Assessment of Municipal Waste Management in Gombe Metropolis for Sustainable Environment and Community Health

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Abstract
The management of municipal solid waste is one of the major environmental problems that big cities throughout the world face. Poor municipal waste management causes environmental degradation, which has an adverse effect on public health. In order to determine the types of waste products released into the environment in Gombe metropolis, survey of INEX final dumpsites as well as intermediate dumpsites from households and governmental institutions was conducted. The waste was classified in accordance with standard practices for classifying waste at landfills. Using Cronbach's Alpha, with a reliability co-efficient index of 0.72, closed-ended questionnaires were administered to gather primary data from 250 respondents. The quantity of indiscriminately dumped plastic waste was estimated using a sachet water production questionnaire. Due to their value as recyclable commodities, aluminum and other metal wastes are generally sorted most effectively in the city of Gombe. The majority of the waste collected in INEX dumpsites was inert waste (36.2 %), while water factories in Gombe Metropolis produced a total of 46,034 kg of plastic per day, which was likely discarded into the environment by water users daily. The results further reveal that health facilities were better than other public institutions in terms of waste sorting and disposal. Results from the three communities surveyed (urban, semi-urban, and urban-rural) showed that the metropolitan areas with adequate infrastructure—roads, well-designed houses, and wealthy residents—were more responsible in waste management. The three communities also showed a considerable variation in awareness and environmental consciousness. Poverty, ignorance/conservatism, and lack of essential social amenities are all directly connected with the three communities in Gombe metropolis's level of environmental awareness and waste management practices. We recommend appropriate education initiatives to guide the citizens on proper rubbish disposal. Government should also strengthen public-private partnerships in waste management and enact relevant legislation to empower enforcement officers.

Keywords: Waste disposal, Environment, Gombe, Community health, Dumpsites

Introduction
Wastes are generally undesired materials that are discarded because they are considered to be useless. Solid waste may refer to rubbish, refuse, garbage, and trash or any unwanted materials from industrialized processes or household activities (Sulemanu *et. al*., 2019). Solid waste management on the other hand involves the generation, collection, transportation, recycling and disposal of unwanted materials or waste. Waste management is also concerned with reduction in waste generation from source, through reuse and recycling.

Incidentally, poor waste management is a persistent problem that is only expected to get worse due to rapid growth in human population of metropolitan areas, particularly in developing countries; and the inability of local governments to fund the required waste management infrastructure (Sulemanu and Maigari 2016).

Waste production rates are rising on a global scale. According to a World Bank report, the quantity of solid waste produced by cities worldwide in 2016 alone was 2.01 billion tons, or 0.74 kilos per person

per day (World Bank, 2019). Open dumping is still the most common way of garbage disposal in most developing nations, and about half of the world's population (3.5 billion) lacks access to waste management services (UNEP, 2005). The volume of rubbish produced annually is astounding. It is uncertain how much waste humans produce, but industrialized nations account for a large portion of it (UNEP, 2005).

One of the main environmental issues facing big cities worldwide is municipal solid waste management (Gutberlet, 2017; Hussein & Mansour, 2018; Bakare, 2020; Zafar, 2020). Poor municipal waste management damages the environment and has a serious impact on public health. Several research (Abila & Kantola, 2013; Wilson & Velis, 2014; Saldana & Messina, 2018) have demonstrated that municipal solid waste disposed unscientifically in open dumps creates problems for human health and the environment. Uncontrolled waste disposal is also linked to drainage system blockages, which trigger seasonal flooding (Saidu and Danlami, 2018) and disease outbreaks (Abba *et al.,* 2021).

Urbanization and population increase are two major causes of waste production (Darbane & Hajilo, 2017). Today majority of people live in cities, especially in developing nations where people frequently move from rural to urban regions in search of better living conditions and jobs (Sharholy *et al.,* 2007; Khatib, 2011). Unexpected and unplanned waste generation always go hand in hand with population growth that is rapid. Cities in developing nations consistently produce more rubbish than they can manage (World Bank, 2019).

Waste management and its associated challenges have grown to worrisome proportions in Nigeria, and are now the most pressing environmental issues facing both urban and rural areas (Bakare, 2019). As a result, institutions responsible for providing municipal waste services frequently struggle to keep up with the cycle of waste production. It is increasingly common to find piles of solid waste strewn throughout public and private spaces. According to Bakare (2019), barely 20 to 30 percent of Nigeria's yearly solid waste production—more than 32 million tons—is collected. The 70–80% of wastes that are carelessly

dumped or not collected are frequently from inaccessible dumpsites, which are generated in urban-rural and semi-urban settlements and populations in most municipalities. Some researchers have attributed this to poverty, poorly planned neighborhoods and the huge cost associated with waste collection and disposal. Household solid waste is highly heterogeneous and generally dependent on the socioeconomic status of the households (Ahmed and Ali, 2004). Apart from constituting an eyesore to the urban environment, solid waste constitutes health hazards and threatens the health of man and animals (Ali *et al.,* 2016).

The magnitude of the solid waste problem in Nigeria is enormous. Public waste bins are inadequate, as the amount of trash that accumulates in a matter of hours would be more than waste collectors could haul in a day (Emankhu and Yamusa, 2018). In Nigeria, considerable volumes of waste are generated at an alarming rate due to increased urbanization (Oladipo *et al.,* 2011).

According to studies carried out by Nnaji (2015), the rate of solid waste generation in Nigeria has been put at an average value of 0.49 kilogram/capital/day. In their study of Lafia metropolis Ogah *et al.,* (2014) reported that the town has experienced increasing volumes of solid waste generation over the years, and with the establishment of Nasarawa Urban Development Board in 1996, one would have expected waste management practices to improve, but most parts of the town still look filthy. In Gombe state, the situation is even more worrisome as a result of the interplay or existence of inherent environmental challenges such as seasonal floods, desertification, dust storms and environmental illiteracy. These environmental issues make it expedient for stakeholders to take urgent actions in order to mitigate the concomitant challenges such as disease outbreaks (Mohammed *et al.,* 2019; Abba *et al.,* 2021; Ofuoku *et al.,* 2021) and declining environmental health) arising from improper disposal and management of waste (Galadima and Shehu 2018; Suleimanu *et al.,* 2019). Other studies (Downs & Acevedo, 2019; Nnaji, 2015), including the Federal Ministry of Environment (2005) have noted the alarming rates at which heaps of solid waste occupy cities and that 87% of Nigerians use methods regarded as unsanitary, which constitute

visual scourge and odour nuisance, encouraging the breeding of rodents, and mosquitoes with their attendant disease outbreaks' (Abba *et al.*, 2021). Efforts should therefore be made to see that waste is reduced to its barest minimum for environmental safety and better community health.

The aim of this study therefore is to assess solid waste management (challenges and prospects) in Gombe metropolis, Gombe State, Nigeria.

To provide recommendations that are well-informed in order to address the threat of solid waste accumulation and its detrimental effects on community health, the following objectives were pursued:

1. Evaluate how waste is handled before disposal and level of public awareness on proper waste management in various communities within Gombe metropolis.

2. Determine the material composition of waste in final dumpsites in Gombe metropolis.

3. Identify the challenges to efficient waste management in various communities of Gombe metropolis.

4. Determine the daily Sachet Water production capacity in Gombe Metropolis as a proxy to estimate the amount of plastic waste released to the environment.

Materials and Methods

Study Area

This study was carried out in Gombe metropolis, Gombe State. Gombe town is located in the North-Eastern region of Nigeria between latitudes $10^{\circ}15'N$ and $10^{\circ}19'N$ of the Equator and between longitudes $11^{\circ}07'E$ and $11^{\circ}15'E$ of the Prime Meridian (Abashiya *et al*, 2017). The projected (2016) population of Gombe Local Government stood at 367,500 persons (CITY POPULATION, 2020).
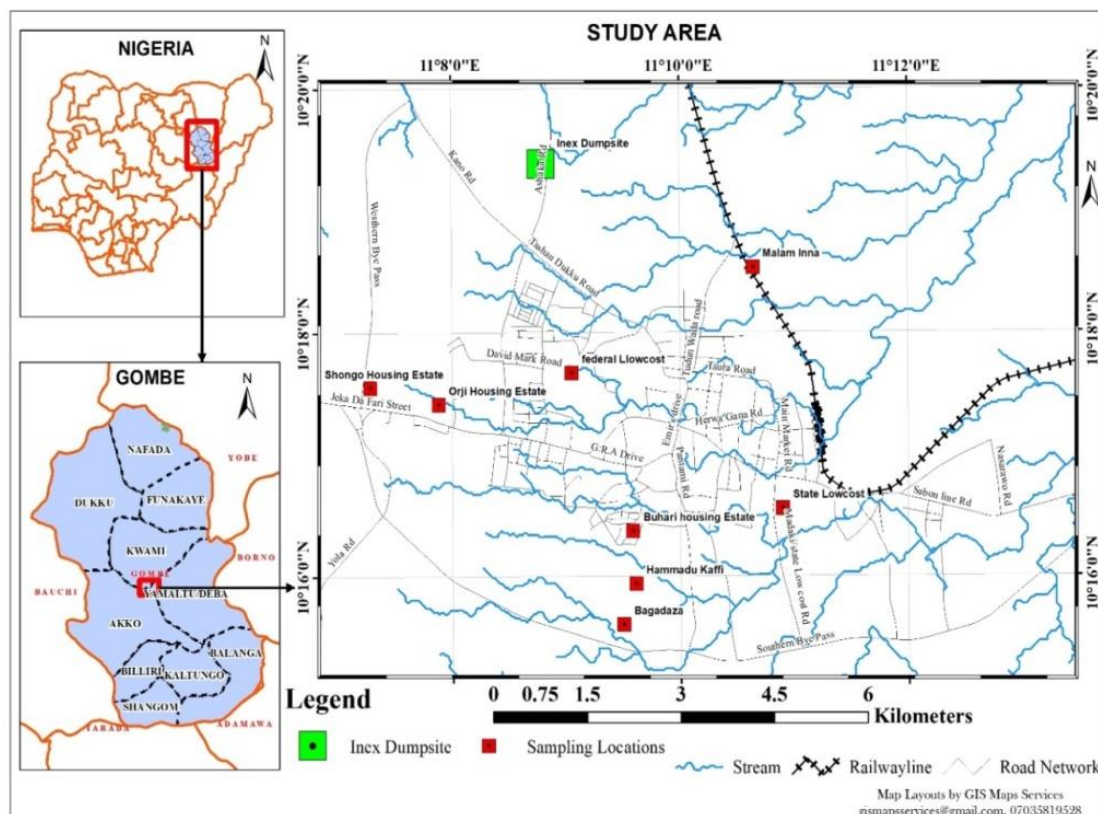

Figure 1: Map of Gombe metropolis showing final waste dumpsite and research sites

Data Collection

Dumpsites in the Study Locations

We characterized and sorted waste from INEX, the largest final dumpsite in the metropolis; located

$(10^{\circ} 18' 54''N \quad 11^{\circ} 3' 33'' E)$ along Gombe-Bajoga road about 6.5 Km from the city center, and 1.5 Km away from the Federal College of Education Technical, FCE (T) Gombe, the nearest human

settlement to the dumpsite. This study was a survey type of research. Waste characterization was carried out in the final dumpsite in Gombe metropolis. A total of 24 days was spent during a four-week long survey of the INEX dumpsite and two random sites from the urban-rural and semi-urban communities. Six days each week (Monday to Saturday), 20 Kg of solid waste was sorted to determine the composition of the waste. A total of 120kg of waste was sorted each week at the INEX dumpsite, in total, 480 kg of waste was sorted at the end of 24 days of field survey. Waste characterization was consistent with the Standard practices for classification of solid waste in a landfill (Oyelola & Babatunde, 2003; Moya, 2011),

Twenty (20 Kg) of solid waste was taken immediately a waste truck offloads the waste at the final dumpsite. The waste taken was emptied on a tarpaulin earlier spread on a flat surface. The waste was then sorted into its various components. Any component of waste less than 500 g was weighed using a Triple Beam Balance with maximum weight capacity of 500 g. Any waste component more than 500 g was weighed using a Camry weighing scale with a maximum weight capacity of 100 Kg.

Administration of Questionnaires
A close-ended questionnaire (Waste Management Questionnaire, WMQ) was designed to elicit responses from respondents. Gombe metropolis was divided into three varying communities designated as 'Urban'; 'Semi-Urban'; and 'Urban-Rural' communities. This division was used as study locations or areas to draw inference on the general practices across various communities in the metropolis.

The questionnaire was first pilot tested in Billiri town, in Billiri L.G.A. of Gombe State. Cronbach's Alpha was used to determine the reliability index of the instrument. The reliability value ranges from 0 to 1, with values close to 1 suggesting a high reliability while values close to 0 a low reliability. However, a reliability index of 0.72 was obtained after testing the questionnaire.

Stratified random sampling technique was used in drawing a sample of 250 households from the three (3) different communities that responded to the questionnaire. The number of respondents differed across the three communities. Respondents were randomly selected. Sixty-three (63) of the respondents were selected from Urban community (GRA), ninety (90) respondents were drawn from Semi-Urban community (federal low cost and Orji estates), while ninety-seven (97) respondents were drawn from the Urban-Rural community (Mallam Inna, Bagadaza and industrial area). However, a total of 234 (93.6%) households responded to the questionnaire. 58 from the 'Urban' community; 89 from 'Semi-Urban' community, and 87 from the 'Urban-Rural' community.

Data were also generated through key informant interviews from relevant government agencies/ institutions such as Directorate of Quality Assurance of National Environmental Standards Regulation and Enforcement Agency (NESREA) Gombe; Operations Department of Gombe State Environmental Sanitation and Protection Agency (GOSEPA); Directorate of Environment, Ministry of Environment, Gombe State.

Data Analysis
Data was analyzed using SPSS (Statistical Package for Social Sciences) version 21. Descriptive statistics was used for data analysis and results were presented in tables and figures. Paired samples t-test at $\alpha \leq 0.05$ level of significance was conducted to test mean differences across groups.

Results
The questionnaires were explored to extract responses from 234 respondents who returned valid responses of the 250 questionnaires administered. The respondents and institutions (Hospitals, schools, mini-factories) differed in the way and manner they handled or managed their waste materials irrespective of the community; Urban, Semi-urban and Urban-rural. There was a strong association between type of community and effective waste management practices (Table 1).

Table 1: Waste handling and storage in Gombe metropolis

S/No.	Institution	Community type	Type of waste	Segregation	Incineration	Recycling	Storage Space
1	Specialist Hosp. Gombe	Urban	Hazardous waste, Plastic, Paper, Food remains, Plant material	Yes	No	No	Available
2	Women & Children Hospital Gombe	Urban	Hazardous waste, plastic, paper, Food remains, plant material	Yes	No	No	Available
3	FTH Gombe	Urban	Hazardous waste, plastic, paper, Food remains, plant material	Yes	Yes	No	Available
4	PHC Dept. Gombe	Urban	Hazardous waste, plastic, paper, Food remains, plant material	Yes	Yes	No	Available
5	PHCC Pantami	Urban-Rural	Hazardous waste, plastic, paper, Food remains, plant material, Hazardous waste, plastic, paper, Food remains, plant material Aluminium.	Yes	No	No	Available
6	PHC Kumbia-Kumbia Gombe	Urban-Rural	waste, plastic, paper, Food remains, plant material Aluminium	Yes	No	No	Available
7	Thagama Medical Clinic	Urban	Hazardous waste, plastic, paper, Food remains, plant material, Aluminium can.	Yes	No	No	Available
8	Maidugu Guest Palace	Urban	Paper, Plastic, Plant Material, Aluminium Can, food remains.	No	No	No	Available
9	Bulma Guest Inn	Urban	Evacuated	No	No	No	Available
				No	No	No	Available
10	GDSS Herwagana Gombe	Semi-Urban	Paper, Plastic, Plant material.	No	Yes	No	Available
11	GSTC Gombe	Semi-urban	Paper, Plastic, Plant material.	No	Yes	No	Available
	Hassan Central Primary School	Urban	Paper, Plastic, Plant material, Food remains	No	Yes	No	Available
12	GSSS Gombe	Urban	Paper, Plastic, Plant material, Food remains	No	Yes	No	Available
13	GDSS Pantami	Urban-Rural	Paper, Plastic, Plant material,	No	Yes	No	Available
	Gombe Pharmacy & Store	Urban		No	No	No	Available
14	Fidelity Bank	Urban	Paper, Plastic	No	No	No	Available
	Main Market Gombe	Semi-Urban	Paper, Plastic, Plant material, Textile.	No	No	No	Available

Results showed that Inert waste (36.2 %) was the most abundant waste material in the final

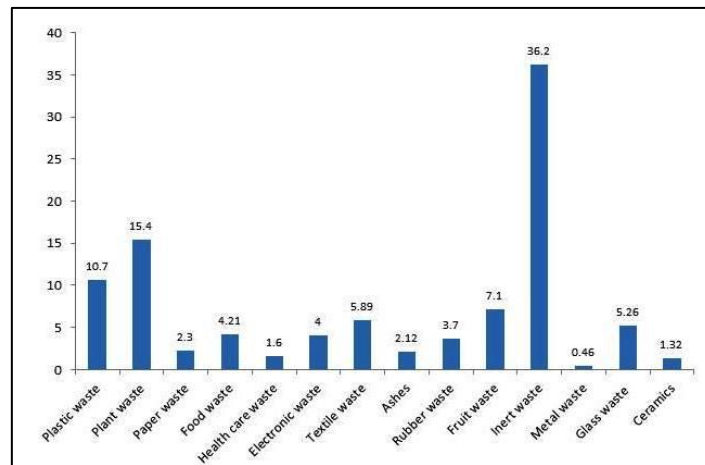dumpsites, while metallic waste was the least abundant (0.46%) (Figure 2).

Figure 2: Composition of solid waste in INEX final waste dumpsite in Gombe metropolis (*values are percentages*)

To compare how the various communities differed in their level of awareness of health implication of waste management we performed a paired sample t-test; results was as follows; Urban vs. semi urban (t4.48 df (87), p>0.00); Urban Rural vs. Urban (t5.74 df (56), p >0.00) and semi-urban vs. Urban-rural (t2.7 df (56), p>0.00) (Table 2).

Similarly, t-test to identify the various challenges encountered across the three communities revealed a significant difference between groups. Urban vs. semi urban (t19.24 df (87), p>0.00); Urban Rural vs. Urban (t23.74 df (56), p >0.00) and semi-urban vs. Urban-rural (t1.85 df (56), p>0.00) (Table 3).

Table 2: Respondents level of Awareness of implication of poor waste management Practices to environment and community health in Gombe metropolis. (Ur=urban, S-ur=Semi urban, Ur-R= Urban-Rural)

S/No.	Item	Mean Ur	SD	Mean S-Ur	SD	Mean Ur-R	SD	Average Mean	Rank
1	Indiscriminate waste disposal causes blockage of water ways.	4.58	0.95	4.36	0.96	4.35	0.95	4.43	1st
2	Waste serves as breeding ground for vectors of diseases e.g., Mosquitoes.	4.64	0.85	4.48	0.66	4.14	0.85	4.42	2nd
3	Improper waste disposal causes outbreak of diseases.	4.60	0.82	4.32	0.86	4.23	0.82	4.38	3rd
4	Wastes are breeding ground for dangerous animals e.g. scorpion.	4.69	0.81	4.26	0.86	4.09	0.81	4.34	4th
5	Wastes causes air pollution by producing foul smelling gases	4.64	0.86	4.34	0.76	4.02	0.86	4.32	5th

Table 3: Challenges to efficient waste management in Gombe metropolis. (Ur=urban, S-ur=Semi urban, Ur-R= Urban-Rural)

S/No.	Item	Mean Ur	SD	Mean S-Ur	SD	Mean Ur-R	SD	Average Mean	Rank
1	Government should re-enforce the monthly sanitation exercise in Gombe metropolis.	4.34	0.52	4.58	0.91	3.83	1.23	4.25	1st
2	Keeping water for too long in open containers serves as breeding grounds for mosquitoes.	4.56	0.52	4.65	0.64	3.63	0.87	4.28	2nd
3	Indiscriminate dumping of waste results in the spread of diseases in Gombe metropolis	4.59	0.59	4.36	1.10	3.64	1.12	4.20	3rd
4	Sorting of waste encourages recycling of waste in Gombe metropolis.	0.57	0.52	4.35	1.17	3.59	1.29	4.17	4th
5	Sorting of waste reduces the bulk of waste being dumped in Gombe metropolis	4.59	0.49	4.36	1.51	3.47	1.21	4.14	5th

We used the production capacity of twenty-nine (29) pure water factories in Gombe to estimate the amount of plastic waste released into the environment on daily basis after production (Table 4). We hypothesized that most of the plastic waste from sachet water consumption do not end up in the dumpsite, hence indiscriminately disposed to the environment. We found that 20 (69%) of pure water factories produce between 11000 and 50,000 sachets of packaged water daily (Table 4). Further evaluation shows that a total of 1,335,000 sachets are produced daily in Gombe Metropolis while an average of 46,034 sachets was produced daily by the 29 pure water factories in Gombe.

Table 4: Capacity of sachet water Production in Gombe metropolis (Daily)

Capacity	Number of sachet water factories	Sachet water Produced	Mean sachets produced
Less than 10,000 sachets	2	13,000	6,500
11,000 - 50,000 sachets	20	382,000	19,000
50,000 -100,000 sachets	3	160,000	53,333
101,0000-150,000 sachets	3	460,000	153,333
320,000 sachets	1	320.000	320,00
Total	**29**	**1,335,000**	**46,034**

Discussion

Waste handling/treatment in Gombe Metropolis
One of the core objectives of this survey was to determine how waste is handled in Gombe metropolis. We visited households, health institutions, businesses and educational institutions to observe how they handle the waste they generate (Table 1) The results show that waste is handled differently by different persons, institutions and communities in Gombe metropolis. Health institutions handle waste according to the provisions of the laws governing health care waste (HCW) generation. All Health Care Institutions from primary health care centres to tertiary health care institutions are provided with the differently coloured containers for the various wastes they generate and the staff adhere to the instructions regarding segregation of waste. Worthy of note is that Primary Health Care Centre (PHCC) Gidan Magani Gombe and the Federal Teaching Hospital (FTH) Gombe have incinerators where hazardous medical waste is burnt under controlled conditions within the health facility.

Business institutions such as banks, hotels, restaurants etc. have storage facilities where waste is stored before it is transported for disposal. Most educational institutions (primary and secondary) do not store their waste mostly paper and plastic waste from pure water sachets and processed foods (snacks etc.); they practice open incineration (open burning) of the waste they generate in specific locations within their premises. This according to Nwufo, (2010) and Ezechi, *et al.*, (2017) contributes to atmospheric pollution. All institutions surveyed do not recycle their waste and rely on waste management agencies to recycle whatever materials are considered useful.

Our field survey of the respondents living quarters, reveal that unsanitary practices are more common among the Urban-Rural settlement as opposed to Urban and semi-urban communities. For instance, we estimated the minimum and maximum distance of waste dumps from each of the communities; we found an average distance of 30 meters between houses in urban communities and their temporary dumpsites, while semi urban and urban-rural were less than 5 meters each. We also observed the presence of GOSEPA (Gombe State Environmental Sanitation and Protection Agency) built waste dumps. Unfortunately, houses have been erected near this temporary dump sites posing serious health risk and air pollution to inhabitants of these ill-planned houses. Similarly, in urban-rural communities, residents have made unoccupied and undeveloped plots of land their dumpsites, while some households throw their waste over the wall from their houses. This result supports the assertions of the World Bank, (2019); Bakare, (2019) and Waste Res., (2019) that uncollected and improperly disposed wastes cause environmental impacts resulting in serious health problems that lead to outbreaks of communal diseases claiming lives of the people.

Waste Characterization and composition in Gombe metropolis
We evaluated various waste dumps and dumpsites to determine the composition of waste. This approach was informed by the need for proper solid waste management planning, which requires knowledge of the composition and quantity of municipal solid waste generated daily or annually. The results reveal that, inert materials (36.20%) are

the major component of municipal waste, followed by plant debris with (15.40%) and plastic waste (10.70%) (Figure 2). Aluminum and other metal waste is absent from the list of waste components. This indicates that these wastes are efficiently segregated from wastes at source before disposal. Children are often seen running after waste pickers with domestic recyclable items for exchange with ice cream, sweets, chewing gum or sometimes money. Women as well segregate aluminum waste for recycling into pots for domestic use. The implication is that metals have after disposal value which has been understood and utilized. Generally, most of the components of waste in the final dumpsites in Gombe metropolis are recyclable; this is in agreement with Gutberlet, (2017). This result also supports the work of Khatib, (2011) that most waste being generated in developing countries are decomposable.

Respondents' perceptions of the Impact of waste on the Environment and Community Health in Gombe Metropolis
In most studies, waste handling and disposal is often associated with the level of awareness of the health implications of a clean environment and the consequences of indiscriminate waste disposal to human health. Our results show that Urban community respondents strongly agree that waste distorts the environment, affects its beauty, causes air pollution; and serve as breeding ground for dangerous animals and vectors of diseases, even of epidemic proportion (Ezra *et al.*, 2021). Furthermore, the respondents were aware that indiscriminate waste disposal blocks water ways; while burning of waste indiscriminately in open dumps leads to pollution of air, land and water. These views were the same even among the Urban-rural and semi-urban communities, begging the question why majority of them still dump waste indiscriminately. Our findings are in tandem with the work of Abdelah and Balla, (2013).

We ranked the views and perception of the respondents in order of strength of agreement with our close ended questions (1st, 2nd, 3rd 4th and 5th rank order) (Table 2 and 3). The results are in concordance with Downs and Acevedo, (2019) who stated that improperly disposed waste constitute visual scourge, odour nuisance, breeding grounds

for rodents, mosquitoes and attendant disease outbreaks.

Public Awareness on Proper Waste Management in Gombe Metropolis

We observed that residents of urban communities are familiar with standard waste management practices (waste segregation, use of specified waste bins usually color differentiated into plastic, biodegradable and recyclable). Residents of Urban areas also displayed a good understanding of the implication of indiscriminate waste dumping on community health and environment. The urban community were in agreement that the monthly sanitation exercise should be reinforced; and that government should introduce waste tax for proper waste management. Similarly, respondents/residents of semi-urban communities shared same views except that they were mostly undecided on the distance waste bins or dumps should be from residential areas. However, they strongly agree that government should reinforce the monthly sanitation exercise.

On the contrary, Urban-rural communities were quite uncertain and divided on the standard measures to be adopted as stipulated in the questionnaires. They were partly of the opinion that waste management should be largely borne by the government and do not quite comprehend the implication of waste sorting, recycling and the consequences of indiscriminate waste disposal on environmental and community health (Ehizemhen and Abubakar, (2018). They were however in agreement with the need to reinstate the monthly environmental sanitation in the state.

Challenges to Efficient Waste Management in Gombe Metropolis

Every metropolitan city today is faced with waste management challenges as a result of unceasing migration of people from rural to urban centers and the attendant housing and population issues (Ezekiel *et al*., 2021). The high population growth rate in metropolitan cities means there will be pressure on social amenities; the implication also is that anthropogenic footprints will be visible everywhere of which solid waste is a major constituent. In Gombe metropolis with a population of over 367,500 residents, the situation is not any better or different from mega cities like,

Lagos (Oyelola and Babatunde, 2003), Porthacourt and Kano; albeit that the scales do vary, but the challenges are the same. In this study, the challenges differed slightly amongst the three communities; the Urban community for instance perceive the following as challenges to efficient waste management in Gombe metropolis: lack of enforcement of environmental laws; population increase in the metropolis; ignorance of extant laws. These challenges according to Lagerkvist and Dahlen, (2012) make it difficult for government to manage waste effectively.

In the same vein, the Semi-Urban Community while acknowledging the poor management practices by residents and households, identified the following as challenges of waste management within their communities; Improper and indiscriminate waste disposal methods, lack of public sensitization on waste management; and lack of enforcement or absence of legislation

In the case of Urban-Rural community they cited lack of enforcement of environmental laws as one of the causes of improper waste disposal; lack of recycling practices to reduce waste accumulation and quantity available for disposal. This result agrees with (Nwufo, 2010; Ezechi, *et al*., 2017; Bakare, 2019). They also identified the need for government to provide incinerators and designated places for transit waste or temporary dumpsites to be periodically evacuated by environmental personnel. However, based on the respondents' views, we came to the sad conclusion that the major problem hindering proper waste management in Rural Urban communities is the attitude of the people. They have poor sanitary habits and engage in indiscriminate waste disposal even when there are other healthy and less expensive alternatives to manage waste (Ezekiel *et al*., 2021).

On a general note, results across the three communities reflect the conclusions of the World Bank, (2019); Jassim, (2017); Lagerkvist and Dahlen, (2012), Ehizemhen and Abubakar, (2018) that population increase, lack of enforcement of regulatory laws, poor town planning, indiscriminate dumping of waste as challenges to effective waste management in developing countries. One peculiar reason for the differences across the three communities is perhaps the sharp differences in the

distribution of social infrastructure, socio-economic setup, and attributes of the residents in the various communities.

Sachet Water Generation in Gombe Metropolis: As proxy to determine the amount of plastic waste released to the environment

Plastic waste, apart from their non-biodegradable nature, are amongst the most common waste materials in most cities in developing countries. In this study we estimated the production capacity of pure water factories in Gombe as a proxy in determining the amount of plastic waste after consumption. Almost every household, irrespective of status (urban, semi-urban or rural-urban) depend on sachet water daily. These empty sachets are often indiscriminately discarded by users in public places and those commuting from one part of the city to the other. A survey of sachet water factories shows that all sachet water producing factories produce water sachets on daily basis (Table 4). While the bulk of the sachet water is consumed in Gombe metropolis, with some transported to other neighboring towns.

From available statistics (Table 4), one million three hundred and thirty-five thousand (1,335,000) sachets of water are produced on daily bases in Gombe metropolis. In other words, 1,335,000 waste water sachets are dumped in the environment daily. This becomes a source of concern when viewed in terms of kilograms of plastic being introduced into the environment. For every 12kg of plastic, 400 bags of twenty sachets are produced. To produce 1,335,000 water sachets, 40,050 kg of plastic is used. This implies that 40,050 kg of plastic waste is being dumped into the environment daily. Annual projection indicates that 11,214,000 kg of plastic is being dumped in the environment from sachet water factories alone. The figures could be higher than the records available because some sachet water producing factories were unwilling to respond to the data collecting instrument, while some were temporarily out of production.

Sachet water is used daily by almost every household in Gombe irrespective of economic status. Regrettably, the empty sachets are not recycled unlike bottle water plastics. Moreso, plastic waste is among the most obnoxious human

waste and the most abundant these days. This study suggests that most of the plastic generated does not make it to the final dumpsite for treatment or recycling.

Conclusion

This investigation was done to learn how solid waste in the Gombe metropolis is handled from generation to disposal. The findings show that waste management practices vary among communities and institutions. The final dumpsite's waste has no aluminum. The absence of aluminum and other types of metal trash indicates that metals are separated from waste because they have value after disposal (recyclable). The findings also show that only a small percentage of those who recognize the value of recycling plastic garbage have focused on its advantages. In addition, this type of waste is one of the most offensive and harmful to the environment among non-biodegradable waste products. The study has revealed some of the obstacles to effective waste management, as well as the effects of waste on the environment, community health, and how well the general populace in Gombe metropolis understands and manages its waste.

Recommendations

Residents should be responsible for the waste the produce and take timely action to avoid accumulation. Government should reinforce the monthly sanitation exercise in Gombe metropolis as the results of this study suggest. Government should encourage public-private partnership (PPP) to establish an integrated waste management facility for efficient waste management in Gombe metropolis. Finally, Government should create awareness on impacts of indiscriminate dumping of waste and enforce penalties for non-compliance to environmental laws.

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