# THEORETICAL ESTIMATION OF BIOGAS POTENTIAL FROM HOUSEHOLD ORGANIC SOLID WASTE FOR BIOGAS PRODUCTION IN ONITSHA NORTH LOCAL GOVERNMENT AREA.

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**ABSTRACT**

This study theoretically estimated the biogas potential from household organic solid waste for biogas production in Onitsha North Local Government Area (ONLGA). The study was carried out in two phases. The first phase of the study was field work for the identification and quantification of the composition of organic solid waste generated by households and the second phase involved the theoretical calculation of the amount of biogas obtainable from the generated quantity of organic waste using the biogas potential estimation equation: *Biogas potential = VS (%) × Biogas yield (m3/t VS*). The study revealed that organic solid waste generated by households in the study area consists mostly of food waste, categorized into 45% fruits and vegetable peels, pits, stems and seeds (F&V); 40% tubers peels (T); 8% leftover cooked food (LCF); 5% protein waste (meat and fish bones and egg shells; P/W) and 2% other scraps associated with meal preparation, by percentage composition. Also with an average 0.299kg of organic solid waste generated per person per day in the study area, and a population of 201,358, ONLGA witnesses a daily generation of about 60.206 tonnes of organic solid waste which can yield about 4,695.398m3 of biogas daily. This translates to 1,713,820.27m3 per annum. The availability of the household organic solid waste and the composition which is mostly high organic content food waste make it an excellent feedstock for biogas production through anaerobic digestion. Hence anaerobic digestion should be drafted into the waste management system in ONLGA.

**Keywords**: Household organic solid waste, biogas potential, biogas, anaerobic digestion, resource recovery.

## INTRODUCTION

The disposal of organic solid wastes in Onitsha North Local Government Area (ONLGA) in unsafe ways mixed with inorganic wastes; burning, indiscriminate dumping and discharging into water bodies results in negative environmental and health consequences. Organic wastes, when disposed and as they decompose generate unpleasant odor and help rats, flies, bugs and mosquitoes to multiply and spread diseases. Organic wastes generate large amounts of methane, a gas that contributes significantly to global warming, as they decompose. Methane is a powerful greenhouse gas that traps heat in the atmosphere more efficiently than carbon dioxide as Sumaya (2020) noted that methane is 25 times more potent than carbon dioxide. According to the Intergovernmental Panel on Climate Change (IPCC), methane emitted from landfills and wastewater accounts for about 90% of greenhouse gas emissions from the entire waste sector; that is 18% of human-caused methane emissions globally and about 3% of total greenhouse gas. UNEP (2013) also stated that the decay of the organic fraction of solid waste in developing countries contributes about 5% of global greenhouse gas. Management of organic solid waste has become a major problem in Onitsha North Local Government Area, as seen in most towns and cities in developing countries.

Ike, Ezeibe, Anijiofor and Nik Daud (2018) in a study titled Solid waste management in Nigeria: problems, prospects, and policies, stated that various online surveys conducted since 2010 revealed that most Nigerian cities including major cities which used to be tourist centers have been ranked as dirtiest and worst livable cities of the world. According to the authors, Ibadan and Lagos which are commercial cities in south west Nigeria, were described as the dirtiest cities in 2010 while Onitsha and Aba in the South East also joined the list in 2015. In the same study, Ike *et al* (2018) also revealed that the problem of solid waste, both organic and inorganic remains a single environmental problem common to all urban centers in Nigeria. Towards solving this problem, the

United Nations Environment Programme (UNEP), 2013 stated in its Guidelines for National Waste Management Strategies that the answer to this challenge lies in rethinking and reorganizing waste management on a life-cycle basis, incorporating waste management into the developing “green economy” and focusing on waste as a resource.

Due to its potential to be degraded by microorganisms into simpler stable compound such as carbon dioxide, water and methane, organic waste is clearly a valuable resource and diverting organic waste for use as a resource is a huge opportunity in waste management. Various technologies have been developed for use in recovering resources from organic wastes, but aiming at sustainability, the two favoured options for dealing with organic solid waste is today argued to be composting and anaerobic digestion (Dübendorf, 2007).While composting yields nutrients; anaerobic digestion (AD) produces biogas. AD is a complex biochemical process for the treatment of organic waste, which occurs in a container in the absence of oxygen. In this process, breaking down of the organic material occurs by micro-organisms in the absence of oxygen, which leads to the formation of mixture of carbon dioxide and methane gas known as "Biogas", which is typically used to provide electrical power generation, heat, and a solid and liquid digestate (Sumaya,2020). UNEP (2013) reiterated that anaerobic digestion of organic waste provides an opportunity for diverting organic waste from dumpsites, landfills and incineration to generate valuable end products (methane for energy production). The high fraction of organic waste in most Nigerian towns and cities (over 50% of solid waste) as reported in several studies suggests that channeling these wastes into biogas production could therefore be one of the most efficient ways of waste disposal, energy production, and environmental protection (Orhorhoro and Oghoghorie ,2019; Ike *et al*, 2018; Akinbomi, Brandberg, Sanni, and Taherzadeh, 2014).

This work is therefore a study of the estimation of biogas potential of organic solid waste generated by households in Onitsha North Local Government Area for biogas production. This was achieved by identifying the composition of organic solid waste and theoretically calculating the amount of biogas obtainable from organic solid waste generated by households in Onitsha North Local Government Area.

**METHODOLOGY**

The study was done in Onitsha-North Local Government Area in Anambra State, one of the 5 states in the south-east geo-political zone in Nigeria (Fig. 1). With a population of 201,358, projected from the 2006 last census population of 125, 918 (Federal Republic of Nigeria Official Gazette, 2009), ONLGA has 8 identified residential zones as shown in fig. 2. The study was carried out in two phases. The first phase of the study was field work in ONLGA for the identification and quantification of the composition of organic solid waste generated by households. This study applied the multi-staged sampling technique. Firstly, all eight identified residential zones in ONLGA namely, G. R. A, Akpaka, Trans-Nkisi, Federal Housing/ 3-3 area, Inland town, Omagba phase 1 and 2, Woliwo North (Oni, Emo and Egolum, 2013, ONLGA database), were selected for representativeness, as each of them has unique characteristics. In each zone, streets were randomly selected. Furthermore, systematic random sampling technique (three houses interval) was employed in selecting residents from households in selected streets. In each street, the first building was selected randomly and then every subsequent third building was selected. All households in each of the selected buildings were surveyed. 50 households were selected in each residential zone and 400 residents, each representing a household were selected. Each selected household was visited several times. In the first visit, contact was made with the prospective households to sample during which participation consent was requested. Upon obtaining consent, information required

was disclosed and appeal was made to ensure that all waste generated was sorted into organic and inorganic and gathered in separate bags daily for a period of three months. Questionnaires and moderate size bags for storing their solid waste over the study period were also distributed. The next visits were made daily to collect the solid waste generated at each household. With the help of trained research assistants, the selected households' waste generated was collected, observed, further sorted into their composition, and weighed daily. From the values obtained, the total weight of organic solid waste generated during the study period and the per capita rate of generation were calculated. The organic waste composition was identified and the percentage composition calculated.

The second phase of the work involved the theoretical calculation of the amount of biogas obtainable from the generated quantity of organic waste using the Biogas potential estimation equation: *Biogas potential = VS (%) × Biogas yield (m3/t VS*) as adopted by Akhator, Igbinomwanhia and Obanor, 2016). This involved the determination of the total solid (TS) of the household organic solid waste, determination of the volatile solid (VS) and application of the value of the VS to determine the biogas potential. From the literature, organic solid waste from households has an average TS% of 23.2%, as well as average VS% of 91.6% (Selvam, Ilamathi, Udayakumar, Murugesan, Banu, Khanna and Wong, 2021) and biogas yield is 367 m3 of biogas per dry tonne (USEPA, 2008).

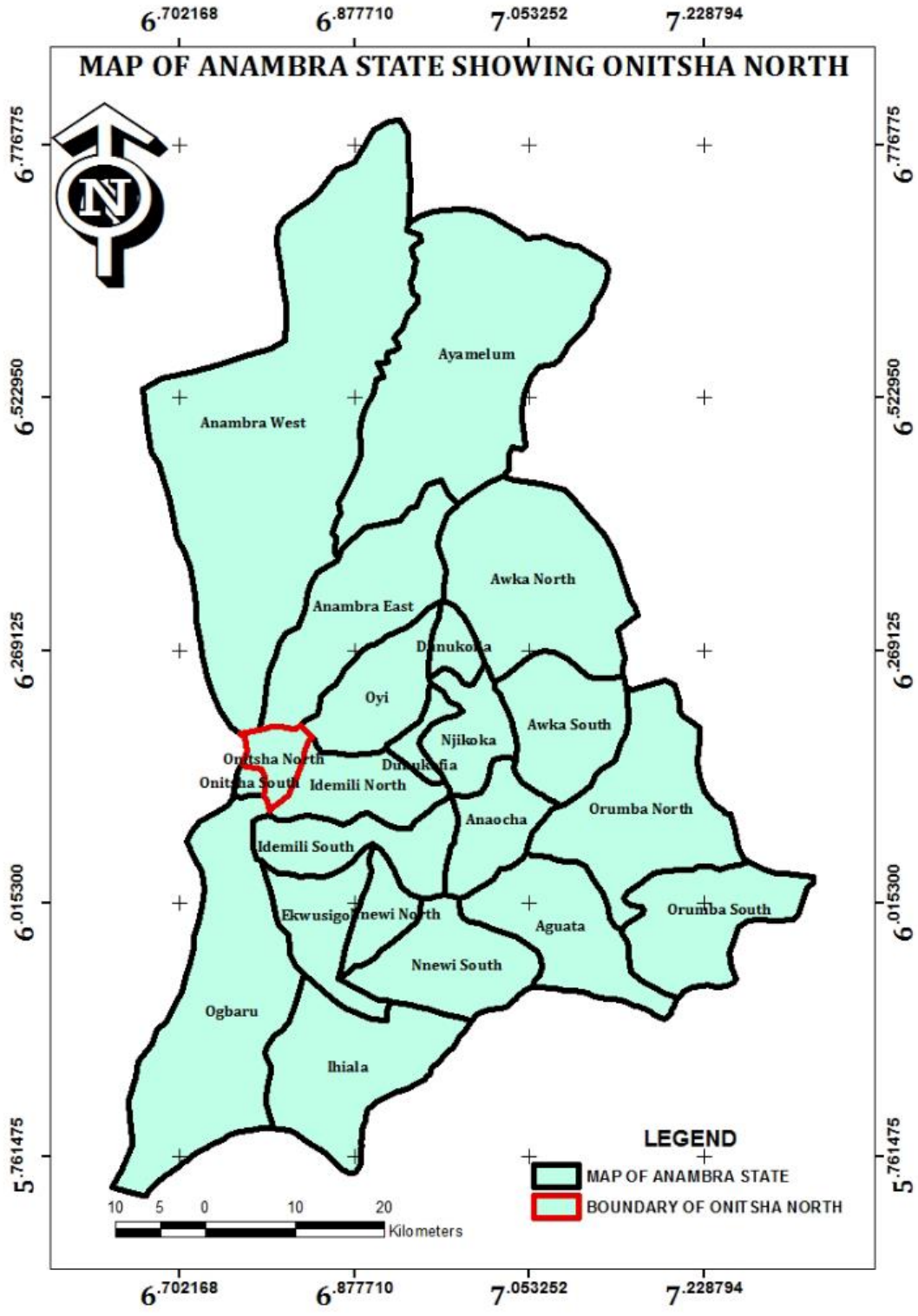


**Fig 1**: Map of Anambra state showing Onitsha North Local Government Area.
Source: Department of Surveying and Geoinformatics, Nnamdi Azikiwe University(2024).

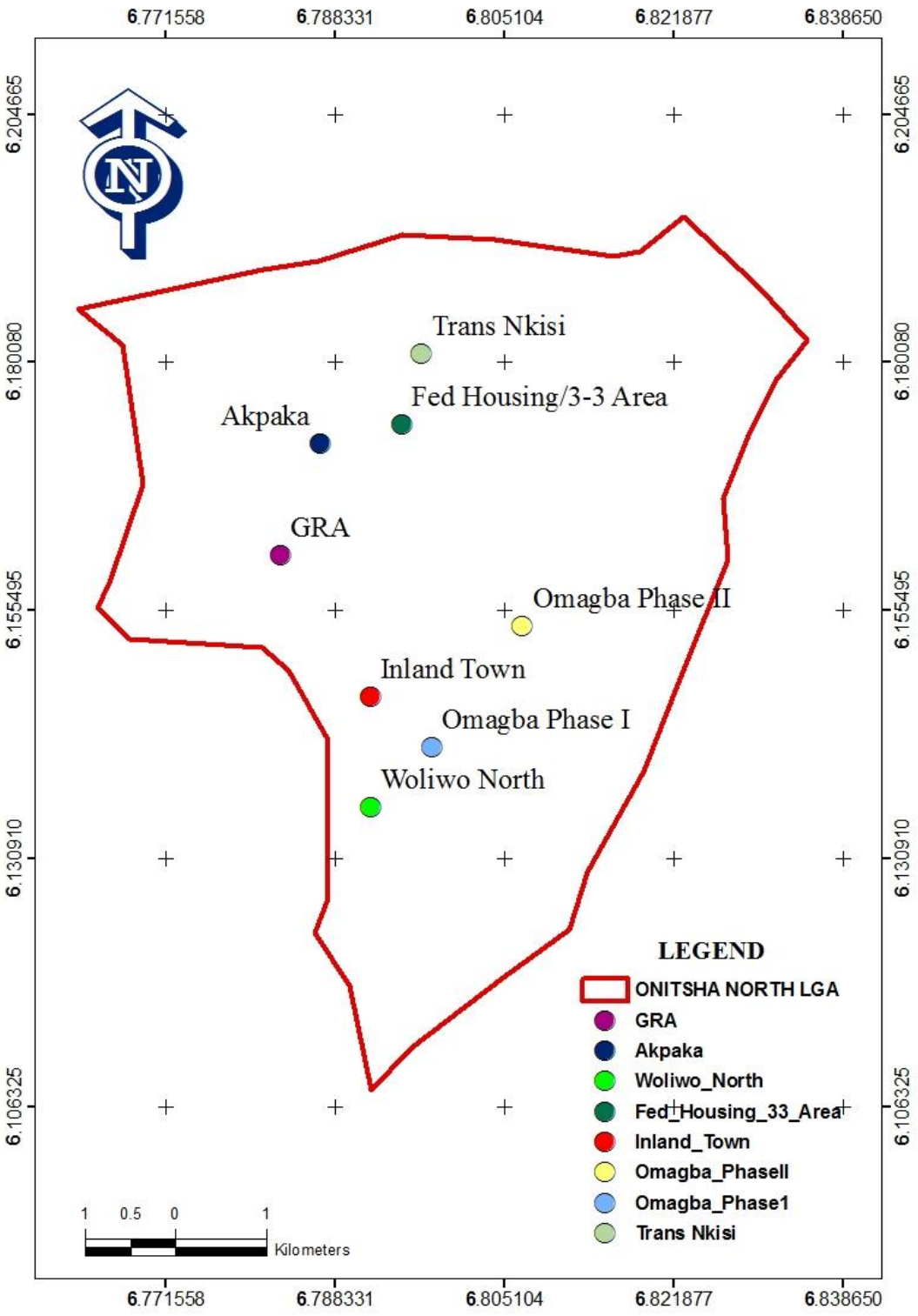


**Fig 2**: Map of Onitsha North Local Government Area showing residential zones.
Source: Department of Surveying and Geoinformatics, Nnamdi Azikiwe University(2024).

## RESULTS AND DISCUSSION

### Organic waste composition

The organic waste generated in each selected household was collected, further sorted, weighed and recorded.

| Residential zones | Number of households | Total household size | Total organic waste generated (kg) |
|---|---|---|---|
| Omagba 2 | 50 | 355 | 9469.26 |
| Omagba 1 | 50 | 280 | 7871.79 |
| Woliwo | 50 | 265 | 7730.37 |
| G. R. A | 50 | 365 | 9028.92 |
| 3/ 3 | 50 | 255 | 7824.87 |
| Trans-nkisi | 50 | 300 | 7701.42 |
| Akpaka | 50 | 230 | 5962.5 |
| Inland town | 50 | 240 | 5975.37 |
| **Total** | 400 | 2290 | 61564.5 |

Table 1: Quantity of organic solid waste generated by households in each residential zone (in kg).

A total of 61,564kg (61.5 metric tons) of organic solid waste made up of 9469.26kg from Omagba 2, 7871.79kg from Omagba 1, 7730.37kg from Woliwo, 9028.92kg from G. R. A, 7824.87kg from 3-3, 7701.42kg from Trans-nkisi, 5962.5kg from Akpaka and 5975.37kg from Inland town was measured as shown in table 1.

| | Omagba | Omagba | Woliwo | GRA | 3/3 | Trans/N | Akpaka | Inland/T | TOTAL | %comp. |
|---|---|---|---|---|---|---|---|---|---|---|
| **F&V** | 4261.17 | 3542.27 | 3478.66 | 4063.02 | 3521.19 | 3465.64 | 2683.13 | 2688.91 | 27704.03 | 45% |
| **T** | 3787.7 | 3148.71 | 3092.15 | 3611.57 | 3129.95 | 3080.57 | 2385 | 2390.15 | 24625.83 | 40% |
| **LCF** | 757.54 | 629.74 | 618.43 | 722.31 | 625.99 | 616.11 | 477 | 478.03 | 4925.15 | 8% |
| **P/W** | 473.46 | 393.56 | 386.52 | 451.44 | 391.24 | 385.07 | 298.12 | 298.77 | 3078.21 | 5% |
| **Others** | 189.39 | 157.44 | 154.61 | 180.58 | 156.5 | 154.03 | 119.25 | 119.51 | 1231.32 | 2% |
| **TOTAL** | 9469.26 | 7871.79 | 7730.37 | 9028.92 | 7824.87 | 7701.42 | 5962.5 | 5975.37 | **61564.5** | |

Table 2: Household organic solid waste composition

The study revealed that organic solid waste generated by households in the study area consists mostly of food waste, categorized into 45% fruits and vegetable peels, pits, stems and seeds (F&V); 40% tubers peels (T); 8% leftover cooked food (LCF); 5% protein waste (meat and fish bones and egg shells; P/W) and 2% other scraps associated with meal preparation, by percentage composition as shown in table 2.

From the values shown in table 1, an average per capita organic waste generation rate was calculated using a basic equation: *Total waste generated ÷ total household size ÷ number of days*. Hence, Onitsha North LGA records an average daily generation rate of 0.299kg per person per day (ppd.) of household organic solid waste. By comparison, the value is within the range as noted in several literatures: 0.281kg ppd. in Benin Metropolis, Nigeria; 0.28kg ppd. for Africa, 0.318kg ppd. in Ghana and 0.234kg ppd. in Tanzania (Akhator, et al., 2016; ISWA, 2020; Miezah, Obiri-Danso, Kádár, Fei-Baffoe, and Mensah, 2015; Kassim and Oberlin, 2018).

**Biogas potential estimation**

With an average 0.299kg of organic solid waste generated per person per day in ONLGA, and a population of 201,358, ONLGA witnesses a daily generation of about 60.206 tonnes of organic solid waste. With TS of about 23.2%, the household organic solid waste of 60.206 tonnes per day will result in TS of 13.967 tonnes per day and VS of 12.794 tonnes per day. Hence, with biogas yield values of 367m3/tVS, a total of 4,695.398$m^3$ of biogas can be obtained from household organic solid waste generated in ONLGA per day. This translates to 1,713,820.27m3 per annum.

## CONCLUSION

A greater part of about 60.206 tonnes (60,206kg) of organic solid waste generated daily in Onitsha North LGA end up being dumped in uncontrolled dumpsites on streets and roadsides. They are afterwards carried by the region's waste contractor and disposed in unregulated landfills. This waste when diverted for resource recovery has the capacity to yield 4,695.398m3 of biogas daily, as well as reduce over 50% of household solid waste disposed. In addition, the availability of the household organic solid waste and the composition which is mostly high organic content food waste make it an excellent feedstock for biogas production through anaerobic digestion. Hence anaerobic digestion should be drafted into the waste management system in ONLGA.

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