DOI: https://dx.doi.org/10.4314/gjpas.v27i4.6

GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 27, 2021: 397-404
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ASSESSMENT OF SOLID WASTE CHARACTERIZATION IN KEFFI LGA, NASARAWA STATE, NIGERIA IN VIEW OF ADOPTING BIOGAS TECHNOLOGY FOR SOLID WASTE MANAGEMENT.

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(Received 10 September 2021; Revision Accepted 26 October 2021)

ABSTRACT

The assessment of solid waste characterization in Keffi Local Government Area in view of adopting biogas technology for solid waste management was carried out. This was achieved through assessment of the quantity of solid waste generation and the composition (organic and inorganic) in the study area. Materials used for data collection are weighing scale and waste bins. Stratified and systematic samplings were used to select households for data collection. The selected households' waste generation were observed and weighed on daily basis for one week and average weight was calculated for each household to quantify the amount of waste generation and composition. Solid waste generation per household per day in Keffi Local government area ranged from 0.9 Kg to 1.5Kg with mean value of 1.26Kg. There was a significant different (F>P@0.05) in the quantity of solid waste generation among the ten wards. Though, solid wastes in Keffi consist of diverse materials from both raw materials mostly farm/animal residues and manufactured goods, it has higher organic (71.79%) than inorganic (28.21%) components. Thus, it was concluded that adoption of biogas technology for solid waste management in Keffi Local Government Area is feasible based on waste characterization of the area. Pilot demonstration of biogas production from organic waste was recommended.

KEYWORDS: Solid Waste, Organic, Inorganic, Waste Characterization, Biogas Adoption.

INTRODUCTION

Municipal Solid Waste Management (MSWM) is a challenging issue globally, especially in developing countries, due to poor capacity and technology to handle solid waste. Solid waste has adverse environmental effects if not properly managed. The standards of waste management are still poor and outdated in many developing countries (Kadafa et al, 2013). Solid wastes are usually not separated at point of generation and are dumped indiscriminately, at the detriment of humans and the natural environment. There are poor documentation of solid waste generation rates and its composition that can affect the planning and implementation of sustainable solid waste management technology. Biogas is an alternative energy source which utilizes various organic wastes in order to produce Biogas for cooking, heating and lighting, mineralized water and organic fertilizers (Ani, 2014). So, in the face of ongoing population growth, increasing waste generation and environmental pollution, biogas energy is becoming a favoured emerging alternative as it convert wastes to energy and reduce the volume of wastes that ends in landfills.

The move from landfill-based to resource-based waste management systems requires a great knowledge of the composition of municipal solid waste" (Burnley, 2007).

In line with Burnley (2007), Walid et al. (2016) stated that "information on both quantity and composition of waste generation is important for the effective planning of household waste handling infrastructure". Similarly, report of Smith in UK Essays (2016) categorically stated that successful management of generated solid wastes begins with the measurement. The paper has it that "if you can measure it you can manage it". The report emphasized that lack of measurement is the weakest point in waste management in the developing countries. According to Vaughan (1971) as cited in UK Essays (2016), information on the composition and quantity of solid waste is indispensable to the design, implementation and operation of any solid waste management system of today and helps to forecast the requirements of tomorrow.

Masafumi et al. (2016) reported the waste per capita per day and the composition of solid waste generated in Njoro Division, Nakuru County, Kenya. According to their report, "waste per day per capita generated was generally low being 105.87±15.54 g which was lower

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than the average generated in low income areas of urban centres of developing countries. Food waste was the largest fraction of total waste at 55%, followed by fines (22%) and plastics 11%". Bader and El-Sayed (2014) observed that amount of household waste (HSW) in Jeddah City was dominated by organics, paper, plastics and other small components. Generally, the production of solid waste has a direct relationship with density of population and economic development (Hussein and Mansour, 2018).

Dieu et al. (2014) reported that in Ho Chi Minh City, household waste generation rate is in the range of 0.53 – 0.63 kg/capita/day (2.1 – 2.5 kg/household/day). Food waste consists of 80.1 – 90.0% of food refuse, whereas in the composition of remaining wastes, recyclable materials consist of 12.2 – 18.0%, combustible waste for heat recovery accounts for 40.1 – 50.0%. The authors suggested that the success in solid waste separation at sources will assist in shifting a remarkable amount of "waste" into "recyclable materials", and significantly affects the efficiency of other processes of municipal solid waste management system in Ho Chi Minh City.

Okeniyi and Anwan (2012) reported that food waste exhibited the highest percentage of (26.2%), followed by polythene bag (19.3%); and plastic bottles(13.6%), metal cans (11.5%), paper (10.5%), plastic food pack (7.2%), other combustible wastes (5.6%) and polystyrene food pack (5.6%) of the average wastes generated per day in Covenant University Ota. Audu et al., (2015) analysed the composition of solid waste generated in Port Harcourt local government area of Rivers state, Nigeria. The generation rate was 1.16kg/cap/day. There was variance in the compositions of the waste from the different locations studied. The waste was categorized into paper, glass, metal, organics, nylon, plastics, and others. The most prominent in the five locations was organics, paper and nylon with mean percentage compositions of 65%, 13% and 12% respectively.

Isaac et al., (2013) assessed the characteristics (composition, bulk density and generation rate) of household solid waste and waste management practices in Wa; an urban community in Ghana. Authors observed that the waste generation rate for the Wa is 0.68±0.24kg/cap/day with the average bulk density of 44.9±28 kg/m^3 and that household solid waste is dominated by organic waste.

Walid et al. (2016) recorded that the average of total generation, daily generation rate, total volume and density were 1415 kg, 0.64 kg/person/day, 19.3 m^3 and 74.4 kg/m^3 respectively in Tripoli city. Household solid waste contains 36.3% organic matter and 32.5% recyclable materials (glass, paper, plastic, metals). Kodwo et al. (2015) determined the rate of household waste generation and composition for each region in Ghana. They observed that "rate of waste generation in Ghana was 0.47 kg/person/day, which translated into about 12,710 tons of waste per day for a population of 27,043,093 in 2015.

Bichi and Amatobi (2013) characterized the municipal solid waste generated in Sabon-gari area of Kano City, Nigeria. They reported that 57.5% of the solid waste generated in the area is made up of: 17.6% plastics and 3.0% metals. Per capita waste generated was 0.31kg/capita/day and the average bulk density of waste generated was 259kg/m^3. According to Bolaji (2018), the composition of municipal solid waste in Developing Countries provides a description of the constituents of the waste and it differs widely from place to place. The most striking difference is the difference in organic contents which is much higher in the low income areas than the high income, while the paper and plastic content is much higher in high income areas than low income areas.

Adoption of new strategies for sustainable solid waste management requires a good knowledge of the prevailing conditions in the sector. Thus, assessment of solid waste characterization in Keffi Local Government Area was carried out in view of advocating biogas technology for solid waste management in Keffi Local Government Area. This was achieved through the assessment of: the quantity of solid waste generation; and the composition in the study area.

MATERIALS AND METHOD

Study Area

Keffi Local Government Area, in Nasarawa State Nigeria is located within Lat 8˚, 51and 9^o 25' N and Long 7˚52' $8^0 40^1$ E. It has an area of 138 km² and a population of 92,664 at the 2006 census. It is bound by Karu, in the West, Kokona and Nasarawa LGAS in the South (Figure1).

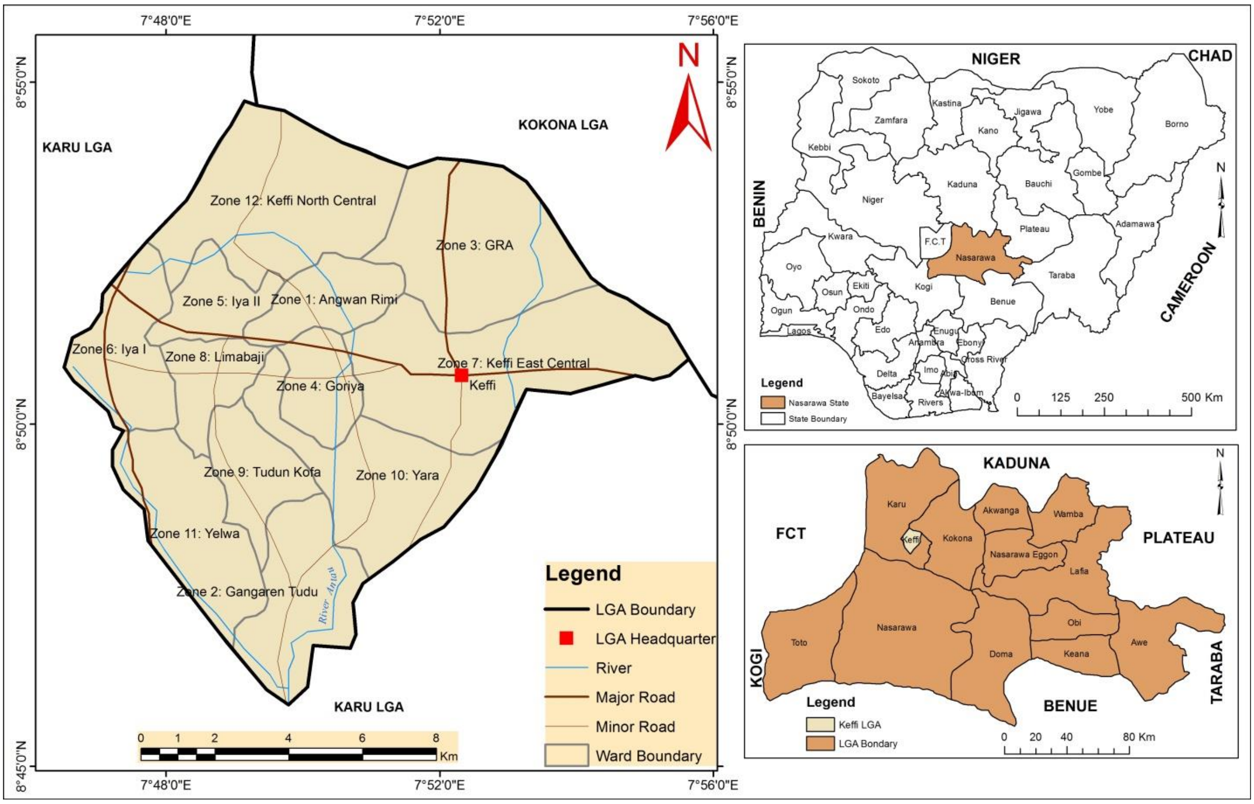

Figure 1: The Study Area

Source: Abugu, 2021

The climatic condition of Keffi Local Government Area is very favourable to biogas production especially with the regard to high temperature (Abugu et al, 2018). Soils in Keffi Local Government Area supports many crops which their waste has been found very useful as biogas substrates examples include cassava, yam, rice, maize, guinea corn, beans, soya beans, sugar-cane, banana and millet. Agriculture is the major land use in Keffi Local Government Area. Apart from crop production, animal rearing is also practice especially by the Fulani people residing in the area. The people of Keffi in addition to farming also engaged in a divert trade, manufacturing and few craft and entertainment industry. The rapid populations in Keffi Local Government Area and Agriculture activities are huge future for Biogas production in the area.

Data Collection Method

Materials used for data collection are weighing scale and waste bins. Stratified and systematic samplings were used to select households for data collection. Prior to data collection, consultations were made with the prospective households to sample during which information required was disclosed and an appeal was made to meet with the requirements. The households were pleaded with to ensure enabling arrangement for data collection. For instance, to ensure that all waste generated were sorted into organic and inorganic and gathered in separate bin daily for a period of one week. With the help of research assistants, selected household waste generation were observed and weighed on daily basis for one week and average weight was calculated for each household to quantify the amount of waste generation and composition. Weighing of waste was done as follows: step i- each waste with waste bin content was placed on a weighing scale and reading was taken. Step ii - empty waste bin was weighed and the weight was deducted from that of step i.

Data collected were analyzed using mean, percentage, ANOVA and t test. The quantity of solid waste generation in the study area was analyzed using mean, percentage and ANOVA. ANOVA was used to find the variations among wards. The Compositions of Solid Waste Generation in the Study Area was analyzed using mean, percentage and t test. Student t test was used compare the organic and inorganic components of Solid Waste in the study area.

RESULTS AND DISCUSSION

The Quantity of Solid Waste Generation in the Study Area

The quantity of solid waste generation in the study area is presented in Table 1

Table 1: The Average Daily Solid Waste Generation in the Study Area

Wards	No. of Households	Waste(Kg)/Household	Waste (Kg)/ward
Gangare tudu	35	1.2	42.5
Jigwada	42	1.5	63
Yara	31	1.1	36.5
Sabongari	41	1.3	51.5
Ang.rimi	38	1.5	57
Ang.-Iya I	35	1.2	42.5
Ang.-Iya II	29	1.3	38.5
Keffi Esat/ Kofar goriya	74	1.5	111
Liman/abaji	41	1.1	45.6
Tundun Kofar t.v	34	0.9	32.5
Total	400	11.4	520.6
Average	40	1.26	52.06

Table 1 shows among other things that solid waste generation per household per a day in Keffi Local government area ranged from 0.9 Kg to 1.5Kg with mean value of 1.26Kg. This is consistent with the report of Kadafa (2017), who reported an average of 0.5-1.5 kg/daily per household of municipal solid waste generation in Abuja Nigeria. Table 1 also showed variations in the average quantity of solid waste generation among wards, daily solid waste generation per ward per day ranged from 32.Kg to 111Kg. The variation is a factor settlement type, population and economic activities. Solid waste generation variations among regions depend on several factors that influence the rate of waste generation which include population, income, economic activities. Spatial variation in waste generation has being reported by previous researches (Ogah et al, 2014; Anyanwu and Adefila, 2014). Ogah et al., (2014) recorded variation in volume of waste generation based on population density, according to their report; area of high population density has higher waste volume than the medium and low density areas.

Moreover, to ascertain the significant of the variation based on average quantity of solid waste generation among wards, Analysis of Variance (ANOVA) was used as a statistical tool to test for the level of significant in solid waste generation among the wards (Table 2).

Table 2: Results of the Analysis of Variance (ANOVA) for Solid Waste Generation among the Ten Wards in Keffi LGA

SOURCE OF VARIATION	SUM OF SQUARES	DEGREE OF FREEDOM	MEAN SS	F RATIO
BETWEEN GROUP	146.6	9	48.87	3.78
WITHIN GROUP	221.6	39	184.67	
TOTAL	2232.61	48	333.54	

Calculated F= 3.78
F-table at 0.05 $F_{9, 40}$ =2.21
Critical F= 2.21

DECISION:
Since the calculated F value of 3.78 is greater than the critical F value of 2.21, H_o "There is no significant different in the quantity of solid waste generation among the ten wards in Keffi Local Government Area at 95% confidence level" was rejected. Therefore, there was a significant different in the quantity of solid waste generation among the ten wards. Then the variation is significant, thus, wards like Keffi East/ Kofar goriya and Jigwada with higher means generated more solid wastes than others (Figure 1).

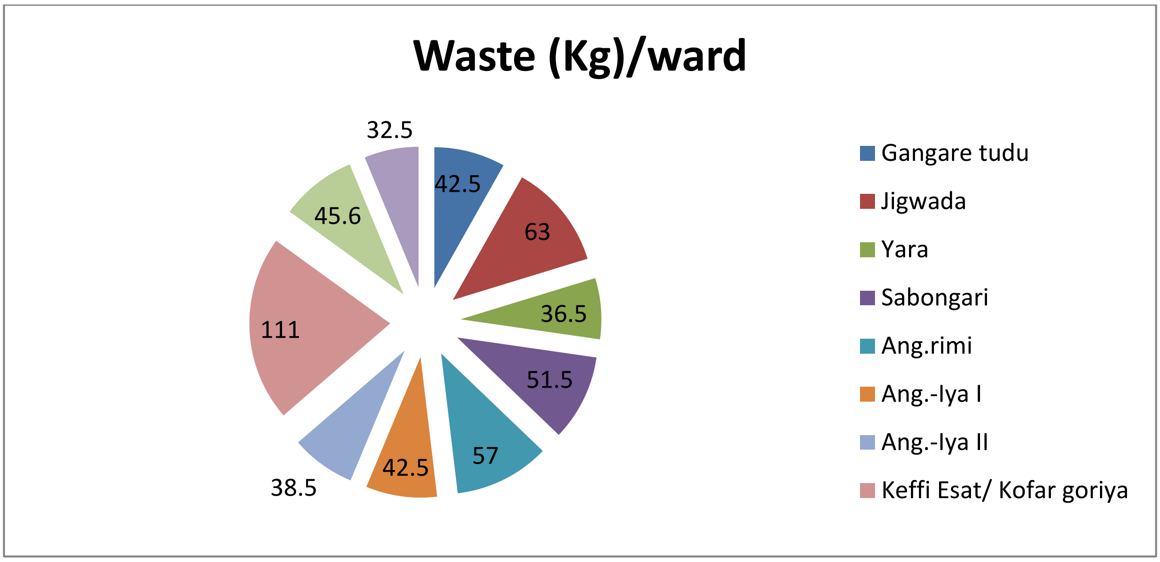

Fig.1: Solid Waste among Wards

It can be assumed that there are higher potential of biogas productions from Keffi Esat/ Kofar goriya and Jigwada than others wards in terms of waste availability. However, the composition of the wastes is the major determinant of its usability as substrate for biogas production. Biogas production requires only organic (biodegradable) wastes, hence, effort was made to analyse the composition of solid waste generation in the study area.

Compositions of Solid Waste Generation in the Study Area

Solid wastes in Keffi consist of diverse materials from both raw materials mostly farm/animal residues and manufactured goods. These include, Kitchen wastes (Vegetables, leftover foods) farm /garden residues (Corn cobs, melon, kernel, coconut shells, sugar cane, cassava peel, guinea corn, beans, rice husks, metal scraps) aluminum scraps, cans/tins, plastics, leaders, bottles/ceramics, paper, rags, and others. However, this study broadly categorized these waste into organic and inorganic because only organic waste are useable for biogas production (Table 2).

Table 2: The Organic and Inorganic Compositions of Solid Wastes in Keffi Local Government Area

Wards	Waste (Kg)/Ward/Day	Organic	%	Inorganic	%
Gangare tudu	42.5	34.2	80.47	8.3	19.53
Jigwada	63	56.4	89.52	6.6	10.48
Yara	36.5	23.6	64.65	12.9	35.35
Sabongari	51.5	42.1	81.74	9.4	18.26
Ang.rimi	57	42.4	74.38	14.6	25.62
Ang.-Iya I	38.5	32	68.11	6.5	31.89
Ang.-Iya II	42.5	30.2	71.05	12.3	28.95
Keffi Esat/ Kofar goriya	111	56.6	50.99	54.4	49.00
Liman/abaji	45.6	29.8	62.66	15.8	37.34
Tundun Kofar t.v	32.5	24.38	75	8.13	25
Total	**478.1**	**365.7**	**717.90**	**148.93**	**281.51**
Average	**52.06**	**36.57**	**71.79**	**14.89**	**28.21**

Table 2 shows on average that 71.79% of households' solid wastes in Keffi Local Government Area are organic materials while 28.21% are inorganic. Student t test was used to test for significant different between the average composition of organic and inorganic wastes (Table 3).

Table 3: Student t Test for Composition of Solid Wastes in the Study Area.

Wards	Organic(X)	Inorganic (Y)	X-X	Y-Y	X-X2	Y-Y2
Gangare tudu	34.2	8.3	-2.37	-6.59	5.6169	43.4281
Jigwada	56.4	6.6	19.83	-8.29	393.2289	68.7241
Yara	23.6	12.9	-12.97	-1.99	168.2209	3.9601
Sabongari	42.1	9.4	5.53	-5.49	30.5809	30.1401
Ang.rimi	42.4	14.6	5.83	0.29	33.9889	0.0841
Ang.-Iya I	32	6.5	-4.57	-8.39	20.8849	70.3921
Ang.-Iya II	30.2	12.3	-6.37	-2.59	40.5769	6.7081
Keffi Esat/ Kofar goriya	56.6	54.4	20.03	39.51	401.2009	1561.04
Liman/abaji	29.8	15.8	-6.77	0.91	45.8329	0.8281
Tundun Kofar t.v	24.38	8.13	-12.19	-6.76	148.5961	45.6976
Total	**365.7**	**148.93**			**1288.728**	**1831.003**
Mean	**36.57**	**14.89**				
Variance	**128.3689**	**183.0609**				
SD	**11.33**	**13.53**				
t Test	**3.21**					

Calculated t=3.21, critical t at 0.05 under 18 degree of freedom (N1+N2)-2 =2.10; therefore, calculated t >critical t

DECISION:

Since the calculated t value of 3.21 is greater than the critical t value of 2.10, Ho, “there is no significant difference between organic and inorganic components of solid waste generation in the study area at 95% significant level” is rejected. Therefore, “there is a significant difference between organic and inorganic components of solid waste generation in the study area at 95% significant level”. The mean value of organic components 36.57 is greater than the mean value of the inorganic 14.89. Thus, solid waste generation of the study has higher organic components than inorganic components.

Several earlier studies in Nigeria and other developing countries reported that organic waste is the major components of households and municipal solid waste (Nabegu, 2012; Dieu et al., 2014; UK Essays, 2016). Nabegu (2012) and UK Essays (2016), uniformly reported 66% biodegradable while Dieu et al., (2014) reported 80.1 – 90.0% of organic waste. Thus, it means that majority of household wastes can be used as substrates for biogas production. The percentage of organic components however varies among the wards. Keffi Esat/ Kofar goriya with the highest quantity of waste generation due to its population and diverse economic activities has almost equal proportion of organic and inorganic wastes while others wards have more of organic components (Figure 2).

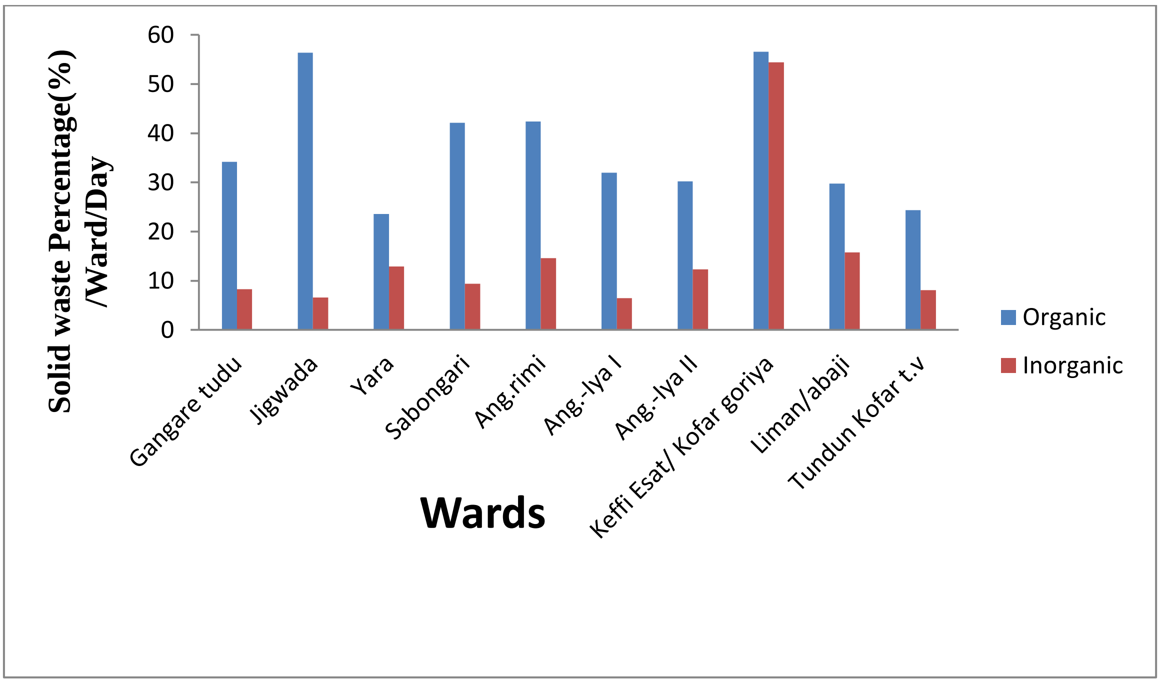

Figure 2: Variation in Waste Components among the Wards

Figure 2 shows predominant of organic wastes in all the wards with only Keffi Esat/ Kofar goriya having high inorganic wastes. This is because solid wastes in most of the interior wards are dominated by agricultural residues due to the predominant farming activities in such wards like Jigwada, Tundun Kofar t.v and Sabongari. Similar, spatial variation has been found by Ogah et al.(2014). Ogah et al. (2014) reported that in the high density area, crop residues and food remains dominated by 51 per cent, papers dominate in the medium density area, while polythene materials dominate in the low-density area. Given the predominant of organic wastes in the study area, there is high feasibility for biogas production from organic wastes in Keffi Local Government Area other things being equal.

CONCLUSION

Based on the solid waste characterization in Keffi Local Government Area, adoption of biogas technology for solid waste management is feasible. Solid waste generation per household per day in Keffi Local government area ranged from 0.9 Kg to 1.5Kg with mean value of 1.26Kg. There was a significant different in the quantity of solid waste generation among the ten wards. Though, solid wastes in Keffi consist of diverse materials from both raw materials mostly farm/animal residues and manufactured goods, it has higher organic components than inorganic components. Thus, pilot demonstration of biogas production and subsequent advancement was recommended.

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