An Assessment of Food Residuals and Development of An On-site Composting Bin for A Community In Ibadan, Nigeria

A, O, Coker[1], M. K. C. Sridhar[2] and J. O. Akinyele[1]
[1]Department of Civil Engineering, [2]Division of Environmental Health,
University of Ibadan, Ibadan, Nigeria
Correspondence: mkcsridhar@yahoo.com

ABSTRACT

Food waste among Nigerian communities constitutes a major environmental problem. This study was carried out in Ibadan, a highly populous indigenous city, the capital of Oyo State. As most of the families are traditional, food is prepared in the house at least twice daily. Various foods consumed by the households were assessed for one week for the quantity of waste generated during processing. The foods included grains, vegetables, fruits, meat, and others. Depending on the food item processed, the amount of waste generated ranged between 0 to 61 per cent of the total waste and is still the largest component of the waste stream. Corn, tubers, plantains generated more waste. For household management of these biodegradable wastes, a simple household composting bin was designed and tested using a family of about 7 to 8. The bin is made from a used drum with a cutting and stirring device for the food residuals. The bin takes waste for about 4 weeks and at the end of 45 days, the finished compost was taken out and used for backyard gardening. This type of onsite composting involving individual families may find useful in sustainable management of household wastes.

Keywords: Food waste, food residuals, compost, bin, sustainability, biodegradable, Nigeria

1. INTRODUCTION

Management of food waste is a serious problem in several cities in Nigeria. Ibadan, the study area, has Yoruba dominant ethnic population together with large-scale immigration of other groups such as Ibos, Ibiobios, Edos, Urhobos, Nupes, Igbiras, Hausas and Fulanis from different parts of the country. They brought with them their culture, lifestyle and food habits, which have influenced the composition of wastes over the years. Along with the population increase, industrial and developmental activities also increased beyond projected limits. Over the years the amount of waste generated in Ibadan has been at the rate of 0.43 kg per head per day and the organic portion stood at 60–80 per cent principally arising from food residuals, leaves, packaging and others. The wastes also showed a relatively high density, 300 kg per m^3 (Sridhar et al., 1985).

A recent work by Sangodoyin and Osaigbovo (1993) indicated that domestic waste generation and composition in Lagos, about 120 km from Ibadan also confirmed the high

proportion of organic matter in the wastes from South west Nigeria. Generally, the waste generated in Ibadan is highly biodegradable and usually not all the wastes are collected promptly. About 30–50% clearing is typical. The fact is that Ibadan had become very heterogeneous over the years and the Environmental Health Officers who used to enforce clearing are not involved effectively under the Local Government administration (Fantola and Oluwande, 1983). As a result indiscriminate open dumping of wastes into wetlands, burrow pits, water courses and drains is common , a practice which was implicated in some disastrous flood incidences experienced in Ibadan in the 1980's (Sangodoyin,1993; Sangodoyin and Essein, 1996).

Food residuals in many areas in Ibadan are left to decompose in the environment, attracting flies, cockroaches, rodents and other vectors of public health importance. Apart from being an eyesore, they create foul odour due to the slow decomposition. (Yuwono and Lammers, 2004). There are lessons to learn from the principles adopted by China to maintain high standards of public health despite her staggering population. China lays emphasis on self-reliance, simplicity, effectiveness and mass participation instead of leaving Government to do everything (Oluwande and Onibokun, 1976). This principle seems to be pivotal in the turn-around experienced in 1949 (popularly called the 1949 revolution).

For effective management of food waste in Ibadan, there should be appropriate and affordable technologies at the disposal of the community. A study carried out on mixture of food wastes with other kinds of municipal wastes in Lagos by Ojolo and Bamgboye (2005) has demonstrated that food waste can be combusted, and thermochemically converted to useful forms. The possibility of biogas production from food and crop residues in developing countries was also investigated by Plochl and Heiermann (2006). Some useful practices in Europe that are transferable to the developing world were given by these authors. The present study is aimed at developing an on-site waste management strategy for communities in Ibadan through a household bin so that a major part of biodegradable waste can be processed and reused while the non-biodegradable recyclables can be segregated and sold to itinerant recyclers.

2. MATERIALS AND METHODS

2.1 Study Location

Ibadan is the indigenous largest city and capital of Oyo State in the South Western part of Nigeria. It lies on the longitude 3°5' East of Greenwich meridian and latitude 7°23' North of the Equator. There has been a remarkable increase in the rate of growth in Ibadan City: the rate of growth was 2.8% (1963), 6.0% (1973 - 1981), and stood at about 5.3% now. In 1996, the total population of the city of Ibadan was estimated to be 1,418,182 based on the 1991 census. Currently the population is estimated to be 3.2 million. Ibadan has seven major residential districts, namely: the Core, Old Suburb, New East Suburb, Newer Western Suburb, Post 1952 Suburb, Bodija Estate and the Reservation Areas. Currently they are grouped into - the high density residential district comprising the older and poor quality residences, the medium density residential district made up of newer eastern and western

suburbs as well as the post 1952 suburbs; and the low density residential district made up of high quality residences comprising the Government Reservation areas (e.g. established in 1893 on Agodi Hill, Jericho, and Commercial Reservations). Even though Ibadan has 'Yoruba' dominant ethnic population, large scale immigration of other groups as Ibos, Ibibios, Edos, Urhobos, Nupes, Igbiras, Hausas and Fulanis entered the city. They brought with them their culture, lifestyle and food habits which have influenced the composition of wastes over the years.

2.2. Methodology

An assessment was made on the weekly generation of food waste among ten selected households in Ibadan. The households were flats from a medium density area at Eleyele and the residents are typically indigenous in their culture and food habits. Each household has occupancy of seven to eight (Nigeria's recommended family size is a couple and four children). The food items processed at each cooking schedule in the houses were assessed over a period of four weeks to obtain the variety and consistency. Each household was given a special plastic bag and the waste generated from food processing activities (peeling and cutting), and leftovers after meals were collected on each day for the whole week from Sunday through Saturday. All the food items processed were weighed (fresh weight) and data on the type of meal, number of people living in the house and consuming that food, the amount food being processed and the waste generation during the processing were recorded. Some of the food items are sold in the market by a special measure called 'Congo' (the contents e.g. rice weigh approximately 1.6 kg) and where such measure was used were computed to express in kg.

Before the design of a suitable household composting bin, a survey was carried out on weekly generation pattern among selected households in Ibadan. The households were typically of indigenes. The households were flats and had occupancy of six people in each that process the local foods for consumption. They lived in medium income group housing area in Eleyele of the city. Different types of food items commonly processed in the houses were assessed over a period of four weeks to obtain the variety and consistency. A unit measure (as normally sold in markets) of each fresh food item processed and consumed was weighed and the waste resulting from processing was recorded. The amount of food processed and the amount of wastes generated were weighed and recorded.

A simple household composting bin was designed and fabricated using a $0.2m^3$ used oil drum with a central rod with sharp paddles and a handle. All the materials were sourced within the locality and appropriate. technology was employed. Once the food waste is put in, the contents are stirred and left for a certain period time, usually 45 days. At the end of curing, the finished compost is ready for use for backyard gardening.

3. RESULTS AND DISCUSSION

3.1 Food Production, Food Habits and Changing Composition of Wastes

During 1967–2000, per capita worldwide cereal production rose substantially; 565 kg in 1967 to 665 kg in 2000 for the developed countries and 176 kg to 253 kg during the same period for developing nations (Singh, 2003). China has carved a niche for herself among the developing nations with respect to this (Zhou et al., 2003). In Nigeria, the Federal Government Policy since 1999 to date encouraged massive food production culminating in enormous food wastes as the problem of adequate storage is yet to be solved in the country.

The waste composition has been changing depending on the population growth, technology development, political atmosphere and affluence of the people particularly after the discovery of petroleum resources. In the early years, leaves used in wrapping food formed the major bulk of the refuse in urban and rural areas. Local foods such as 'amala' made from yam flour, 'lafun' made from cassava flour, 'iyan' pounded yam, 'eba' and 'fufu' made from cassava tuber, 'moin moin' made from cow peas, and 'ogi' and 'eko' made from maize are traditionally wrapped in leaves during cooking and once the food is consumed the leaves are thrown into the garbage. These traditional practices in the old town have contributed to 81.3 per cent of the waste (Oluwande, 1974 and Adebayo et al., 1990). A decade later, there have been significant changes in composition particularly the use of leaves have dropped and plastics have taken over most of the households. Plastic technology has displaced some of the traditional practices of using copper, bronze and brass in cooking and domestic chores. More affluent and middle income families, restaurants and 'bukhas' still generated significant amounts of food residuals which entered the garbage dumps (Sridhar et al., 1985 and Coker et al., 2005).

By 1990s governmental policy on 'Structural Adjustment Programme' has brought down the value of local currency which resulted in a drastic change in the attitude of people (Sridhar et al., 2002 and Onibokun et al., 2000) who resorted to minimizing the waste generation and recycling as a means of conserving limited resources. The changes in the composition of wastes were beingn monitored by our research group over the decades as this programme is an ongoing one since 1970s and the changing trend is shown in Figs. 1 and 2. Many middle and low income families were unable to pay for the waste management services, which are in the hands of the government, particularly the State and the Local Government. Thus reuse and recycling have become a part of their life.

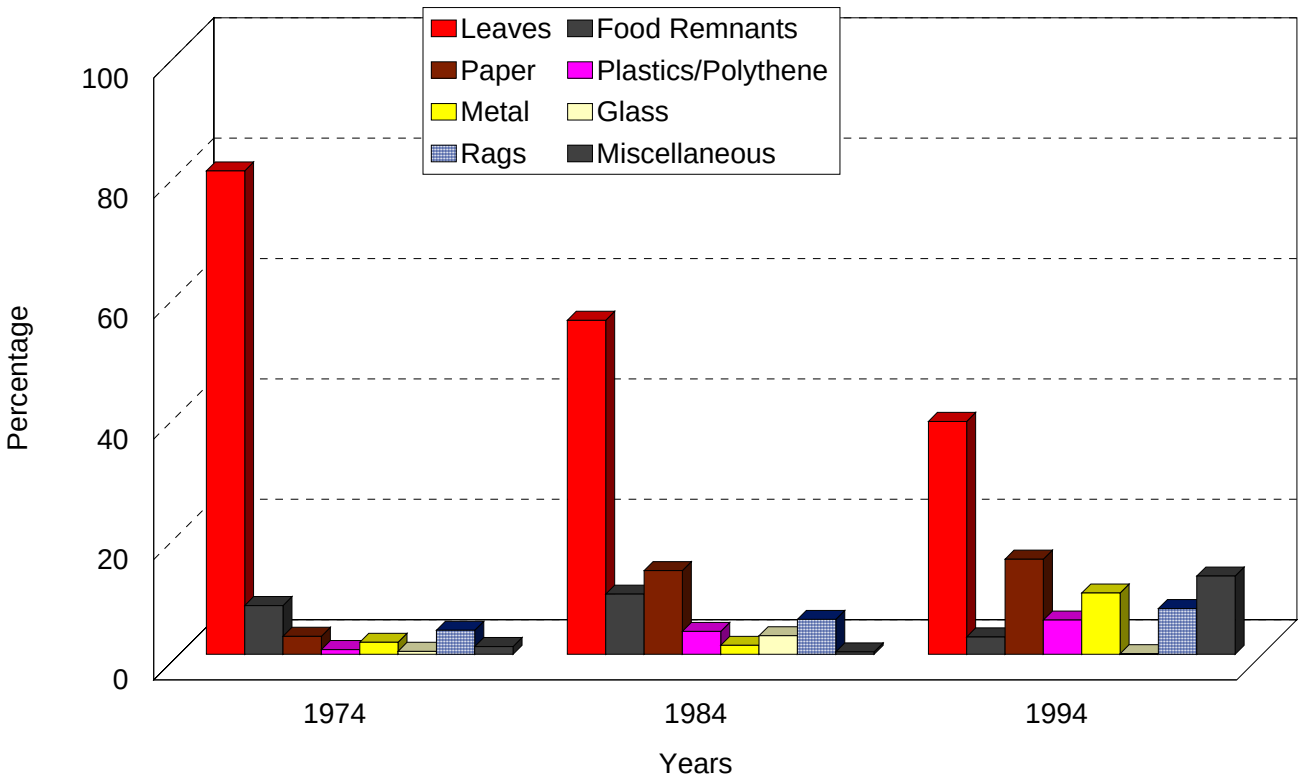

Figure 1. Changing composition of household waste in Ibadan (Old Town)
(Leaves constitute the major component traditionally)

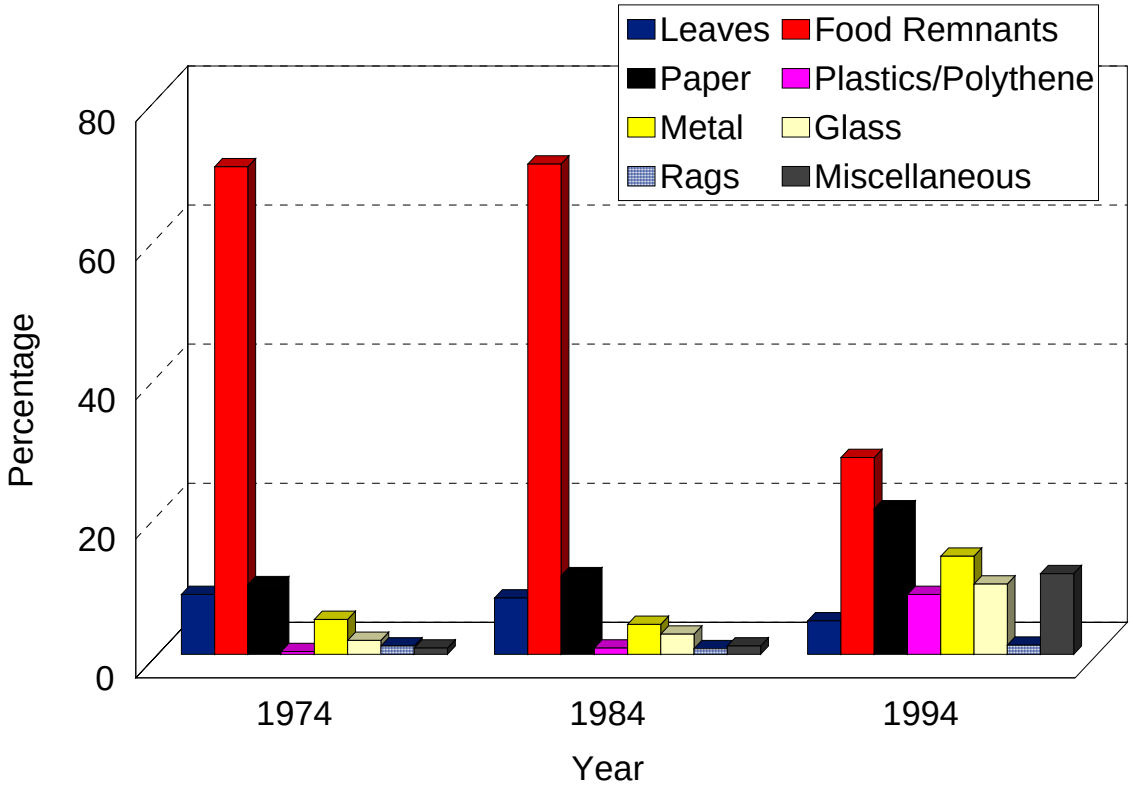

Figure 2. Changing composition of household waste in Ibadan, (New Town)
(Food waste is the dominant component)

3.2 Assessment of Food Waste Generated in Households

The amount of wastes generated per unit weight of food processed is given in Table 1.

Table 1. Amount of wastes generated through food processing in the households (A typical Nigerian household with 7 to 8 members)

Food Item	Quantity used by the family in one serving	Fresh Weight Range (g)	Waste generated Range (g)	Waste Generated %
Yam	1 tuber	1035.6-1085.2	138.5-179.7	12.8-16.6
Rice (Polished)	1 Congo*	1535.1-1675.0	0.0-7.6	0.0-0.45
Beans	1 Congo	1418.2-1465.5	381.2-418.6 (husk)	26.9-28.6
Groundnut	1 Congo	1021.0-1036.0	429.2-437.2	42.1-42.2
Maize	7 Cobs	1002.8-1005.7	518.3-615.1	51.7-61.2
Banana	12 Pieces	1023.1-1057.0	351.2-417.3	34.3-39.5
Plantain	8 Pieces	1000.9-1037.5	354.6-372.5	35.4-35.9
Orange	8 Pieces	1013.2-1072.4	583.4-673.2	57.6-62.8
Pineapple	1 Piece	920.0-1563.9	504.1-593.2	54.8-37.9
Cassava	3 tubers	1042.9-1063.8	221.5-228.2	21.2-21.5
Yam powder (Elubo)	1 Congo	723.6-724.3	58.2-62.2	8.04-8.6
Meat	8 Pieces	334.0-453.2	43.0-65.2	12.9-14.4
Fish	4 Fish	970.6-1012.9	107.3-257.4	11.1-25.4
Green Amaranth	4 Bundles	1030.8-1061.2	526.2-571.5	51.0-53.9
Lime / Lemon	43 Pieces	981.2-1151.7	567.3-635.8	57.8-55.2
Eggs	17 Pieces	1008.8-1016.5	116.2-118.7	11.51-11.7
Carrot	43 Pieces	1010.5-1038.2	81.5-87.0	8.1-8.38
Coco yam	12 Tubers	1019.5-1053.5	342.8-384.1	33.6-36.5
Garden egg	42 Pieces	1009.9-1012.6	39.2-48.3	3.9-4.8
Coconut	3 Pieces	856.5-1049.6	217.5-306.1	25.4-29.2
Pawpaw	3 Pieces	985.6-1293.6	391.2-483.5	39.7-37.4
Iryingia fruit (Oro)	5 Pieces	1048.7-1055.8	371.3-380.1	35.4-36.0
Pepper	1 Congo	1031.2-1051.5	36.4-41.3	3.53-3.93
Potatoes	9 tubers	949.7-1052.0	253.6-282.6	26.7-26.9
Pear	5 Pieces	827.5-1017.8	349.0-423.3	42.2-41.6
Onion	9 Pieces	548.3-601.3	53.6-62.6	9.8-10.4
Breadfruit	1 Piece	931.6-1172.8	317.0-329.0	34.0-28.1
Guava	59 Pieces	982.1-1002.3	32.1-59.3	3.3-5.9
Melon	1 Congo	639.0-650.0	286.0-298.0	44.8-45.85
Okro	48 Pieces	983.5-1006.4	89.4-107.2	9.1-10.65

- *'Congo' is a local measure, usually a gourd bowl used by the traders; a 'Congo' filled with grains (e.g. rice, maize etc.) weighs approximately 1.67 kg.*

From Table 1, wastes from fresh food ranged from 1 g for guava to as high as 593 g for pineapple.

In addition to the wastes generated during the processing of food, an assessment of the food leftovers after each meal (eating three meals is common which include breakfast, lunch and dinner) is also collected from each family.

Table 2. Weekly left over food waste in a middle-income household

Day of the week	Meal type	Food residuals wasted at each meal (g)	Food residuals wasted per day (g)	% of the weekly generated food waste
Monday	Breakfast Lunch Dinner	215.6 198.5 454.7	868.8	12.77
Tuesday	Breakfast Lunch Dinner	164.5 123.1 893.4	1181.0	17.37
Wednesday	Breakfast Lunch Dinner	100.2 - 189.3	289.5	4.26
Thursday	Breakfast Lunch Dinner	376.7 - 257.0	633.7	9.31
Friday	Breakfast Lunch Dinner	351.9 104.4 583.5	1039.8	15.29
Saturday	Breakfast Lunch Dinner	312.6 817.4 415.8	1545.8	22.73
Sunday	Breakfast Lunch Dinner	683.2 396.2 162.8	1242.2	18.27
Weekly Mean	-	-	6800.8	100

The results (Table 2) indicated that about 0.63 to 1.6 kg of food is being wasted per day as leftovers on each day amounting to about 6.8 kg per week per family.

3.3 Design and Construction of Household Composting Bin

A drum is usually used in collecting food residuals wastes is employed in the design and construction of household composting bin. Three key elements – air, humidity, and temperature were considered in the design and construction. The size of the drum chosen was 0.2 m^3 and the inside was painted to prevent rusting. Before pouring the waste into the barrel, 20 kg of sand and 5Kg of sawdust were poured into the drum as the bottom layer which helps in maintaining moisture level in the drum which can promote the microbial development when the wastes are introduced. Two sets of three openings of 1cm diameter were made around the top third and the bottom third of the barrel at a distance of 52 cm from each other. Another opening of 1cm diameter was made at the bottom of the barrel for drainage. The top is cut by half to provide an opening fitted with a pair of hinges that will allow the top of the barrel to be opened and closed when the bin is in operation.

For stirring device, a long rod C (Figure 3 A and B) were inserted into the inside of the barrel through another hole bored through the half-cut part of the top lid of the barrel. A set of sharp-edged paddles are welded to this rod so as to facilitate stirring and shredding of the wastes inside the barrel. The stirring and shredding enhances easy access of air into the decomposing waste which is also cut to smaller pieces for easy decomposition. All the openings were closed with pieces of nylon or metal wire mesh to prevent entry of flies. The barrel is placed on a tripod at 25 cm height with a plastic bowl put underneath to collect any leachate that may escape. The various components of the composting bin are given inFigure 3.

Figure 3. A household composting bin with its stirring device and the finished compost

A= The bin with lid and openings for aeration
B= Inside of the bin with shredding and turning device
C= The finished bin with handle to turn the contents and ready for use
D= The finished compost at the end of the period

3.4 The Composting Process, Operation and Maintenance

The food residuals were daily collected from the surveyed households and were put into the drum. They were stirred every 3-day interval over the 28-day experimental period. Stirring continued for further period of 45-days so as to ensure full decomposition of the degraded wastes. The leachate collected from the bottom opening of the bin was continually poured back into the drum. At the end of the test period, about 11 weeks, the household waste was converted to golden brown organic fertilizer (Figure 3 D). The finished product showed a pH value of 6.4, carbon 6.19%, nitrogen 2.22%, phosphorus 0.505%, and potassium 0.525% and was found suitable for backyard gardening.

The drum used in the experiment is easily available in the communities at an affordable cost. It is simple to design and maintain. Once in a while the contents may be removed, the bin washed and set again for continuation. The time required for compost formation depends on the nature of the waste, the amount, and the ambient temperature. The unit can be conveniently placed on the backyard nearer to the kitchen and handy for the housewife. Smell and fly nuisance is not a problem if the contents and the process are controlled regularly by one of the family members. More than these benefits, the family can save the cost of engaging private service for their waste disposal. Many households are showing interest in using this device.

4. CONCLUSIONS

A study was carried out on the quantity and nature of food wastes produced in a typical Yoruba household with a population size of seven to eight. Most of the foods processed and prepared in the household generate varying amounts of waste, up to 62%. There is also a difference in the composition of waste in that the leaves which are traditionally used to wrap certain foods have started decreasing thus reducing the volume of waste generated. A household compost bin was designed and fabricated using local materials. The design has stirring and cutting device for the fibrous food residuals. The composting process followed the normal pattern and lasted about 45 days. This technology will be very useful for household management of solid wastes at the point of generation and helps in recycling valuable resource which is a concern to public health.

5. REFERENCES

Adebayo, O., Sridhar, M.K.C. and Hussain, M.A. 1990. Traditional food wrapping practices and solid wastes problem in Nigeria. *Africa Health*, 12: 26-27

Coker, A.O., Sridhar, M.K.C. and Akinyele, J.O. 2005. A simple bin design for managing food residuals, *Biocycle--Journal of Composting & Organic Recycling,* 46: pp 59, 63.

Fantola, A and Oluwande, P.A. 1983. Administrative and Technical Aspects of Solid Waste Management in Ibadan. *Africa Journal of Science and Technology,* Vol. 2, No. 2, 35 – 46.

Ojolo, S.J. and Bamgboye, A.I.2005. Thermochemical Conversion of Municipal Solid Waste to Produce Fuel and Reduce Waste, Agricultural Engineering International: the CIGR Ejournal, Vol. VII.

Oluwande, P.A. 1974. Investigation of certain aspects of refuse in Western State of Nigeria. *Journal of Solid Wastes Management, 64*: *22 – 32.*

Oluwande, P.A. and Onibokun, A.G. 1976. Some Aspects of Public Health and Medical Care in China (challenges to developing countries), *East African Medical Journal,* Vol. 53, No. 10, 590 – 595.

Onibokun, A.G., Adedipe, N.O. and Sridhar, M.K.C. 2000. Affordable Technology and Strategies for Waste Management in Africa: Lessons from experience. Centre for African Settlement Studies and Environment (CASSAD), CASSAD Monograph Series No. 13 January, pp. 1 – 134.

Plochl, M. and Heiermann, M. 2006. Biogas Farming in Central and Nothern Europe: A Strategy for Developing Countries, Agricultural Engineering International: the *CIGR Ejournal*, Vol. VIII.

Sangodoyin, A.Y. 1993. Domestic Waste Disposal in South west Nigeria, *Environmental Management and Health***,** Vol. 4, No 3, 20-23

Sangodoyin, A.Y. and Osagbovo, J. 1993. Case Study Evaluation of Domestic Waste Component, Services and Pollution Aspects, *Journal of Engineering for International Development***,** Vol. 1, No. 3, 23-29

Sangodoyin, A.Y and Essein, E.O. 1996. Effect of Urbanization, Waste Disposal and Hydrological factors on flooding of Ogunpa stream in Nigeria, *Discovery and Innovation***,** Vol. 8, No. 1, 11-19

Singh, G. 2003. Population and food production: Prospects and challenges for Asia. Agricultural Engineering International: *the CIGR Journal of Scientific Research and Development***,** Vol. V

Sridhar, M.K.C., Bammeke, A.O. and Omishakin, M.A. 1985. A Study on the Characteristics of refuse in Ibadan, Nigeria, *Waste Management and Research*, 3: 191-201

Sridhar, M.K.C., Olateju, B.A., Lasisi, and Jaja, F.N.O. 2002. Refuse dumps and waste recyclers in the era of structural adjustment: The environmental crisis and its effects. *In Money, Struggles, and City Life:*

Devaluation in Ibadan and Other Urban Centres in Southern Nigeria, 1986-1996, (Eds) Jane I. Guyer, LaRay Denzer, Adigun Agbaje, Heinemann, Portsmouth, NH, USA, pp. 173-185

Yuwono, A.S. and Lammers, P.S. 2004 Odor Pollution in the Environment and the Detection Instrumentation. Agricultural Engineering International: *the CIGR Journal of Scientific Research and Development* Vol.VI

Zhou X., Dong, R., LI,S., Peng, G., Zhang, L., Hou, J., Xiao, J. and Zhu, B. 2003. Agricultural Engineering in China. Agricultural Engineering International: The *CIGR Journal of Scientific Research and Development.* Vol. IV