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Research Paper

Assessing Household Solid Waste Management and Disposal Practices in Biu Local Government, Nigeria

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Abstract: Solid waste generation is inseparable from mankind, the unprecedented increase in global population inevitably means an increase in waste generation. This study designed household surveys, to assess current waste management practices in Biu. Biu town becomes important particularly due to the establishment of tertiary institutions which recently increased the population of households. Waste disposal approaches indicated that the majority (76%) engaged in unsustainable disposal measures. These measures include burning, disposing of waste along water drains, disposal along the roadside, and burying waste. Although the study results indicate that majority (89.4%) of the respondents were aware of the implications of these approaches, only a few practice reuse of waste (8.6%), recycling (10.4%), and waste segregation (22%). The drawbacks of achieving effective waste disposal and management system within the study area were the inability of the local authority to provide a waste collection and disposal system (83.3%), the lack of a well-designated waste disposal site (98%), and the high cost of waste handling charges by unregistered and unmonitored waste collectors within the municipality (57.6%). Findings of this study show that in Biu LGA, lapses in waste management by the local authorities are responsible for most of the waste management problems encountered and, at the same time, there are areas of opportunity to improve the efficiency of management particularly in the physical aspects, such as collection, treatment, and safe disposal systems and services.

Keywords: *Household waste, Waste disposal, Waste management, Sustainability*

Introduction

Solid waste generation has become inseparable from humankind since humans use materials and resources for survival. More so, the increase in population accompanied by an increase in consumption from agricultural and industrial development has contributed to the unprecedented rise in the volume of solid waste in many developing countries (Alamgir *et al.,* 2012; Asase *et al.,* 2009). In addition, the poor management of waste disposal systems within rural and urban cities in many developing countries constitutes environmental degradation, with cities dealing with high pollution levels from solid waste and wastewater. The non-degradable composite of household wastes such as plastics and polyethylene, blocks drainages, leading to widespread flooding and the spread of diseases in many cities (Wilson *et al.,* 2015; Wilson *et al.,* 2013). Some unsustainable waste management practices such as burning and open dumping waste have polluted air, soil, and water systems, posing serious public health concerns (Ndum, 2013). These practices have imposed challenges on the government and environmental managers due to the volume of waste that must be managed.

The management of waste consists of careful planning, collection, treatment (when required), and disposal (Abdulredha *et al.,* 2020). It in addition involves, collecting reliable and valid data relating to the amount of waste generated, the factors that influence the volume of waste generated, and the predictions for future waste generation (Godfrey *et al.,* 2012; Salau *et al.,* 2021; Singh *et al.,* 2014). This means that adequate waste disposal and management system is now a key driver in achieving sustainable development goals (SDGs), particularly in making cities safe, resilient, and sustainable (Gunarathne *et al.,* 2019). However, sustainable solid waste management is yet to be adopted as a practice in most cities in developing countries. This is partly due to the attitudes of the residents towards waste disposal and, the government's failure to provide landfill and waste collection and disposal systems. The benefits of

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waste management have been numerous, ranging from a better quality of life within the environment, reducing pollution, conservation of energy, and achieving sustainable development (Batista *et al.,* 2021; Ikhlayel, 2018; Ferronato *et al.,* 2020). Waste has been utilized as raw material in the construction and manufacturing sectors. Plastics and polyethylene have been used as addictive in brick and paving constructions in many Sub-Saharan cities. The waste to energy management approach has converted non-recyclable waste into heat and fuel to drive development (Joseph & Prasad, 2020; Nguyen *et al.,* 2021; Zhang *et al.,* 2020). However, the benefits accrued from effective management have not been adopted in many semi-urban to rural cities in Nigeria, hence, the need for waste managers to begin to explore these novel opportunities.

With a fast-growing population, Nigeria will have a high consumption rate which will mean a high volume of waste generated across most cities. The volume of waste generated is already alarming and therefore requires urgent attention (Salau *et al.,* 2021). Although the amount of waste generated will vary depending on the region, season, lifestyle, frequency of waste collection, population characteristics, thus, the type of waste produced (Obongo *et al.,* 2021). Consequently, the waste composition will depend upon similar factors like culture, geography, income, and therefore the proximity of the town to other economic activities. Pollution of soil and water from waste will also depend on the proximity of such a system to the population and disposal sites (Joshua, 2021). Therefore, the reuse and recycling of waste particularly in the global South needs to be adopted as a sustainable approach to reducing the actual waste that ends up in landfills and other waste disposal sites (Azevedo *et al.,* 2021; Mekonnen and Tokai, 2020; Schoot *et al.,* 2011).

Due to its growing population, waste management in Biu local government area is expected to increase exponentially. The establishment of the new Army University and the existing College of Education has seen an increase in the number of persons coming in to settle for work or study. In addition, the insurgency in other parts of the state has increased the number of displaced persons coming into the town for safety thereby contributing to the volume of waste generated. There is, however, a lack of a waste management system within the local area, and most individuals have been solely responsible for the collection and disposal of their waste. Personal waste disposal is unsustainable, resulting in contamination of the air, soil, and water. As a result, this study examined existing waste management practices within households to identify inefficient practices.

Material and Methods

Study Design and Administration of Survey Questionnaires

The study adopted the NBS, (2012) general community survey procedures and practical guidelines for designing household surveys. The survey questions were designed in two parts: the respondents' demographic data and the waste and environmental management practices within the homes and communities. The questionnaire was tested through a pilot survey with a small number of participants in the Wukari community of Taraba state. The pilot testing helped to verify the question items investigated for clarity, viability, feasibility, and completion time of the questionnaire. The revised questionnaire from the pilot test was tested for thorough reflection of the intended objectives by collecting expert opinions. The opinions and advice of the two experts who were consulted were followed. The improved copy of the questionnaire obtained through reliability and validity tests was retained as the research study's ready copy.

The study sample design was adopted from Sandelowski, (1995) using the equation:

$$\textbf{Sample size } (\mathbf{n})\ \mathbf{SD(1-SD)} \times \left(\frac{\mathbf{Zscore}}{\mathbf{ME}}\right)^{\mathbf{2}} \quad (1)$$

Where Z-score is the critical value of confidence level, taken as a 95% confidence level
SD is the standard deviation (0.5), ME is the margin of error at a confidence interval of ±5%

The minimum number of households covering the study area was determined to be about 385 using equation (1). Specifically, the survey has a statistical margin of error of ±5% at a 95% confidence level. A purposive sampling technique was used to achieve the minimum sample size, as described in related social research by Sandelowski, (1995); James *et al.,* (2001); Sim *et al.,* (2018).

A total of 451 of the 700 questionnaires were distributed (within Galtimare, Mbulamel, Mbulachive, Tabbra, Tashan-Danfulani, Ungwan sarki, and Zara-wuyaku) were returned. 55 of the 451

completed questionnaires were discarded from the sample due to missing information. The total number of questionnaires used in the analysis stands at 396 (56.6 %). Between September and December 2020, questionnaires were distributed to a representative sample of households. The heads of households were the ones who were targeted. However, household members with knowledgeable information on the waste management and disposal system in the home were asked to complete the survey on behalf of the family to avoid a low return rate.

The data collected were analyzed using descriptive approaches. Descriptive statistics using frequency distributions and percentage rating gave a critical understanding of measurement terms used. The distributions of the participants using frequency and percentage were presented in tables and charts.

Results and Discussion

Demographic Data of Respondents

The questionnaire's result was grouped and tabulated according to the key components and sub-topics that will inform the discussion of the study. The demographic distribution showed that 59.8% of the representative households were males while 40.2% were female. The age distribution showed that the age range of 26-33 had the highest turnout of representatives with 34.1%, followed by 34-41 (31.1%), 42-49 (14.6%), 18-25 (12.4%), and age range above 50 constituted 7.8% respectively. Educational qualification shows that 44.4% of the participants had at least a bachelor's degree, 26% had NCE/HND/Diploma, and 18.7% had attended secondary and primary certificates, while 10.9% had no formal form of education. In addition, the family size distribution showed that a family size of 5-8 persons constituted 52.3%, a family size above 9 was 32%, and 1-4 constituted 15.7%. Household income with the highest distribution was within ₦19,000-50,000 (35.6%), ₦51,000-100,000 (26.3%), ₦100,000 and above (19.9%), and those below the minimum wage of ₦18,000 constituted 18.2% respectively as can be seen in Figure 1 ($1 = ₦450).

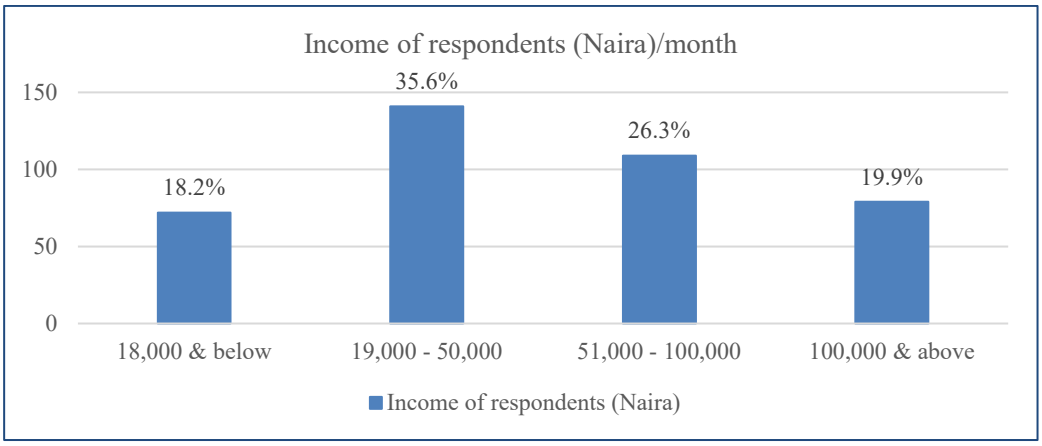

Figure 1: Distribution of income per month of households within the study area

Waste Disposal measures used by the sampled households

Table 1 shows the different solid waste disposal measures used by the households in Biu Local Government Area. The results indicated that the majority (76%) of households are currently engaged in unsustainable solid waste disposal practices that can likely impact human health and the environment. The distribution of unsustainable practices shows that open burning of wastes within the household (26.4%), dump-pit/burying wastes (22.5%), waste disposed of along the roadside (14.5%), and waste disposed of within water drains (12.6%), account for the unsustainable ways households have been using to dispose of their wastes (Figure 3). These disposal measures have been known to contribute to Air, soil, and water pollution (Joshua, 2021; Ajah *et al.,* 2015) which can result in severe health impacts. Consequently, it has also increased the presence of rodents, mosquitoes, snakes, scavenger birds, and other parasitic insects that can likely impact the overall health of the community and environment including environmental aesthetics as seen in Figure 2.

Furthermore, the findings indicate that most of the households (88.9%) dispose of their waste weekly as against monthly and this was regardless of the category (organic, paper, plastics, glass, metals, and others) of waste. Although most of the waste generated was organic waste from leftover food and

vegetables, there were other chemicals including heavy metals from batteries that were disposed of. These can be dangerous to ground and surface water sources particularly residents that burry waste and those that dispose of waste along water drains that can equally be washed into surface water bodies. Similar findings were observed by Ajah *et al.,* (2015); Azodo and Ismaila, (2016); Egun, (2012); Miezah *et al.,* (2015), which suggests that the unsustainable disposal of waste within the study site can likely pose a severe risk to water quality which can directly impact health due to the lack of water treatment facility within the area. Similarly, environmental aesthetics and air quality are often impaired by the indiscriminate disposal of waste. Just as poor water quality affects health, poor air quality can also increase the likelihood of health implications.

Figure 2: Waste disposal points along the roadside within different points in Biu municipality

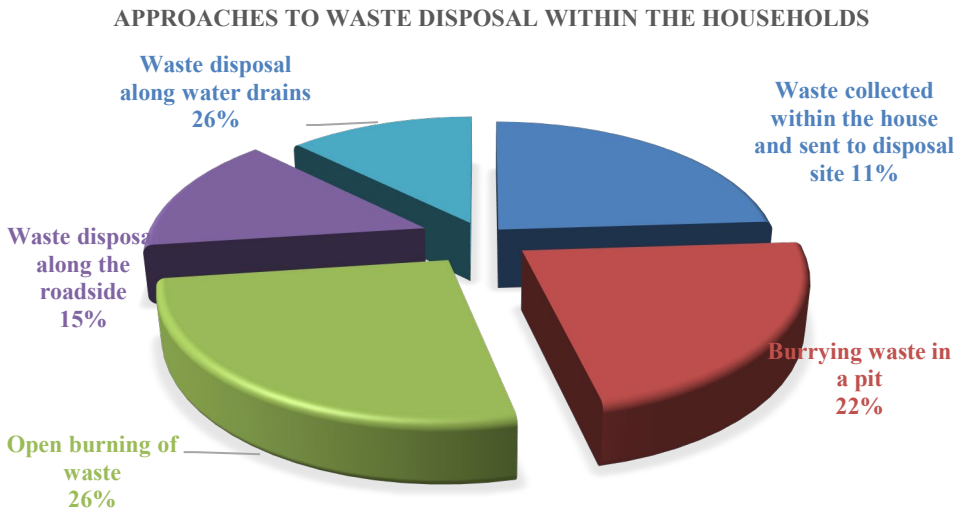

Figure 3: Approaches to the different types of waste disposal within the study area

Table 1: Waste Disposal practices among Households (n = 396)

Variables	Frequency (n)	Percentage (%)
Waste disposal system in use within households		
Waste bin within the house	94	12.9
Dump pit within or around the house	164	22.5
Direct burning of waste within or around the house	193	26.4
Waste collected and sent to the designated dump site	81	11.1
Waste disposed of by the roadside	106	14.5
Waste disposed within water drain	92	12.6
Frequency of household waste disposal		
Daily	44	11.1
Weekly	352	88.9

Other negative consequences of indiscriminate and unsustainable disposal of waste include unpleasant odor which often attracts flies and other disease-carrying pathogens, emission of gases such as methane (CH_4), and groundwater contamination through leachate (Ohaka *et al.,* 2013). Waste disposed of within drains was found to block drainages, while open burning is associated with the release of toxic gasses into the environment (Ndum, 2013; Abdulredha *et al.,* 2020; Oumarou *et al.,* 2012).

Management of solid waste materials from source as a process of disposal

To maintain environmental quality, check human health, and protect the natural resource, effective solid waste management utilizes many waste control strategies based on the waste hierarchy, including avoidance, reduction, recycling, reuse, recovery, treatment, and disposal (Mekonnen and Tokai, 2020; Schoot *et al.,* 2011; Kabera and Nishimwe, 2019). Effective solid waste management for environmental quality and sustainability assessed in this study showed that only 28.3% of the study participants were aware of sustainable waste management practices as seen in Table 2. In addition, waste control methods in the waste handling approach by participants assessed in this study and presented in Table 3 showed that waste segregation (22%), waste reuse (8.6%), and waste recycling (10.4%) were not effectively used within the study area. The lack of awareness (71.7%) of most of the participants has been shown to contribute to the volume of waste disposed of weekly within the community. It is necessary to separate biodegradable and non-biodegradable waste to provide an environmentally friendly waste management alternative. Segregation helps in the separation of recyclables and compostables. Less than a quarter of the study population (22%) segregate the household waste. The reuse of waste materials either in part or whole reduces the volume of waste generated for disposal in households. A study by Khan *et al.,* (2016) showed that the reuse of waste practice is typical with trading the material in second-hand goods such as clothes, electronics, automobiles, furniture, and other merchandise. It is worth noting that the reuse of materials often replaces segregation because successful material reuse is accomplished by sorting at the source rather than at the disposal site. However, waste recycling is based on waste materials that cannot be reused directly but can be transformed into a new product or raw material through transformation processes (Schoot *et al.,* 2011). Pyrolysis, incineration, anaerobic digestion, gasification, palletization, and composting are some of the ways waste can be recycled (Zhang *et al.,* 2020; Hettiarachchi *et al.,* 2020). Only 41 samples of the household participants representing 10.4% of the households studied, managed their waste through waste recycling.

Table 2: Awareness of sustainable waste management practices (n = 396)

Variables	Frequency (n)	Percentage (%)
Awareness of sustainable waste management practice		
Yes	112	28.3
No	284	71.7

Table 3: Process to disposal of the solid waste management practices from the source (n = 396)

Variables	Frequency (n)	Percentage (%)
Segregating waste		
Yes	87	22
No	309	78
Reusing of waste		
Yes	34	8.6
No	362	91.4
Recycling of waste		
Yes	41	10.4
No	355	89.6

3.4. Knowledge of the implication of improper waste disposal among the households

The importance of waste management in promoting sustainable environmental management that can significantly decrease the likelihood of health-related issues due to pollution from indiscriminate disposal of waste cannot be overemphasized. The improper disposal of solid waste contributes significantly to environmental degradation, public health threats, and climate change (Jalil, 2010). Since the result of improper disposal of solid waste is hazardously harmful to the environment and human

health, knowledge, and caution in the generation and disposal of these wastes are important for environmental quality and good health (Ajah *et al.,* 2015; Addo *et al.,* 2017). The knowledge and awareness of improper waste disposal to human health and the ecosystem showed that most (89.4%) of the study participants were aware of the implication of inappropriate waste management approaches, however, they indicated despite the knowledge, they have no alternatives and have to dispose of the waste. The categories of the various impact of the awareness of improper waste disposal among the households are presented in Table 4.

The consequences of improper solid waste management cut across human life and the environment. The environmental impact includes land pollution, water contamination, and environmental degradation. Exposure to the toxic materials present in solid waste are determinants of respiratory and dermatological problems, eye infections, and low life expectancy (Ajah *et al.,* 2015). Studies have shown that improper disposal of waste leads to the production of gases such as methane, carbon dioxide, carbon monoxide, nitrogen, and heavy metals, which can contribute to climate change and cause diverse health and environmental issues.

Additionally, solid waste is one of the dangerous local pollutants produced within households. This is due to the composition of waste within the waste disposal system. Waste will degrade and can have a toxic mixture effect especially waste containing metals and other chemicals. Consequently, poor waste disposal practice predisposes man's environment to all sorts of environmental hazards, including flooding, erosion, and degradation of natural resources (Ferronato *et al.,* 2020; Addo *et al.,* 2017).

Table 4: Implication of improper waste disposal among the households (n = 396)

Variable	Frequency(n)	Percentage (%)
Spread of diseases	50	8.9
Breeding of mosquitoes, rodents, and pest	66	11.7
Blocking water drain causes flooding	173	30.7
Air pollution	35	6.2
Unpleasant sights and environment	111	19.7
Release of GHG that contributes to climate change	69	12.2
Unaware of implications	60	10.6

Role of the Municipal Authorities in the Solid Waste Management in the Study Area

Generation, processing, and disposal activities involved in solid waste management include all the solid waste management activities, prevention, storage, collection, monitoring, transportation, characterization, treatment, reuse, and processing aimed at preserving the natural environment, protecting environmental quality, human health, and life in general (Godfrey *et al.,*2012; Gu *et al.,* 2015). Solid waste management for environmental quality and sustainability starts from the waste generation through to the disposal activities. Individual waste producers, as well as external support organizations and governments at all levels, are encouraged to actively participate in municipal authorities, which include the informal private sector. The study results showed that neither a waste temporary disposal system (83.3%) nor a government-designated waste site was available in the study area (98 %). This may have influenced the waste handling fees, as most of the respondents believed that waste collection and disposal fees in their municipality were excessively high in their city (57.6%). Similar findings were observed by Boateng *et al.,* (2019), therefore, a cost-effective waste management system is key to fostering sustainable management of waste particularly in poor and remote areas. This is because the waste handling fees were said to foster a negative attitude (62.1%) against waste disposal services available to households as shown by the study findings in Table 5.

Table 5: Role of local authorities in solid waste management within the study area (n = 396)

Variables	Frequency	Percentage (%)
Charges for waste collection		
Expensive	228	57.6
Moderate	93	18.9
No charges	75	23.5
People's attitudes towards waste disposal		
Positive	150	37.9
Negative	246	62.1

Provision of waste disposal system by government		
Yes	7	1.8
No	330	83.3
Not aware	59	14.9
Availability of government-designated waste site		
Yes	8	2
No	388	98

Conclusion

Controlling the generation, storage, collection, transportation, processing, and disposal of solid waste from source to disposal is part of solid waste management, aiming to protect environmental quality, human health, and natural resource protection. The existing waste management and disposal system practices among households investigated in this study identified unsustainable practices. For environmental sustainability, human health, and natural resource protection, the factors that influence wasteful activities, such as the lack of waste management and government-designated waste sites, as well as high charges on the few available, must be addressed. An attitudinal change that focuses on incorporating both the top-down and the bottom-up approach must be adopted. This will promote a participatory solution that will foster a synergy between the government, waste managers, and local people. Overall, it will create a relationship that will enhance awareness, especially on the dangers of unsustainable waste management practices within the community.

Recommendation

For an effective waste management practice that guarantees sustainable development, the following recommendations were articulated.

- Waste disposal points must be located and constructed according to standards to limit the risk of surface and groundwater contamination
- The government needs to create awareness of the dangers of unsustainable waste practices currently practiced to reduce the negative impacts
- The cost of collecting, transporting, and disposing of waste should be reviewed and sanctions placed on those who dispose of waste, particularly along waterways and drainages.

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References

Abdulredha M, Kot P, Al Khaddar R, Jordan D, Abdulridha A,. (2020) Investigating municipal solid waste management system performance during the Arba'een event in the city of Kerbala, Iraq, *Environ., Develop. & Sustain.,* **22**(2), 1431-1454. doi: 10.1007/s10668-018-0256-2.

Addo HO, Dun-Dery E, Afoakwa E, Elizabeth A, Ellen A, Rebecca M, (2017) Correlates of domestic waste management and related health outcomes in Sunyani, Ghana: a protocol towards enhancing policy, *BMC Public Health,* **17**(1), 615. doi: 10.1186/s12889-017-4537-8.

Ajah KC, Ademiluyi J, Nnaji CC, (2015) Spatiality, seasonality and ecological risks of heavy metals in the vicinity of a degenerate municipal central dumpsite in Enugu, Nigeria, *J. Environ. Health Sci. & Engin.* **13**(1), 15. doi: 10.1186/s40201-015-0168-0.

Alamgir M, Bidlingmaier W, Cossu R, (2012) Successful waste management strategies in developing countries require meaningful involvement of the concerned stakeholders. *Waste Manag.,* **32**(11),. 2007-2008. doi: 10.1016/j.wasman.2012.07.028.

Asase M, Yanful EK, Mensah M, Stanford J, Amponsah S, (2009) Comparison of municipal solid waste management systems in Canada and Ghana: A case study of the cities of London, Ontario, and Kumasi, Ghana, *Waste Manag.,* 29(10), 2779-2786. doi: 10.1016/j.wasman.2009.06.019.

Azevedo BD, Scavarda LF, Caiado RGG, Fuss M, (2021) Improving urban household solid waste management in developing countries based on the German experience. *Waste Manag.,* **120**(2021), 772-783. doi: 10.1016/j.wasman.2020.11.001.

Azodo AP, Ismaila SO, (2016) Effective solid waste management for environmental quality and sustainability: knowledge and practices among Nigerian households. Proceedings of the 2016 *International Conference on SET: A driving force for Sustainable Development Tagged COLENG 2016,* Federal University of Agriculture Abeokuta, March 7-11, 289-297.

Batista M, Goyannes Gusmão Caiado R, Gonçalves Quelhas OL, Brito Alves Lima G, Leal Filho W, Rocha Yparraguirre IT, (2021) A framework for sustainable and integrated municipal solid waste management: Barriers and critical factors to developing countries. *J. Cleaner Produc.,* **312**(2021), 127516. doi: 10.1016/j.jclepro.2021.127516.

Boateng, KS., Agyei-Baffour, P., Boateng, D., Rockson, G.N.K., Mensah, K.A. and Edusei, A.K. (2019) 'Household Willingness-to-Pay for Improved Solid Waste Management Services in Four Major Metropolitan Cities in Ghana. *J. Environ. & Public Health,* 2019. 5468381-9. doi: 10.1155/2019/5468381.

Egun NK, (2012). The waste to wealth concept: waste market operation in Delta State Nigeria. *Greener J. Social Sci.* 2012; **2**:206-212.

Ferronato N, Guisbert Lizarazu EG, Velasco Tudela JM, Blanco Callisaya JK, Preziosi G, Torretta V, (2020) Selective collection of recyclable waste in Universities of low-middle income countries: Lessons learned in Bolivia, *Waste Manag.,* 105(2020), 198-210. doi: 10.1016/j.wasman.2020.02.014.

Godfrey L, Scott D, Difford M, Trois C, (2012) Part 1: The role of waste data in building knowledge: The South African waste information system. *Waste Manag.,* **32**(11), 2154-2162. doi: 10.1016/j.wasman.2012.04.019.

Gu B, Wang H, Chen Z, Jiang S, Zhu W, Liu M, Chen Y, Wu Y, He S, Cheng R, Yang J, Bi J, (2015) 'Characterization, quantification and management of household solid waste: A case study in China. *Res., Conser. & Recy.,* **98**. 67-75. doi: 10.1016/j.resconrec.2015.03.001.

Gunarathne AND, Tennakoon TPYC, Weragoda JR, Weragoda JR, (2019) Challenges and opportunities for the recycling industry in developing countries: the case of Sri Lanka. *J. Mat. Cycles & Waste Manag.,* **21**(1), 181-190. doi: 10.1007/s10163-018-0782-x.

Hettiarachchi H,., Caucci S,. and Schwärzel K, (2020) *Organic Waste Composting through Nexus Thinking Practices, Policies, Trends.* 1st edn. Cham: Springer International Publishing.

Ikhlayel M, (2018) Development of management systems for sustainable municipal solid waste in developing countries: A systematic life cycle thinking approach', *Journal of Cleaner Production,* 180, 571-586. doi: 10.1016/j.jclepro.2018.01.057.

Jalil A, (2010) Sustainable Development in Malaysia: a case study on household waste management. *Susta. Develop..* **3**(3), 91-102.

James EB, Joe WK, Chadwick CH, (2001) Organizational research: Determining appropriate sample size in survey research. *Infor. Tech., Learning, & Perform. J.,* **19**(1), 43.

Joseph LP, Prasad R, (2020) Assessing the sustainable municipal solid waste (MSW) to electricity generation potentials in selected Pacific Small Island Developing States (PSIDS), *J. Cleaner Produc.,* **248**, 119222. doi: 10.1016/j.jclepro.2019.119222.

Joshua WK, (2021) Assessing rural water quality: comparing improved and unimproved drinking water sources in Hawul LGA. *SNRU J.Science & Tech..* **13**(2), 55-62.

Kabera T, Nishimwe H, (2019) Systems analysis of municipal solid waste management and recycling system in east Africa: benchmarking performance in Kigali city, Rwanda', *E3S web of Conferences,* **80,** 3004. doi: 10.1051/e3sconf/20198003004.

Khan, D., Kumar, A. and Samadder, S.R. (2016) 'Impact of socioeconomic status on municipal solid waste generation rate, *Waste Manag.,* **49**, 15-25. doi: 10.1016/j.wasman.2016.01.019.

Mekonnen GB, Tokai A, (2020) A Historical Perspective of Municipal Solid Waste Management and Recycling System in Japan: Learning for Developing Countries, *J. Sustain. Develop.,* **13**(3), 85. doi: 10.5539/jsd.v13n3p85.

Miezah K, Obiri-Danso K, Kádár Z, Fei-Baffoe B, Mensah MY, (2015) 'Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana. *Waste Manag..,* **46**, 15-27. doi: 10.1016/j.wasman.2015.09.009.

National Bureau of Statistics, (NBS) (2012) *Nigeria - General Household Survey-Panel 2010-2011 (Postharvest), First Round (wave one)*, Abuja, Nigeria: NBS.

Ndum AE, (2013) *Bottom-Up Approach to Sustainable Solid Waste Management in African Countries.* PhD Thesis. The Brandenburg University of Technology.

Nguyen TDT, Kawai K, Nakakubo T, (2021) Drivers and constraints of waste-to-energy incineration for sustainable municipal solid waste management in developing countries*. J. Mat. Cycles & Waste Manag.,* **23**(4), 1688-1697. doi: 10.1007/s10163-021-01227-2.

Obongo T, Okotto L, Kinaro Z, (2021) Solid Waste Management Along Lake Victoria Beeches', *World Environ.,* **11**(1), 1-8. doi: 10.5923/j.env.20211101.01.

Ohaka A.R, Ozor P.E, Ohaka C.C. (2013). Household waste disposal practices in Owerri municipal council of Imo State. *Nigerian J. Agri. Food & Environ.*. **9**(4), 32-36.

Oumarou MB, Dauda M, Abdulrahim AT, Abubakar AB, (2012) Characterization, and generation of municipal solid waste in North central Nigeria. *Int. J. Modern Engin. Res.* **2**(5), 3669-3672.

Salau, O., Fatusi, O. and Bwala, S. (2021) 'Assessment of household waste disposal system in tudun-wada area of billiri local government, Gombe state. Nigeria. *IOSR J. Environ. Sci.* 15(1), 59-62. doi: 10.9790/2402-1501015962.

Sandelowski, M. (1995) 'Sample size in qualitative research', *Research in Nursing & Health,* **18**(2), 179-183. doi: 10.1002/nur.4770180211.

Schoot Uiterkamp BJ, Azadi H, Ho P, (2011) Sustainable recycling model: A comparative analysis between India and Tanzania. *Resour., Conser. & Recyc.,* **55**(3), 344-355. doi: 10.1016/j.resconrec.2010.10.009.

Sim J, Saunders, B, Waterfield J, Kingstone T, (2018) Can sample size in qualitative research be determined a priori? *Int. J. Soc. Res. Method.,* **21**(5), 619-634. doi: 10.1080/13645579.2018.1454643.

Singh RK, Yabar H, Mizunoya T, Higano Y, Rakwal R, (2014) Potential Benefits of Introducing Integrated Solid Waste Management Approach in Developing Countries: A Case Study in Kathmandu City. *J. Sustain. Develop.,* **7**(6), 70-83. doi: 10.5539/jsd.v7n6p70.

Wilson DC, Rodic L, Cowing MJ, Velis CA, Whiteman AD, Scheinberg A, Vilches R, Masterson D, Stretz J, Oelz B, (2015) Wasteaware' benchmark indicators for integrated sustainable waste management in cities. *Waste Manag.* **35**, 329-342. doi: 10.1016/j.wasman.2014.10.006.

Wilson, D.C., Velis, C.A. and Rodic, L. (2013) 'Integrated sustainable waste management in developing countries. *Proceedings of the Institution of Civil Engineers. Waste & Res. Manag.,* **166**(2), 52-68. doi: 10.1680/warm.12.00005.

Zhang H, Liu G, Xue L, Zuo J, Chen T, Vuppaladadiyam A, Duan H, (2020) Anaerobic digestion-based waste-to-energy technologies can halve the climate impact of China's fast-growing food waste by 2040. *J. Cleaner Produc.,* **277**, 123490. doi: 10.1016/j.jclepro.2020.123490.