ENVIRONMENTAL WASTE MANAGEMENT IN ILORIN METROPOLIS USING SOFTWARE APPLICATION

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ABSTRACT: One of the major causes of death in Ilorin metropolis which is the capital of Ilorin Kwara State is the issue of environmental waste. Wastes are unused and rejected materials from household, schools, industries and highways. The waste materials are increasing as the population also increases. This paper aimed at developing a software model that is capable of predicting the waste generation and number of RORO bin needed based on population. Visual Basic programming was used to interpret the model developed and with this, we can predict the waste generation and number of RORO bin in One Dimensional representation. This will help both the government of Kwara state and Nigerian as a whole to tackle the environmental treat causes by waste generation by predetermine the number of RORO bin a particular environment or city we be needed. It will also assist the government to plan ahead especially in procurement of RORO bin and also reduce the number of disease (such as Malaria, Typhiod) which the government spends millions of Naira on yearly.
KEYWORDS: Waste, RORO bin, Population, Generation.

INTRODUCTION

The activities of human being affect the environment either directly or indirectly ([KS16]). A stone crusher adds a lot of suspended particulate matter and noise into the atmosphere. Automobiles emit from their tail pipes oxides of nitrogen, sulphur dioxide, carbon dioxide, carbon monoxide and a complex mixture of unburnt hydrocarbons and black soot which pollute the atmosphere. Domestic sewage and run off from agricultural fields, laden with pesticides and fertilizers, pollute water bodies. Effluents from tanneries contain many harmful chemicals and emit foul smell. These are only a few examples which show how human activities pollute the environment. Pollution can simply be defined as release of unwanted materials into the environment due to various human household, commercial and industrial activities. Those agents that cause environmental pollution are called pollutants ([Car17]). Pollutants are any harmful substances released into the environment which have direct effects to human life and other living organisms ([Tie06]).

Environment pollution is a global problem which has a great influence on human health ([F+11; PI10]).
Environmental waste pollution has been a major global concern over the public health for the past years ([Kim07]). The exposure of human to environmental pollution is believed to be pollution is believed to be more intense now than the past year in human history ([S+06]).

Various types of Environmental Pollution
Air Pollution, Water Pollution, Noise Pollution, Soil Pollution, Solid Pollution, Thermal Pollution, Thermal Pollution, and Radiation Pollution are being the major types of environmental pollution in the world today.
The release of any solid, liquid and gaseous substances into the environment is known as air pollution, this also include noise and radioactive radiation which causes hazard to human and living organism existence. Air Particulate matter, lead, ground-level ozone, heavy metals, sulphur dioxide, nitrogen dioxide, and carbon monoxide are the major pollutants found in the air we breathe in ([EPA09]). This cause of untimely death by most of the people that lives in the cities is as a result of Air pollution ([PI10]).
Sound is atmospheric vibration perception to the listeners. Noise Pollution is a sound without meaning or any unorganized sound that is unwanted by the recipient. Noise such as crushing and cutting of stone, loudspeakers, steel forgings, shouting by hawkers selling their wares, movement of heavy transport vehicles, railways and airports leads to irritation and an increased blood pressure, loss of temper, decrease in work efficiency, loss of hearing which may be first temporary but can become permanent in the noise stress continues ([Kry96]).
Water pollution can be regarded as the presence of the undesirable such as organic, inorganic and biological substance in water to as to make it unfit to drink which result to water borne diseases and other health related problems. Water pollution is caused by different human activities such as domestic, agriculture and industrial while the natural causes of

water pollution are decaying of organic material, sediments brought by runoff water from agricultural fields and release of both untreated or partially treated sewage and industrial effluents, disposal of fly ash. Drinking polluted water can cause great damage to human being and also causes waterborne diseases like, Hookworm, Kidney or Liver diseases Giardiasis, Amoebiasis, Ascariasis, Typhoid ([***06]).

Soil Pollution is caused by the addition of substances which adversely affect the quality of soil or its fertility. Solid waste is defined as any garbage deposited in the environment which includes solid, liquid and semi liquid or gaseous materials which affects human health. Environmental Solid waste such as sewage, dumping of refuge, application of chemicals to the field is one of the main causes of environmental pollution ([Kim07]). Land or soil pollution is also a form of environmental catastrophe that the world is battling today ([Kha10]). Pollution is a threat affecting both plant and animals, in order to make this paper work more effective it must be related to the term waste or solid waste pollution.

Waste is any object that has negative effects on its environment; it is the production of any processing residue, substance, material or any personal abandoned property. The daily dumping of both solid and liquid household activity result to household waste. In a growing population, waste management is the situation of proper collection, transportation and environmentally sound disposal of waste products.

Environmental waste needs to properly manage, and the collection, processing, recycling of waste materials is basically known as waste management. Various materials are produced by human activities and this need to undergo processes to reduce the effects of all this materials on human health and its environment. Waste management is an improvement practice for recovery resource in a developed country which focuses on reducing the rate of consumption of natural resources ([AP13]). The management waste is the ability to treat all waste materials as a single object solid, liquid, gaseous, radioactive substance, and attempt to reduce the harm it does to the environmental. ([Mal14]).

Waste can be in form of solid, liquid, gas, or energy in the form of noise or heat. A waste is said to be in liquid state when it is at 20°C regardless of whether it is packaged or otherwise contained and irrespective of whether or not the packaging container is to be disposed of together with the liquid that it contains ([EPA09]). Gaseous wastes are produced by individuals at their various homes which result to as air pollution; it can also be from mines and construction industries.

Solid waste is any household garbage, trash; refuse and rubbish of human activity within the house. Solid waste also includes various liquids, gas and semisolids that are produced from industrial activities, agricultural activities and commercial activities. Mostly liquid and gas substances are close inside solid containers and disposed of with more conventional solid wastes. Sewage, effluent and wastewater from commercial enterprises, organizations and private homes are not solid waste, but once wastewater is treated and various residues are removed from the water to form sludge, the sludge is usually treated as a form of solid waste ([APO07]).

Solid waste material are of two types which are municipal and industrial solid waste; municipal solid waste are waste produced by homes, institutions and businesses while This study will only focus on waste produced by various household.

Asian Production Organization APO ([APO07]), defined solid waste management as the method of controlling generated waste, storage, collection, movement, processing human waste materials. The method of solid waste management should be in respect with the best principles of good health, engineering, economic, aesthetics, conservation, and other environmental considerations, and that is also responsive to public attitudes. It can also cause serious pollution that may result in environmental degradation. It is therefore important that this solid waste be managed effectively and efficiently to promote a healthy population in the community.

Ilorin, the state capital of Kwara State in Nigeria, is witnessing the growth in population every year and as a result of this, the human activities also increases, this lead to record of high number of waste and it is highly essential to find ways of reducing the waste so that environment can be conducive for the people to live. One of the major duties of any metropolis is to collect, manage, transport, process and safely dispose waste generated within its area.

The planning of waste management policy normally occur at the ministries level, that is the ministry of environment are responsible for making policy on waste management which in most cases cause political pressure for environmental protection, and so time this result to conflict of power in the sense when the ministry and the local authorities have different goals to manage the waste materials on daily basis ([UNE96]).

Integrated Waste Management Approach
This approach to waste management is most compatible with an environmentally sustainable development. It refers to the complimentary use of a variety practices to effectively hand solid waste materials in any metropolis. Integrated waste management system was developed to identify the level at which the highest values of individual and collective waste materials can be recovered.

Integrated waste management approach is favoured by reduction with the reusing more, thereby saving material production, resource, cost and energy. The least desirable is landfilling. The approach not only aims at maximizing recovery of reusable and recyclable material, also reduces solid waste and promotes human health and the environment ([USE95]). Reduce, Reuse and Recycle are the 3R concept emphasized by United States Environmental Protection Agency to manage sound environment. This concept lay more emphasis on increase in the ratio of recyclable materials ([USE02).
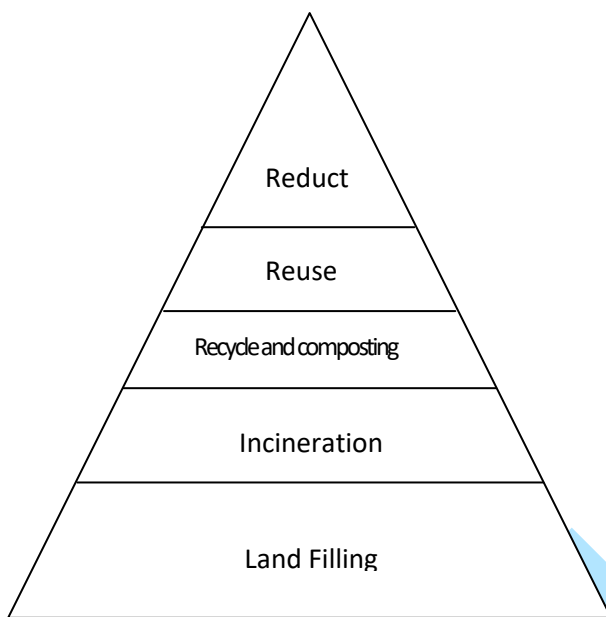

Figure 1: Integrated Waste Management Hierarchy

Waste Reduction

Waste reduction is a technique of solid waste management. This technique is to reduce the amount of solid waste generated. A successful method of reducing waste material enhances the effectiveness and promising ways of dealing with solid waste management as the amount of waste for disposal is reduced and kept in check. But waste material production involves an aspect of culture on people's behavior and attitudes ([USE02]).

Reuse

Plastic bags, paper, bottles, cardboard, and cans are the most common materials for reuse which are recovered for domestic uses normally at municipal levels. These materials are sold to commercial centers which also sell it to the end final consumers. The materials therefore only enter the waste stream when it cannot be use for domestic consumption again. Reuse plays a valuable resources conserving role in solid waste management. ([ADB02])

Recycling and Composting

Recycling is an empowerment activity for the low income population who cannot manage to be employed by the industry, while composting is the control of natural process of decomposition of organic waste materials. Both the recycling and composting are of great importance which leads to low rate of pollution in Africa.

Landfilling

Landfilling is the last preferred option in the hierarchy of integrated waste management. It is a common waste disposable in most cities of the world. After municipal solid waste materials have been collected, landfill is the only available option. The types of landfill include controlled dump, uncontrolled open dumps and secure sanity landfills. When landfills are done below standards of sanitary practice, it leads to air and water pollution.

Solid Waste Material Management Practices

The State Government have authority over waste material management systems which includes municipal waste generation (households), producers to ensure proper collection and transport, waste pickers as well as other private waste participant and disposal at the dumpsites.

Waste materials collection process is done in a different mode of operation which involves house to house waste collection for the planned household and a selected area for inhabitants of unplanned environments. Waste materials are convey from the households where they are collected by the use of pushcart handled by the street boys who engage in waste materials collection activities as the main source of getting their income and after they have been paid, the collected waste materials are moved to the dumpsites where they will be processed and reuse.

As discussed earlier, municipal solid waste materials are generated from individual household. Not all the generated waste at household level is being collected; some of it is disposed off by burning or by throwing inside the pit. Those who do not have enough space at the environment to burn the solid waste material or throw inside the pit will eventually use the municipal solid waste management system.

Solid waste material management passes through various stages from when it is being collected at the household level to the dumpsite. From the household point where the pushcart boy collected the solid waste material and send it to the collation site when doing this, they use this medium of conveying the waste materials to sort out the valuable materials from the solid waste before getting to the dumpsite. At the collection site, another group of people known as waste pickers are preset whose main concern is to recover materials in order to sell for reuse purpose, sometimes they also find materials for their own consumption ([Dia16]).
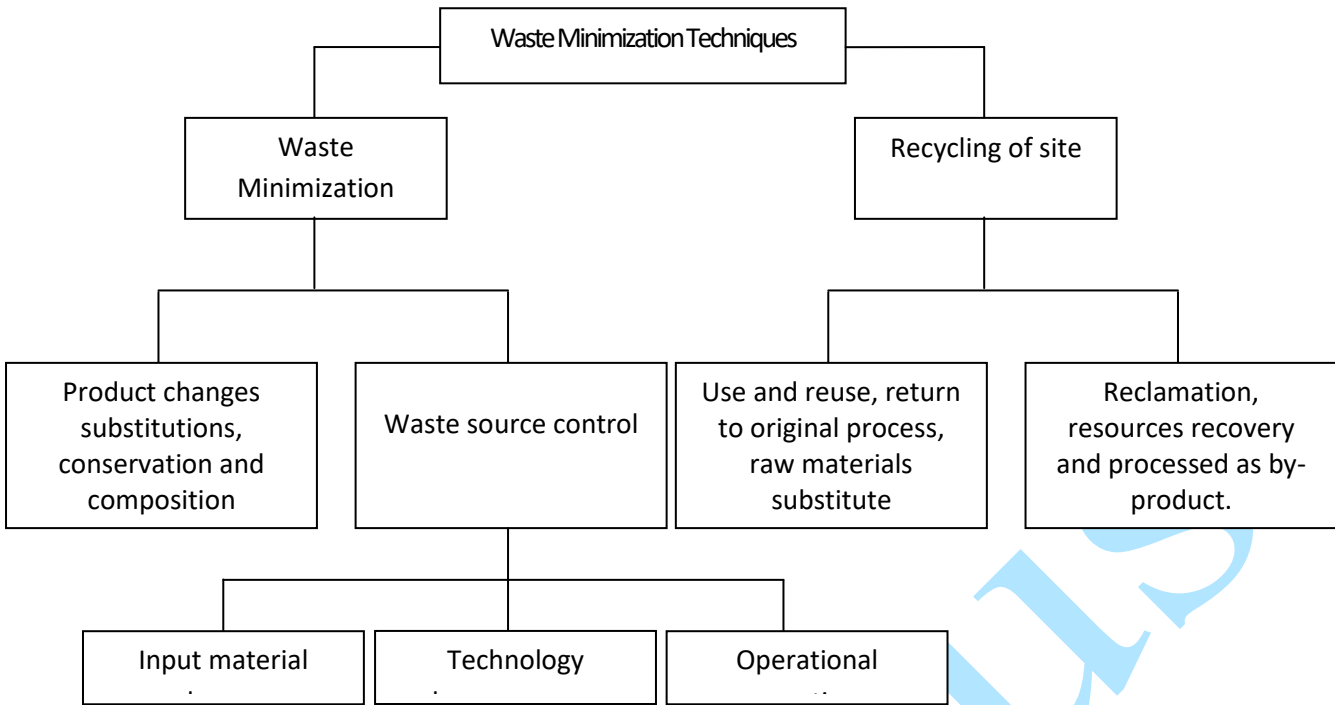
Figure 2: Waste material minimization Techniques
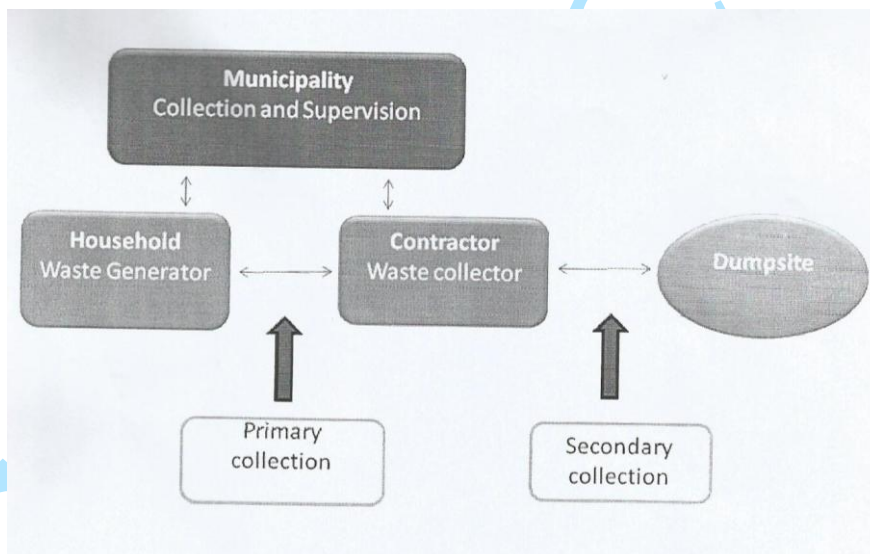

Figure 3: Municipal Solid Waste Management Relationships. This figure displays relationship for solid waste management between the municipalities, households and contractors including the two stages of waste material collections

Figure 4: Waste collection using pushcart

Figure 5: Waste collection using trucks

Waste pickers earn high as they were also found at the dumpsites where solid waste is finally deposited by the pushcart boy. The operation performed by the waste pickers at the dumpsite is similar to the operation they perform at the sites. When the solid waste material is dumped on the ground by the household, waste pickers engage themselves on the waste by sorting out the good materials to their personal uses, sold for reuse as paper wrapper items in shop or recycling sin the steel and bottle industries.

Figure 6: Waste Pickers sorting value materials from the solid waste

Figure 7: Bulldozer compacting after the waste picker has finish sorting

The most common methods normally used by household to dispose solid waste materials are through Burning, through water channel and throwing inside the pit. The advantages of these methods are:

1. It reduce the cost
2. It can easily be managed
3. It does not involve any techniques.

The disadvantages include:

1. It cause pollution
2. It causes erosion blockage
3. It affects the human health.

As a result of the above disadvantages, there is need to carry out a proper review.

1. LITERATURE REVIEW

Emergy analysis (EA) describes emergy as the total amount of available energy requires to be used up in transformations, either directly or indirectly for a product or services. Emergy analysis is an evaluation method of considering of both environmental and economics values ([HB04]).

Advantages of the above methods is that it can easily be used to analyze the amount of waste in a product while the main disadvantage is that it is not easy to use without involving an expert. Base on the disadvantages of all this method, there is need to come up with another method that will enable us to ascertain amount of waste in a particular product either solid, liquid or gas.

Ilorin, the capital of Kwara State, comprises of three Local Government Areas which includes: Ilorin West local government, Ilorin East and Ilorin South local government. The city (Ilorin) performs the function of a state capital to Kwara state and headquarters for the three local government areas.

In the setting of the geological of the city, it consists of pre-cambian basement complex with an elevation between 273m to 333m above the sea level. There is an isolated hill in the city called sobi hill of above 394m above the sea level towards the north of the western part and 200m to 346m in the east. The city is covered mainly by ferruginous soil on crystalline acidic rock. The pattern of the drainage system of Ilorin is dendritic due to its characteristics ([AT10]). The most important river is Asa River which flows in south-northern direction. Asa river occupies a fairly wide valley and goes a long way to divide the city into two parts; the eastern and the western part. The eastern part covers those area where the GRA is situated while the core indigenes areas of the city fell under the western part. The other rivers that drain into Asa river are Agba river, Alalubosa river, Okun river, Osere river and Aluko river. The vegetation is characterized by scattered tall trees such as Locust bean, Shearbutter, Baobab, Acacia. The city climate is tropical continental with high temperature throughout the year; which is favoured with wet and dry seasons ([Ifa99]). Ilorin falls within dried savannah vegetation cover with the existence of dry lowland rain forest vegetation cover. The wet season is between March to October while the dry season is between the months of November and February. The mean annual rainfall in the city is 1200mm.

The population census conducted in 2006 shows that the population of the city is about 766,000 ([NPC06]). The major occupation within the

metropolis includes civil service or different cadres, trading and persuasions and host of informal sector services.

The local part of Ilorin is located at the west side of the city with a concentric pattern. The centre of the city includes the central mosque, Emir's palace and Emir's market. This is followed by the zone of transition, which contain deteriorating houses. The third zone is the independent working man zone, comprising residence of second generative immigration into the city. The fourth zone is zone of better residences i.e. middle class, small businessmen, professional people, and salesmen etc. The last zone is the commuter zone of small cities, towns and hamlets which serves as dormitory suburbs for the weather city dwellers e.g. Tanke, Ganmo etc. The modern residential part of Ilorin developed along the east and south of Asa river attracted Industrial, Residential, Administrative, Commercial, Transportation, Institutions, Communication, Health, Religious, Recreation, Financial, Primary land use and general services etc. As the population of the urban area increases, the amount of solid waste generated increases also. People immigrate from various areas in Kwara State to Ilorin Metropolis. Since the city is known as the capital of Kwara state, so everyone hopes for a better job opportunity to improves their livelihoods. Ilorin has about twenty-one solid waste dumpsites provided by Kwara State Environmental Protection Agency (KWEPA) and about 108 RORO-bins spatially distributed by Keep Kwara Clean/ (KWMC) within Ilorin Metropolis. ([AT10]).

Ilorin Metropolis

As earlier discussed, Ilorin is made up of three local government areas, which includes: Ilorin West, East and South. The city has been selected for the research work because of the increased heterogeneous population over the years and urbanization, which made it a goof ground for the study of this nature (Ajadi and Tunde 2010). As the city developed over the years, some social economic activities and physical development increases and affects the inflow of people to the city which gives rise to the daily increase in solid waste generated by the household.

In order to tackle the challenges of solid waste management by the people of Ilorin metropolis, the government of Kwara state established Kwara State Waste and Environmental Protection Agency (KWEPA) under ministry of environment and tourism. Due to in proper funding of this agency, their activities in order to fight solid waste material in the city was limited and as a result of this heaps of refuse and waste became rampant and unbearable in the metropolis making the operation keeping Kwara clear to fail.

In this light another agency was established known as Kwara Waste Management Company (KWMC) and was under the ministry of environment and tourism and was given the enlisted mandate:

1. Cleaning and maintenance of waste in the metropolis.
2. Collection and disposal of waste materials.
3. Maintenance of waste dumpsites
4. Planting and maintenance of flowers in the metropolis

The Kwara Waste Maintenance Company were given some equipment's like Trailer trucks, Dyno trucks, Ro-Ro bins, shovel, brooms to tackle solid waste challenges in the metropolis.
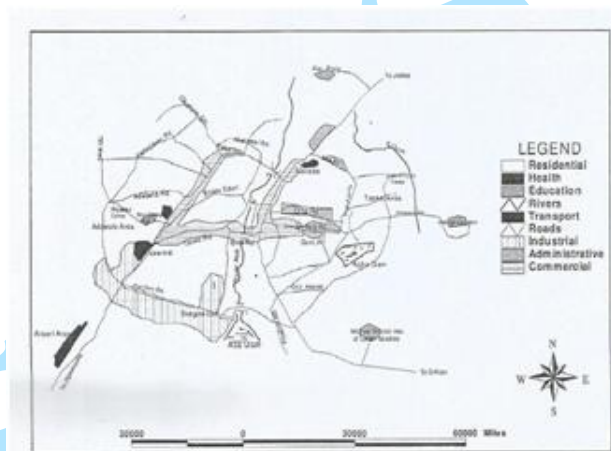

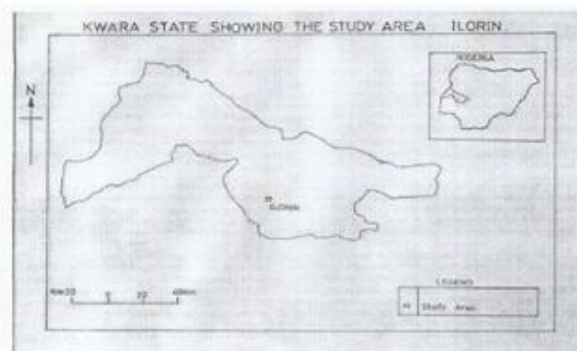**Figure 8: Kwara State Map, showing the research city (Ilorin Metropolis)**

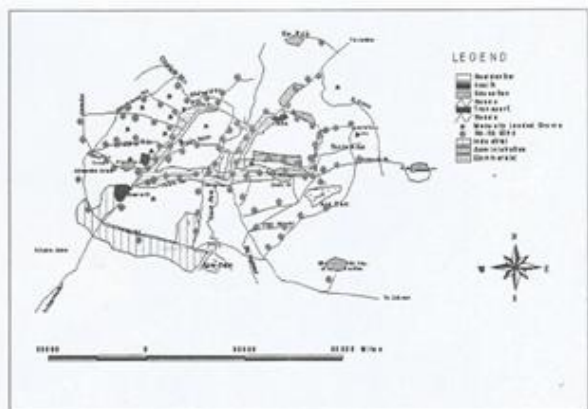**Figure 9: Ro-Ro bins distribution across the sites in Ilorin metroplis**

Figure 10: Proposed distribution of Ro-Ro bins and Drums in the metropolis

Figure 11: Heap of Refuse across the street in the metropolis

Waste Categories

Solid Waste materials have been categorized into different forms which are:

Waste generated from Agricultural Produce: This are caused by the application of chemicals to the soil which causes land pollution, not only that those materials, containers causes waste materials to the street. The waste which agricultural chemical plastics, empty pesticide containers, clinical waste, old machinery and oil.

Waste from Civic Amenity: These are household waste, which consists of bulky items such as beds, cookers, garden waste as well as recyclables.

Waste from Industries: any dumped materials from the factory and it environs which are useless are regards to as solid Waste material

Clinical waste: This source of waste are generated from both human being and animal tissue, blood or other body fluids, drugs, excretions, pharmaceutical products, syringes, swabs or dressings, all these items are prove to be hazardous to any person that come in contact with them; and any waste from medical practices can cause infection to any person that come in contact with them.

Municipal waste: This include material used by household and any other related wastes collected by any Waste management agents, such as garden waste, municipal parks, commercial waste, beach cleansing waste, industrial waste and waste resulting from the clearance of fly tipped materials.
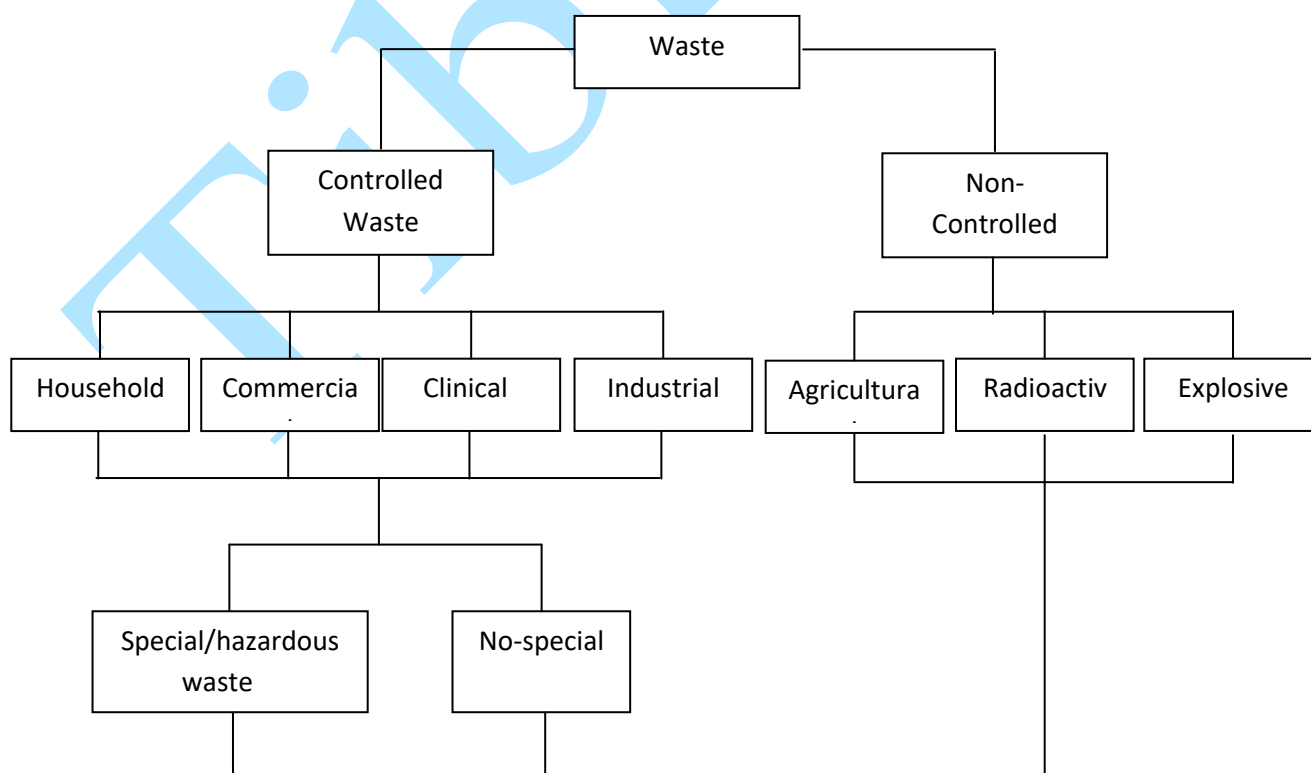

Figure 12: Solid Waste Classification Framework

2. METHODS AND MODELING FORMULATION

The method used in this research work is called (RORO). Roll-On Roll-Off (RORO) bins are methods used removal of bulky, non-compactable waste generated by household, commercial and industrial clients, building sites, large scale developments through to office clean ups and home renovations.

The Roll-On Roll-Off bin is ideal for materials such as timber, green waste, wood, steel, concrete, bricks, general waste and asbestos. The fully opening rear door on the bins allows easy access to dispose of materials. The bin use called container are made of heavy duty steel with sizes range from $2m^3$ to $40m^3$. Onsite stationary and transportable compactor can be used to reduce cost and service of high waste producers. Roll-On Roll-Off bin can be fed by hand which makes it easy to use by the refuge dumpers, chute, conveyor, tippler and other specialist equipment. The large rear doors make bulky depositing materials simple and safe

Modeling Formulation

The essence of this study is to develop a mathematical model based on their following assumption:

1. The population is increasing with grow rate of 3.4%
2. The waste generation also increases with 3.4%
3. RORO bin has the capacity of 8 tonnes.
4. The waste is evacuated once in a week

The model is developed as follows:

$$\frac{3.4}{100} \; x \; p^i \; x \; n^i \tag{1}$$

Where p=population

n= population index on the table.

i= 0,1,2,3………… (increase in population and index increase

The equation 1 above can be use to determine increase in population and also to determine the waste increase which give equation 2 below

$$\frac{3.4}{100} \; x \; w^i \text{x} n^i \tag{2}$$

Where w = the number of waste

To determine the linear relationship between the equation 1 and equation 2, where equation 1 generate the independent and equation 2 generate dependent. Therefore the equation 3 can be formulated.

$$w = -1014194.945 + 1.590p \tag{3}$$

Where:

w= (dependent population) estimated wastes in tonnage
p = (independent population) the estimated population of Ilorin

3. DISCUSSION OF RESULT

With visual basic programming language, we were able to determine the population and waste prediction within a given range of year.
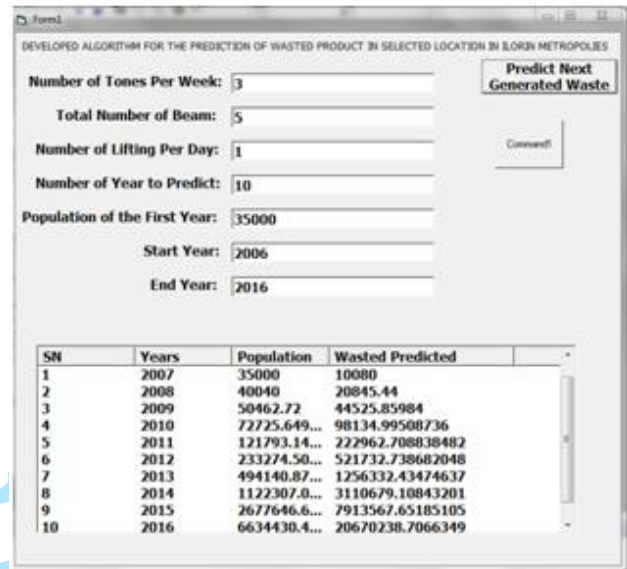

Figure 13: Population and waste prediction from year 2006 to year 2016

From figure 13, it can be described that the waste increases as the population increases over the year.
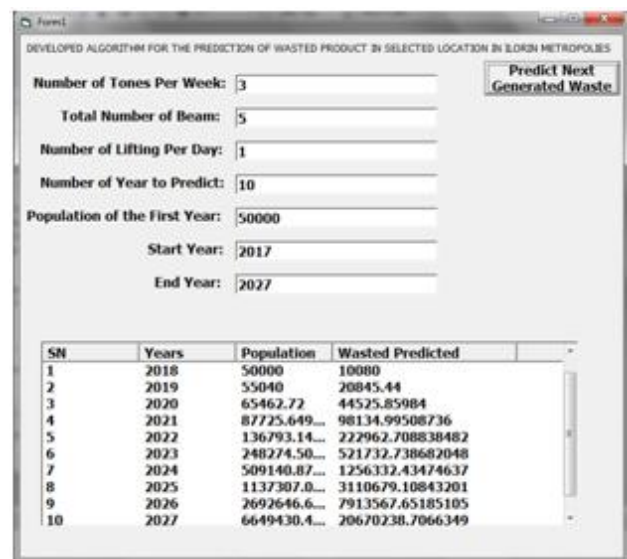

Figure 14: Population and waste prediction from year 2017 to year 2027

From figure 14, it can be described that the waste increases as the population increases over the year with the same inputs as of figure one.
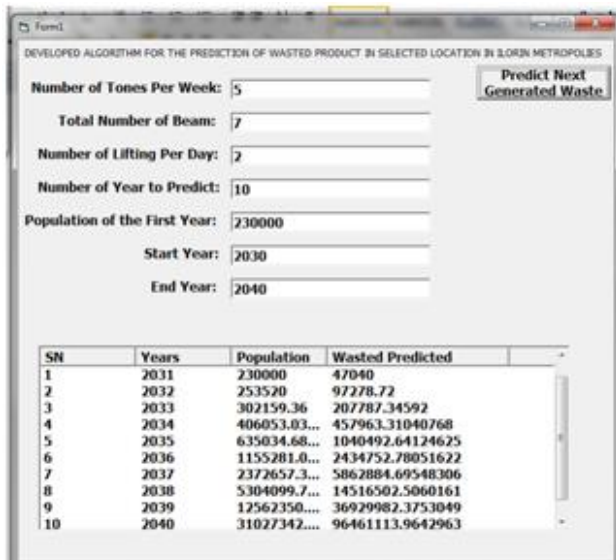
Figure 15: Population and waste prediction from year 2030 to year 2040

From figure 15, it can be described that the waste increases as the population increases over the year, despite the input variables change, the waste also increases. So there, it is shown clearly that the higher the population of a country, the higher the waste the country we be generating yearly.

4. CONCLUSION AND RECOMMENDATION

This study develop the framework for studying the effect of population growth on waste generated in form of table to estimate the waste generation based on population growth at Ilorin metropolis.
Based on the findings in this study, we conclude that:
1. The population has effect on waste generation.
2. The apparatus for disposal of waste, which is RORO Bin, must be in proportion with amount of waste available.
3. The disposal period used in this research work is one per week; this can be varied by increasing the number of disposal period to two or more based on the financial availability.
We recommend the following:
1. The government and all the stakeholders should consider the population before embarking on disposal of the waste.
2. The sizes of the RORO bin placed in different location can be of various sizes depending on the population of the location.
3. The composition techniques can also be provided in an area not very far from the resident.
For further research work and development, the following areas should be focused on:
1. E-waste management should be provided.
2. Instant decomposition RORO bin should be provided.

3. High technology should be employed in area of waste management especially in recycling of waste for proper usage in the country.

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