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Impact of Locally Cultured Effective Micro-Organisms on Organic Waste Composting in Juba County, South Sudan

Josephine. Nackeny Augustino
Pan African University Life and Earth Sciences Institute (PAULESI), University of Ibadan, Ibadan, Ibadan 200284, Oyo State, Nigeria.
Department of Geography, University of Ibadan, Ibadan 200284, Oyo State, Nigeria.
Address: Juba, South Sudan.
ORCID: 0000-0002-3210-7801

Olayinka O. OGUNKOYA
Prof. , Obafemi Awolowo University, Ile-Ife, Nigeria
Department of Geography

Andrew. L. Athiba
University of Juba
Department of Environmental Management
Address: Juba, South Sudan

Abstract:- Developing countries has experience a rapid expansion of cities largely due to the massive migration of people from rural to urban centres leading to generation of Municipal Solid Waste (MSW). Open dumping in Juba County calls for waste management techniques that could eliminate the risks, and possibly promote profitability to its communities. Composting is one of techniques that can minimize this problem.

This study aimed at production of locally cultured Effective Microorganisms (EM) at household level, apply it on organic wastes for composting, monitor its influence on organic wastes composting by observation and measuring the temperature of the compost, evaluate the duration of composting and convert organic waste into value-added bio-product such as bio- fertilizer or compost.

EM were locally cultured at the household for 13 days and applied on the organic waste for composting and its impact was monitored for a period of one month while the other buckets controlled. Temperature measured on daily basis using DIGITAL COMPOST THERMOMETER TP 101 brand for all the composting bins showed three phases: mesophilic phase, thermophilic phase, and maturation phase. The duration of the compost process varied, those with EM took two months, while the controlled ones took more than three months.

Eighteen farmers were engaged and trained on how to make their own EM and how to compost organic waste at home in order to minimize the quantities of Municipal Waste, improve sustainability of urban agriculture using organic compost, raise awareness, and build capacity towards sustainable farming practices.

Keywords:- *Organic Wastes, Effective Microorganisms (EM), Compost, Municipal Solid Waste Management.*

I. INTRODUCTION

In recent years, there has been a rapid expansion of cities globally. This is largely due to massive migration of people from rural areas to urban centers, coupled with considerable increase in per capita generation of wastes. Hence, the volume of Municipal Solid Waste (MSW) has increased across the world (Saha et al., 2010). Incidentally, over 90% of the wastes is openly dumped on the outskirts of towns and cities or on un-engineered (unsanitary) landfills. This has serious implication for global warming since Greenhouse Gases such as methane are released into the atmosphere (Sharholy et al., 2008) and (Narayana, 2009).

Thus, South Sudan is not an exception to this global environmental problem. This is due to abrupt urban population explosion and its associated waste generation, which requires significant waste management resources that are often not available (Gasim, 2019).

Although Juba City Council is managing large amounts of waste being produced on daily basis, some of the consequences of improper waste disposal are still a major challenge. Apparently, mixed wastes are brought and dumped along the main streets by the inhabitants, without any type of sorting, and Juba City Council is responsible for collecting the garbage and transporting dumping Site, managed by Rejaf Payam. In Juba Solid Waste Management is not properly implemented due to security situation and financial constraints caused by internal political instability (Gasim, 2019). Therefore, illegal dumping and burning practices are common in Juba. As a result, environmental pollution and the spread of diseases have become a major public health concern. Although, SWM is a key priority for Juba City Council and related costs represent a heavy financial burden for the city's coffers (Luate, 2015).

In a study conducted by United Nations Environment Programme (2013), the municipal wastes of Juba County were characterized into the following: - Organic waste (40.0%), Plastics (21.0%), Paper and Cardboard (13.0%), Soil/sand/ash (11.0%), Metals (5.0%), Glass (4.0%), Textile (3.0%), Special car wastes (1.0%) and other wastes (2.1%). Under a situation of inability to adequately and efficiently manage municipal waste given the poor resource status of the Juba City Council, there is a need for recourse to attain sustainable solid waste management, with an innovation that is environmentally friendly, effective, efficient, and less costly techniques that can be carried out by ordinary citizens (Taiwo, 2011). There are many alternative ways of managing waste in developing countries, and these include: landfilling, composting, biogas capture, incineration, pyrolysis and gasification. However, this study aims to monitor and evaluate the impact of using locally cultured Effective Microorganisms (EM) on the duration of organic waste composting at the household level and to produce a bio- fertilizer.

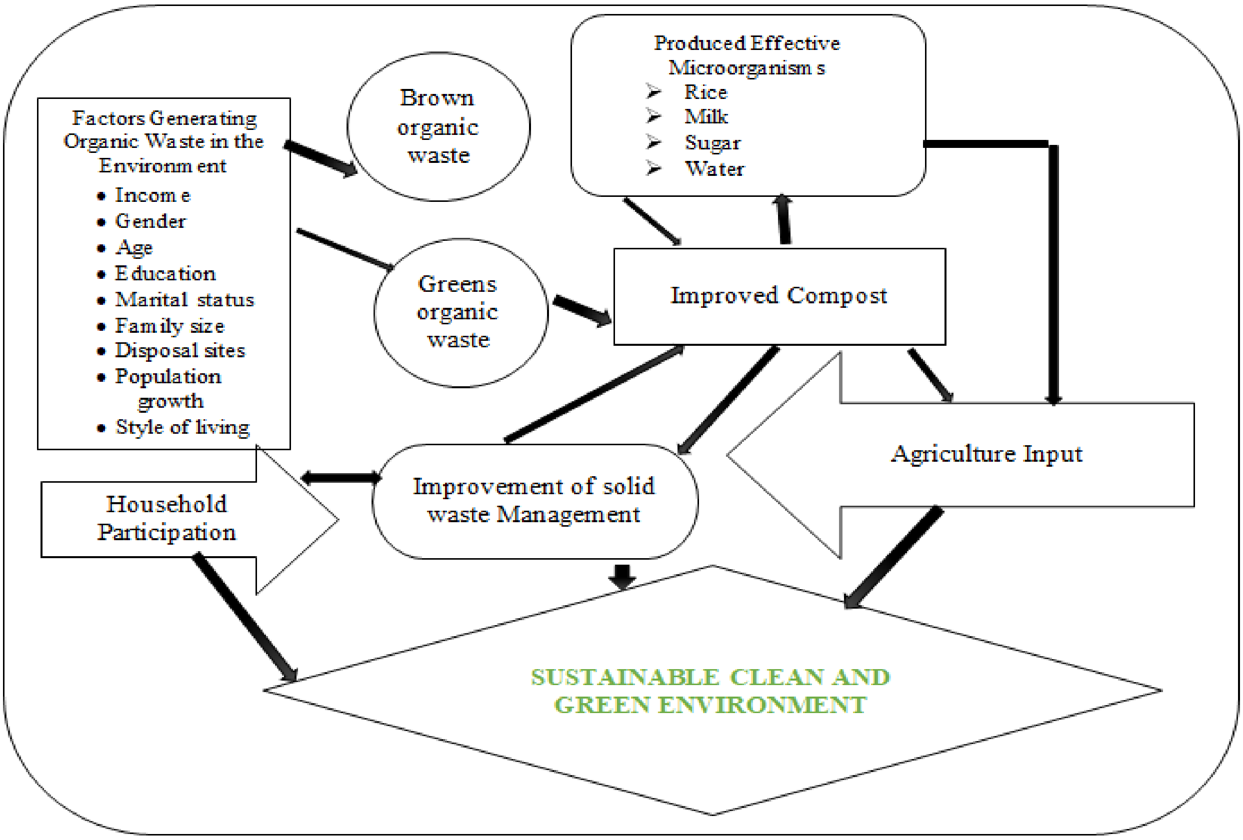
Composting is a biological process in which air is introduced to organic and agricultural waste by mechanical turning that stimulates aerobic micro-organisms to minimize or effectively reduce organic materials such as kitchen and agricultural wastes, to more stable materials similar to humus ((Taiwo, 2011); and (Vich et al., 2017).

Composting not only mitigates problems of atmospheric pollution but it is used by many small- scale farmers in low-income countries as a soil conditioner, since it is relatively cheap compared to commercial inorganic fertilizers and is more readily available than animal manure (Chrysargyris & Tzortzakis, 2015).

However, one of the issues in the composting process is the long duration before attaining the end product - compost. For example, a small-scale organic matter composting scheme using windrow method takes three to four months to produce compost and emission of unpleasant odours (Kumar et al., 2014), (Namsivayam et al., 2011), and (Bailey et al., 1914). The rate of the composting process may be significantly accelerated and enhanced using effective microbes or microorganisms (EM) a type of microbial inoculant which was developed by Teuro Higa, a Japanese horticulturist from the University of Ryukyus in Japan (Olle & Williams, 2013).

Effective Micro-organisms are a culture of coexisting beneficial microorganisms consisting basically of three genera of microorganisms; (i) lactobacilli -common in curd or yogurt, (ii) yeast -used in the production of bread, beer and wine, and (iii) photosynthetic or phototrophic bacteria - found in some pickles and cheeses, and in the roots of water hyacinths (Namsivayam et al., 2011). These microorganisms are said to be physiologically compatible with one another and can coexist in liquid culture. There is also an evidence that EM inoculation to the soil can improve the quality of soil, plant growth and yield of crops (Iriti et al., 2019; Bargaz et al., 2018) and (Shalaby, 2011).

II. CONCEPTUAL FRAMEWORK OF THE STUDY



Solid Waste Management Practices in most of the Developed and Developing (Ezechi et al., 2017)

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Activity	Low income	Middle income	High income
Source reduction	No organized programmes, but reuse of waste and low per capita waste generation rates are common.	There are some ongoing discussions of source reduction, but are rarely incorporated into any organized programme	education programmes are being organized and are beginning to emphasize on source reduction and reuse of materials
Collection	Sporadic and inefficient. Service is limited to high visibility areas with wealthy people, and businesses that are willing to pay.	A need to improved service and increased collection from residential areas. Larger and more mechanized vehicles are of importance	The collection rate is greater than 90 percent and compactor trucks and highly machined vehicles are mostly used.
Recycling	Most recycling is through the informal sector, companies and waste picking.	Informal sectors are involved, with some high technology sorting and processing facilities. Materials are often imported for recycling	Recyclable material collection services and high technology sorting and processing facilities. Increasing attention towards long-term markets.
Composting	Rarely undertaken formally even though the waste stream has a high percentage of organic material	Large composting plants are generally unsuccessful, some small-scale composting projects are more sustainable.	Becoming more popular at both backyard and large-scale facilities. Waste stream has a smaller portion of compostable than low and middle-income countries
Incineration	Not common or successful because of high capitaland operation costs, high moisture content in the waste, and high percentage of inerts	Some incinerators are used, but experiencing financial and operational difficulties; not as common as high- income countries.	Prevalent in areas with high land costs. Most incinerators have some form of environmental controls and some type of energy recovery system
Landfilling	Low-technology sites with scattered open dumping of wastes around the cities.	Controlled and sanitary landfills with some environmental controls are available but open dumping is still commonly practiced.	Sanitary landfills with a combination of liners, leak detection, leachate collection system, and gas collection and treatment systems
Costs	The collection costs of developing represent 80 to 90percent of the municipal solid waste management budget. Waste fees are regulated by some local governments, but the fee collection system is very inefficient	Collection costs represent 50 to 80 per cent of the municipal solid waste management budget. Waste fees are regulated by some local and national governments, more innovation in fee collection	Collection costs can represent less than 10 per cent of the budget. Large budgets are allocated to intermediate waste treatment facilities that are of more importance. Upfront community participation reduces costs and increases options available to waste planners that are knowledgeable (e.g. recycling and composting)

Source:(World Bank 1999)

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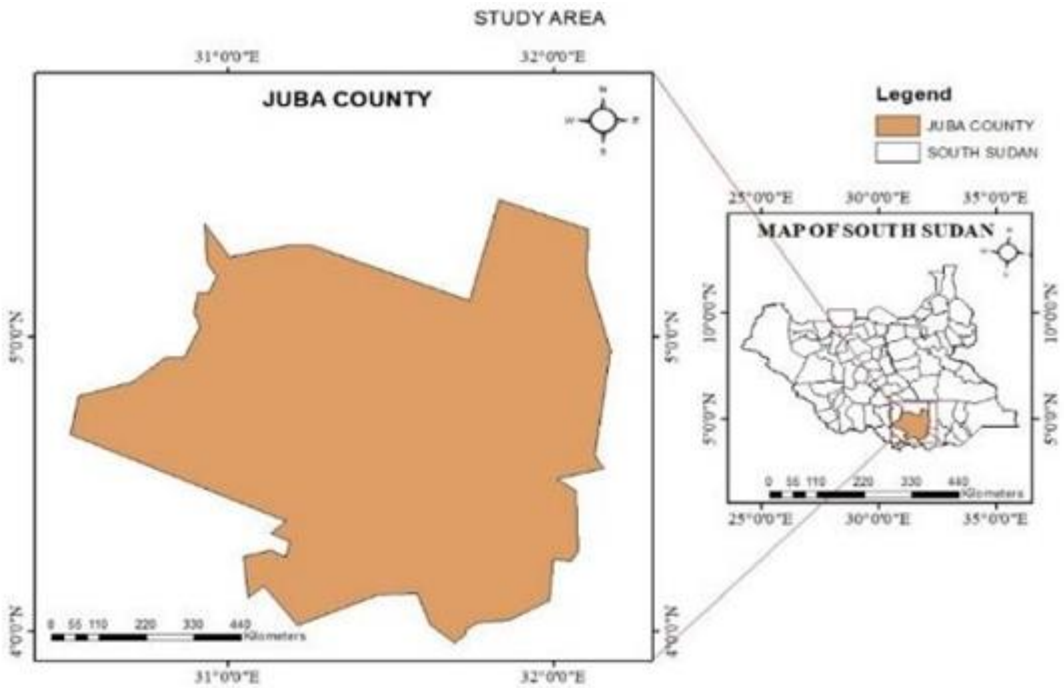
III. MATERIALS AND METHODS

Study area Description

Juba County is one of the counties of Central Equatoria State. It is a county within Juba, the capital city of the Republic of South Sudan. The county is situated in the north eastern part of the city, along the western bank of the River Nile. It is made up of three Payams (the second- lowest administrative division, below counties that consist of a minimum population of 25000 people), which include Juba, Kator and Munuki and it is directly administered by the Juba City Mayor.



Research Study Area
Source: Author, 2020

United Nations Environment Programme (UNEP, 2012) reported that Juba is currently amongst the fastest developing places in the world (UNEP, 2012). In 2011, the population of the city of Juba was estimated more than 500,000 (Global Water Intelligence, 2011).

The municipal solid waste (especially organic waste) pollution problem in Juba County is real serious, pervasive, and needs a very urgent solution. Juba's huge piles of wastes always amaze many visitors that are not familiar with such scene. Organic waste tends to be dumped along streets, clogging and blocking streams, bobbing down into the River Nile from residential districts that are closer to it, littered around buildings with resultant bad odour, and even strewn across the graves within the municipal cemetery.

In Juba County, many water channels are blocked by municipal solid waste, resulting in pools of stagnant water, which provide prime breeding habitats for several disease vectors including mosquitoes that transmit malaria, which is an endemic disease in the the county. In Juba, there are certainly high health risks from other vector transmitted diseases, thanks to the open dumping and therefore the poor drainage caused by improper disposal of wastes.

Data Collection

Primary Data Collection

The primary data for this study was generated from the following:

- Effective Microorganisms experimentation
- Compost experimentation
- Culture of Effective Microorganisms

The Effective Microorganisms to be utilized in the study was cultured at home by a group of women who were trained on how to make Effective Microorganisms for easy monitoring of the process and the cultured solutions.

Items that were purchased to produce effective microorganisms were:

Brown Rice

- Water
- Tissue papers
- Fresh Milk
- Strainers
- Brown Sugar
- Plastic containers with covers.

Procedure on how to Culture the EM at Home

- 1 kilogram of brown rice was poured in two litters of clean tap water in a plastic container and stirred for 5 minutes
- The mixture was left for at least 3 minutes to stand in order to get concentrated rice water for the experiment
- A cloth or strainer was used to collect the rice water or extract into an empty clean plastic container and covered with tissue paper and the start date of the culture was labelled appropriately on the container.
- The rice water/ extract was then stored in a dark place for 3 days under room temperature for yeast to grow.
- After 7 days, the mixed cultured rice water was mixed with 1 litre of milk and stored for 7 more days.
- After the 7 days, the lactic acid bacteria were formed and was strained in another clean container and the cheese was given to chicken at home.
- Then brown sugar, which is an alternative to molasses, was added to the solution and left to stand for 2 days and the final Effective Microorganisms was ready.

Collection of Organic Waste for Composting

10 kg of kitchen wastes (including vegetables, fruits, cartons, tea bags, and tea leaves), dry leaves, paper, and agricultural wastes (which consists of nitrogen and carbon) were collected in a plastic container with a 1:3 of browns: greens or nitrogen: carbon for a fruitful mixture. The collection of organic wastes for composting was done by the researcher and other women groups formed in the study area, that is, Munuki, Kator, and Juba payams.

The wastes were collected from 18 households in which each household was represented by one woman (a woman per household). Each one of them was given a 10-litre bucket to use for composting. They collected the wastes for each week but the composting was started separately.

Preparation of Materials for Composting

- Identifying the composting spot:

A place outdoors was identified for the composting. Since the type of compost that has be selected is the aerated compost, the outdoor corner is essential for the free air movement for the Effective Microorganisms to break the organic waste faster in their favorable place of growth.

- Segregating the Waste:

The wastes were first collected all in one place from the kitchen into a container but when the process of composting was about to start, the waste was segregated, sorted, or separated for the organic waste to be composted only in plastic buckets.

The kitchen waste that was collected include vegetable, fruit peels, small amounts of wasted cooked food, etc. with dry waste such as dried leaves, sawdust, newspaper, and packaging material. The containers remained closed to avoid infiltration of bugs, flies, and worms.

Compost Process

Organic wastes were collected from 18 households in 3 different areas by different women (each area consisted of 6 women). 18 buckets of 10 litres capacity were distributed to each one of them. The EM cultured locally at home is a concentrated solution that cannot be added directly into the compost. Two teaspoon of EM was diluted in a two litres of water and the two-litre mixture was added to the organic waste for composting.

Turning (To Bring the Maturity of Compost to an Equal Level)

The waste during compost process requires turning to allow the best conditions for the Effective Microorganisms to breakdown the waste faster, and subsequently, twice every week for uniform decomposition of the waste.

Measuring The Temperature

The temperature was measured twice a week to understand the condition needed for the right decomposition of organic wastes.

Secondary Data Collection

Secondary data were collected from but not limited to documentaries, published articles and journals, books, YouTube videos, newspapers, google search, reports, textbooks, magazines, libraries, etc...

Data Analysis Technique

The data collected from was analysed using Statistical Package for the Social Sciences (SPSS) version 21.0 software most especially the compost temperature.

IV. RESULTS AND DISCUSSION

Results

Mixture of Items used in the production of Effective Micro-organisms

Items	Units	Quantities
Brown Rice	Kilogram	2
Milk	Litres	2
Brown Sugar	Kilogram	2
Water	Litres	2
Buckets	Pieces	2/Household
Strainers	Pieces	2/Household
Small jerry cans	Litres	5

In the process of mixing different items to get the final product which is the Effective Microorganisms, the following procedures were put into consideration under room temperature condition in all the three research locations (Kator payam, Munuki Payam, and Juba Payam):

- 2 kg of rice was washed using 2 litres of water and the rice water was strained in a bucket and stored in a room temperature for 3 days. After the three days, the yeast on top of the water was trained in a separate container.
- The strained yeast was mixed with 2 litres of milk and stored in the same temperature for 7 days to get the lactic bacteria that was also strained in another bucket.

- On the 7th day, the collected lactic bacteria were mixed with 2 kg of sugar and stored for more two days to get the final mixture of Effective Microorganisms.
- The whole process took 13 days for the EM to be ready but in its dormant stage and can be activated by mixing 1 litre of EM to 1 litre of unchlorinated water and applied on the organic waste.

Application of Locally Cultured Effective Microorganisms on Organic Wastes for Compost

The EM after being cultured and stored in a plastic containers was then reactivated from its dormant and concentrated stage and applied on the waste that needed to be composted.

Quantity of EM and water applied to which quantity of wastes, number of times applied, and days it took compost to be ready for use.

Quantity of organic Waste	Quantity of EM	Quantity of water	Number of application	Days taken to get the compost
18 kg	1 litre	1 litre	4 times	60 days
15 kg	1 litre	1 litre	5 times	59 days
13 kg	1 litre	1 litre	4 times	54 days
12 kg	1 litre	1 litre	6 times	60 days
11 kg	1 litre	1 litre	5 times	58 days
11 kg	1 litre	1 litre	7 times	52 days

*Research site area

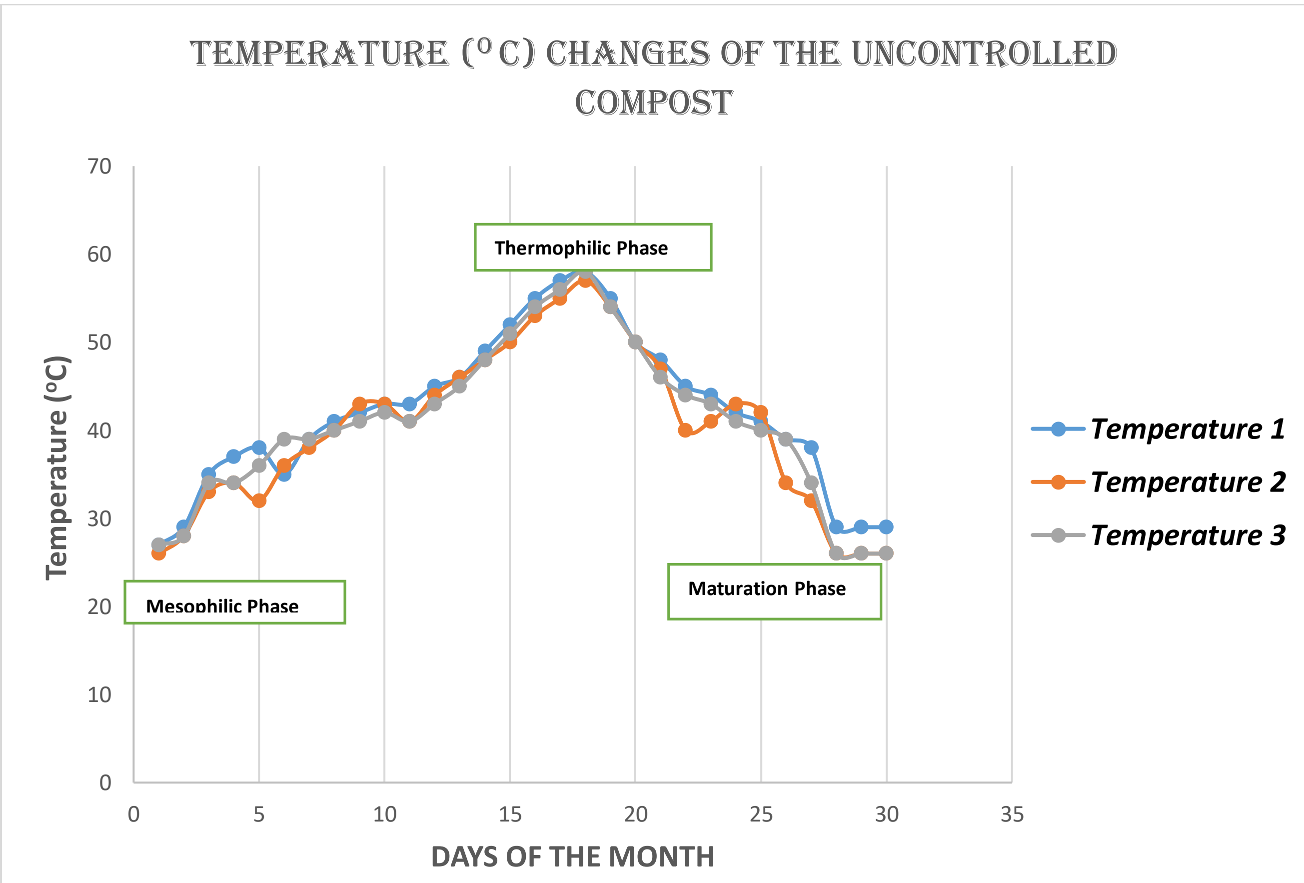
Carbon: Nitrogen Ratio

The mixture of the greens (Carbon) and browns (Nitrogen) of the compost materials was ratio of 3:1. During the process of composting, microorganisms utilize the C as a source of energy and the N for building cell structure (Gonawala & Jardosh, 2018).

Compost Temperature

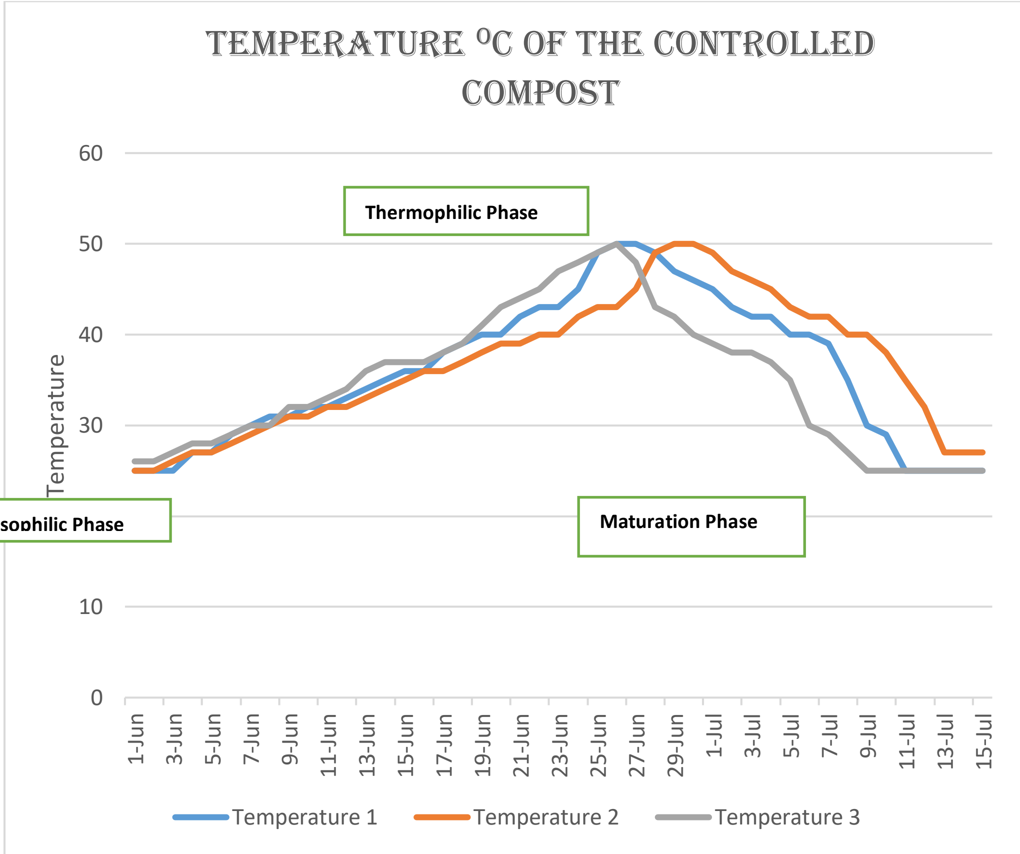
In the process of composting, temperature was measured to monitor the changes in the composting process within a month as composting with the locally cultured EM only take one and a half or two months to be ready for use in agricultural system. The compost temperatures in the containers were measured once daily at 7:00 am. Using the compost thermometer, the compost temperature ranges between 26-57ºC (location 1), 27-58ºC (location 2) and 26-58ºC (location 3) in each of the buckets where EM was applied in the three different locations.

For the buckets that were controlled, the temperature showed different ranges from that with the EM. The temperature ranges are 25-50ºC (location 1), 26-50ºC (location 2) and 25-50ºC (location 3). Temperatures did not rise higher compared to that with the EM and this is due to the number of the microorganisms in the process of composting that generates heat and enhance the process.



Temperature Changes during Composting process

Presents information on the changes in the temperature of the organic wastes in the buckets where the EM was applied. This measurement was done within a period of one month (June 1st-30th) which is a period of one month. During the process, temperature changes in three phases: the mesophilic phase (27-41ºC), thermophilic phase (42-58ºC), and the maturation phase (26-48ºC) were observed. Temperature 1: represents bucket 1, temperature 2: represents bucket 2, and temperature 3: represents bucket 3 respectively of the uncontrolled buckets.



Temperature changes in the controlled buckets

The graph indicates, the temperature of the compost that was controlled (EM not applied). This measurement was done within a period of one month and a half (June 1st-July 15th) total number of 45 days because the presence of microorganisms was not much compared to that with the EM. During the process, temperature changes in three phases like that in the uncontrolled buckets: the mesophilic phase, thermophilic phase, and the maturation phase. Temperature 1: represents bucket 1, temperature 2: represents bucket 2, and temperature 3: represents bucket 3 respectively with detailed in the discussion.

Changes During the Composting Process

a) Colour

From the beginning of the collection of the waste from the household to the days the composts were ready for use, the colour kept changing. In the first 1-2 days, the waste was looking fresh since the microbes had not acted on them yet. When the microorganisms started decomposing the waste, there were dark spots all over the green waste and after some days, the waste pile became darker and darker. The final compost was completely black in colour and looked like loam dark soil.

b) Odor of the organic wastes

The smell of the waste changed as days went by during the composting process. In the first week, the waste perceived good but in the second week, the odour stinks and was not easy to handle by some group members. When the EM was added to the waste the odour changed gradually and in the last days of the process, perceived like honey with sweetest flavour.

Discussion

The Culture of Effective Microorganisms

The concept of culturing beneficial microorganisms in one place to improve crop yields in the agricultural field has evolved from the first study of a Japanese Professor Higa and has spread across the world. Farmers that use EM in their field mostly purchase the readymade product and then activate it for use in the farms (Cóndor-Golec et al., 2007). This study has trained a number of 18 farmers from different households on how to produce their own EM within 14 days and afterward activate it for the final use on composting. The EM that is produced locally at the household level in this study is based on items such as brown rice, milk, and brown sugar.

Mixture of EM and Its Impact On Compost

By actively using beneficial microorganisms, EM increases the number and diversity of microbes in the soil and speeds up the decomposition of organic matter and nutrient cycling (Sekeran et al., 2005). This study has found out that, EM in the process of composting, enhance the process of decomposition of the organic matter to compost. Based on the monitoring and the observation during this study, the composting process lasts for less than three months compared to the normal types of composting (composting devoid of use of EM) that mostly takes three and more months. The compost was easy to be handle by the trained farmers since it had reduced odour.

Temperature Changes During Composting

Temperature maintained during composting serves to promote efficiency and effectiveness of compost by accelerating the process and by destroying pathogenic microorganisms that might be harmful if the compost is added to crops. Measuring temperature was one of the elements that was taken during the study as the study was to determine the heat changes when microorganisms are added into the composting process compared to that without the addition of microorganisms. During the process, when the temperature of the compost becomes cold, it indicated that the microbes are inactive and the pile becomes cold. During the maturation phase of composting, the temperature of the compost pile drops to the ambient temperature level (20-30ºC) and mostly during this phase, condensation of carbonaceous compounds and polymerization occurs, which further helps in formulation of fulvic and humic acids (Meena & Dutta, 2021)

While hot temperatures indicate that there is a high increase in the number of microorganisms in the organic waste that is being composted. There were majorly three distinct temperature phases that happened during the composting process and they are:

Mesophilic (27-41ºC)

Once the organic waste started decomposing, the temperature also started rising up. During this stage, the temperature changed gradually within few days from the 1st of June-10th of June and it is the stage where bacteria began to eat the organic waste in the pile and building up themselves. Fungi were visible at this stage and can be seen with the naked eyes. This stage shows that there are microorganisms that are working actively in the organic waste and the quantity of the waste started reducing from the first day. The compost bin that had addition of Effective Microorganisms showed different result of (27-41ºC) in this phase from 1st of June-18th of June 2021. The temperature in the compost bin that was controlled started at 25ºC to 39ºC.

Thermophilic (42-58ºC)

This second phase, the temperature corresponds to a period of 8 days from the 11th to 18th of June 2021 in the compost bin with the EM and there was an increase of compost temperature from 42ºC to 58ºC. This happened at the second stage of the process, when thermophilic microorganisms became extremely active and produced a lot of heat, which produced methane the odourless gas. This statement is in agreement with the findings of (Azim et al., 2018) who stated that the thermophilic stage is characterized by a temperature usually between 40 and 60 °C. Once temperatures increase above 57ºC, thermophilic bacteria (bacteria that grow in high temperature condition) continue to eat simple compounds with high energy yield. The thermophilic stage lasts a few days when the Effective Microorganisms was added to it compared to the one that was just natural and depending also on the size of the pile and type of inputs. During the time taken, most of the organic matter was reduced to humus and materials began to resemble finished compost. Compared to the bins with the EM, those without the EM had more days in this stage which extended from the 19th to the 26th of June with the temperature of 40ºC to 50ºC and it is an indication that, the EM were not as much as they were expected to be like that with the ready EM.

Maturation or Curing (26-48ºC)

Curing was marked by a sustained drop in temperature back into the mesophilic range. As the pile cools down, fungi and actinobacteria become more active, metabolizing the more complex cellulose and lignin-rich materials (Gonawala & Jardosh, 2018). The compost temperature slowed down in this stage drastically in both the controlled and the uncontrolled bins of the compost. The temperature in this stage ranged between 26ºC and 48ºC from 19th of June to 30th of June 2021, while the controlled one took longer days from the 27th of June to 15th of July with the temperature ranging from 25ºC to 48ºC.

Changes Observed During Composting

In the days when the experiment was carried out, changes have been observed in the process of composting especially in the bins with EM. The quantity of the waste started reducing from the first week when the EM was added and kept on reducing till the last day of the experiment with example of one bin which reduced from 18 kg to 5 kg an indication of waste minimization and reduction. The presence of EM in the organic waste showed that they feed majorly on the waste and the condition was suitable for their growth.

During composting, the microorganisms highly consumed oxygen while feeding on organic waste for survival. Active composting generates large amount of heat, and large quantities of water vapour and carbon dioxide are released into the atmosphere. The carbon dioxide and water losses can amount to half the weight of the initial organic materials, so composting reduces both the volume and mass of the raw materials while transforming them into a beneficial humus-like material (Ayilara et al., 2020). The colour of the compost started changing from the second week of the process looking brownish in colour to the last days of the process where it looked black (black gold).

Application of EM on the Organic Wastes

The application of Effective Microorganisms on the organic waste during composting varies based on the quantity of the waste in the compost bin. Heavy weight of the waste requires many times application of the EM that enhanced the compost process in a speedy way and takes less than two months or exactly two months. The final compost produced with the application of the EM was well matured, free from pathogens and the processes took two months or less compared to organic waste without the application of EM which took longer period to mature. According to Daly & Arnst (2005) there was a significant visual difference between compost treatments with and without EM where EM treated compost were fully composted compared to the one without EM.

V. CONCLUSION AND RECOMMENDATION

Conclusion

Due to the increase in wastes generation and their negative impacts on the communities of Juba County, an alternative method on how to mitigate the environmental effects of the large quantities of organic waste that are being produced by different households on daily basis is required. This research found that composting using locally produced Effective Microorganisms can be an alternative method. Proper application of EM can accelerate the composting process and may reduce the volume of solid organic waste if it is successfully conducted by households.

The EM enhanced the composting process based on the feedstock and the ratio of carbon: nitrogen present in the organic waste. The process has relatively low capital and operating costs, simple operation and design, and is efficient to reduce organic waste problems.

Farmers (women) summing up to 18 in number from three payams of Juba county were trained on how to produce Effective Microorganisms and applied them on organic waste for the purpose of compost as a final product. The experiment on composting was conducted with and without the application of EM. The final compost that was produced with the application of the EM was well matured, free from pathogens and the processes took two months or less and some less for those with EM compared to organic waste composting without the application of EM which took longer period to mature. According to Daly & Arnst (2005) there was a significant visual difference between compost treatments with and without EM where EM treated compost were fully composted within short period of time compared to the one without EM.

The EM enhanced the composting process based on the feedstock and the ratio of carbon: nitrogen present in the organic waste. The process has relatively low capital and operating costs, simple operation and design, and is efficient to reduce organic waste problem.

More women can be trained to produce Effective Microorganisms and applied them on organic waste for the purpose of compost as a final product. The compost can be used in urban and peri-urban agriculture or be sold to fetch money.

Waste recycling is hence a source of economic revenue since wastes were bought to be recycled and therefore the by-product obtained are often sold-out to horticulturers, foresters, gardeners and persons willing to backfill their wet ground for livestock rearing. EM finds fairly wide application in several areas of human society because they are not-naturally organized, not with chemicals synthesized, not dangerous and not pathogenic and has low opportunity cost. This technology can improve the environment.

One of the challenges to the composting method is how to get people to separate their recyclables. However, most people who actually begin to work with EM in home composting find it to be easy and rewarding experience, especially in kitchen composting.

Recommendation

It is recommended that: has the total quantity of municipal solid waste increase every day in Juba County, farmers should be trained on how to compost organic waste which is of importance in the agricultural field. A better way is to produce Effective Microorganisms that enhance the process of composting, hence minimising waste in a short period of time and having a great produce without a chemical agricultural input.

The use of composting is recommended in the planting of food crops, trees, flowers, gardens development, composting therefore can be classified in the SDG 11 (sustainable cities and communities) projects because it support sustainable green cities projects. So it is advisable for horticulturers, foresters and gardeners in Juba County. Besides organic compost should be applied a long period before planting, because it takes sometimes for the nutrients to be readily available to the plants.

A good communication strategy should be implemented to disseminate information on radio, television stations and socio-media platforms about the different benefits and projects related to composting with EM that can be done at small and medium scale.

Also, food waste composting incentive should be promoted by the local government and be implemented at households for gardening, small and medium scale farming. To get the population more involve, price should be awarded, more importantly South Sudan government should widely open the market for household wastes treatment companies, ie to allow the entrance of new wastes treatment techniques and competition.

Nevertheless, such initiatives should be developed in Juba County and South Sudan at large to encourage farmers, horticulturers, gardeners and foresters not only to use chemical fertilizers but also compost in their various activities.

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