Information and Knowledge Management
ISSN 2224-5758 (Paper) ISSN 2224-896X (Online)
Vol.4, No.8, 2014
www.iiste.org

Developing Information System for Renewable Energy Production in Ilorin Kwara State, Nigeria

Emmanuel Oriola[1]* Olabanji Kolade [2]
1.Department of Geography and Environmental Management, University of Ilorin, Ilorin. Nigeria
2.National Planning Commission, GIS/MIS Division, Abuja, Nigeria
* E-mail of the corresponding author lolaoriola@gmail.com

Abstract
This paper explores Geographic Information Systems (GIS) to analyse the potentials for Biogas production Ilorin, with a view to developing a spatial decision support system for biogas plant developers/engineers and potential users. Global Positioning Coordinate of the raw materials locations was taken. The Coordinates and Attributes data on organic wastes location and generation were harvested and imported to GIS environment to create a database. ILWIS 3.3 and ArcGIS 10.1 were used for spatial data processing, GIS operations, and spatial analysis. The results revealed that Biogas raw materials locations are many in the eastern part of Ilorin with eleven (11) locations and three (3) in Ilorin west to make a total of fourteen (14) locations in the Metropolis. The result also showed that all the raw materials locations are well connected by road network such that the raw materials locations are easily accessible such that the materials can be easily sourced and collected. A database query on one of the identifiers shows that BRM 009, a located in Ilorin East with 240 poultry birds and 5 turkey, generates a total of 44.1kg will produce 3.1 m^3 volume of biogas. The capacity of Geographical information system makes the solution to spatial problems such as identification of renewable energy raw material sources for its production easy to evaluate and analyzed. The paper has clearly presented an analysis of the potentials for biogas production in Ilorin.
Keywords: Biogas, Potential, Location, Raw material, Production, Information

1.Introduction

The European Biogas Association current global energy supply is highly dependent on fossil sources (crude oil, lignite, hard coal and natural gas) as observed by Kirchner, et al(n.d) and Mahajan and Chopra(2013). These are fossilized remains of dead plants and animals which have been exposed to heat and pressure in the Earth's crust over hundreds of millions of years. For this reason, fossil fuels are non-renewable resources whose reserves are being depleted much faster than new ones being formed. Unlike fossil fuels, biogas from anaerobic digestion is permanently renewable, and will not only improve the energy balance of the country but also make an important contribution to the preservation of the natural resources and facilitates environmental protection (Sunnyjane, 2012). Developing and implementing renewable energy systems such as biogas from anaerobic digestion will increase security of national domestic energy supply and diminish dependency on firewood from the forest and epileptic kerosene and cooking gas supply from the Fossil based energy. Mohammad Al Asoomi (2009) observed that it would also help in protecting the environment in terms of climate change caused by uncontrolled emission to the atmosphere and forest depletion. Furthermore, ORS Consulting Engineers (n.d) reported that one of the main environmental problems of today's society is the continuously increasing production of organic wastes. In many countries, sustainable waste management as well as waste prevention and reduction have become major political priorities, representing an important share of the common efforts to reduce pollution and greenhouse gas emissions and to mitigate global climate changes. Many people according to Lee Rebel Writers (n.d.), have the environment's best interests at heart. These people are dedicated to protecting the Earth from the detrimental effects of those who inhabit its every corner. In this direction, IEA (2010) reported that the bioenergy currently provides 10% of global primary energy supply, 1.3% of electricity production and 1.5% of transport fuels.

According to De Graaf and Fendler (2010), liquid and liquefied excrements of cattle, pigs and poultry are used as the primary substrate for many biogas plants as they are easy to handle due to being pumpable. Possible combination of substrate for biogas production is dung from animals such as cattle, pig and chicken droppings have been reported by FAO (1997) and Nagamani and Ramasamy, (2003). Al Seadi (2008) observed that the production of biogas from anaerobic digestion is widely used in modern society for the treatment of livestock manure and slurries (Kirchmeyr et al n.d), the aim is to produce renewable energy and also to improve their fertilizer quality. Biogas can also be used to generate renewable compressed natural gas for vehicle fuel and family cooking and lighting needs.

Table 2.1: Possible Combination of Substrate to Produce 1m^3 of Biogas

Substrate	Gas production rate(l/kg waste)	Manure availability (Kg/day)	Number of animal required
Cattle dung	40	10	2-3
Buffalo dung	30	15	2-3
Pig dung	60	2.25	7-8
Chicken droppings	70	0.18	80
Human excreta	28	0.4	90

Source: Nagamani & Ramasamy, 2003

The importance of utilizing GIS in determining optimum locations of solid waste collection places at the neighbourhood level was utilized in Dhaka city (Anwar, 2004); the ultimate goal was to find out for the suitable location of waste collection points in order to improve the solid waste collection system of the community. On the other hand, a sustainable solid waste management system depended highly on the level of participation of key stakeholders in the city. In the circumstances, GIS as a tool was used in the analysis of the existing situation and then selected some suitable locations of the waste bins in the area. This situation assisted to improve the service efficiency.

Geographic Information System is among the Management Information Systems and part of the Geo-information technology adopted in solid waste management in many countries. Experiences may be obtained from developed countries such as the USA, France, Britain, and some developing countries such as Mexico, China, Ghana, South Africa, Kenya and Nigeria (Kyessi and Mwakalinga, 2009). GIS has been demonstrated to strengthen the functioning of infrastructure service delivery and to enhance sustainable development in the cities (see Anwar, (2004), Yusuf (2010) and Ogwuche (2013)).

With the current energy and waste generation and disposal scenario described above and the emerging technology for ultimate decision making, this paper explores the use of Geographic Information Systems (GIS) in analysing the potentials for Biogas production Ilorin, with a view to developing a spatial decision support system for biogas plant developers/engineers and potential users.

2.The Study area

Ilorin is the capital of Kwara State, and Nigeria can be found in the North Central Geo-Political zone. It lies between latitudes 08o 30'N and 08o 50'N and longitudes 04o 20'E and 04o 35'E of the Greenwich meridian and occupies a land area of about 100km2 (Figure 1).

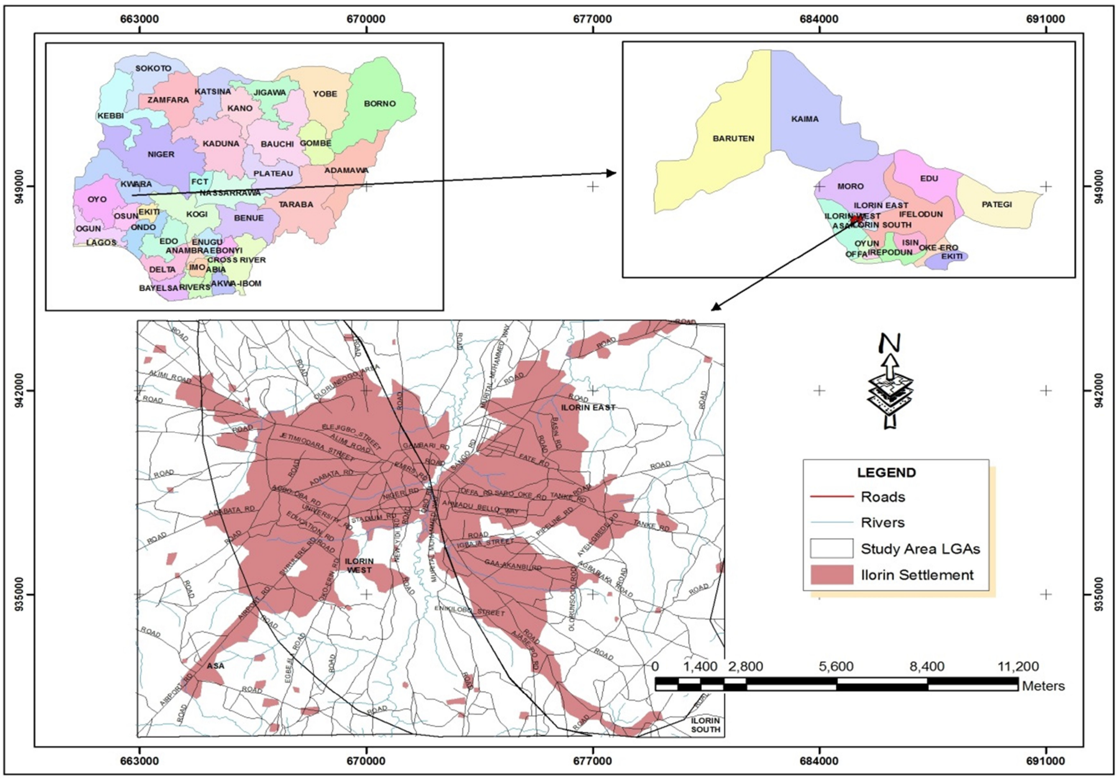

Figure 1. Map of the Study Area

Ilorin is experiencing two main climatic conditions. The wet season which begins towards the end of March when the tropical maritime air mass is prevalent and ends in October, often abruptly. Dry season that commences with the onset of tropical continental air mass is predominant between the months of November and February (Ifabiyi, 2011). The months of December and January according to Jimoh and Azubike (2012) are usually cold-dry months, as a result, of the hamarttan from the desert region of the North (Oyegun, 1983). The mean annual total rainfall is 1,200 mm, while the mean monthly temperature in Ilorin is uniformly high throughout the year ranging from 25oC to 28.9oC, the Relative humidity in the wet season is between 75 to 80% while in the dry season it is about 65% (Ajibade, 2008, Akpenpuun and Busari, 2013). The climatic condition of Ilorin favours the production of biogas as the temperature range for biogas production falls within the mean temperature of Ilorin.

Ilorin falls into the Southern Savannah zone. This zone is a transition between the high forests in the Southern part of the country. The vegetation is characterized by scattered tall trees and shrubs of between the heights of 10 feet to 12 feet. Oyebanji (2000) also described the vegetation as being predominantly derived savannah found in Ilorin East and West and of which are noted for their dry lowland rain forest cover. Plant biomass is also a potential material for biogas production, though this work is limited to organic waste from animal that are sourced from the city.

The 2006 population census showed that Ilorin has 847,582 inhabitants (N.P.C, 2007). It is one of the fastest growing cities in Nigeria. For instance, in 1952the population was 40,990 in 1952 and 208,546 in 1963, the population rose to 480,000 in 1984 (Oyegun, 1987). The increase in the population can be attributed to the administrative status (state capital) of the city. Increase in population often leads to higher waste generation especially organic waste that is needed for biogas production. More importantly the people are engaged in poultry farming and cattle rearing to supply the teaming population with animal protein and income for their living. The wastes from these animals and birds are good material for biogas production.

3. Conceptual Framework

Any Information System aims to support operations, management and decision making. Specifically, information system is a working system whose activities are devoted to capturing, storing, processing retrieving, manipulating, transmitting, and displaying information (O'Brien, 2003). As such, information systems, inter-relate with data systems on the one hand and activity systems on the other. Geographical Information System performs this role in a unique way. It integrates location and attributes data for meaningful and effective decision making. In this study the various locations where organic wastes are available are integrated with the attributes and requirements of biogas production the outcome of the processing are easily displayed on a map for accessibility

4.Materials and Methods

The Local government area delineation from the Administrative map of Kwara State to show the study area. Settlement map and Road network map of Ilorin metropolis were also acquired, and Global Positioning Coordinates of the raw material locations were taken. The Coordinates and Attributes data on wastes were harvested and imported to GIS environment where ILWIS 3.3 and ArcGIS 10.1 were used for spatial data processing, GIS operations, and spatial analysis.

The two major source of raw material for this study are Piggery and Poultry. These are the two major organic wastes materials that are relevant and readily available in the study area. The database was created for basic analysis of needed to achieve the objective of this study.

4.1.Estimation of the Quantity of Biogas from the raw material

Based on the report of Nagamani and Ramasamy, (2003) the biogas production estimates are derived thus:

For poultry birds,

Quantity of waste (kg) = Number of birds x 0.18 kg (1)

Volume of Biogas (m^3) = [Quantity of waste (kg) x 70 liters/kg] / 1000 (2)

For pigs,

Quantity of waste (kg) = Number of animals x 2.25 kg (3)

Volume of Biogas (m^3) = [Quantity of waste (kg) x 60 liters/kg] / 1000 (4)

5.Results and Discussion

5.1Biogas Production

Gas production rate varies with the substrate used in the biogas plant. According to Bates, (2007), 1m3 of biogas is enough to cook three meals for a family of 5-6. Many substrates are used as feedstock in biogas plants and the potential for biogas production varies with feedstock. Animal waste, human waste, kitchen waste and some crop residues are used in small scale biogas plants. De Graaf and Fendler (2010), identified liquid and liquefied excrements of cattle, pigs and poultry as the primary substrate for many biogas plants because they are easy to handle, and they can be pumped. In addition, liquid manure is an ideal substrate due to its biochemical properties. It has a high buffering capacity, contains sufficient micro-nutrients in a convenient form and makes available the required bacteria population for the anaerobic fermentation

Biogas raw material areas are many in the eastern part of the study area having eleven (11) locations where the raw material could be gotten from and three (3) in Ilorin west to make a total of fourteen (14) places in the Metropolis.

From this result, more quantity of raw materials would be gotten from the eastern part of the metropolis compared to the western part thereby leading to more volume of Biogas production and more users benefiting from the production.

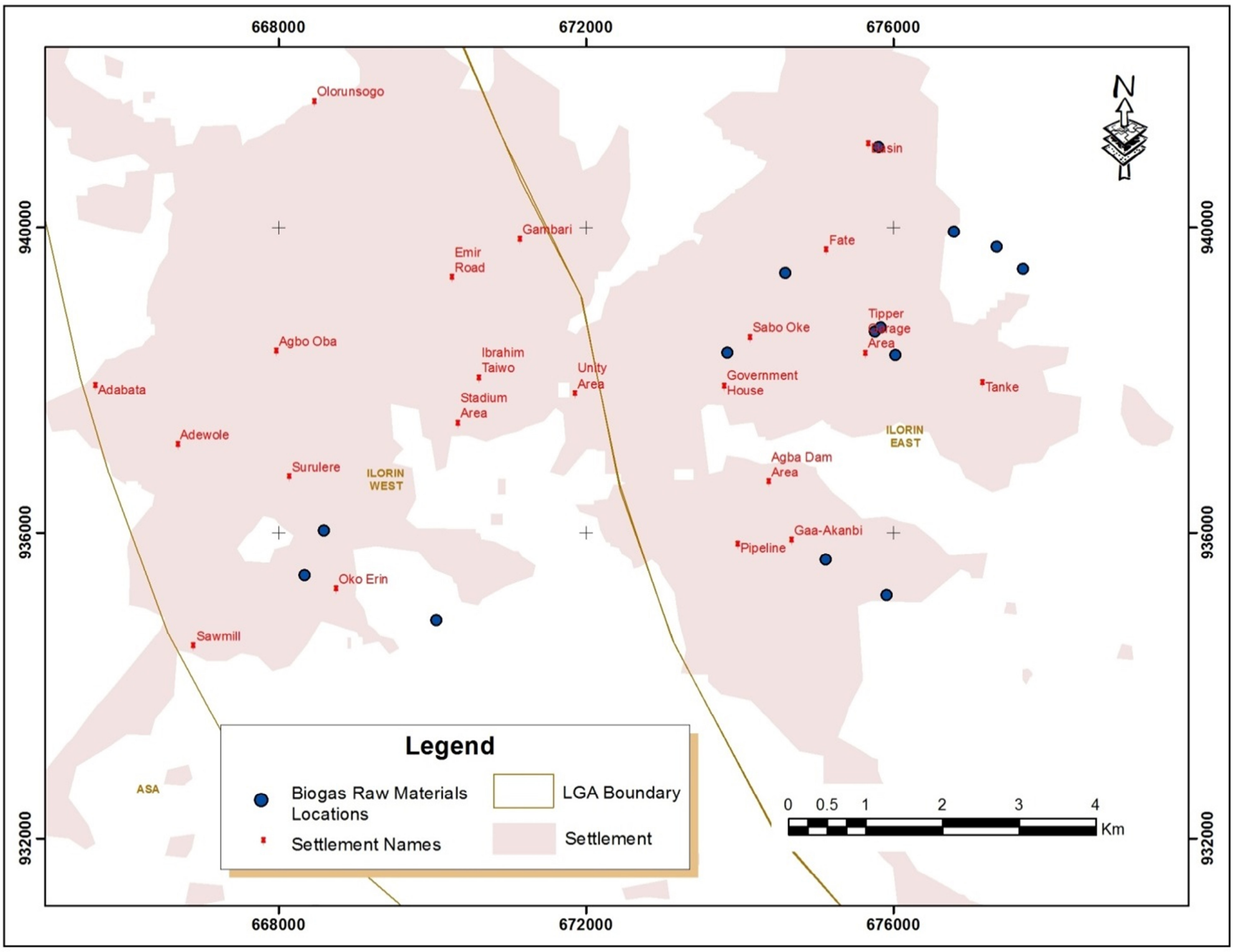

Figure 2: Spatial Distribution of Biogas Raw Materials

5.2Accessibility to Biogas Raw Materials locations

In this context, Geographic accessibility often referred to as spatial or physical accessibility, is concerned with the complex relationship between the spatial separation of the population and the locations of Biogas raw materials locations. Hence, accessibility within the context of this study is the measure of constraints imposed on the movement of individuals to desired Biogas raw materials destinations. The map shows that all the raw materials locations are well linked or connected, accessible, and the materials can be easily sourced and collected.

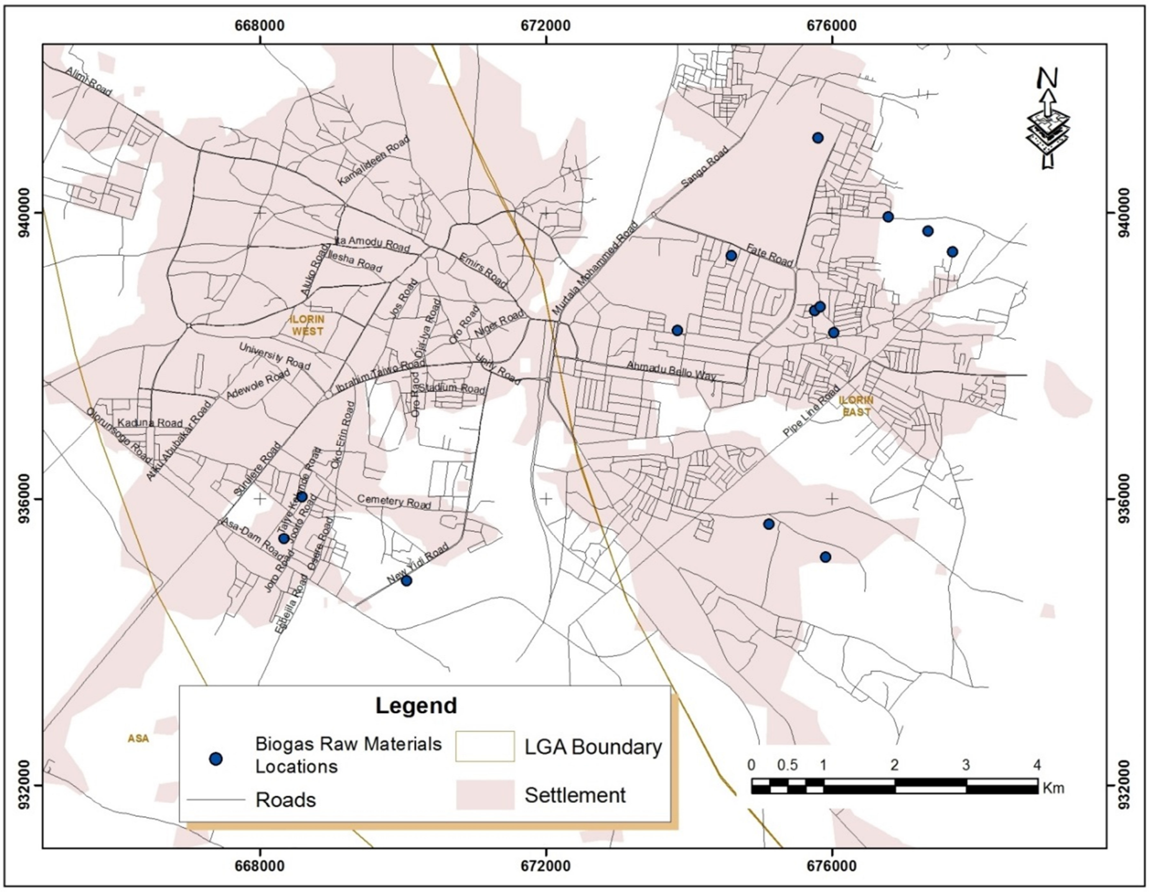

Figure 3: Accessibility to Biogas raw materials locations

5.3.Biogas Production Volume

Figure 4 shows the distribution of the volume of biogas that can be produced in the study area. The variation in quantity was visually presented. This was done in other to relate the type and quantity of raw materials found at each location to the expected volume of biogas to be produced and thus evaluate the number of households that will utilize the produced biogas in the study area.

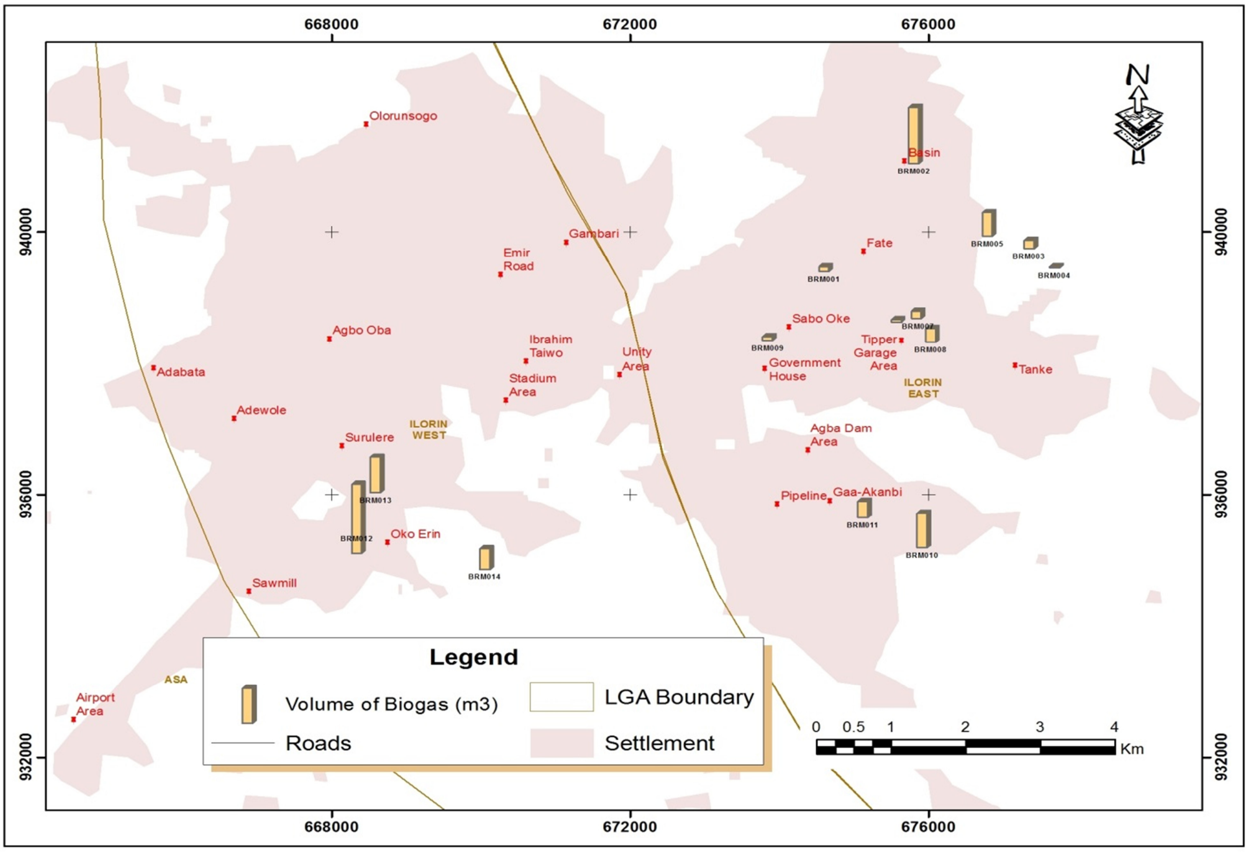

Figure 4: The Volume of Biogas Production

5.4.Spatial Query of Biogas Raw Material Positions

The uniqueness of a Geographic Information Systems is the ability to integrate spatial and non-spatial data from different sources to develop a database that can be subjected to query. When a database is developed, it is often queried to test the functionality of the system's databases. The result of such test is presented in Figure 5

A clicking on a Biogas raw material location displays its attributes. The result showed that the identified raw material has a unique identifier of BRM 009, located in Ilorin East and having 240 poultry birds with 5 turkey birds. The total quantity of raw material expected from this location is 44.1kg which will produce 3.1 m3 volume of biogas.

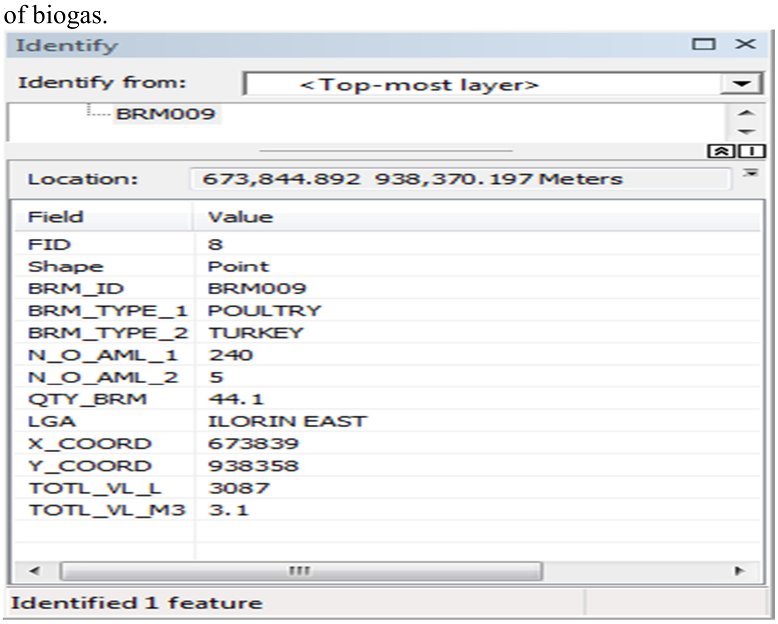

Figure 5: Query result of a Biogas raw material location

6.Conclusion

Developing and implementing renewable energy systems will increase security of national energy supply and reduce dependency on energy from fossils, it will also protect the environment in terms of climate change, as a result, of their uncontrolled emission into the atmosphere.

The capacity of Geographical information system makes the solution about spatial problem such as identification of renewable energy raw material sources for its production easy to evaluate and analyzed. The location of these raw materials for the biogas production is an important factor for citing a biogas plant and even for domestic users in the area as it affects its potential for production and utilization, this is what the information system has been developed to cater for.

References

Ajibade, L. T. (2008) Waste Ergonomics Optimization in Ilorin, Nigeria. *Ethiopian Journal of Environmental Studies and Management* Vol. 1 No. 2 June, 2008

Akpenpuun, T. D.and Busari, R. A. (2013) Impact of Climate on Tuber Crops Yield in Kwara State, Nigeria. *American International Journal of Contemporary Research* Vol. 3 No. 11;179-183

Al Seadi, T. (2008) *Biogas Handbook*, University of Southern Denmark Esbjerg, Niels Bohrs Vej 9-10, DK-6700 Esbjerg, Denmark

Anwar, S. M. (2004) Solid Waste Management and GIS: a Case of Kalabagan Area of Dhaka City, Bangladesh, *M.Sc. Dissertation,* Department of Geography, Norwegian University of Science and Technology (NTNU), Trondheim, Norway

Bates, L. (2007) Biogas Technical Brief, Practical Action, http: // practicalaction.org / practical answers

De Graaf, D. and Fendler, R. (2010) *Biogas Production in Germany: The Baltic Sea Region Programme 2007-2013,* Federal Environment Agency, Dessau-Rosslau, January, 2010

Food and Agriculture Organization of the United Nations (FAO), (1997) A System approach to biogas technology, *Sustainable Development Department (SD),* FAO

Ifabiyi, I. P. (2011) Willingness to Pay for Water at Household Level in Ilorin, Kwara State, Nigeria. *Global Journal of Human Social Science* Volume 11 Issue 2 Version 1.0,

International Energy Agency (IEA) (2010b) Energy Technology Perspectives 2010, *International Energy Agency,* OECD publishing, Paris

Jimoh, H.I. and Azubike, J.O (2012) The Roles of Geographic Information System on the Spatial Pattern of Health Care Facilities in Ilorin, Kwara State of Nigeria. *International J. Soc. Sci. & Education* 2012 Vol. 2 Issue 3,508-518

Kirchner, F, Hahn E.R, Kulisic, B, Rutz, D (n.d) *Capacity building for administrative bodies regarding the Implementation of Biogas Project.* Retrieved June 28, 2014 from http://www.biogasin.org/files/pdf/WP3/D.3.3_EBA_EN.pdf

Kyessi, A. and Mwakalinga, V. (2009) *GIS Application in Coordinating Solid Waste Collection:* The Case of Sinza Neighbourhood in Kinondoni Municipality, Dar es Salaam City, Tanzania. FIG Working Week 2009 Surveyors Key Role in Accelerated Development Eilat, Israel, 3-8 May 2009. Retrieved June 22, 2014 from http://www.fig.net/pub/fig2009/papers/ts04b/ts04b_kyessi_mwakalinga_3219.pdf.

Lee Rebel Writers. (n.d.) *Worth the Change*. | Retrieved June 22, 2014 from http://www.leerebelwriters.com/worth-the-change/

Mahajan, J A and Chopra M.K (2013)Sugar Indusrtry Waste to Renewable Energy. *International Journal of Emerging Technologies in Computational and Applied Sciences*, 6(3), 248-250

Mohammad Al Asoomi (2009) In Theory: Why UAE qualified for International Renewable energy Agency Gulfnews.com. Retrieved from http://gulfnews.com/business/opinion/in-theory-why-uae-qualified-for-irena

Nagamani, B. and Ramasamy, K. (2003) *Biogas production technology: An Indian perspective,* Fermentation Laboratory, Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore 641 003, India

National Population Commission (2007) Official Gazette on the National and State Provisional Totals: 2006 Census. Federal Government Printer, Lagos, Nigeria, No. 24, Vol. 94

O'Brien, J. A. (2003) *Introduction to information systems: essentials for the e-business enterprise.* McGraw-Hill, Boston, MA

Ogwuche, J. A. (2013) spatial location of solid waste dumpsites and collection scheduling Using the geographic information systems in Bauchi metropolis, Nigeria *European Scientific Journal* 9 (11) ISSN: 1857-7881 (Print) e - ISSN1857-7431

ORS (n.d) *Anaerobic Digestion* - ORS Consulting Engineers. Retrieved June 28, 2014 from http://www.ors.ie/index.php/anaerobic-digestion/

Oyebanji, J. O. (2000) “Kwara State” in Udo, R. K. and Mamman, A. D. (Eds), *Nigeria: Giant in the Tropics,* Vol. 2, State Survey,2nd Edition Gabumo Publishing Co. Ltd. Lagos

Oyegun, R. O. (1983) *Water Resources in Kwara State*: Matanmi and Sons Printing and Publishing Co. Ltd. Ilorin

Oyegun, R. O. (1987) Man-Induced Movement of Earth Materials into Ilorin City, Nigeria *Journal of Environmental Education and Information* 6 (2): 142-152

Sunnyjane (2012) Of Gas Prices and Gasbags: Who is Responsible for America's Pain at the Pump? Retrieved from http://politicalgates.blogspot.com/2012/03/of-gas-prices-and-gasbags-who-is.html

Yusuf, F. A. (2010) Solid Waste Generation and Management in Akwanga Town, Nasarawa State, Nigeria. *Unpublished M.Sc. Dissertation*, Department of Geography, Benue State University, Makurdi, Nigeria