A Spatial Data Model for Environmental Health Surveillance System in Nigeria

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***Abstract*— In Nigeria, environmental health problems arise from population pressure on housing, poor environmental sanitation, coupled with lack of safe potable water and basic facilities. The availability of clean water and proper sanitation are base necessities to ensuring good health and the eradication of environmental health related diseases. As earlier mentioned, vaccines are not enough to prevent diseases. The simple use of surveillance or tracking system would always make the difference needed. In order to develop any efficient and effective tracking system, there is a need for reliable data model. The data model captures information required for the development of environmental health surveillance systems.**

The model is developed using the Unified Modelling Language. In the literature, there are three existing stages used in developing any data model, in this paper, four stages were proposed and used to develop the model and this make the model more reliable, efficient and effective to develop environmental health tracking system for Nigeria. The model is implemented in XML, and was applied to a system using service oriented architecture with a focus on environmental health in Nigeria.

***Keywords*— Include at least 5 keywords or phrases**

I. INTRODUCTION

This In Nigeria, environmental health problems arise from population pressure on housing, poor environmental sanitation, coupled with lack of safe potable water and basic facilities. The availability of clean water and proper sanitation are base necessities to ensuring good health and the eradication of environmental health related diseases. As earlier mentioned, vaccines are not enough to prevent diseases. The simple use of surveillance or tracking system would always make the difference needed.

The developed nations are addressing environmental related problems, which the developing nations are yet to understand as a major challenge facing the effective deployment of health care delivery. In developed nations of the world such as the United States of America, Europe, and Canada there are existing environmental health tracking systems (Alan *et al.*, 2009; Centre for Disease Control and Prevention, 2006a; Ono *et al.*, 2006 and Quebec Comited éthique de santé publique du, 2004).

However, none of these systems can be adopted for Nigeria because they are not designed to address issues like housing conditions and safe drinking water. Beside the environmental health problems in the western world are quite different from that of Nigeria. There are standardized environmental health techniques, organized housing condition and reliable source of drinking water in these countries. These are quite different from what is applicable in Nigeria. The environmental health problems most of these developed nations focus on are air pollution, tobacco smoke exposure, recreational water quality, waste and toxic management among others (Sladden *et al.*, 2000; Taylor and Bettcher, 2000; and Centre for Disease Control and Prevention, 2006b). In Nigeria, though these problems are also in existence, the major concerns for now are safe drinking water, good housing quality and general sanitation.

Therefore, a web-based real time spatial environmental health tracking system is essential and in order to develop an environmental health tracking system there is a need for environmental health data model which is a focus of this paper. In this paper, contextual data model was proposed as the first step in developing data model followed by conceptual, logical and physical data model. This paper proposes four stages in developing any data model as against three stages in the existing literatures.

II. ENVIRONMENTAL HEALTH

Environmental health, which is also known as environmental public health, deals with the human health and diseases that are determined by the factors in the environment (Californian Policy Research Centre, 2004). It encompasses the assessment and control of those environmental factors that can potentially affect health. It is targeted towards preventing diseases and creating health-supportive environments. This definition excludes the behaviour that is not related to environment, as well as the behaviour that is related to the social and cultural environment, and genetics (World Health Organisation, 2009).

There are quite some numbers of definitions of environmental health in literature and these definitions have also included the processes or actions related to dealing with environmental health issues. These definitions go beyond simply defining the relationships and the potential health effects of environmental determinants, to stressing the implicit actions. In some cases, it is also from proactive measures, to protecting public health from environmental stresses. Environmental health in layman's terms is the health impact of the air we breathe, the homes we live in, the water we drink, the soil growing the food we eat, and the many other environmental exposures in our lives.

The World Health Organization (WHO) defines environmental health as "the theory and practice of assessing and controlling factors in the environment that can potentially affect health." The WHO also stated that: "Environmental health is comprised of those aspects of human health and disease that are determined by factors in the environment" (World Health Organization, 2008).

Environmental health in Nigeria

The environment is the totality of all external conditions and influences to which an organism is subjected. On the other hand, health, according to the World Health Organization, is said to be a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

However, a healthy environment is essential to the well-being of the planets and the productivity of its inhabitants, who depend solely on it for the air they breathe, the water they drink, as well as the food they eat (World Health Organisation / United Nations Environment Programme, 1996). In this regard, environment becomes a composite of behavioural settings that has great consequence on our health. Lack of access to resources essential for healthy living such as food, uncontaminated water, and fresh air contribute to ill health. Other essential indices that measure horrific health environment include, inadequate sanitary and refuse disposal facilities, lack of coordinated health and environmental safeguard, air pollution, over-consumption of natural resources, widespread water pollution, population sprawl, climate changes, and stratospheric ozone depletion. Therefore, this research intends to develop a spatial tracking system for environmental health in Nigeria. This is with a view to monitoring the problems identified above in order to prevent and control environmental health problems.

The absence of a reliable national database on environmental health related diseases are one of the major challenges facing the management of environmental health related diseases in the country. There is therefore a need for an effective and efficient spatial environmental health data model which can be used as a guide for the systematic capture of environmental health related data, to provide the impetus for the development of a national database that can be used in the monitoring and management of environmental health related diseases in Nigeria. This is the focus of this paper.

III. PROPOSED METHOD

Extensive study on related and existing body of knowledge on public health, environmental health, environmental health surveillance, and geographical information system in public health was carried out. This was with a view to designing a robust spatial environmental health data model for Nigeria. The design of the spatial environmental health data model was done using the Unified Modelling Language (UML). In order to develop the data model, the data modelling stages algorithm was developed using Microsoft Visio and the algorithm developed was followed to develop the environmental health data model

With data modelling, important things, both abstract and concrete, in the problem domain were captured and this approach is consistent with that of Keuffel (1996). This was useful in order to analyse and identify the relationships between data objects in the model. As a result, every possible ambiguity among database designers, end users and system developers was reduced to define entities and relationship among them. With these ambiguities removed, a sound basis for a database schema that eliminates redundancy; allow easy data entry; gives room for easy update of database; and retrieval of data and information was arrived at.

Of the different techniques used in developing data model such as semantic, functional, entity relationship, and object oriented techniques; the entity relationship technique was employed to analyse the semantic structure of information needed in the study. This provided the basis for entity relationship, and object oriented approach which

make use of classes/entities and relationship to be applied in this research. Object oriented technique was used because it gave clear representation and definition of the objects of the data model.

UML is the formal language of object oriented technique for data modelling and was used to specify, represent and visualise the processes involved in the system development. The main elements of UML object oriented approach is encapsulation, modularity, abstraction and hierarchy. The class notation was used in connection with semantics, relations, operations and attributes (Dimitrijevic *et al.*, 2007) to realise the UML elements. In the model, all the objects had attributes, instances and methods. Relations between objects were defined through associations, as a result of which the environmental health data model was developed

IV. The Environmental Health Data Model

In literature, there are three stages involved in developing a data model. These stages include: The conceptual data model, the logical data model and the physical data model stages (Idowu, 2010 and Amber, 2003). But this research proposed a four stages in its model development. The purpose was to have a more reliable, flexible, complete, usable and efficient data model for any system.

The fourth stage of the developed data model is the contextual data model and it is the first stage in this paper. The other three data models are the ones earlier highlighted. Figure 1 shows the data modelling stages' algorithm developed and how to derive the physical data model from the contextual data model. These developed data modelling stages were used in order to develop the environmental health data model for Nigeria

Contextual Data Model for Environmental Health

In order to design the contextual data model, which is the first step in the data modelling as proposed by this paper, it is necessary to clearly state the user and organization's requirement. In the contextual model, after the major entities were identified, the next step was to identify the entities, classes and sub classes as shown also in Figure 2.

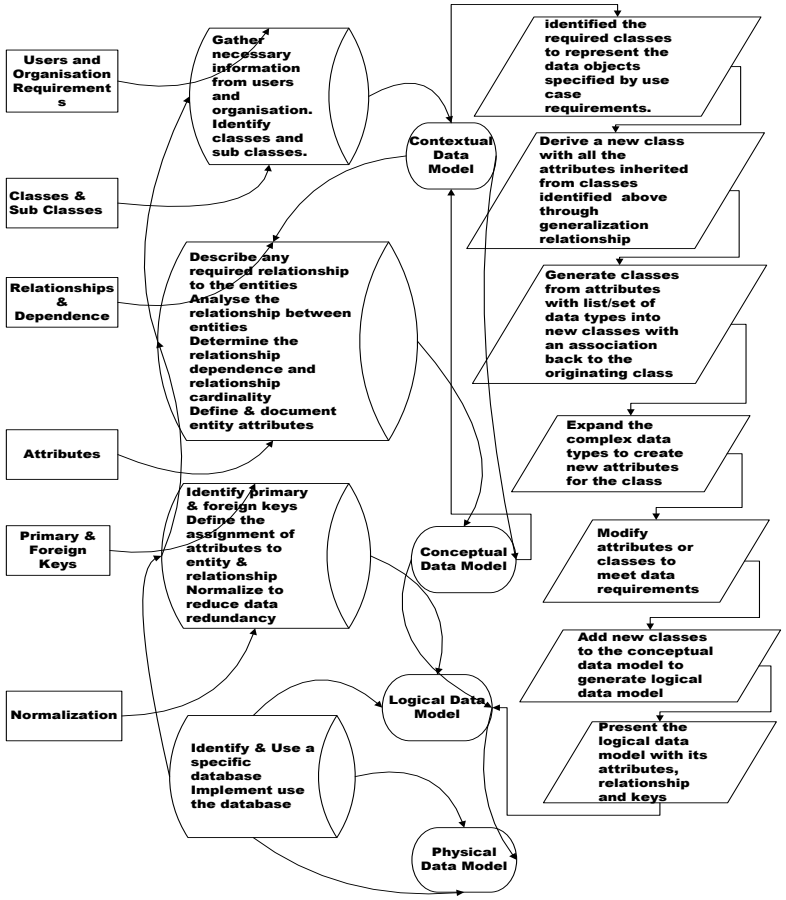
As the first step in the development of any data model, the contextual data model served as an input to the conceptual data model. It was therefore necessary to ensure that its features were well thought out, for the conceptual data model to perform its usefulness better. As a result, the Spatial Data Model for HIV/AIDS Surveillance and Monitoring (DSMPN) developed for Nigeria (Idowu, 2012) were adopted, modified and extended with environmental features.

The resultant contextual data model has major subject areas with respect to its super class and sub classes. A subject area is a useful partitioning of a model into a cohesive collection of classes. Subject areas are a way to subset a model into chunks that permit the model to be more readily digested. Thus, the developed data model comprises of three major subject areas namely: Health activities, parties and locations.

The subject area, which is also known as a package or the core component of a data model, is a way of grouping related classes into higher level of units within a model (Idowu *et al.*, 2009; Centres for Disease Control and Prevention, 2000). The use of subject area was to allow the easy understanding and digestion of the model.

Conceptual Data Model for Environmental Health

The conceptual data model is the second stage in the developed data modelling stages. In the modelling of the developed model, relationship association was used to depict the relationship between two entities, which are associated with each other. The relationship association in the developed data model was also used to show the type of relationship that exists between the super type class and sub type class. Relationships were featured with cardinality such as zero to one, zero to many, one to many, and many to many. The relationships in the model are represented with four classes and each of the classes has association with the three subject areas. Party relationship, health activity relationship, and location relationship are the three relationship classes. The relationship associations in the developed data model are shown in Figure 3.



Fig, 1: Data Modelling Stages Algorithm

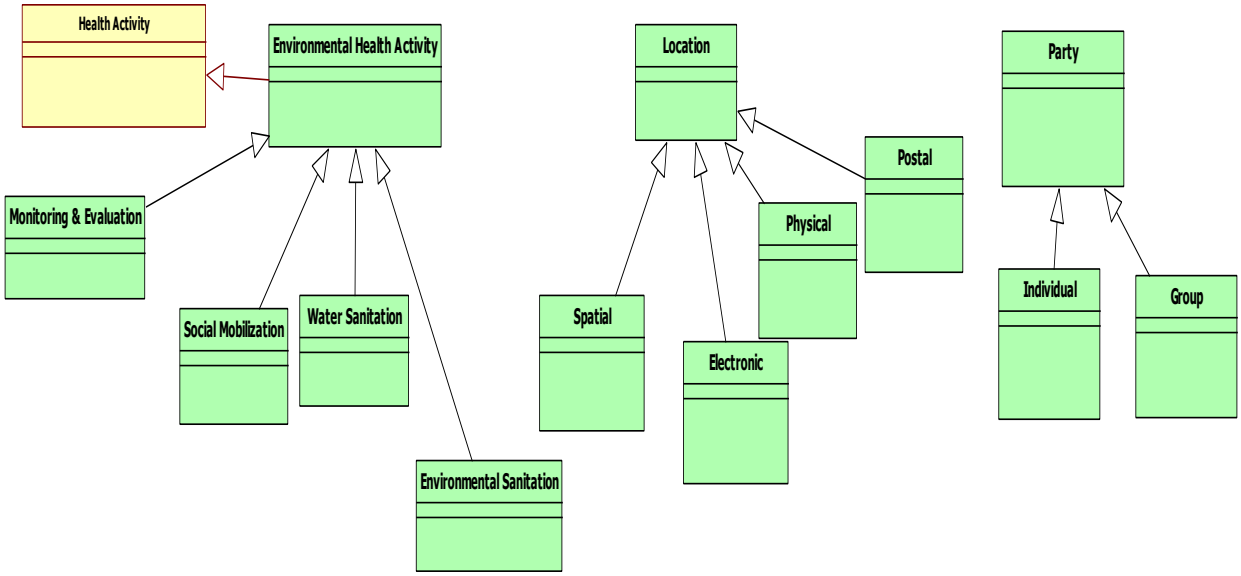


Fig. 2: Contextual Data Model for Environmental Health

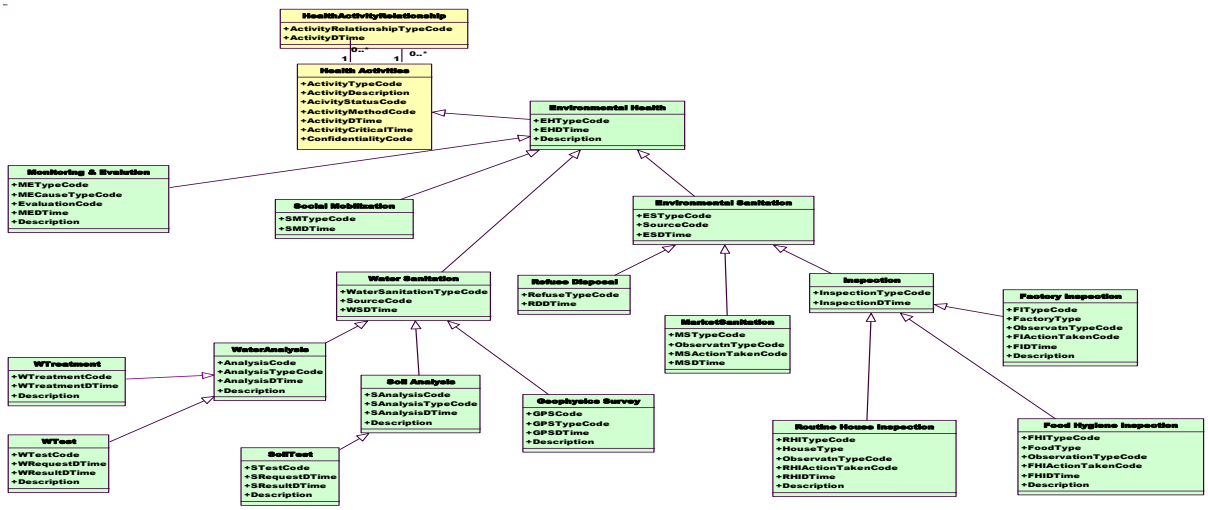


Fig. 3: Health Activities Component of the Data Model

0, 1, 0...1, and 0..* were the symbols used to show the association that exist between the subject area and the relationship class in the association line. The multiplicity of the association is an indication of the number of instances of a class, which has the ability to be involved in any one association. Multiplicities also imply that each of the activity relationship is associated with one and only one health activity. Each of the health activity is associated with zero or more activity relationship. For example, observation of cases of diarrhoea, cholera and malaria in a particular location can be linked to environmental health problems such as lack of potable water, poor sanitation, bushy environment and so on. Both the observation and environmental health are subtype of health activity.

Party relationship is the relationship that exists between two or more parties in the health activity. One example is the relationship between environmental health workers and a particular community; and the relationship between a physician and a patient living with malaria. Health activity relationship is the relationship between health activities such as a relationship between a routine inspection by environmental health officers and cases of cholera. Location relationship provides information about the relationship that exists between locations in the health activity. One example, is the relationship between the location where there are cases of certain environmental health related diseases and the location of refuse bins. Another example is the relationship between two locations with a similar number of a particular environmental health related disease.

Participation association is used to show the relationship that exists between the subject areas. Each of these classes has a many to many relationship to all of the other major classes in the model. For example, roles played by environmental health workers in order to make sure a particular location is clean, role played by government to supply potable water, and roles played by certain group of people to report the bad state of their environment are examples of their relationship.

In the developed data model, participation association is depicted using a participation class. Three participation classes were used, namely; party location participation, actor participation, and target participation to show relationships between the subject areas. Party location participation shows the relationship between a party and a location. For example, the relationship between people having a particular environmental health related disease such as malaria and the environment the people reside. Actor relationship is the active roles played by a party in a health activity. For example, roles played by an environmental health worker in order to trace the cause of an epidemic in a particular location, while the target participation is the passive roles played by a party in the health activity. Another example, is the role played by certain people in order to report an environmental health problem in a particular location, which may serve as threat to the health of the people in such location. The core components of the developed model are discussed as follows.

i. Health Activities

The health activities subject area contains information about different health services, activities and actions which are required in environmental health sector in Nigeria. In the developed environmental health data model, intervention, health education and environmental health (such as market sanitation, refuse disposal, water analysis, and so on) which are the major contribution to the existing health data model are the major classes in the health activity subject area. With the developed data model, environmental health officers would capture the data that has to do with the environment. Example of such data include that of water supply, conditions of the environment, and food related (see Figure 3).

ii. Parties

The parties' subject area holds information concerning the people that are involved either directly or indirectly in health activities. It contains information about individual person and group of persons. The person class stores information about the demographic data of individual person among other things. Group of persons are the people with the same features. The group of person's classes has two sub-classes, namely: Formal and informal sub-classes. The formal sub class stores information about environmental health officers, hospitals, laboratories, pharmacies, and so on. The informal sub class contains information about people living with a particular disease and these are depicted in Figure 4.

iii. Location

The location's subject area contains information about the places where the parties that are involved in health activities reside. It also contains information about where health activities take place; and that of the location that is prone to disease or where certain diseases were discovered. Location's subject area holds information for about three different types of location, namely: The physical location (such as house number), electronic location (such as phone number, e-mail address) and spatial location as shown in Figure 5

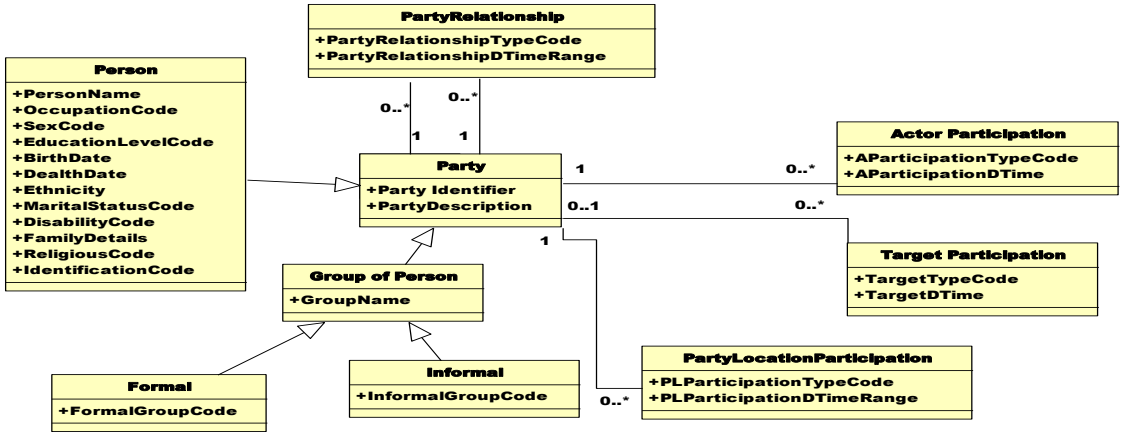


Fig. 4: Party Component of the Data Model

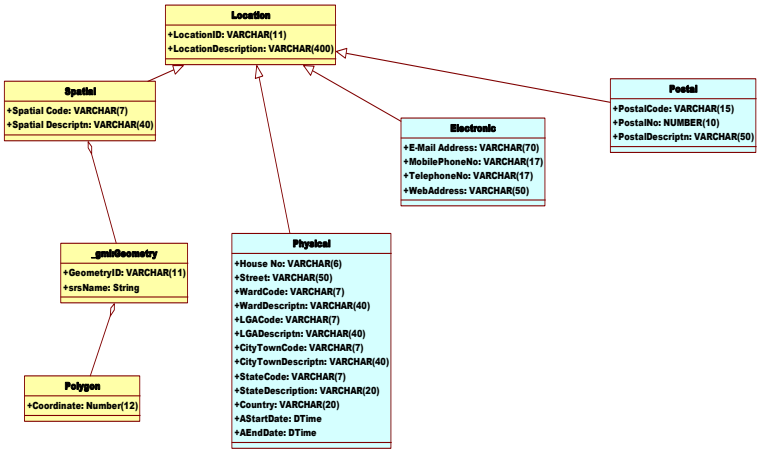


Fig. 5: Location Component of the Data Model

Figure 6 shows the developed conceptual environmental health data model for Nigeria and it shows the super classes, sub classes, relationships and the attributes of the classes

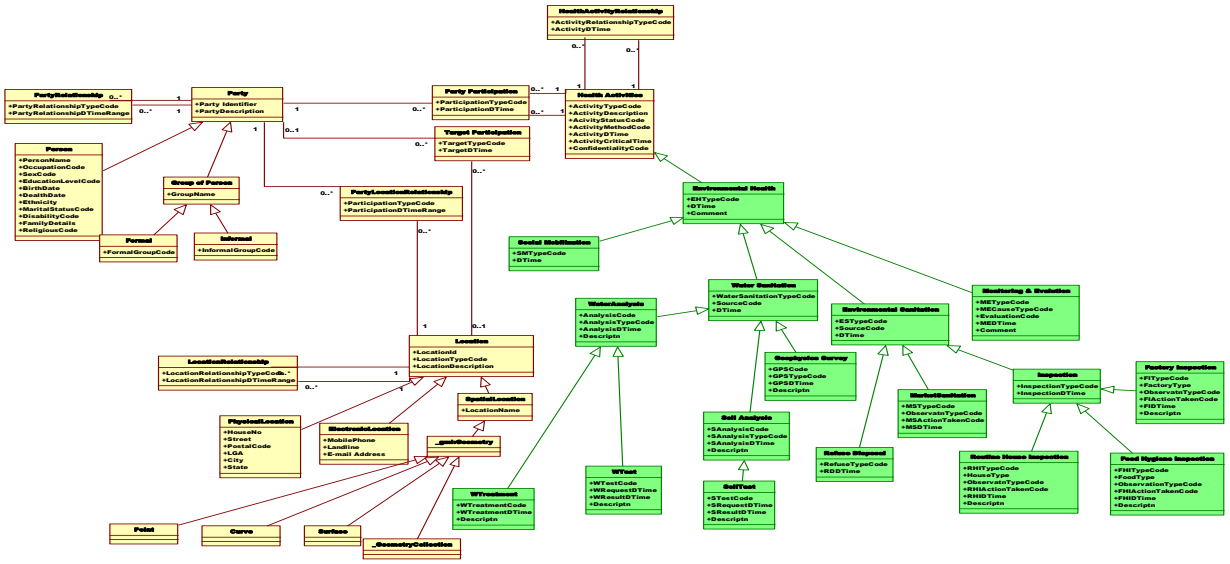


Fig. 6: The Developed Conceptual Environmental Health Data Model for Nigeria

Physical Data Model for Environmental Health

In this paper, the physical data model represents the actual structure of various data that are utilized in the tracking system. The physical schema is the actual system design and it described how the information represented from the logical data model is actually implemented. The physical data model is shown in figure 7 below.

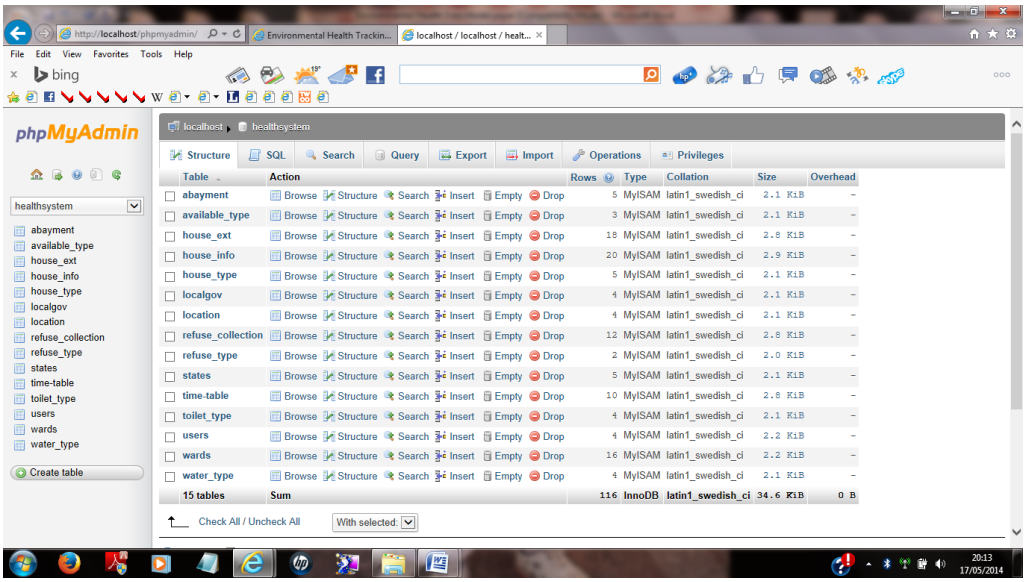


Fig. 7: Physical Data Model for Environmental Health

V. DISCUSSIONS

In order to effectively a model effectively, there are some data model evaluation criteria. The evaluations of the developed model were based on these criteria and are discussed as follows.

The environmental health data model is fully complete. This is in terms of its ability to support all the necessary data required for an environmental health tracking system, particularly for Nigeria for which it was designed. The model captures all the data needed for an environmental health tracking system. For example, the model capture attributes that can be used to query and get more information about location such as street, ward, among others. The model also captures information that relates to environmental health tracking system such as type of water, availability of toilet facilities, and availability of refuse disposal facilities and so on

The major contribution of this paper to data modelling theory is the introduction of contextual data model as the first step in data modelling as against what is the literature for use of conceptual data model as the first step. These steps were followed to develop an environmental health data model for Nigeria and this was used to develop environmental health tracking system for Nigeria.

VI. Conclusions

This Nigerian environmental health model would assist the country to be able to have a complete, consistent and reliable environmental health tracking system. This would eventually make the management and tracking of environmental health easier and also improve the reliability and availability of environmental health data in Nigeria as a whole. In the process, an environmental health data model, and an algorithm to move from conceptual data model to logical data model were formulated. In order to develop the environmental health tracking system, This model was used to develop the environmental health tracking system and the model can also be used to develop any web based GIS application with ease.

The environmental health data model has contributed by improving the existing health data models through the introduction of environmental features and this makes this model unique as compared with other health data models. With the environmental health data model when used to develop environmental health tracking system, a user could query and view the environmental health condition of any location.

VII. Acknowledgement

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