

Municipal solid waste management at the University of Nigeria during the COVID-19 pandemic: A justice and sustainability perspective

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Abstract

During the COVID-19 pandemic, a marked increase in the rate of municipal solid waste generation was observed at the Nsukka campus of the University of Nigeria, leaving the campus an eyesore. Garbage glut was largely consigned to the realms of public health and environmental emergencies during the pandemic. While previous studies in Nigeria have focused on technical, social and cultural aspects of Municipal Solid Waste Management (MSWM), very little research exists on the management of MSW in a university campus during a pandemic from the viewpoint of justice and sustainability. Therefore, this study aims to investigate MSWM in the University of Nigeria during the COVID-19 period and the university's waste-to-energy project

with a view to unravelling their implications for justice and sustainability. The study elicited its data from a survey of the MSWM system of the campus, interviews with key informants, field observations and review of literature. Findings indicated a significant increase in the rate of waste generation on the campus from the first wave to the fourth wave of the pandemic. The study recommends that the generation of energy from waste would be a veritable approach to tackling the MSWM challenges and justice issues in the University of Nigeria.

Keywords: Municipal solid waste management, University of Nigeria, COVID-19, environmental justice, sustainability, waste-to-energy.

Introduction

The outbreak and historic spread of the Coronavirus disease (COVID-19) created palpable uncertainty and unprecedented instability in global socio-economic, health, environmental and cultural systems. The COVID-19 pandemic probably represents one of the most critical challenges in current history (Mpho & Okpoko, 2021). Activities in many sectors have been remarkably transformed with the introduction of social distancing, mandatory use of face masks, the reorganization of the public health system, the manufacture, distribution and frequent use of hygiene products such as alcohol-based hand sanitizers, as well as the associated generation of large volumes of new waste products (Nzeadibe & Ejike-Alieji 2020).

In Nigeria, the number of COVID-19 infections continued to decline from the first wave of the pandemic, which started in February 2020 and peaked in July 2020 (Amazonwu et al., 2021), to the fourth wave which commenced in December 2021. Over 5,593,537 persons was tested, which resulted in 266,138 confirmed cases, 3,523 active cases, 259,460 discharged cases and 3,155 deaths as of Friday, November 4, 2022 (NCDC, 2022b). The pandemic has revealed many lapses across countries in the existing socio-economic, health and environmental sectors (Sarkodie & Owusu, 2020). Hence, this shocking revelation has resulted in a rethinking as regards the functionality of the established economic system (Onah & Ugwuibe, 2021). On the other hand, the outbreak, spread and containment of

COVID-19 have had numerous direct and indirect environmental impacts (Zambrano-Monserrate et al., 2020). Positive environmental impact of COVID-19 lockdowns such as clear skies, cleaner rivers, clean beaches and air quality improvements have been reported in some cities and countries across the world (Zambrano-Monserrate et al., 2020; Rodrigo & Liane, 2021). In spite of these apparent improvements, the increased generation of solid waste and decreased collection during the pandemic have created remarkable concerns in many communities (Zambrano-Monserrate et al., 2020) with implications for justice and sustainability especially in closely knit-communities such as university campuses.

At the University of Nigeria, many researchers have attempted to harness the opportunities presented by the pandemic's challenges to produce research with significant potential to enhance lives, support livelihoods, and help overcome or adapt to the impacts of COVID-19 (UNN, 2021). Thus, crucial research, science and innovation arising from the university during the pandemic, could be vital to people's surviving and thriving in the post-COVID era (Nzeadibe

et al., 2022). Based on the findings of a previous research on university undergraduates, it was ascertain that university campuses are centres of innovation and a suitable place to conduct an investigation relating to justice and sustainability in MSWM, which is the premise this study is anchored on (Nzeadibe, 2022). The study focused on the challenges of MSWM during the COVID-19 pandemic and the innovative solution to these challenges, which is, the waste-to-energy project in the University of Nigeria during the period under review, with a view to drawing out the implications for MSWM during COVID-19 in this leading African University for justice and sustainability.

The University of Nigeria

The University of Nigeria was founded in 1955 but commenced academic activities in October, 1960, as the first land-grant university in Africa and the first full-fledged indigenous and autonomous university in Nigeria. It was established by leveraging a multi-party collaboration between the founding regional government in Nigeria, Michigan State University in the United States of America (USA) and the University of Exeter in the United Kingdom (UK). Thus,

it was built on the tradition of collaboration, and it has maintained long-standing research and other collaborations with several universities in Europe, the USA, Canada, Asia and Africa (UNN, 2022a).

The University has three campuses situated in Nsukka, Enugu and Ituku-Ozalla, with a student population of over 54,000 and a staff strength of 9,317 out of which 567 are full professors in various fields of specialization. It has seventeen faculties and 102 academic departments that offer 128 undergraduate programmes and 211 postgraduate programmes, and serves as a hub for educational, information and communication technology and ancillary services to the region and international community (UNN, 2022a).

Given its position and function as a premier university, it trains manpower for newer universities and establishments within and outside the region and this accounts for its large and diverse staff and student population (UNN, 2022a). It is estimated that about 580 housing units exist in the University of Nigeria, Nsukka staff quarters (Appendix 1). The campus also has 3 administrative departments, 16

administrative support units, students' hostels, 4 other non-academic departments, and 7 research institutes including the College of Postgraduate Studies as well as School of General Studies, 25 centers including the University Guest Houses all of which contribute to the solid waste burden in the university (UNN, 2022a).

The university is located on 871 hectares of land on a hilly savannah in the Nsukka town of Nsukka Local Government Area of Enugu State, Nigeria (Figure 2). The climate here is tropical with much more rainfall and an average temperature of 24.9 °C. The next section provides an overview of the MSWM challenge in UNN during the period of the pandemic.

Problem of MSWM in UNN

Municipal Solid Waste Management (MSWM) was arguably the most visible and challenging environmental problem during the pandemic (UNN, 2019). There were large volumes and a diversity of wastes generated in the university, from the households, offices, hostels, classrooms and the surroundings. These include food remnants, food containers, used cooking oil cans, waste from toilets, bathrooms, kitchen drains, papers, sanitary pads, glass, bottles, cans,

sewage, clothing materials and wears, debris or landscaping trash. The COVID-19 pandemic and its associated challenges also introduced new forms of waste some of which are hazardous into the UNN (Nzeadibe & Ejike-Alieji, 2020). Currently, there are about 15 open dumps

located at different places around the campus for the disposal of solid waste, a practice that is unsustainable and poses social and environmental justice challenges to visitors and residents of the campus (Dzawanda & Moyo, 2022).

Figure 1: Open dump in Nsukka Campus of UNN showing overflowing dumpsters



Note: *University of Nigeria, Nsukka (2019).*

Instructively, the pandemic appeared to have changed the dynamics of waste generation, causing anguish among staff, students and visitors to the campus. Poorly managed waste can result in social, environmental and health consequences, including an increased risk of spreading infectious diseases, especially during pandemics like COVID-19 (Kaza et al., 2018). The enforcement of lockdown protocols forbidding in-person dining led to an increased use of single-use plastics for the packaging of takeout food and food delivered to residences. During the fieldwork, the researchers directly observed that mandatory use of Personal Protection Equipment (PPE), spending more time at home, bulk purchasing and storage of food especially perishable food, has skewed the trend of solid waste generation, resulting in an increase in the quantity of waste produced daily. There was also a drastic reduction in the frequency of waste collection because waste collection crews were not operating during the lockdown, while recycling was almost non-existent during the period.

Thus, waste generation rate noticeably increased in some streets on the campus, among which are Fulton Avenue, Ekpo

Convocation Arena, Eni-Njoku Street, Odim Street, Danfodio Street, Zik's Drive, and Elias Avenue. The sight of refuse dumps in some strategic areas on campus was a huge source of embarrassment to residents and visitors alike. Recent research on MSWM in Nigeria has noted that the ubiquitous waste materials in urban centres represent a major threat to public health and environmental well-being (Nzeadibe & Ejike-Alieji, 2020). On the other hand, pandemic situations, as are being experienced globally since the last quarter of 2019, have consigned MSWM issues to the realms of public health and environmental emergencies. While previous studies such as Wilson (2023) and Simpson et al. (2025) have focused on technical, social and cultural aspects of MSWM, very little research exists on the management of municipal solid waste in an African university campus during the COVID-19 pandemic, especially from a justice and sustainability viewpoint. This study aims to investigate MSWM in the University of Nigeria during the COVID-19 period and the university's waste-to-energy project with a view to unravelling their implications for justice and sustainability. The next section presents a conceptual framing for justice and sustainability in

COVID-19 MSWM in Africa as an entry point into further discussion of the subject.

Conceptualizing justice and sustainability in COVID-19 MSWM in Africa

In recent years, the concept of sustainability has been subject to varying debates and definitions with this dynamism giving rise to a certain degree of confusion and multiple interpretations of the concept (Bova, 2022). Although some authors anchor their articulation of sustainability on the social, economic and environmental pillars (e.g. Adams, 2006; Sarkis et al., 2006, Boström, 2012, Garren & Brinkmann 2018), compelling evidence, however, appears to favour the interpretation and conceptualization of the term based on four dimensions namely the social, economic, environmental and cultural – with the United Nations Scientific and Cultural Organization (2001) being the first and leading proponent of culture as the fourth pillar of sustainability (Throsby, 2017). The four interrelated facets of sustainable development are the economy, culture, environment, and society. Accordingly, sustainability is a way of thinking about the future that balances economic, social, political, and environmental factors in order to achieve

a higher standard of living and livelihood (Okolie et al., 2024; Elliott, 2013; Mensah, 2019). Given that culture is always intertwined with the built environment (Opoku 2015), Dessein et al. (2015, p. 8) argue that "recognising culture as at the root of all human decisions and actions, and as an overarching concern (even a new paradigm) in sustainable development thinking, enables culture and sustainability to become mutually intertwined so that the distinctions between the economic, social and environmental dimensions of sustainability begin to fade." Following this reasoning, a recent study on MSWM in Nigeria having cultural sustainability as its overarching concern, challenged previously held notions about MSWM (Nzeadibe et al., 2018), arguing that MSWM was a problem rooted in cultural activity (Dessein et al., 2015, p.14). With the outbreak of the COVID-19 pandemic, drastic and unprecedented changes were unleashed on urban and rural cultures, human mobility, occupancy and activities and on the way human activities are organized and operated. These invariably gave rise to far-reaching challenges to sustainability across the world.

Evidently, the Sustainable Development Goals (SDGs) were developed and adopted to serve as the road map to guide achieving sustainability of global development post-2015 (United Nations Department of Economic and Social Affairs, 2015). Unfortunately, the unexpected outbreak and unabated spread of COVID-19, with its impact on societies, organisations' performance, on the daily lives of the general population, appeared to have greatly affected sustainability thinking and practice. This scenario arguably opened a new vista of what constitutes sustainability and inadvertently necessitated an expansion of the boundaries of the concept of sustainability, thus, leading to rethinking and redefinition of sustainability to include an intersection with human health (Hakovirta & Denuwara, 2020; Marques et al., 2021). Considering that the pandemic and its associated challenges have become a public health emergency of international interest and with implications for sustainability, a redefinition of the concept of sustainability, to embrace the human health dimension, becomes not only apposite but also imperative.

In this context, COVID-19 has been described as 'the evasive, invasive, elusive, invisible one' that came to expose the underbelly of our decadent healthcare system and the depravity in our society (Tomori, 2021). COVID-19 has revealed the glaring level of inequity in every aspect of our society from health to education and on to the standard of living. Tomori (2021) further argued that 'COVID-19 disease has had, is having and will continue for a long time to have serious and far-reaching impact on every aspect of our life and living – social, education, economy and human development' (Nzeadibe et al., 2022).

On the other hand, an intimate relationship has in recent years been developed between sustainability and environmental justice (Brinkmann & Garren, 2018), with a change in one accentuating or reinforcing the other. Thus, whereas Mupara et al., (2017) aver that environmental justice in sub-Saharan Africa is highly mediated by political, historical, social, economic and ecological factors, 21st century; research on MSWM in Africa has been significantly framed within the purview of justice and sustainability, largely from studies in the Democratic Republic of Congo, South Africa and Nigeria

(Kubanza & Simatele, 2015; Simatele & Etambakonga 2015; Kubanza et al., 2017; Iheanacho et al., 2018). The outbreak and spread of COVID-19 across the continent has arguably intensified the debate on the linkages between MSWM, justice and sustainability (Nzeadibe & Ejike-Alieji, 2020) and appear to have expanded the previously held belief of the concepts of waste as materials requiring collection, handling and, ultimately, disposal or as resource out of place (Nzeadibe & Mbah, 2015; Moore 2012; Velis et al., 2012; Wilson & Velis, 2014) to include its impact on populations who are inequitably imposed with the health, environmental and social burdens of the failure of society (Iheanacho et al., 2018).

Regarding COVID-19 and MSWM, Nzeadibe and Ejike-Alieji (2020) held that the response to the coronavirus outbreak ought to provide an opportunity to improve the management of MSW thus contributing to the sustainability agenda. Unfortunately, this has not been the case. Thus, the impacts of COVID-19 would arguably have wide-ranging implications for justice and sustainability in MSWM in communities such as university campuses where intense human-environment interactions are commonplace. With research on MSWM in the context of

COVID-19 just emerging on the continent, the need to interrogate its justice and sustainability dimensions would not only be timely but also apposite as the plight of households and waste workers under COVID-19 pandemic has not been considered in MSWM policy and in a situation where MSWM policy in a pandemic is non-existent (Federal Republic of Nigeria 2018; Nzeadibe & Ejike-Alieji, 2020b).

This scenario is worrisome with increased consumption, increased accumulation-working from homes and increased online shopping, reduced waste collection rates by municipal authorities, emergence of new kinds of wastes including those regulated by the Basel Convention, lack of COVID-19 advisories to deal specifically with the management of the new kinds of wastes arising from the pandemic, and non-provision of PPE appropriate for a pandemic situation to waste workers. Added to these, also, are abuse and violations of the use of available PPE all of which call for interrogation of the MSWM system through a justice and sustainability lens.

It is noteworthy that Nzeadibe and Ejike-Alieji (2020) have argued that the changing of solid waste generation dynamics and the need for continued

waste collection and recycling, improved risk communication to citizens and stakeholders, and protection from the hazards faced by waste workers represent some of the critical waste management areas requiring attention in the light of COVID-19. Unfortunately, the unprotected working conditions of most waste pickers put this population at high risk of viral infections, such as COVID-19, for which they usually have very few resources to protect themselves (Uddin et al., 2020). MSWM under COVID-19 conditions, thus, needs to be treated as an important justice issue with implications for the sustainability of heterogeneous, vibrant and dynamic communities such as university campuses.

In the case of the Nsukka Campus of the University of Nigeria, the MSWM situation during the period of the pandemic seemed helpless. In an interview with the Director of *UNN Don't Litter Initiative*, a non-governmental organization involved in sensitization of the University Community on effective waste management for over a decade, it was noted that:

The University is a big city, and waste management should be given priority in UNN. There

exists an unnecessary accumulation of waste within the Campus. Within the COVID-19 pandemic period, waste was littered virtually everywhere within the campus, both at waste disposal sites and along the road. Waste dumps were already an overflowing which were too ugly to behold. There were more patients within the University Medical Centre, and this contributed to overflow of waste dumps. (Egodi Uchendu, personal communication, August 9, 2022).

Both the public and private institutions' handling of waste seemed to show a lack of adequate manpower, logistics capacity and materials capacities to evacuate the refuse dumps at strategic streets on campus, especially during the period of the COVID-19 lockdown. MSW discarded within the campus during the COVID-19 waves showed variation at different strategic locations (whether academic/administrative, staff residential, commercial or student hostel) as directly observed by the researchers.

Waste characterization within the campus indicates organic waste (fallen leaves from trees/ ornamental flowers), polythene bags (bags used to package

water and food items), and plastics (these are Polyethylene Terephthalate (PET) bottles). They are mostly used for packing bottled water, liquors and soft drinks.

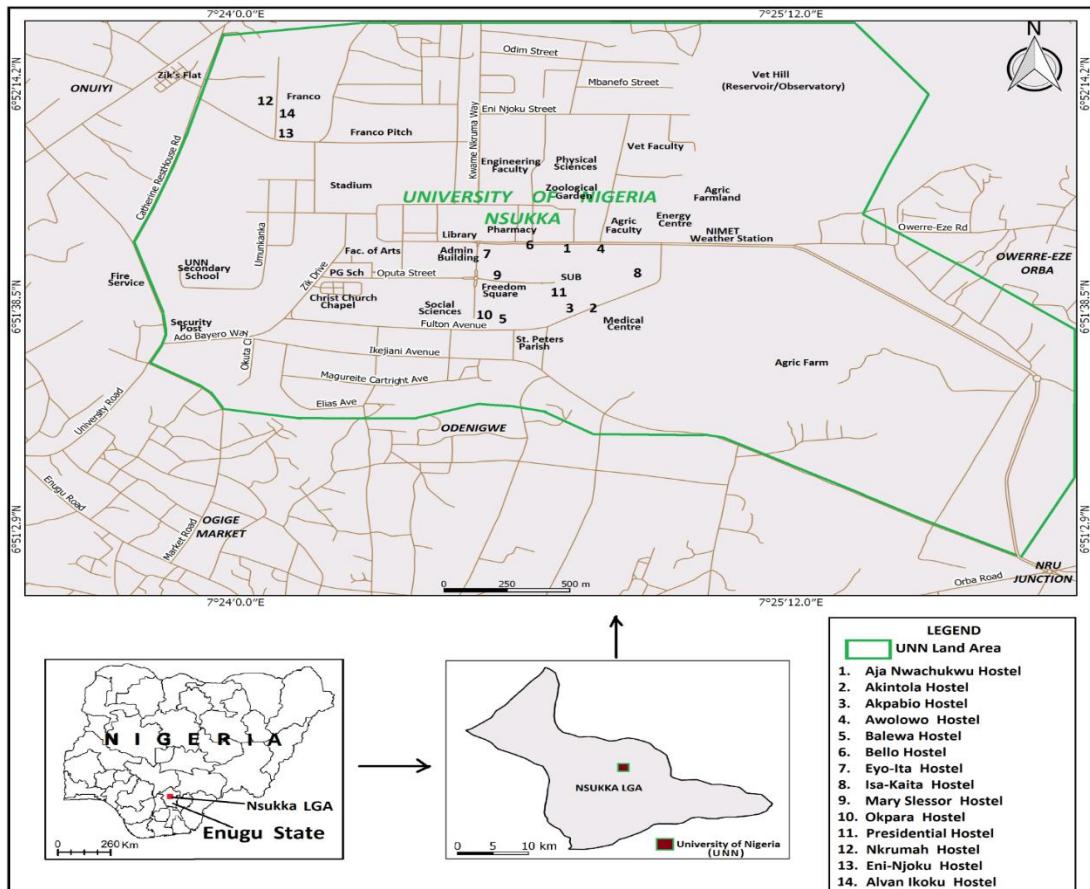
Instructively, disease outbreaks with far-reaching implications have often resulted from uncollected piles of solid waste (Nzeadibe & Madu, 2012). When the MSWM challenge is exacerbated by a public health emergency such as the COVID-19 pandemic, its real significance as an essential service may be better appreciated (Kaza, 2020). While SWM is one of the most important sanitary barriers to prevent transmission of diseases (International Solid Waste Association, 2020), piles of uncollected waste on campus represent a major source of embarrassment to the visitors and anger to the university community (Moore, 2009).

While this study supports the view that "addressing waste management as a priority will facilitate early progress against more than half of the SDGs" (United Nations Environment Programme. 2015 p. 303; Mbah & Nzeadibe, 2017) and by extension sustainability, only a few studies have examined MSWM in the

context of the COVID-19 pandemic (e.g. Torkashvand et al., 2021; Nzeadibe & Ejike-Alieji, 2020; Ikiz et al., 2021; Ismail et al., 2020; Abdulaziz et.al., 2021; Lima et al., 2020; Mihai, 2020; Penteado & De Castro, 2021; Ragazzi et al., 2020; Alexis, 2021).

While these studies show that different countries have adopted and adhered to different measures based on their context; no comprehensive study of MSWM during the pandemic has been attempted from a justice and sustainability perspective. We further noted that actors in the informal MSWM economy are particularly vulnerable (Mbah & Nzeadibe, 2017). This vulnerability became heightened during the period of the pandemic (Morais et al., 2022) for a variety of reasons, namely public health as well as, social and economic policies which tended to neglect social structures and the way the local economy works (Amazonwu et al., 2022; Nzeadibe et al., 2022b). Therefore, this study, explored MSWM and its justice and sustainability challenges during the pandemic within a university campus of an African country.

Figure 2: Map showing the University of Nigeria, Nsukka Campus



Note: GIS laboratory, Department of Geography and Environmental Sustainability, University of Nigeria, Nsukka

Methods of data collection

This study was largely qualitative and adopted a case study approach involving a survey of the prevailing MSWM system of Nsukka campus of the University of Nigeria, direct observation, and

interviews with key informants, namely directors of UNN Don't Litter Initiative, the UNN Medical Centre, the deputy director of the World Bank ACE-SPED as well as officials of Enugu State Waste Management Authority. In all cases, the

choice of interviewees was guided by the need to present the views and experiences of decision makers, persons knowledgeable and involved in MSWM on the campus (Mbah et al., 2019), as well as people with hands-on experience in the management of the pandemic and perspectives on justice and sustainability. In order to accomplish the objectives of this study, we conducted a rapid review of literature in various databases, including Scopus and Web of Science, for information relevant to MSWM during the pandemic. The search keywords are 'Municipal Solid waste', 'COVID-19', 'pandemic', 'novel coronavirus', 'SARS-CoV-2', 'types of solid waste', and 'solid waste management'. The literature elicited for the study was further screened with respect to its reference to justice and sustainability issues. A rapid review of official documents and websites of the university as well as relevant articles from blogs was conducted. Only articles published in the English language were selected for this review.

Findings on the MSWM system at the University of Nigeria, Nsukka

Indiscriminate dumping of wastes

Municipal solid waste management is a ubiquitous and highly visible issue and a

critical concern of the University community at the moment (UNN, 2019; Nzeadibe & Ajaero, 2011). A tour of the University campus revealed visible and indiscriminate dumping of waste at different points making these places an eyesore. This was compounded by the disheartening observation that inhabitants of adjoining communities such as Hilltop, Obukpa, Odenigwe and Odim usually sneaked into the campus to indiscriminately dispose of their waste.

This unfortunate development has far-reaching implications which border on health and environmental justice and sustainability. The heaps of refuse seen around students' residential hostels, offices, and some commercial areas expose the students and other campus dwellers to serious health risks and infestation of rodents that feed and hide in the heaps of refuse. Similarly, the waste dump reduces the aesthetics of the university. During the rainy season, water carries waste from the dumps into some drains and this has led to flooding of the University as a result of obstructed drainage systems.

Prevailing waste management initiatives

Commendable effort has, however, been made by the university management through the implementation committee

on environment to manage waste and maintain the aesthetics of the campus, although the approaches adopted have often relied on reactive and end-of-the-pipe solutions (UNN-Tenure Report, 2019). Collection and disposal of waste have tended to overlook pro-active culturally-based actions, or social drivers of sustainable solid waste management such as knowledge, attitude and behaviour modification (Ejike-Alieji et al., 2025), community participation and environmental education, as a strategy for tackling the perennial problem of municipal solid waste and also inculcating environmentally responsible behaviours in residents. Resource recovery and circular economy have also not been part of previous waste management strategies at the university. The campus can be demarcated into three sub-areas: Administrative/Academic areas, Staff Quarters/Student Hostels and Business Ventures Layout and other areas. The estimated amount of solid waste generation per day is 476 tons based on an average per capita generation rate of 0.49kg for Nigeria. According to Uwadiegwu and Chukwu (2013), there are two major approaches to solid waste management in Nigeria. It can be managed through private and public operators. The private system is a

contractual arrangement between waste generator(s) and a person or institution who undertake carting away of solid waste as a business pursuit while the public system involves a situation where government sets up a public agency with the mandate to collect solid waste from generators and dispose them at designated dump site.

The University of Nigeria engages both the private and public agencies in handling of its waste. The public agency responsible for the management of solid waste in UNN is Enugu State Waste Management Authority (ESWAMA). ESWAMA was established by Enugu State Government with the mandate to take the responsibility of the general cleanliness of the urban areas such as Enugu, Nsukka, 9th Mile Corner, Oji River, Obollo Afor, Awgu and any other settlement as may be designated as urban by Enugu State Government from time to time (Uwadiegwu & Iyi, 2014). Presently, ESWAMA handles the collection and disposal of waste from municipal solid waste bins in UNN free of charge. The university also entered into a Service Level Agreement (SLA) with two private waste operating companies – Total Facilities Management Ltd and Sonafem Agencies Ltd (Total Facilities

Management, 2019). The former had a contract agreement with the university authority in the provision of cleaning the Vice-Chancellor's office, the School of General Studies (SGS) Unit, the New and Old Library and their immediate environment on a daily basis. The latter had a contract for the provision of waste management/evacuation, sweeping/litter control and vegetation control for the institution. These contractual agreements seem not to have been faithfully implemented, resulting in abandonment of services.

There are a total of 123 of such dumpsters within the university premises, and ESWAMA uses a fleet of medium-duty trucks to haul the dumpsters. We also have the University Implementation Committee on Environment (ICE). The committee is involved in the collection and disposal of waste. The ICE has purchased and distributed more than 100 giant waste bins to enhance the activities of service providers, as waste is expected to be deposited in the waste bins and not on the bare ground (UNN End-of -Tenure Report, 2019). For ease of waste

collection and disposal, the campus premises were categorized into three major designations, Category A, Category B and Category C, by the waste management agencies.

Recently, voluntary initiatives are springing up on the campus as a way to bridge the waste collection gap. These include the UNN-Rotaract Club, Equity Watch Initiative & UNAA-UK and UNN-Don't Litter Initiative. These volunteers, from time to time, assist in the collection and disposal of waste materials. In spite of these initiatives, the waste management outlook of the campus has not improved significantly.

Waste generation during COVID-19 in the University of Nigeria

It was estimated that the rate of MSW generation increased from 131.24 tons/day in August 2020 to approximately 318.92 tons/day in January 2021 during the COVID-19 pandemic second wave in Nigeria (Oyedotun et al., 2020). Table 1 presents a summary of MSW generation in the University of Nigeria, Nsukka campus during the four waves of the COVID-19 pandemic.

Table 1: Summary of MSW generation within the four waves of the COVID-19 pandemic on campus

S/No	Stages of COVID-19 waves in the University of Nigeria	Estimated average waste generation(Kg)
1.	First wave of COVID-19: 27 th of February, 2020	5,918.54
2.	Second wave of COVID-19: 18 th December, 2020	5,271.98
3.	Third wave of COVID-19: 18 th July, 2021	4,658.24
4.	Fourth wave of COVID-19: 19 December, 2021	3,967.89

Note: Field survey, 2022.

Table 2 shows that the University of Nigeria, Nsukka generated an average of 5, 918.54 kg by weight of solid waste during the first wave of the COVID-19 pandemic in Nigeria. During the second wave, it was estimated that an average of 5,271.98 kg was generated on campus. During the third wave, an average of 4,658.24 kg of solid waste was generated. The fourth wave recorded an average MSW generation of 3,967.89 kg. The study shows that waste generation in UNN showed variation by waves and different locations (whether academic/administrative, staff residential, commercial or hostel areas). The volume of waste was 1249 kg/day from the selected strategic points, and the average

MSW generation rate was 0.84 kg/day. The data presented also show that the largest volume of MSW generated occurred during the first wave when strict lockdown and stay-at-home measures were strictly enforced and waste collection services were at their lowest ebb.

Waste reuse/recycling

Recycling of waste in UNN during the period of the pandemic is being driven by informal workers, namely waste pickers, scrap dealers, Itinerant Waste Buyers (IWBs) and Itinerant Waste Collectors (IWCs) who recover materials from households, dumps and open spaces for reuse/recycling. However, their activities were limited as a result of the movement

restrictions enforced by the government (Amazonwu et al., 2022).

Improper handling and disposal of plastics and other hazardous materials from the University Medical Centre, such as face masks, gloves and hand sanitizers may be potential sources of viral disease spread within the university community. From direct observation, used cans, plastics, fabrics and trashed papers constituted significant portions of the MSW stream and may be easily contaminated with the virus. Unfortunately, used plastic bottles are often recovered and reused to package locally made drinks within the campus. One of these locally made drinks regularly consumed by some residents, students and visitors is *Kunu*. This is a creamy white drink featuring a blend of sweet and spicy flavour, with ginger added for extra taste. According to Nwokolo (2020), *Kunu* is popularly called "Nigeria's Irish Cream". It is a non-alcoholic beverage mainly made of fermented millet. Occasionally, tiger nut and groundnut are added to it to make it richer. *Kunu* is nutritious and widely consumed by both the young and the old, irrespective of tribe. It is best enjoyed when cold; *kunu* can be taken alone or with food or snacks.

Tiger nut milk, also known as *Kunnu Aya*, is another locally made drink packaged in used bottles. It is another local drink that is readily available for consumption on campus. Tiger nut milk is delicious, creamy and gives a sweet, rich and nutty flavour (Nwokolo, 2020). We also have *Zobo* drink, which is a healthy, tasty non-alcoholic drink that is made from the flowers of the roselle plant. It is this flower that gives the drink its unique reddish-wine colour. Many things, such as ginger and fruit, go into the production of the drink, and it always comes out tasting great. Due to its colour and rich taste, some people see it as a substitute for foreign drinks. Packed with enough nutrients that help reduce blood pressure, a cold glass of *zobo* drink is a delight to consumers. However, the reuse of contaminated plastic bottles in repackaging these drinks and the indiscriminate disposal of the containers could increase the spread of diseases. Accordingly, refuse and municipal waste constitutes visible environmental problems on campus (UNN, 2019b; Resource & Environmental Policy Research Centre, UNN, 2021).

Consequently, the quantity of waste generation was more influenced by the quantity of waste collected in the

academic/administrative and hostel-dominated areas. But when the collection sites were considered exclusively because of where they are positioned, the values for staff's residential and commercial areas were affected greatly at 245.77kg and 311.63kg, respectively.

Waste-to-energy utilization of MSW

One area that was extensively explored in UNN to reduce MSW in the university campus and environs during the period of this study was the energy-to-waste project of the UNN. Under the aegis of the Laboratory of Industrial Electronics, Power Devices and New Energy Systems (LIEPNES), a multidisciplinary team of researchers in UNN has generated 500KVA of electricity using a locally-fabricated gasification plant (Njoku, 2021). Through this project, waste is used to salvage the current epileptic power supply in the country, occasioned by the regular collapse of the national grid. The plant was designed and built with 100 per cent local content, organic solid materials were also converted into synthetic gas for electric power generation and other uses (Njoku, 2021). This was facilitated by the recent establishment of the World Bank-supported Africa Centre of Excellence for Sustainable Power and Energy

Development (ACE-SPED) at the Nsukka campus following an intense and rigorous multilateral evaluation process. The thematic area of ACE-SPED relevant to this study is renewable energy, waste-to-energy and energy conservation (Africa Centre of Excellence for Sustainable Power and Energy Development, 2022). In a recent interview, the ACE-SPED Centre Leader, Emenike Ejiogu, remarked that 'the UNN have the best and alternative solution to power supply that would save organizations from the huge financial burden it incurs subscribing to the national grid'. 'The economic relevance of a designed gasification plant is that it converts solid waste into gas, just like the refineries which turns crude oil into petrol and other products' (Ikem, 2022 p. 1). The relevance of this project to justice and sustainability lies in its application of local content and use of waste materials that would have ordinarily caused environmental, health and social problems in the university community. With the increasing generation rate of solid waste during and post-pandemic era, the project could also lead to savings in energy cost while also contributing to the improvement of environmental situation in UNN.

The waste-to-energy project also supports Nigeria's energy transition and the Nigerian Local Content Development policy which among other things provides comprehensive framework, structures, programmes, and schemes for the institutionalization and strengthening of Nigerian local content in all sectors of the Nigerian economy for self-sufficiency, job creation, international competitiveness of Nigerian domestic businesses and economic diversification and for matters connected therewith' (KPMG, 2021 p.3).

Conclusion and implications of COVID-19 MSWM for justice and sustainability

Municipal solid waste management is a major environmental-development challenge in the University of Nigeria and should be accorded high priority. There is a need to develop a post-pandemic Municipal Solid Waste Management Policy for the University of Nigeria in order to cater for the new kinds of waste arising from the pandemic, such as used face masks, gloves, empty hand sanitizer containers and other plastic personal protective equipment. MSWM needs to be treated as an essential service and given priority attention in view of its public health implications, especially during a pandemic. Poor MSWM could

lead to air pollution and the contamination of the campus premises. This could facilitate the rapid spread of the COVID-19 infection thereby making habitation on campus difficult. Generation of energy from waste can be a veritable approach to tackling the MSWM challenge and justice issue in UNN, as the capacity of her researchers in this direction has been demonstrated. This is in light of the increasingly large volumes of organic waste generated in UNN campus. We argue, therefore, that the waste-to-energy project supports Nigeria's energy transition and the Nigerian Local Content Development policy, both of which have public health, economic, social and environmental justice implications. All stakeholders in MSWM activities on campus should, from time to time, sensitize and create awareness on attitudinal change on waste management using the university radio station, "The Lion FM". Furthermore, the Implementation Committee on Environment should provide a permanent solution and sustainable measures in MSWM within the campus. By so doing, it is argued that the health, environmental and social burdens imposed on populations on campus will systematically be addressed.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this research.

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