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AN OBJECT ORIENTED SYSTEM FOR THE LOCATION OF LANDFILLS FOR NIGERIAN MUNICIPALS.

*AGAJI, I.[1] & WAJIGA, G. M[2].

[1]Department of Mathematics/Statistics/Computer Science, University of Agriculture, Makurdi, Nigeria

[2]Department of Computer Science, Modibbo Adama University of Technology, Yola, Nigeria
*sasemiks@gmail.com

ABSTRACT
The management of solid waste is one of the major environmental problems facing developing nations, Nigeria inclusive. This is evidenced by the uncleared solid waste seen in most Nigeria cities. The accumulation of solid waste has not only become a breeding ground for mosquitoes and other disease causing organism but also the bad odour emanating from such wastes is a source of discomfort for the teaming population of such cities. An integrated solid waste system is made up of many facilities, the most important among them being the landfill. The current practice in Nigeria where site selection for the situation of solid waste facilities is done arbitrary done posses a lot of danger to our public health system. In this work the various design issues are undertaken and an object oriented system is designed and implemented that handles site analysis for the location of landfills. The results show that the system was able to select the site with the most minimum pollution. The system can be used for sitting landfills for Nigeria cities.

Keywords: Landfill, site, waste, pollution, odour, selection

INTRODUCTION
The problems of solid waste management are a major test for Nigerian's public health system. The term solid waste means materials such as household garbage, food wastes, yard waste and construction ad demolition debris.

It also includes discarded items like household appliances, furniture, computer parts, car parts or abandoned junk vehicles. Solid wastes are classified according to their sources. The sources for the solid wastes are residential, industrial, commercial, institutional, construction and demolition, municipal services and agriculture. Currently the management of solid waste in Nigeria is traditionally handled using the truck and landfill system. There are no facilities for recycling, waste compost or waste reuse facilities. More symbolically the current solid waste management model used in Nigeria can be defined as having four sets G, T, D and M where G denotes the set of all waste generation nodes whose membership is mostly drawn from households, industries and hospitals. T denotes the set of transfer stations, D stands for the set of terminal sites and M represents the set of all edges (streets or roads) connecting G, T and D which is traversed by garbage trucks. Diagrammatically the truck movement model is represented as shown in Fig. 1. The diagram becomes more complex for bigger towns with multiple waste generation sites, transfer stations and disposal sites.

Landfills are one of the most important facilities in a solid waste management system. This is where inert waste is openly dumped and sometimes burnt into ashes. Ohio State University Fact Sheet reports that modern landfills are highly engineered containment system designed to minimize the impact of solid waste on the environment and human health. The sitting of landfills is critical to any successful solid waste management system. The goal of the work is to bring about a system where landfills will be located in areas that give the most minimum pollution. The desire to investigate the sitting of landfills is influenced by the arbitrary nature in which landfills are currently sited. The current practice gives rise to more pollution in most cases.

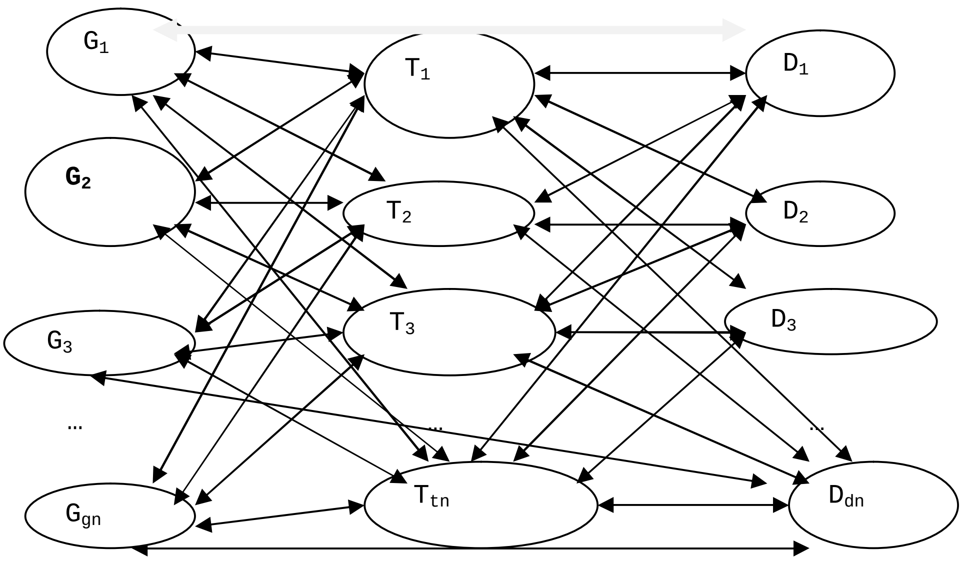

FIG 1. TRUCK MOVEMENT MODEL

Many methodologies have been developed in the past to aid the sitting of landfills in order to minimize environmental degradation and effects of solid waste on human health.

Nicolas *et al.,* (2006) proposed the method of sniffing team campaigns to the particular case of fresh waste odor. The method hinges on the field determination of odor perception points followed by data processing with a bi-Gaussian-type model adapted to handle the odors. In the method field observers first delineate the region in which the odor impact is experienced and the emission rate is manipulated in a dispersion model until the predicted size of the impact zone matches the observed in the field. In the second step the adjusted emission rate is entered into the model to calculate the percentiles corresponding to the average annoyance zone.

Javaheri *et al.,* (2006) used multi-criteria evaluation methods under the name of weighted linear combination using GIS as a practical instrument to evaluate the suitability the vicinity of Giroft city in Kerman province of Iran for landfill.

Yaw *et al.,* (2006) use GIS and remote sensing techniques to identify appropriate areas suitable for waste disposal in Niamey, Niger Republic. Agaji & Wajiga (2007) proposed the use of computer as a tool in all aspects of solid wastes including the selection of landfills for Nigeria cities.

Sumathi *et al.,* (2007) addresses the sitting of a new landfill using multi-criteria decision analysis and overlay analysis using GIS. Erham *et al.,* (2008) present a new multi-criteria mixed integer linear programming model to solve the location- allocation problem for municipal solid waste management at the regional level. They applied the lexicographic minimax approach to obtain a fair nondominated solution.

Zamorano *et al.,* (2008) describe a landfill sitting method which is based on EVIAVE, a landfill diagnosis method developed at the University of Granada with the use of GIS to generate spatial data for site assessment.

MATERIALS AND METHODS

Study areas: The Solid waste management systems of six towns selected randomly from each of the six geo-political zones of the country was studied. These towns are Makurdi, Calabar, Enugu, Ibadan, Kaduna and Jalingo.

Observations made: The following observations were made from the study with respect to landfills. All the towns under study implement a truck and landfill method of waste management whereby a truck leaves a garage to any of the waste bins of the driver's choice picks up wastes and heads straight to a landfill. Landfills are manually selected without computer based site analysis. This often creates more pollution. GIS as a tool is not employed in the area of solid waste management especially in the selection of landfills. Mathematical models are not also utilized in the selection of landfill sites

System Design: The design phase is the phase which begins the building of software. It is an important phase in software development where the designer plans how a software system should be produced such that it will be functional, reliable and easy to understand, modify and maintain. Modularity is the current paradigm of software design as it seeks to fulfill the above conditions.

Data Model: The nature of integrated solid waste data calls for discussion on geographically referenced data. This type of data is different from other types of data in that it has two components: the spatial component and an attribute. The spatial data spells out the location whereas the attribute data spells out the characteristics of a location. A house for example has a spatial data which spells out where it is located and its characteristics could be its name. Spatial data could be continuous or discrete but in the design of the integrated solid waste management system discrete spatial data was used.

Input Tables: Five tables were used by the database and these were HGC which holds hydrological data. Fields in HGC are depth of water table (wt), nearness to erosion sites (pq) all measured in metres; degree of infiltration (di) and degree of elevation (Li) all measured on a scale of 1 to 100. LOCATION table provides the location of the prospective landfill in terms of longitude and latitude. LUC provides land use data. Its fields are distance to road network(rn), distance to arable land(al), distance to settlements(s) and distance to sensitive sites(ss) all numeric and measured in Metres. RATING table assigns weight to a set of miscellaneous factors. Its fields are economic impact, environmental impact, transport issues, historical factor which are all measured on a scale of 0 to 1. CHK table dynamically stores the result of the analysis as the software executes. Sites is a field in all the tables. The tables were normalized to remove all redundant records. The tables were randomly populated with hypothetical data because of lack of availability of real data for landfills selection in the towns covered in the study. However the hypothetical data bear semblance with the actual data for the selection of landfills

Output design: The output displays results for our computation. In the work a form is used to capture the output. There are two types of outputs in the work. The first type of output displays candidates site which are sites that are all suitable for sitting of solid waste management facilities with varying degrees of suitability. A site is suitable if it possesses majority of attributes needed for a landfill. The second type of output brings out the most suitable site(s) for the sitting landfills.

Detailed Design: Detailed design is concerned with the architectural specification that leads to detailed data structure and algorithmic representation of the software. The objects of the software are ProcessCheck (PC) which triggers the process of checking the most suitable sites for landfills. NextProcessCheck(NP) allows the software to consider other sets of criteria for the selection of landfills. The back end of the software has a database made up of five tables four of which are used in hold hydrological and environmental attributes of sites, Land use attributes of sites, other essential considerations and locations of sites respectively. Location table provides the location of the site on the surface of the earth. The location is given in terms of latitude and longitude. The remaining table holds the result of each analysis. The detailed design of the software is given in the Fig. 2.

In the above model RP stands for the report the human operator receives from the software system, R is the output forwarded internally by the system to be used in the next stage of analysis, PC triggers the process of selecting the landfills, NP moves from one stage of site analysis to another, HG module check for hydrological conditions, LU checks for land use criteria and RATING checks the set of miscellaneous factors, LOC provides the location of the sites in terms of latitude and longitude. In the above figure the objects involved in the interaction are arranged horizontally and the interaction between objects represented by arrows. The thin rectangles represents the time when the object is the controlling the landfill selection system. An object takes control at the top of its thin rectangle and releases control to another object at the bottom of its thin rectangle. The HG object receives a request for site analysis from its external environment notably a user /operator to carry out analysis. It carries out the analysis, selects sites that meet hydrological conditions and its result is put in a table called CHK. The user /operator further requests site analysis on Land use criteria through NP. The above process is repeated until the sites are screened with regards to all factors. Finally the location(s) of the selected site(s) is obtained and result stored in CHK table. The selected sites are finally sent to user/operator.

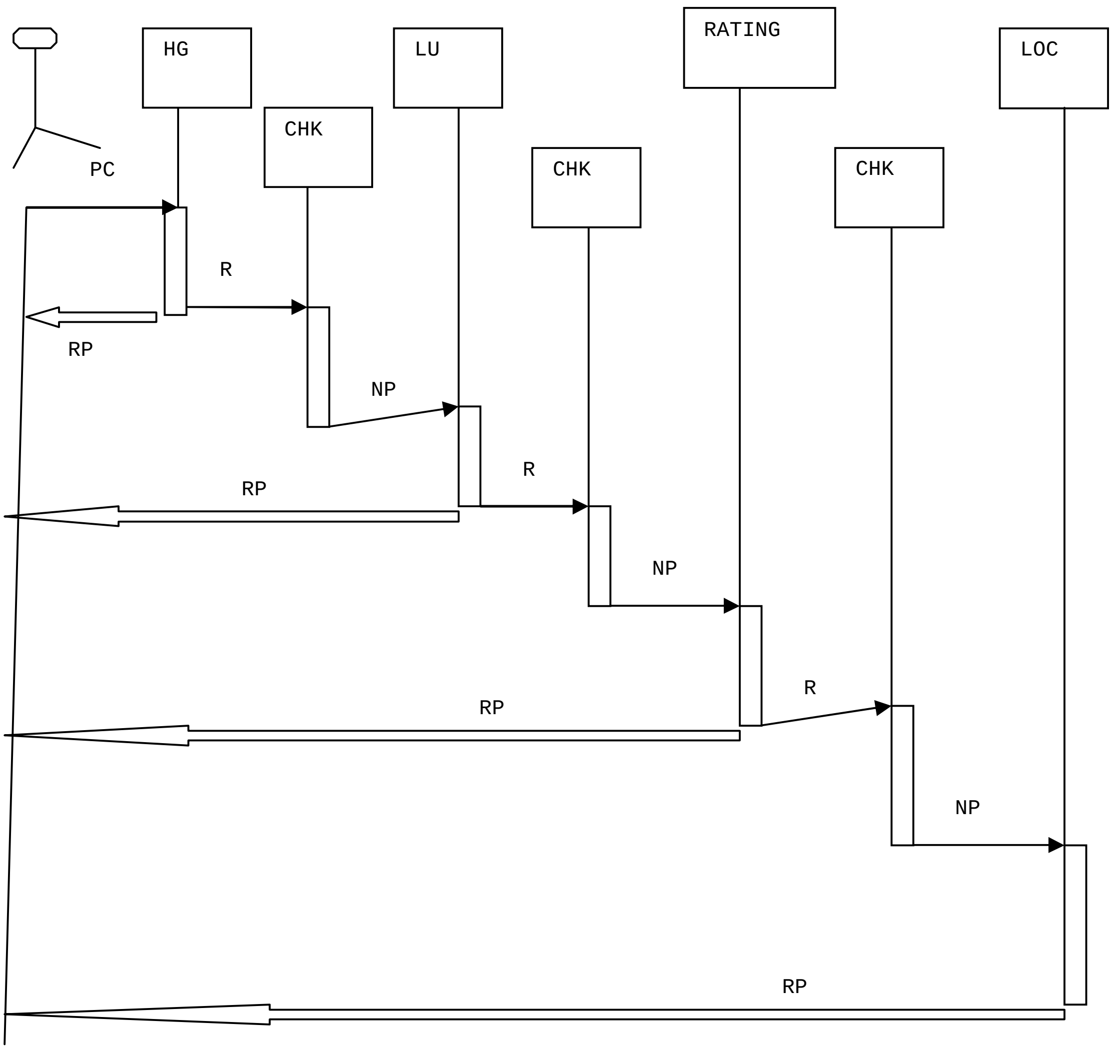

FIG. 2. A MODEL FOR LANDFILLS SELECTION

PROGRAM SIMULATION

Programming translates the design into a form that can be coded into a computer system for execution. In this work VB 6.0 was selected as a programming language not just because of its excellent graphical interface but also its good interface facilities to the database. The back end of the software is a data base made of five tables created in Microsoft Access. Access is a relational database which defines its database in terms of tables. Access is chosen because of its excellent link facilities to visual basic. Five tables where created in Access and randomly populated to reflect the nature of the data for testing the software.

RESULTS

Twenty (20) hypothetical sites numbered $site_A$, $site_B$, ..., $site_T$ were covered and their attributes defined in five tables .The sites though hypothetical, have attributes like real sites. Lack of data on landfills selection in Nigeria made the researchers to resort to hypothetical data. The tables are named HGC, LUC, RATING, LOCATION and CHK. The tables were populated randomly using data that has semblance of actual data. The nature and range of data was gotten from staff of the sanitary agencies covered in the study. The database was created using MS Access.

DISCUSSIONS

Landfill Selection: We began the selection of the landfill by running Processcheck (PC) which first checks the hydrological factors. A site was selected here based on the following criteria; site.wt≥80 and site.Li <= 40 and site.de<=40 and site.qp ≥200 where wt stands for distance from water tables in metres, Li stands for degree of infiltration of the soil on a scale of 0 to 100, de stands for degree of elevation on a scale of 0 to 100 and qp stands for distance from erosion sites in metres, based on this after the hydrological test sites B, D, E , F , I, M, N, R and S were selected.

Land Use Criteria(LUC) Selection: The second phase of the experiment has to do with selection of landfills based on land use criteria. A site is selected based on the following criteria: site.wb>400 and site.rn<1000 and site.al>300 and site.s<150 and site.wl<1000 and site. ss>900, where wb represents distances to water bodies rn represents distances to road network, al represents distances to Arable land, s represents distances to settlements, ss represents distances to sensitive sites, wl represents distances to waste land. Based on the above criteria the sites B, D, E, R I and S were selected. The sites selected are from the sites that has earlier passed the hydrological selection criteria.

Rating: Other set of criteria were used to rate the sites. These factors are all put on a scale of zero to one. The selection crireria is if site.ti >= 0.4 and site.ei >= 0. 4 and site.ec >= 0.4 and site.hm >= 0. 4 where ti is traspotastion issue, ei is economic impact, ec is environmental impact and historical factors. Sites B, D, I and S were finally selected and the Location table provides their physical location.

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