

Original Research Article

Municipal Solid Waste Management System in Enugu Metropolis South-Eastern, Nigeria.

Abstract

Waste characterization is a fundamental step taken for effective and sustainable waste management strategies in order to safeguard public/environmental health. This study investigated the working system of Municipal solid waste management system (MSWMS) in all the zones of Enugu metropolis both by residents and by the municipal authority- Enugu State Waste Management Authority ESWAMA). Findings revealed that the elements of MSWMS in the metropolis include: waste collection, transfer, separation, recycling, and disposal. Furthermore, the study revealed no form of solid waste separation before being dumped for transfer and disposal. The only form of recycling in the study area however is the done by the scavengers and their activities include: separation and selling of valuables recovered from solid waste dumpsites. Conclusively MSWMS, as established by this study, should be managed towards creating an enhanced employment opportunity and wealth creation. The inability of agencies responsible for waste management to anticipate and plan for sustainable management is the major reason for the surge in MSWMS generation and tenacity. The study recommends shift from the conventional disposal to the application of integrated sustainable waste management ISWM which is more effective, efficient and eco-friendly.

Keywords: Solid Waste Management, Waste Generation, Waste Characterization, ESWAMA,

1 Introduction

Municipal solid waste management system (MSWMS) is generally associated with urbanization. Recent developments in manufacturing processes have lowered the cost of production, enhancing the ability of manufacturers to produce goods that captures different income groups in population. This has led to astronomical increase in MSW generation and composition in urban areas with resultant adverse environmental effects (Akindayo, 2019). Municipal solid wastes (MSW) refer to all wastes generated, collected, transported and disposed of within the jurisdiction of a municipal authority. In most cases, it comprises mainly food waste, discarded materials from residential areas, street sweepings, commercial and institutional nonhazardous wastes as well as (in some countries) construction and demolition waste. MSW has been variously described as aggregation of unwanted materials generated from a range of human-related activities denominated from domestic to production. The origin of what is regarded as MSW can be closely associated with the earliest attempts by humans to transit from migrant to settler modes of living, which imposed the need to modify or change the character of raw or primary materials available to support or sustain the new modes of living and originating human activity (Akindayo, 2019). Municipal solid waste management has emerged as one of the greatest challenges facing many developing countries. Daily human activities lead to the generation of various classes of waste, which is seen as a major environmental threat for many cities in developing nations worldwide (Klundent *et al.*, 2000; Ohaka *et al.*, 2013; Olukani *et al.*, 2018).

The factors affecting such a high rate of change in solid waste generation includes things such as population growth, changing lifestyles, income growth, increasing use of disposable materials, excessive packaging of items, and consumer habits (Olukani *et al.*, 2015; Olukani & Orasanya,2018). Despite the several investment opportunities that waste management offers with a very high return on investment for public and private sectors, most developing countries, including Nigeria, have solid waste management issues which are different from those found in industrialized countries in regard to composition, density, political and economic frameworks, quantity of waste, access to waste for collection, awareness, and attitude (Adebola, 2000; Olukani *et al.*, 2016; Olukani & Orasanya,2018) .

It has been recorded that, Nigeria generates over 32 million tons of solid waste yearly which most cities such as Enugu is inclusive, and only a fraction is collected (Bakare, 2020). Most of these wastes are generated by households and in some cases, by local industries, artisans and traders who litter the immediate surroundings. Improper collection and disposal of municipal wastes has led to different levels of environmental challenge such as blockade of sewers, drain networks and the choking of water bodies (George, 2010). Although, the country lacks a well-coordinated waste management system, Solid Waste Management (SWM) is under the purview of Ministry of Environment at the Federal and State levels and Environmental Health Department at Local Government level under established legislations and guidelines relating to waste management. Some of these legislations include: the Harmful Waste Act (Special Criminal Provisions, etc of 1988), the National Environmental Standards and Regulations Enforcement Agency (NESREA). Act 2007 (NESREA Act, repealed the Federal Environmental Protection Act of 1988), Environmental Impact Assessment act of 1992, National Environmental (Sanitation and Wastes Control) Regulations, 2009 and the National Environmental Protection Regulations (Pollution Abatement in Industries and Facilities Generating Waste). In emerging countries, local authorities like Enugu Metropolitan Councils spend 77–95% of their revenue on collection and the balance on disposal (Ogwueleka, 2009), but are only able to collect around 50–70% of municipal solid waste (Bayemi & Dauda, 2009). In Nigeria, municipal waste densities generally range from 250–370 kg/m³ (Ogwueleka, 2009; Amber *et al.*, 2012). Unfortunately, people in many developing countries (including Nigeria) have, until recently, regarded the issue of proper solid waste management as trivial, which may have diverted attention away from the most urgent and serious problem of achieving a fast rate of economic growth. This attitude stems from the belief that solid waste generation is an inevitable price of development (Chukwu, 2007; Olukani *et al.*, 2018).

Waste generation and characterization is a fundamental step taken for effective waste management. Sha'Atoet *et al.*, (2007) carried out a study of waste generation profile of Makurdi, in North-Central Nigeria. He reported that the bulk of the solid waste generated in the area originated from households than from commercial, institutional and industrial premises. These wastes, constituted majorly, various putrescible materials, ash, dust and sand. On the other hand, a study of solid medical waste showed that health outfits and hospitals in the Federal Capital Territory, Abuja, generate a sizeable amount of solid waste collected daily which poses serious harm to the environment and man (Bassey *et al.*, 2006). The study stated that, of the total solid waste generated daily, 26.5% was hazardous innature and waste segregation was found not to be practiced by any of the hospitals sampled. Similarly, Fadipe *et al.*, (2011) pointed out that medical wastes in Osun state are not being properly disposed of and as such, pathology wastes such as unclaimed dead bodies, placentas, umbilical cords are being dumped into unlined pits and other wastes in open dumps.

A comparative analysis of municipal solid waste (MSW) composition in three local government areas in Rivers State revealed that waste generation rate was 0.45, 0.98 and 1.16 kg/capita/day for Emohua, Obio/Akpor and Port Harcourt, respectively (Babatunde *et al.*, 2013). The most prominent categories identified were organic waste, paper and nylon. Mean percentage composition was 59, 65.5, 65 for organic waste, 6, 11 and 13% for paper and 14, 16 and 12% for nylon in Emohua, Obio/Akpor and Port Harcourt LGAs, respectively. They pointed out that there are potentials for resource recovery and energy generation. Similarly, Sha’Ato (2007) noted that of the waste from households, a substantial proportion consists of various putrescible materials (36-57%) and suggested composting as the best form of waste management. The rate of generation of plastics, water-proof materials and diapers has assumed an upward trend (Nnaji, 2015). Most food waste was found to constitute close to 50 percent of overall municipal solid waste in Nigerian cities (Nnaji, 2015; Aliyu, 2010). Due to the dysfunctional state of many municipal waste management authorities, many cities in Nigeria have been overrun by open dumps. There is a need for both government and individuals to adopt holistic and sustainable waste management strategies in order to safeguard public/environmental health (Nnaji, 2015). Sustained cooperation could be developed among all key actors (government, waste managers, public health workers and inhabitants) to implement an economic, sustainable, and reliable management practices in Nigeria (Olukanni & Mnenga, 2015). A provision of sizable funds by the government and proper education to the people among others will help in sustainably managing the solid waste problem.

This study investigated the working system of MSWM in all the zones of Enugu metropolis both by residents and by the municipal authority- Enugu State Waste Management Authority (ESWAMA). This study also revealed the main elements of the MSWM system existing in the study area and their respective characteristics.

2 Materials and Methods

The study area is Enugu metropolis, the capital of Enugu state Nigeria. It is located between latitudes 6° 20' N and 6° 32' N of the equator and longitudes 7° 28' E and 7° 36' E of the Greenwich meridian. It extends over an area of about 145.8 square kilometres (Enugu State Ministry of Lands and Survey, 2022). The area is administered by three Local Government Authorities namely: Enugu North, Enugu South and Enugu East Local Government Areas (LGAs). Enugu metropolis is bounded in the north by Isiuza and Igbo Etti LGAs, in the west by Udi LGA and in the south and east by Nkanu west and Nkanu east LGAs respectively (Fig. 1). Enugu metropolis as a geographical entity has many administrative divisions basically into: LGAs, zones, wards, layouts among others. Available records in the ESWAMA main office indicates that Enugu metropolis was divided into ten (10) zones based on their SWM coverage schedule. The ten ESWAMA zones of Enugu metropolis includes: Abakpa, Trans-Ekulu, Emene, Idaw River, GRA, Ogui, Independence Layout, Agbani Road, Uwani and New Haven (Fig. 2). Table 1 shows that the ESWAMA zones cover the three Local Government Areas (L.G.As) that make up Enugu Metropolis.

Table 1: The ESWAMA Zones of Enugu Metropolis and some of the Wards/Layouts in Each Zone

| S/No | Zones | Wards / Layouts |
|------|------------|---------------------------|
| 1 | Abakpa | Abakpa 1&2 and Nike |
| 2 | TransEkulu | TransEkulu and UgboOdogwu |
| 3 | Emene | Emene and Thinkers corner |
| 4 | Idaw River | Idaw River and NgeneEvu |

| | | |
|----|---------------------|----------------------------------|
| 5 | GRA | GRA and Ogbete/Coal camp |
| 6 | Ogui | Ogui and Ogui New layout |
| 7 | Independence Layout | Independence Layout and Maryland |
| 8 | Agbani Road | Awkunanaw and Gariki |
| 9 | Uwani | Uwani and Achara Layout |
| 10 | New Haven | New Haven and Asata |

Source: Author's Construct, 2022

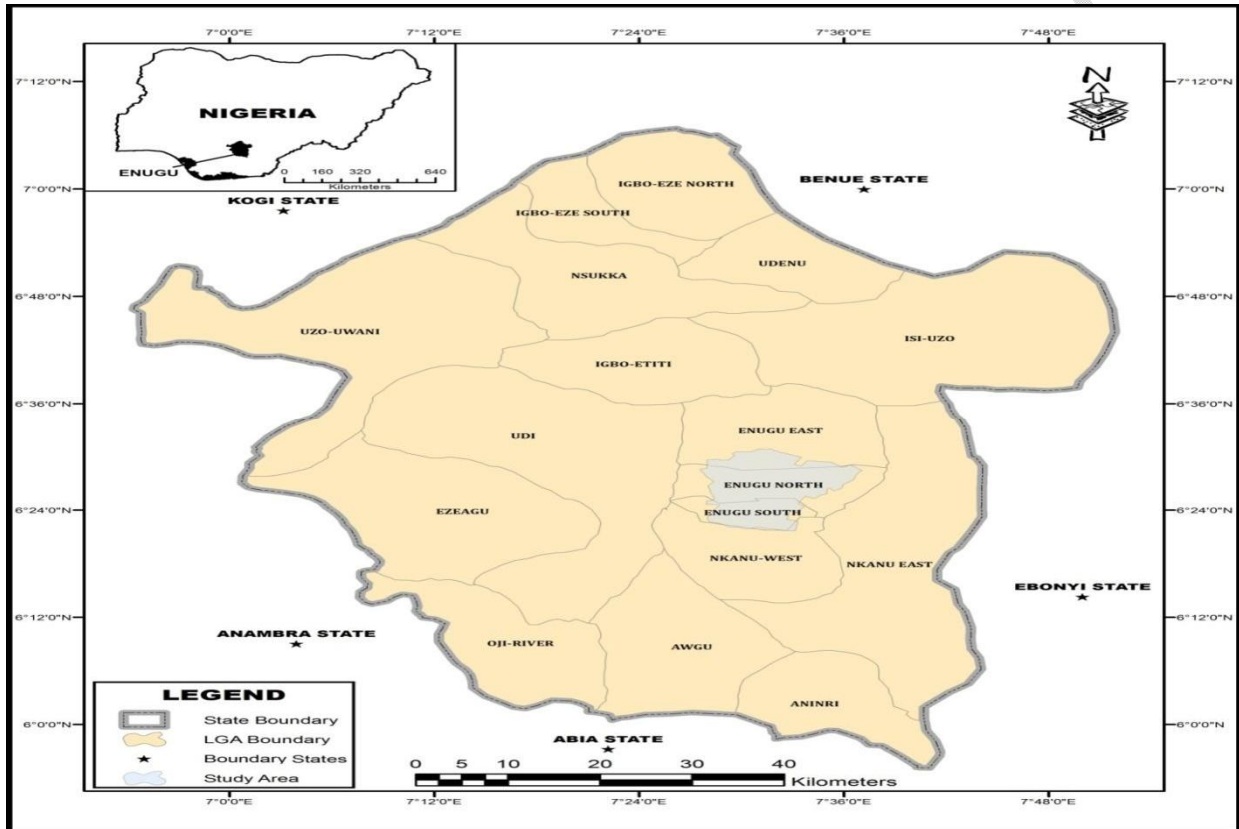


FIG. 1: Enugu State Showing the Study Area
Source: Enugu State Ministry of Lands and Survey, 2022

3. Results and Discussions

The Main Elements of the MSWM System in Enugu Metropolis

The SWs generated in Enugu metropolis are managed in a variety of ways by both the residents and the Enugu State Waste Management Authority (ESWAMA). ESWAMA is the body charged with the responsibility of the management of wastes in Enugu state, established through law No 8 of 2004 with the vision to ensure sustainable waste management in the state. The MSWM system in Enugu metropolis is characterised by the following elements:

3.1 Solid Waste Collection

Solid Waste collection is a very important element of MSWM in Enugu metropolis and it occurs in two stages namely: primary collection and secondary collection.

Primary Collection of SWs: This involves the temporary storage of SWs at homes and other places of human endeavour (shops, offices among others). During field work, it was noted that virtually all the sampled household have waste bin or bag(s) with which they collect their SWs. The questionnaire responses indicates that 188 (62.7%) households use bags (polythene or sack) to collect their SWs; 89 (21.7%) uses bucket/basket; 10 (3.3%) push cart and 13(4.3%) no specific order. These constituted the primary collection level. The major means of collecting SWs by residents in Enugu metropolis according to zones is mapped to show the spatial distribution (Fig. 4).

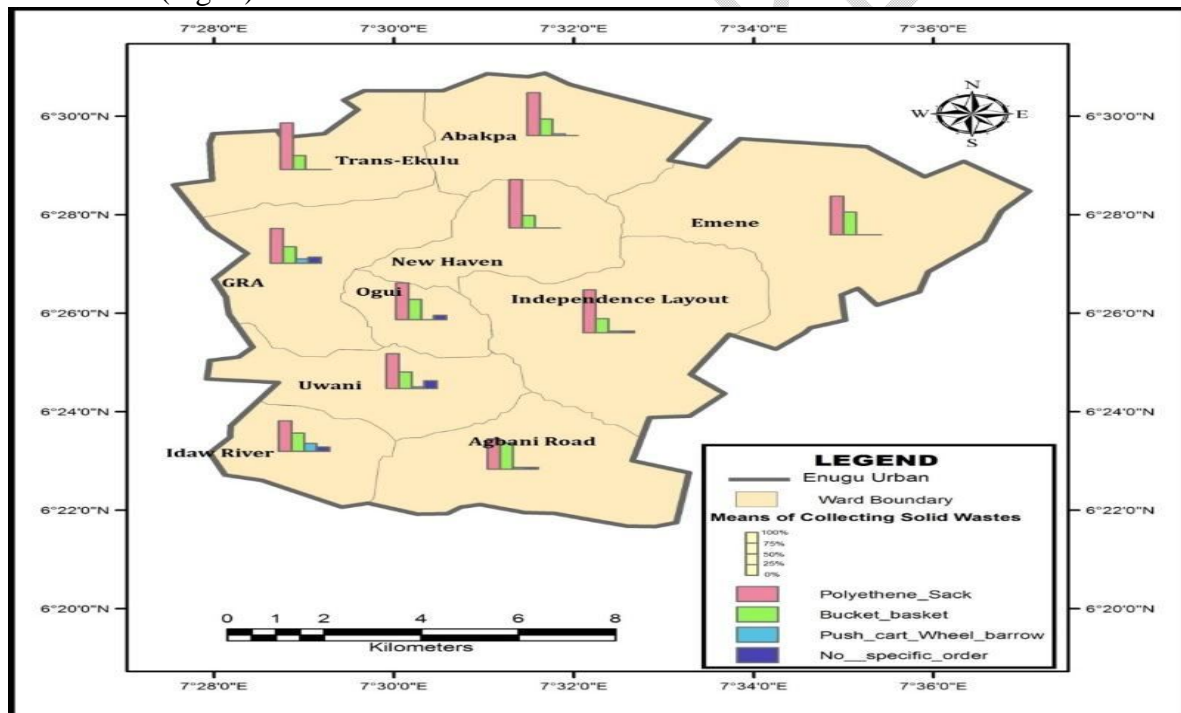


Fig 4: Spatial Distribution of Means of Collecting SWs in Enugu metropolis.

Source: Author's Field Work, 2022

The spatial distribution map in Fig. 4 shows that the use of bags as means of collecting SWs is dominant in all the zones of the study area. However, New Haven and Trans-Ekulu zones recorded the highest percentage of respondents in this category while Idaw River and Agbani Road zones recorded the least. The prevalent use of bags to collect SWs in the study area may be

connected with the UK- DFID SWM pilot project of New Haven area described by Ofong (2004).

Secondary Collection of SWs:SWs from households and other sources were further collected in dumpsters (large metal containers with lid) and dumpsites before evacuation or transfer to disposal site. This study investigated the distribution of dumpsters/dumpsites in the various zones of the study area to find out what the coverage is like. To achieve this, schedules for distribution of dumpsters for all the zones in Enugu metropolis was collected from ESWAMA office the data were collated and the result is presented in Table 2:

Table 2: Distribution of Dumpsters over Enugu Metropolis

| S/No | Zones | Total Number of Dumpsters Distributed |
|--------------|---------------------|---------------------------------------|
| 1 | Abakpa | 248 |
| 2 | TransEkulu | 226 |
| 3 | Emene | 218 |
| 4 | Idaw River | 205 |
| 5 | GRA | 249 |
| 6 | Ogui | 241 |
| 7 | Independence Layout | 240 |
| 8 | Agbani Road | 231 |
| 9 | Uwani | 234 |
| 10 | New Haven | 233 |
| Total | | 2325 |

Source: ESWAMA Main Office, Enugu, 2022

Table 2 shows that dumpsters are not equitably distributed among the zones as some zones were allotted more dumpsters than others based on their size and importance; hence GRA and Ogui zones located within the Central Business District (CBD) and are more likely to have high population density as well as Abakpa zone which is a large zone were allotted more dumpsters than the other zones. On the other hand, Idaw River zone which is the smallest zone and located at the outskirts got the least number of dumpsters. The average number of dumpsters per zone is approximately two hundred and thirty three (232.5).

This study further inquired into the distribution of dumpsters in the different neighbourhoods of the study area by asking the sampled households: ‘Do you have dumpsters in your neighbourhood?’. Data analysis shows that 75% of the respondents have dumpsters in their neighbourhoods. The spatial distribution of households’ responses according to zones is illustrated with a bar graph as shown in Fig. 5:

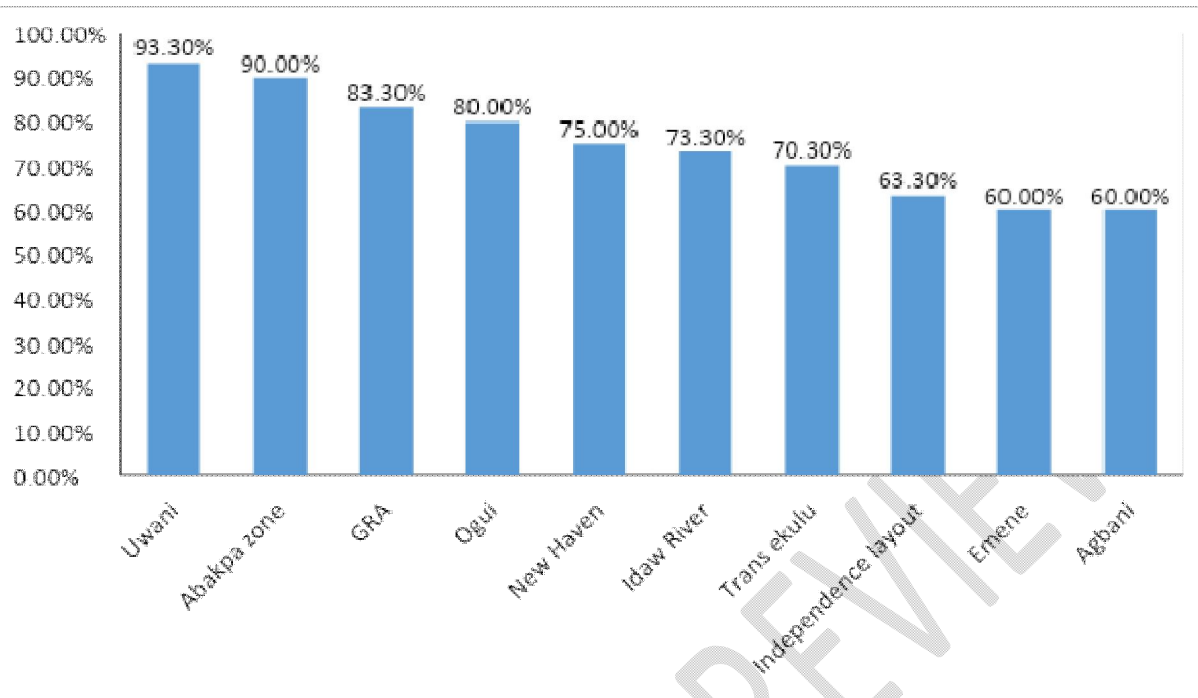


FIG. 5: Spatial Distribution of Households' Responses on the Availability of Dumpster(s) in their Area

Source: Author's Field Work, 2022

From the analysis in Fig. 5, Uwani zone recorded the highest percentage of respondents with dumpsters in their neighbourhoods followed by Abakpa zone, GRA zone, Ogui zone in that order; this shows that the spatial ranking of residents' responses differ from ESWAMA records in Table 2. In the quest for an explanation to this disparity, it was noted that some residents had dumpsters before but lost them to vandalism and related incidences.

Dumpsters are systematically distributed and strategically located for easy access by the population as well as the ESWAMA compactor truck and crewmen that evacuate wastes from them (Plate 1).



Plate 1: Dumpster at a Strategic Location at New Haven in Enugu metropolis.

Larger dumpsters are located in areas with large concentration of population in order to contain the high SW generation in such places e.g. community areas; large private and public institutions. These constituted secondary SW collection level. Every resident and institution was required by law to deposit SWs into appropriate containers while illegal waste disposal methods were prohibited. However, some of the dumpsters have become vandalized and kept out of use, though a good number of them are still very sound and are used by the populace. In

some neighbourhoods, there are dumpsites (spaces designed for dumping wastes by communities) where people dump their SWs for collection. Incidentally, many dumpsites appeared abandoned and showed no signs of recent evacuation of wastes from them. A key informant (Anyaji, Personal communication, 2022) was interviewed to find out why SWs were not being evacuated; and he responded that “ESWAMA had prohibited dumping of wastes in such places but residents failed to comply with the directives. He further stated that the dumping of SWs are strictly in dumpsters but for few exceptions especially around major markets (Plate 2) where people are allowed to carefully dump their SWs at authorized dumpsites along the roads.



Plate 2: Dumped SWs along a Major Road near Ogbete Market.

SWs are tied in different bags and deposited in the centre demarcation of a major road that has dual lane. The respondents were requested to rate the surrounding/vicinity of dumpsters in their neighbourhoods; the analysis of their responses indicates as follows: 21.7% rated their surrounding as tidy while 78.3% rated theirs as untidy. The analysis further indicate that for tidy, 15.4% and 6.3% rated their dumpster vicinity as tidy and very tidy respectively. For untidy, 62.7% and 15.6% rated theirs as untidy and very untidy respectively. This shows that the surrounding/vicinity of most dumpsters in the study area are often untidy/ very untidy.

3.2 Solid Waste Transfer

Before the SWs collected in Enugu metropolis can be adequately disposed of, they must be moved to disposal site using appropriate means of transfer/ transportation. Transportation of wastes to disposal site occurs in two stages namely: Primary transportation and secondary transportation.

Primary Transfer of Solid Wastes: SWs generated by homes and various human activities in the study area are first of all moved to dumpsters or collection points/ESWAMA authorized dumpsites (primary transfer). The study investigated into the key players in the primary transfer of wastes. The responses show that 75.3% of the respondents move their SW to the dumpsters/dumpsites by themselves or a member of their family, while 23.3% and 1.3% employ the services of Private Service Providers (PSPs) and volunteers respectively. It was also noted that 48.7% of the respondents carry their SWs in bags/bins by hand/head while 24.7% and 23.3% convey theirs using pushcart/wheel barrow and automobiles respectively whereas the remaining 3.0% do not have specific order of taking SWs to dumps. The analysis of respondents' means of moving SWs to dumpsites is shown in Table 3.

Table 3: Means of Moving Solid Wastes to the Dumpsite in Enugu Metropolis

| ZONES | Head/hand carrying (%) | Using push cart/wheel barrow (%) | Using motor cycle (%) | No specific order (%) | Total (%) |
|--------------------------|------------------------|----------------------------------|-----------------------|-----------------------|-------------|
| Abakpa Zone | 20 (66.7) | 4 (13.3) | 6 (20.0) | 0 (0.0) | 30 (100) |
| Trans Ekulu Zone | 13 (43.3) | 8 (26.7) | 9 (30.0) | 0 (0.0) | 30 (100) |
| Emene Zone | 14 (46.7) | 11 (36.7) | 5 (16.7) | 0 (0.0) | 30 (100) |
| Idaw River Zone | 14 (46.7) | 6 (20.0) | 9 (30.0) | 1 (3.3) | 30 (100) |
| GRA Zone | 12 (40.0) | 13 (43.3) | 3 (10.0) | 2 (6.7) | 30 (100) |
| Ogui Zone | 15 (50.0) | 10 (33.3) | 4 (13.0) | 1 (3.3) | 30 (100) |
| Independence Layout Zone | 16 (53.3) | 7 (23.3) | 7 (23.3) | 0 (0.0) | 30 (100) |
| Agbani Road Zone | 16 (53.3) | 3 (10.0) | 11 (36.7) | 0 (0.0) | 30 (100) |
| Uwani Zone | 10 (33.3) | 8 (26.7) | 11 (36.7) | 1 (3.3) | 30 (100) |
| New Haven Zone | 16 (53.3) | 4 (13.3) | 6 (20.0) | 4 (13.3) | 30 (100) |

Source: Author's Computation, 2022

Secondary Transfer of Solid Wastes: The SWs deposited at various collection points in the study area as approved by ESWAMA are further transferred (Secondary transfer) to the landfill site at Ugwuaji by the ESWAMA compactor trucks. A municipal official was interviewed on the number of municipal transport facilities and from available records at ESWAMA truck yard (Plates 3 and 4) the municipality has seventy (70) Compactor trucks, ten Tipper (10), three (3) Wasco truck and five (5) Shuttles used for the transfer of SWs. Also, the municipality contracted the services of (120) tricycle (Keke) operators who use their tricycle to collect bagged wastes from busy areas or around major markets and other areas that may be difficult to access by compactor trucks and shuttles. It was also noted that there are one hundred and seventy five (175) Crewmen and fifty four (54) Drivers directly involved with SW transfer in Enugu metropolis. According to the ESWAMA Public Relation Officer (Igbodike, Personal communication, 2022) “about twenty seven of the compactor trucks are not in use because of their poor condition”. This shows that only forty three are presently working.



Plate 3 and 4: Some Compactor Trucks parked in ESWAMA Truck Yard, Enugu.

In the quest to find out if the municipality manage to transport SWs efficiently from dumpsters/dumpsites to disposal site in Enugu metropolis. A household interviewee said that the municipality do not evacuate SWs appropriately hence the enormous piles of SWs around dumpsters in their area (Uche, 2022). The municipalities on their part blame inaccessible roads in some areas and breakdown of compactor trucks as the major constraint to the efficient transportation of wastes from dumps to the disposal site.

The temporal pattern of SW transfer/evacuation from dumpsters in the study area was investigated in order to find out the commonly observed interval between SW collections events. Data analysis shows that 30.7% (7.0% daily+23.7% 2-3days) of households are served within (1-3days) collection of SWs from dumpsites in their areas whereas 58.0% (31.3% 4days-1week+26.0% above 1week) said that collection of SWs at dumpster or at approved dumpsites delayed for 4days to over a week. This is contrary to the information obtained from ESWAMA office that “more than half of the zones in Enugu metropolis are served with daily collection of wastes from dumpsters/dumpsites” (Igbodike, 2022). The summary of the data analysis is presented a cluster mapped to show the spatial distribution in Fig. 6.

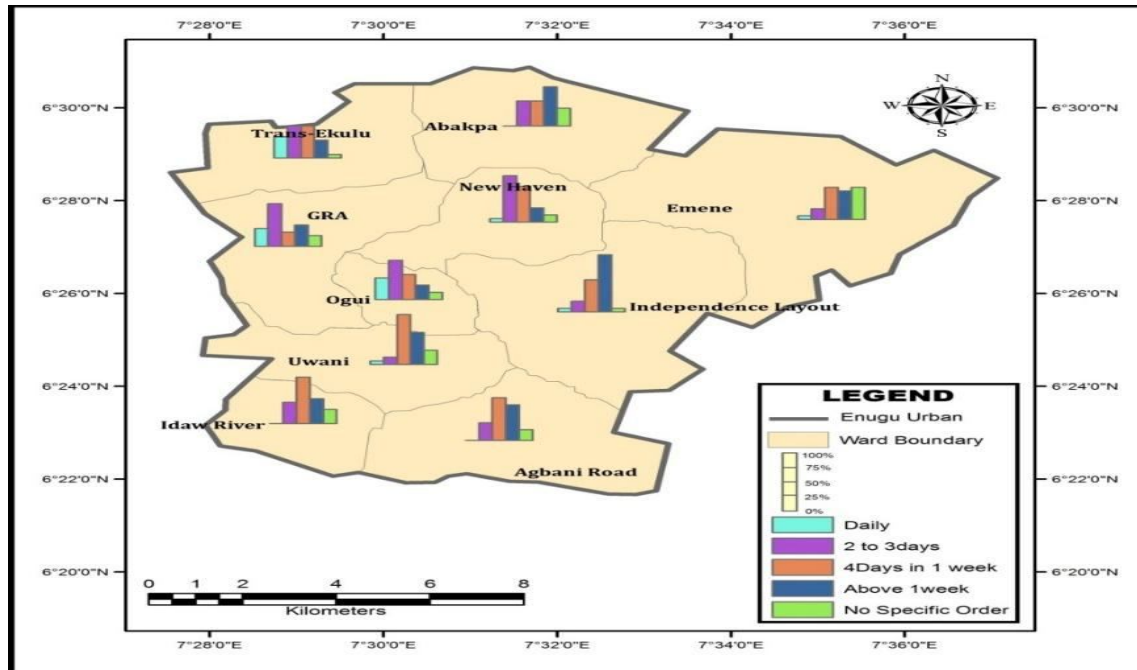


Fig 6: Spatial Distribution of the Temporal Patterns of SW Transfer in Enugu Metropolis.
 Source: Author's *Field* work, 2022

The information in Fig. 6 indicates that SW transfer from dumpsters/dumpsites in Enugu metropolis vary both temporally and spatially. Most of the zones in the study area are served within 4 days to 1 week and above 1 week pattern of SW transfer from dumpsters in their neighbourhoods. Independence layout zone recorded the highest percentage of respondents in this category followed by Uwani zone. However, few of the zones recorded appreciable number of respondents who are served with daily and 2 to 3 days pattern of SW transfer from the dumpsters in their area; GRA and Ogui zones are leading in this category.

The respondents were asked to state: 'what happens if there is a long delay in MSW transfer?'; the analysis of their responses indicates that 'the SWs remain there indefinitely' as responded to by 86.6% of the respondents while the remaining 13.4% said the residents will resort to burning the wastes (including the dumpster). This was further confirmed by the author's physical observation which noted that wastes continued to pile around dumpsters until the municipality evacuates them. A typical example was noted along Mgbemene street in Ogbetelayout, GRA zone of the study area; enormous SWs were commonly seen abandoned around dumpsters/dumpsites in a haphazard and filthy manner (Plate 5). This study inferred that such long delays compelled residents to resort to illegal SW dumping.



Plate 5: SW Dumpsite along Mgbemene Street, Ogbete in GRA Zone
N.B: The SWs overflowing from the site.

3.3 Solid Waste Separation

SW separation involves the segregation/sorting of SWs into different components for reuse or recycling. SWs separation occurs at two different stages in the SWM system of Enugu metropolis. These are: Solid waste separation at the source and Solid waste separation at the controlled dump.

Solid Waste Separation at the Source: This refers to the sorting or segregation of SWs at the point of generation before sending them out for collection and disposal. In the study area, majority of the residents do not separate SWs before dumping them for disposal as only 29.3% of the respondents sort their SWs at home before sending them out for disposal. This population separate their SWs chiefly into reusable/recyclable and non- re-usable/non- recyclable. The reusable/recyclable components of their SWs consist of: Plastics, glass bottles, papers, metals among others. The analysis of the components of reusable/recyclable that are separated at source in the study area is presented in Table 4:

Table 4: Components of Recyclables Separated at Source in Enugu Metropolis

| ZONES | Plastic only (%) | Plastic and glass bottle (%) | Plastic, glass bottle and metal (%) | Plastic, glass bottle, metal and papers (%) | Total (%) |
|------------------|------------------|------------------------------|-------------------------------------|---|-------------|
| Abakpa Zone | 0 (0.0) | 3 (37.5) | 4 (50.0) | 1 (12.5) | 8 (100) |
| Trans Ekulu Zone | 1 (25.0) | 2 (50.0) | 0 (0.0) | 1 (25.0) | 4 (100) |
| Emene Zone | 0 (0.0) | 0 (6.0) | 14 (87.5) | 2 (12.5) | 16 (100) |
| Idaw River Zone | 0 (0.0) | 2 (16.7) | 8 (66.7) | 2 (16.7) | 12 (100) |
| GRA Zone | 0 (0.0) | 3 (33.3) | 4 (44.4) | 2 (22.2) | 9 (100) |

| | | | | | |
|----------------|-------------|-------------|-------------|-------------|-------------|
| Ogui Zone | 1 (10.0) | 1 (10.0) | 3 (30.0) | 5 (50.0) | 10 (100) |
| Independence | 1 | 3 | 2 | 1 | 7 |
| Layout Zone | (14.3) | (42.9) | (28.6) | (14.3) | (100) |
| Agbani Zone | 0 (0.0) | 4 (80.0) | 2 (25.0) | 2 (25.0) | 8 (100) |
| Uwani Zone | 2 (28.6) | 2 (28.6) | 3 (42.9) | 0 (0.0) | 7 (100) |
| New Haven Zone | 0 (0.0) | 3 (42.9) | 4 (57.1) | 0 (0.0) | 7 (100) |

Source: Author's Computation, 2022

SW separation at source in Enugu metropolis varies from zone to zone and Emene zone has the highest percentage of respondents that separate SWs at source, while Trans-Ekulu and Independence layout zones has the least percentage of respondents in this category. In general, most of the SWs generated in the study area do not undergo any form of separation before being dumped for transfer and disposal.

Solid Waste Separation at the Controlled Dump/Landfill site: Solid Waste separation was equally noted at the controlled dump (landfill site) by scavengers. This was observed during the field visit to Ugwuaji landfill site where many scavengers were found ransacking the dump and separating the SWs brought by the ESWAMA compactor trucks before their disposal. They separate reusable/ recyclable SWs such as: metals, plastic containers, glass bottles, used tyres among others (Plates 6 and 7).

The researcher could not interview any of the scavengers at the landfill site as they bluntly refused to grant that. Based on observation, this study found that direct recovery of materials from waste was done at the landfill site by the scavengers in a disorganized manner.



Plate 6: Separated SWs at the Landfill Plate 7: Separated Recyclables

3.4 Solid Waste Recycling

This study noted that there were no formal recycling activities in the study area presently. Nonetheless, it was gathered that “the Government of Enugu State has plans to establish a recycling plant in partnership with a prospective Chinese company that will handle SW recycling at the landfill site” (Anyaji, Personal Communication, 2022). The only form of recycling in the

study area however is the one done by the scavengers and their activities include: separation and selling of valuable SWs (see Plates 5 and 6).

3.5 Solid Waste Disposal

Solid Wastes collected in dumpsters and dumpsites from all parts of Enugu metropolis are transferred to the landfill site located at Ugwuaji, 1.6Km from the Port Harcourt expressway, Enugu. This study found that SWs were dumped in heaps even along the minor road to the landfill site (Plate 8). The dumped wastes are being disposed by burning(Plate 9). There were no incinerator machines, compacting machines or any other waste disposal equipment seen at the landfill site. Also, the dumped SWs are left bare on the surface (not covered with soil or compacted as in the case of ideal landfill). Furthermore, there is marked incomplete disposal of SWs at the landfill site as shown by the existence of enormous piles of partially burnt SWs heaped unsightly around the landfill site (Plate 10).



PLATE 8: SW Dumped along the Minor theRoad to the Landfill site.

Note: Heaps of SWs along the road.



PLATE 9: Disposal of SWs by Burning in Landfill site.

Note: The smoke oozing out of the burning waste.



PLATE 10: Piles of Partially Burnt SWs at the Landfill

Conclusion and Recommendations

The MSWMS anticipated parameter should be in accordance to the prerequisite of the National Environmental Standards and Regulation Enforcement Agency's (NESREA) Statutory Instrument No. 28 titled National Sanitation and Waste Control Regulation 2009 should be responsible for the specific role of states in Nigeria. Furthermore, MSWMS, as established by this study, should be managed towards creating an enhanced employment opportunity and wealth creation. The inability of agencies responsible for waste management to anticipate and plan for the increase of MSWMS is the major reason for the surge in MSWMS generation and tenacity. These will eventually become sources of sometime unexplained indiscriminate dumping, land and water pollution and/or public health problems such as disease outbreaks. The following recommendations are of paramount in the study.

1. Characterized wastes linked with dumpsite and landfill is to deliver information on risk assessment of dumpsite or landfill products.
2. Data on neighboring surface water and groundwater quality and their consumption by inhabitants.
3. Data on physio-chemical assessment of pollutant on soil.
4. Build cognizance on the need to sort waste from source before disposal.
5. Inspire embracing of recycle and reuse of wastes to reduce wastes generated.

References

Adebola, O. (2005): Investment Opportunities in Integrated Solid Waste Management

(A.K.A Waste to Wealth) for Public Private Sector; The Abia State Environmental Summit: Umuahia, Nigeria, 2005; p. 2.

Akindayo .A.S (2019): Municipal Solid Waste Management. Municipal Solid Waste Management and the Inland Water Bodies: Nigerian Perspectives DOI:

<http://dx.doi.org/10.5772/intechopen.84921>. Licensee IntechOpen

Aliyu, B. N. (2010): An Analysis of Municipal Solid Waste in Kano Metropolis, Nigeria. *Journal of Human Ecology*, 31(2), 111-119. DOI: 10.1080/09709274.2010.11906301

Amber, I.; Kulla, D.M.; Gukop, N. (2012): Municipaal waste in Nigeria generation, characteristics and energy potential of solid. *Asian J. Eng. Sci. Technol.* **2012**, 2, 84–88.

Babatunde, B. B., Vincent-Akpu, I. F., Woke, G. N., Atarhinyo, E., Aharanwa, U. C., Green, A. F., & Isaac-Joe, O (2013). Comparative analysis of municipal solid waste (MSW) composition in three local government areas in Rivers. *African Journal of Environmental Science and Technology*, 7(9), 874– 881. <https://doi.org/10.5897/AJEST12.112>.

Babayemi, J.O.; Dauda, K.T.(2009) : Evaluation of solid waste generation, categories and disposal options in developing countries: A case study of Nigeria. *J. Appl. Sci. Environ. Manag.* **2009**, 13, 83–88.

Bakare, W. (2020). Solid Waste Management in Nigeria. Retrieved March 31, 2020, from <https://www.bioenergyconsult.com/solid-waste-nigeria/>

Bassey, B. E., Benka-Coker, M. O., & Aluyi, H. S. A. (2006). Characterization and management of solid medical wastes in the Federal Capital Territory, Abuja, Nigeria. *African Health Sciences*, 6(1), 59–63.

Chukwu, K.E (2007): Recycling of used Plastic Products: Its Sanitary and Commercial Un- publication in Enugu State. In Proceedings of the Stakeholders' Workshop, Converting Waste to Wealth through Waste Recycling, Enugu State Waste Management Authority, Enugu, Nigeria, 30–31 January 2007.

Fadipe, O. O., Oladepo, K. T., Jeje, J. O., & Ogedengbe, M. O. (2011). Characterization and analysis of medical solid waste in Osun State, Nigeria. *African Journal of Environmental Science and Technology*, 5(12), 1027– 1038.

George, O. (2010). Social effects of poor sanitation and waste management on poor urban communities: a neighbourhood-specific study of SabonZongo, Accra. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 3:2, 145- 160, DOI: 10.1080/17549175.2010.502001

<https://doi.org/10.5897/AJEST11.130>

Klundert, A.V.; Anschitz, J (2000): The Sustainability of Alliances between Stakeholders in Waste Management-Using the Concept of Integrated Sustainable Waste Management; UWEP/CWG Netherlands Ministry for Development Co-Operation: CW Gouda, the Netherlands, 2000; pp. 1–22

Nnaji, C. C. (2015). Status of municipal solid waste generation and disposal in Nigeria.

Management of Environmental Quality: An International Journal, 26(1), 53-71.

<https://doi.org/10.1108/MEQ-08-2013-0092>.

Ogwueleka, T.C (2009). Municipal solid waste characteristics and management in Nigeria.

Iran J. of Environ. and Health Sci. Engr. 6(3):173-180.

Ohaka, A. R., Ozor, P. E., & Ohaka, C. C. (2013). Household Waste Disposal Practices in Owerri

Municipal Council of Imo State, *Nigerian Journal of Agriculture, Food and Environment* 9(2), 32-36.

Olukanni, D. O., & Mnenga, M. U. (2015). Municipal Solid Waste Generation and

Characterization: A Case Study of Ota, Nigeria. *International Journal of Environmental Science and Toxicology Research*, 3(1), 1-8.

Olukanni, D. O., Adeleke, J. O., & Aremu, D.D. (2016). A Review of Local Factors Affecting

Solid Waste Collection in Nigeria. *Pollution*, 2(3), 339-356.

<https://doi.org/10.7508/pj.2016.03.008>.

Olukanni, D. O., Aipoh, A. O., & Kalabo, I. H. (2018). Recycling and reuse technology: Waste

to wealth initiative in a private tertiary institution, Nigeria. *Recycling*, 3(3), pp 1-12.

<https://doi.org/10.3390/recycling3030044>.

Olukanni, D.O.; Oresanya, O.O (2018): Progression in Waste Management Processes in Lagos State, Nigeria. *J. Eng Res. Afr.* 2018, 35, 11–23.

Sha’Ato, R., Aboho, S. Y., Oketunde, F. O., Eneji, I. S., Unazi, G., &Agwa, S. (2007).

Survey of solid waste generation and composition in a rapidly growing urban area in Central Nigeria. *Science Direct: Waste Management* *q.* 27, 352–358.
<https://doi.org/10.1016/j.wasman.2006.02.008>.

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