Available online at www.elixirpublishers.com (Elixir International Journal)

Biosciences

Elixir Biosciences 146 (2020) 54820-54823

ISSN: 2229-712X

Potential of Biogas Generation in Complementing Energy Demand in Nigeria's Tertiary Institution: A Review

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ARTICLE INFO

Article history:
Received: 20 July 2020;
Received in revised form:
9 September 2020;
Accepted: 19 September 2020;

Keywords
Biogas,
Organic Waste,
Anaerobic Digestion,
Municipal Solid Waste (MSW).

ABSTRACT

Power remains a germane ingredient of national development. It serves as bedrock of societal growth as it is needed in almost area of economy ranging from education, health, transportation, Information and Communication technology and manufacturing. Educational institution serves as centers of innovation where cutting edge researches are carried out to improve societal wellbeing and at the same time provide affordable solution to various problems facing nature. For this research to be effectively carried out, stable supply of electricity is needed as most equipment needed for the research are powered by electricity. Unfortunately, Nigeria power system has been facing a lot of challenges that sabotages the stability of its supply. This review takes a look at the available resources inherent in Nigeria's tertiary institutions that can provide a substitute and at the same time complement the existing supply. Biogas been a renewable energy product was identified and estimated to be a veritable means of generating independent power for the academic community. It was evaluated based on reasonable population prediction that a total of 177,000m^3 of biogas corresponding to energy generation of 221.25MWh can be generated daily from total waste in Nigeria's tertiary institutions. Challenges facing adoption of biogas policy were highlighted and recommendations were made.

1.0 Introduction

It is a known fact that energy in any of its forms are required in day to day human activities; it ranges from electrical energy required for powering of appliances, cooking, lighting; chemical energy in fuel required for automobiles; heat energy required for cooking; solar energy for electricity generation. Countries all over the world have been doing their best to shore up their renewable energy availability and at the same time preserve and minimize their dependency on the non-renewable energy sector. Nigeria is among the countries that heavily depend on crude oil as a major source of fuel and this is expected to be used up one day since it is a non-renewable resource. The main energy focus is now on renewable energy. This renewable energy exists in different form ranging from solar energy, wind energy, hydropower, and biomass and so on. The world has experienced a rigorous shift from petroleum-based economy to a bio-based global economy, hence, biological wastes, which is usually regarded as low-valued materials, are now being transformed from high volume waste disposal environmental problems to generating natural resources for the production of a sustainable and an eco-friendly fuel (Gomez et al, 2008).

Nigeria is adjudged the largest economy in Africa, with a GDP of USD448.10 billion as at 2019 according to the report from World Bank (www.tradingnews.com). However, its power sector is performing below the level of its peer countries. It is of major concern that over half of the population (~55%) is not connected to grid electricity and those who have access to the grid suffer serious power outages (Nigeria power baseline report). Nigeria power generation industry has a higher composition of thermal power plants which constitute over 70% of power generation while the remaining is from hydro. Nigeria's tertiary institutions are one of major electricity consumption industry in Nigeria. This cannot be unconnected with the fact that it involves huge human population that requires electricity for various activities ranging from powering of machines and equipment in the laboratory, to lighting to heavy usage in their hall of residence due to student dependency on it for cooking and other activities. Majority of Nigeria's tertiary institutions are paying millions of naira as monthly bill to the electricity distribution companies in Nigeria. Many universities in Nigeria today are now considering options to secede from the Nigeria power grid and put in place their own power generating system which are majorly in the solar renewable energy system which they believe will in turn ease the grid, reduce their cost and at the same time ensure stable supply of electricity. It is estimated that the world population which stood at around 7 billion people produce about 14 million tonnes of faeces per day and 25% of this possesses the needed potential power to generate roughly 40,000 MW of energy (Onojo et al, 2013). According to Bakare (2016), Nigeria which has a huge population that exceeds 160 million people turns out close to 32 million tons of solid wastes yearly, but only 20-70% of the said amount are effectively gathered. The huge human population in Nigeria's tertiary institutions can be a great source of blessing and potential in generating biogas which can be provided at a cheaper price to student thereby reducing their dependency on electricity for cooking or using this biogas in generating power using biogas generator.

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2.0 Nigeria's Tertiary Institutions Distribution

As of December 2018, Nigeria has a total of 162 universities that are licensed and approved by the Federal Government through the NUC. This comprises of 40 federal universities, 47 state universities and 75 private universities as obtainable from the database of Nigeria University commission. Presently, Nigeria has 26 federal polytechnics, 45 state polytechnics, 41 private polytechnics, 35 federal monotechnics, 28 state monotechnics, 5 private monotechnics and 11 college of health sciences (www.jamb.gov) and more than 57 colleges of education in Nigeria. The student enrollment in Nigerian universities stood at 1.9million as at 2018 according to a statement by the NUC boss prof. Abubakar Rasheed at a two-day retreat for governing council member of Nigerian universities in Abuja in 2018. Hence the total students' enrollment in Nigeria's tertiary institutions can be arguably predicted to be above 3million. This excludes the teaching and non-teaching staffs of tertiary institutions, traders who are also a part of these institutions' population. This population provides a great means of energy generation if properly tapped into.

3.0 Waste Generation in Nigeria's Institutions

Higher institution of learning in Nigeria are established to carry out research, impact knowledge, provide solutions to various problems of humanity and at the same time nurturing future leaders. Higher institution of learning in Nigeria has been on the increase due to the increase in demand for formal education and also as a result of intervention from the private sector. It houses many people from different ethnics, tribes and background.

In a community that has thousands of people, it is expected that the waste generated from such environment will be unarguably large, ranging from food waste, plastic waste, paper waste, agricultural waste, and industrial waste due to the fact that most higher institutions of learning today have different small and medium enterprises and factories to provide basic needs of students and staff and at the same time shore up their revenue generation, hence the need to device means of converting this waste to wealth most especially using them in energy generation.

Waste generation is also defined as an intrinsic part of human existence that is usually characterized by their components, quality and nature (Coker et al, 2015). Amori et al, 2013 identified major waste generated in institution of learning to include food waste, paper, plastic, glass, can/tins, leather, nylon, sand sanitary, e-waste and human waste. It is to note that most of the waste generated at the academic and administrative area are majorly non-degradable waste (paper, nylon, can) while most of biodegradable waste are generated in the residential areas which include food waste, human waste (urine and excreta) and waste water. Human wastes are passed to the septic tank directly from the toilet which causes a lot of environmental problems sometimes when it gets filled up. Food waste which is also a biodegradable waste are often collected together with non-biodegradable waste like cans and plastic thereby causing problems in waste separation and management.

Indiscriminate dumping of solid waste can have serious consequences if left unchecked, particularly in relation to human health and on the ecosystem (Akeh and Sheu, 2018). The most problematic functional element of solid waste management that is bedeviling most developing countries can be attributed to waste disposal (Kasseva and Mbuligwe, 1999). Waste collection and management has been a serious issue to deal with in most tertiary institutions, according to the research conducted by Akeh et al (2018) in Ramat Polytechnic, Nigeria, the study revealed that 44.83% of the respondents store their wastes in waste bins/receptacles while 38.36% of the respondents practiced open surface dumping. The results showed that solid waste receptacles provided by the institution were inadequate. The findings also revealed that solid wastes were regularly collected by the polytechnic sanitation workers. Generally, 56.47% of the respondents were satisfied with the performance of the polytechnic sanitation unit in managing solid wastes in the institution. Inadequate personnel, lack of solid waste vehicles and funding were identified as the major challenges in solid waste management (Akeh et al, 2018). Series of development has been taking place in most tertiary institutions on how to maximize the benefit of proper waste management. This, if properly done will contribute meaningfully to the green energy advocacy and at the same time ease the national grid, provide source of electricity and ensure smooth running of academic activities.

The Unilag Akoka campus generated an average of 32.2 tons of waste daily during the year (Adeniran et al, 2017), a research which was conducted with a population of 8,000 students and 2000 staffs with family members. In a research conducted by Amori et al (2013) on some selected institution of learning in Nigeria, he opined that food wastes constitute the highest proportion of wastes generated (46%) from the halls of residence in the institution. The higher proportion of putrescible food waste could be responsible for the inherent odour problems arising from most of the refuse transfer depots in the halls of residence, Nylon/polythene bags constitute the second highest proportion (13%) of the wastes. The other waste materials generated include; plastic 5%, paper 4%, sanitary wastes and hairs 6% each, sand 7%, cans/tins 2%, e-waste, textiles and glass 1% each, while other unclassified components were 8%. The total quantity of wastes generated from the halls of residence in the institution was estimated using information on the total number of students residing in the different halls of residence of the universities and their per capita waste generation rates. Hence, the total quantity of waste generated from the halls of residence in the institution is estimated at 4373.4 kg/day (Amori et al, 2013).

4.0 Biogas Generation Technology

Biogas is generated from a process called anaerobic digestion. Researches have shown that anaerobic digestion is the most modern and efficient means of converting waste to useful materials which includes biogas and bio-fertilizer. Anaerobic digestion is preferred as Anaerobic Digestion (AD) of MSW offers certain clear advantages over the option of Aerobic process, in terms of energy production, compost quality and net environmental gains (Bhattacharjee et al 2013). Biogas production through anaerobic digestion (AD) is an environmental friendly process utilizing the increasing amounts of organic waste produced worldwide (Horvath et al 2016). The performance of the AD process is highly dependent on the characteristics of feedstock as well as on the activity of the microorganisms involved in different degradation steps (Batstone et al., 2002). This anaerobic digestion takes place in a specially design apparatus called digester. The digester is an enclosed vessel or container in which anaerobic process takes place in the absence of oxygen. There are two main types of digester namely; wet digester and dry digester. Wet digesters contain water as the

continuous phase, while dry digesters produce biogas as the continuous phase. Dry digesters are used if the substrates are in dry form and cannot be mixed easily, a good example of that is the garden and grass waste. The wet system type of digester is inarguably the most preferable type due to its embedded advantages over dry system.

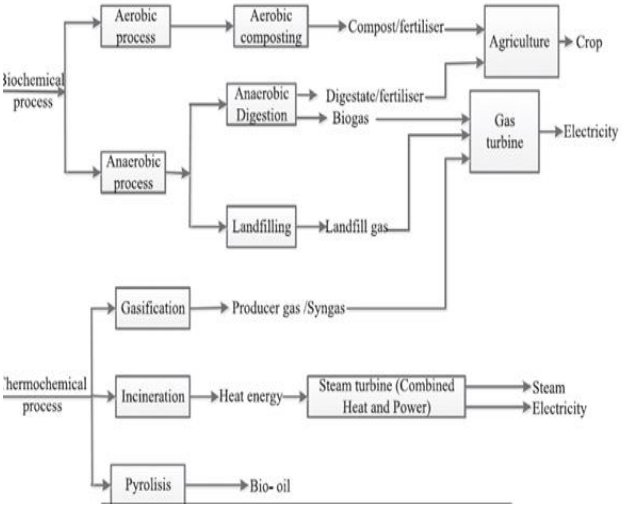

Fig 1. Biogas generation technology
Sources: Ogunjuyigbe (2017)

5.0 Potential of Biogas Generation from Waste in Institutions

With the high number of tertiary institutions in the country, it is believed that each institution can be energy dependent if she optimally harnesses the potential embedded in her waste generation capacity. In Nigeria, research has shown that 80% of the total waste generated is predominantly organic (Igwe, et al, 2002). Organic waste has been identified to be the larger constituent of waste generated in tertiary institution (Amori et al, 2013). Coker et al, 2015 identified the percentage composition of organic waste in a private tertiary institution in Nigeria to be 29% which is second highest, hence organic waste which is the major raw material for biogas generation virtually has highest composition in waste generated in higher institution. Onojo et al 2013, finds out from their research conducted at the Federal University of Technology Owerri, Nigeria on the potential of generating energy from waste that the student hostel soak away pit has the capacity to generate biogas that can power a 5kW generator for 6 days, this a tremendous relief for the grid dependency on energy. The estimated least population in Government owned Nigeria tertiary institution today stood at an average of 10000 considering the yearly intake of students, Khendelwal and Mahdi (1986) have estimated an average production of human excreta to be at 400 g/capita/day, Coker et al, 2015 conclude that 0.3 and 0.4 kg/capita/day was generated daily by the students in their respective halls of residence, then it can be estimated that the most tertiary institution in Nigeria has an organic waste generation capacity of 800kg per day with the assumption of 2000 people generating their waste in school per day. Atta et al (2016) estimate the energy content of human waste to be 9.6MJ/kg which is around 19200MJ for a total mass of plications which include, lighting, cooking and electricity generation.

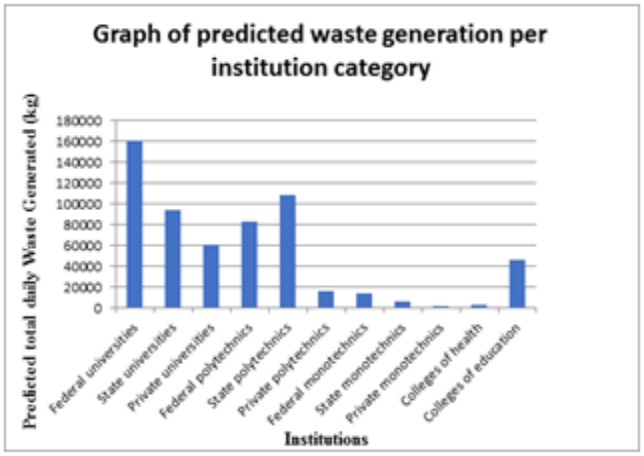

Fig 2. Graph of predicted total daily waste generation per institution category

Deublin et al, (2008) reported that about $0.3m^3$ of biogas production from 1 kg kitchen/organic waste. This variation might be dependent on environmental condition, source of waste and waste constituents under which the study was carried out. Hence, it is estimated that Nigeria's tertiary institutions can produce about $177{,}000m^3$ of Biogas which is a huge plus to Nigerian renewable energy generation by generating an approximate of 221.25MWh per day.

Table 1. Estimated waste generation capacity in Nigerian's tertiary institutions

s/n	Institution category	No of institution	Estimated average population per institution	Estimated total population per institution category	Estimated total waste at 0.4kg per person(kg)
1	Federal university	40	10000	400000	160000
2	State university	47	5000	235000	94000
3	Private university	75	2000	150000	60000
4	Federal polytechnic	26	8000	208000	83200
5	State polytechnic	45	6000	270000	108000
6	Private polytechnic	41	1000	41000	16400
7	Federal monotechnics	35	1000	35000	14000
8	State monotechnics	28	500	14000	5600
9	Private monotechnics	5	200	1000	400
10	College of health	11	500	5500	2200
11	College of education	57	2000	114000	45600
	Total	410	36200	1473500	589400

Note: The population of the various institutions in the table above was predicted based on the random sampling of some selected institution, hence they are not adjudged accurate.

Table 2. Biogas usabilty and equivalent

Lighting	equal to 60 -100 watt bulb for 6 hours
Cooking	can cook 3 meals for a family of 5 – 6
Fuel replacement	0.7 kg of petroleum
Shaft power	can run a one horse power motor for 2 hours
Electricity equivalent	can generate 1.25 kilowatt hours of electricity

Source: Adriani et al, 2014

6.0 Challenges of Biogas Generation

Due to the fact that biogas generation, as a means of energy generation, has not witness a serious attention from the Nigerian government either due to its undervalued potential or perceived lack of both human and material resources for its operation. A major setback to biogas generation is the waste collection and management system in Nigeria. The mode of waste collection and management in most Nigeria's tertiary institutions has been below standard compared to what is obtainable in developed nations. Another major setback to the adoption of biogas is integration of new waste system to the existing design with little or no disruption and minimal cost input. Hence the need for adoption of new design that accommodates modern waste collection incorporating bio-digester connected directly to the septic tank. Problem of poor maintenance culture is also a perceived major setback to the biogas adoption. Lack of modern technology in biogas production, processing and utilization, Government policies, mismanagement of fund and inadequate intervention are also part of hindrances to the adoption of biogas generation in Nigeria tertiary institutions.

7.0 Conclusion

This paper has successfully reviewed the potential of biogas generation from Nigeria's tertiary institutions, based on reasonable population prediction, it was estimated that 177,000m^3 of biogas corresponding to 221.25MWh of electricity can be generated from total daily waste in various tertiary institutions in Nigeria. This provides a great supplement to national grid and at the same time provides organic fertilizer which can be a good source of revenue for these institutions.

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