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Design of Composting Unit for Bio-fertilizer Production using Organic Matter: An Assessment of Municipal Solid Waste Generation in Maiduguri-Nigeria

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Abstract: *In recent times, there has been a significant increase in the importance of preserving the environment, especially by utilizing waste as a valuable resource for the benefit of both humans and the environment. The presence of abundant solid waste plays a vital role in achieving sustainable development, including energy generation, bio-fertilizer production, and biogas creation. Unfortunately, these waste materials are rarely utilized for urban or rural development purposes. Consequently, they are disposed of within cities without proper control measures, leading to health hazards. This study aimed at identify various locations where Municipal Solid Waste (MSW) is generated and evaluate its sustainability when converted into bio-fertilizer. The objectives of this work are to identify the MSW production locations in Maiduguri, estimate the quantity of MSW generated in each location, and assess and generate primary data (sampling, quantity, composition) for future of fertilizer composting model plant design. The significance of this study lies in providing engineers with essential information on the amount of waste generated in Maiduguri, which can be utilized to design composting unit for bio-fertilizer production and discourage the use of synthetic fertilizers. The data collected will be useful in designing, modifying, and constructing composting units that can improve the farming system in Maiduguri and its surroundings. Two methods were employed for data collection (questionnaire and literatures): 100 questionnaires were administered to the respondents (20 for each location) and conducting physical survey to examine waste composition in all the study areas. The findings indicate that 17 % and 3 % of the respondents fall into certain demographic categories where as 50 % of the respondents had non-formal education, while 23 %, 3 %, and 2% had completed primary, secondary, and tertiary education, respectively. Results from Gamboru Market show that 50 % of the waste is Vegetables, 37 % Card-board paper, 2 % Polythene, 6 % Wood, and 5 % other materials. While at Monday-Market shows 10 % Vegetables waste, 25% card-board paper, 55 % polythene, 5 % wood, and 5 % other materials. Timber-shed shows, Vegetable/Cow-dung 4 %, Card-board paper 5 %, Polythene 10 % Wood/Saw-dust 71 % and 10 % for other materials. Similarly, at Sulumri mini market, it results revealed 50 % is Vegetables waste, 5 % Card-board Paper, 5 % Polythene, 30 % Wood, and 10 % other materials. Kasuwan-Shanu cattle Market revealed 70 % Vegetable/Cow dung waste, 5 % Card-board Paper, 3 % Polythene, 15 % Wood/Saw dust, and 8 % other materials. Based on the available data obtained, it provides valuable insights for composting as an effective method to reduce overall waste volume into Bio-fertilizer.*

Keywords: *Bio-fertilizer, composting, sustainability, Organic waste, perishable goods,*

1.0 Introduction

In recent times, the significance of environmental preservation has grown significantly, particularly in harnessing waste as a valuable resource for the well-being of both humans and the environment. The abundance of solid waste plays a crucial part in achieving sustainable development, generating energy, producing bio-fertilizers, and creating biogas. This approach represents a commendable strategy for managing pollution. (Mujahid, et al., 2023). Annually, the world produces 2.01 billion tonnes of waste, and this figure is anticipated to increase to 2.2 billion tonnes by 2025 (Kaza, et al., 2018). A significant amount of this waste is generated in urban and peri-urban areas. Municipal waste management in numerous developing world cities is at its poorest state, especially in sub-Saharan countries like Nigeria, Cameroon and Ghana where many locations such as urban fringes or city centres lacking access to public waste disposal services (Babayemi & Dauda, 2009). Most cities and towns in this region spend 20-50 % of their environmental budget on solid waste management and only 20-80 % of the waste is collected (Orhorhoro & Oghoghorie, 2019).

It is approximated that the waste produced in Nigeria ranges between 0.65 to 0.75 kg/capita/day. In Maiduguri, the daily waste production increased from an estimated 390 tons per day to 570 tons per day, according to UNDP's report in 2016. The majority of substances composing municipal solid waste, in this region, include paper, vegetable matter, plastics, metals, textiles, rubber and glass. According to Dauda and Osita (2003), the largest portion of the waste stream is made up of organic waste, including leaves, yard trimmings, food scraps, and agricultural waste. Interestingly, agricultural waste, specifically straw, stems, and stalks, make up about 6.4 % of the total solid waste in the city, which equates to roughly 25 % of the total organic waste. Organic waste constituted around a quarter of the waste composition, while plastics made up about one-fifth. Burning was the most common method of waste disposal, accounting for over 40%. In general, households in the study area have a tendency to inadequately plan their food purchases, which leads to food waste. Urban households have a higher rate of food waste compared to rural households. (Calvin, et al., 2022). Nonetheless, waste disposal would not pose a concern if it is appropriately handled as it can yield valuable products such as organic fertilizer and biofuel.

Among the various waste treatment methods like recycling, incineration, and land-filling commonly employed by developing countries (Oumarou, et al., 2018), composting is one of the promising ways of transforming waste into a valuable resource. Composting is a promising method for promoting material recovery, reducing landfill waste, utilizing renewable resources, and improving solid waste management. The global trend is focused on enhancing environmental and human health, and composting as an organic fertilizer can play a crucial role in achieving this goal. Emphasizing composting over the use of chemical fertilizers will reduce the release of toxic chemicals into the environment, thus promoting environmental and human health. Composting is also posed to reduce agricultural food loss since about 183.3±8.9 million metric tonnes of these foods which make up 27% of the average yearly total domestic supply of edible agricultural food products are lost annually (Afolabi, et al., 2021). Maiduguri is characterised with average temperature of (~ 50 ^{O}C) and is one of the cities in the Lake Chad regions that engages in the import and export of food commodities, whereby the production of agricultural (or organic) wastes also dominates. However, these wastes are rarely utilised for developmental (urban or rural) purposes, therefore at the end, the wastes are only disposed within the city areas without proper control mechanisms, hence resulting into health-related hazard. Therefore, this work intends to

identify the numerous MSW locations, quantify it availability and ascertain its sustainability when converted into bio-fertilizer.

2.0 Methodology

2.1 Materials

The materials used in conducting this study are categorised as follows; questionnaire, national and international journals, conferences, reports, articles, lap-top and Hand-set for accessing both primary and secondary data. Vegetable, Cow-dung, Card-board paper, polythene, Wood, Saw-dust and Others were the parameters under investigation.

2.2 Methods

This study was carried out in Maiduguri, the capital of Borno state, Nigeria. Located in north-eastern Nigeria, Maiduguri shares borders with Chad, Niger, and Cameroon republic, making it a major commercial hub in the region. This factor attracts migrants from other towns and countries to Maiduguri. According to the 2006 census, the population of Maiduguri Metropolitan area was estimated to be 803,000, it increased by 0.37 % in 2022 which raised to 822,000. The sampling method used in this study was random sampling. A well-structured questionnaire was distributed in the study areas for primary data collection, while secondary data was obtained through various literature reviewed. Different areas (Agricultural based Market) was visited and only five were considered and selected at random within the city for the purpose of this studies, the places are Gamboru-Moromoro Market, Monday Market (new side), Timber-shed Maiduguri, Sulumri and Cattle Market (Kasuwan Shanu). Two methods were adopted for data assessment; i- a total of 100 questionnaires were administered to the respondents, 20 for each location. Some were filled instantly while others were collected the following day, 98 questionnaires were filled and recovered. ii-personal survey was also conducted for physical assessment in order to identified and examined the waste composition in all the locations. Excel were used for data interpretation inform of pie-chart, and descriptive statistics was also used to show some parameters as shown in Table 3.1.

3.0 Results

Based on the findings from the respondents shows that out of 100 questionnaires administered, 98 was able responded and collected as presented in table 3.1.

Table 3.2: Demography of the Respondents at Gamboru ward

Demography		Number	Percentage (%)
Sex	Male	17	0.85
	Female	3	0.15
Educational status	No formal education	50	0.50
	Primary education	23	0.23
	Secondary education	3	0.15
	Higher education	2	0.10
Occupation	Farmer	35	0.35
	Wholesaler/ Retailer	55	0.55
	Food seller	10	0.10

Table 3.3; shows the perishable food vendors were predominantly male with very few females as established by the respondents, 85 %, and 15 % respectively. However, about 50 % of the food vendors under goes non-formal education, 23 % accomplish primary education, with 3 % pass through secondary level while 2 % attained tertiary education. Moreover, the study area reveals that 55 % were whole sellers/retailer, 10 % are food vendors and 35 % were mostly farmers.

Table 3.2: Shows a different waste composition at different location, Saw-dust, card-board papers and wood are used as Carbon based material and were predominant in some of the locations, while some location indicates availability of Nitrogen based materials such as green leaves. All these waste components play a crucial part in the production of bio- fertilizer as presented in Table 3.2.

Waste Composition	Study Areas				
	GM	MM	TS	SM	CM
Vegetable/Cow-dung	50	10	4	50	55
Card-board paper	37	25	5	5	2
polythene	2	55	10	5	3
Wood/Saw dust	6	5	71	30	15
Others	5	5	10	10	23

Note; GM: Gamboru, MM: Monday Market, TS: Timber-shed Market, SM: Sulumri Mini-Market, CM: Cattle Market

3.1 Various Crops Distribution at Gamboru (Moromoro) perishable Market, Maiduguri.

Figure 1 displayed different types of crops sold by the vendors at the study areas which include; Cabbage, Pepper, Onions, Sweet Potatoes, Tomatoes, Mango, Melon and others which amounted to 16 %, 21 %, 11 %, 5 %, 11 %, 5 %, and 10 % respectively, thus representing the dominant products available in the study area.

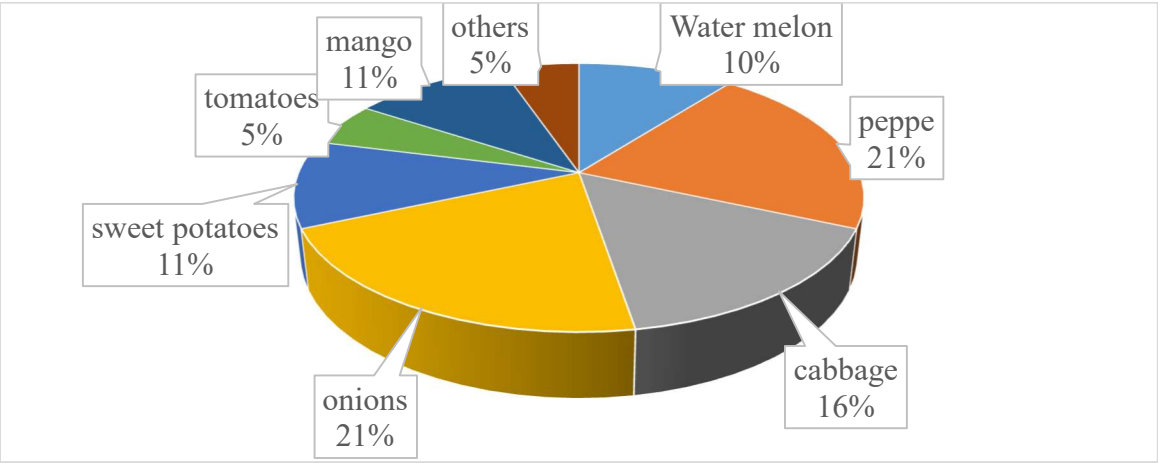

Figure 1: distribution of perishable goods at Moromoro Market

3.2 Patronage level

Figure 2 Presented the patronage level at Gamboru-Moromoro Market. The trend revealed that, the commodities that falls between five thousand to ten thousand has more patronage.

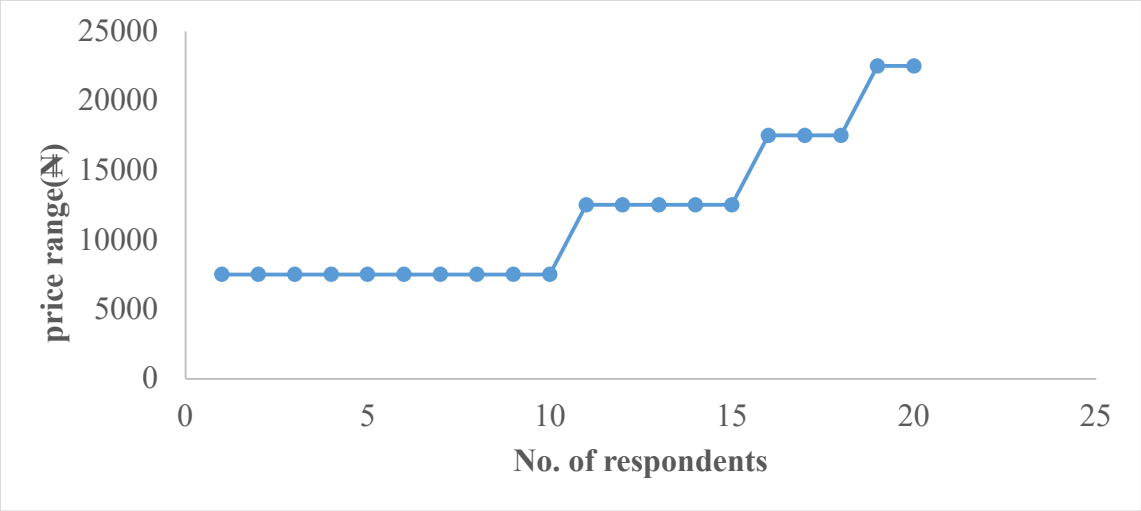

Figure 2: Results shows a purchasing rate per/day at Gamboru ward Maiduguri.

3.3 percentage wastes composition at Gamboru-Moromoro Market, Maiduguri.

Figure 3. Revealed that, waste generated were predominantly biodegradable, with vegetables waste amounted to 50 %. Polythene constitutes 4 % of the waste, followed by paper/cardboard paper at 30 %, wood at 5 %, and other materials at 5 %.

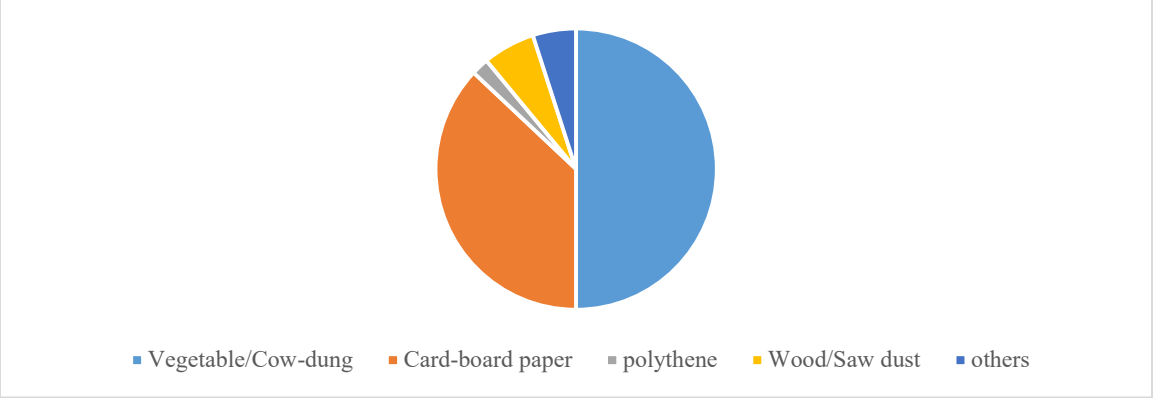

Figure 3: presents various wastes distribution at Gamboru-Moromoro market

3.3 Monday Market Maiduguri.

Figure 4 revealed that polythene, Card-board paper, vegetables, wood and others which amounted to 55 %, 25 %, 10 %, wood 5 % and others contains 5 % respectively.

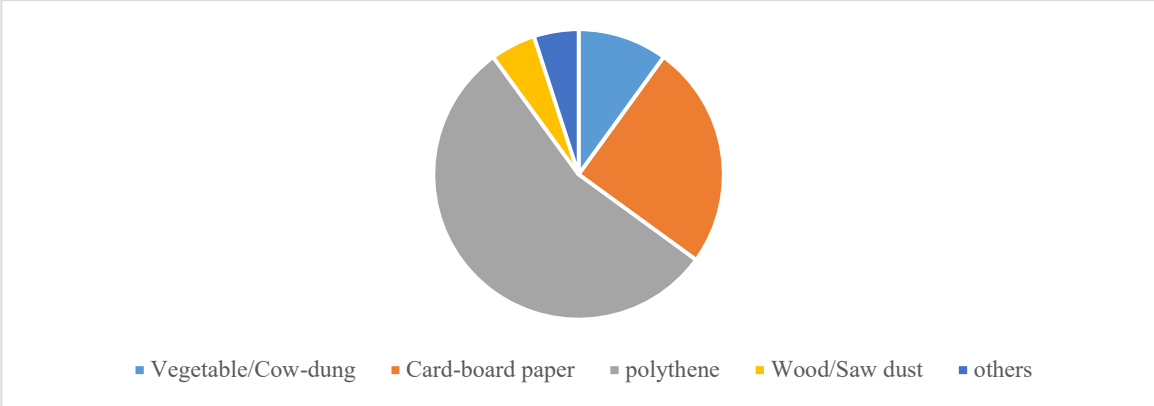

Figure 4: Waste distribution at Monday Market Maiduguri, Borno state.

3.4 Timber-shed Market Maiduguri.

The chart in Figure 5 shows the waste compositions at timber-shed Maiduguri, in which 3 %, 18 %, 65 %, 7 %, 65 % and 7 % are Vegetables, polythene, Saw-dust, paper/card board paper, and others respectively.

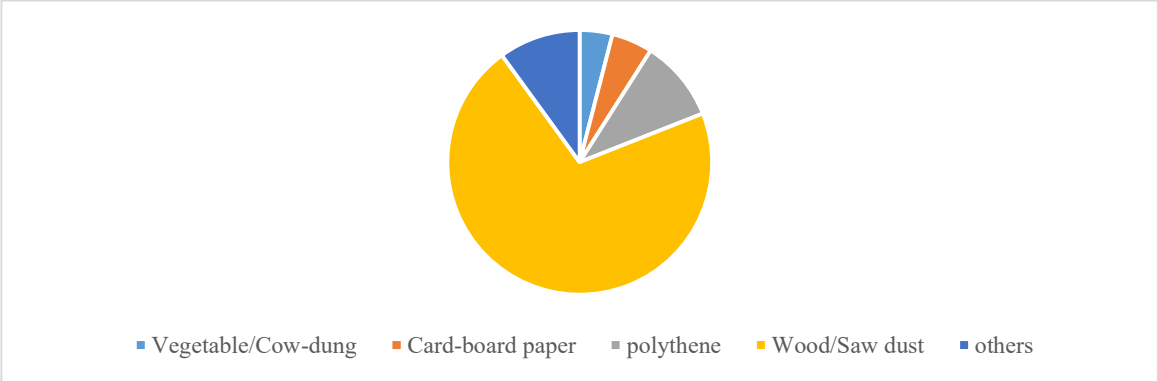

Figure 5: the chart shows the waste compositions at timber-shed Maiduguri.

3.5 Sulumri Mini Market Maiduguri.

Figure 6 depicted a wastes assortment at Sulumri Mini Market with 50 %, 5 %, 30 %, 5 %, and 10 %, are waste vegetable, polythene, wood/Saw-dust, paper and card board paper, wood and others respectively.

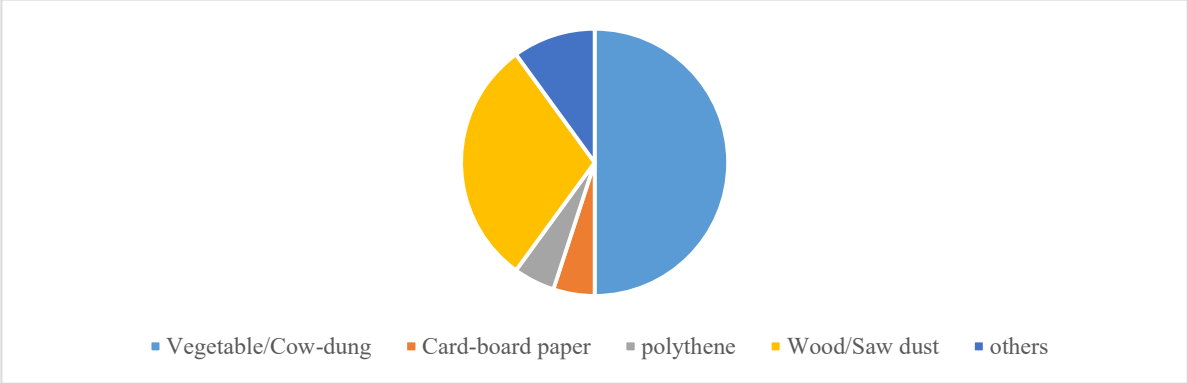

Figure 6: presents various waste assortment at Sulumri mini market

3.6 Cattle Market (Kasuwan Shanu), Maiduguri

Figure 7 also revealed that waste compositions at cattle market were 35 %, 30 %, 10 %, 3 %, and 3 % were Cow dung, Vegetables, wood/saw-dust, paper/card board paper and others respectively.

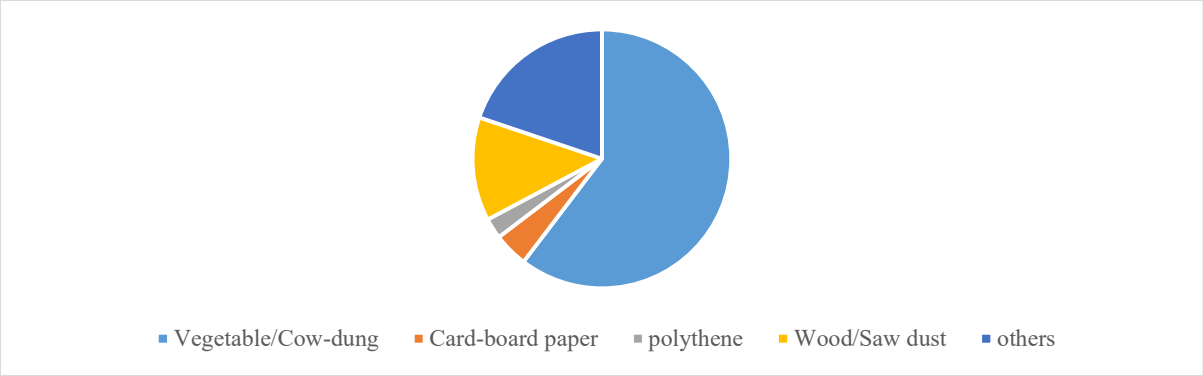

Figure 7: present various waste distribution at Sulumri market

Inadequate facilities by the perishable food vendors were identified as the major caused of waste as presented in Table 3.3 with 18 % due to lack storage facilities, 5 % Poor storage facilities and 3 % poor storage.

Causes of food waste	Options	No. of respondents	%
	Lack of storage facilities	5	0.25
	Poor storage facilities	3	0.15
	In adequate storage facilities	12	0.60

3.6 Influence of weather on rate of waste generation

Findings from respondents revealed that commercials and house-hold waste production rate increase during dry season as a result of inadequate facilities.

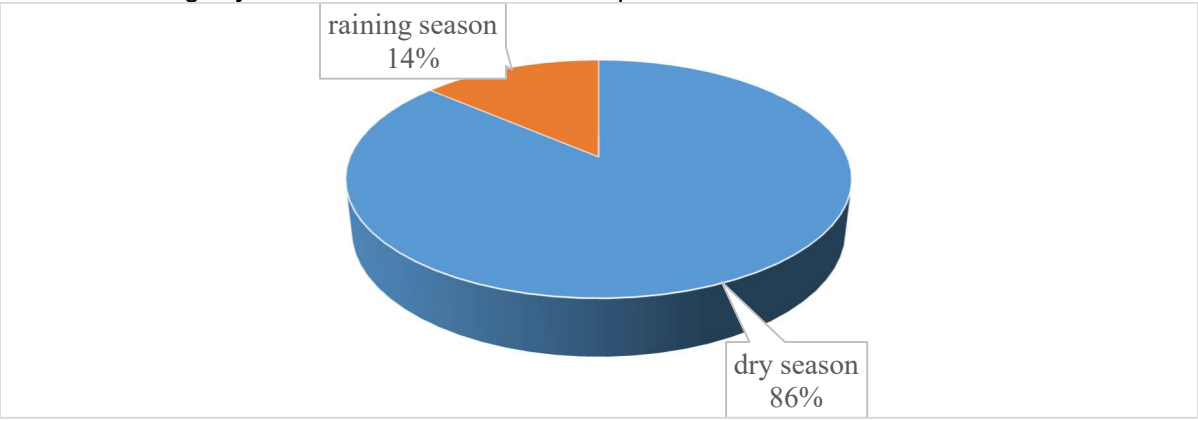

Figure 8: present percentage of waste generation as a result of variation in season

3.9 Choice of fertilizers

Figure 9 shows the distribution of various fertilizers used at some of the study areas, 53 % of the farmers uses synthetic fertilizer, 36 % animal dung (manure), while 11% goes for alternatives.

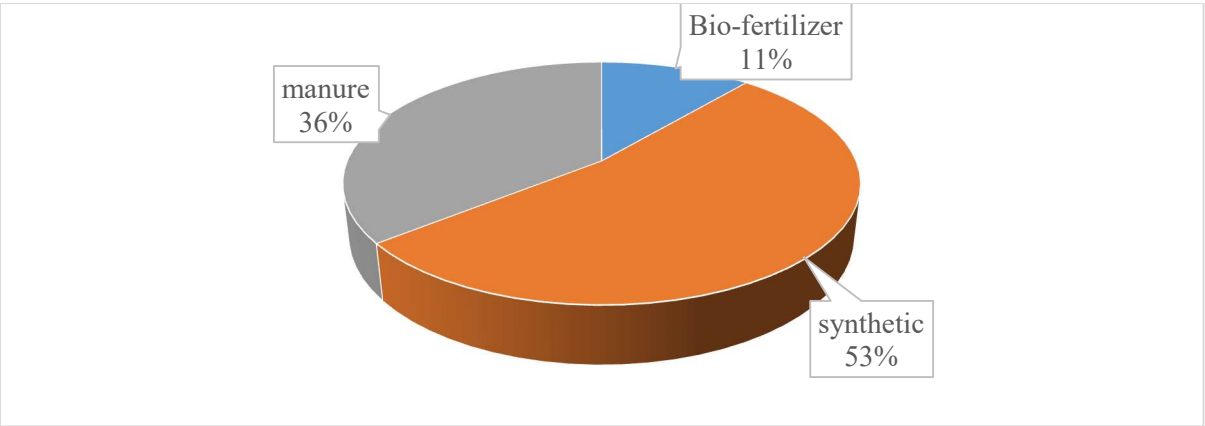

Figure 9: presents the choice of fertilizers by the farmers at the study area

4.0 Conclusion and Recommendation

4.1 Conclusion

All the selected areas were successfully identified, evaluated and presented a significant amount of organic solid waste at locations. Results from Gamboru Market show that 50 % of the waste is Vegetables, 37 % Card-board paper, 2 % Polythene, 6 % Wood, and 5 % other materials. While at Monday-Market shows 10 % Vegetables waste, 25% card-board paper, 55 % polythene, 5 % wood, and 5 % other materials. Timber-shed shows, Vegetable/Cow-dung 4 %, Card-board paper 5 %, Polythene 10 % Wood/Saw-dust 71 % and 10 % for other materials. Similarly, at Sulumri mini market, it results revealed 50 % is Vegetables waste, 5 % Card-board Paper, 5 % Polythene, 30 % Wood, and 10 % other materials. Kasuwan-Shanu cattle Market revealed 70 % Vegetable/Cow dung waste, 5 % Card-board Paper, 3 % Polythene, 15 % Wood/Saw dust, and 8 % other materials. However, findings revealed that the all the study areas presented a appreciable amount which proved it sustainability when converted into bio-fertilizer. The data generated as a result of the assessment yielded a significant result for the design of composting unit for fertilizer production

4.2 Recommendation

Utilization of composting products can effectively reduce the overall volume of waste by targeting the substantial portion of organic waste within the waste stream. The results of this study provide valuable insights for the design of waste management facilities that are specifically tailored to particular areas or localities such as Maiduguri, Borno State, Nigeria.

References

Afolabi, O., Sunday, A. L., Elizabeth, N. O., & Karen, B. B. (2021). *Country-level assessment of agrifood waste and enabling environment for bioenergy in Nigeria.* Germany: Elsevier.

Babayemi, J., & Dauda, K. (2009). Evaluation of Solid Waste Generation, Categories and Disposal Options in Developin. *13*(3).

Bhardwaj, D., Ansari, M., Sahoo, R., & Tuteja, N. (2014). Biofertilizers function as key player in sustainable agriculture by improving soil fertility, plant tolerance and crop productivity. *13*(66).

Calvin, O. S., Fatai, A. S., & Oluwakemi, A. O. (2022). *Disentangling Drivers of Food Waste in Households: Evidence from Nigeria.* Nigeria: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Carvajal-Muñoz, J., & Carmona-Garcia, C. (2012). Benefits and limitations of biofertilization in agricultural practices. *24*.

Chen, J. H. (2016). The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. In Proceedings of the InternationalWorkshop on Sustained Management of the soil-Rhizosphere. Bangkok, Thailand: InternationalWorkshop.

Hani, A. Q., & A., M. (2016). Evaluating composting and co-composting kinetics of various agro-industrial wastes. *5*.

Jones, A. N., & Alkali, A. N. (2019). Evaluating Municipal Solid Waste Generation Rate and Its Composition between High and Low-income Groups in Maiduguri. *8*(1).

Kaza, S., Yao, L., Bhada-Tata, P., & VanWoerden, F. (2018). *A Global Snapshot of Solid Waste Management to 2050;World bank:Washington, DC, USA,.* USA: What a Waste 2.0:.

Kit, W. C., Shir, R. C., Hong-Wei, Y., Saifuddin, N., Yeek-Chia, H., & Pau, L. S. (2019). *Transformation of Biomass Waste into Sustainable Organic Fertilizers.* China: MDPI.

Li, X., L., G., Julian, P., Xiaojie, L., Erica, V. H., & Åsa, S. (2017). *Missing Food, Missing Data? A Critical Review of Global Food Losses and Food Waste Data.* China: Enviromental science and technology.

Mohammed, D., & Osita, O. O. (2003). Solid waste management and re-use in Maiduguri, Nigeria. *29th WEDC International Conference Abuja, Nigeria, 2003.* Nigeria: WEDC.

Mujahid, U. Y., Kiman, S., Ali, L. Y., & Bitrus, H. K. (2023). Development of Biofertilizer from Locally Sourced Materials. *3*(1).

Oluwasola, O. D., Sunday, A. L., Elizabeth, N. O., & B., K. B. (2021). *Country-level assessment of agrifood waste and enabling environment forsustainable utilisation for bioenergy in Nigeria.* Nigeria: elsevier.

Orhorhoro, E. K., & Oghoghorie, O. (2019). Review on Solid Waste Generation and Management in Sub-Saharan Africa: A Case Study of Nigeria. *23*(9).

Oumarou, M. B., Abubakar, A. B., & Abubakar, S. (2018). Municipal Solid Waste Incinerator Design: Basic Principles. *6*(1).

Saeed, K., Ahmed, S., Hassan, I., & Ahmed, P. (2015). effect of bio-fertilizer and chemical fertilizer on growth and yield of cucumber in green house condition. *effect of bio-fertilizer and chemical fertilizer on growth and yield. 18.* Nigeria: Pak. J. Biol. Sci.

Shekarau, J. A., Muhammed, D. Z., & L., Y. Z. (2019). Household Solid Waste Generation and Characterization for the Determination of Waste. *15*(4).

Srinath, R. I., & Prashant, P. B. (2006). In-vessel composting of household wastes. *26*.

Umara, Z., Shettima, M. K., & Ahmad, V. C. (2020). Indiscriminate Refuse Disposal and Its Implication on Public Health in Maiduguri metropolis. *7*(2).