Mapping of Existing Solid Waste Dumpsites Using Geographic Information System in Kaduna South Local Government Area

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Abstract

Indiscriminate dumping of solid waste on the environment poses a serious environmental problem in many countries of the world including Nigeria. Kaduna South local government area has over the years experienced increased waste generation and illegal disposal sites, due to population surge and poor waste management approaches. This study therefore attempts to map existing solid waste disposal sites in Kaduna South Local Government Area; using Geographic Information System and Remote Sensing techniques for improved environmental sustainability. The ArcGIS software version 10.0 was used to geo-reference the digitised map, create different layers showing spatial distributions of features in relation to usable dumpsites for analysis. Global Positioning System was used to determine the location of solid waste dumpsites using coordinates based on Universal Traverse Mercator system for mapping. Findings of the study show among other things that the present dump sites in the study area are located farther away from each other within the study area. Result of study shows that a buffer of one hundred meter (100m) is sufficient to optimise possible sites for aesthetic considerations. Solid waste dumpsites are found to be located less than 100 meters off streams, major highways, city streets or other transportation routes; creating serious mobility problems in the area.

Key words: Solid waste, Geographic information system, suitable dump sites, environmental problems, population surge, Kaduna South Local Government Area

Introduction

Waste has been recognised as one of the major problems confronting governments and city planners in Nigeria, thereby posing serious threat to environmental quality and human health (Ogwueleka, 2009). Generally, Waste creation by man is inevitable, consequent upon development of the environment and service provision (Techobanoglous and Frank, 2002). World Health Organisation expert committee held in 1995, considered waste as unwanted or discarded materials that arise from man's activities. As a result of our daily activities to survive, we produce waste in millions of tons annually (Sener, Sener

and Karagüzel, 2010). Waste is either an asset or liability depending upon our attitude towards it. The principal sources of Solid Waste in an urban area according to Sener, Sener and Karagüzel (2010), are: municipal, (from street sweeping, sewage, waste from schools, markets and other institutions); domestic, (garbage, rubbish and often large waste from homes); commercial (from stores and offices); industrial (from manufacturing plants); mining, (from coal mining and strip mining.), construction and demolition (new construction sites, road repairs, renovation sites, raising broken pavements) and agriculture practices.

Singh (2009) classified solid wastes as follows:

i. **Garbage:** these are waste from food, slaughter houses, canning and freezing industries.
ii. **Rubbish**: non putrescible wastes, either combustible or non-combustible. Combustible wastes, either combustible or non-combustibles include metals, glass, ceramics, stones, dirt, masonry and some chemicals.
iii. **Ashes:** residues (such as cinders and fly ash) of the combustion of solid fuels, for heating and cooking or the incineration of solid waste by municipal, industrial and apartment house incinerators.
iv. **Large wastes** from demolition and construction rubble, automobiles, furniture, refrigerators, and other home appliances, furniture, refrigerators, and other home appliances, trees, tires among others.
v. **Dead animals** – household pets, birds rodents and zoo animals
vi. **Hospital Waste** – anatomical and pathological wastes from hospitals.
vii. **Sewage treatment process** – screenings, settled solids, sludge
viii. **Industrial solid waste** – chemicals, paints, and explosives.
ix. **Mining Waste** – tailings, slag heaps, culm piles at coat mines.
x. **Agricultural wastes** – farm animal manure, crop residues etc.

Municipal Solid Waste (MSW) are commonly known as trash or garbage consisting of rubbish, market spoils, leftover food stuffs, construction and demolition debris, street trash, non-hazardous industrial refuse, treated biomedical solid, abandoned vehicles and electrical parts (Singh, 2009). MSW generated in most urban centres of Nigeria are creating serious environmental problems, as a result of improper waste disposal management. This is because, in many of these areas, heaps of municipal solid wastes are found along major roads, stream channels, river banks and in open spaces (Aliyu, 2010).

Solid waste proliferation is considered a major consequence of economic growth, development and rapid population growth (Singh, 2009). Some of the greatest challenges to its management are most keenly felt in less developed countries of the world (Elizabeth, 1998). Solid waste is usually used to describe non-liquid materials from domestic, trade, commercial, agricultural and industrial activities, as well as from public services. Solid waste therefore consists of any refuse, sludge, discarded materials, small amount of liquid, semi-solid substance among others (Ezeah, Roberts, and Phillips, 2010). In rural or urban areas of Nigeria, the volume of solid waste being generated continues to increase, coupled with lack of infrastructure for adequate waste treatment and disposal of waste. Nigeria with a population growth rate of about 2.8% per annum and an urban growth rate of about 5.5 % per annum generates about 0.58 kg solid waste per person per day (Babyemi and Dauda, 2009). Due to high rate of urbanisation in Nigeria, like other developing countries of the world, more solid waste is generated and not properly disposed; hence culminating in to an environmental degradation problem (Filemo and Uriat, 2008). Solid waste disposal therefore, is one of the major global environmental problems. The problem is severe in most cities of developing countries, where recycling of waste is not sufficiently practiced (United Nations, 2010).

In recognition of these challenges and the increasing waste generation, the government in Nigeria has attempted to tackle waste management issues through some approaches such as policy development that involves consistent evacuation of waste, waste designation collection point by waste management agencies, among others (Ogwueleka,

2009). Waste management is the collection, transportation, processing, recycling or disposal of waste materials. The term usually relates to materials produced by human activities and it is generally managed to reducing their effects on human health, the environment and its atheistic value (Babyemi and Dauda, 2009).

Due to unsustainable waste management practices in Nigeria that involves techniques such as waste reduction, recycling, thermal treatment, and waste dumpsites; the municipal solid waste management system has been inefficient (Ayo and Ibrahim, 2010). Mapping of solid waste dumpsites for proper waste management is a major environmental issue, because of the problems associated with solid waste such as; water contamination, health hazards, and damage to the biophysical environment (Mokhtar, Zurina, MarksonandAminuddin, 2008). Due to increasing human population vis-a-vis waste generation, there is need for new suitable landfill sites every few years that would be useful in managing the waste generated.

The availability of bare land in most urban centres of Nigeria for indiscriminate municipal solid waste disposal has resulted to environmental degradation; and has made it difficult for sitting of dumpsites as an option for managing municipal solid waste. This common place scenario in Nigerian urban centres has created difficulty in choosing suitable locations for solid waste dumpsites. This is more so because, locating solid waste dump sites is confronted with planning permits and sitting requirements for operation, which could take months or years for approval of construction and operation, thereby leading to a waste management deadlock (Akpe and Aondoakaa, 2009). Allen, Brito and Caetano (2013) observed that mapping of suitable solid waste dump sites is essential for managing waste sustainably. This is meant to curtail environmental degradation, ecological and social damage (Allen *etal*, 2013). It is therefore imperative to seek a suitable site that ensures environmental conservation and sustainability. However, the process is complicated and time consuming because it must conform to environmental regulations.

Waste collection and disposal strategy differs from one country to another. Land filling, incineration and recycling are often used in developed countries to dispose

municipal solid waste; but in developing countries like Nigeria MSW are often disposed in an unsustainable manner open dumps, streets, ravines and in some cases into drainages; which eventually flow into streams; and thereby poisoning the sources of water to the people residing in such localities (Ayo and Ibrahim, 2010).

- Production or consumption residue.
- Product whose date for appropriate use has expired.
- Contaminated or soiled materials.
- Substances that no longer perform satisfactorily".

The management of solid waste requires adopting appropriate management techniques that involves less environment degradation impacts. The sustainability of solid waste management in urban centres like Kaduna South LGA requires the identification of suitable dump sites; as well as adopting appropriate solid waste management techniques. This is to ensure that the environment is conserved for sustainable development.

Geographic Information System (GIS) techniques are therefore, veritable tool for effectively selecting suitable solid waste dumpsites (Sener, Sener and Karagüzel, 2010). GIS can be utilised in the search for suitable new waste dumpsites because it allows accurate processing of spatial data, efficient storage, retrieval, analysis and visualisation of information from a variety of sources; and enabling tailored solutions to observed problems. GIS can be used as a tool to aid decision-making process in solid waste management. It can process large amounts of data in a short time and also help in storing the links between environmental issues and potential impact of environmental variables on the environment. However, the capability of GIS can be hampered due to digital data availability.

Over the last decade, many developing urban centres in Nigeria have been faced with the challenge of managing solid waste, as a result of increased waste generation and improper disposal sites (Aliyu, 2010). MSW disposal in Kaduna South Local Government Area (LGA) remains a challenge due to indiscriminate dumping of solid waste along roads, river banks and any open space available. Therefore, the siting of suitable waste dumpsites has become necessary for waste management in the area. It is against this backdrop that

this study attempted to locate and map suitable solid waste dumpsites; needed to ensure that collected municipal solid wastes are properly disposed in designated areas to enhancing sustainable waste management in the area.

Study area

Kaduna South Local Government Area is situated in southern part of Kaduna State, Nigeria. It has its headquarter in Makera town. It has an area of 59km^2 and a population of 402, 390 (National Population Commission, 2006). Kaduna South LGA is located between latitude 10° 30'N and latitude 10^0 30' of the equator and longitude 8^0 25' E and longitude 7^0 29' E (Fig.1). The area lies in the northern guinea savannah zone, which is characterised of two distinct seasons. That is the wet and dry seasons. The wet season starts in the month of May through to the mid of October with intense concentration of rainfall in the month of July and August. The amount of rainfall received in this area ranges from 1700mm^3 to 1755mm^3. The dry season begins in late February through to the month of April. This season is usually accompanied with rampant diseases such as measles, malaria fever, typhoid fever, conjunctivitis (Apollo), diarrhoea, dysentery among others (Aliyu, 2010). The harmattan period which is part of the dry season starts in late December through to the early part of February.

The relative humidity in this area exceeds 30%, and fluctuates between 70% - 80% from June to September. Temperature ranges between 8°C - 10°C with highest temperature in March - April (35°C – 40^{o}C) and the lowest temperature in the months of December through January (20°C - 25°C). This period is usually replete with haze and dust regimes. The nature and type of vegetation originally found in the study includes tall grasses *(andropogon),* stubborn grasses, and moderately tall grasses, grassland and scattered vegetation. Common species of vegetation in the study area include among others: isoberlina, sheabutter trees, maligna trees, mango trees *(mangnifera indica).* Vegetables and fruits found in the area are: paw-paw, guava, citrus trees, grapevine, grapes, pears and eucalyptus species among others. Agricultural products in this area are mostly cereals such as Sorghum, Maize, Guinea Corn, and vegetables such as Carrots, Onions, Pepper, Garden

eggs, Cabbage, Lettuce, and Spinach (market gardening). These are mostly cultivated in fadama areas and along river banks; while staples are brought in from the suburbs. Economic activities of the people in this area are majorly administrative and commercial activities such as petty trading, food selling, groceries outfit, transportation, water vendors among others. Small populations of the inhabitants are farmers while others engage in poultry farming, (small scale) animal husbandry and fish farming.

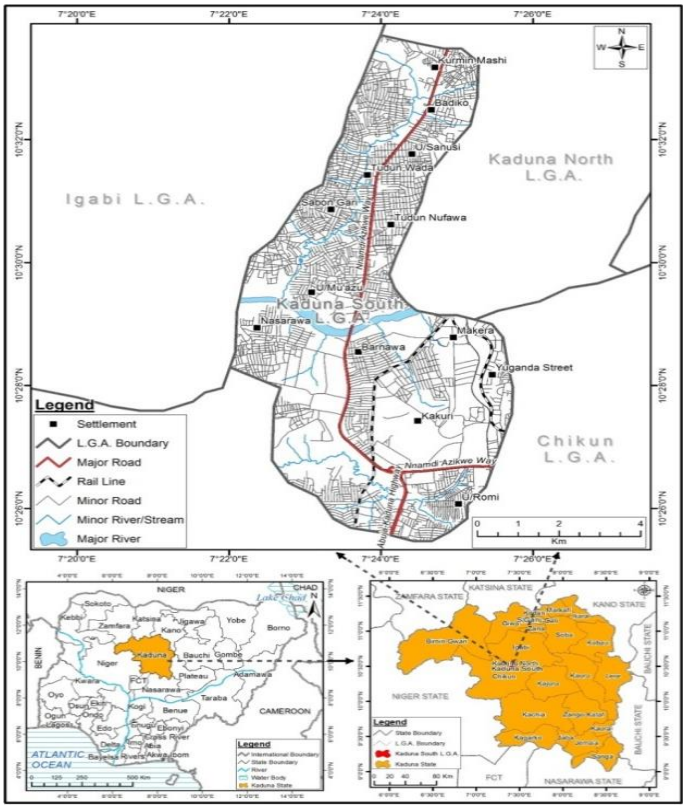

Fig. 1: Map of Kaduna State showing the study area

Source: Ministry of Land, Housing and Urban Development Kaduna State (2018)

Materials and methods

This study was carried out in Kaduna South LGA of Kaduna State. The research design adopted for this study was observational design that ensured direct field observation; and taken of readings from the field as regards location of solid waste

dumpsites in the study area. The Global Positioning System (GPS) was used to obtain the coordinates of the existing solid waste dumpsites in the study area based on UTM system, Administrative map of the study area was then digitised using a laptop computer and scanner to identify the proximity of existing dumpsites to major roads, minor roads, streams, rivers and facilities based on the coordinates obtained from the field.

To establish the location of dumpsites, the ArcGIS verion 10.0 software was used to georeference the scanned map of the existing dump site and to create different layers showing the spatial distributions of dumpsites in the study area; and various layers were created such as the different types of roads, railway and water bodies. The criterion used to assess the proximity of solid waste dumpsite to the public utilities such as roads, rivers, rail, and settlement was based on the National Environmental Standards and Regulations Enforcement Agency (NESREA) rules for siting dumpsites. It is an agency responsible for enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria, as well as enforcing compliance with provisions of international agreements, protocols, conventions and treaties on the environment to which Nigeria is a signatory. NESREA recommended that any solid waste dumpsite should be sited 100 metres away from public utilities. Buffer analysis was carried out in the ArcGIS environment to determine the proximity of dumpsites to public utilities and natural resources like streams and rivers.

Identification of locations for solid waste dumpsites in the study area

Identification of location for dumpsites was done by creating a buffer zone of 100m away from the public utilities as stipulated by NESREA regulations in the ArcGIS environment based on the coordinates collected from the field for mapping. All the areas that fell below the 100m buffer zone from public utilities were considered not suitable for the location of the dumpsites in the study area. Hence, all location of dumpsites proposed in the study were those areas that met the minimum requirement of 100m buffer criterion as recommended by NESREA.

Results and Discussion

Location of existing solid waste dumpsites in the study area

Solid wastes have become recurring features in our urban environment. It is no longer in doubt that our cities are inundated with the challenges of un-cleared solid wastes. Thus, urban residents are often confronted with poorly managed waste which oftentimes becomes hazardous to their collective health and safety. The increased worry over the health consequences of exposed and fermenting rubbish remains a thing of concern, with the impacts been quite noticeable Nwocha et al (2011). Results of the analysis on location of existing solid waste dumpsites in the study area is shown in Figure 2.

Figure 2 shows that most of the solid waste dumpsites identified in the study area and mapped were not located 100m away from public utilities. The implication of this is that the location of these solid waste dumpsites was observed to have negative impacts on the environment. For instance, most of the dumpsites like the one located at Kakuri and Makera among others were located very close to the major roads. These solid waste dump sites are capable of obstructing movement on such roads and poisoning surface water for those close to stream source. The dumpsites located at Nasarawa settlement is very close to the streams which has implication on the quality of surface water in the area.

The solid wastes collected in such dumpsites are likely to pollute the streams and thereby, affecting human health in the area. The dumpsites located at Barnawa and SabonGari settlements are located in built-up areas. It was observed that in such built-up areas with high population density, solid waste dumpsites were found to be few. This situation probably gave rise to the usage of open space dumping of solid waste as was observed in the field in the course of this study.

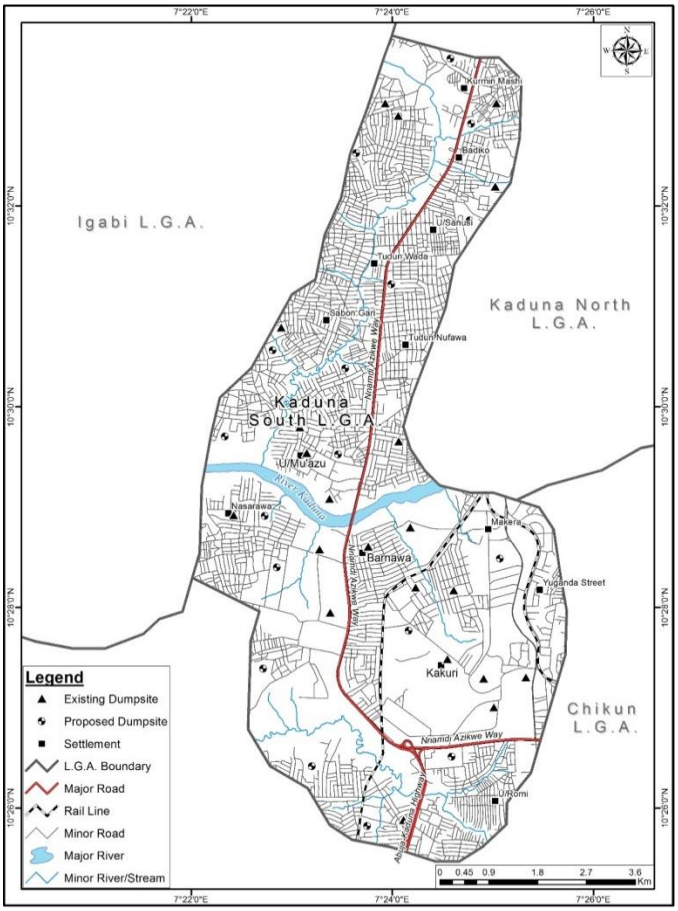

Fig. 2: Location of existing and proposed dump sites
Source: Authors' analysis, 2018

The findings of this study confirmed those of Nkwocha, Pat-Mbano and Dike (2011) in Owerri, where they discovered that solid wastes were deposited along motor ways, and thereby obstructing the free flow of traffic as well as, generating offensive odour to the neighborhood and unpleasant sight to the people. Nkwocha*et al*, (2011) also observed that inadequate management of solid waste contaminates surface and ground water due to pollution from waste deposited close to water sources; causing outbreak of diseases like cholera and typhoid fever. Also, Ogwueleka (2009) identified open dumping of solid waste as a common practice in Nigeria and considered it a breeding ground for

flies, insects, bacteria fungus and many microorganisms. This could spread diseases and often become worst during rainy season, with offensive odour polluting the environment and making it unsuitable for habitation.

In identifying potential suitable solid waste dumpsites in the study area, a number of variables were taken into consideration, which includes environmentally sensitive areas, exclusive protected area distance to streams, distance to water body, proximity to settlement, and proximity to infrastructure provision as well as, the distance from transportation routes for effective waste management. The capabilities of GIS for generating a set of alternative decisions are mainly based on the spatial relationships observed, principles of connectivity, contiguity and proximity and overlay methods. For example, overlay operations was used for identifying suitable areas for proposed or new solid waste dumpsites in Kaduna South LGA.

The results of this study were mapped (for the purpose of understanding the actual locations of the existing solid waste dumpsites, as well as the proposed suitable dumpsites). This was done with the view to understanding the implications of these solid waste dumpsites for environmental aesthetics and management.

Proposed suitable dumpsites for solid waste management in the study area

Appropriate location of the solid waste dumpsites that is not very close to a road and other public utilities would help reduce the effects such solid wastes have on the environment. To accomplish this, the major road layer and a buffer zone around the major roads were created. For this study, it was found that a buffer of one hundred meter was sufficient to optimise possible sites for aesthetic considerations based on NESREA recommendations. Solid waste dumpsites are not to be located within 100 meters of any major highways, city streets or other transportation routes. Therefore, the 100 metres was chosen based on NESREA recommendations (Figure 3).

Figure 3 shows information on the proposed suitable solid wastes dumpsites locations in the study area. The location of dumpsites as noted on the map in yellow colour is based on the 100m buffer from public utilities like roads, streams among others as

recommended by NESREA. These dumpsite locations are considered better over the existing dumpsite locations shown on the map in pink colour. The essence of designing the new suitable locations is to show the deviation in pattern of solid waste dumpsites distribution in Kaduna South Local Government Area.

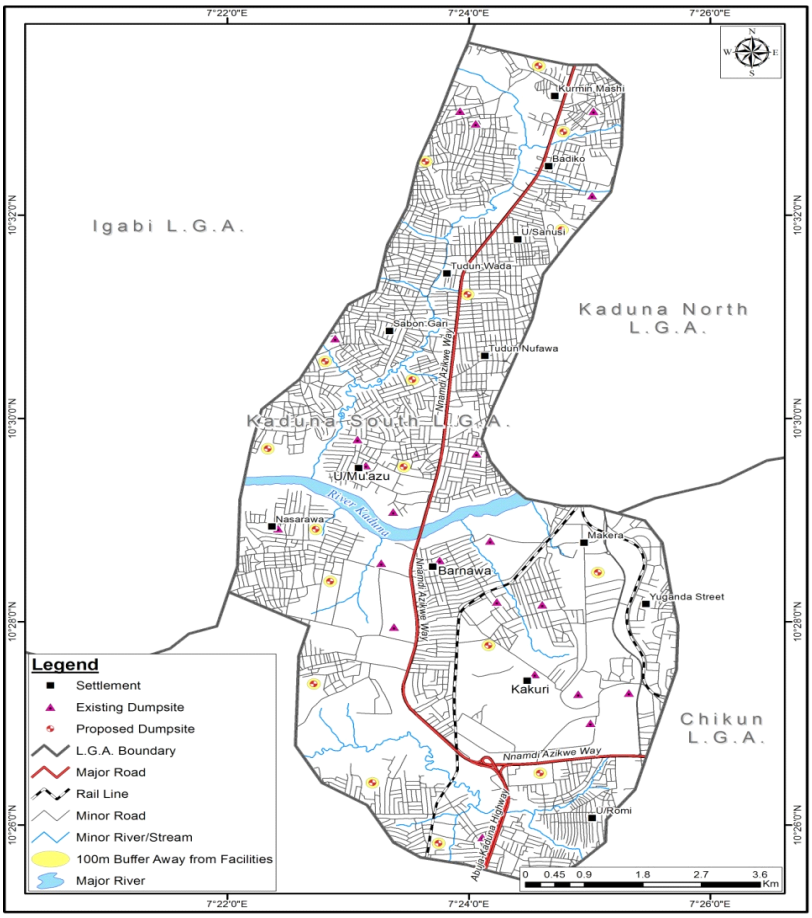

Fig. 3: Proposed suitable solid waste dumpsites location
Source: Authors' Analysis (2018)

This management approach has clear implication on the aesthetics quality of the environment, as well as, controlling the incidence of disease proliferation in the area. This study corroborated the findings by Akpe and Aondoakaa (2009) in Gboko LGA of Benue

State, where it was discovered that inappropriate location of dumpsites led to disposal of solid wastes on open space, and in water bodies; which enhanced environment deterioration and the proliferation of diseases like malaria fever, typhoid fever, cholera among others in the area. Hence, provision of enabling waste management system for successful implementation of a waste program is very important for the protection of the environment. Site selection should be performed for every municipal area in Nigeria despite the fact that it is very cumbersome, time consuming and expensive. The use of GIS as a decision tool can effectively be employed in doing this because of the ability of GIS to manage spatial attributes from a variety of sources. This allows decision makers to combine environmental criteria with other constraints based on established guidelines for selecting suitable sites.

Conclusion

Based on the results obtained in this study, it was concluded that patterns of solid waste dumpsites and management are inefficient in the study area. This was evident in the sporadic heaps of refuse in most places in the study area. This was because most of the solid waste dumpsites were located far away from one another as observed in settlements like SabonGari and Barnawa among others. Also, some of the solid waste dumpsites were located close to roads and water sources; with the tendency of poisoning the water sources due to increased bacteria growth. These were evident in settlements like Nasarawa, Makera among other settlements.

GIS as a decision support tool for siting waste dumpsites has proved to be useful in mapping suitable sites for landfill siting purposes. Landfill siting process requires evaluating many criteria and processing much spatial information. Using GIS for locating landfill sites was considered a practical way for the evaluation and production of maps in a short span of time. It was therefore recommended that the suitable solid waste dumpsites proposed in this study with 100m buffer zone be implemented by the government to reducing the effects of solid waste disposal on the environment. Also, environmental education in schools and public campaigns are needed to be intensified through media, to

sensitise the residents in the study area about proper waste management. Funding by Government should be encouraged at specific intervals for the purchase of machinery and equipment's for proper collection of solid waste and replacement of non-functional ones. Also, recycling should be encouraged in our society; as well as use of paper containers rather than plastics, so that the volume of solid waste produced will be curtailed.

References

Akpe, G.D. and Aondoakaa, S. C. (2009). Assessment of Solid Waste Management in Gboko Town. *Global Journal of Environmental Sciences*. 8(2):71-77

Aliyu, B.N. (2010). Analysis of Municipal Solid Waste in Kano Metropolis, Nigeria. Unpublished project, *Department of Geography, Kano University of Science and Technology*.

Allen, A.R, Brito, G., Caetano, P., Costa, C., Cummins, V.A, Donnelly, J., Fernandes, C., Koukoulas, K., O"Donnell, V.A, Robalo, C. and Vendas, D. (2013). A landfill site selection process in GIS modeling. *Proceedings of Sardinia 2003, Ninth International Waste Management and Landfill Symposium. Margherita di Pula, Cagliari, Italy; 6 - 10 October, 2003.*

Ayo. B. and Ibrahim, B. (2010). Selection of Landfill Sites for Solid Waste Treatment in Damaturu town-using GIS Techniques. Department of Remote Sensing Faculty of Geo-information Science and Engineering, UniversitiTeknologi Malaysia, Malaysia. *Journal of Environmental Protection. 2: 1-10.*

Babayemi, J.O. and Dauda, K. T. (2009). Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A Case Study of Nigeria. *Journal ofApplied Science and Environmental Management. 13(3): 83 – 88*

Elizabeth, T.M. (1998). *Solid Waste Management issues for Developing Countries*. Mona Kingston: Canoe press.

Ezeah, C., Roberts, C. and Phillips, P. (2010). Evaluation of Public Health Impacts of Scavenging in Abuja, Nigeria using Q Methodology. Paper presented at the International Solid Waste Association World Congress (ISWA) 2009, Lisbon, Portugal, 12-15 October 2009.

Filemo, A., and Uriat, J. (2008). *Solid Waste Management: Principles and Practices: An Introduction to the basic Functional Elements of Solid Waste Management, with Special Emphasis on the needs of Developing Countries*. Ibadan: University Press

Mokhtar, D., Zurina, J., Rev. Markson, M., and Aminuddin, H. (2008). How GIS can be a useful Tool to deal with Landfill Site Selection. Paper presented at the International
Symposium on Geoinformatics for Spatial Infrastructure Development in Earth and Allied Sciences.2008.

National Population Commission (2006). *Kaduna State Population*. NPC Publications

Nkwocha, E. E., Pat-Mbano, E. C., and Dike, M. U. (2011). Evaluating the Efficiency of Solid Waste Collection Services in Owerri municipality, Nigeria. *International Journal of Science and Nature. I.J.S.N.2(1) 2011: 89-95.*

Ogwueleka, T.C. (2009). Municipal Solid Waste Characteristics and Management in Nigeria. *Iran. J. Environ. Health. Sci. Eng. 6(3): 173-180*

Sener, S., Sener. S., and Karagüzel, R. (2010). Solid Waste Disposal Site Selection with GIS andAHP Methodology: A Case Study of Senirkent–Uluborlu (Isparta) Basin,Turkey. *Environmental Assessment. 173:533–554.*

Singh, J. (2009). Solid Waste Management. New Delhi: IK international

Techobanoglous G. and Frank, K. (2002). Handbook of Solid Waste Management. United States of America: McGraw Hill.

United Nations (2010). *Collection of Municipal Solid Waste in Developing Countries. Siege Publications.*

APPENDIX (Proposed Dumpsites Coordinates)

Name	Latitude	Longitude
U/Romi	0°31'51.46"N	7°24'46.30"E
Makera	10°26'30.68"N	7°24'35.52"E
Nasarawa	10°25'49.25"N	7°23'45.02"E
Nasarawa	10°27'23.35"N	7°22'42.93"E
U/Mu'azu	10°28'54.62"N	7°22'43.95"E
SabonGari	10°29'31.48"N	7°23'27.70"E
U/Mu'azu	10°30'22.94"N	7°23'31.95"E
Kakuri	10°29'42.22"N	7°22'20.04"E
Abuja Highway	10°27'46.11"N	7°24'9.84"E
Nasarawa	10°26'25.02"N	7°23'12.10"E
Makera	10°28'23.93"N	7°22'51.10"E
SabonGari	10°28'29.14"N	7°25'4.24"E
Tudun Wada	10°30'33.77"N	7°22'48.57"E
KurminMashi	10°32'31.73"N	7°23'38.51"E
Tudun Wada	10°33'28.21"N	7°24'34.78"E
Tudun Wada	10°31'13.26"N	7°23'59.40"E
Badiko	10°32'49.31"N	7°24'47.04"E