

GIS ANALYSIS IN THE SITING OF INCINERATORS AS A PANACEA FOR SOLID WASTE MANAGEMENT IN KADUNA STATE

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ABSTRACT

Solid waste represents a key issue that threatens environmental quality in Kaduna metropolis. One of the most viable options to treat such an issue is to incinerate the collected solid waste, which can reduce the cost of solid waste disposal as well as pollution and generate electricity. Despite the significance of incineration, there is no single incinerator in Kaduna metropolis. Distance to major dump site is a factor in the creation of illegal dump sites within the metropolis. Selecting appropriate site for a solid waste incineration is a crucial step due to its economic and environmental implications. This would require assessing various constraining and favourable factors that determine feasibility and sustainability of the site. This paper brings to light the need for a GIS-based model for siting a municipal solid waste incinerator in Kaduna metropolis.

Keywords: Dump sites, Municipal Solid Waste, Kaduna metropolis, Site Selection, GIS

INTRODUCTION

Waste can be almost anything, including food, leaves, newspapers, bottles, construction debris, chemicals from a factory, candy wrappers, disposable diapers, old cars, or radioactive materials. Solid wastes constitute a growing problem and have gained increased political awareness over recent years. The amount of solid waste generated in the world is steadily increasing and every government in the world is currently focusing on methods to approach the challenges posed by urban waste (Schwarz-Herion, Omran and Rapp, 2008).

The increase in population resulting in the expansion of cities which brings about the concentration of industrial, commercial, infrastructural, administration and government activities in urban cities, thus resulting in waste generation (Amuda *et al*, 2014). The volume of waste generated in any city is often a reflection of the intensity of human activities such as population growth, urbanization and social development, resources exploitation and unchecked technological advancement (Adejobi and Olorunnimbe, 2012).

Butu *et al* (2013) observed that urbanization affects land-use, when not controlled it causes the emergence of illegal structures. This type of illegal and unplanned residential areas endangered waste collection services and eventually enhances indiscriminate dumping of domestic waste generated. Despite the importance of adequate solid waste management to the urban environment, the performance of many city authorities in Africa and Nigeria in this

respect leaves much to be desired. Kaduna metropolis fits perfectly into this scenario, the slums, ghettos, sprawls and filthy neighborhood often refers to as *Angwar* areas that formed more than 70% of residential areas are poorly planned with pitiable sites for human habitation thus increasing the challenges of waste management (Ajiboah and Terdoo, 2013).

The fast tracking development in Kaduna metropolis is surpassing conurbation into megacity operates within this scenario. This development is beginning to show evidence especially in the area of quantity and quality of different types of municipal wastes generation. The issues of waste collection, disposal and dumpsites management are of immediate importance particularly when this is combined with rapid urbanization. The national profile observed that in many Nigerian cities, the volume of solid wastes has overwhelmed urban administrators' capacity to plan for their collection and disposal. Thus, it is not uncommon to find urban streets and roads practically blocked by solid wastes (Momodu, Dimuna and Dimuna, 2011). Butu *et al* (2013) states that between one-third and one-half of the solid wastes generated within most cities in Nigeria are not collected. They usually end up as illegal dumps on streets, open spaces and waste land. This buttresses Ajibuah (2013) claims that indiscriminate disposal of wastes along Kaduna Metropolis is the main factor influencing susceptibility of residents along Kaduna River to floods annually. According to Amuda *et al* (2014) the estimated volume of solid waste in Kaduna in 2010 was 761,479 tonnes while the projected volume of waste in 2020 will be 1.04×10^5 .

Although Kaduna State Government instituted various agencies for city planning and developmental control such institutions include; Kaduna Environmental Protection Agency (KEPA) and Kaduna State Urban Planning and Development Authority (KASUPDA) but they are bedeviled by sharp practices, professional inadequacy and technical inefficiency by all standards. The administrative structure and financing arrangements of Nigeria government are pointers to the problem of solid waste management (Ogu, 2000). Kaduna Environmental Protection Agency (KEPA) is the sole agency saddled with the responsibility of maintaining a clean and healthy environment. The Kaduna State Environmental Protection Authority (KEPA) was established by edict of 1994 and later revised in 1998. The authority is charged with the responsibility of addressing all environmental problems in the state including but not limited to organising Programmes aim at changing people's negative attitudes towards environmental management for sustainable development. This is all aimed at making Kaduna State an environmentally friendly state. KEPA is meant to address all environmental problems in the state from all point and non point

sources such as industries, domestic, commercial, institutional etc, and to change people's negative attitudes towards environmental management for sustainable development.

The best approach to solid waste management (SWM) in developing countries has been an important concern for researchers and policy-makers. Effective management of municipal waste is required, but local authorities in many countries are constrained by limited finances and inadequate services (Omran and Gavrilesco, 2008). The importance of waste collection, transfer and disposal cannot be over-emphasized. Apart from the issue of aesthetics, uncollected wastes constitute a health risk, which can be a serious consideration in low income residential areas. Leachate from uncollected and decomposed garbage waste can contaminate groundwater and this could have enormous health implications in low-income communities where the use of well-water for drinking is common (Amuda *et al*, 2014).

Throughout history, there have been four basic methods of managing waste: dumping it, burning it (incineration), finding another use for it (reuse and recycling), and not creating the waste in the first place (waste prevention). How those four methods are utilized depends on the wastes being managed. Today's growing problem of waste had given way to many waste management systems. In industrialized countries, waste disposal via landfills is expensive and spaces for them are getting scarce. Incineration then becomes an attractive alternative. Waste incineration is a method of waste disposal whereby high temperatures are used to sufficiently oxidize the combustible components in waste. Compared with landfills and composting, incineration is more effective in dealing with municipal waste due to a few advantages, such as taking up comparatively small space, decreasing the volume of waste and generating electricity. Although there are bright prospects regarding the waste incineration industry, some issues, such as improper locations, lack of environmental impact assessments (EIA) and an excessive production of fly ash. Hence, it is necessary to ensure the process of waste incineration is harmless to the environment and public health.

Site selection for municipal solid waste incineration is one of the essential steps to ensure proper planning and implementation. Generally, site selection for a certain activity requires conducting suitability analysis involving, based on the type of activity, a variety of criteria. The main objective of suitability analysis, in general, is to identify the most appropriate spatial pattern for future land uses by classifying various parts of the considered area according to their suitability for a particular activity (Malczewski, 2004). This is done according to specific requirements and preferences of the proposed activity taking into account a number of constraining and favoring factors that represent the requirements and preferences of this activity.

Suitability analysis for siting municipal incineration solid waste power plant should consider mainly economic and environmental issues associated with its operation (World Bank, 1999). This means that the site of solid waste incineration power plant should contribute not only to ensure feasibility of the plant, but also to mitigate environmental adverse impacts that may be arisen from such a plant. Generally, three main categories of criteria for siting solid waste incineration power plant are typically suggested;

exclusionary, avoidance and suitability ones. Exclusionary criteria represent the requirements that should be satisfied by the site and whatever site is not satisfying these requirements should be excluded. Avoidance criteria are those requirements, which should be fulfilled, at varying degrees, by the site to mitigate annoying factors that may be resulted in by the plant. Meanwhile, suitability criteria represent those criteria that affect the relative suitability of different potential sites (Turner, 2002).

To conduct suitability analysis, there is a need to integrate wide range of spatial variables that represent different factors determining the location optimization (Shi *et al*, 2008). For this purpose, GIS have been employed in suitability analysis due to their capabilities to deal with spatial data. In this context, it was argued that suitability analysis is one of the most valuable applications of GIS (Malczewski, 2004).

MATERIALS AND METHODS

This was a descriptive analysis of the need for the introduction of waste incinerators within Kaduna metropolis to help ameliorate the challenges of waste management which has bedeviled the State but most especially the metropolis. The data types used in this study are topological map of Kaduna state, administrative map of Kaduna North, Kaduna South and Chikun local government areas. The geographic coordinates of waste dumps was collected from the field using a hand-held Global Positioning System (GPS) and images from Google Earth was used to depict the locations of the 2 KEPA owned and approved dump sites. There are waste collection centres created and managed by Local Government and mostly in the neighbourhood, accumulation of these are been evacuated to the main enclosed waste collection centre. The two major dumpsites are: Along kilometre six (6) Kaduna - Abuja expressway and is fenced round with two exits the dump site is where laterite was excavated for road construction. The second is along Birnin Gwari Lagos road Buruku the dumpsite also enclosed with two outlets and exit for vehicle to drive in and out. A reconnaissance survey was also carried out across the Kaduna metropolis to identify potential sites for siting incinerators. Interviews were conducted with the staff of KEPA to determine its position on incinerators. Arc GIS 10.1 software was used to digitize the map in this work.

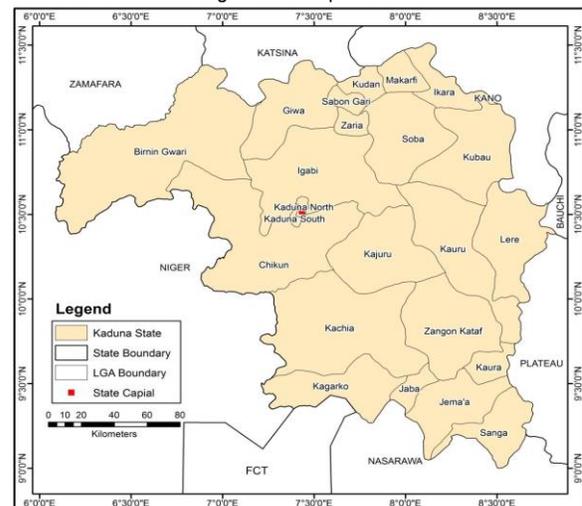


Fig. 1: The Study Area: Kaduna State, Nigeria

RESULTS AND DISCUSSIONS

A physical survey of the Kaduna metropolis gave some eyesores with the amount of waste that is uncollected or not properly disposed. There are so many illegal dumpsites across many locations within the metropolis. With KEPA having only 2 recognized dump sites at Gonin Gora and along Birnin Gwari, with only the latter been functional while the former has been

closed down because of urban encroachment as residential buildings have cornubated the dump site leading to its abandonment. Although there is a great improvement in waste collection across the state, disposal is a major issue as illegal dumping of wastes has been found in Trikania along the Nnamdi Azikiwe Express road. One of the major challenges is the distance from the metropolis to the active KEPA dump site.

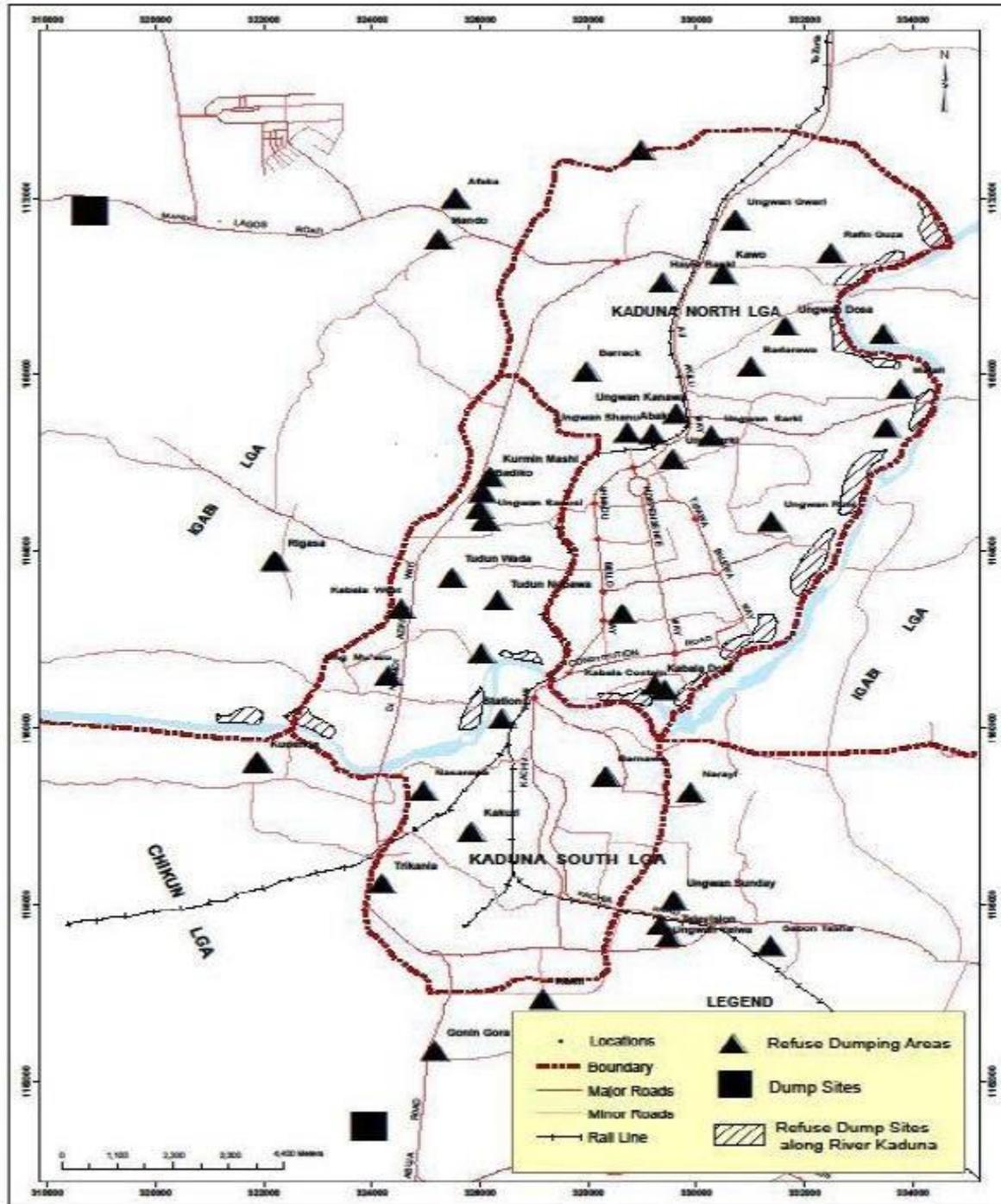


Fig. 2: Waste Disposal Points in Kaduna Metropolis.



Fig. 3: KEPA Active Dump Site along Birnin Gwari Road.



Fig 4: KEPA Abandoned Site at Gonin Gora along Abuja Road



Fig. 5: Illegal Dump Site along Nnamdi Azikiwe Express Road Trikania

From the result of the interviews conducted, it shows that one of the major reasons for illegal dump sites is the distance from the collection centres to the officially designated dump sites. Because there are private participants in the metropolitan waste disposal scheme with unhealthy vehicles that cannot cover reasonable distance to the designated dump site. The introduction of incinerators within the borders of the metropolis will reduce the distance from collection centres and also reduce the quantity of waste to be transported to the main dump site. The interview with KEPA also reveals that the agency is in support of the establishment of incinerators within the metropolis for controlled burning as it will certainly contribute immensely in reducing the quantity of waste littering the metropolis.

Conclusion

Waste has hazardous effect on the environment including every living thing. It does not only pollute the land but also affect indirectly living beings. The sequence discussions affirmatively show that waste is not properly managed in Kaduna metropolis. It is common sight to find heaps of waste, with its attendant decay and foul smells, serving as reception in the nooks and crannies of Kaduna metropolis; this has corroborated the findings of Ajiboah and Terdoo (2013). There are heap of unattended waste lying around that attracts flies, rats, and other creatures that in turn spread disease. This could lead to unhygienic conditions that pose varying challenges to human health, this finding also agrees with the work of Butu *et al.*, (2013). Effective waste management is an important component of a strategy for improving environmental health, waste that is not properly managed, especially uncollected solid wastes from households and other communal activities are serious health hazard which could manifest through the spread of infectious diseases, for instance,

organic domestic waste poses a serious threat, since they ferment, creating conditions favourable to the survival and growth of microbial pathogens and also increase risk of injury particularly children and other high-risk group population living close to waste disposal sites within the Metropolis.

This paper has come to the conclusion that one dump site in faraway Birnin Gwari road is a major factor causing the indiscriminate dumping of refuse in many open space around the outskirts of Kaduna metropolis. The introduction siting of GIS researched incinerators will help in waste management in Kaduna metropolis by reducing the distance in which waste disposal operators and managers will have to cover in order to dump collected waste.

Recommendations

This research paper is making the following recommendations:

- i. There is the need for KEPA and all stake holders involve in waste management in Kaduna State to understand the relevance and accept the use of incinerators at specific locations at the periphery of the metropolis.
- ii. There is the need for KEPA to partner with institutions to conduct Geographic Information System based site suitability and site selection analysis to come up with sites that are suitable for the siting of incinerators in Kaduna metropolis.
- iii. It is easier to monitor all waste operators especially those involve with evacuation, transportation and dumping of municipal waste from an incinerator as it will be known how many trips they

make per day.

iv. There are several good reasons why incineration is a good waste management system to augment, if not replace other systems like landfills. In incineration, the volume of burnt waste is reduced by about 90% which increases the life of landfills. Incinerators can generate electricity from the produced heat and it can supplement current power needs. These incinerating plants generate a biomass-powered energy that offsets the greenhouse emissions from fossil fuel-fired power plants. If introduced, Kaduna state can benefit from these advantages.

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