigorous growth of plants. Plants that are mostly constituted of leaves require plenty of Nitrogen and therefore, a sufficient supply should be affixed. Fertilizers used for lawns are especially high on Nitrogen because of usual presence of grass and leafy plants. Plants take up Nitrogen in the form of nitrate and ammonium ions from soil.

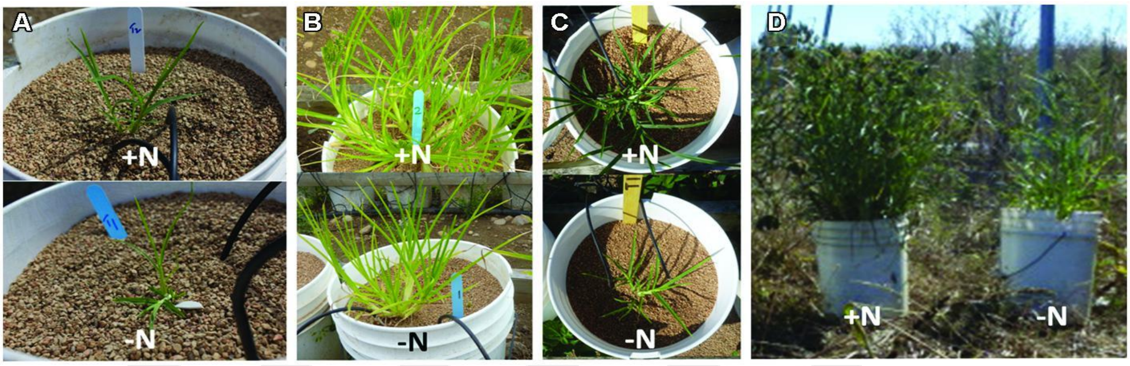

Figure 2.2. Finger millet shoot responses to low N at different growth stages (Goron et al., 2015).

- ✓ **Phosphorus**

Phosphorus forms the second important element that is popularly provided by the NPK fertilizers because of its role in root development and therefore strengthening the plants. It plays an important role in enhancing blooms on flowers and helps in to ripen fruits. Usually because of its role in supporting the plants to soil, it is very important to be sprayed to newly germinating plants and for bulbs and perennials. Phosphorus is also a part of the energy giving molecule ATP and therefore necessary in maintaining metabolism for plants.

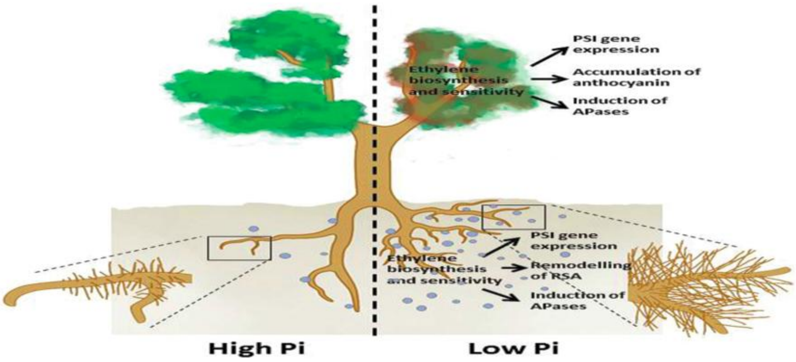

Figure 2.3. An overview of the plant responses to Phosphate deficiency that involve ethylene (Song and Liu, 2015).

- ✓ **Potassium**

Potassium is the third among the three primary macronutrient elements required by the plants. It aids in overall health of plants such as during cold and hot weathers, defense against diseases, fruit formation, and uptake of other elements and during photosynthesis. It works in association with Nitrogen and therefore, it is important to add it along with Nitrogen.

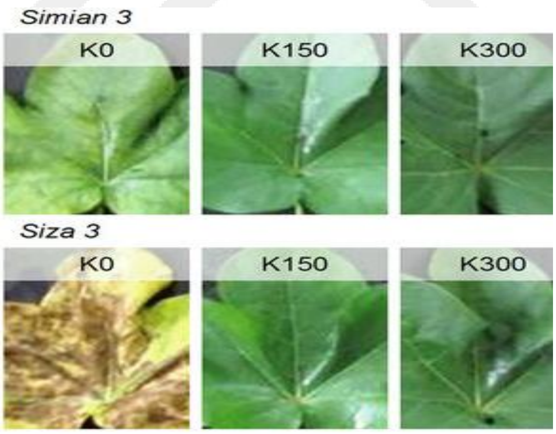

Figure 2.4. Appearance changes in cotton functional leaves due to changes in Potassium (Yang et al. 2016).

2.7.2. Secondary Macronutrients:

- ✓ **Calcium, Magnesium, and Sulphur**

Calcium is taken up by the soil in the form of Ca^{+2} ions. It is a chief constituent of the cell wall and thus plays a major role in providing strength to new plants. It is specifically required for the peg development in peanut plants. Stem and root tip elongation are other two major roles. Magnesium is required for growth and chlorophyll production. It is taken up by plants in the form of doubly charged Magnesium cations. It is a mobile element, therefore, its symptoms are seen in old leaves. Sulfur is taken up from leaves in the form of SO_2. It maintains the dark green color of leaves and is a constituent of three of the 21 amino acids. Its deficiency is more apparent in young leaves.

2.7.3. Trace Elements:

Remaining elements are required in trace but are necessary for a proper growth of plants. Such elements include Boron, Chlorine, Copper, Iron, Manganese, Molybdenum, and Zinc. These elements have functions such as in metabolism, photosynthesis, chlorophyll synthesis, assistance to other macronutrients, and enzymatic actions.

2.8. FACTORS AFFECTING THE VERMICOMPOSTING PROCESS

Meena et al. (2007) defines that environmental factors such as the temperature, pH level, and moisture content in the air or humidity govern the rate of vermicomposting of a particular solid waste. Additionally, the distinct earthworm species and substrate are also important for the evaluation of the vermicompost process. As per the research done by the author, the adequate level of moisture should be between 50 to 58% in air. This moisture content is ideal for different earthworm species such as the *E.foetida* and *P.excavetus*. Likewise, the adequate level of temperature must be kept at 34.50 C for the proper initiation of the vermicompost process. Both the *E.foetida* and *P.excavetus* were found to be performing adequately at this temperature. Whereas the pH level of the particular solid waste was 6.3, and with the addition of soil, and cow dung, it rose to 6.7. The findings revealed the loss of vermicompost weight over a period of 60 days with the *E.foetida* at 62%. On the other hand, *P.excavetus*showed 52%. Therefore, it also presented *P.excavetus* as a more efficient species to produce vermicompost.

2.9. EFFECT OF WHEAT STRAW IN VERMICOMPOST

Wheat straw is used as a feed for worms during the preparation of Vermicompost. Sheoran et al.(2015) presented a research report that explored the optimum levels of

Nitrogen and Vermicompost in the soil for an enhanced yield of different crops. They conducted an experiment on the effect of wheat straw in the quality of vermicompost. The findings of the research proved that production of Indo-American hybrid tomato and groundnut produced a higher yield when vermicompost is utilizing wheat straw as mulch was used.

2.10. EFFECT OF TEA LEAVES ON VERMICOMPOST

The application of tea leaves as plant fertilizer is a well-known concept. Its application with vermicomposting is also beneficial for the plants.It has been proved in different researches that compost formed by mixing tea leaves is highly beneficial for the plants. Sinha et al. (2013), explained that the tea leaves added to the compost creates concentrated nutrients and bacteria in liquid form that are easily absorbed by the plant roots. The research carried out by the research group showcased that the application of tea leaves in the formation of vermicompost adequately prevents any soil borne disease which can affect the plant. The research also presented that leaves of the plant develop a protective coating due to the application of tea leaves, as well.

Further, the tea compost formed of tea leaves is marginally acidic in nature which can be utilized to neutralize the pH of a basic soil. Besides, many plants require acidic soils and hence, addition of tea compost can adequately lower the pH of the soil for such plants. The authors presented that tea leaves are rich in potassium which is essential for optimum growth of the plants. Another major factor detailed in the research was the use of tea leaves in the vermicomposting for high yield of mushrooms. The author presented that a ratio of 1:1 between tea leaves and peat is optimum for mushroom growth. By application of tea leaves, high yield of mushrooms can be obtained. The authors conducted an experiment on the growth rate of the rose plant on which tea leaves vermicompost is applied. The results showed that soil mixed with tea leaves hastens the growth rate of the rose plant by 13%. The reason can be attributed to the tea leaves being a rich source of antioxidants, which are essential for high growth rate in certain plants.

2.11. EFFECT OF OLIVE OIL WASTE ON VERMICOMPOST

The research conducted by Capowiez et al. (2009) elaborated the concept of using dry olive cake in vermicomposting. The research explains that the dry olive cake is the by-product obtained during the production of olive oil. The author claims that the use of this by-product in vermicomposting can produce optimum results in proliferating the biomass of earthworms. The author conducted a nine month experiment, in which biomass and enzyme activities of the earthworm population were monitored. The results obtained in this experimented proved that the biomass, number and enzyme activity of the earthworm population increased by 12 folds, with the addition of the dry olive cakes. The high increase in the enzymatic activated was attributed to the biodegradation of the dry olive cakes. The experiment also described the role of dry olive cakes in decreasing the overall phytotoxicity of the substrates.

2.12. EFFECT OF COW MANURE ON VERMICOMPOST

Wang et al. (2010) described in their research the effects of vermicompost formed with the addition of cow manure. The paper describes the effect of cow manure vermicompost on the growth and development of the Chinese cabbage plant. In addition to that, the authors also evaluated metabolic activity, antioxidant production, and biodegradation parameters in the conducted experiment. The authors conducted the experiment on Chinese cabbage in distinct pot cultures. Further, the experiment constituted of creating five different treatments which contained cow dung mixed vermicompost and soil in the following proportions respectively: 0:7, 1:7, 2:7, 4:7, and 7:0. According to the results of this experiment, the Chinese cabbage culture was grown in 2:1 proportion showcased a very high magnitude of marketable weight. Whereas, the culture was grown in 7:0 treatment that contained no compost had the least magnitude of marketable weight of the Chinese cabbage. Additionally, other findings of the experiment suggested that nutrient content of the Chinese cabbage was significantly higher in the 4:7 treatment culture as compared to the other treatments. In contrast with the full soil culture, the nutrient content was approximately 25% higher in the 4:7 treatment culture. Further, the antioxidant activities exhibited by the treatments containing vermicompost were also considerably higher than the pure soil treatment. The 4:7 exhibited 92% higher antioxidant level, whereas the 1:7 treatment had 36% higher antioxidant level than the 0:7 treatment. Therefore, the overall experiment proved that the addition of cow dung manure in the vermicompost could significantly increase the productivity and yield of the plants.

2.13. EFFECT OF CARDBOARD ON VERMICOMPOST

Cardboard has been used as a bulking material supplement in vermicomposting because of it helps in reducing the extra moisture from the mixture along with being an excellent source of organic carbon which is beneficial for microbial activity in immobilizing excess ammonia. In a work by Marsh et al., the aptness of mixing shredded cardboard along with aquaculture effluent solids as additives in making a vermicompost was examined. In order to achieve the desired C:N ratio the workers utilized a specific ratio of organic material to cardboard and attained optimal earthworm growth (Marsh et al., 2005).

2.14. BENEFITS OF VERMICOMPOST

Red worm castings possess a higher fraction of humus aids soil particles to form clusters creating grooves for the crossing of air and enhance its potential to retain water. The presence of worms restores condensed soils and enhances water diffusion in such soils by over 50%. (Ghabbour, 1973; Bhat, and Khambata, 1996; Capowiez et al., 2009). A study conducted in US shows that 10,000 worms in a farm plot render the same advantage as 3 farmers working for 8 hours in the squad all year with ten tons of manure administered in the plot (Li, 2005). Humic acid found in humus renders active binding sites for nutrients, such as phosphorus, calcium, potassium, sulphur and iron. These nutrients are collected in the humic acid in a form that is readily available to be used for the plants, and are discharged when the plants need them. The humic acid present in vermicompost incites plant growth even when present in a small amount (Canellas, 2002). The humic acid found in humus support plants in four ways; it enables plants to gain nutrients from soil; it helps in the dissolution of unresolved minerals making the nutrient readily available to the plants; it stimulates better root growth; it helps plants to overcome stress. Humus in the soil helps in a better activity of the chemical fertilizers too (Li and Li, 2010).

As per Sinha et al. (2013), vermicomposts produced by the earthworms are highly beneficial for the efficient development of quality fruits and vegetables. Moreover, it has been shown in the research that vermicompost is an effective alternative for the agrochemicals utilized in the horticulture farming. Besides, being economic, it is also environment friendly and chemically safe. As compared to the artificial and chemical fertilizers, the vermicompost is a nutrient rich and healthy source of minerals and antioxidants for the plants. Additionally, the authors explain that with the use of vermicompost on a very large scale, the carbon dioxide present in large amount in the atmosphere is utilized by the green plants and with further processes, the carbon is retained in the soil. This phenomenon improves the soil fertility and prevents the occurrence of erosion.

Quaik et al. (2012), presented a report which explained the benefits of the vermicomposting in both the industrial and agriculture sectors. As per the report, the present level of research in this domain is focused on the processing of wastes to developing value-added products. Similarly, the vermicomposting is an environment-friendly and green technology, which also acts as a great nutrient supplement. The leachate produced in this process is full of important nutrients. Hence, the leachate is often used as a liquid fertilizer for plants and crops. The authors also explained the application of leachate as an efficient nutrient solution in the hydroponics cultures. Although, the authors explained that the present research done on the application of leachate is minimum and further research is required to understand its composition in detail.

Sheoran et al. (2015), explained the application of vermicompost in enriching the nutrient levels of the soil. The soil organic matter is required to be above 5%. The soil which contains more than 5% of the organic matter is considered as fertile. Importantly, organic carbon plays a major role in providing the shape and structure to the soil. Whereas, the soil organic matter governs the quality and fertility of the soil. The authors explained that the organic content binds itself to the soil particles in such a way that each soil particle develops a particular structure. On the other hand, parameters such as infiltration rate, air porosity, water-holding capacity, and nutrient levels also define the quality of the soil. Further, it is important to note that the quality of the soil along with fertility gradually decreases over long periods of time and repetitive farming. This occurs due to the loss of carbon content from the soil. The vermicompost has an important property of replenishing the soil carbon levels and ensuring maximum quality and fertility of the soil.

Humus is extremely beneficial for a plant since it provides the prevention of harmful pathogens such as fungi, nematodes and bacteria. Humus present in the vermicompost can fight against plant diseases that emanate from the soil such as root rot. Humus enhances the water permeability and water retention capacity of the soil and therefore, contributes to better plant productivity. It enhances the overall efficiency of the plants. Nitrogen concentrations are greater in vermicompost as compared to aerobic compost. Suppression of soil-borne diseases and decreasing the salinity of the soil are two other agronomic benefits of application of compost. A study also announced that average expectancy of root diseases was diminished from 82% to 18% in tomato and in the case of capsicum from 98% to 26% in soils treated with compost (Ayres, 2007).

The vermicompost is also rich in a number of antibiotics and enzymes that show anti-microbe activity (Li and Li, 2010). Therefore, a plant growing in vermicompost mixed soil will exhibit particular biological resistance against a number of diseases causing microbes. The research was done in this domain further explains that such a property of plants can prevent a high number of pesticide spray which is hazardous for health. In farms, where earthworms are utilized to produce natural fertilizers in the soil, the number of pesticide sprays required is almost 20% of the sprays required in normal farms (Sinha et al., 2013). Moreover, the vermicompost is able to induce efficient pest resistance in the important plant species. This resistance safeguards the plant against different types of pests, arthropods, nematodes, aphids, bugs, caterpillars and mites (Li and Li, 2010).

A surprising phenomenon of the conversion of organic matter to vermicast which is essentially a mound of nutrients that are biologically active carrying numerous of bacteria and enzyme along with the undigested remains of plant materials. A striking fact is that the diversity and number of bacteria present in a vermicast are way higher than that present in a worm's gut or ingested soil. The microbial activity in a vermicast lump is much greater than the same in soil or organic matter. Castings consist of plant nutrients packed in mucus membranes secreted by the worms. These slowly released nutrients are readily available for usage for the plants. Easy and fast dissolution in soil and easy extraction for the plants inhibits any unfavorable leaching out of the nutrients. Castings can carry 2 - 3 times additional water than their weight in soil. Worm castings have the potential to reduce erosion, protect the roots from high temperatures, and control weed growth around the plant. The material is a mass of 100% recycled elements. Due to the high humus content, vermicompost possesses high porosity, aeration, seepage, and water retaining capacity as compared to the conventional compost.

The worm castings are also used for the purpose of potting the soil. It is predominantly done in the formation of the greenhouse, where the potting soil is mainly constituted of worm castings (Scheu, 1987). The most important aspect of the worm casting is that its nutrients are highly soluble in water, and it acts as an excellent nutrient medium for the highly delicate and fragile plant species. Due to such properties, the worm castings are a readily available food for the plants. As a result, worm castings are consumed by the plants at a quick rate. Another important usage of earthworm castings except in potting the soil is in the plantation of gardens, trees, and plants.

The gut of a worm behaves in the same way as a minute composting tube. The moisture, pH, and number and kinds of microbial populations present in the gut of a worm favours for the synthesis of a material called the vermicast. The worms engulf the organic matter along with soil, gizzard. Ground and digest them in their gut with the help of several enzymes. 90-95% of the ingested matter is released by the worms and rest is absorbed for their own use. The released materialswere covered with mucus, granular, and rich in NPK, favorable micronutrients and microbes (Scheu, 1987). Worm castings are amazing for use in household gardens and potted plants. The risk of burning of even the most delicate roots of some plants is prevented. The nutrients are soluble so helpful for immediate use by the plants.

Recent studies in this field have shown that different crops, fruits and vegetables specifically grown under the application of vermicompost mixed soil reduce the risk of cancer in the human beings. Ferguson et al. (2004) explained the anti-mutagenic properties of organic food, especially grown in vermicompost mixed soil. Besides, phenolic compounds produced by the earthworms have an anti-proliferative effect and slows tumour progression in the cancer patients. Similarly, plant flavonoids inhibit important precursors that can lead to tumour progression. Galati et al. (2000) explained the important properties of flavonoids that prevent the proliferation of abnormal cells. The authors presented that the flavonoids have an important role in suppressing various cancer-causing reactions inside the human body.

Benbrook (2005), presented a research paper which showcased the anti-cancer mechanism of the flavonoids that disrupts various proteins which proliferate cancer cells. Further, the author has mentioned in his research that the flavonoids are efficiently produced under organic farming conditions as chemical fertilizers effect their production.

As per the research was done by Scheu (1987), the majority of the carbon element present on the Earth is present in the soil. This includes the soils utilized for agriculture and industrial usage. The soil organic carbon is the term given for the organic carbon present in the particular soil type. The high conversion of soil organic carbon into carbon dioxide due to large scale farming throughout the world has created the problem of the greenhouse effect, which leads to global warming. The global warming has further resulted in climatic changes and melting of ice capes in the Antarctica. As per the research conducted by Robbins (2004), about the 35% of the atmospheric carbon dioxide has resulted from the agricultural activities done over the past 150 years. Therefore, the researchers and scientists from all over the world are engaged in reversing this phenomenon by a process called as carbon sequestration. The process of carbon sequestration involves the use of vermicompost to trap large amounts of atmospheric carbon dioxide and to convert them into the form which can mix in the soil. Further, the author states that the vermicompost contains very stable carbon forms which can be retained in the soil for very long periods of time.

There are strong pieces of evidence that vermicast repels pests in some cases (Arancon, 2004). Statistically meaningful reduction is observed in populations of arthropods (mites, aphids, mealy bug, buds and spider mite) along with consequent decline in damage, in a few cases of tomato, pepper, and cabbage when vermicompost was added with the mass percentage of 20-40% (Edwards and Arancon, 2006). In a study conducted by (Domínguez et al., 2000), the effect of cardboard as a bulking material on the reproduction and growth of the earthworm *Eiseniaandrei* population was examined. Recirculating aquaculture bodies are highly intense farming systems for earthworms that filter and reuse the same water. This lowers the water requirements and creates smaller volumes of thick waste as compared to the flow-through aquaculture systems. Usage of earthworms for vermicast is employed as a treatment of industrial, municipal and agricultural waste with high-moisture content. The study determines that effluent solids released from a large recirculating aquaculture department were appropriate for vermicomposting using the species of earthworm *Eiseniafetida*. Two separate experiments were conducted in which worms were made to feed on mixtures of solids that were removed from aquaculture sludge and broken down. Mixtures containing varied amount of sludge from 0%, 5%, 10%, 15%, 20%, 25%, and 50% of dry weight, were used and worms were made to feed for over a 12-week period and the growth of the earthworms was observed. Worm mortality that occurred only in the first phase of the experiment was not affected by the concentration of the feedstock. As an observation, in both the experiments, the worm growth rates were found to be enhanced with increased sludge concentration. The highest growth rate was observed in the batch with 50% by weight of aquaculture sludge (Marsh et al., 2005).

2.15. CONCLUSION

With a number of applications such as waste management, cheap way of soil fertilization, high rate of plant growth, environment-friendly application and advantages over chemical fertilizers; the Vermicomposting is an efficient and effective process which can transform the entire dynamics of modern agriculture. With different environment-related issues such as the global warming, high pollution and degrading level of nutrients in the soil; it is quintessential to formulate and adapt an environment-friendly approach to agriculture that can be cost-effective as well. As the chemical fertilizers have a diverse number of health effects, the scope of using the vermicomposting technique is immense. Further, it is essential to develop sustainable agriculture and efficient waste management at the same time. Therefore, it is essential to prolong the research and investigation in this domain that can lead to important insights and improvements in the vermicomposting.

CHAPTER 3

EXPERIMENTAL PART

3.1. TEST REGION

[Loc.37°04′30″N 36°15′00″E]

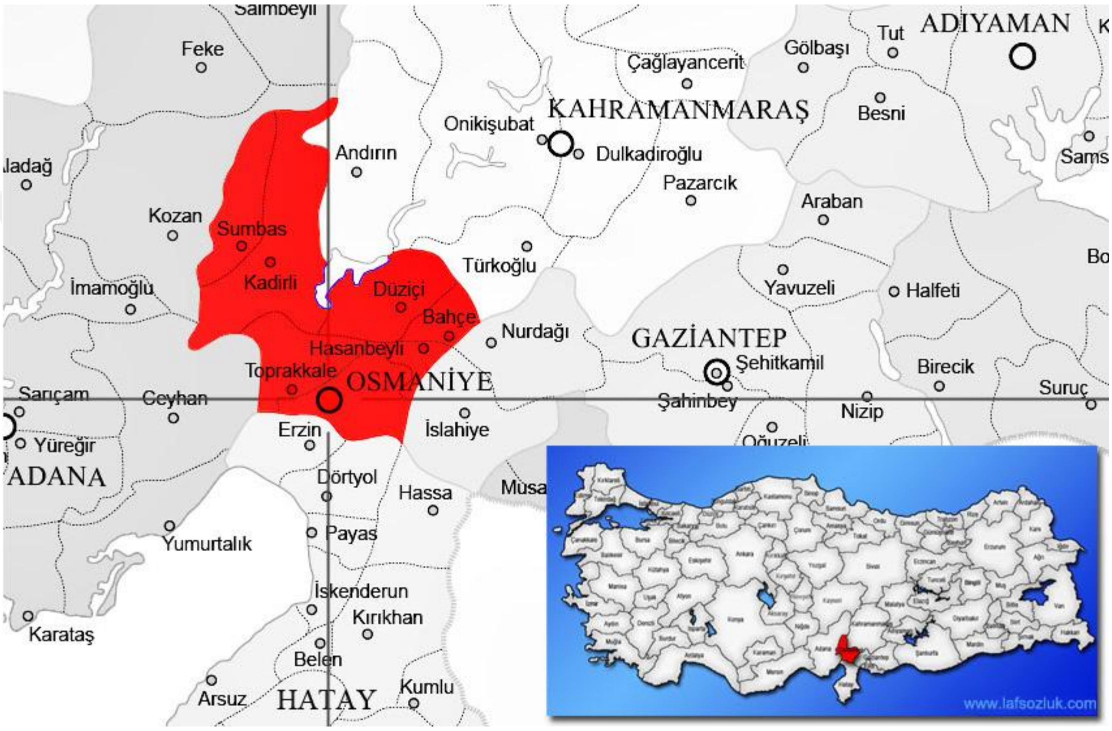

Figure 3.1. Location of the test region on Google map.

Located on the eastern edge of the Çukurova plain in the foothills of the Nur Mountains, the gateway between Anatolia and the Middle East.TodayOsmaniyeisthe center of a rich agricultural region well-watered by the Ceyhan river system and well known for growing groundnut. There is plenty of forest too and much of the surrounding countryside is very attractive.Osmaniye has a Mediterranean climate. Summers are very hot and dry while the winters are cool and wet (Osmaniye).

Figure 3.2. Osmaniye region where the experiment was conducted.

Many experiments have carried out in small area; the worms bring the stress(stress). Whereas our experiments provide a large area for both the full automatic continue flowing system and pool worms, which is why we do not put worms in a stress(stress) and relax them.

+ Worm food mixture is large enough.

+ The area is wide.

+ The ideal climatic conditions.

+ Older worms commit suicide(Selfdestruction) if the place becomes small for them.

+ Worms spawn by area width.

3.2. MATERIALS

As material, type of worm composts named *Eisenia Foetida*, cow manure fertilizer, dry olive cake, cardboard, tea pulp, MDF (Medium Density Fiberboard) dust, wheat straw and wheat bran were used.

3.2.1. Eisenia Fetida Earthworm

Eisenia Foetida earthwormshas been taken from worm farm in Osmaniye. The earthworms were fed with worm food mixture of fermented cow manure, tea pulp,straw and cardboard until the beginning of the experiment.During this time, they were cultured in the appropriate humidity and temperature in indoor environment without sunlight.

3.2.2. Natural Cow Manure Fertilizer

Nature cow manure, have been taken from the worm farm.

3.2.3. Dry Olive Cake

Dry olive cake was taken from Karamıklar Olive Oil Factory which takes place in Düziçi-Osmaniye, was kept six months and obtained from a certain proportion of its rotting waste.It was used after drying and weighing.

3.2.4. Cardboard

The cardboard was collected from waste facilities in the same area. It was used after separating the adhesive parts on top of the cardboard.

3.2.5. Tea Pulp

The tea pulp was obtained from the wastes of the tea factory in Rize

3.2.6. MDF

MDF dust was obtained from thin flours which formed during fabrication from furniture workshops.

3.2.7. Wheat Straw and Wheat Bran

They have been taken from worm farm.

3.3. USED DEVICES

3.3.1. Full Automatic Continue Flowing System

The system is located in a concrete, non-sunlight, closed environment. The ambient temperature is usually between 20 and 30 degrees Celsius. The height of the system is 40 cm. Dimensions are 6×1.5 meters in diameter, 0.7 meters in height.

The incubation experiment of the fourth mixture was carried out in this system.

Figure 3.3. Full automatic continue flowing system.

3.3.2. Sterilizator (ETUV)

Some samples were dried at 70 degrees before XRF analysis.

Technical specifications of the device:

- Elektro.mag M 420 P , Hot Air Sterilizer Laboratory Oven.

- Microprocessor controller with Fe-Cons temperature sensor.
- Working temperature range: Ambient temperature +5 - 300 ^{0}C
- Digital Controlled Electronic Thermometer
- Power ratings: 220 V 50 Hz.
- 48 Liter, Aluminum inner body sterilizer.
- Thedevice has TSE, CE, ISO 9001:2008, ISO 13485:2003, CE 1984 certificates.

Figure 3.4. ETUV instrument.

3.3.3. Analytical Sieve Shaker

After incubation, the dried samples taken were screened. Samples were passed through Loyka ESM-200 type Analytical Sieve Shaker.

2.5 mm grain size sample for chemical analysis and 109 micron grain size sample for XRF analysis were used.

Figure 3.5. Analytical Sieve Shaker.

3.3.4. Auto Touch Hydraulic Press

Specac's Atlas™ Series Autotouch Hydraulic Press is available in 8 Ton, 15 Ton, 25 Ton and 40 Ton load configurations. It is particularly popular with users conducting analysis through Fourier Transform Infrared Spectroscopy (FTIR) and X-Ray Fluorescence (XRF).

The Autotouch Press has fully programmable, microprocessor-controlled, power-assisted hydraulics for ease-of-use and repeatability. It also boasts a small footprint, ergonomic design and low noise characteristic. Its ease-of-use makes this hydraulic press appropriate for both lab and industrial.

Features

- 8T, 15T, 25T and 40T available.
- Color LED touchscreencontrol
- Programmable micro processor controlled pressure application
- Simple user operation via symbols&prompts
- End of cycle alarm
- Integralhigh-clarity PETG safety guards
- Ideal for FTIR or XRF sample preparation

Figure 3.6. Autotouch Hydraulic Press.

The samples were sieved to 109 micron particle size was pressed at 20 ton pressure with a hydraulic press.XRF analysis was performed on the tablets.

Figure 3.7. Pressed samples.

3.3.5. X-Ray Fluorescence Spectrometer (WDXRF)

Tube-above wavelength dispersive X-ray fluorescence spectrometer. High performance WDXRF was used for rapid quantitative elemental analysis.

Figure 3.8. X-ray fluorescence spectrometer.

Rigaku ZSX Primus II delivers rapid quantitative determination of major and minor atomic elements, from beryllium (Be) through uranium (U), in a wide variety of sample types — with minimal standards.

Features

- Analysis of elementsfrom Be to U
- Tube above optics minimizes contamination issues
- Small footprint usesless valuable labspace
- Micro analysis to analyze samples as small as 500 µm
- 30µ tube delivers superior light element performance
- Mapping feature for elemental topography/distribution
- Helium sealmeans the optics are always under vacuum

With today's modern semi-quantitative methods, which operate without needing elemental standards, the analysis can be performed quickly and easily.Elemental analyzes of the samples were made on the XRF instrument.

3.4. METHOD

3.4.1 Incubation

In order to carrying out Incubation experiment:

1-3 Mixtures

Perforated plastic fruit boxes (40×60 cm inside dimensions and 20 cm height dimensions) were used. For base and side wall of fruit boxes were put 250g cardboards to prevent mixture pour out and above them 10 kg worm food mixture was put. 8 kg of the mixture is animal manure and 2 kg is other additives (olive oil cake or tea pulp or cardboard …etc.)

This food mixture has been moistened every 2 days at the end of the time, 100 of the same size *EiseniaFoetida* were placed in each different ingredient mixture.

Above of fruit boxes were closed with cardboard in order to provide optimum conditions for the worms, water were added to the samples in the fruit boxes. Water addition was made so that each mixture contained 75% humidity.

Sample boxes incubated in natural environmentin garden under the tree , closed with cardboard in dark between 32-20^{o}C, during 90 days(temperature in August is between 30-32^{o}C, in September 23-28^{o}C ,in October 20-25^{o}C).As to be protected from heat of August,cartons were always kept wetting from above always humidity controls have been made every week. For this samples in boxes was squeezed by hands so that moisture controls was done getting a drop of water from squeezed from food means that moisture of water is %75.The amount of decreasing water was added in a controlled manner.

PH values was controlled always pH changed during incubation between 6-8.

At the end of 90 days, in order to move away from the environment where the worms are located, the box containing the earthworms was placed on top of the box of newly prepared worm food mixture. Thus, the earthworms are allowed to migrate from their current environment to the new habitat.

Waited for 2 months for worms to migrateduring this periodworm manure grew mature. At the end periodworm number was controlled.

Totally, at the end of the period was made chemical analyzes of Vermicompost samples.

1-4 Mixture

It was carried out different method. Incubation experiment was 40cm from floor. Dimensions (6mx (length)×1.5m (width) × 0.7m (height)was made in full automatic continue flowing system reinforced concrete in environment without sunlight, has been made for 5 months between at 20-30^{o}C. Moisture rate and pH values always have been monitored during incubation period. PH value has been between 6-8 .

At the end of period, vermicompost samples which is poured under continue flowing system has been chemical analyzed.

Ratio of mixtures as following table:

Table 3.1. Percentage components of sample mixtures.

Components	Cow Manure	Tea Pulp	Olive oil cake	Cardboard	Wheat Straw	Wheat Bran	MDF Wood Flour
Mixture (V)	100%						
Mixture (VC)	80%	20%					
Mixture (VP)	80%		20%				
Mixture (VM)	80%	0.5%	0.5%	10%	7%	1%	1%

3.4.2. Analysis and Characterization of Vermicompost Samples from the Incubation Experiment

After vermicomposting samples received from the incubation having been separated by sieving, without heat treatment Vermicompost Samples were analyzed. Analyses were made at Selcuk University Faculty of Agriculture, Soil Fertilizer Plant Nutrition Research Laboratory.(Analyzed with the methods described in Annex-13, the regulation on supply of Organic, Organomineral Fertilizers and soil conditioners used in agriculture and production, importation and market of microbial, enzyme-containing and other products published in Official Gazette dated 04 June 2010 and numbered 27601.)

3.4.2.1. XRF Analysis of Dried Samples at Room Temperature

For comparison purpose in other method Vermicompost Samples Received from the incubation having been separated by sieving dried at room temperature. These samples were separated with 109 micron (150 mesh) sieves and after having been pressed with 10 tons of pressure was obtained tablets 3.5 mm diameter and made XRF analysis.

Samples: named as V -25^{0}C, VC-25^{0}C, VP-25^{0}C, VM- 25^{0}C (Table 4.1-4.4)

3.4.2.2. XRF Analysis of Dried Samples in The Oven.

Apart from drying at room temperature, was dried in oven at 70^o C, XRF analyses was made on the vermicompost tablets obtained by the same method at 70^o C and these results were compared among themselves.

Samples: named V-70^{0}C, VC-70^{0}C, VP-70^{0}C, VM-70^{0}C (Table 4.1-4.4).

3.4.2.3. Chemical Analysis

The samples were dried before analysis and were passed through a 2.5 mm sieve. After that analyzed for total Nitrogen, organic substance, total Humic and Fulvic Acid, useful P, K, Ca.

Total Nitrogen- Kjeldahl Method

The Kjeldahl method is a determination the nitrogen content of organic and inorganic substances. The Kjeldahl method is divided into three main steps:

- ✓ **Digestion** - the decomposition of nitrogen in organic samples by using a concentrated acid solution. This is accomplished by boiling a homogeneous sample in concentrated sulfuric acid (H_2SO_4). The product is an ammonium sulfate solution.

Organic N + $H_2SO_4 \rightarrow (NH_4)_2SO_4 + H_2O + CO_2$ + other sample matrix by-product

- ✓ **Distillation**- adding excess base to the acid digestion mixture to convert NH_4+ to NH_3, next step is boiling and condensation of the NH_3 gas in a receiving solution.

- ✓ **Titration** - to determination the amount of ammonia in the receiving solution.The amount of nitrogen in a sample can be calculated from the quantified amount of ammonia ions in the receiving solution (Labconco, 1998).

Organic Substance- Walkley-Black Method

The Walkley-Black (WB) titration method is a classical method for analysis of organic carbon (OC) in soils. The method is based on the oxidation of organic matter by potassium dichromate ($K_2Cr_2O_7$)-sulfuric acid (H_2SO_4) mixture followed by back titration of the excessive dichromate by ferrous ammonium sulfate ($Fe(NH_4)_2(SO_4)_2.6H_2O$). The titrant volume is inversely related to the amount of C present in the soil sample (Gelman et al., 2011).

Total Humic and FulvicAcid - TSE 5869 ISO 5073.

Humic substance content can quantify in different ways which are spectroscopicmethods such as fluorescence spectroscopy, ESR spectroscopy, FIA (flow injectionanalysis), and wet methods such as TSE 5869 ISO 5073. In this study, humic substance content was calculated according to "TSE 5869 ISO 5073" method. With this method, the amount of total humic substance in brown coals and ligniteswas determined through calorimetric method. The essence of the method was the same as Walkley-Black method used for determining organic substance in soil (Ozkan, 2008).The method is based on oxidizing the organic part with chromate and the titration of the remaining chromate (Canieren et al. 2016).

Naturally occurring humic substances from low grade lignites and leonardites are excellent fertilizer ingredients. The best source of humic substances for fertilizer use is from leonardites. Leonardite is defined as highly oxidized low grade lignite that contains high concentration of the smaller molecular units (Fulvic acids (FAs)).The smaller humic acid (HA) and Fulvic acid (FA) molecules have higher fertilizer value and are readily taken into the plant along with trace minerals.

Humic acids (HAs) include a mixture of weak aliphatic (carbon chains) and aromatic (carbon rings) organic acids which are not soluble in water under acid conditions but are soluble in water under alkaline conditions. Humic acids consist of that fraction of humic substances that are precipitated from aqueous solution when the pH is decreased below 2 (Pettit, 2004).

Table 3.2. Generalized Features of Humic Acid Substance.

Molecular weight	100,000
Cation exchange capacity (c mol/kg) and acidity.	300
Carbon content (g/kg)	620
Oxygen content (g/kg)	290
Nitrogen content (g/kg)	55
Hydrogen content (g/kg)	29

Useful P (Phosphor) in $NaHCO_3$ extract phosphor specification – Olsen method:

Olsen method, is used to determination of phosphor content in sample , introduced 0.5 M sodium bicarbonate($NaHCO_3$) solution at a pH of 8.5 to extract P from calcareous, alkaline, and neutral soils. This extractant decreases calcium in solution (through precipitation of calcium carbonate), and this decrease enhances the dissolution of Ca-phosphates. Moreover, this extracting solution removes dissolved and adsorbed P on calcium carbonate and Fe-oxide surfaces (Elrashidi, 2001).

Useful K (potassium), Ca (Calcium) in Ammonium acetate extract

For determination of extractable cations with neutral 1N ammonium acetate is a modification of the procedure made by Pratt for exchangeable K(Potassium). The modification concerns the single equilibration of the sample with the extracting solution (1:20 ratio of soil to extraction solution) rather than three successive extractions as shown in the original procedure.

Cations are determined on the same soil extract and dilution. The single extraction procedure for cations in non-calcareous soil gives values which are equivalent to at least 95% of the values get by the process of multiple extractions. For samples which contain carbonates of Ca or Mg, the multiple extractions with ammonium acetate may dissolve these carbonates and give higher values for Ca and Mg than are obtained with a single extraction (Dean and Hugh, 1976)**.**

CHAPTER 4

RESULTS AND DISCUSSION

With a number of applications such as waste management, cheap way of soil fertilization, high rate of plant growth, environment-friendly application and advantages over chemical fertilizers; the Vermicomposting is an efficient and effective process which can transform the entire dynamics of modern agriculture. The present study deals with the determination of the basic components in Vermicompost produced from different solid wastes with different treatments process.

Vermicompost Sample Mixture

The compositions of the obtained vermicompost samples are discussed in this section of the report. Here in, four sample mixtures were prepared using different basic components including natural animal manure, tea pulp, Olive oil cake, cardboard, wheat straw, wheat barn and MDF wood flour that previously tabled (Table 3.1) and shown in this section of the report. The percentages of the components in the sample mixtures are shown in Table 3.1 as follow:

Table 3.1. Percentage components of sample mixtures.

Components	Cow Manure	Tea Pulp	Olive oil cake	Cardboard	Wheat Straw	Wheat Bran	MDF Wood Flour
Mixture (V)	100%						
Mixture (VC)	80%	20%					
Mixture (VP)	80%		20%				
Mixture (VM)	80%	0.5%	0.5%	10%	7%	1%	1%

4.1. XRF ANALYSIS RESULTS

4.1.1. The Result Elements of Samples

C, N, P, K and Ca

Results of the elemental sample treated at 25 and 70 ^{O}C are shown in Table 4.1 with graphical representation in Figures from 4.1 to 4.5.

Different carbon contents were found in the four tested samples. The highest content was recorded in VP sample at 25^{O}C (15.8650%) followed by VM sample (Figure 4.1). VC samples contained the lowest carbon content even lower than the original V sample.

The nitrogen content showed different behavior compared with carbon content. The highest content was found with the V sample (100% of natural animal manure) then decreased via modification with other solid wastes (Figure 4.2). Approximately, similar nitrogen content can be found in V and VP samples (3.4557 and 3.2699%, respectively). Modification with 20% tea pulp (VC sample) reduced N content by about 22%.

Different ratios of potassium, calcium and phosphorous were recorded (Figures 4.3 to 4.5). Potassium and calcium content increased with the modification of the basic sample. The highest potassium (K) content was found in VM sample (2.1289%) which was improved by about 37.8% than the original value (Figures 4.3). Similar to potassium, the VM sample showed the highest calcium content (8.2313%) compared with all other samples (Figures 4.4). Contrary, values of phosphorous (P) decreased in all samples compared with the original V sample (Figures 4.5).

Vermicompost is rich in Nitrogen (N), Potassium (K), Phosphorus (P) (nitrogen 2 - 3%, potassium 1.37-2.29% and phosphorus 1.10-2.03%), micronutrients, beneficial soil microbes and also contain ‘plant growth hormones & enzymes’. Similar was findings of Sinhaet al., (2009) and Edwardset al., (2004). Other major and minor elements are present with different ratios depending on the nature of the sample and thermal treatment. Total Carbon contents are between 12-15% in our work. Contreras et.al (2005) reported the total carbon 163 g/kg of cow manure used in the vermicomposting.

By discussing the above mentioned results in the light of other studies, Chen (2015) reported total nitrogen content between 2.91 and 3.12% and 1.8 to 2.14% in the Orgro and Leafgro compost. The present compost showed higher content of P, K and Ca than reported by Chen while the organic carbon was lower. The contents of other metals including Cu, Zn, Fe were also higher. These results indicate that the nature of the composite sample and treatment conditions plays a good role in reducing or inducing the major content of the elements included.

Table 4.1. Result of different mass samples.

Component	mass%							
	V– $25^{O}C$	V– $70^{O}C$	VP– $25^{O}C$	VP– $70^{O}C$	VC– $25^{O}C$	VC– $70^{O}C$	VM– $25^{O}C$	VM– $70^{O}C$
C	13.758	9.6036	15.8650	12.1268	12.5095	7.0630	14.9224	13.5600
N	3.4557	2.5748	3.2699	2.6147	2.7189	2.0451	2.7426	2.8499
P	2.0291	1.5725	1.4567	1.4495	1.4290	1.1009	1.1841	1.2819
K	1.5441	1.6748	1.3781	1.4101	1.7988	1.8812	2.1289	2.2926
Ca	7.2065	7.1649	6.8115	7.7184	6.7869	6.3409	7.6430	8.2313

N.B: The original data tabulated in the above table were attached in the Appendix section.

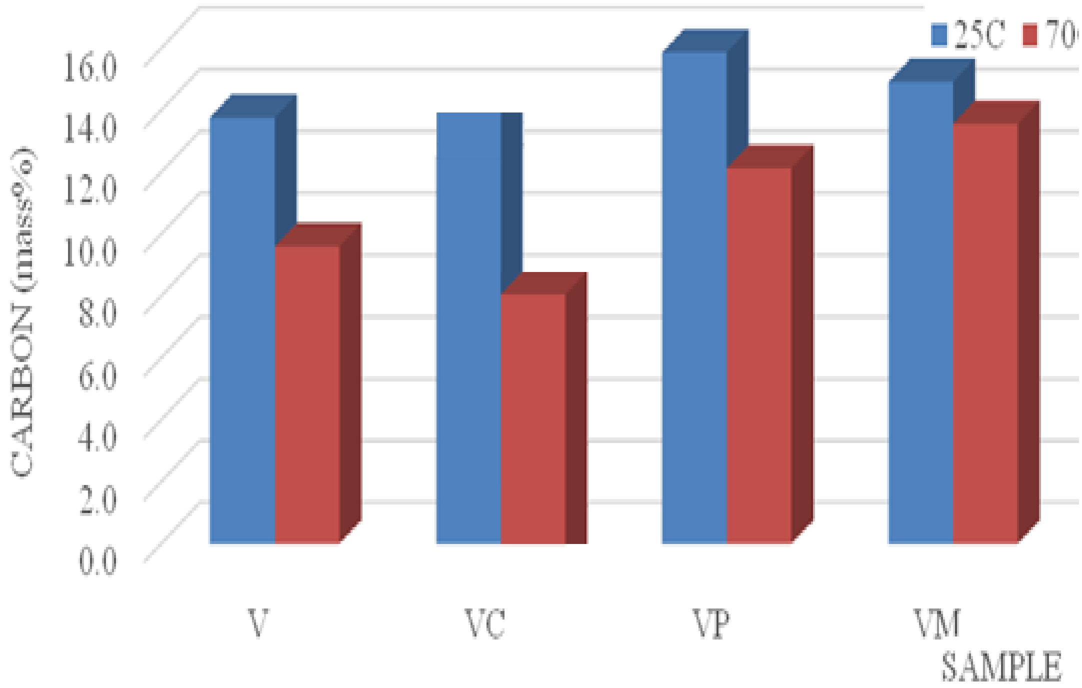

Figure 4.1. Change in the total carbon content after incubation for different temperatures.

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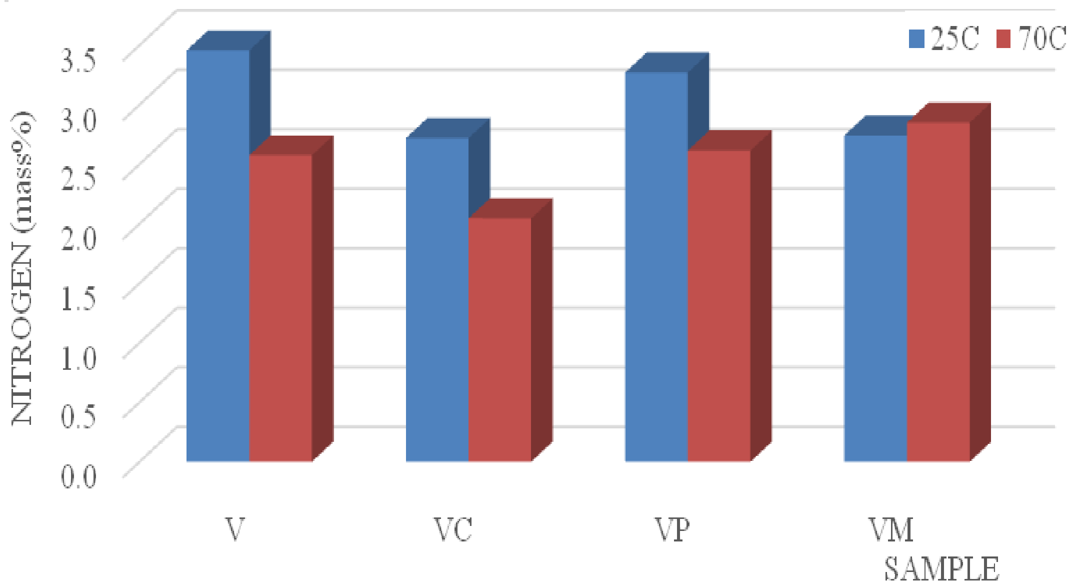

Figure 4.2. Change in the total nitrogen content after incubation for different temperatures.

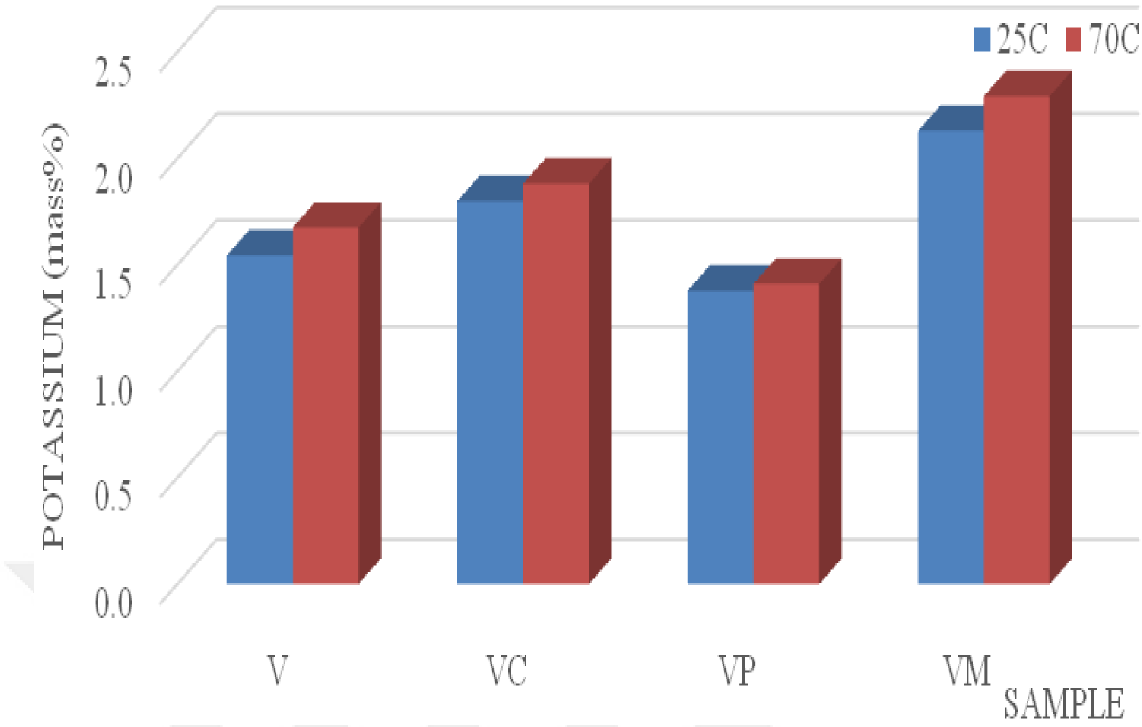

Figure 4.3. Change in the total Potassium content after incubation for different Temperatures.

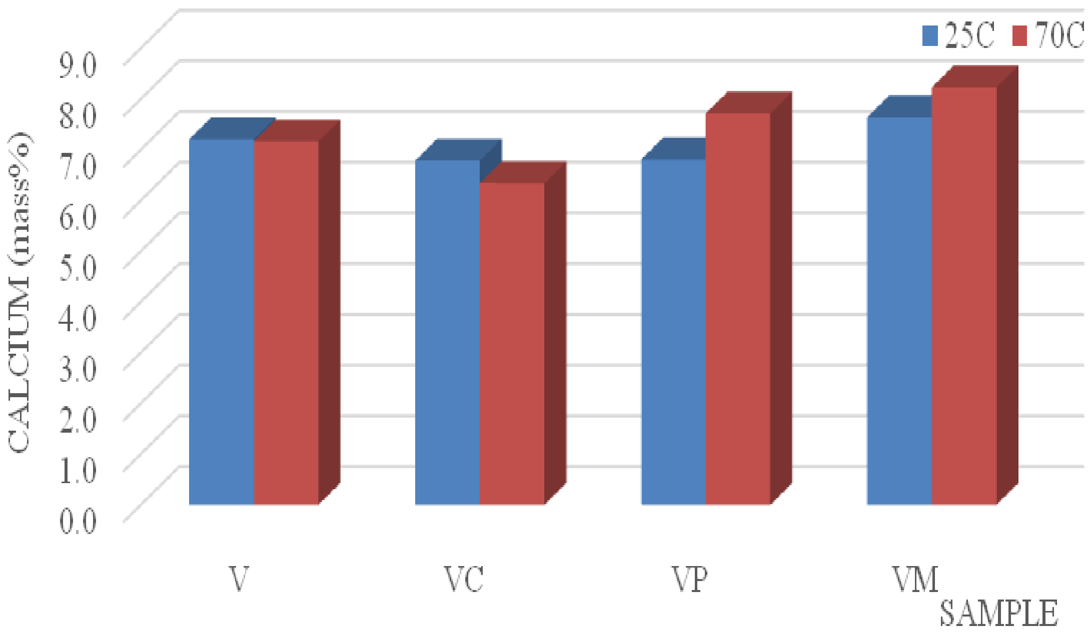

Figure 4.4. Change in the total calcium content after incubation for different Temperatures.

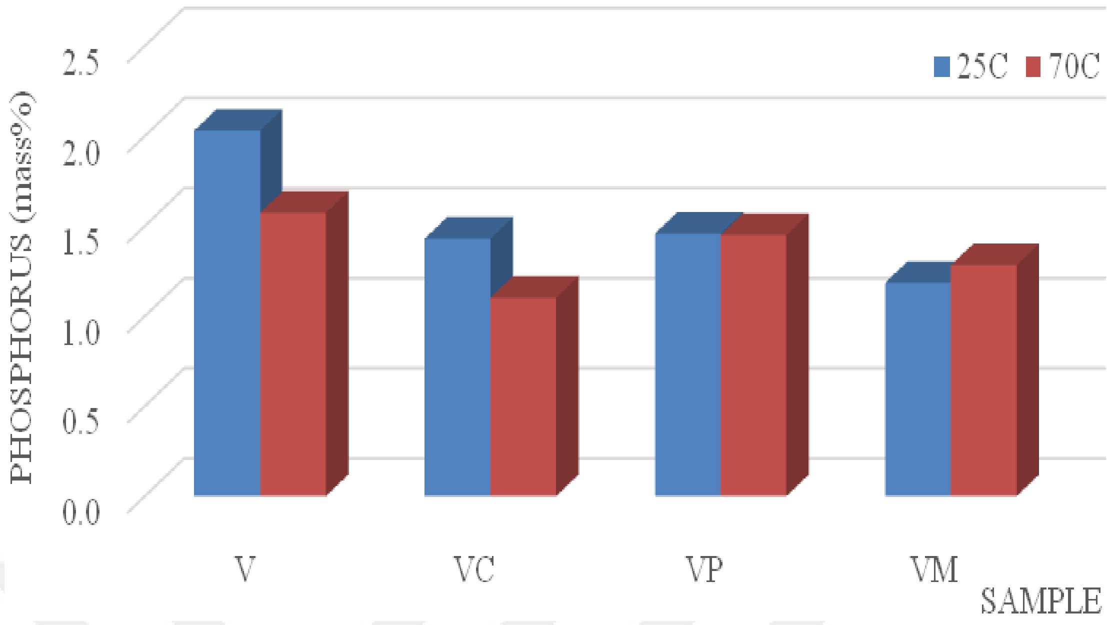

Figure 4.5. Change in the total phosphorous content after incubation for different Temperatures.

In literatures, natural animal manure is subjected to heat treatment at 70 °C and transport is carried out in this way. However, when heat treatment is applied at 70 °C, there is a decrease in the proportion of beneficial minerals. In our study, the values of C, N, Ca, K and P were changed upon heat treatment at 70 degree. The carbon content was reduced to 69.78, 74.44, 56.46 and 90.87% of its original values at 25 ^{O}C for V, VP, VC and VM samples, respectively (Figure 4.1 to 4.5).

Similar to carbon, the nitrogen content decreased with various extents in the V, VC and VP sample with ratios ranging between 10 to 15% (Figure 4.2). On the other hand, the VM sample showed slight increase in the N content (about 4%) at 70^{O}C.

Regarding the potassium content, all sample increased at 70^{O}C with different percentages (Figure 4.3). Irregular changes were recorded for the Ca (calcium) and P (phosphorus) content ((Figure 4.4 and 4.5) where, their values decreased only in V and VC sample while a slight increase was observed in other two samples VP and VM.

Generally, the produced Vermicompost was rich in Nitrogen (N), Potassium (K), Phosphorus (P) (nitrogen 2.0451 to 3.4557%, potassium 1.37 to 2.29% and phosphorus 1.10-2.03%), micronutrients, beneficial soil microbes and also contain ‘plant growth hormones & enzymes similar to findings of Sinha*et al*.(2009) and Edwards et al., 2004. The total carbon ranged between 7.06 to 15.86% in our work in agreement with Contreras et al., 2005 who reported the total carbon 163 g/kg of cow manure used in the vermicomposting.

The carbon in the sample is necessary for increase in cellular growth of the worm (Epstein, 2011). The highest value of carbon was found in VP sample as it composed of purely animal manure. At the beginning of the experiment, the fermentation resultant C (carbon) ratio falls, falling because the worm feeds. Therefore, it is possible that the worm count in the sample will be the highest. As the percentage of animal manure decreased in the sample, the value of carbon continued to decrease because the amount of worm feed in the sample reduces.

4.1.1.1. C/N Ratio

The values of the C/N ratio is required to determine the extent at which bacteria decomposes the organic materials present in the soil. The worm convert the carbon content in the soil into energy and then uses the nitrogen for protein synthesis (Edwards *et al.*, 2011). The value of C/N ratio is obtained as the ratio of the mass of carbon in the sample to the mass of .Nitrogen, Phosphorus, Potassium (NPK) and Carbon/Nitrogen Ratio: The increased trend of NPK in the vermicompost and C/N ration is about 15 to 20:1 for good compost. But the C/N ratio is depends upon the quality of raw organic waste used (Dandotiya and Agrawal; 2014). In the present study, the C/N raio ranged between 3.95 for the Vsample to 5.44 with VM sample Table 4.2 and Figure 4.6).

Table 4.2. The results of the C/N ratio for the various samples.

Sample	V- 25^{o}C	V– 70^{O}C	VP– 25^{O}C	VP– 70^{O}C	VC– 25^{O}C	VC– 70^{O}C	VM– 25^{O}C	VM– 70^{O}C
C/N ratio	3.98	3.73	4.85	4.63	4.60	3.45	5.44	4.75

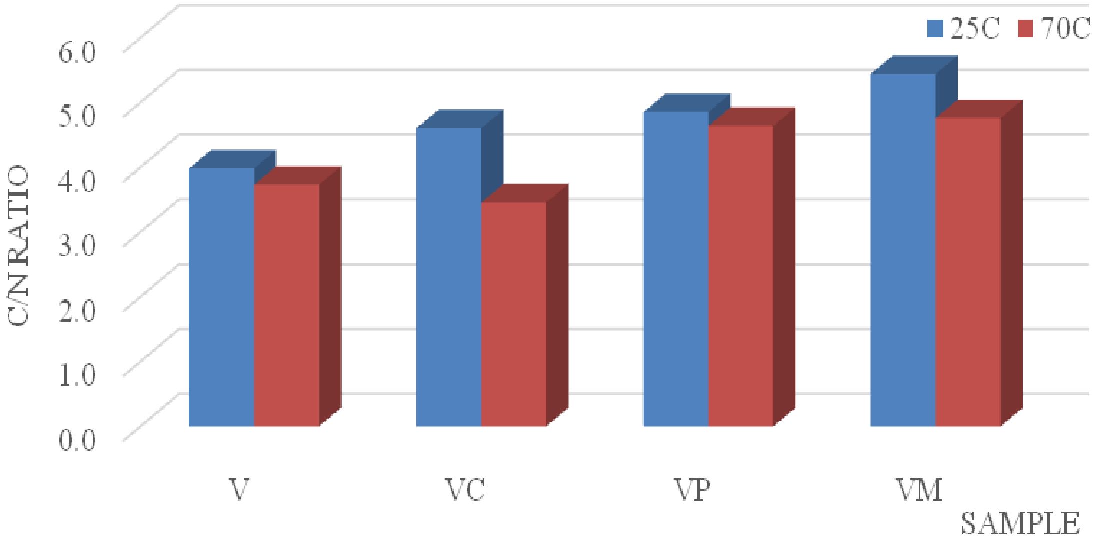

Figure 4.6. C/N ratio after incubation for different temperatures.

The C/N ratio increased with modification of the parent natural animal manure to reach it maximum value with VM sample (about 36.7% increase in the C/N ratio). The C/N value of VM sample was found to be the highest, which can be attributed to the presence of Olive oil cake in the sample. However, it is noticeable that sample V 25^{O}C has the highest nitrogen content.

As the present sample showed moderate C/N ratios, they could also be converted and as a carbon source in composting process. A very high C/N ratio would reduce the vermicomposting process and cause a release of ammonia (Epstein, 2011). The process for computation of C/N for various organic fraction was analyzed in the literature (Kulbaivab and Tchobanoglous, 1992).

For the worm; If C multiples worms increase, N multiples the mass of worms increases by the way.

4.1.2. The Result Oxides of Sample

Table 4.3. The results of the oxides content for the various samples.

Component	Mass%							
	V-25^oC	V-70^OC	VP-25^OC	VP-70^OC	VC-25^OC	VC-70^OC	VM-25^OC	VM-70^OC
P_2O_5	6.4015	4.8002	4.9182	4.6877	4.4389	3.3505	3.9757	2.7800
K_2O	2.6410	2.7452	2.5332	2.4640	3.0122	3.0664	3.8941	3.9452

N.B: The original data tabulated in the above table were attached in the Appendix section.

P_2O_5 and K_2O

The results of the oxides content for the various samples are shown in Table 4.3 and the mass fractions of P_2O_5 and K_2O in various samples are shown in Figures 4.7 and 4.8, respectively.

For P_2O_5 content, the highest value was recorded in the V sample (6.40%) and this value decreased via modification with other additives (Figure 4.7). The lowest value was found in VM sample which may be attributed to the modification with solid wastes. Moreover, the P_2O_5 content decreased at higher thermal treatment compared with samples at 25^OC and the largest change (about 30%) was recorded in VM followed by V sample.

Similar to the K profile in the samples, K_2O content was the lowest in V and the highest with VM sample (Figure 4.8). Contrary, the thermal treatment has no noticeable effect on the K_2O content.

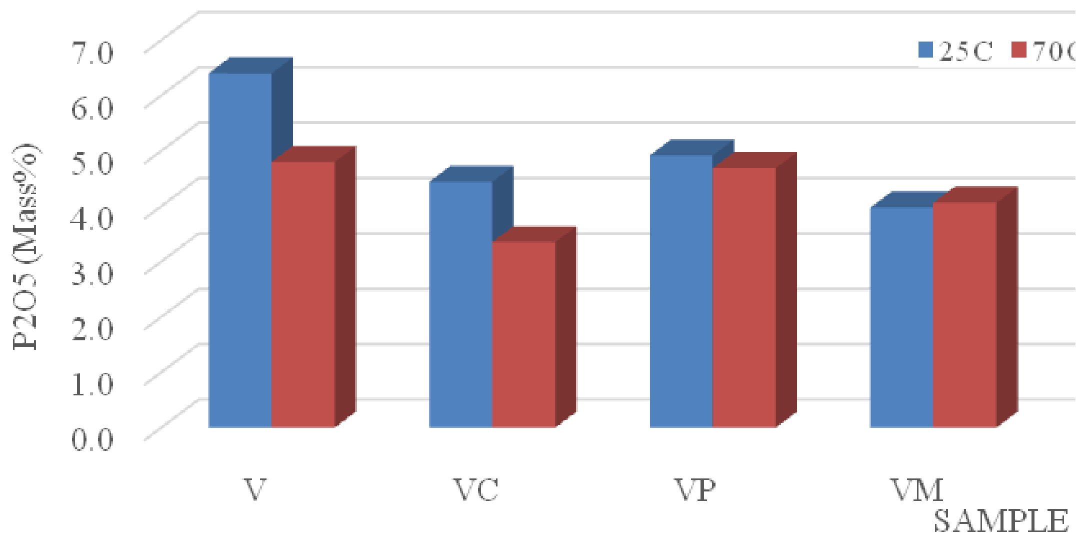

Figure 4.7. Change in the total P_2O_5 content after incubation for different temperatures.

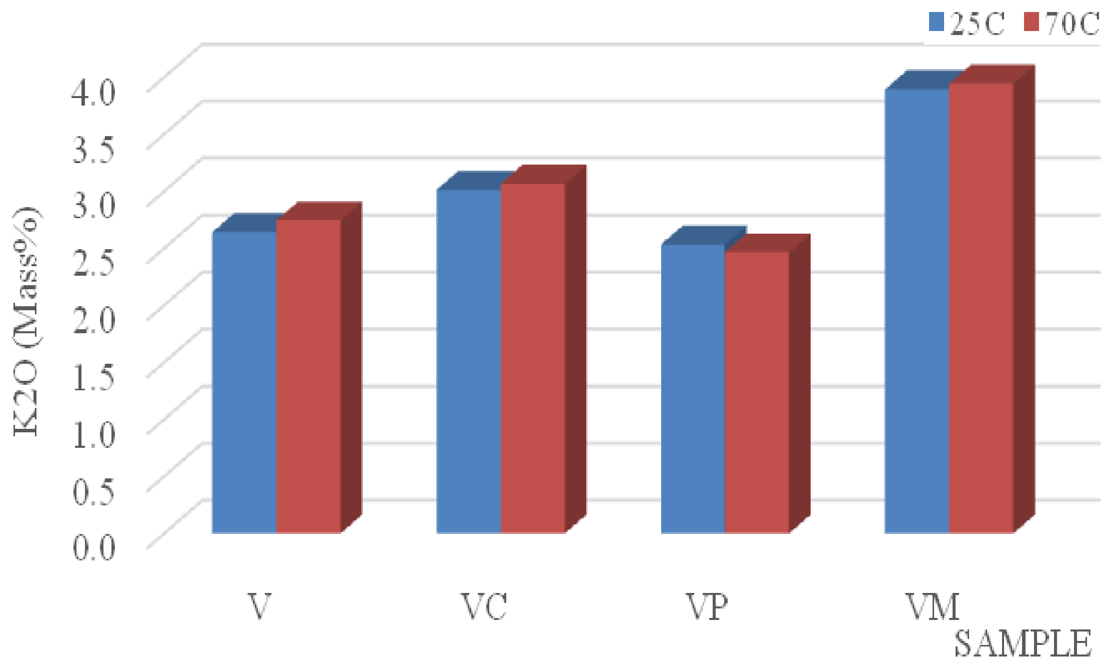

Figure 4.8. Change in the total K_2O content after incubation for different temperatures.

4.1.3. The Result Carbonate of Samples

$CaCO_3$

The results of the Calcium Carbonate for the various samples are shown in Table 4.4 and graphically represented in Figures 4.9. The $CaCO_3$ content was arranged as following: VP > VM > V and the lowest value recorded in the VC sample. Thermal treatment decreased the $CaCO_3$ content especially in the V and CV samples.

Table 4.4. The results of the oxides and carbonate for the various samples.

Component	mass%							
	V-25^{o}C	V–70^{O}C	VP–25^{O}C	VP–70^{O}C	VC–25^{O}C	VC–70^{O}C	VM–25^{O}C	VM–70^{O}C
$CaCO_3$	48.998	40.263	52.639	49.389	43.815	38.125	50.435	50.227

N.B: The original data tabulated in the above table were attached in the Appendix section.

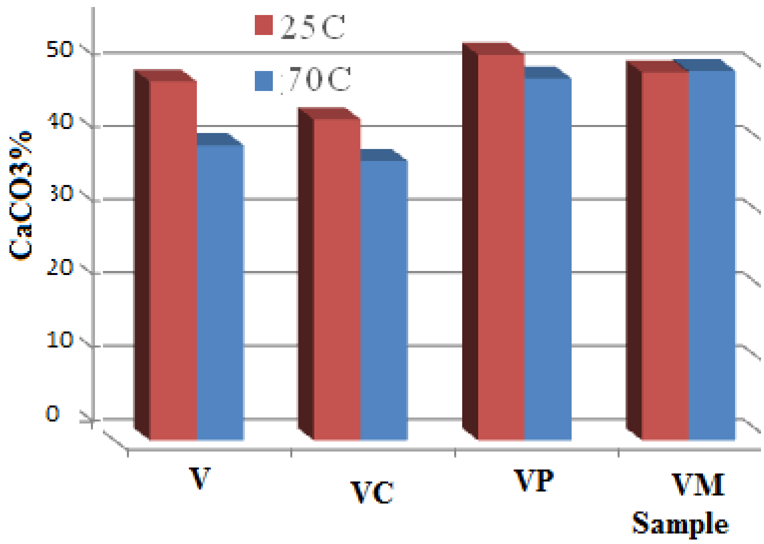

Figure 4.9. Change in the total $CaCO_3$ content after incubation for different.

4.2. CHEMICAL ANALYSIS RESULTS

Various components of the four collected vermicompost samples are shown Table 4.5 and graphically represented in Figures 4.10 to 4.14.

Table 4.5. Chemical Analysis of the Collected Samples.

Component	V	VC	VP	VM
Organic substance %	15.5	16.0	15.2	17.5
Total Nitrogen %	1.83	1.50	2.62	1.52
Total Humic and Fulvic Acid %	29.1	28.1	36.8	9.36
Availability K mg/kg	4034	4495	3936	6161
Availability Ca mg/kg	4460	4496	4748	5745
Availability P mg/kg	672.0	482.5	527	1312

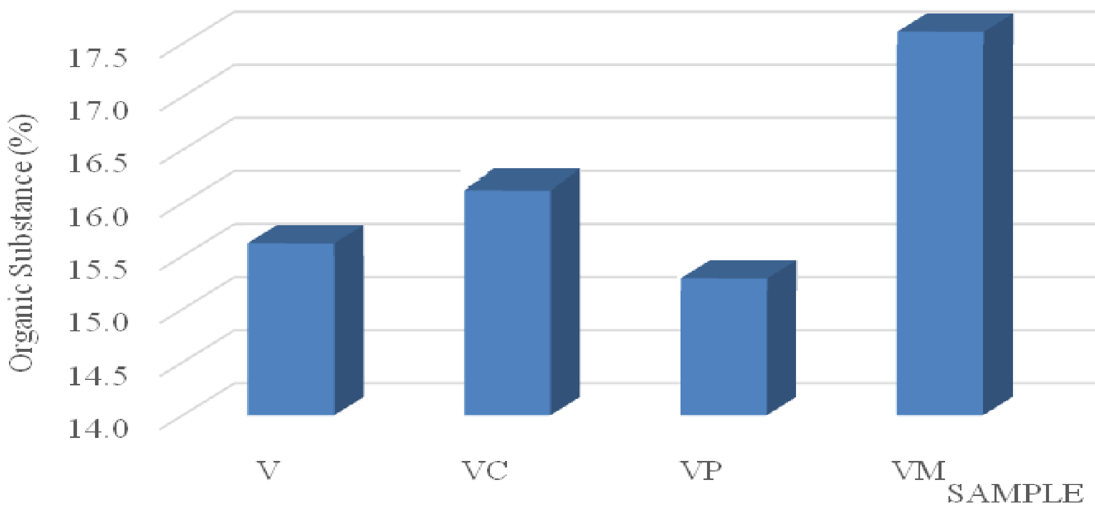

Figure 4.10. Organic Substance values for collected samples.

The obtained results (Figure 4.10) revealed the organic substance ranged between 15.2 (for VP sample) to 17.5% (with VM samples). Different nitrogen contents were showed in the four collected sample. The VP sample contained the highest N content (2.62%) with 1.5% recorded with VC sample (Figure 4.11) which may be attributed to modification with Olive oil cake.

Our results are better when compared to the results of Contreras-Ramos et al., (2005). Their vermicompost obtained using cow manure and oat straws contains organic carbon content of 16.3 %; a Humic-to-Fulvic acid ratio of 0.5 (HA/FA) and total N content of 0.9 %.

The total Humic and Fulvic acid value of the collected samples are shown in Figure 4.12. Higher content of the aforementioned organic acids were found in the VP sample (36.8%) which modified with 20% Olive oil cake. Both V and VC samples approximately contained equal amounts of such organic acid with lowest value for the VM sample.

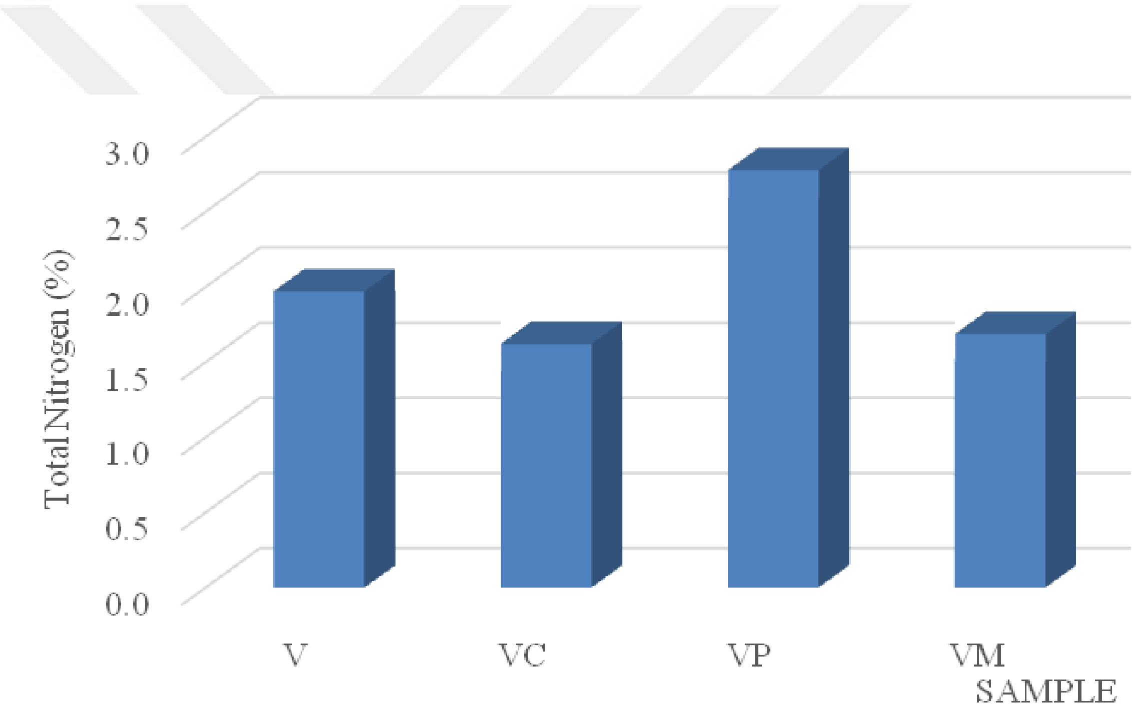

Figure 4.11. Nitrogen values for collected samples.

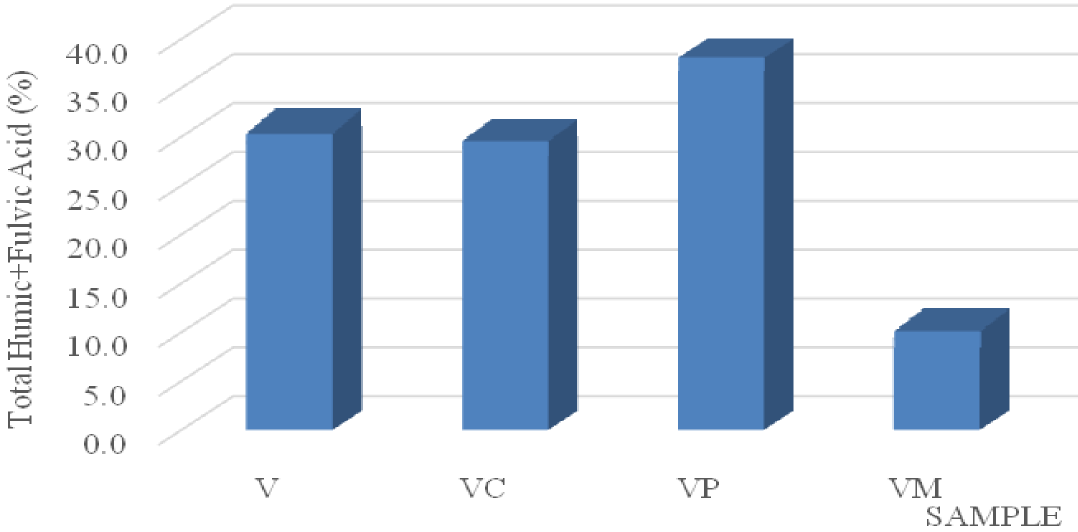

Figure 4.12. Humic and Fulvic Acid values for collected samples.

The total potassium of the collected samples is shown in Figure 4.13. The VM sample has the highest total potassium content and the VP contained the lowest value.

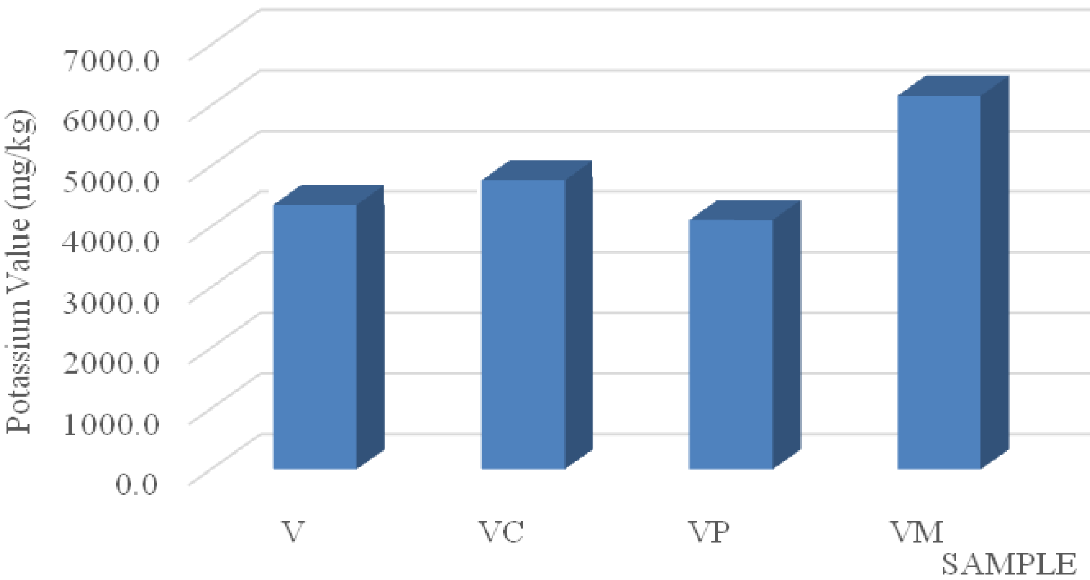

Figure 4.13. Potassium value for collected samples.

Similar to potassium, the VM sample has the highest total calcium (Figure 4.14). Other tested samples approximately contained the same calcium content.

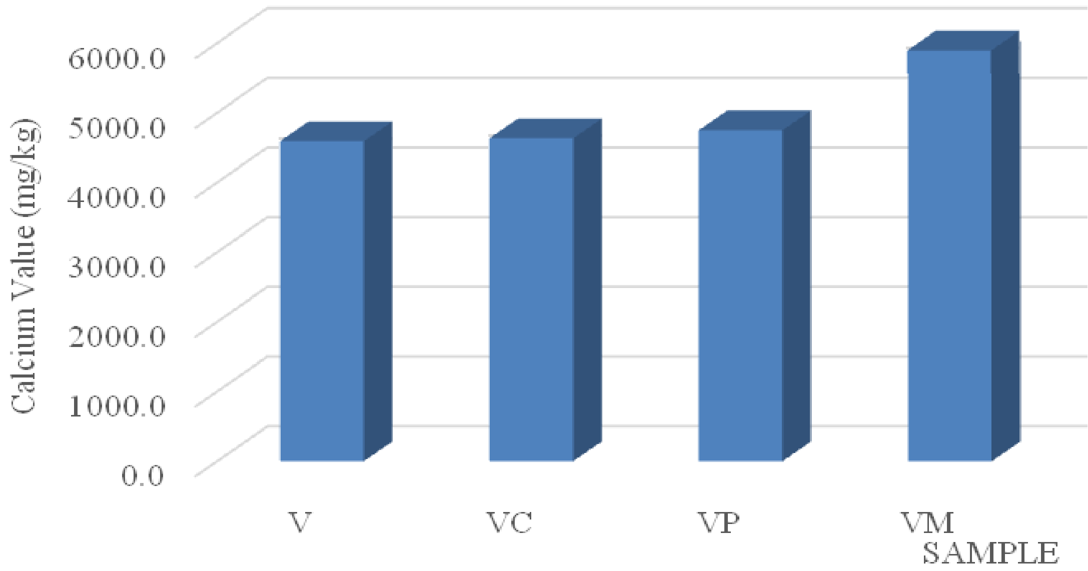

Figure 4.14. Calcium value for collected samples.

The total phosphorus of the collected samples was represented in Figure 4.15 with highest phosphorous content in the VM sample (about two fold of other samples).

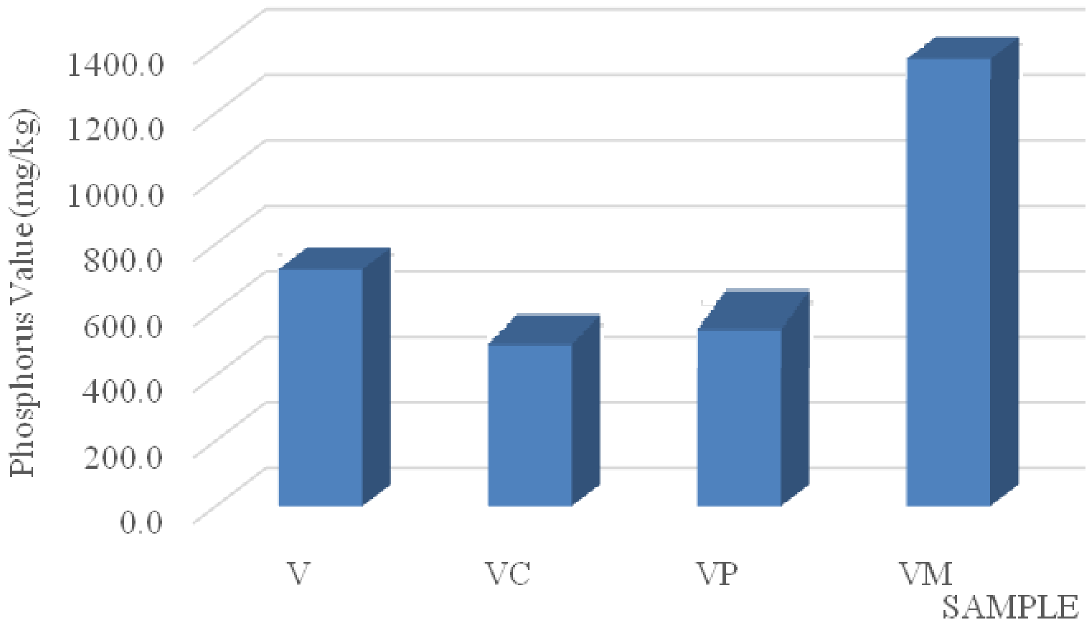

Figure 4.15. Phosphorus value for collected samples.

The significantly total phosphorous was increased in all the combinations. This may be due to the addition of phosphate in the vermicompost by phosphobacteria (Kumar and Singh, 2001). The higher level of total potassium was regarded in vermicompost. The reason for more effective humification of the earthworms left in the waste mix. The results of the present study are consistent with the previous study done by Sathisha (2000).

The finding of this present research is also agreed with many published work. Garg and Kaushik explores the potential of an epigeic earthworm *Eisenia foetida* to compost different livestock excreta (cow, buffalo, horse, donkey, sheep, goat and camel) into value added product (vermicompost). Vermicompost contains a higher percentage of macro- and micronutrients than ordinary compost (Garg and Kaushik, 2005; Nagavallemma et al., 2004). It contains 9.8–13.4% organic carbon, 0.51–1.61% nitrogen, 0.19–1.02% phosphorus, and 0.15–0.73% potassium. The nutrients present in the vermicompost are in water soluble forms which are immediately available for plant use (Suthar, 2009; Ndegwa and Thompson, 2001; Adhikary, 2012).

According to the various researches, the chemical property of the ordinary compost such as Nitrogen, Phosphorous and Potassium concentration are recorded 0.92%, 0.14% and 0.26% etc. But in this research Nitrogen, Phosphorous and Potassium percentage were found 2.62%, 1.312% and 6.161% respectively. Therefore, if we compare compost and vermicompost according to their nutrient quality then it can say that the vermicompost is better than normal compost.

Calcium and Calcium Carbonate

Availability Calcium was found between 4460-5745 mg/kg. Singh found that the amount of calcium in the vermicompost was 276 mg / kg, which was prepared from food and garden wastes (Singh, 2009).

The highest value of calcium and calcium Carbonate value (Figure 4.4 and 4.14) were found in VM sample which is an automatic continuous flowing system. During the summer, the mixture in the full automatic continues flowing system is kept 70-80% damp (wet). The region where the experiment is conducted is watery lime. A lot of calcium in summer can pass through water. The presence of calcium increases the pH value of the water, thus benefiting the ripening of the worm eggs, the Worm reproduction depends on it. At the beginning there were about 50 worms, reaching a million levels for 12 months.

The total calcium and total magnesium increase might be due to the loss of organic carbon and reduction of total mass of the vermicompost materials during the composting process (Anand, 1998). At the same time, it may also be due to the mixing of the lime with water in the mix.

$N + P_2O_5 + K_2O$ (NPK)

According to Parthasarathy and Ranganathan (2001) enhanced N, P and K contents in vermicomposts may be due to microbial enzyme activities while passing through the gut of earthworms.

For solid organic fertilizer of vegetable and animal origin, the organic matter should be at least 30%, organic nitrogen at least 2%, total $N + P_2O_5 + K_2O$ at least 6% (Anonim, 2004). According to our results, the organic matter was ranged between 15.2 to 17.5%. The nitrogen content in the produced sample was reasonable (1.52 to 2.62%). The presented NPK value reported for the samples were recorded to be higher than the recommended values (%10.966, 10.9735, 11.831 and 14.741 for V, VC, VP and VM samples, respectively) which recommend it as a nutrient eco-friendly vermicomposts beneficial for plant growth and crop yield.

The obtained vermicompost sample compositions are in agreement with many published work. Garg and Kaushikexplores the potential of an epigeic earthworm *Eiseniafoetida* to compost different livestock excreta (cow, buffalo, horse, donkey, sheep, goat and camel) into value added product (vermicompost). Vermicompost contains a higher percentage of macro- and micronutrients than ordinary compost (Garg and Kaushik, 2005). It contains 9.8–13.4% organic carbon, 0.51–1.61% nitrogen, 0.19–1.02% phosphorus, and 0.15–0.73% potassium. The nutrients present in the vermicompost are in water soluble forms which are immediately available for plant use (Suthar, 2009).

*Comments, since there are no regulations on Worm Guidance in Turkey have been interpreted in accordance with the content of "EK-1 Organic Fertilizers" in "TR Organic fertilizer regulation".

4.3. FACTORS INFLUENCING WORM INCREASE

In general, temperature, humidity, feed, pH, amount of calcium in food, cardboard, wheat bran, MDF wood flour will promote worm breeding due to the presence of very fine particles and animal manure. As such, it explains the reason why the region where the samples were obtained is an ideal environment for worm farming and organic worm farm production.

The location of the farm where samples were obtained was surrounded by hills and therefore, the duration of sunlight on the surface of the farm land is low during summer. Furthermore, during the winter, the farm land is protected against extreme cold weather.

This changes in temperature will increase the microbial activities in the soil and thus, increase the amount of worm that metabolizes the various organic materials to useful components in the farm environment (Epstein, 2011).

The lime in the water regulates the pH of the soil in the farm. Increasing the additive substances on the farm will increase the microorganism activities, which will then lead to an increase in the amount of worms on the farm.

In conclusion, as the experiment is carried out in a large area for both fully automated continuous flowing system and pool worms system. This large area promotes the reproduction of worms, by the way limiting the space that causes death of older worms.

Many researchers have carried out their experiments in tight bins. Narrow area, the worms bring the stress. Whereas our experiments provide a large area for both the full automatic continue flowing system and pool worms, which is why we do not put worms in a stress and relax. The fact that the worm food mixture is large enough, the area is wide, and the ideal climatic conditions are the elements that encourage the reproduce of worms (Worm food mixture is more than enough, to be wide of the field and the ideal climatic conditions are the factors that promote the reproduce of worms) .Older worms commit suicide (self-destruction) if there is not enough space. Worms spawn by area width.

CHAPTER 5

CONCLUSION

The production of degradable organic waste and its safe disposal becomes the current global problem. Vermicomposting offers a promising approach for treatment of the organic wastes and production of mature compost. In the present study, seven solid waste materials including; natural animal manure, tea pulp, Olive oil cake, carton board, wheat straw, wheat bran and MDF wood flour, were applied for vermicompost production. In general, temperature, humidity, feed, pH, amount of calcium in food, cardboard, wheat bran and MDF wood flour will promote worm breeding due to the presence of very fine particles and animal manure.

The carbon content in the tested wastes ranged between 12.1268 to 15.8650% which is suitable earthworm growing. The total nitrogen content found in the waste samples ranged between 2.7189 and 3.4557%. Consequently, the present sample showed moderate C/N ratios (from 3.45 to 5.44) which are excellent for vermicomposting process. Different ratios of potassium, calcium and phosphorous were recorded in the waste samples. Potassium and calcium content increased with the modification of the basic sample (from 1.7988 to 2.1289% for K and 6.7869 to 7.6430% for Ca). Values of phosphorous (P) decreased in all samples compared with the original natural animal manure sample (from 2.0291 to 1.1841%). Generally, the present compost show higher content of P, K and Ca than reported in literature. The contents of other metals including Cu, Zn and Fe were also higher.

The concentration of soil solution in the soil is constantly changing with precipitation, irrigation and evaporation. However, these events do not have much effect on the ability of the (K, Na, Ca, Mg) cations to hold onto the earth.

Different P_2O_5 contents were recorded; the highest value was recorded in the animal manuresample (6.40%) and this value decreased via modification with other additives while lowest value was found in VM sample (3.9757%). Contrary, K_2O content was the lowest in manure and the highest with VM sample.

Results of the calcium carbonate were also reported. $CaCO_3$ contents were arranged as following: VP > VM > V and the lowest value recorded in the VC sample (43.815%).The purpose of calcification is to bring the soil reaction to the optimum level for the uptake of plant nutrients (pH 6.5-7.5). Excessive lime application can also damage plant growth.

The produced vermicompost samples were rich in organic materials, nitrogen, humic substances and minerals. The organic substance ranged between 15.2 (for VP sample) to 17.5% (with VM samples). The VP sample contained the highest N content (2.62%) compared to 1.5% recorded for VC sample Organic materials enable to gain land loose and permeable structure. This increases the aeration and water holding capacity of the soil. Microorganisms living in the soil provide the release of plant nutrients while separating the organic matter in order to feed and provide energy.

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Higher content of Humic and Fulvic acids were found in the VP sample (36.8%) which modified with 20% Olive oil cake. Both V and VC samples approximately contained equal amounts of such organic acid with lowest value for the VM sample (9.36%).Humic + Fulvic acid gives the amount of humus. .Humus has important functions in regulating soil nutrition, loosening heavy and sticky soil, raising the quality of irrigation and air conditioning in the soil, and feeding the living organisms in the soil to form the necessary nutrients for the plants. Humus combines with phosphorus to form well-soluble phospho-humic compounds in water.

Sufficient and suitable mineral contents were recorded in the produced vermicompost. The available mineral contents were as follow; potassium (K) ranged between 4.034 to 6.161%, calcium (Ca) from 4.46 to 5.74%. The phosphorous content in the vermicompost samples were 0.672, 0.482, 0.527 and 1.312% for V, VC, VP and VM samples, respectively. Minerals strengthen the roots and cell walls of the plant, it has a duty to carry energy. It has important factors in the growth and development of the plant.

C/N ratio is found below 20%. It is thought that N is mixed with water. At the beginning of the experiment, the fermentation resultant C ratio falls, falling because the worm feeds. When the C ratio increases, the number of worms and reproduction increases if the N ratio increases, the worm mass increases. There has been a noticeable increase in the number of worms in the farm. Nitrogen, is present in the form of ammonium in cow manure, whereas in vermicompost is present in nitrate form.

Increase in worm count:

1. The highest increase in the mixture of tea leaf with cow manure (VT)
2. Cardboard with cow manure
3. Wheat straw with cow manure
4. Olive oil paste with cow manure
5. The least reproductive progress has been made on cow manure. This is also in accordance with the literature.

Worms are fed with microorganisms in the environment. Too much different additive substances increase microorganisms, which leads to an increase in the number of worms.

The presented NPK (nitrogen, phosphorus, potassium) value reported for the samples were recorded to be higher than the recommended values (from 10.966 to 14.741) which recommend the vermicompost as a nutrient eco-friendly vermicomposts beneficial for plant growth and crop yield.

The location of the farm where samples were obtained was surrounded by hills and therefore, the duration of sunlight on the surface of the farm land is low during summer. Furthermore, during the winter, the farm land is protected against extreme cold weather.

Generally, as the experiment is carried out in a large area for both fully automated continuous flowing system and pool worms system. This large area promotes the reproduction of worms, by the way limiting the space that causes death of older worms.

In conclusion, vermicopmost will also be given support to good ecosystem and can be an efficient technology to convert negligible vegetable-market solid wastes into nutrient-rich biofertilizer if mixed with bulking materials in appropriate ratios.

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APPENDIX

Result of the elements for the various samples

Component	mass%							
	V–25^{O}C	V–70^{O}C	VP–25^{O}C	VP–70^{O}C	VC–25^{O}C	VC–70^{O}C	VM–25^{O}C	VM–70^{O}C
C	13.7580	9.6036	15.8650	12.1268	12.5095	7.0630	14.9224	13.5600
N	3.4557	2.5748	3.2699	2.6147	2.7189	2.0451	2.7426	2.8499
O	50.6243	51.3384	52.0021	52.3129	50.4727	52.3418	50.0336	50.2521
Na	0.3609	0.5560	0.3755	0.4091	0.5599	0.7095	0.5605	0.6071
Mg	3.4613	4.3384	3.3216	3.9974	3.8554	5.1917	3.6186	3.7235
Al	2.0980	2.9997	1.9494	2.4036	2.6282	3.3840	2.0954	2.2184
Si	10.5601	12.5454	9.3004	10.8371	11.3188	13.3972	8.9318	9.4884
P	2.0291	1.5725	1.4567	1.4495	1.4290	1.1009	1.1841	1.2819
S	0.7957	0.6113	0.7000	0.6534	0.6950	0.5486	0.6183	0.6724
Cl	0.1519	0.1202	0.1465	0.1208	0.2841	0.2860	0.4388	0.4791
K	1.5441	1.6748	1.3781	1.4101	1.7988	1.8812	2.1289	2.2926
Ca	7.2065	7.1649	6.8115	7.7184	6.7869	6.3409	7.6430	8.2313
Ti	0.2420	0.3742	0.2318	0.2758	0.3567	0.4796	0.2530	0.2633
V			0.0036			0.0114	0.0079	
Cr	0.0324	0.0440	0.0411	0.0447	0.0393	0.0536	0.0425	0.0440
Mn	0.1084	0.0971	0.0852	0.0846	0.1146	0.1046	0.0859	0.0936
Fe	3.4588	4.2653	2.9442	3.4395	4.2941	4.9080	3.4863	3.8149
Co	0.0036	0.0030	0.0026	0.0031	0.0031	0.0043	0.0034	0.0027
Ni	0.0306	0.0366	0.0342	0.0401	0.0310	0.0392	0.0321	0.0364
Cu	0.0093	0.0073	0.0071	0.0074	0.0073	0.0071	0.0073	0.0095
Zn	0.0326	0.0276	0.0229	0.0228	0.0259	0.0220	0.0233	0.0247
Ga		0.0012			0.0009	0.0021		0.0015
Br	0.0033	0.0021	0.0023	0.0021	0.0025	0.0019	0.0021	0.0026
As			0.0009		0.0011	0.0014	0.0014	0.0015
Rb	0.0029	0.0033	0.0028	0.0029	0.0029	0.0033	0.0034	0.0032
Sr	0.0254	0.0261	0.0204	0.0220	0.0266	0.0288	0.0209	0.0235
Nb	0.0014	0.0013	0.0011	0.0014	0.0012	0.0021		0.0011
Y		0.0012			0.0012	0.0008		
Zr		0.0034				0.0055	0.0073	0.0067
Pb	0.0038	0.0062						
Ba			0.0231		0.0344	0.0370		0.0172

Results of the oxides and carbonate for the various samples

Component	mass%							
	V-25^oC	V-70^OC	VP-25^OC	VP-70^OC	VC-25^OC	VC-70^OC	VM-25^OC	VM-70^OC
Na_2O	0.5826	0.8807	0.6349	0.6720	0.8995	1.1219	0.9563	0.9945
MgO	7.0365	8.6019	7.0757	8.2476	7.7588	10.2651	7.7583	7.6437
Al_2O_3	5.0065	6.9764	4.9047	5.8473	6.2052	7.8631	5.3003	5.3498
SiO_2	29.2937	33.8988	27.3227	30.7240	31.0592	36.1632	26.3254	26.5817
P_2O_5	3.9757	3.2482	4.9182	4.6877	4.4389	3.3505	6.4015	4.8002
SO_3	2.7786	2.0546	2.6178	2.3326	2.3789	1.8337	2.2928	2.3511
K_2O	2.6410	2.7452	2.5332	2.4640	3.0122	3.0664	3.8941	3.9452
CaO	14.8063	14.0168	15.1720	16.2290	13.6171	12.3121	17.0314	17.1680
TiO_2	0.6344	0.9212	0.6718	0.7455	0.9043	1.1628	0.7298	0.7045
V_2O_5			0.0098			0.0282	0.0231	
Cr_2O_3	0.0750	0.0957	0.1055	0.1070	0.0881	0.1147	0.1084	0.1041
MnO	0.2252	0.1892	0.1967	0.1814	0.2306	0.2008	0.1972	0.1984
Fe_2O_3	8.0098	9.2559	7.5924	8.2273	9.6347	10.5122	8.9317	9.0275
Co_2O_3	0.0062	0.0063	0.0044	0.0074	0.0069	0.0091	0.0060	0.0062
NiO	0.0660	0.0738	0.0830	0.0895	0.0650	0.0782	0.0773	0.0805
CuO	0.0197	0.0145	0.0170	0.0164	0.0151	0.0140	0.0172	0.0206
ZnO	0.0692	0.0546	0.0547	0.0500	0.0533	0.0431	0.0552	0.0537
Ga_2O_3		0.0025			0.0020	0.0044		0.0036
As_2O_3			0.0023		0.0025	0.0029	0.0034	0.0036
Rb_2O	0.0054	0.0058	0.0058	0.0057	0.0052	0.0056	0.0071	0.0061
SrO	0.0515	0.0494	0.0467	0.0463	0.0524	0.0540	0.0475	0.0488
Nb_2O_5	0.0034	`0.0030	0.0030	0.0035	0.0029	0.0048		0.0027
PbO	0.0071	0.0107						
ZrO_2		0.0073				0.0118	0.0172	0.0141
Y_2O_3		0.0022			0.0023	0.0014		
BaO			0.0449		0.0611	0.0630		0.0309
$CaCO_3$	48.998	40.263	52.639	49.389	43.815	38.125	50.435	50.227

CURRICULUM VITAE

Samira Salem Omar Radwan was born in 1980, Mesrata - Libya, and she completed primary and secondary school in Kaddahia Central School. She started undergraduate program in Al-Thady University, Department of Analytical in 2006. Then she as a lecturer in the same University. She nominated at this scholarship and complete Karabuk University (Turkey) to get the master degree.

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