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Spatial Distribution Mapping and Analysis of Solid Waste Disposal Sites in Bosso Town Using Geographic Information System

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ABSTRACT

The collection and disposal of solid waste in Bosso has become a major public health issue due to the sporadic and unorganized manner in which these wastes are generated, which is a vital factor affecting the quality of the environment. Solid wastes (biodegradable and non-biodegradable) ranging from papers, polythene bags and nylon, metal, tires, kitchen garbage to animal dung are deposited haphazardly all around Bosso community. Bosso area, due to its rapid population growth vantage by the location of the Federal University of Technology, Minna has attracted many waste generating services centres such as eateries, business centres, Suya joints, internet cafes etc. without any organized waste disposal method. Solid waste either by students, traders, and children are dumped under the cover of night in most cases on streets watercourse, open spaces and drainage channels. In view of this development, this paper attempts the spatial distribution mapping and analysis of solid waste sites in the area using Geographic Information System (GIS) in order to ascertain the number and the concentration of the waste sites for it effective management and planning. The study created a spatial database model for solid waste generation in Bosso Township (central) and identified thirty-one (31) unauthorized and one (1) authorized solid waste disposal sites and carried out the analysis of the disposal sites distribution patterns. The study revealed that several numbers of the authorized/unauthorized sites are really not permanent, as property owners or people in the neighborhood sometimes clear them permanently in attempts to carry out physical developments on their plots or for commercial initiatives. Some health and environmental dangers posed to the community and problems inhibiting its effective management were identified and recommendations on how to effectively manage solid waste disposal in the area were made

Key Words: Spatial distribution Mapping, Analysis, Solid Waste Disposal, GIS

Introduction

The most essential parts of waste management have to do with the generation, collection, transportation and disposal. In the developed world, advanced technology equipment are commonly used in waste management but in the under developed or developing parts of the world such as Nigeria and Minna in particular is still using the manual labor techniques in solid waste management, which results in improper waste collection, transportation and disposal. Improper waste management constitutes great environmental hazards and risks to human lives, animals and plants. The WHO reports from the mid-nineteen sixties to-date have consistently alerted the world on the urgent and deliberate needs of achieving environmentally sustainable development, through effective waste management (WHO 1966, 1971, and 1986). The world environment day held on 5th June 2006 further reaffirmed the importance of a clean and safe environment today, to guarantee an environmentally healthier future.

The Federal government of Nigeria declared June 28th of every year as a national environmental sanitation day; in which different activities such as tree planting, essay competition, seminars and environmental value orientation, etc., shall take place in Nigeria for more awareness creation on the importance of healthy, safe and aesthetic environment. Though there is no internationally accepted definition of solid waste, it has been described by many as 'any ***unwanted*** materials found in any environment'. According to this description, wastes could be seen in relative terms, as what is taken to be unwanted by a person in a place at a given time may be useful to another person in another place and time. Despite the relativity of the meaning of waste, there are common items that are always referred to as unwanted and waste to all social classes and state of the society. Social and cultural affiliations play strong roles in the definition and characterization of waste matters in Nigeria and Africa in general.

A mark of uncontrolled urban development in any city is a proliferation of unauthorized waste disposal sites along drainages, frontage of residential and commercial buildings, shops and recreation centres. People hurriedly remove wastes from their houses, shops and other living and working apartments and dump them in any available space without given considerations to the health hazards and other environmental impact of such practices. Most of these solid wastes are papers, nylon, kitchen garbage etc. Because, the environment and man operates a kind of symbiotic relationship, whatever man puts into it whether good or bad comes back to him in either positive or negative manner.

Okpala (1983) linked the increase in solid waste generated in urban centres to the increase in population and Oluwande (1974) classified the composition of waste in the layout of Ibadan and concluded that waste generation in layout vary according to the social status of the residents in the different layouts. It was also revealed by Akintola (1978) that out of tones of solid waste generated in Ibadan in 1975, only 140,000 tones were cleared; which implied that, the disposal

system was commensurate with the amount of waste generated. Umuakuka and Mba (1999), in their study noted that, open dumping is the most commonly used refuse disposal methods in Nigeria urban centres.

The factors to be considered in the selection of disposal methods of solid waste include characteristics of refuse economy, availability of disposal sites, and cost of labour. Okoye (1989) observed that, attempts and efforts by different governments in Anambara state to improve the environmental condition of the state have not been effective in Onitsha. The open pilling of refuse breeds such household pest like mosquitoes and cockroaches, which in turn contaminate food in homes and bring about diseases. WHO (1971) stressed that, dumping of solid waste on land without prior treatment or planned operation can lead to the degradation of land and surrounding area thereby subjecting it to nuisance from insects, rodents, dust and smoke. The increase in the production of waste is causing storage, collection and transport difficulties as well as problems of treatment and final disposal. Different solid waste disposal methods in the world include; incineration, open dumping sanctuary landfill, trench technique and composting (WHO, 1966; Cointreau, 1982). Due to the increasing population and demand for urban lands, the space for waste tipping will become scarce and expensive, and the increase in domestic and industrial wastes resulting from the increase in urban population will create an even bigger demand for waste disposal facilities. Okereke (1988) observed that, the situation where solid waste management is left entirely in the hands of the environment mediocre and public health officials is the most singular cause of solid waste management crisis in Onitsha. He attributed lack of data compilation and purposeful studies on solid waste to inefficient management.

The State of Solid Waste Management in Minna

Before now solid waste management in Minna was the traditional responsibility of the municipal authority. When the government noticed that the authority lack the capacity to evacuate wastes on open spaces and along the streets, it then launched the task force on environmental sanitation in 1985 during the Buhari/Idiagbon administration. Thereafter, an environmental sanitation edict was also passed for every last Saturday of every month by 7am to 10am declared as environment sanitation day, which the people a relevant task force fairly responded to. However, when the Task force lost its grip over the sanitation programme, people went back to their old and unhealthy sanitation life style. When the weakness of the force was noticed by the government it was scrapped and this informed the founding of Niger State environmental protection agency (NISEPA) by the state government in conjunction with World Bank assisted programme.

Niger State Urban Development Board (NUDB) was established under the Niger State edict No 3 of 1999 to carry out solid waste management as one of its operational obligations in urban development control and management strategies. At the establishment of NUDB, NISEPA who was formerly responsible for solid waste management was then moved to NUDB, thereby making NUDB the sole manager of solid wastes in Minna metropolis. In May 2000, the Niger State Urban and Regional Planning Development Board thereafter put in place some regulations to enhance solid waste management in the metropolis; in which they specified the type of containers to be used for solid waste storage, places not to be used as dump sites and other activities that may pose health hazards to human lives, animals and the environment within the metropolis. Despite these regulations, indiscriminate depositions of wastes still continue unabated in Minna and Bosso in particular.

Statement of Research Problem

One feature of most urban centers in Nigeria in the past years is the gradual conversion of any available open spaces, drainages and even uncompleted buildings to refuse dump sites. These sites not only obstruct human activities, it has also become a convenient ground for flies, mosquitoes and other pests that constitute harmful health hazards to human beings.

The location of Federal University of Technology in Bosso has obvious multiplier effect on the population growth of Bosso in particular and Minna in general; which has attracted multiple waste generating services such as, eateries, business centres, suya joints, internet cafes etc. Solid wastes generated by students, traders, children and other individuals are dumped indiscriminately under the cover of the night in most cases on streets, open spaces and drainage channels. In view of this development, this study attempts the spatial distribution mapping and assessment of solid waste sites in Bosso area of Minna using GIS, in order to model the spatial patterns of authorized and unauthorized refuse disposal sites, as a tool for environmental planning and safety evaluations. The study also intend to identify the environmental dangers posed to the community and problems of effective waste management and to make recommendations on the best refuse disposal and monitoring practices for the area.

Aim and Objectives

The aim of this study is to carryout the spatial distribution mapping and analysis of solid waste sites in Bosso area Minna using geographic information (GIS) for the purpose of environmental planning and safety evaluations. The objectives of the study include:

i. Identify the authorized and unauthorized waste disposal sites in Bosso
ii. To map and create spatial database of the waste disposal sites (authorized and unauthorized)
iii. Analyze the distribution pattern of the waste disposal sites

iv. Identify the problems inhibiting solid waste management in the area and make recommendations for its effective management

Scope and Limitation

The study is focused on solid waste disposal sites and it covers only the built up areas of the Bosso town. The primary data collected is limited to questionnaires and GPS coordinates and sample photographs of identified waste disposal sites.

Study Area

Bosso Local Government Area (LGA), with the headquarters at Maikunkele, approximately lies between latitudes 09° 25'N and 09° 45'N of the equator and longitudes 06° 15'E and 06° 32'E of Greenwich Meridian. It is located on the basement of distinct complex rocks made up of gneiss and magnetite to the north.

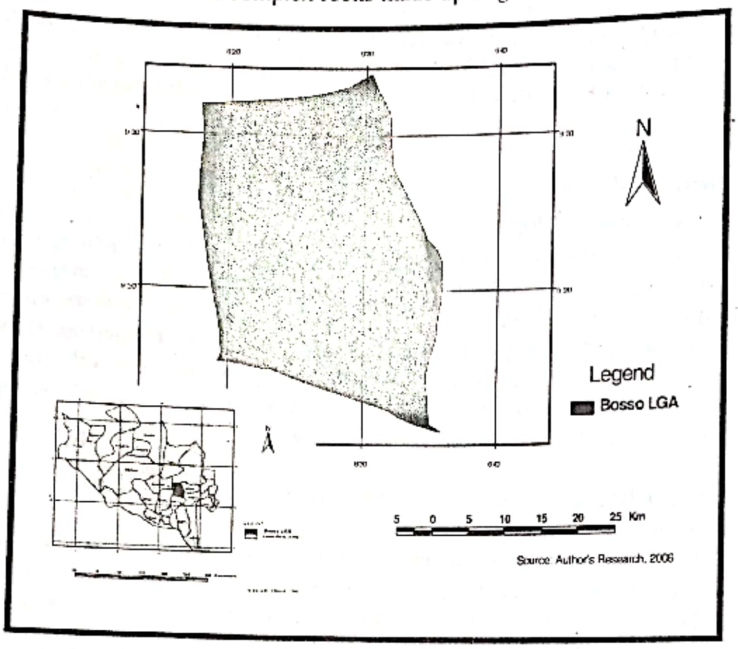

Figure 1: The Map of Bosso Local Government Areas of Niger State

However, Bosso Township under study covers a rectangular coordinates range of 1067000mN to 1069000mN and 228300mE to 230400mE (equivalent of about 2 x 2.1 km, or 4.2km square in area), which is a very small portion of the entire LGA. Bosso is fairly on a plain and gentle valley, with its centre comprising less continuous steep granite ground. The landscape is generally sloppy and hilly to the east and north with much surface drainage across the landscape.
The natives and original owners of Bosso are the Gwaris (Gbagys), but early migrants were made up of laborers who engaged in the arrangement and construction of the railways. These migrants were majorly Nupes and Hausas, who settled in separate camps. According to NPC, (1991), the population of Bosso was 157,159 people. The only Federal University in Niger State is located in Bosso local Government Area. The Bosso Campus is within Bosso town, while the Main Campus is the rural suburb of the Local Government Area.

Methodology of Data Collection and Spatial Modeling

The study is based on the use of both primary and secondary sources of data on solid waste disposal sites in Minna in general and Bosso community in particular. A reconnaissance survey of the study area was conducted to observe and study the physical characteristics of refuse disposal sites. Photographs of interesting manifestations of the problems noted were taken. An NUDB staff in sanitation department in charge of Bosso area was also personally interviewed. The method of Geographic information system (GIS) is used to create the spatial model to map waste disposal distribution and pattern in Bosso.

Types of Data

(i) Number and spatial location of refuse points (legal and illegal). Four refuse sites were randomly sampled in Bosso Low-cost area, which is outside the Okada road boundary of the central area of concern in this study. However, a total of 29 sites were sampled within the study area (Bosso Township). (ii) Number of sanitation workers and collection frequency, (iii) Private waste management in Minna, etc.

Data Set and Sources

Primary data includes, Answered Questionnaire and Global Positioning System (GPS) coordinates information, and photographs of the waste and locations. The Digital Base map of Minna sourced from Ojigi and owoyele (2005) was the main secondary data in this study.

Survey Field Work and Questionnaire Administration

The fieldwork for the study includes reconnaissance and location surveys. The hand held Garmin 76 GPS instrument was used to locate the waste sites. The questionnaires were used to gather spatial attribute data of each of the refuse dumps, their location, legal status, how often were they cleared, who is responsible for the waste generation and management respectively, etc. A systematic sampling of the available waste sites was done in order to cover the entire Bosso Township in good time.

Spatial Database Creation

A digital base map of Minna created by Ojigi & Owoyele (2005) was up dated for roads, streets, waste sites and defined area of Bosso under study. In the up-dating of base map, new themes were created with ArcView GIS. The process of vectorization was through the method of on-screen digitization of points, lines and polygons. This was followed by the annotations of the buildings, and roads leading to the creation of an attribute data theme table.

Spatial Buffering

Spatial buffers were created for the features in the solid waste site-theme as multiple rings of 50m apart. The purpose is to find out whether the clustered and non-clustered areas of the Bosso Town are adequately covered by the waste disposal sites for easy reach by the residents.

Results and Discussion

Spatial Pattern Analysis

The collection and disposal of solid waste has become a major public health issue and a vital factor affecting the quality of our environment. Figure 2 shows Spatial Layout of Bosso Township and the Solid Waste Disposal Sites (authorized and unauthorized) with a total measured area and perimeter of about 465 hectares and 8km respectively and with 32 waste sites. Figure 3 represents the spatial buffer of 50-m distance for 3 rings around all solid waste sites (authorized/unauthorized) in Bosso area of Minna. Figure 4 shows the spatial query of all unauthorized waste sites in Bosso Township, numbering 31. The balance of just one site located near Royal Paint and 7-Up Depot along, Minna-Zungeru road represent the only authorized solid waste site in Bosso Township.

It was however discovered in the course of the research that, the one (1) authorized waste site is basically a community built disposal site. The so-called authorized site does not have adequate government backing, making it look like the unauthorized ones, because it was a suggested or proposed site to NUDB by the community heads for a period of time pending when the owner of the site wants to carryout any meaningful development. In its present status, there are no formal-permanent refuse collection sites in Bosso Township.

The spatial occurrence of waste sites are actually sporadic, hence does not follow any definite pattern. However, from the spatial buffer in figure 3, the clustered area of Bosso Township, on the northern axis of Bosso road has adequate waste disposal points within 50m, 100m and 150m reach of the resident respectively. The buffer-free zones in the southern axis of the Bosso road reveals long distances of reach for residents to deposit their wastes; hence proved inadequate. It should be noted that, the location of these waste site frequently disappears and appears depending on the exigencies of property development in the area.

The residents indicated that there are increases in volumes of waste when the Federal University of Technology and other schools in the area are in session and decreases when they are on vacation because this group of people constitutes major waste generators in the area of study.

The spatial geometry of waste sites are often altered by scavengers who go to these disposal sites to check for useful materials, though help to reduce the volume of waste but carry out their exercise in an unfriendly and unskilled manner by scattering the waste. When wind blows the wastes are further scattered within the area; thereby generating another set problem, with serious health implications

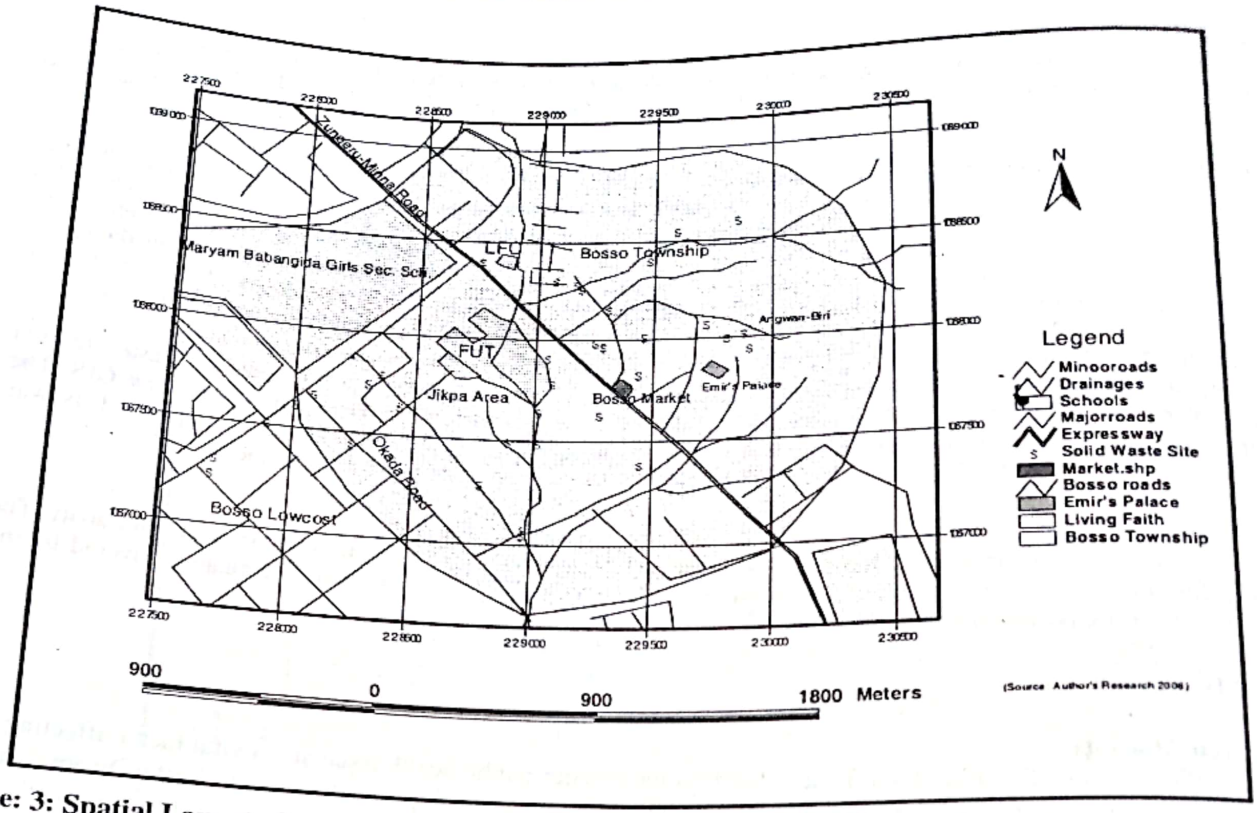

Figure: 3: Spatial Layout of Bosso Township and the Solid Waste Disposal Sites (authorized/unauthorized)

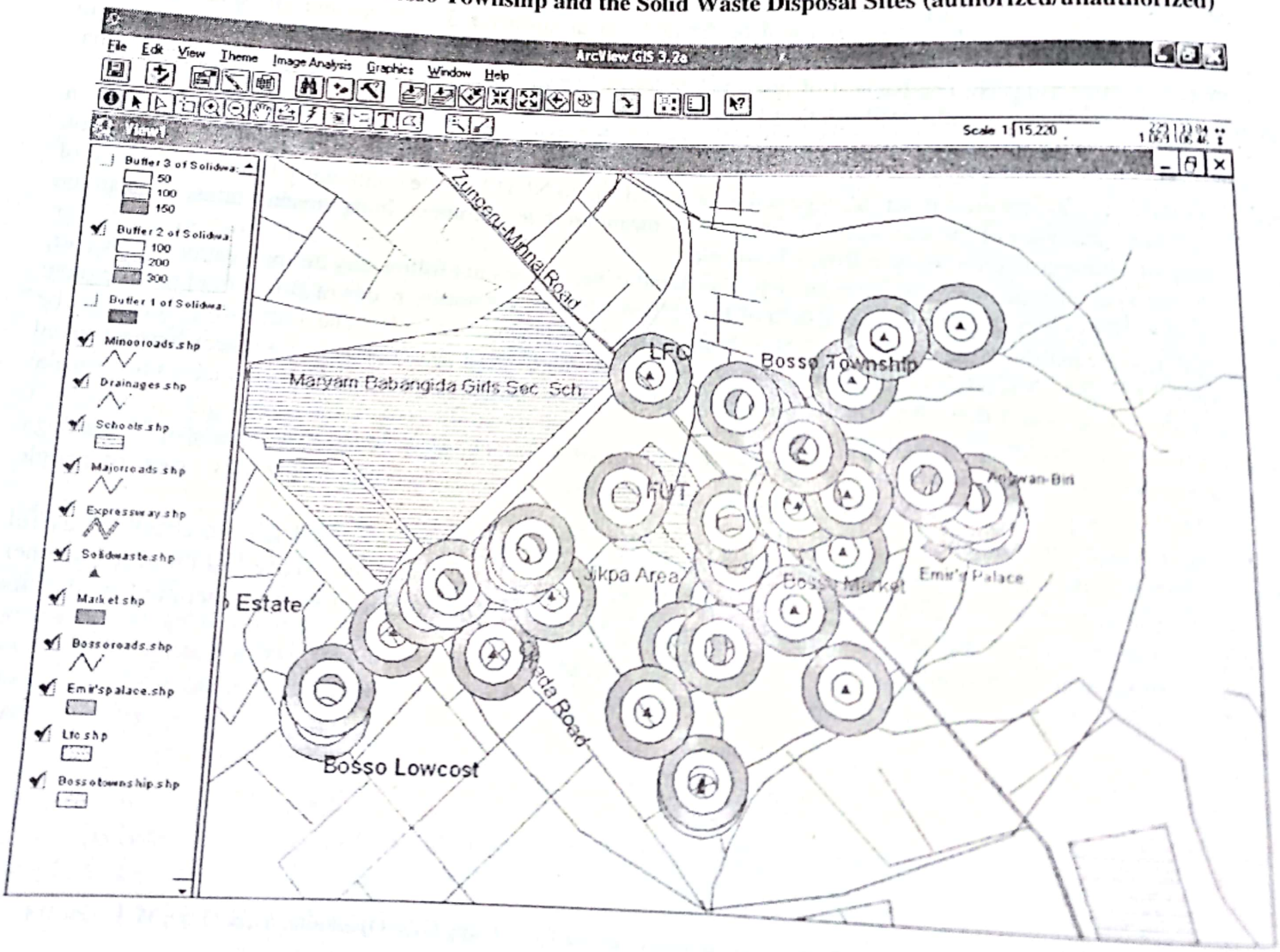

Figure 3: Spatial Buffer of 50m, 100m and 150m Distance from Solid Waste Sites in Bosso, Minna.

Majority of the waste sites in figure 3 are not cleared or visited by the appropriate agencies, which has turned into breeding ground for rodents, mosquitoes, flies and other pathogens that spread diseases. The indiscriminate waste dumping sites in Bosso Township has over the years become great impediment to drainage systems under heavy rainfall and surface run-off. In figure 3, there quite number of waste sites located at the mouth of major drainages across the study area, which are likely to migrate into the drainage channels.

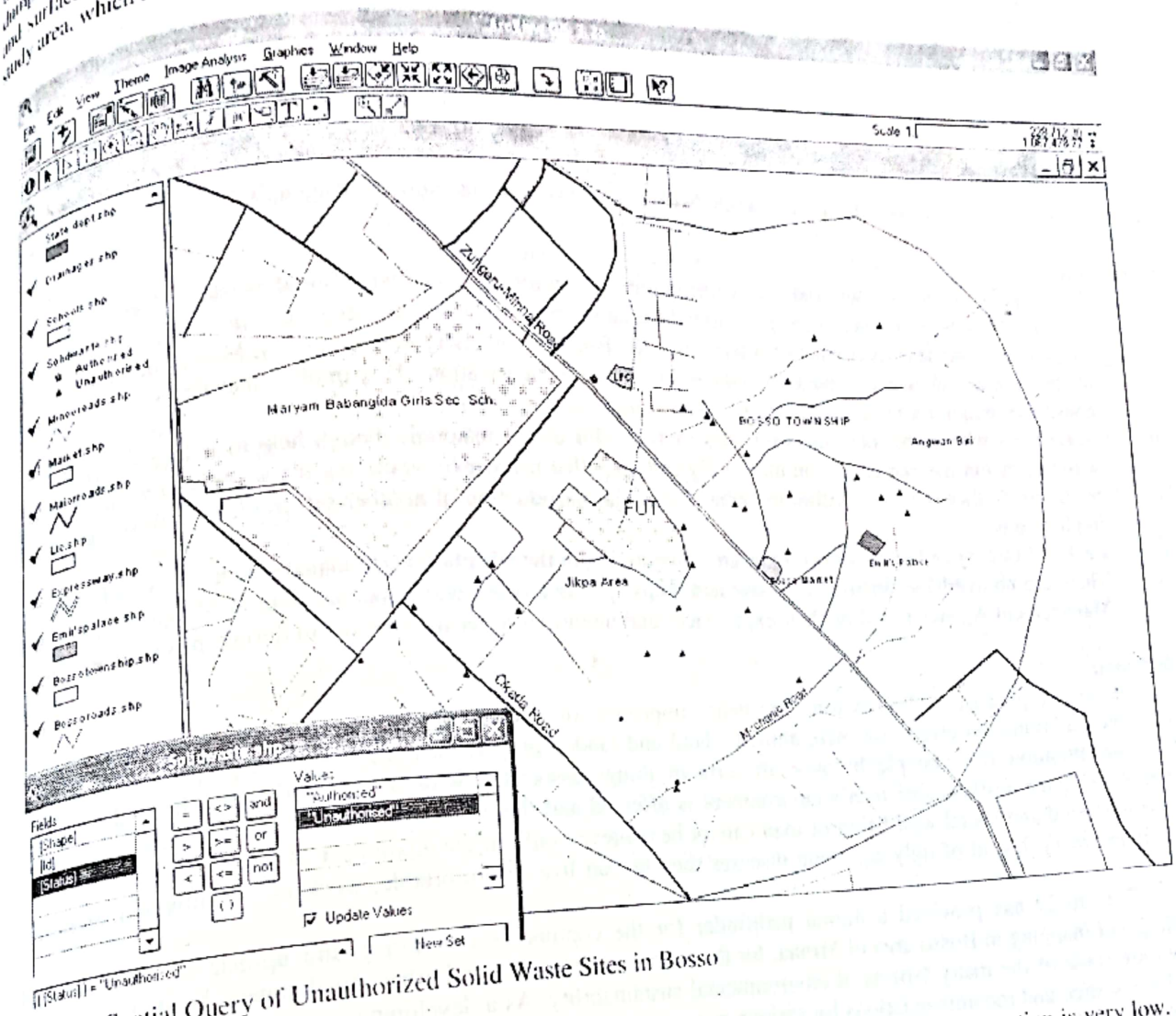

Figure 4: Spatial Query of Unauthorized Solid Waste Sites in Bosso

Solid Waste Management Analysis

The frequency of refuse collection in the study area, compared with the volume of generation is very low. The agency collects waste only about two and at most three times a week. Some collection points receives more attention than others e.g. road side disposal points, and area with free access, while settlements of the low income class with clustered houses with or without access roads receives little or no attention by the waste management agencies. The reason for this practice as deduced from study was that, because Minna is made up of traditional inner core and modern sections and very often no form of refuse disposal service is provided for the traditional core areas due to the haphazard location of houses with unpaved narrow streets which are not easily accessible by the garbage trucks to evacuate the refuse.

The refuse management agency (NUDB) is faced with financial problems, because the possibility of the government to recover cost is very low as it is difficult to get people to pay for their annual service charges. It lacks equipment for the evacuation of waste from disposal sites to the final disposal point along Bida road. It has about four (4) tippers and hires every other equipment from private construction companies such as Julius Berger Plc. The staff strength is also very weak. It has just about 115 sweepers, 98 laborers in the whole of Minna metropolis. So the bulk of the work is handled by private waste managers numbering about eight (8) namely, Violet park, Maishara, Alif maintenance, Satec investment, Spring investment, Rover holding and two others. These agencies concentrate more on GRAs and Federal and State Housing Estates, with little or no attention to the low income areas like Bosso, which generates huge amount solid wastes. The study shows that the residents pay certain sum of money to the private manager, though these payments however, depend on the frequency of the waste collection. Also, the low income neighborhood tends to generate more waste than the higher income neighborhood, because of the population density of the former. Proximity advantage to the waste sites are exploited by most residents, shop owners and [illegible] to frequently deposits

more waste than those far away from the refuse sites. Table-1 considered the distance of refuse collection site and the disposal rate, which shows that the frequency and daily response of waste dumping is largely determined by the proximity of the waste sites.

Table 1: Distance of Refuse Collection Site and Disposal

Distance	% Daily	% Every 3 days	Weekly	Rarely	Total
Below 500m	20	30	50	-	100
Above 500m	-	10	90	-	100

Source: Field Survey, 2006.

The bulk of wastes in the study area are commonly domestic and institutional wastes consisting pieces of paper, polythene bags and pure water sachets formed the larger proportion of waste generated in Bosso Township. Field inspection of the magnitude of the waste generation shows that raining season waste surpasses those of dry season due to agricultural waste like corn curbs, leaves and vegetables, rotten fruits, etc. Sample photographs of wastes (biodegradable and non-biodegradable) like polythene bags, and other waste component are shown in Appendix 1.

Specific Findings

i. The bulk of wastes in the study area are commonly **domestic** and **institutional wastes.** Pieces of paper, polythene bags and pure water sachets formed the larger proportion of waste generated in Bosso Township
ii. There is also increase in volume of waste when the Federal University of Technology, Minna and other schools in the area are in session and decreases when they are on vacation. This implies that this group of people constitutes major waste generators in the area of study.
iii. Scavengers who go to these disposal sites to check for useful materials though help to reduce the volume of waste carry out the exercise in an unfriendly and unskilled manner by scattering the waste, and wind blows the waste are further scattered within the area. This is an introduction of another set problem, with serious health implications.
iv. Lack of Funding and good access roads are a major clog in the wheel of waste management in Bosso Township.
v. There are no available certified database and maps specifically for waste management in Minna; hence staff at Management Agency relied on their experiences and memories to recap every detail during the oral interview.

Conclusion

Man is a product of the environment; hence improper solid waste disposal systems have negative health and socio-economic valuation effects on man, animals, land and landed properties. Land or landed properties will receive little or no attention from people because all sorts of things associated with unmanaged waste have defaced the properties. Also the aesthetics of man's environment is affected and this has a negative effect on human productivity because the metal and social well being of man cannot be achieved only in the attainment of material wealth but also a clean environment devoid of ugly sight and diseases then he can live a comfortable, workable, healthy and stress-free life.

This study has provided a digital pathfinder for the continuous monitoring and up-date of waste disposal modeling and mapping in Bosso area of Minna, for the purpose of planning and urban development. Waste management policies are some of the many aspects of environmental sustainability. As a developing community, we need to use the available resource and recommendations by various groups and individuals to put an end to refuse in our environment as part of our commitment to achieving the Millennium Development Goals.

Recommendations

n view of the findings,-the following recommendations are made to better solid waste management in Bosso area Minna.

(1) The state government should allocate land spaces to NUDB to use as their disposal site because Niger State is blessed with land, hence land should not be a major problem in solid waste management in the State.
(2) Public-Private Partnership Option in waste management should be encouraged in Minna and it environs, and more skilled staff should be recruited to handle the job of waste management
(3) The NUDB should organize periodic public awareness programme to enlighten the people on the dangers of indiscriminate solid waste disposal practices and a re-orientation of the public on packaging and consumption habits
(4) The board should also acquire new modern equipment to enhance easy and fast evacuation of waste in study area, which suggests better funding and staff development for NUDB for meaningful collaboration with private sector in waste management, control and monitoring.
(5) Temporal spatial mapping and monitoring of waste sites and clearance should be carried out in Bosso using the modern techniques of high resolution remote sensing and geographic information system, using this study a base.

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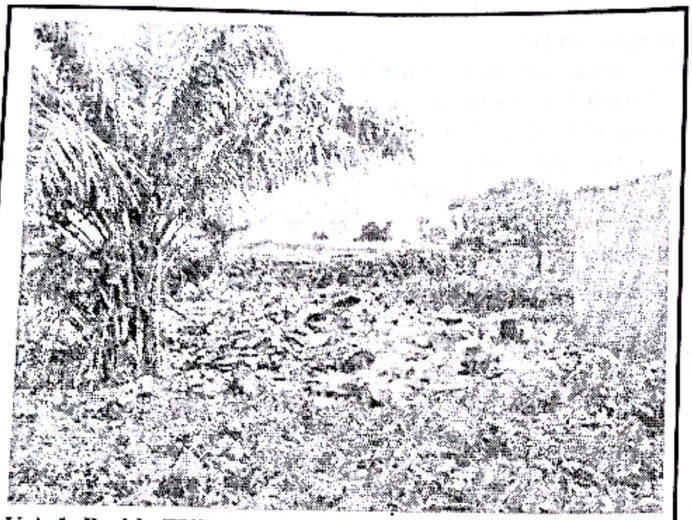
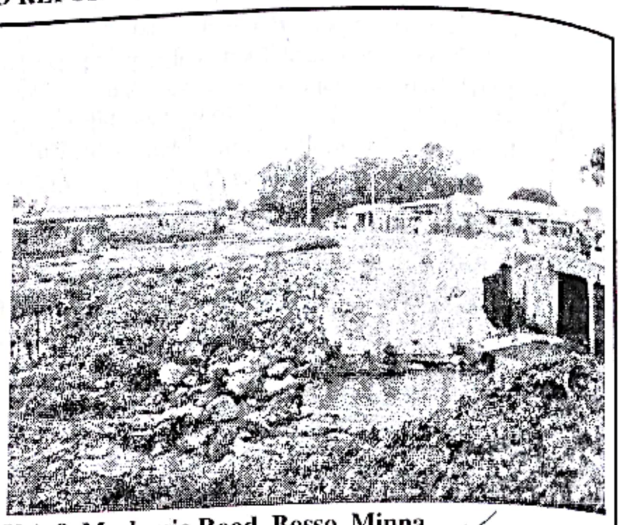
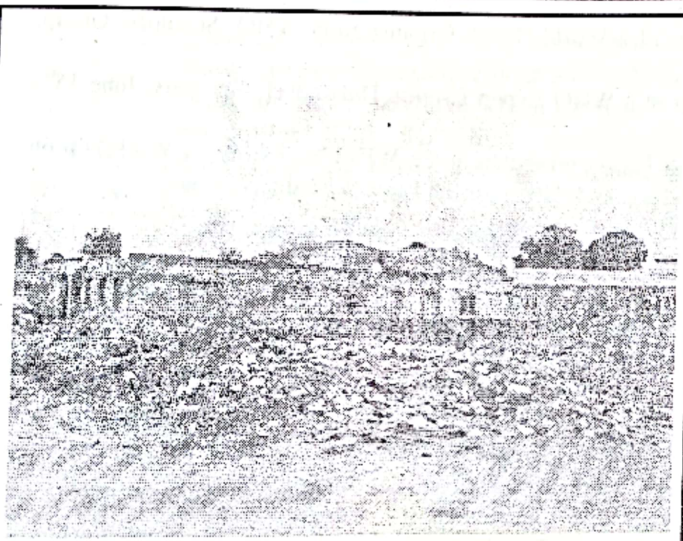
APPENDIX I: SOME SAMPLES OF UNAUTHORIZED REFUSE SITES IN BOSSO, MINNA



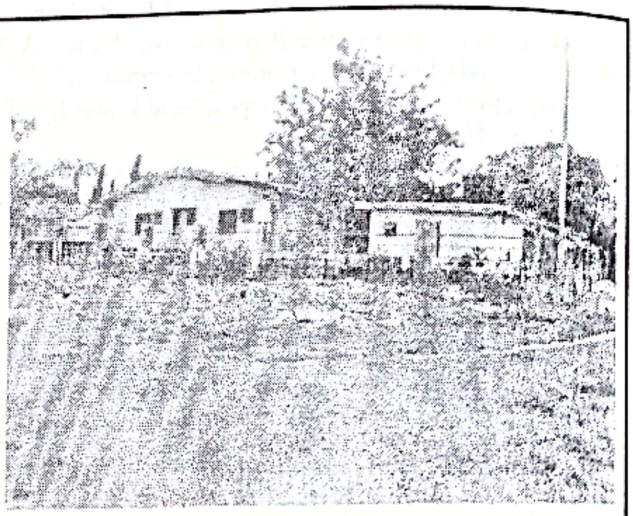
U.A-1, Beside FUT, Gate, Bosso, Minna



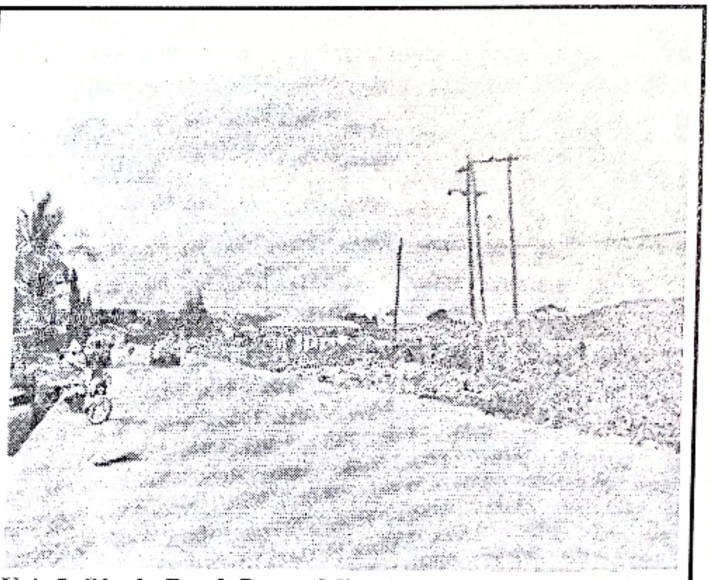
U.A-9, Mechanic Road, Bosso, Minna



U.A-3. Jikpa Area. Bosso. Minna



U.A-11, Near Bosso Water Works, Bosso, Minna.



U.A-5, Okada Road, Bosso, Minna

(Source: Authors' Field Work 2006)