

Application of GIS in Solid Waste Management in Chanchaga Local Government Area of Niger State, Nigeria

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Abstract: *This study aims at developing a decision support tool for solid waste management in Chanchaga Local Government Area of Niger State using Geo-information Technology. Waste management is a global environment issue, which constitutes a very significant problem in today's world. There is a considerable amount of waste disposal without proper segregation, which is leading to both economic and environmental problems. There is tremendous amount of loss in terms of environmental degradation and health hazards, due to direct disposal of waste. There has to be appropriate planning for good waste management by assessing the waste situation of the area. The method employed was to acquire attribute and spatial information using handheld Global Positioning System receiver (GPS) and satellite imagery. The image was geo-referenced and digitized showing the location of existing waste disposal unit and the final dumpsite. A database was created using ArcGIS 9.3 software. Queries and analysis of results were carried out. The results show primary, secondary disposal units and the condition of the disposal units.*

Key words: *Solid Waste Management, Environmental Hazard, GIS, GPS, Spatial Information*

I. Introduction

In developing countries such as Nigeria, the international policy that the generator of waste is responsible for the proper management, treatment and disposal of waste has remained on paper and is yet to be implemented^[1].

Solid waste is the term used to describe non-liquid waste materials arising from domestic, trade, commercial, agricultural, industrial activities and from public services. Eight major activities generate solid waste. These are residential, industrial, commercial, institutional, construction, municipal services, process and agricultural. It comprises of different materials: dust, food waste, packaging in form of paper, metal, plastic or glass, discarded clothing, garden waste, hazardous waste and radioactive waste^[2].

“The ‘Municipal Solid Waste’ includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes.”^[3]

Urban solid waste management is one of the most immediate and serious environmental problems confronting authorities in developing countries. Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management of non-hazardous waste, residential and industrial waste in metropolitan areas is usually the responsibility of local government authorities, while management of non-hazardous commercial and industrial waste is usually the responsibility of the generator^[1].

Waste management is a global environmental issue which constitutes a very significant problem in today's world. The most common problems associated with improper management of solid waste include diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses^[4]. The environment is heading towards a potential risk due to unsustainable waste disposal. It is a sensitive issue, which concerns serious environmental problems in today's world. The present situation of direct dumping of the waste without proper inspection and separation leaves a serious impact of environmental pollution causing a tremendous growth in health related problems. “Domestic, industrial and other wastes, whether they are of low or medium level wastes, are causing environmental pollution and have become perennial problems for mankind”^[5].

A study conducted by^[6] on problems of solid waste management in Minna, using GIS showed that there are lapses or inefficiency on the part of the body responsible for solid waste management in the towns and cities of Niger State. It also provides solution to the problems by suggesting an enforcement of sanitation laws, intensified public enlightenment campaign on solid waste management and provision of refuse bins at strategic locations.

^[7] investigated the use of GIS ideal for the selection of optimum location of transfer stations by combining relevant dataset of satellite imagery, land use map, identification of existing locations of municipal bins through

GPS coordinates, and map showing road network. GIS provides an efficient and effective means of analyzing the best location for waste transfer stations.

^[8] enumerated that GIS support a formal process of optimum location of community waste bins based on buffer electronic maps. The process enables an analyst to consider a variety of geographic factors essential for the planned facility and others merely desirable. However, GIS is an appealing strategy for an agency seeking a rational unbiased location for a local facility such as an incinerator or dumpsite.

^[9] used GIS for preliminary disposal sites around Ranchi urban complex. From this study it was possible to relate the ground water of a site with health parameters of its inhabitants and that once a GIS database is developed, it can provide efficient means of analyzing the best site for disposal of solid waste while the manual method of selection is very tedious.

As a result, this paper aims at studying solid waste management in Chanchaga Local Government Area, Minna, Niger State, Nigeria, using Geographic Information System (GIS).

II. The Study Area

Chanchaga local government area is one of the 25 local government areas in Niger State with its headquarters in Minna the state capital as shown in Fig. 1 below. It lies between latitude $9^{\circ}35' 00''$ to $9^{\circ} 41' 00''$ and longitude $6^{\circ} 25' 00''$ to $6^{\circ} 37' 00''$. It covers an area of 72km^2 with a total population of 201,429.

Chanchaga local government area is located within the basement complex area of the country, which is characterized, by different forms of sedimentary rocks and alluvial deposit. It has a tolerable climate, immense opportunities for socio-economic and agricultural activities. It has a dry and wet season. Rainfall occurs between April and November with high concentration in August.

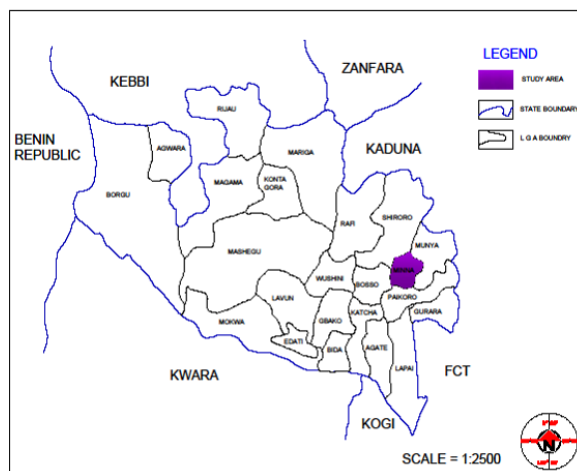


Figure 1: Map of Niger State showing Chanchaga Local Government Area.

The most predominant type of soil found in Chanchaga local government area is ferruginous tropical soils derived from the basement complex rocks and old sedimentary rocks. Data used in this study include, satellite imagery, road network map of the study area, existing location of waste transfer stations of the study area and location of the disposal sites of the area.

III. Methodology

Reconnaissance survey was carried-out, in order to identify the existing locations of the dumpsites within the study area. During the reconnaissance, it was observed that, most of the existing locations of the dumpsites are along the major road for proper monitoring and effective collection of the waste by Niger State Environmental Protection Agency (NSEPA). The reconnaissance survey also helped to identify areas where illegal dumping sites are located. The final disposal site is located along Minna - Zungeru road that is 15km away from the metropolis and it is an open land.

3.1. Method of Data Collection

The satellite imagery of the study area was obtained from Google earth software at a high resolution. The map was geo-referenced using ArcGIS 9.3. The location of the existing waste transfer station within the study area

was obtained from the Niger State Environmental Protection Agency (NSEPA) and the x and y coordinates of each station was collected using a handheld GPS (Garmin 76S) receiver. Snapshots of some waste transfer locations were taken.

The coordinate of the final dumping site was obtained with the hand held GPS receiver, which is the only approved dumping site. The amount of waste generated on daily basis was also obtained from NSEPA.

The second phase consists of preparation of thematic maps, which include digitization of spatial data. The map layers created from the ArcCatalog were Stream, Railway, Major road, Minor road, Waste disposal units, Open space, Agricultural areas, Administrative buildings, Commercial area, and Residential areas. Some of these layers were created as points, lines and polygons layers.

IV. Results and Discussion

The figures below display pictures of waste units, results of queries for satisfactory and unsatisfactory disposal units.



Figure 2: Illegal Dumping of Refuse within the Metropolis

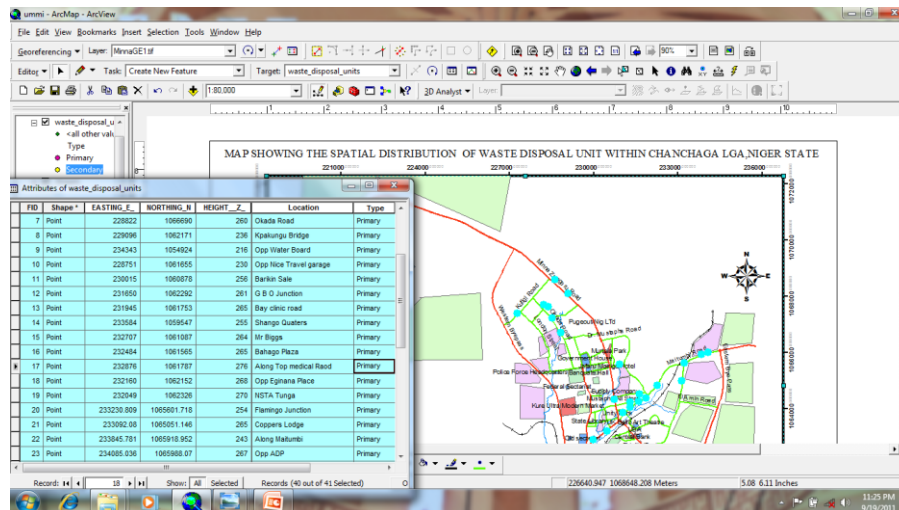


Figure 3: Query Result Showing the Primary Disposal Units.

Fig. 3 shows the query result of primary disposal units within the study area. It reveals that there are 41 primary disposal units within the study area. These waste disposal units are inadequate to make the city clean and bring the aesthetic view of the town. In Fig. 4, it can be seen that the secondary disposal unit situated 15km from the residential area is the only approved final disposal unit.

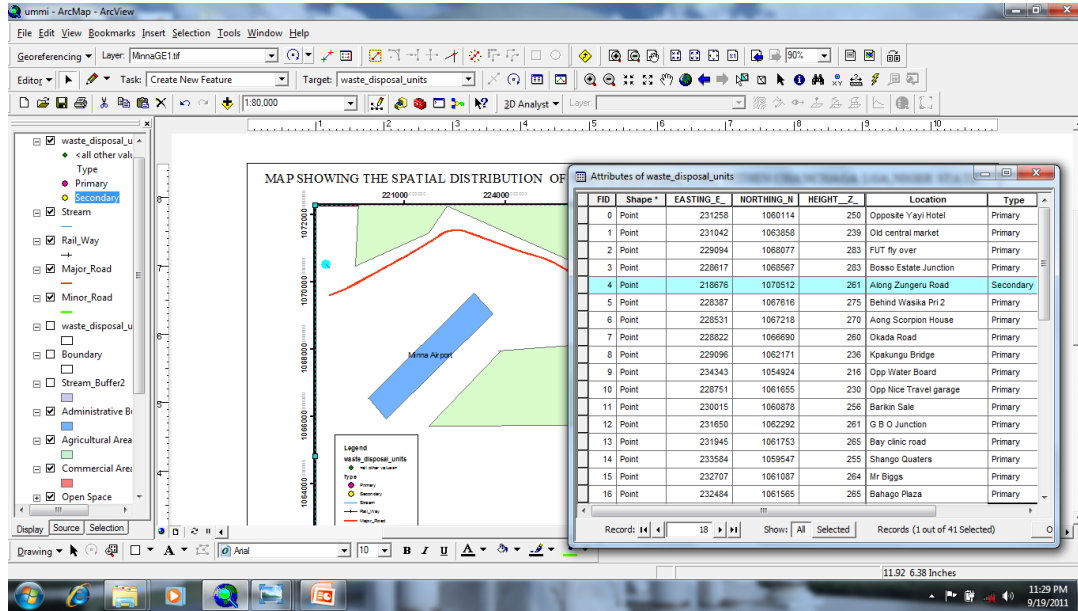


Figure 4: Query Result Showing the Secondary Disposal Units

4.1 Analysis of Results of Queries/Bufferings

The analyses were based on the suitable distance to disposal unit for all users and environmentally sensitive areas.

4.1.1 Suitable Distance to Disposal Unit for All Users

The first assessment is meant to check for the suitable and convenient distance from the disposal unit to the users within the study area. Therefore, a buffer of 30m was created round the disposal units to check proximity to main roads as proffered by decision makers^[10].

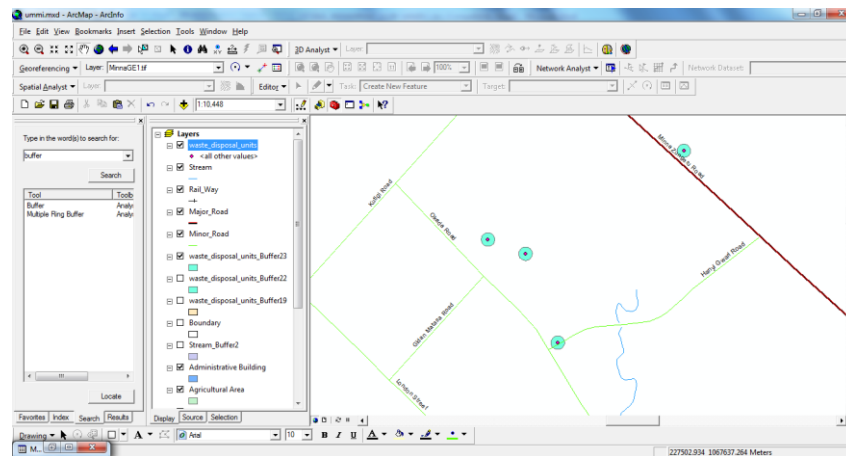


Figure 5: Buffer Operation Indicating Waste Disposal Units within 30m to Road

From the Fig. 5 above, the only two (2) waste disposal units that didn't fall within the 30m buffer between roads and waste disposal units can be clearly seen at Gidan Matasa road off Okada road.

4.1.2 Environmentally Sensitive Areas

Buffer operation of 150m was also carried out to check for the proximity of the disposal units to environmentally sensitive areas such as streams that are used as source of water for irrigation^[11].

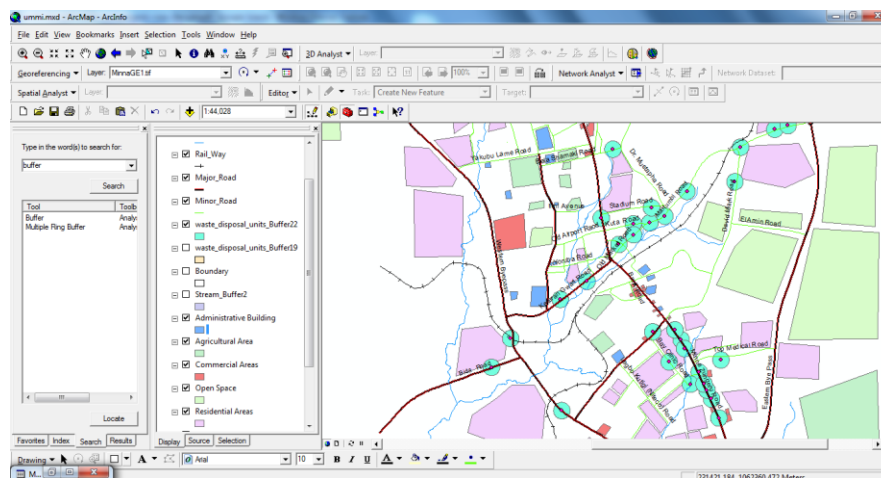


Figure 6: Buffer Operation Indicating Waste Disposal Units within 150m to Streams

From Fig. 6, nine (9) waste disposal units along Okada road, Dr. Mustapha road, Sabon Gari road, Gwari road, Bay Clinic road, Magatakarda Garden and Minna/Zungeru road did not comply with the 150m buffer regulations' standard between waste dumpsites and streams. Therefore, new disposal units must be created at a suitable location that is away from these streams. This will prevent the contamination of the streams, thereby reducing harmful effect to human and aquatic life and help promote irrigation farming. There are about 19 satisfactory disposal units and 22 unsatisfactory disposal units within the Minna town. This shows that there are more unsatisfactory disposal unit within the town. The locations of these disposal units need to be adjusted or change to give the town a better look as well as present hygienic environment for the residents within the area.

V. Conclusion

The study presents the type and condition of the waste disposal units in Chanchaga Local Government Area with at least 41 waste disposal units. Forty (40) are primary disposal units and only one (1) is secondary disposal unit. Analysis can be made from the results of query/buffering operations conducted, which will enhance decision making by government, and those interested in solid waste management. The database system allows easy access to the condition of waste disposal units, type, and the location of the waste disposal units, storage and updating of the database in the nearest future.

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