Evaluation of Solid Waste Storage and Disposal Practices in Nsukka, Enugu State

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Abstract. Poor waste management has remained a nagging environmental issue for many developing countries. This paper examined the mode of solid waste storage and disposal in Nsukka, with the aim of providing and synthesizing data needed for waste management planning and policy making. A total of three hundred (300) well-structured questionnaires were administered to households cutting across ten communities to generate quantitative data on demographics as well as waste storage and disposal practices. The qualitative methods such as oral interviews, observation surveys, and secondary data were also employed. An initial environmental quality assessment of the selected households showed that 58.5% of houses surveyed were littered with waste and 71% had bushy surrounding. The study reveals that the distribution of waste storage container sizes are: 0 – 5 L (4%), 6 – 10 L (43%), 11 – 20 L (51%) and > 21 L (2%). It was also observed that the prevalent types of waste storage containers in Nsukka are: plastic bins (49%), polythene bags (15%) and cartons (10%) with volume ranging from 0.1 to 0.625 m³. The remaining twenty-six (26%) was distributed among other unconventional waste storage types. Eighty-eight percent (88%) of the residents in the study area can access waste dumps within a radius of 1 km or five minutes walking distance. The waste storage containers in the study area were of varying types and capacities which makes waste management more tasking. Indiscriminate solid waste disposal is necessitated by perceived non-proximity of waste dumps to residents. Door to door services should be provided to residents by integrating private sector into waste management. Material such as aluminum should be used in manufacturing of waste containers because of its lightweight and durability.

1. Introduction
Solid waste is the end product of human daily activities. They are residues from domestic, commercial, industrial, institutional and agricultural activities [1,2]. These wastes that are generated on daily basis include polythene, paper, food waste, bottles, plastics, metal scraps, aluminum, rubber, bones, saw dust, and fabrics. An evolving and occasional waste such as mobile phones, computers and other kinds of electronic gadgets are also generated [3]. Solid waste generation in Nigerian cities have been estimated to be an average value of 0.49 kg/capita/day (Table 1) with over 25 million metric tonnes generated annually [4]. The generation rate varies widely depending on the peculiar features of the city [5]. Solid waste is generated largely from households followed by urban markets and stores. In Nigeria, household waste generated ranges from 49 percent to 78.9 percent and is greatly influenced by the economic status, lifestyle/habits, gross domestic product, sensitization on environmental sanitation, and population density as shown in Table 2 [6, 7]. According to [8], China is the leading solid waste generator in the world with an annual waste generation of 190 million tonnes in 2004 and 480 million tonnes was projected by the year 2030.
Between 35 and 50 percent of the solid waste generated in most developing countries are not collected. They usually end up in illicit dump sites, open spaces, waste land and drainages [9]. The percentage of solid waste collected and disposed ranges between 25 and 60 percent in Tanzania, Pakistan and Indonesia. It has been suggested that 80 to 90 percent of wastes generated in countries within the sub Saharan Africa are not collected for safe disposal [10].

In Nigeria about 30-60 percent of solid waste generated is not collected owing to low accessibility resulting from poor road networks, technical, economic and management failures on the part of waste management authorities, inadequate facilities, refusal to pay collection bills and non-implementation of route optimization [4]. About 80 percent of residents in most cities of Nigeria get rid of their waste by open air burning, unauthorized open dumping, burial and other unconventional means. Solid waste collection, storage and disposal are the most important aspects of municipal waste management. Wastes generated in urban areas in Nigeria are collected and disposed by the municipal waste authorities. Municipal waste collection in Nigeria is characterised by routine primness, bureaucracy and intriguing politics, unsuitable and unsustainable solid waste management techniques [5]. Waste collection and disposal services are offered mainly by the public sector through the State governments and involvement of formal public private participation (PPP) [11].

Waste containers are used for temporal storage of waste. It can be made of plastic, metal, wood and polythene materials of different sizes and shapes. Plastic bins and polythene bags are the most common waste storage containers found in most household in Nigeria with paper bags, used drums and sacks as unconventional waste storage containers. Polythene bags are usually provided by municipal waste management authorities to encourage bagging of waste. Bagging makes waste collection less chaotic compared to plastic bins though not durable [3]. The choice of waste storage containers used depends on the nature of waste to be stored, conveyance, durability and affordability. Storage and collection form the final link between waste generators and waste managers. Proper waste storage makes for easy collection and disposal of waste. In cities where there is effective waste management, large and more durable metal containers are used in order to make waste collection and disposal more expedient.

### Table 1. Waste Generation and Composition in some Cities in Nigeria.

| City        | Population | Tonnes/month | Density (kg/m³) | kg/capita/day |
|-------------|------------|--------------|-----------------|---------------|
| Lagos       | 8,029,200  | 255,556      | 294             | 0.63          |
| Kano        | 3,228,700  | 156,676      | 290             | 0.56          |
| Kaduna      | 1,458,900  | 114,433      | 320             | 0.58          |
| Port Harcourt | 1,053,900  | 117,825      | 300             | 0.6           |
| Onitsha     | 509,500    | 84,137       | 310             | 0.53          |
| Ibadan      | 307,840    | 135,391      | 330             |               |
| Makurdi     | 249,500    | 24,242       | 340             | 0.48          |
| Abuja       | 159,900    | 14,785       | 280             | 0.66          |
| Nsukka      | 100,700    | 12,000       | 370             | 0.44          |

Source: [11]

Solid waste management has posed enormous challenge in most developing countries of the world due to rapid increase in waste generation and laxity in effective waste management [12]. The volume of solid waste generation globally in the past few years has increased resulting in overstressing of waste management facilities (such as storage containers, collection trucks etc.) and ineffective waste management by authorities concerned. Serious challenges that are being faced by municipal solid waste management in various cities of the world includes urbanisation, population growth, lifestyles, rapid industrialisation and consumption of foods with materials that are less decomposable [13].

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issue of effective waste management is not only the obligation of government but is a shared responsibility that includes the citizens and households, who are the main end-users of waste management facilities and services. Some of the nagging challenges associated with solid waste management are: quantity of waste generated, low technical experience, inadequacy and frequent breakdown of collection vehicles, low level of manpower and low financial resources which often cover only collection and transfer costs, leaving no resources for safe final disposal [14].

Table 2. The Percentage Generation of Solid Waste by Different Sector in Nigeria.

| City     | Domestic | Industrial | Commercial | Institutional | Hospital | Agricultural |
|----------|----------|------------|------------|---------------|----------|--------------|
| Abeokuta | 73.9     | 0.5        | 17.5       | -             | -        | 8.2          |
| Ado-Ekiti| 78.9     | 2.7        | 14.3       | -             | -        | 4.1          |
| Akure    | 70.3     | 4.8        | 18.6       | -             | -        | 6.3          |
| Ibadan   | 66.1     | 11.4       | 20.3       | -             | -        | -            |
| Osogbo   | 68.2     | 6.2        | 23.5       | -             | -        | 2.1          |
| Umuahia  | 8        | 12         | 80         | -             | -        | -            |
| Zaria    | 49       | 14         | 23         | 10            | 4        | -            |

Source: [3]

It was observed by [3] that with a population of about 97,000 residents in Nsukka, Enugu State Waste Management Authority (ESWAMA) uses only two collection trucks to service the metropolis and its environs. As at 2012, only one of the trucks was functional. Poor services from this waste management authority could be attributed to none payment for waste collection by residents. The inability of waste management authorities to cope with the volume of waste generated has left residents of most cities in Nigeria with no option than to discard their waste in approved open waste dump sites. These wastes are evacuated in turns by collection vehicles. Involving private firms in waste management of waste makes it more efficient as attested by [13], that over 80 percent of waste generated is adequately collected for disposal.

Municipal solid waste management is an important aspect of urban infrastructure that ensures the protection of environment and human health [15, 16]. Where there is no effective waste management, waste generated will be indiscriminately dumped in open spaces, access roads, along water courses or burnt. These dumps are invaded by scavengers and animals thereby constituting a nuisance to the environment. Open dumps also serve as breeding grounds for disease vectors, primarily flies and rodents. Leachate from decomposing garbage contaminate the soil, groundwater and surface water sources. Uncollected wastes may also find their way into open drains, causing blockage and dammed-up stagnant water which encourages the breeding of mosquitoes. Some of the health problems associated with improper collection storage and disposal of solid wastes include typhoid fever, cholera, dysentery, skin disease, malaria, hepatitis and guinea horn disease [17]. Also some chemical waste when touched or inhaled in excess can cause outbreak of epidemic. Hence, there is a growing global concern about the sterility of our environment and the need for proper handling and disposal of solid waste [1]. Burning of municipal solid waste has severe impact on public health resulting in the release of toxic substances [17].

Solid waste management has become an area of major concern in Nsukka today. It was observed by [5, 12] that 87% of Nigerians practice unhygienic methods of waste storage and disposal. Waste storage and disposal in developing countries is still largely indiscriminate and uncontrolled. Gharaibeh et al. [18] observed that in Saudi Arabia, the municipal solid waste collection services are faced with an increasing number of problems such as increasing population growth, changes in habits and lack of awareness of the impact of solid waste on the environment. Proper solid waste management (i.e., storage, collection and disposal) requires accurate information regarding waste generation rates and quantities, mode of generation, sources, storage containers and locations of waste [19]. The lack of information on
waste storage containers is partly responsible for inefficient waste collection and disposal practices in many Nigerian cities. Without this information, it would be difficult to effectively plan for solid waste collection. Moreover, there is no reliable database indicating the amount of various types of waste collected and the volumes of waste generated per capita. It is against this backdrop that this study seeks to evaluate the nature and types of waste storage containers that are prevalent in the study area. Therefore, it is the aim of this paper is to evaluate the types and capacity of waste storage containers, distance from households to waste disposal points and common solid waste disposal practices in Nsukka, Enugu State.

2 Methodology

2.1 Description of Study Area
This study was carried out in Nsukka Local Government Area, Enugu State. Nsukka is bounded by Igbo-Eze South, Igbo-Eze North, Enugu-Ezike and Uzo-Uwani Local Government Areas. It has an average temperature of about 27°C (80°F) and a typical vegetation of rain forest. It lies between longitude 6°51'24"N and 7°23'45"E with an elevation of 550 m above sea level (Figure 1). Nsukka had a population of 309,633 as at 2006 census and an area of 5,545.38 square kilometres. Its inhabitants are predominantly civil servants, traders and farmers. The main campus of University of Nigeria is located in the study area.

2.2 Data Collection
Data was collected through the use of well-structured questionnaire, oral interview, and physical observation. A total number of 300 questionnaires were administered to households in Nsukka communities, out of which 234 were retrieved and analysed, giving a response rate of 78%. The questionnaires were constructed to achieve the aim and objectives of the study. It was categorised into three sections. Section A consisted of bio-data of the respondents, Section B focused on general waste-related practices such as mode of waste generation, frequency of waste collection, waste storage, waste transportation and waste disposal and Section C was designed to assess the attitude of respondents towards waste management. Oral interview was introduced to give clarification of question to respondents and also obtain additional information that was not captured in questionnaire. The physical observation was employed to get more information about the environment of the respondents. Measuring tape was used to measure the dimensions of waste storage containers in order to determine the volume of waste generated in households.

2.3 Sampling Site and Size
The sampling site was divided into 10 sections spreading across the entire city. Ten (10) communities were carefully selected to represent the sections (Table 3). Stratified random sampling at each of the section was used to ensure appropriate representation of the entire classes in the population. The first household in each residential area was selected and the households were subsequently followed alternatively until all the households were exhausted. The distribution of the sample size among the ten communities and the number of respondents are presented in Table 3. Relevant Statistical tools in Microsoft excel were used for data analyses. The use of tables, pie chart, and bar charts was employed for the data analysis and presentation. Both the descriptive and inferential techniques were applied in the data analysis.
Table 3. Communities in Nsukka and Questionnaires response data.

| S/N | Zone         | Administered | No. of Respondents |
|-----|--------------|--------------|--------------------|
| 1   | UNN          | 60           | 50                 |
| 2   | Obukpa       | 30           | 21                 |
| 3   | Amaezani     | 30           | 21                 |
| 4   | Onuiyi       | 25           | 20                 |
| 5   | Leija        | 20           | 15                 |
| 6   | Alor-Uno     | 30           | 24                 |
| 7   | Ede-Oballa   | 25           | 20                 |
| 8   | Nru          | 30           | 26                 |
| 9   | Eha-Alumona  | 30           | 27                 |
| 10  | Ede-Ani      | 20           | 10                 |
|     | Total        | 300          | 234                |

3 Results and Discussion

3.1 Environmental Quality Assessment
The on-the-spot assessment are presented in Figure 2. The environment of the respondents was assessed in order to evaluate the hygienic status of the premises of respondents. It was observed that a greater number of 137 households dispose their waste around their premises despite the fact that 147 houses placed waste bin in front of their building.

Figure 2. On the Spot Assessment of Respondents Environment.
The culture of disposing wastes in waste bin is not practiced in most homes in Nsukka. Another useful information gathered from this assessment was the nature of development of the respondent’s environment. It was also observed that a total of 166 houses were surrounded by bushes which entails that the study area is still undeveloped. It also indicated a low level of environmental sanitation and personal hygiene.

3.2 Personal Information of the Respondents
Some of the personal information of respondents are presented in Figures 3 & 4. The results indicate that 53 percent of respondents are female while 56 percent are single. On level of education, it was recorded that a favourable percentage of respondents are learned. The result also showed that 118 houses within the study area has a range of 4 to 7 inhabitants. There seems to be a poor correlation between educational status and best waste management practices.

Figure 3. Charts showing the marital status, level of education, family size and type of household of the respondents.

The monthly income of respondents within the study area was low with 54 percent of respondents earning N20,000 or less monthly. All these features could be a strong factor affecting the rate of waste generation, storage and disposal pattern. For instance, a household of 1-3 inhabitants will not generate the same quantity of waste with a house of 8 to 11 inhabitants, owing to the fact that waste is as a result of human activities. Results from Figure 3 shows that 62 percent of household assessed were residential apartment, which 9 and 29 percent were institutional and commercial building respectively. About 45 percent of these buildings were blocks of flats and was situated within the urban centre of Nsukka and the university community. Fifty-nine percent of the houses have waste bin in their premises but a greater percentage of 53 choose to discard their waste within the surrounding and others in nearby river/stream.

Figure 4: Charts showing the monthly income, type of building, waste container material and size of container of the respondents.
3.3 Waste Collection and Storage Containers

Solid waste storage container is a receptacle used for the temporary storage of solid waste while awaiting collection. The design of an efficient waste collection system requires careful consideration of the type, size and location of containers at the point of generation for storage of wastes until they are collected for disposal. The type and size of storage containers largely depends on the size of household and the purpose of the premises. Single-family households generally use smaller containers while residential units, commercial units and institutions require larger containers. Smaller containers are usually handled manually whereas the larger, heavier ones require mechanical handling. The desirable characteristics of a well-designed waste storage and collection containers are, low cost, weight, shape, resistance to corrosion, water tightness, strength and durability. Containers used in all the households in Nsukka are manually handled by one person. The weights of the containers including waste were between 5 and 15 kg. Households in the study area are very sensitive about the weight of their containers and wastes because emptying is done by members of the household. Heavy big heavy containers could lead to muscular strain. Larger containers are more suitable for waste dumps where several households deposit their wastes prior to collection. The container plus waste weighs up to 40kg, although emptying of wastes into collection vehicle is manually done by two or more crew members when it is filled. The process usually results in low collection efficiency and requires more manpower. Containers at collection points had handles and wheels to facilitate mobility. The body is made strong enough to resist and discourage wandering animals and scavengers from ripping it as well as withstand rough handling by the collection crew.

In Nsukka the type of waste containers used in most households are plastic containers, polythene bags, cartons and others such as metal containers, drums, etc. The plastics may be thin or heavy. On the average, 49% of Nsukka residents uses plastic containers, 15% uses polythene bags, 10% uses cartons, while 26% uses other means such as metal containers and drums (Table 4). The choice of plastic containers used by most households could be attributed to the fact that it is affordable, flexible and lightweight compared to metal container. Afullo and Frank [20] observed that in Nairobi, plastic bins were used by most households because it is relatively cheap and affordable compared to metal bins.

| City                  | Abeokuta | Ibadan | Awka   | Uyo   | Nsukka (This study) |
|-----------------------|----------|--------|--------|-------|---------------------|
| Plastic bin           | 48.89    | 40     | 81.5   | -     | 49                  |
| Paper bags            | 6.53     | -      | -      | 71.4  | -                   |
| Polythene bags        | 28.44    | 39.6   | 7.7    | -     | 15                  |
| Carton                | -        | -      | -      | -     | 10                  |
| Used drums            | 15.15    | 28.4   | -      | -     | -                   |
| Sacks                 | 6.53     | -      | -      | -     | -                   |
| Metal tin             | -        | -      | 10.8   | 25.6  | -                   |
| Others                | -        | -      | -      | 3     | 26                  |

[3, 21]

Some household used polythene bag for storage of waste, because it makes waste disposal less chaotic and flexible. Cartons were used mostly in commercial premises (such as stationaries stores, café,
computer business centres, etc) which generates mostly non-biodegradable waste and paper. Some households convert old metal and drums as waste bin. It was observed in this study that the size of solid waste containers mostly used ranged from 11 to 20 litres representing 51% of the total households, 6 to 10 litres representing 43% and 0 to 5 litres representing 4. Large containers greater than or equal to 21 litres were used by only 2% of Nsukka residents. Household with single family unit use storage containers ranging in size from 0 to 10 litres, while residential unit, commercial and institutional use larger storage containers > 11 litres containers. Generally, the size of storage containers used is a function of the anticipated rate of waste generation and frequency of disposal.

Solid waste storage containers are classified as stationary and hauled containers. Stationary containers are used for contents to be transferred to collection vehicles at the site of storage while the later are used for contents to be directly transferred to a processing plant, transfer station or disposal site for emptying before being returned to the storage site. Hauled containers are made of durable materials and are also made large enough to accommodate a reasonable amount of waste generated in order to reduce the cost of haulage. The containers in the study area were predominantly 1 m³ stationary containers kept at a convenient position in the occupant’s residence. These containers are emptied once they are filled into larger stationary container placed at designated locations provided by Enugu State Waste Management Agency (ESWAMA). These containers are made of metal material and are coated regularly to avoid corrosion. When the container is full, the contents are transferred into collection vehicles for disposal at the municipal landfill. These containers are also fitted with lids to keep insects and other animals, and also to minimize infiltration of rainfall. An ideal container is shown in Figure 5, but open containers known as skips are often used (Figure 6).

Figure 5. Solid Waste Storage/Collection Containers with Lid

Figure 6. Solid Waste Storage/Collection Container without Lid.
3.4 Waste disposal Practices

It was observed that waste stored in waste bin was not disposed frequently where 46 percent does not empty their waste bin within one week. The result also revealed that 49 percent of respondent use plastic containers for waste storage while the remaining 51 percent use either polythene bag, carton or any other means. The volume of containers used in storing waste is reliable means of determining the quantity of waste generated in each household. The minimum volume of waste container with a uniform value of 0.01m3 was observed in all the communities while the maximum volume varies between 0.10 to 0.625 cubic metres. The sizes of waste containers available in most of the households are relatively small. Coupled with the habit of inhabitants not disposing of their waste within one week could be a major pointer as to why wastes were littered within the environment. Small waste storage containers necessitate frequent disposal Large containers will take a longer time to fill but will provide adequate residence time for the wastes to decompose and create unsightly and unhygienic conditions such as odour and leachate production.

Table 5. Descriptive statistics of volume of Solid Waste Storage Containers.

| Zone         | Mean  | Standard Deviation | Maximum | Minimum |
|--------------|-------|--------------------|---------|---------|
| UNN          | 0.036 | 0.00227            | 0.27    | 0.01    |
| Obukpa       | 0.044 | 0.0038             | 0.3     | 0.01    |
| Amaze-Aoni   | 0.107 | 0.0113             | 0.41    | 0.01    |
| Onuiyi       | 0.042 | 0.0016             | 0.041   | 0.01    |
| Leija        | 0.048 | 0.00119            | 0.1     | 0.01    |
| Alor-Uno     | 0.057 | 0.02699            | 0.45    | 0.01    |
| Ede-Oballa   | 0.029 | 0.00099            | 0.1     | 0.01    |
| Nru          | 0.092 | 0.01459            | 0.47    | 0.01    |
| Eha-Alumona  | 0.063 | 0.00868            | 0.41    | 0.01    |
| Ede-Ani      | 0.099 | 0.003428           | 0.625   | 0.01    |

Figure 7 present results of respondent’s view on solid waste management by municipal waste management authorities. The result indicates that 69 percent of respondents are fully aware of municipal waste management agency. The poor management of waste by these agencies could be attributed to none payment for waste collection as reported by [3].
Field survey showed that 88% of residents can access a waste dump within a radius of one kilometre or five minutes walking distance. However, 63% of respondents perceived the distance from their residence to waste dump as unfavourable. The perceived non-proximity of waste dumps coupled with unavailability of waste bins in open places is responsible for waste littering and indiscriminate dumping of refuse in places like farmlands, roadside drains and streets. It is also responsible for the creation of illegal dumping points, especially along access roads. Another intriguing aspect that was revealed by this research was the size of collection containers at approved dumpsites. The volume of collection containers at dumpsite provided by municipal agencies were not enough to accommodate the volume of wastes generated by some households. As a result, the containers at the waste dumps are always in perpetual state of overflow.

4 Conclusion

The type, size and weight of waste storage containers help in determining the volume of waste generated by households and their perception. The prevalent type of waste storage containers in Nsukka are, plastic bins, polythene bags, cartons, metal boxes and used drums with widely differing volumes. The preference for plastic waste bins is because of their flexibility, affordability and ease of disposal. The volume of containers used in most households were small owing to the fact that agency concerned doesn’t provide door to door services, individuals are responsible for emptying their bins. Using containers of smaller volume will require frequent disposal, with collection points not close to most households will make waste disposal stressful. Aluminum containers of considerable size should be introduced because of its lightweight and durability. A knowledge of the volume of waste generated by households will help authorities in strategizing, planning and formulation of waste management policies. Indiscriminate disposal of solid waste can be mitigated if municipal waste agencies provide door to door services and individuals are willing to pay for such services. It was observed that private sector was not actively engaged in waste management, thereby stressing the agency available. More collection points should be established close to residents, services rendered should not be limited only to urban areas. Individuals should be enlightened on the adverse effect of improper waste storage and disposal. It was seen that households where collection point is close were still discarding their waste to the surrounding. Further study should be carried out on the cost and durability of the prevalent types of solid waste storage containers in households.

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