Creating a GIS geodatabase for waste management: A case study of University of Lagos

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Abstract
Solid waste is a major environmental problem in many developing cities of the world including Lagos, Nigeria. University of Lagos located in Lagos State is not an exception. Preliminary findings indicate that the University of Lagos, Akoka campus generates about 32.2 tons of waste daily and has an existing method of management which has its challenges of frequency of collection, sorting, and recycling. The current management plan can be made to be automated which will be more effective, efficient, and environmentally sustainable. Incorporating the use of Geographic Information System (GIS) in the field of Solid Waste Management (SWM), is a major way of achieving this. In this study, data were acquired using two methods: the first was field based, which included direct field observations using GPS, questionnaires and interviews; and the second was image based, which is Google Earth satellite image data of the University of Lagos. A geo-database was created, and several spatial analyses were performed using ArcGIS 10.6 and MySQL software. To ensure a workable model, the model created was tested to assess the issues arising in the management of wastes in the University. In conclusion, the model created serves as a useful alternative method in managing waste in the University.

Keywords: Waste Management, GIS, MySQL, Geodatabase

1.0 INTRODUCTION

Waste management is a global environmental issue that has brought serious concerns and constitutes a very significant problem in today's world. Over few years, the world has experienced a large gathering of its population in urban areas and its continuity is marked by a remarkable increase in the absolute number of urban settlers worldwide (Francis, 2019). The environment is key to keeping and improving human activities and wellbeing because without a healthy environment, the quality of life is reduced in that area. Waste accumulation occurs when waste is not readily disposed and then leads to filthy, diseased conditions and poor aesthetic appeal (Onuminya and Nze, 2017).

Nigeria a third world country, like other developing countries is experiencing drastic increase in population with the attendant environmental change which create more centers of daily activities and the intensity of these centers are of increasing environmental liabilities (Onuminya and Nze, 2017). According to Berry (1974), the result of rapid urbanization combined with industrialization in most of these cities gives rise to the concentrations of waste than the city's system can handle. Onuminya and Nze (2017) defined waste simply as leftovers or already used items waiting for disposal. In Nigeria, open dumping of solid wastes into wetlands, watercourses, drains, and burrow pit is a common form of disposal which regularly leads to littering of surroundings and odor nuisance in the environment. In confirmation, Oladiran (2010) also defined waste as any unwanted or discarded material which may be in either solid, liquid, or gaseous form and apparently has no consumer value to the person disposing it. There is a considerable amount of disposal of waste without appropriate separation policy and eventually it has led to the degradation of the community both economically and environmentally. In Afon

(2007), the study defined the role of the informal sector in the collection of waste from the source of generation to the point of disposal. The participation of the informal sector in urban solid waste management refers to unregistered, unregulated, or casual activities carried out by individual and or family or community enterprises. For effective waste management, there is need to consider the location of the dumpsite in which all the waste collected will be dumped. Aziz and Khidakarami (2013) conducted a study of the required conditions for the establishment of disposal centers in Koya city north east of Iraq. They stated that landfill has become more difficult to implement due to resident's opposition and environmental contamination. Since land is an invaluable and finite resources, its use must be carefully considered.

In the present world, universities can be regarded as "smaller cities" compared to the normal cities we have, this similarity is in the aspect of large land coverage (territoriality), several human activities which have different level of effect on the environment; universities in Oyo and Lagos state an example were said to operate on their own as smaller cities (Adeniran *et al.,* 2017). Moreover, universities and also colleges have been required by state and international bodies to adopt sustainable development policies or strategies in all their operations in order to have a positive impact on the socio-economic and environmental well-being of their immediate and extended communities. The problem of waste generation rises from the technological advancement in a society and in an immense manner, mainly because of an inadequate management system. This system includes the collection, transportation, treatment, and disposal of waste together with monitoring and regulation of the waste management process, a challenge in the University of Lagos. Therefore, implementing a good waste management practice not only helps to protect the environment but can be beneficial to the day to day activities in the area. According to Bai and Sutanto (2001), the waste management hierarchy has been adopted by most industrialized nations as the menu for developing solid waste management strategies. Therefore, this study assessed the existing waste management system in the University of Lagos with the view to creating a geo-database for waste management using Geographical Information System (GIS) and built a model to ensure effectiveness and efficiency.

2.0 METHODOLOGY

2.1 Study Area

The University of Lagos, Akoka campus is located in Lagos, a coastal city in the western part of Nigeria. The University being a major one in the country is reported be occupy an estimated 560 hectares of land that host 10 faculties and about 330 housing units for staff, 15 hostels for students and several administrative and academic buildings (Adeniran *et al.,* 2017). It is estimated that the daily waste generation of the institution is about 32.2 tons with polythene product having the largest percentage; and the university has a high recyclable potential of about 75% (Adeniran *et al.,* 2017). Hence for the purpose of these recyclable potential, the university campus was divided into two zones A and B for which two private waste managers (Mr. Wash and Magnum enterprises) were contracted to collect for both zones, respectively. The waste product gathered by these two agencies after been collected and dumped on the landfill site, are been sorted by workers on site into recyclable products which can furthermore be re-processed once more. Figure 1 shows the Solid Waste Management Zones, in the University of Lagos, Akoka while Table 1 states information regarding each waste agency

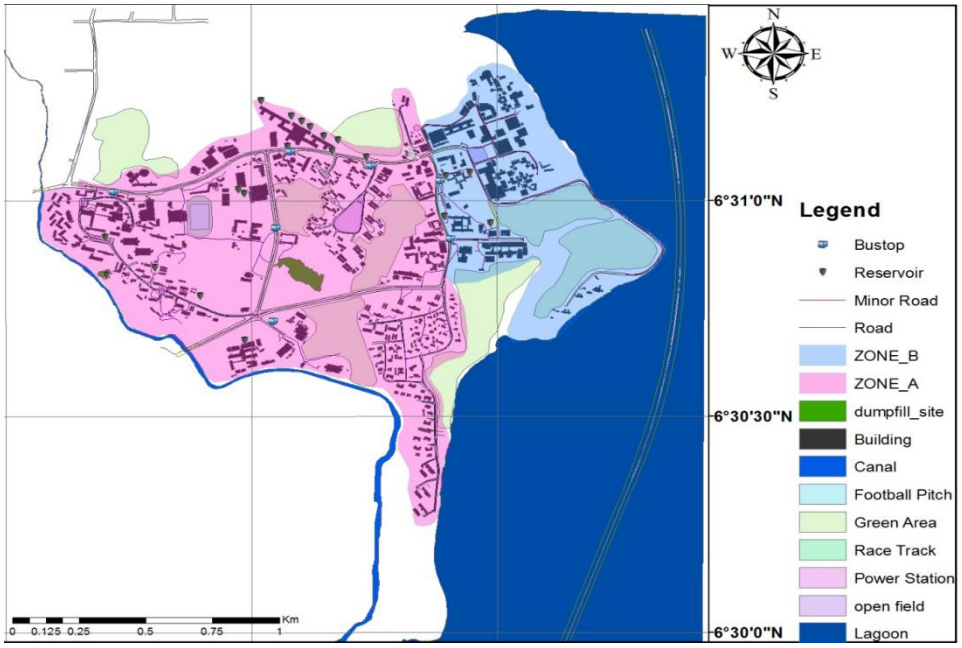

Figure 1. Map of the University of Lagos, Akoka showing the Solid Waste Management Zones

Table 1. Statistics of the two agencies handling waste in the University of Lagos

Agency	Zone	No of Employees on Site	Number of Vehicles	Vehicle Capacity
MR. WASH	A	8	2	9.4m^3 and 17.5m^3
MAGMUM	B	6	Not stable at the moment but at least 1	10.7m^3

2.2 Data collection

The data used for this study was acquired in two phases: Field and Image data. The field data included direct field observations using a handheld Garmin GPS, questionnaire, and interview. Physical interviews were conducted for some staff in the waste agencies, students, traders and other residents on campus while the questionnaire was used to obtain information on the perception of the residence of the university to waste agencies and waste in the University environment. All data from the questionnaire were inputted into the SPSS software and one-way ANOVA was used to analyze the data. The image data is the Google Earth image of the University of Lagos. This data was then transferred to ArcGIS 10.1 software, then the layers were projected to UTM Zone 31, Minna Datum. After which the features on the image data were digitized in layers consecutively. The buildings, bare lands, parks, vegetation were represented with polygons, while lines were used for features such as road, stream flow, waterways etc. Other spatial features such as the dumpsters, bus stops, waste points, trees were identified and represented using point. The field and image data were synchronized, processed and analyzed.

2.2.1 Proximity Analysis: GIS Model for Suitability

During our field data collection, we observed indiscriminate dumping of waste in areas which are sensitive e.g. administrative buildings, lecture halls, hostels, relaxation centers, reservoirs/boreholes etc. This was because of the delay in collection of waste by the agency in charge of those areas. This is a challenge. To solve this, we developed proximity criteria in Table 2 which were applied to create a suitability order of placing dumpster (dumpster) in those areas. In order to do this, four scenarios were analyzed: (i) Proximity of dumpsters to sensitive areas (ii) Proximity of dumpsters to areas of higher concentration (iii) Proximity of dumpsters to

buildings including buildings which do not have dumpsters around them and (iv) Proximity of dumpsters to major road.

Table 2. Criteria for Suitability of placing dumpsters (Berrocal, 2012)

Restriction source	Minimum buffer Distance (m)	Maximum buffer Distance (m)	Analysis buffer Distance (m)
Reservoir	30	200	100
Roads	5	10	4
Buildings	3	20	10

We also looked at the suitability of relocating the landfill in the University from its current location using these three scenarios (Table 3): (i) Proximity of landfill to buildings (ii) Proximity to reservoir and (ii) Proximity to road. The suitability analysis applied for the siting of dumpsters and landfill were determined using equation 1 (Berrocal, 2012):

$$S = \sum WiCi\prod \mathrm{R_j} \quad (1)$$

Where:
S: suitability for the location of a dumpster
W*i*: weight of the criteria
C*i*: criteria for suitability
R*i*: requirements

Table 3. Suitability requirement table for Landfill (Berrocal, 2012)

Restriction source	Minimum buffer Distance (m)	Maximum buffer Distance (m)	Analysis buffer Distance (m)
Reservoir	30	200	200
Roads	100	300	300
Buildings	300	3000	1000

A GIS geo-database was created for this study to have a comprehensive record of the dumpsters and their locations. The layers extracted in the ArcGIS 10.1 Software for analysis were used to feed the GIS Model. These layers include buildings, roads, dumpster, reservoir, canal, and lagoon (Figure 2).

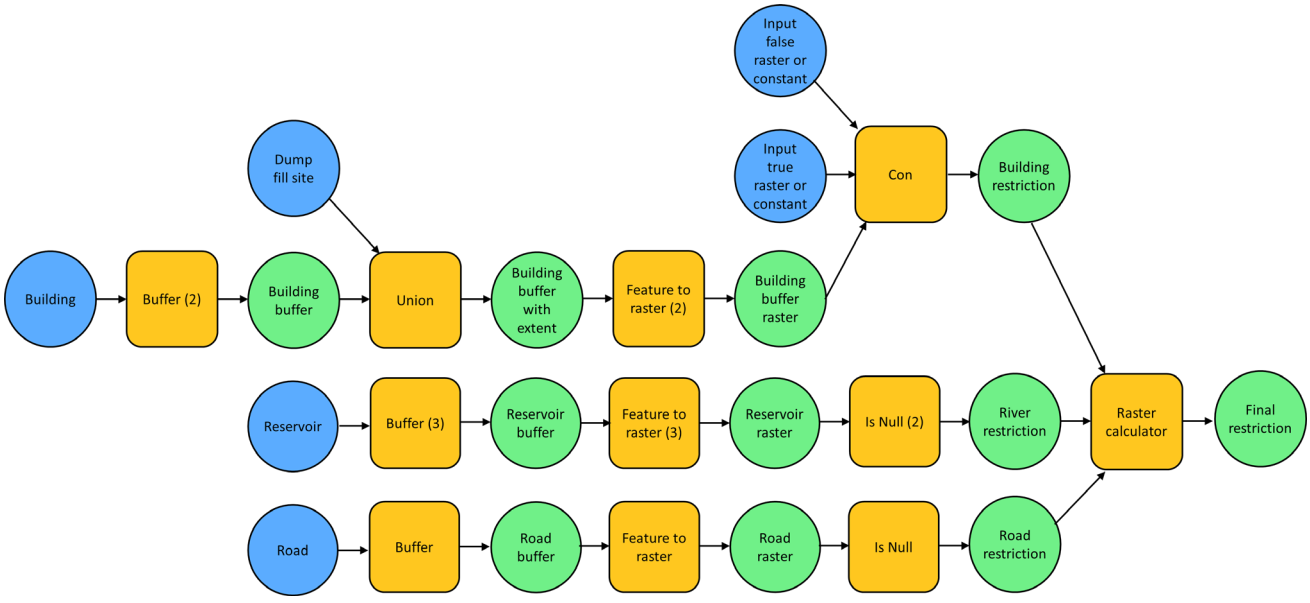

Figure 2. GIS Model

2.2.2 Analytical method

Opinions of residents were also gathered on the issue of waste management in the university premises. A questionnaire was served to solicit information from residents on campus on their perception of the current waste management system. The questionnaire was issued to 220 people, out of which about 70% were administered to the students residing on campus (hostels, quarters, staff, and residential areas), while 15% were administered to traders on campus. And the remaining 15% were given to staff in the university. Analysis of Variance (ANOVA) was the statistical technique used to test the perception of the residents towards the current waste management system in the university.

3.0 RESULTS AND DISCUSSION

3.1 Geospatial analysis of the waste management facilities

A total of 126 dumpsters and 13 major waste collection points were identified in the University of Lagos and mapped. The resulting feature layer was used to develop a waste collection system (Figure 1). It was observed (Figure 3) that there were more dumpsters located in the southern part of the university when compared to the other parts. This could be because of the high population of people occupying that axis of the university. The administrative offices of the university, residential quarters and guest house are in this section of the university.

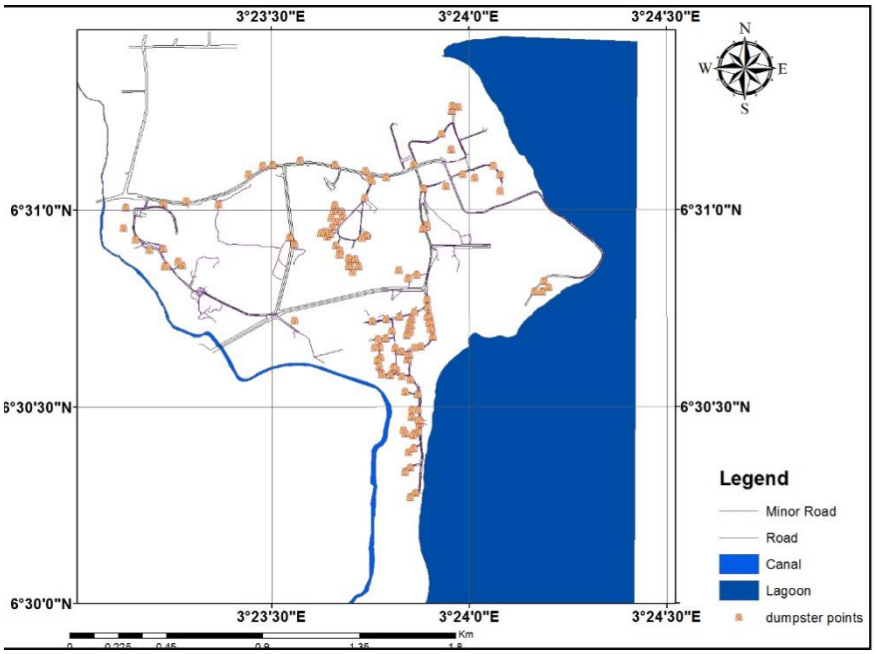

Figure 3. Solid waste collection/dumpsites map for University of Lagos Akoka, Lagos

The proximity between water reservoirs and dumpster were assessed (Figure 4). It was observed that within 50m radius, certain areas on campus had their dumpster filled up and litters around the dumpster. Although, this study did not focus on the water contamination from waste, there is a possible of leaching seeping down to contaminate the water. To avoid the possibility of water contamination in areas such as New hall, Jaja and the Guest house, we recommend that dumpster should not be placed within 50m radius of water reservoirs which also house boreholes.

Also, a proximity analysis was performed of dumpsters to buildings on campus (Figure 5). It was observed that most of the buildings do not have any dumpster located within 4m. Places such as Ozoluwa had its closest dumpster within about 10m and it was filled up. Others were DLI and

CITS areas of the campus. Thus, it is suggested that dumpster should be placed at least 4m of every building on campus for proper waste management.

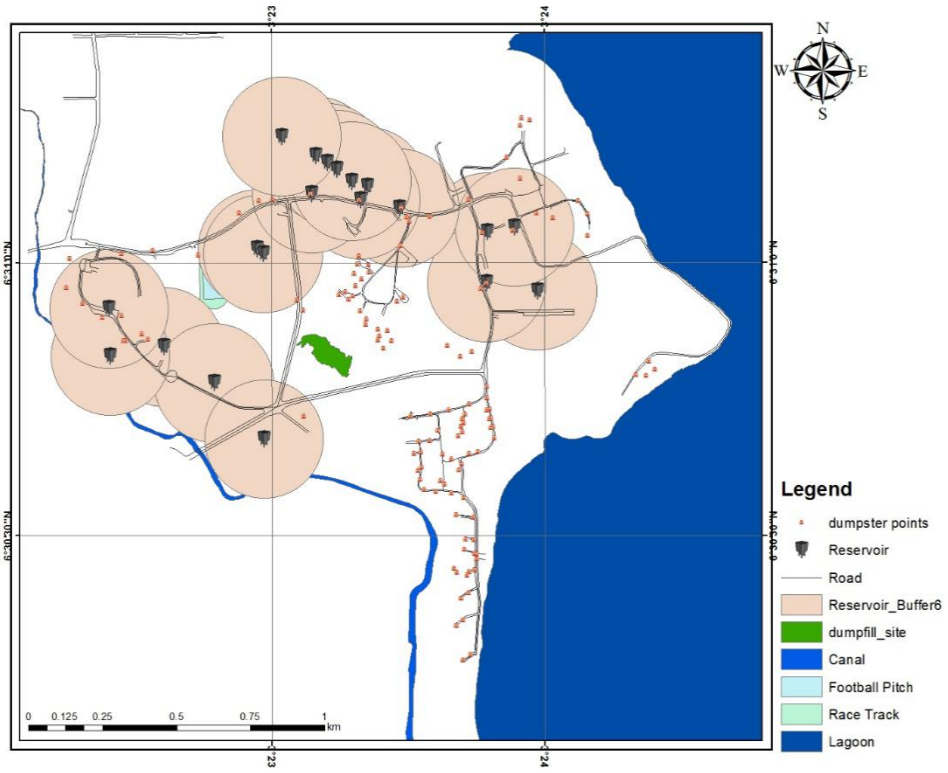

Figure 4. Map showing the proximity of dumpsters to reservoirs within 50m buffer

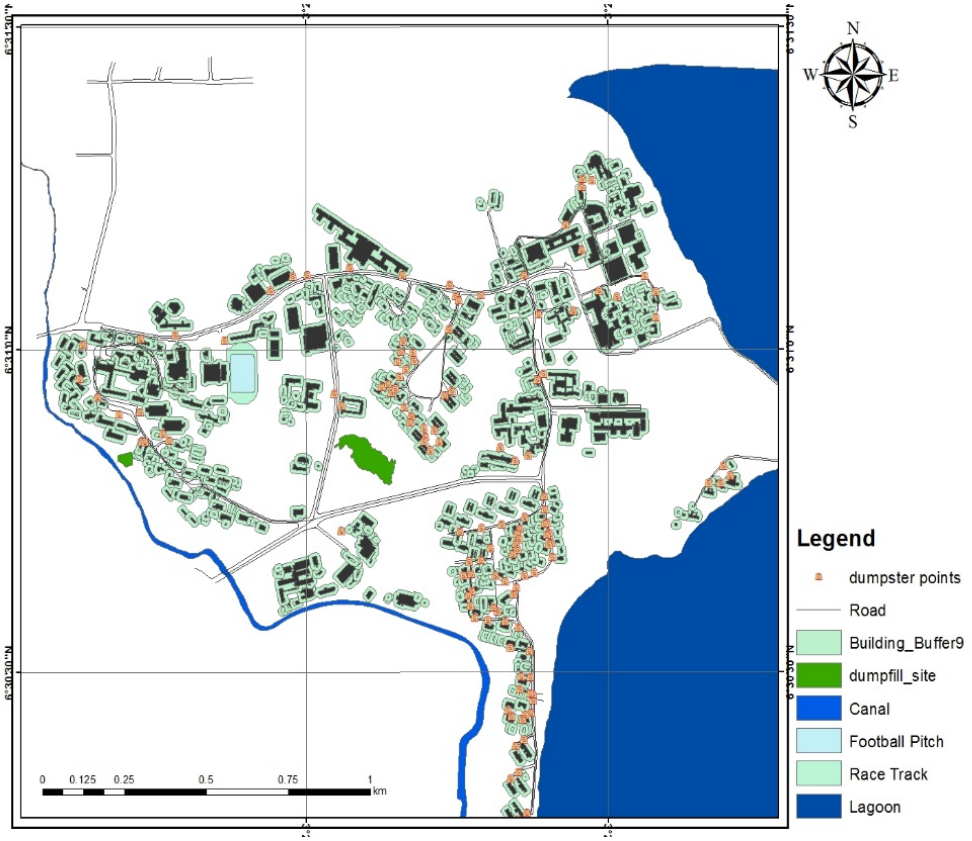

Figure 5: Map showing a buffer of placing dumpsters within 4m radius

An analysis was performed to identify the location of dumpsters along the roads, to assess the ease of pedestrians disposing their waste on campus (Figure 6). We observed that the Ransome

Kuti Road, Akinpelu Adesola Road and Oduduwa drive did not have sufficient roadside dumpsters.

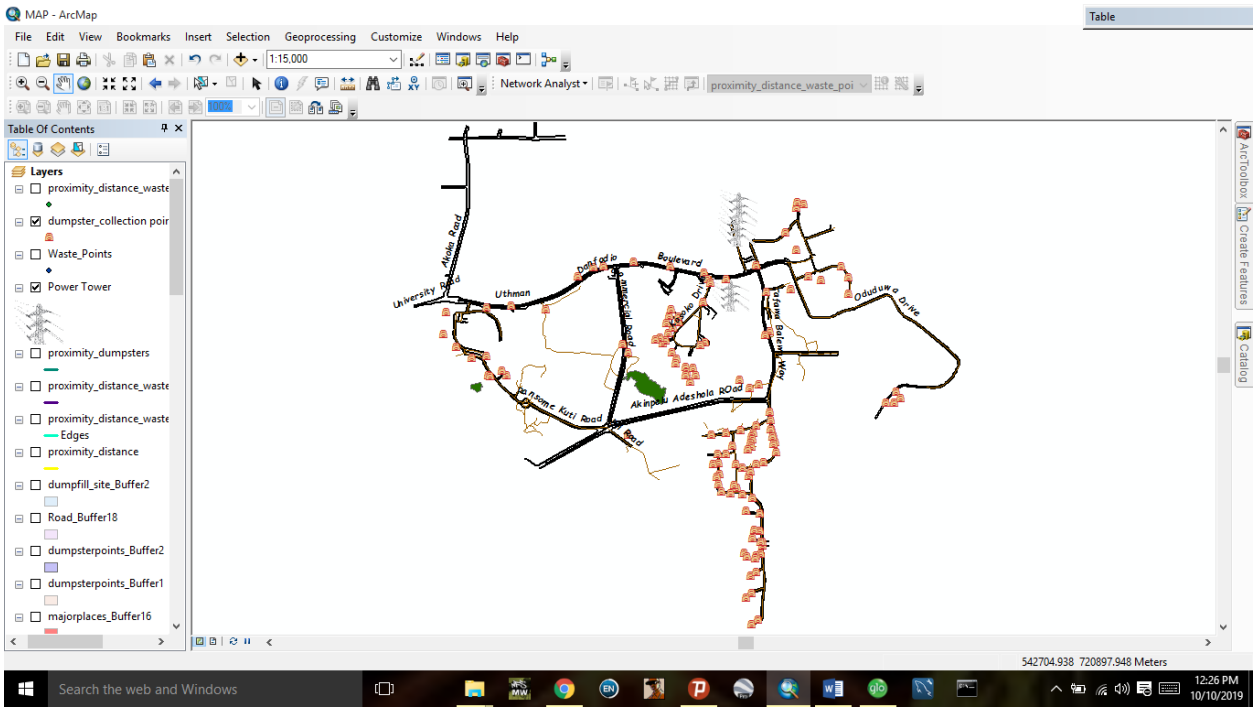

Figure 6. Proximity of dumpsters to road side

We observed that there are currently two major dumpsites on campus: the first one (which is the main one) is located opposite Faculty of Social Sciences while the second is located behind Amina Hall or residence. Waste is moved from second dumpsite to the first for sorting and some form of recycling. A borehole was identified in the dumpsite located around the Faculty of Social Science that the workers of the waste agency used. Although, this study did not conduct any test on water quality, however, depending on the amount of lichen from the waste, the bore hole water could be contaminated.

Suitability analysis was applied to assess the location of these two dumpsites, and it was observed that the dumpsite behind the Amina Hall fell within the 500m buffer (Figure 7). It is recommended that this dumpsite should be relocated based on health reasons. Further findings also revealed that the university has a proposed dumpsite outside the university.

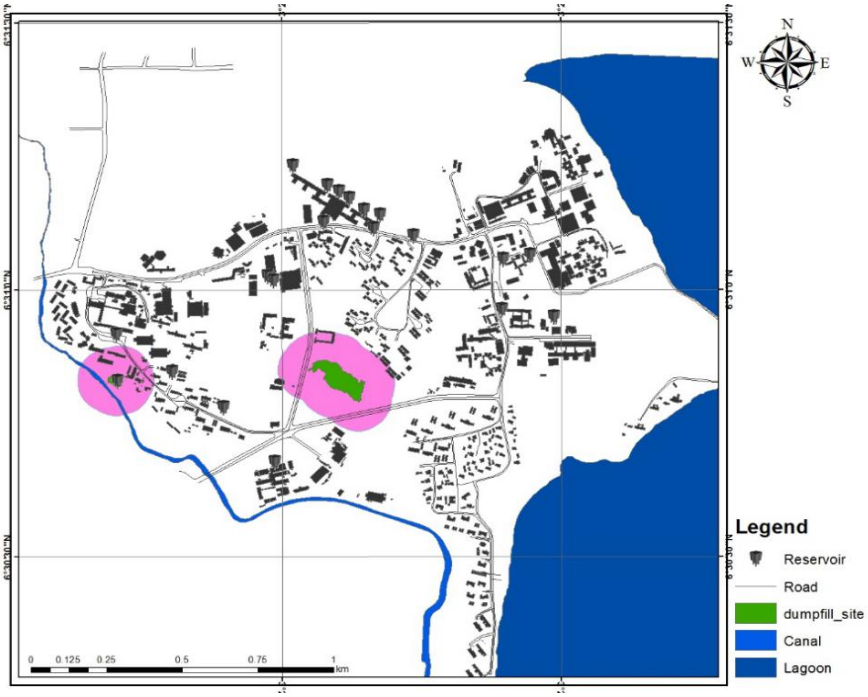

Figure 7. Map showing the suitability analysis for siting a dumpsite

3.2 Questionnaire analysis

In this study, a questionnaire was administered to a total of 220 people. Figure 8 indicates the kind of waste mostly generated in the university. Findings indicate that food waste is the most generated kind of waste which accounts for about 73.30% as compared to paper waste which accounts for 7.77%.

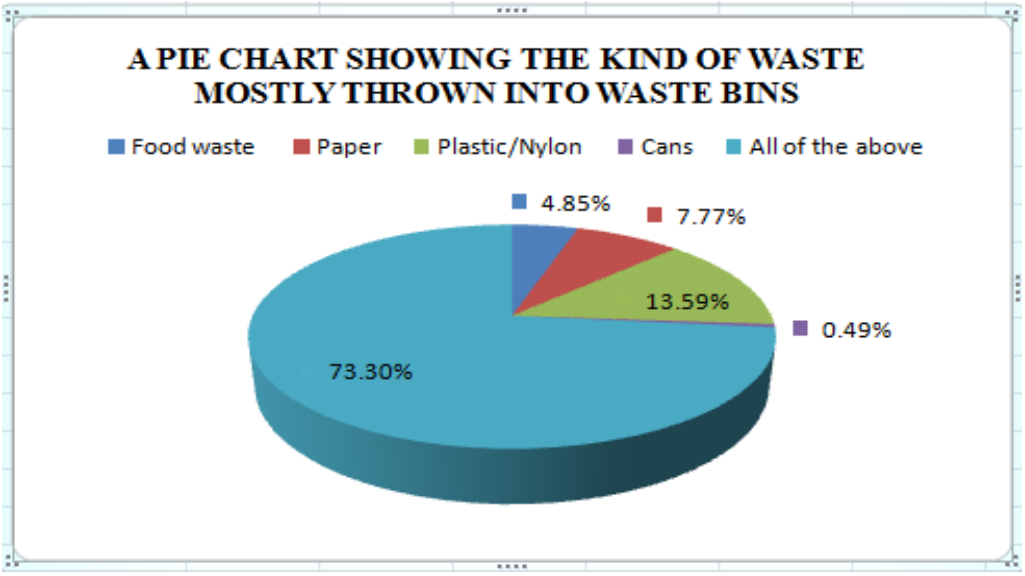

Figure 8. A pie chart showing the kind of waste being thrown into the dumpster

The responses from the administered questionnaire were analysed using the Analysis of Variance (ANOVA) statistical techniques to test the variation in the level of the occupational status of the university community on their perception of waste management. The result (Table 3) shows there is a significant difference in the opinion of the respondents regarding the kind of waste that is thrown into waste bin (dumpster) ($F=29.589$, $p<0.05$), knowledge of waste recycling ($F=5.707$, $p<0.05$), and use of the available roadside dumpsters ($F=5.462$, $p<0.05$). There was also

a significant difference in the frequency at which waste is collected to ($F=5.848$, $p<0.05$) and collecting waste during public holiday ($F=8.919$, $p<0.05$). Their occupation affected the way they responded to these questions.

Table 3. ANOVA table showing the perception of residents with respect to their Occupation

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
What kind of waste do you mainly throw in the dumpster?	Between Groups	71.083	2	35.542	29.587	.000
	Within Groups	243.854	203	1.201		
	Total	314.937	205			
What kind of waste do you produce which you dump in the dumpsters?	Between Groups	10.170	2	5.085	3.066	.049
	Within Groups	336.685	203	1.659		
	Total	346.854	205			
How do you store/collect waste in your place?	Between Groups	3.237	2	1.619	1.974	.142
	Within Groups	166.457	203	.820		
	Total	169.694	205			
Do you know that UNILAG recycle waste?	Between Groups	2.070	2	1.035	5.707	.004
	Within Groups	36.804	203	.181		
	Total	38.874	205			
Do you find it okay to sort the waste into different bins before disposal?	Between Groups	3.014	2	1.507	2.224	.111
	Within Groups	137.534	203	.678		
	Total	140.549	205			
Is the general dumpster close to your room?	Between Groups	.456	2	.228	1.027	.360
	Within Groups	45.097	203	.222		
	Total	45.553	205			
Do you make use of the road dumpsters?	Between Groups	7.001	2	3.500	5.462	.005
	Within Groups	130.106	203	.641		
	Total	137.107	205			
Does the waste generated in your wing of the hall of residence/office/residential area affect your environment?	Between Groups	.956	2	.478	2.335	.099
	Within Groups	41.568	203	.205		
	Total	42.524	205			
What day of the week are the cleaners available to collect waste?	Between Groups	7.066	2	3.533	5.848	.003
	Within Groups	122.647	203	.604		
	Total	129.714	205			
Do the cleaners come to collect your waste during public holiday?	Between Groups	7.582	2	3.791	8.919	.000
	Within Groups	86.282	203	.425		
	Total	93.864	205			
How many dumpster(s) do you think that is/are enough for waste collection in your wing of the hall of residence?	Between Groups	8.188	2	4.094	4.179	.017
	Within Groups	198.865	203	.980		
	Total	207.053	205			
How do you think waste buyers will contribute to your personal waste management?	Between Groups	2.576	2	1.288	1.325	.268
	Within Groups	197.346	203	.972		
	Total	199.922	205			
As a student of university of Lagos, do you have any contribution about waste management in the school?	Between Groups	1.331	2	.666	1.115	.330
	Within Groups	121.193	203	.597		
	Total	122.524	205			

Table 4. ANOVA table showing perception of residents' base on their educational status

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
What kind of waste do you mainly throw in the dumpster?	Between Groups	30.876	3	10.292	7.319	.000
	Within Groups	284.061	202	1.406		
	Total	314.937	205			
What kind of waste do you produce which you dump in the dumpsters?	Between Groups	8.857	3	2.952	1.764	.155
	Within Groups	337.997	202	1.673		
	Total	346.854	205			
How do you store/collect waste in your place?	Between Groups	2.133	3	.711	.857	.464
	Within Groups	167.561	202	.830		
	Total	169.694	205			
Do you know that UNILAG recycle waste?	Between Groups	1.144	3	.381	2.042	.109
	Within Groups	37.730	202	.187		
	Total	38.874	205			
Do you find it okay to sort the waste into different bins before disposal?	Between Groups	.549	3	.183	.264	.851
	Within Groups	140.000	202	.693		
	Total	140.549	205			
Is the general dumpster close to your room?	Between Groups	.576	3	.192	.863	.461
	Within Groups	44.977	202	.223		
	Total	45.553	205			
Do you make use of the road dumpsters?	Between Groups	2.969	3	.990	1.490	.218
	Within Groups	134.138	202	.664		
	Total	137.107	205			
Does the waste generated in your wing of the hall of residence/office/residential area affect your environment?	Between Groups	.226	3	.075	.359	.782
	Within Groups	42.298	202	.209		
	Total	42.524	205			
What day of the week are the cleaners available to collect waste?	Between Groups	4.402	3	1.467	2.366	.072
	Within Groups	125.311	202	.620		
	Total	129.714	205			
Do the cleaners come to collect your waste during public holiday?	Between Groups	1.867	3	.622	1.366	.254
	Within Groups	91.997	202	.455		
	Total	93.864	205			
How many dumpster(s) do you think that is/are enough for waste collection in your wing of the hall of residence?	Between Groups	1.428	3	.476	.468	.705
	Within Groups	205.625	202	1.018		
	Total	207.053	205			
How do you think waste buyers will contribute to your personal waste management?	Between Groups	2.004	3	.668	.682	.564
	Within Groups	197.918	202	.980		
	Total	199.922	205			
As a student of university of Lagos, do you have any contribution about waste management in the school?	Between Groups	1.083	3	.361	.600	.615
	Within Groups	121.441	202	.601		
	Total	122.524	205			

The response of the residents to question 1, shows that the answer was as result of their level of education. The results show that there is a significant difference in the opinions of the respondents as regards what kind of waste they throw their dumpsters at $F=7.319$ and $P<0.05$. It was observed that we had about a hundred and thirty-six (136) dumpsters within the school premises of which about 49 of them are placed at points of less waste generation, whereas there are other regions of higher waste generation but short of waste dumpsters.

4.0 CONCLUSION

This study created a GIS database model for waste management in the University of Lagos. It incorporated the use of GIS and GPS methods of survey to solving the management of waste. Spatial analysis was performed, and maps created. The maps created can be used as a decision support tool to enhance the current management system. Furthermore, this research can serve as a primary beacon with which another research can be founded upon.

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