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Domestic Waste in Aule Gra, Akure Nigeria: The Role of Geoinformatics in Generation and Its Management

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ABSTRACT

An environmental and global issue concerning a very significant problem in today's world is the challenges of waste generation, collection, and its management. It is obvious that waste generation, collection, and management issues are not considered as a priority in the planning of our town estate and settlements which have eventually led to the refuse hill, a threat to human habitats, and economic descend. In the case of Aule GRA part of Akure metropolis, there has to be an appropriate determination of solid waste generated at the household level, effective collection and its evacuation at regular interval. In this paper, geoinformatics was considered as a decision support tool for the location of the household, a collection of waste generation, and its management. Google earth imagery of the study area was downloaded, GPS control point of six prominent places was taking, the imagery was georeferenced and digitized to produce a digitized map of the study area, questionnaires were distributed to the household in the study area, 64% out of questionnaires given were returned and used. The waste of each household was weighed over a period of one month to determine the rate of generation. From the result of the questionnaire, the number in each house were known and the waste per head per day was determined. The population of each household was used together with the waste per head to determine the total waste generated at each family household. A spatial database was developed which are used to predict the evacuation day for each household.

Keywords: Geoinformatics; Household; Waste; Aule; Georeferenced

I. INTRODUCTION

The environment is heading towards an impending risk due to unmanageable waste disposal. It is a sensitive and delicate issue which concerns about the serious ecological and environmental problem in our today's world. The present situation of direct dumping of waste without proper inspection and separation leaves a serious impact of environmental pollution. Domestics, industrial and other wastes, whether they are of low or medium level wastes, they are causing environmental pollution and have become a perennial problem for mankind [10].

Waste is hazardous to the environment because it provides a breeding ground for insects that are harmful to human. The issue of waste is not only because of the inadequate management system [15]

Waste management is the collection, transport processing, recycling or disposal and monitoring of waste materials. It is observed that solid waste management can be divided into two phases. One is the waste management of the area where it is generated and secondly the management of waste at dumping ground. This paper, however, deals mainly with waste management in the area where it's being generated, it includes the waste generation, their collection, and removal from the generation point. The poor state of waste management is attributed to an inadequately formulated and poorly implemented environmental policy [13]. Addressing this issues collection of solid waste from generation source is very important. That

was the basis for this research. There has been awareness regarding waste management amongst many countries like California in the United State of America, Germany, and part of India. Hence different techniques and technologies have been applied or tried in solving the problem.

In Nigerian cities, wastes are generated and deposited at some chosen locations for the convenience of the local population and city authority. More often the sites of dumps are chosen without having the idea of the situation of the people of the area even the time and route required by the authority to evacuate them as such leads to refuse hills, blocking of roads, adverse visual impact and causing environmental pollution.

It is expected that this research is implemented, it will help to affect the habit of residence in waste disposal and management and that the database will be useful in other governmental services to the people and will improve the environmental condition of the cities for healthy living, and future planning of Nigerian cities and facility management. Investigations showed that waste management issues are not considered in the planning of our settlements. These provisions are not made for dump sites in our layout plans [12].

Therefore, residence turns undeveloped plots to refuse dumps. As the layout is built up, the refuse dump is shifted to the roadside. Since the evacuation of the waste is not regular, it eventually grows into a refuse hill, blocking drainages and roads, hence causing environmental menace. Over time, the residents set it on fire to reduce the quantity to some level. This contributes to air pollution and underground water pollution. This paper tries to suggest ways eliminate open site dumping in favor of house to house collection; hence the rate of generation of the waste has to be determined through the weighing of family wastes over a period of time.

In Nigeria, waste management problem have not really been given the attention it deserves by the government, and the general public [8]. According to [1], solid waste management problem in Nigeria was caused by the poor implementation of government policies on the environment, lack of public and the intensity and continuity to correct the pathetic public attitude towards the environment. The mountainous heaps solid waste that deface Nigeria cities continuous discharges of industrial containment into streams and rivers motivated the Federal Government to promulgate Decree 58 for the establishment of Federal Environmental Protection Agency (FEPA) in December 1988 to secure a quality of environment adequate for the well-being and health of Nigerians. They were also to see the collection and disposal of solid waste in an environmentally safe manner, setting up and enforcement of law, regulation and standard encourage public participation, environmental monitoring and the imposition of penalties on defaulter to encourage compliance. In spite of the formulation, it has been a failure. The environment has not been adequately protected, improperly site open dumps everywhere endangering public health by spreading odors and diseases; uncontrolled recycling contaminated goods and pollution of water sources. In fact, the government policy is not comprehensive.

An attempt by Lagos State government to solve the waste problem in Lagos mega city led to the signing of a memorandum of understanding (MOU) with Clinton foundation and the Konsadem consortium [14].

The aim of the agreement is to operate and transfer structures for 20 years which will lead to the development of comprehensive closure, collection, and utilization of landfill gas and establishment of integrated solid waste management recycling and composting facilities as well as a sanitary landfill for residual waste. It aimed at closing 180,000 tons of waste usually disposed of at the landfill sites, which will be processed for reuse so as to reduce greenhouse gas emission by approximately 95,000 metric cubic tons per year and will be designed to accept a maximum 900 tons of municipal waste daily. This is a major stride in waste management situation in Nigeria [16]. [5], tried to propose an effective solid waste management system for municipal waste management through the planning of bin and optimizing the vehicle route for waste collection vehicles. The following points were considered in the framework: appropriate method of onsite storage: appropriate method of primary collection. The planning of bins and optimizing the vehicle route for the waste collection vehicle was the two major points. Satellite data was used for the generation and updating of spatial databases like road network, waste bin location landfill

site and waste collection, vehicle garage, and the work was divided into phases that are, waste storage, waste collection and waste methodology.

According to [3] as supported [18], Abu Dhabi city in the UK statistically shows that the rate of waste generated depends on the income average of household which is the average rate of 1-76kg per day. The analysis revealed was that this rate was dependent on the income level with an increase of 35% for high resident over the average rate and 50% of their waste is food waste generated from household or family.

Looking at the reviewed all researchers centered on open site dumping as the source of the waste less was talked on segregation generation and sorting. This paper tries to see the family as the source of the waste. However, other notable researchers on the waste generation and management includes [2],[4], [6] and[7] This is because, in general terms, dump sites are not provided for in the planning of our settlements. Since there is no record of waste generation data in Nigeria, it becomes necessary to try and determine the rate of the generation which will form the basis for planning the evacuation of municipal waste. Hence this research determines the waste by weight which can be generated per person, and the frequency of evacuation.

Consequently, geoinformatics and GIS (Geographical information system) is one of the new technologies [11]. "GIS is a system of computer hardware and software designed to allow users to collect, manage analysis and retrieve a large volume of spatially referenced data and associated attribute data collected from a variety of sources" [17]. Due to the multifunctional features of the geographical information system, the information can be related spatially with a very good flexibility to exchange, compare, evaluate, analyze and process. This Technology was applied in this work. The database of the study area was created using information from questionnaires which include House number, the number of family or household and their ages, the number of days they dispose of their waste etc. After generating the map of the study areas showing the family location-flats, the waste was weighed over a period of one month. The data generated was linked to the map of the study area.

The Study Area

Akure is a city in the southwestern region of Nigeria and is the largest city and capital of Ondo state. The city has a population of approximately two million. The people are of the Yoruba ethnic group of other tribes living in this city. Akure remains the administrative headquarters of Ondo state. The oil boom of the 70s has changed the feature of many Nigerian cities such as Akure. People move from rural area to urban cities to look for green pasture and better-living conditions. The population of the city increased tremendously, for this reason, government increases the number of government reserved area (GRA) in Akure to spread out the population of the city towards Aule village where the present Aule GRA is located in eastern part of the main Akure city with a population of about 200,000 people.

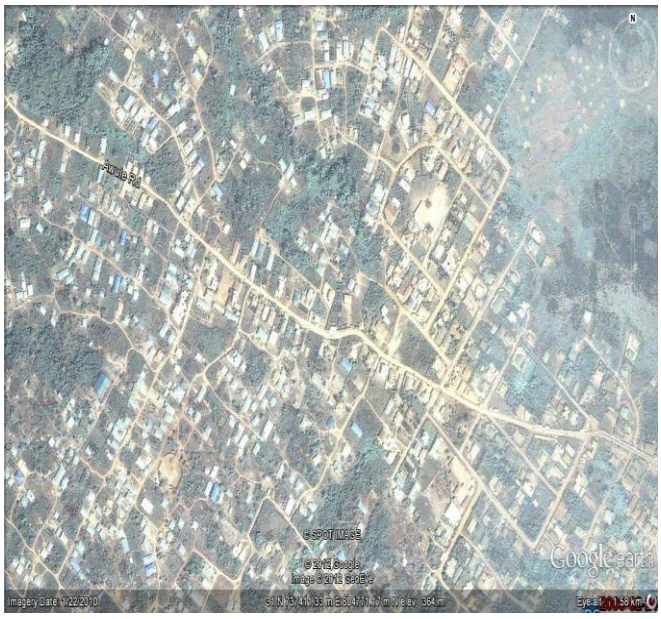

Figure 1 : Google Earth image (2010) of part of Aule GRA, Akure.

The organization of this document is as follows. In Section 2 (**Methods and Materials**) were discussed, In Section 3 (**Result and Discussion**) was made to show the possibilities and application of Geoinformatics in the solution to domestic waste problems, and section 4 is the conclusion of the study.

II. METHODS AND MATERIAL

The methodology used includes the collection of information about solid waste management situation in part of Aule GRA Akure, data was collected for analysis by means of personal interview, observation, questionnaires and google imagery of Akure. The composite map of the study area was produced as shown below. Cellophane bags were distributed to each household for the collection of solid waste materials at the generation source and scale was used for weighing each cellophane bag to ascertain the quantity of waste generated by an individual household which is used to determine the quantity generated. Location points in the study area such as prominent junctions as shown below was then obtained by going around the site with GPS, acquiring the coordinates of each point.

The google image was imported into the ArcGIS environment so as georeferenced the image, this is done to make the image coordinate system correlate with the actual coordinate on the ground. It is also referred to as the process of associating various object positions to the corresponding ground position. A minimum of 6 points was used for the georeferencing i.e. X and Y coordinates of different points as shown below.

TABLE 1
Coordinates Used for Georeferencing

Points	Easting	Northing
A	738107.45	804550.77
B	738033.07	804450.37
C	737962.39	804577.15
D	737996.50	804793.76
E	737916.89	804613.20
F	737906.77	804676.80

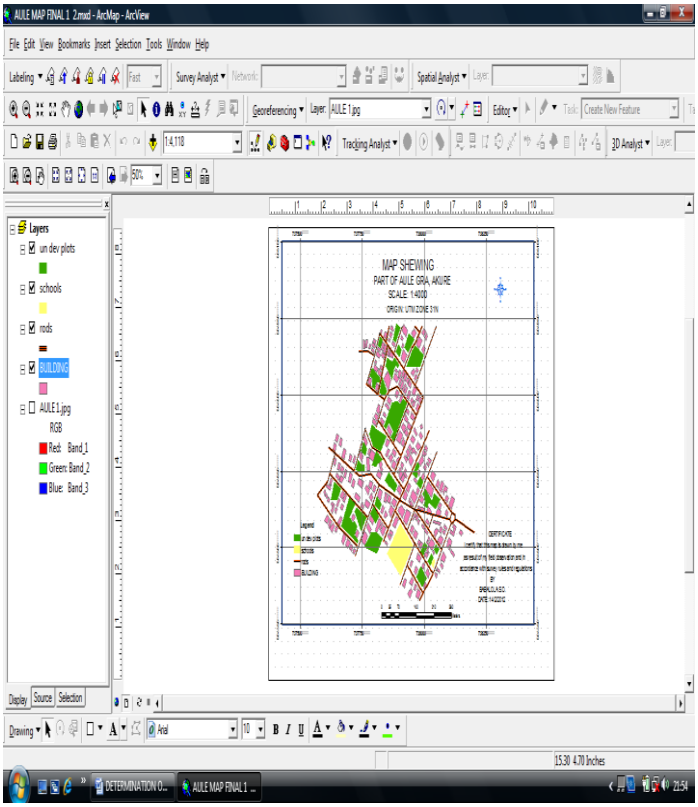

Figure 2 : Digitized map of part of Aule GRA Akure

TABLE 2

S/no	House no	WEEK ONE 12/12/15		13/12 14/12 (Kg)	WEEK TWO 19/12	20/12	21/12 (Kg)
1	Hc2	8	9	14	12	8	10
2	Hc3	5.5	8	8	8	10	7
3	Hc4	7	6	6.5	5	5.5	7
4	Hc5	6.5	4	6.5	8	4	7
5	Hd1	6	4	14	14.5	4	11
6	Hd2	5.5	5.5	10.5	10.5	7	12

WEEK THREE 26/12		27/12 28/12 (Kg)	WEEK FOUR 29/12		30/12 31/12 (Kg)
10.5	7	10	13	14.5	9
6	10	11	8	8.5	6
6	6.5	5	8.5	5.5	7
6	4	4.5	7	4	6
10	4	14	12	4	11.5
10	10	9	8	6	12

Sample of field book showing information on some household waste weighed

The result of the questionnaire was calculated in percentage from the total number of the person that answered the questionnaire.

Figure 3 : Weighing Scale

III. RESULTS AND DISCUSSION

Determination of Average Waste Generated Daily / Person

TABLE 3 Attributes table

S/no	Road No	House No buildings	Family size	Waste generated /Household daily WG_hh_day	Average Waste generated daily/person AvWGDay_pe	Day of evacuation Day evacuate
1	Road A1	Ha1	10	8.66	8	6
2		Ha2	9	9.13	7.2	7
3		Ha3	10	8.99	8	6
4		Ha4	4	5.19	3.2	20
5	Road B1	Hb1	7	8.07	5.6	10
6		Hb2	10	7.32	8	6
7		Hb3	13	8.58	10.4	4
8		Hb4	9	8.54	7.2	7
9		Hb5	18	8.92	14.4	3
10	Road B2	Hb6	11	9.6	8.8	5
11		Hb7	11	9.35	8.8	5
12		Hb8	10	8.62	8	6
13		Hb9	15	8.58	12	3
14		Hb10	13	8.49	10.4	4
15	Road B3	Hb11	10	11.71	7.2	7
16		Hb12	10	9.33	8	6
17		Hb13	12	9.03	9.6	5
18	Road C1	Hc1	18	10.01	14.4	3
19		Hc2	13	9.42	10.4	4
20		Hc3	12	7	9.6	5
21		Hc4	8	5.21	6.4	8
22	Road C2	Hc5	12	5.81	9.6	5
23		Hc6	14	10.58	11.2	4
24		Hc7	12	13.75	9.6	5
25		Hc8	11	8.54	8.8	5
26	Road D1	Hd1	10	8.08	8	7
27		Hd2	9	8.58	7.2	14
28		Hd3	6	6.67	4.8	6
29	Road D2	Hd4	10	6.29	8	6
30		Hd5	10	9.71	8	6
31		Hd6	16	17.21	12.8	3
32		Hd7	8	5.46	6.4	8
33	Road D3	Hd8	11	7.67	8.8	5
34		Hd9	9	8.42	7.2	6
35		Hd10	12	11.33	9.6	5
36	Road D4	Hd11	21	20.83	16.8	2
37		Hd12	16	11.08	12.8	3
38		Hd13	10	6.38	8	6
Total			429	346.14		

The above calculations were done and shown on the database such as the amount of waste generated per household and amount of waste generated per person.The format used for the calculation is as follows.

For average amount of waste generated/household (WG/H) WG/H Daily

WG/H weekly = WG/H daily multiply by the No. of days weighed in a week.
WG/H Monthly = WG/H weekly multiply by 4. For average amount of waste generated/person (WG/P)

WG/P daily = WG/P weekly = WG/P daily multiply by the No. of days weighed an in the week.

WG/P Monthly = WG/P weekly multiply by the number of days weighed. Now, to calculate the average waste generated daily/person. The population of all household was summed up and the daily measured waste generated/household summed up. Then divided by the daily total measured waste generated/house by the total population of all household

i.e

= Average waste daily/person

The household population was calculated to be =429. The waste generated daily was calculated to be = 346.14kg 346.14/429= 0.80kg/day/person

Determination of Daily Waste Generated/House
Then, use the average waste daily/person to multiply the number of persons/household to get the daily waste generated/house.

This also appears in the attribute table created is the database. The database is a system that is essentially a computer record keeping system and an electronic filing cabinet its allows adding files to database, inserting new data into existing files, retrieving data, updating data from existing files, removing existing files from the database and also gives room for different analysis and queries.

For instance, for house no. Ha1, 0.80x10 = 8.0kg

When determining the daily waste/household, the houses that were weighed was used. The daily waste generated per house covers all the houses, both the ones measured and the ones not measured which can also be applicable in Akure or Nigeria as a whole. The size of the bin can be determined since the average waste generated/house has been calculated.

Determination of Size of Bin

The size/volume of the bin is based on the volume of waste generated per household. A picture of a standard bin with a covering lid on top in the market was taken.
Therefore, based on assumption, the size of the bin was determined by looking at the possible lowest and highest weight especially the highest weight because it is the highest weight that will be used to determine the frequency of waste collection. From the determination of daily waste generated/house, the lowest was 0.80kg and the highest weight was 16.8kg. Note that if the size of the bin almost equivalent to the daily volume of the waste generated, it means one will have to be going for collection every day which is not advisable. Therefore, the size/volume of the bin is assumed to be able to contain at least 38kg of waste after considering the highest weight of the waste generated/house so that the highest waste generated/house will take at least two to three days before evacuation. This will be made possible so that by the time one finish going round for those of 3 days, 4 days 5 days etc, the day to go for the one that is two days, one may still have the other ones of 4 days, 5 days etc. required to be evacuated. The size of the bin will have to be the same for every household for the evacuation to be done according to the calculation below. The size of the bin can now be used to determine the days of evacuation. Below is the sample of the bin considered for the purpose of this work.

Figure 4: Sample of waste bin

Evacuation

Since the size of bin is now decided, one can determine the days the family bins will get filled and evacuation at an appropriate time interval. The days of evacuation was determined by dividing the size of the waste which is 38kg by the average waste generated/house. That is,

$$\frac{size\ of\ bin}{average\ watse\ generated/house} = \text{day of evacuation}$$

Taking for instance from the table above, the highest waste generated/house is 16.8kg and the assumed size of bin is 38kg.

38/16.8 = 2.262 $\simeq$ 2 days

Therefore, the highest waste generated/house will be evacuated within two days. The reason for choosing the

size of the bin to be 38kg is that the waste generated/house will not be completely full and overflow before the day of evacuation. A column is also created in the database for days of evacuation. Based on the table now, one can query the database. Such data analysis could Show the family that the bin will be full in two days. It will then be highlighted alongside the building.

Queries

The query is a means of manipulating information to get new information. Queries are useful at all stages of GIS analysis for checking the quality of data and the result obtained. The query result proved the effectiveness and capability of the software and produce a map for specific user need for research, improvement, development, decision making, and any other purpose. A query is usually a series of word command that enable the operator to activate certain capability of the computer without having to write a program. Below is sample of data analysis queried made in this study.

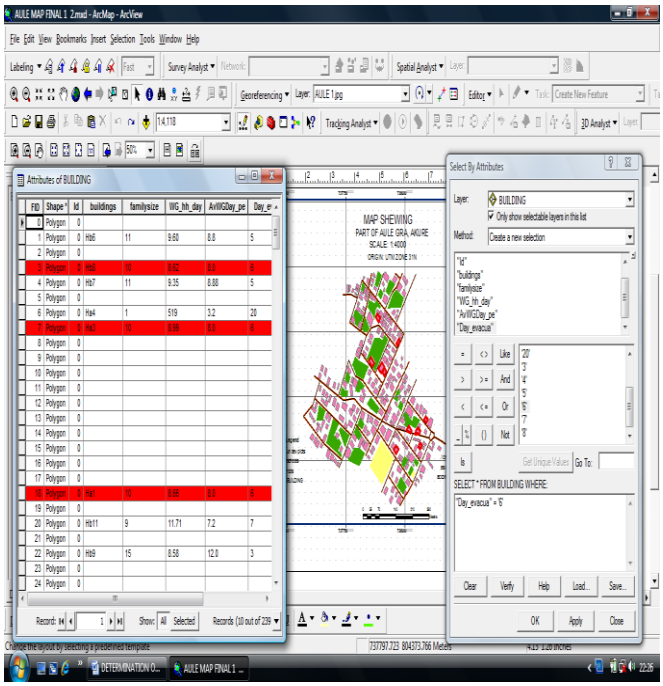

Figure 5 : Query showing houses whose waste is to be evacuated every 6 days.

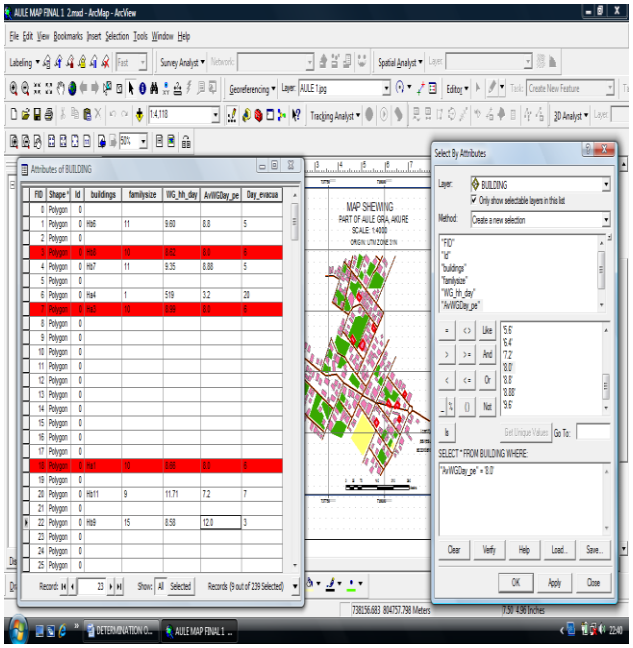

Figure 6 : Query showing houses that generate waste 8.0 kg.

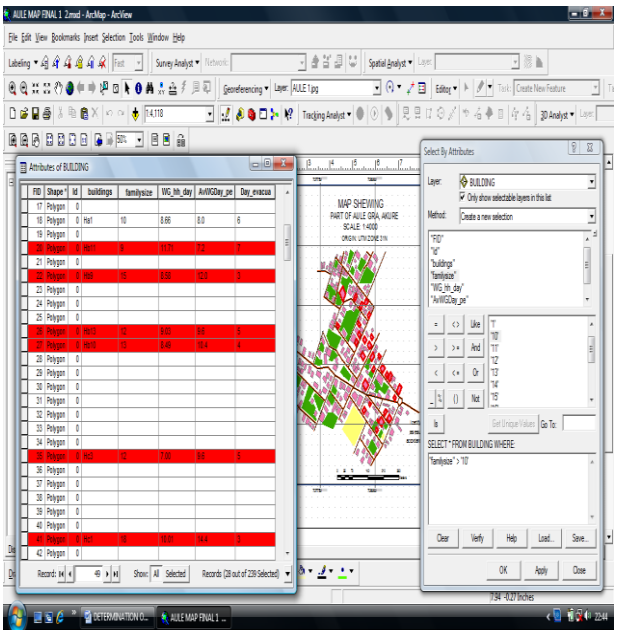

Figure 7 : Query showing family size above 10

IV. CONCLUSION

Lack of adequate consideration in waste management issues in the planning of settlements has been the motivation for this paper. Average waste generated daily per household was successfully known, the size of the waste bin to be provided was also determined and the days of evacuation at the regular interval was determined in this study. Taking a general overview of the results generated from this research as shown in the queries, it was discovered that using the waste bin provided by the evacuation of waste must take place within two days interval otherwise waste bin for some house would be over-filled. Therefore, geoinformatics has proven to be an effective technique for environmental management even in the area of waste management. The achievement of effective collection and evacuation at regular interval provides healthy living and will improve the environmental condition of the cities and also affects future planning of Nigeria cities and facility management. Consequently, it is recommended that this work is expanded to cover commercial/public places like schools and markets for the government, organization, industry, and individuals to enhance and improve waste management in the study area. The implementation of this work is very critical so that the waste management situation in Nigeria can change for the better. There are also further works that can be considered in improving waste management. Route planning for waste collection vehicles. Sorting at the source can also be done to reduce the volume of disposable waste.

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