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A Feasibility Study on Sustainable Management of Municipal Wastes in Ogbomoso

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ABSTRACT: *Solid waste characterization study is a basis to any proper planning of solid waste management in an area. This study was undertaken to assess the characteristics of the waste generated in the three zones of Ogbomoso, in Nigeria to enhance scientific management of solid wastes in the town. This study consists of carrying out survey, characterization of municipal solid waste (MSW) and exploring it's potential to be used for biogas production. The direct waste collection and sorting was applied to solid wastes collected from ninety (90) households, thirty (30) from each zone with different socio-economic characteristics for a period of four (4) weeks. The result shows that Ogbomoso solid waste consists to a large extent of organic and other biodegradable matter. They were dominated by food, vegetable, paper and animal waste (50.6 %), plastics (7.3%), metals (10.3%), glass (10.2%), ash and dirt (7.6%) suggesting that an integrated waste management approach supported by willingness to separate wastes from source could be the best option for the town. A questionnaire was designed for collecting information about waste generation in all the three zones. The questions asked, were so as to get a essential information about the two important qualities of the waste generated viz quantity and disposal. The study recommended the adoption of the biogas technology because of its potential to address both economic and sanitation challenges being faced by local authorities in developing countries.*

Keywords: *Biodegradable, Characteristics, Management, Municipal solid waste, Sustainability*

I. INTRODUCTION

Proper management of solid waste is critical to the health and well-being of urban residents [1]. Ogbomoso, like most towns in the developing countries is facing potential threat from unhealthy waste disposal practices prevailing in almost all the urban centers in the country. Though the living standard has significantly changed, the method of public health and sanitation still remains primitive. A vast quantity of waste generation in the town is one of the serious outcomes of unplanned development. Due to rapid population growth the town faces many problems. One of the major problems of the city is improper disposal of municipal solid waste. The management of municipal solid waste has become an acute problem due to enhanced economic activities and rapid urbanization. Urban population growths together with the development of markets resulted in the quantum of a huge amount of hazardous organic and inorganic waste daily. Proper management of the waste is a challenging issue that must be addressed adequately. The sources of waste are multiple and haphazard and disposal method is not scientific, as a result of it the environment is getting polluted day by day and gradually. The trace elements polluted the air and poses as a health risk to the people. Many tons of municipal solid waste is left uncollected, clogging drains, creating feeding ground for pests that spread disease and creating a numerous of related health and infrastructural complications. Municipal solid waste management is an important part of the urban infrastructure that ensures the protection of environment and human health [2]. The rising growth of urban population, increasing economic activities and lack of training in modern solid waste management practices in developing countries with unplanned urbanization complicates the efforts to improve solid waste services. Ludwig et al. [3] wrote that the changes in consumption patterns with alterations in the waste characteristics have also resulted in a quantum jump in solid waste generation. In their report, [1] wrote that solid waste management is hampered by a lack of data at all levels from the ward, district and municipality, and where available, is generally unreliable, scattered and unorganized. To this end, the planning of solid waste management has remained a difficult task.

Energy is one of the most significant factors for human development and to worldwide prosperity. Energy demand is a critical reason for extensive climate change, resource exploitation, and also restricts the living standards of humans [4]. [5] Reported that Cooking accounts for 90% of energy consumption in the households of developing countries. While 80% of the world's energy consumption still originates from combusting fossil fuels [6]. Yet the reserves are limited; means do not match with the fast population growth, and their burning substantially increases the greenhouse gas (GHG) concentrations that contributed for global warming and climate change [7]. The over dependence on fossil fuels as primary source of energy, has led to global climate change, environmental degradation, and consequently human health problems.

One technology that can successfully treat the organic fraction of wastes is anaerobic digestion; it has the advantages of producing energy, yielding high quality fertilizer and also preventing transmission of disease [8].Harnessed biogas can either be processed and sold directly or used to generate energy, which can then be sold. Anaerobic digestion also produces savings by avoiding costs of synthetic fertilizers, soil conditioners and energy from other sources [9].

The classification of waste composition is thus, essential for the selection of the most appropriate technology for treatment, taking necessary health precautions and space needed for the treatment facilities. In spite of this acknowledgment, there has been no study on the analysis of municipal waste composition in Ogbomoso town and environ. This work attempts to fill this gap by providing pre-data on the composition, and sources of municipal waste in three different zones of the town with the aim of understanding the type of waste generated, waste flow, initiate and investigate a feasible sustainable waste disposal and implication for management.

II. MATERIALS AND METHODS

This work was carried out in three stages. The first is direct sampling of solid waste from specific sources, secondly, questionnaire was designed for collecting information about waste generation in the town and lastly characterization of solid waste was carried out.

2.1 Sampling and data collection

The determination of the composition of unprocessed municipal solid waste during this study was done according to ASTM D5231 – 92 [10] Standard Test Method which involves the direct sampling of solid waste from specific sources, a labour-intensive manual process of sorting, classifying and weighing all items in each sampling unit and a detailed recording of the data. Composite solid waste samples were sorted into ten categories namely; food scrap, waste paper, textile material, plastic material, metal, glass, ash dirt, vegetable, animal waste (dung,etc) and others which comprise unidentified waste types. Each category was weighed and its percentage composition determined. A total 60 households were surveyed (20 from each zone), each of the households was visited every day for four (4) weeks in November, 2014 and the waste sorted and weighed at source. Statistical quantities such as the mean and standard deviation were used to summarize the findings in this study. Standard deviation showed variation in the values of variables from the mean.

2.2 The Questionnaire

A questionnaire was designed for collecting information about waste generation in the town. The questions included, were so as to obtain a basic idea about the two important qualities of the waste generated viz quantity and disposal. A total 300 questionnaire was distributed (100 for each zone).

2.3 Laboratory

The characterization of solid waste was done to by finding moisture content, organic matter (total solid (TS) and volatile solid components (VS)) of solid waste. These were done so as initiate and investigate a feasible sustainable waste disposal

2.3.1 Determination of moisture content of samples: The moisture content of the solid waste was determined using the method used by Cioabla et al. [11]. The samples were weighed in a dish and dried in an oven at 105°C overnight. The weight of the dried sample plus dish was noted and the percentage moisture content was calculated by this equation

$$\% \text{ moisture content } = \frac{(m_2-m_1)-(m_3-m_1)}{(m_2-m_1)} \times 100 \quad (1)$$

Where,

m_1 = mass in grams of the empty dish,

m_2 = mass in grams of sample plus the empty dish before drying,

m_3 = mass in grams of sample plus empty dish after drying.

2.3.2 Determination of total solids (TS): The total solids (TS) were determined using the convection oven method which involved heating samples of 10g each of the biodegradable municipal solid waste and air dried at 105 ± 3^{0}C for three hours. The dried waste was then allowed to cool to room temperature in a desiccator after which it was weighed. The weight of the sample plus weighing dish was recorded. The sample was again heated in a convection oven at 105 ± 3^{0}C, until a constant weight change of ± 0.1% change was achieved upon one hour of re-heating the sample. The TS was then calculated from the formulae.

$$\text{TS} = \frac{\text{mass of dried sample remains}}{\text{initial mass of sample}} \qquad (2)$$

2.3.3 Determination of volatile solids (VS): The volatile solids (VS) of the substrate was determined by igniting the dried samples from (a) in a muffle furnace for two hours at 500^{0}C. The initial mass of the dried sample prior to ignition was recorded and the final mass of the solid remained after 2 hours of ignition was recorded. VS was then determined from the formulae.

$$\text{VS} = 1 - \frac{\text{mass of solid remains after igniting sample}}{\text{initial mass of dried sample}} \qquad (3)$$

III. RESULTS AND DISCUSSION

From the samples of solid wastes collected from the sampled households in the three zones, ten different types of wastes were categorized. These are food scrap, waste paper, textile material, plastic material, metal, glass, ash dirt, vegetable, animal waste (dung,etc) and others. Table 1 shows the different categories of waste observed in the three residential zones of Ogbomoso. Analysis of waste type shows that solid waste consists to a large extent of biodegradable matter (51.3 %) and the non biodegradable made up of substantially dirt, ash and other household trash typical of low income developing country [12, 13]. However, a closer look at the composition of municipal solid waste provides a description of the constituents of the waste and it differs widely from place to place [14]. The most remarkable difference is the difference in organic content which is much higher in the low income areas (metropolis) than the high income (lautech), while the metal and plastic content is much higher in high income areas than low income areas. It is a reflection of the difference in consumption pattern, cultural and educational differences. Due to the composition of the waste, especially the findings in this study of substantial presence of faecal matter and animal dung in the waste, many health and environmental issues are foreseen. The biodegradable wastes generated are in high quantity, these could be utilized by adopting appropriate technologies for processing it into a source of green energy and bio-fertilizer. While promoting sustainability, it would help prevent the degradation of the urban environment.

3.1 Responses to Questionnaire

There were 248 respondents to the questionnaire from 300 distributed. The respondents consisted of male and female with various age, occupational and educational status. Of the 100 questionnaire distributed to each zone 79, 87 and 82 were returned from metropolis, lautech and suburban respectively.

3.1.1 Type(s) of waste generated: Identification of waste composition is crucial for the selection of the most appropriate technology for treatment, taking essential health precautions and space needed for the treatment facilities. The type of municipal solid waste generated varies according to the various sources within the town as shown in Table 1. In higher income areas disposable material and packaged food are used in higher quantities. In the case of lower income areas, the usage of fresh vegetables with lack of refrigeration, keeping of livestock like goats and waste food is responsible for the high decomposable material. The availability of space encourages the keeping of livestock in the suburban area of Ogbomoso hence has more animal dung as seen in Table 1.

Table 1: Waste type and composition (%) in the three residential zones of Ogbomoso

Categories	Metropolis (%)	Lautech (%)	Suburban (%)
Food scrap	23.2	12.8	18.4
Waste Paper	7.7	6.7	8.3
Textile material	10.7	9.8	11.1
Plastic material	5.1	12.1	3.9
Metal	6.4	18.4	6.2
Glass	7.2	16.7	6.7
Ash, dirt	6.4	4.7	11.5
Vegetable	14.3	10.5	7.9
Animal waste (dung,etc)	17.7	7.6	25.1
unidentified waste types	1.3	0.7	0.9

3.1.2 Current method of disposal: As shown in Table 2, the use of authorized dump site was highest among lautch resident 65.8%, followed by those in the metropolitan 33.7%, while it was least among those living in the suburban area of the town 26.9%. A reverse pattern was observed for unauthorized site dumping with lautech having the least 14.5%, followed by the metropolis with 61.4%, while suburban has the highest of 72.7% this could be as a result of availability of empty space which encourages indiscriminable disposal. For water ways disposal the practice is more pronounced in the metropolis 52.4%, suburban area recorded 38.7%, while lautech area has the least of 27.6% this could as a result of the area consisting of much higher percentage of educated people. Burning of refuse is higher in the metropolis area (49.3%) than the other two zones suburban 43.1% and lautech 23.4%. The lower percentage observed in the lautech area could be as a result of the knowledge of the effect of burning as will be seen later. Lack of space for disposal might be responsible for the high percentage of burning in the metropolis. The suburban area recorded the highest method of burying refuse (37.5%), followed by lautech with 8.1%, while the metropolis has the least of 3.6%. Availability of empty space could be responsible for this trend of waste disposal. The use of waste bin is highest in the lautech area with 62.7%, followed by suburban 21.1%, while metropolis is 6.3%. The trend could be as a result of the financial implication involved in this method.

Table 2: Current methods of disposal.

Place	Metropolis (%)	Lautech (%)	Suburban (%)
Authorized dump site	33.7	65.8	26.9
Unauthorized site	61.4	14.5	72.7
Water ways	52.4	27.6	38.7
Burning	49.3	23.4	43.1
Burying	3.6	8.1	37.5
Personal bin	6.3	62.7	21.1

Note: Multiple responses were allowed for disposal methods

3.1.3 Awareness of waste separation and disposal options: As shown in Table 3, Awareness of waste collection service (WCS) was highest in the lautech area 88.6%, followed by suburban area 72.9%, while it was least among metropolis 63.3%. The same pattern could be observed for awareness of waste management regulations (WMR). The percentage of those who used WCS was highest among lautech area 81.2% and least in metropolis 28.8%. The percentage of those who used WCR was higher among those resident in lautech 66.5% and lowest among those resident in the suburban area 22.1%. The separation of waste from source was also higher in the lautech area 52.3% , compared to metropolis 15.7 and 18.7% for suburban areas. The influence of education on solid waste management could then be inferred.

Table 4 shows reasons for not using WCS. Those who used other WDO like open dumping, open burning, dumping in drainages and burying gave the reason of being not been effective where the existed 67.8, 31.3 and 75.9% for metropolis, lautech and suburban respectively. The other reason gave was in availability of WCS in their area of residence 58.4, 12.3 and 76.7% for metropolis, lautech and suburban respectively. Furthermore 67.3, 45.3 and 73.2% for metropolis, lautech and suburban areas gave the reason of too far from dump sites. The awareness of WMR was highest among those who are educated. The percentages of those who used WCS seemed not to be influenced by educational status as the results did not follow an orderly pattern; the reasons could be the availability and effectiveness of WCS. As seen in Table 4.

Table: 3 Awareness of waste separation and disposal options

Question	Metropolis	Lautech	Suburban
Aware of WCS (%)	63.3	88.6	72.9
Aware of WCR (%)	28.8	81.2	41.3
Use of WCS (%)	33.1	66.5	22.1
Separate the waste at source (%)	15.7	52.3	18.7

Where,

Awareness of waste collection service (WCS)

Awareness of waste management regulations (WMR)

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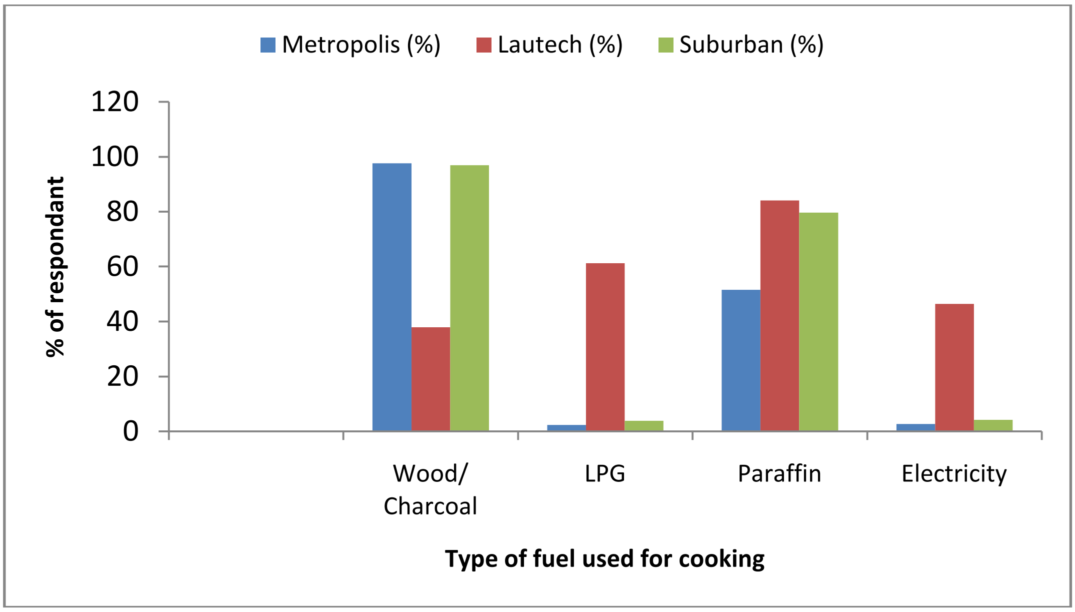
Table 4: Reasons for not using WCS

Reasons	Metropolis (%)	Lautech (%)	Suburban (%)
Not effective in my area	67.4	31.3	75.9
Not available in my area	58.6	12.3	76.7
Collection service too costly	88.7	35.8	75.8
Dump site too far from home	67.5	45.3	73.2

Note: Multiple responses were allowed for sources of energy

3.1.4 Type of cooking fuel used: Figure 1 presents an aggregated view of the type of energy used for cooking in the three zones under study. It can be deduced that wood is the most used source of energy followed by paraffin with electricity and the use of LPG very small. The distribution of energy used in each zone shows that Metropolis and the suburban areas relied heavily on wood and charcoal for cooking 97.6 and 96.9% respectively. The used of LPG and electricity in the two zones of metropolis and suburban is less than 5% compared to lautech area which has 84.1 and 46.4% relying on LPG and electricity for their cooking respectively. The lack of usage of electricity for cooking in the metropolis could be as a result of lack of constant electricity supply in the areas compared to lautech areas that have almost 24 hours constant power supply per day. However the lower usage of LPG in the two areas of metropolis and suburban compared to lautech area might not be unconnected to the cost of LPG and its availability.



Note: Multiple responses were allowed for types cooking fuel

Figure 1: Type of cooking fuel used

3.1.5 Daily cooking fuel requirement: Most respondents in the metropolis, suburban and those that uses wood in lautech areas indicated that they consumed wood for 2-3 hours for cooking purposes. This was compared to less than 1 hour when paraffin was used for the same purpose. Heating about 2 litres of water using wood was generally observed to take slightly less than 1 hour. This probably indicates that the technology used for cooking with wood is less efficient when compared to the use of paraffin stoves. It might also reflect the relative cost of each source of energy for the various purposes as discussed above.

3.1.6 Health impacts on the use of various sources of energy for cooking: The study also sought to ascertain the perceptions of respondents on the knowledge of the various effect of usage of various sources of energy for cooking. Lautech areas resident 69.8% are aware of the hazards associated with burning of wood. Metropolis and suburban areas recorded 27.9 and 33.4% knowledge of the effect of the used wood for cooking. All respondent also perceived gas as being potentially dangerous because of their ability to cause accidental fires.

3.1.7 Awareness of biogas technology: The awareness of biogas technology as shown on Table 5, is very low in the metropolis (3.7%) and the suburban (6.8%) areas, while the knowledge of biogas technology is 53.6% in the lautech area. The high percentage awareness of the biogas technology in the lautech area might be due to higher educational level of the resident of the area.

Table 5: Awareness of biogas technology

Question	Metropolis (%)	Lautech (%)	Suburban (%)
Perception of health impact on the use of wood	27.9	69.8	33,6
Awareness of biogas	3.7	61.3	6.8
Ready to adopt to biogas technology if available	69.2	87.7	71.6

3.2 Laboratory tests results

As observed from Table 6, the moisture content of the waste varied from 70 to 75%. It is comparable to the moisture content obtained by Hafid et al., [15]. This can be a potential problem if we derive energy in the form of steam as a huge amount of fuel would be wasted in drying the waste. Biogas is a better option as there is a requirement of moisture in 50%. The findings from laboratory experiments carried out to determine solid content of solid waste are as shown in Table 6. A large fraction of this waste is biodegradable thus it can be used as a feedstock for methane production. The low percentage of total solids (TS) is due to the composition of food waste, vegetables, fruit remains and peels which had high moisture content (MC). The high percentage of the volatile solids (VS) 75% to 80% indicates the organic portion of the feedstock, which characterizes the digester systems input feedstock when expressed as a fraction of total sample (wet) weight. City of San Rafael Sanitation Agency [16] indicated that VS contents of 70% and above make solid wastes biodegradable.

Table 6: Characteristic of substrate

Substrates	**Metropolis (%)**	**Lautech (%)**	**Suburban (%)**
Moisture content (MC)	75 ± 1.4	71 ± 1.1	73 ± 1.8
Total solids (TS)	15.3 ± 0.7	16.2 ± 0.4	15.8 ± 0.9
volatile solids (VS)	87.1 ± 1.2	86.3 ± 0.8	88.4 ± 1.3

Due to the composition of the waste, especially the findings in this study of substantial presence of faecal matter in the waste, many health and environmental issues are foreseen. From the data presented in this work, it can be seen that biodegradable materials make up about half of the waste generated by households, therefore segregation at source should be encouraged, effectively reducing the bulk of municipal solid waste for disposal and the space required for the purpose causing a reduction in the expenses. The segregated organic waste could be utilized by adopting appropriate technologies for processing it into bio-fertilizers or as a source of green energy.

The characterization of MSW collected from three areas of Ogbomoso, the average moisture content of the samples was found to be between 70 and 75%. High moisture content makes thermal recovery from solid waste uneconomical as considerable fuel is used up by the latent moisture in the solid waste. Anaerobic digestion, which requires high moisture content for the sustenance of the methane bacteria, was the preferred alternative for energy recovery from organic waste in the Ogbomoso. Bioconversion processes are suitable for wastes containing moisture content above 50% than the thermo- conversion processes [17]. Waste-to-Energy transformation has been identified as a veritable option in the integrated waste management processing of MSW. A higher volatile matter content leads to a better biogas yield. The test samples contained an average of 87% of volatile matter, thus strengthening the case for the adoption of anaerobic digestion in Ogbomoso. Apart from biogas, the anaerobic digestion process produces byproduct (digested residual) which can have a value as a fertilizer or soil amendment. The bio-fertilizer enriches soil with no detrimental effects on the environment [18, 19]. However, if biogas is adopted, it should be accompanied by intensive awareness campaigns about the safety use of the fuel so as to take of the people's perception on the use of gas for cooking. For the respondents who use electricity for various purposes about 40% of them paid US$ 21-55 in monthly bills. About 55% of the respondents spent between US$11-40 on wood and 65 % spent between US$1-50 on paraffin per month. This gives a daily average household energy expenditure of US$1-50. It would seem most households will be able to pay for biogas and biodigester maintenance from the savings of buying wood and paraffin but this depends on the price visa vies cost

IV. CONCLUSION

From this work, it is believed that no single waste management option can be employed in isolation for MSWM in Ogbomoso. Considering the nature and components of waste generated in Ogbomoso, a blend of certain management options in the waste management hierarchy would be more suitable in tacking the challenge of MSWM. These management options should be integrated in a sustainable agenda with adequate consideration be given to their hierarchical importance. In order that the desired result is accomplished, these options should also be considered and employed based on local conditions rather than foreign methods. The backbone of most options in the waste management hierarchy is waste segregation at source. Other key aspects are proper storage, more efficient waste collection systems, sustainable recovery and disposal. Public education and properly planned waste management programs need to be introduced into the current waste management system. These are relevant because households should know and understand the importance of waste segregation and proper storage, as well as those of recycling and compost production. In order, to encourage and enhance cooperation of households, inclusion of incentives should not be overlooked when designing programs for waste management.

REFERENCES

[1]. World Bank 2003. Thailand Environmental Monitor. A joint publication of the Pollution Control Department, Royal Thai Government. The World Bank, US Asia Environmental Partnership, 2003 .

[2]. World Bank 2002. Data by country. Website http://www.worldbank.org/data/countrydata/ countrydata.html (Retrieved June 11, 2003).

[3]. C. Ludwig, S. Hellweg, S. Stucki (Eds.), Municipal Solid Waste Management: Strategies and Technologies for Sustainable Solutions. Berlin Heidelberg: Spring er-Verlag, 2003.

[4]. The World Bank Report 2009. Titled, "How we Classify Countries," in *Little Data Book*, Urban Development Series, 2009.

[5]. A. Bandhu, Government of Uttar Pradesh, "Detailed Project Report for Solid Waste Management in Agra, Uttar Pradesh," RCUES, September 2008.

[6]. J. Goldemberg, and T. B. Johansson, World energy assessment overview 2004 update. New York: UNDP. 2004, pp 88.

[7]. W. Schamphelaire, G. Verstraete, Biological Energy Conversion, Biotechnology. Bioeng. 103(2) 2009

[8]. B. Nirmala, S. Deepa, and K. Sunil, Biomethanation of Banana peel and Pineapple waste, Bioresource Technology, 58: 1996, 73-76.

[9]. A. Kalantaifard and G. Yang, Energy potential from municipal solid waste in Tanjung Langsat landfill, Johor, Malaysia, International Journal of Engineering Science and Technology (IJEST), 3(12) 2011, 8560-8568.

[10] ASTM D5231 – 92, Standard Test Method, 2008.

[11] A. E. Cioabla, L. Lonel, G. A. Dumitrel, and F. Popescu, Comparative study of factors affecting anaerobic digestion of agricultural vegetal residues, Biotechnology Biofuels,. 5:39, 2012.

[12] T. V.Ramachandra and S. Bachamanda, Environmental audit of Municipal Solid Waste Management. International Journal Environmental Technology and Management, 7(3/ 4), 2007, 369–391.

[13] A. B. Nabegu, An Analysis of Municipal Solid Waste in Kano Metropolis, Nigeria, Journal of Human Ecology, 31(2) 2010, 111-119.

[14] P. Kuruparan, O.Tubtimthai, C. Visvanathan, and J. Tränkler, Influence of Tropical Seasonal Variation, Operation Modes and Waste Composition on Leachate Characteristics and Landfill Settlement. Proceedings of the Workshop on Sustainable Landfill Management, December 3-5, 2003, Centre for Environmental Studies. Anna University, Chennai, India.

[15] A. Apte, V. Cheernam, M. Kamat, S. Kamat, P. Kashikar and H. Jeswani, Potential of Using Kitchen Waste in a Biogas Plant International Journal of Environmental Science and Development, 4(4) 2013, 370 – 374.

[16] G. Sibanda, D. Musademba, H. C. Chihobo and L. Zanamwe, A Feasibility Study of Biogas Technology to Solving Peri-urban Sanitation Problems in Developing Countries. A Case for Harare, Zimbabwe. International Journal of Renewable Energy Development, 2(2) 2013, 97-104.

[17] M. Sharholy, K. Ahmed, G. Mahmood and R. C. Trivedi, Municipal solid waste management in Indian cities – A review, Waste Management, 28(2) 2008, 459–467.

[18] E. I. Iyagba, I. A. Mangibo, and Y. S. Mohammad, The study of cow dung as co-substrate with rice husk in biogas production. Science Research Essays 4 (9) 2009, 861-866.

[19] E. O. Uzodinma, A. U. Ofoefule, J. I. Eze, I. Mbaeyi and N. D. Onwuka, Effect of some organic wastes on the biogas yield from carbonated soft drink sludge. Science Research Essays 3 (9) 2008, 401-405.