The Attitude of the Ghanaian Towards the Recycling of Agricultural Waste into Methane Gas: A Case Study of Takoradi Market Circle

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***Abstract* - The main purpose of this paper is to assess the attitude of Ghanaians' towards the recycling of agricultural waste into methane gas . The study is also to identify the benefits of methane production, to create an Organic Processing Facility to create biogas which will be more cost effective, eco-friendly, cut down on landfill waste, generate a high-quality renewable fuel, and reduce carbon dioxide & methane emissions, to identify the process of methane production. The paper seek to solve rampant disposal of waste in the market square and how it can be converted into methane gas.**

Qualitative and quantitative research design was used for the study. Questionnaires, interviews and personal observations were used to solicit data for the study. Primary data was collected through a field survey from traders, food vendors and residents in Takoradi . Data was collected through the use of a written questionnaire, hand-delivered to participants in their shops and residents in Takoradi. The research found out among other things that majority of the respondents are aware of recycling, majority of the respondents think it is important to recycle, majority of the respondents do not recycle, majority of the respondents confirmed that non availability of recycling plants is the main reason why they do not recycle, majority of the respondents recycle rubber waste, majority of the respondents confirmed that production of energy is a benefit of methane production. The researcher made the following recommendations, the government and waste management stakeholders must educate Ghanaians to cultivate a good attitude towards agricultural waste , residence and food vendors must be encouraged to further their education and create more public awareness about the importance of recycling and methane production, there is the need to elaborate the importance of recycling agricultural waste materials to the residents of Takoradi metropolis. Residents of Takoradi must be encouraged to recycle waste materials.

Keywords: Biogas, Methane gas, Waste Recycling, Attitude, Agricultural waste.

I. INTRODUCTION

Organic waste is produced wherever there is human habitation. The main forms of organic waste are household food waste, agricultural waste, human and animal waste. In industrialised countries the amount of organic waste produced continues to increase each year. Although many gardening enthusiasts 'compost' some of their kitchen and garden waste, much of the household waste goes into landfill sites and is often the most hazardous waste. The organic waste component of landfill is broken down by micro-organisms to form a liquid 'leachate' which contains bacteria, rotting matter and some chemical contaminants from the landfill. This leachate can present a serious hazard if it reaches a watercourse or enters the water table. There is a lot of research being done on renewable energy, Example solar energy, wind energy, different source thermal and hydro energy, biogas and methane are all renewable energy resources. But, methane gas is distinct from other renewable energies because of its characteristics of using, controlling and collecting organic wastes and at the same time producing fertilizer and water for use in agricultural irrigation. Methane and Biogas do not have any geographical limitations nor do they requires advanced technology for their production. Deforestation is a very big problem in developing countries like Ghana, a higher percentage of the population depends on charcoal and wood-fuel for fuel supply which leads deforestation, deforestation leads to soil erosion and subsequently to decrease in soil fertility. Kitchen waste is disposed of in landfill or discarded which causes public health hazards and diseases like malaria, cholera and typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences: It not only leads to polluting surface and groundwater through leachate and further promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. Mankind can tackle this problem(threat) successfully with the help of methane gas, however till

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now we have not been benefited. This fact can be seen in current practices of using low calororific inputs like cattle dung, distillery effluent, municipal solid waste (MSW) or sewerage, in biogas plants, making methane generation highly inefficient. We can make this system extremely efficient by using kitchen waste/food wastes.

Anand Karve Shalini, (2000),(ARTI) developed a compact biogas system that uses starchy or sugary feedstock material and the analysis shows that this new system is 800 times more efficient than conventional biogas plants. While calculating the cost effectiveness of waste disposal we have to think more than monitory prospects. The dumping of food in places and making the places unhygienic can be taken good care of. It adds to the value of such Biogas plants.

Anaerobic digestion is controlled biological degradation process which allows efficient capturing and utilization of biogas (approx. 60% methane and 40% carbon dioxide) for energy generation. Anaerobic digestion of food waste is achievable but different types, composition of food waste results in varying degrees of methane yields, and thus the effects of mixing various types of food waste and their proportions should be determined on case by case basis. Anaerobic digestion (AD) is a promising method to treat the kitchen wastes. While Anaerobic digestion for treatment of animal dung is common in rural parts of developing countries, information on technical and operational feasibilities of the treatment of organic solid waste is limited in those parts. There are many factors affecting the design and performance of anaerobic digestion. Some are related to feedstock characteristics, design of reactors and operation conditions in real time.

II. THEORETICAL FRAMEWORK OF THE STUDY

Biogas is a renewable form of energy. Methanogens (methane producing bacteria) are last link in a chain of microorganisms which degrade organic material and returns product of decomposition to the environment.

III. PRINCIPLES FOR PRODUCTION OF BIOGAS

Organic substances exist in wide variety from living beings to dead organisms. Organic matters are composed of Carbon (C), combined with elements such as Hydrogen (H), Oxygen (O), Nitrogen (N), Sulphur (S) to form variety of organic compounds such as carbohydrates, proteins & lipids. In nature, microorganisms (MOs), through digestion process breaks the complex organic matter into smaller substances. [1]

There are 2 types of digestion process:
Aerobic digestion
Anaerobic digestion

The digestion process occurring in presence of Oxygen is called Aerobic digestion and produces mixtures of gases having carbon dioxide (CO_2), one of the main "green houses gases" responsible for global warming. The digestion process occurring without (absence) oxygen is called Anaerobic digestion which generates mixtures of gases. The gas produced which is mainly methane produces 5200-5800 kj/m^3 which when burned at normal room temperature and presents a viable environmentally friendly energy source to replace fossil fuels (non-renewable) [1]

Anaerobic Digestion

Anaerobic digestion is also referred to as biomethanization, is a natural process that takes place in absence of air (oxygen). It involves biochemical decomposition of complex organic material by various biochemical processes with release of energy rich biogas and production of nutrious effluents. [1]

Biological Process (Microbiology)

1. Hydrolysis
2. Acidification
3. Methanogenesis

Hydrolysis

In the first step, the organic matter is enzymolysed externally by extracellular enzymes, cellulose, amylase, protease & lipase, of microorganisms. Bacteria decompose long chains of complex carbohydrates, proteins, & lipids into small chains. For example, Polysaccharides are converted into monosaccharide. Proteins are split into peptides and amino acids. [2]

Acidification

Acid-producing bacteria, involved in this step, convert the intermediates of fermenting bacteria into acetic acid, hydrogen and carbon dioxide. These bacteria are anaerobic and can grow under acidic conditions. To produce acetic acid, they need oxygen and carbon. For this, they use dissolved O_2 or bounded-oxygen. Hereby, the acid-producing bacteria creates anaerobic condition which is essential for the methane producing microorganisms. Also, they reduce the compounds with low molecular weights into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane. From a chemical point, this process is partially endergonic (i.e. only possible with energy input), since bacteria alone are not capable of sustaining that type of reaction. [2].

Methanogenesis

Methane formation or Methane-producing bacteria, which are involved in the third step, decompose compounds having low molecular weight. They utilize hydrogen, carbon dioxide and acetic acid to form methane and carbon dioxide. Under natural conditions, CH_4 producing microorganisms occur to the extent that anaerobic conditions are provided, e.g. under water (for example in marine sediments), and in marshes. They are basically anaerobic and very sensitive to environmental changes, if any occur. The methanogenic bacteria belongs to the archaebacter genus, i.e. to a group of bacteria with heterogeneous morphology and lot of common biochemical and molecular-biological properties that distinguishes them from other bacterias. The main difference lies in the makeup of the bacteria's cell walls [2].

Symbiosis of Bacteria

Methane and acid-producing bacteria act in a symbiotical way. Acid producing bacteria create an atmosphere with ideal parameters for methane producing bacteria (anaerobic conditions, compounds with a low molecular weight). On the other hand, methane-producing microorganisms use the intermediates of the acid producing bacteria. No single bacteria is able to produce fermentation products alone as it requires others too. [3]

IV. THE CONCEPT OF WASTE MANAGEMENT

The business of keeping our environment free from the contaminating effects of waste materials is generally termed waste management. [4], for instance, has referred to waste management as involving "the collection, transport, treatment and disposal of waste including after care of disposal sites". Similarly, [5], has defined waste management as "purposeful, systematic control of the generation, storage, collection, transportation, separation, processing, recycling, recovery and disposal of solid waste in a sanitary, aesthetically acceptable and economical manner", While [6], focus on municipal solid waste management which they define as "the collection, transfer, treatment, recycling, resource recovery and disposal of solid waste in urban areas". It can be deduced from these definitions that waste management is the practice of protecting the environment from the polluting effects of waste materials in order to protect public health and the natural environment. Thus, the priority of a waste management system must always be the provision of a cleansing service which helps to maintain the health and safety of citizens and their environment [7].

V. METHODOLOGY

The popular ways to collect primary data consist of questionnaire surveys, interviews and focus groups, which promote direct relationship between the researcher and the respondents [6].

Secondary research is a means to reprocess and reuse collected information as an indication for betterments of the research. Both primary and secondary data are useful for the research but both may differ from each other in various aspects. In secondary data, information relates to a past period. Hence, it lacks aptness and therefore, it has unsatisfactory value. Primary data is more accommodating as it shows latest information. Primary data is accumulated by the researchers particularly to meet up the research objective of the project.

The type of research design employed was questionnaire, interview and observations. These types of research were used because these eventually enabled the researchers to make judgment about the effectiveness, relevance or desirability of the programme. SPSS software was use to analyze the data collected from the field.

VI. PRESENTATION AND ANALYSIS OF DATA

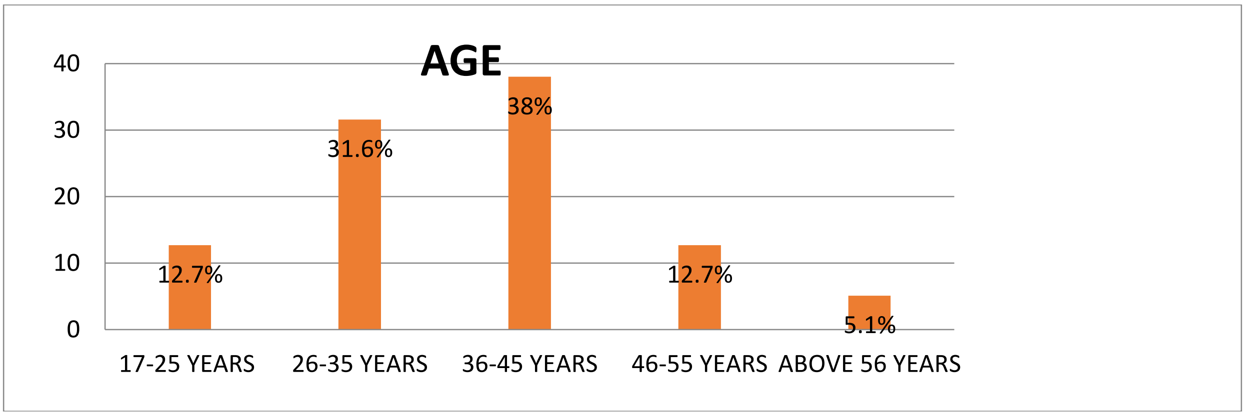

Figure 1

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According to figure 1, 30 respondents representing 38% are in age group 36-45 years, 25 respondents representing 31.6% are in age group 26-35 years, 10 respondents representing 12.7% are in age group 17-25 years and 46-55 years respectively and 4 respondents representing 5.1% are above 56 years. The main findings suggest that majority of the respondents are in age group 36-45 years.

NATURE OF BUSINESS

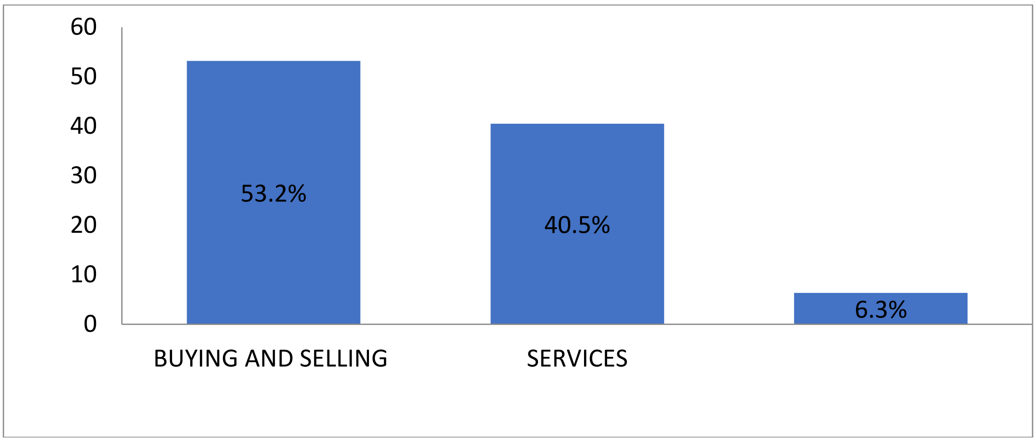

Figure 2

According to figure 2, 42 respondents representing 53.2% are into buying and selling business, 32 respondents representing 40.5% render services and 5 respondents representing 6.3% are into manufacturing. The main findings suggest that majority of the respondents are into buying and selling business.

EDUCATIONAL LEVEL

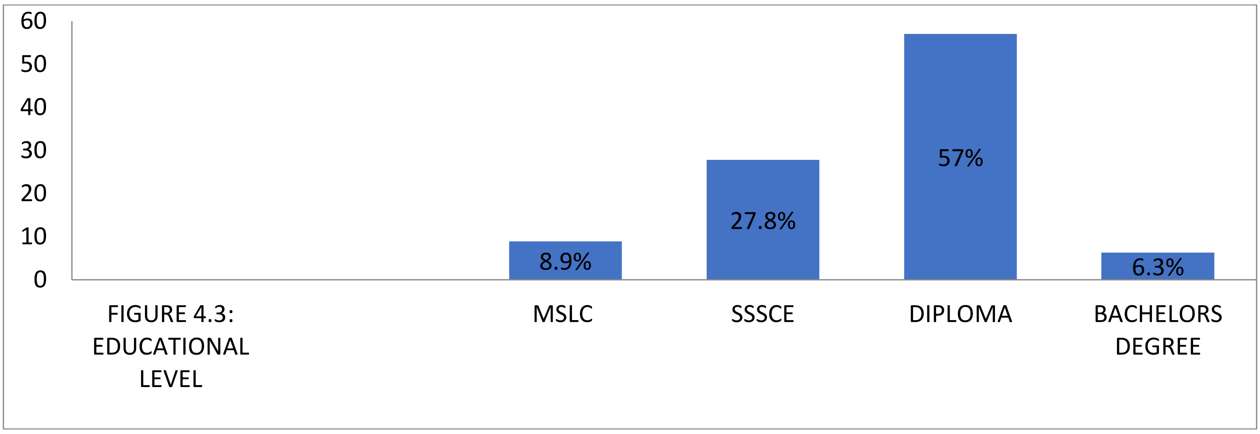

Figure 3

According to figure 3: 45 respondents representing 57% have Diploma as their highest qualification, 22 respondents representing 27.8% have SSSCE as their highest qualification, 7 respondents representing 8.9% have MSLC and 5 respondents representing 6.3% have Bachelors degree as their highest qualification. The main findings suggest that majority of the respondents have Diploma as their highest qualification.

DO YOU KNOW THE MEANING OF RECYCLE?

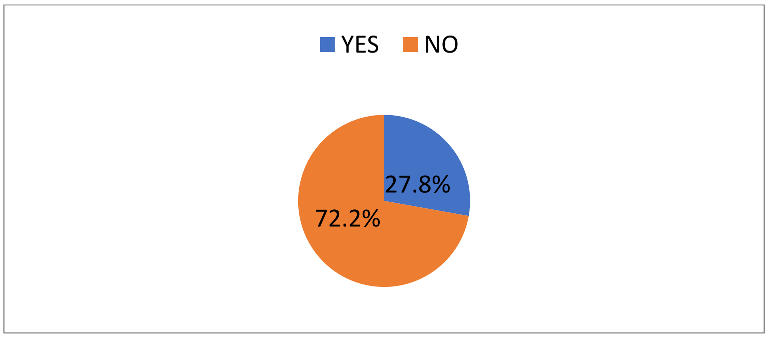

Figure 4

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According to figure 4, 57 respondents representing 72.2% confirmed that they know the meaning of recycling and 22 respondents representing 27.8% don't know what recycling means. The main findings suggest that majority of the respondents are aware of recycling.

DO YOU THINK IT IS IMPORTANT TO RECYCLE?

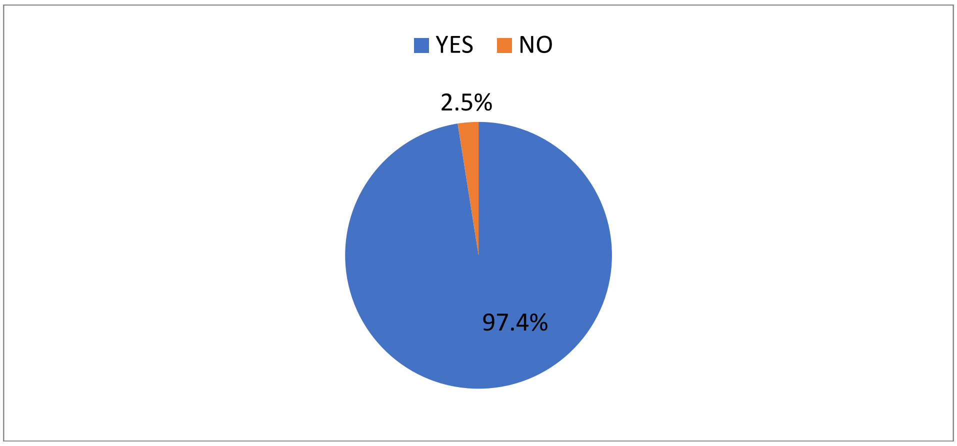

Figure 5

According to figure 5, 77 respondents representing 97.4% confirmed that it is important to recycle and 2 respondents representing 2.5% said it is not important to recycle. The main findings suggest that majority of the respondents think it is important to recycle.

DO YOU RECYCLE?

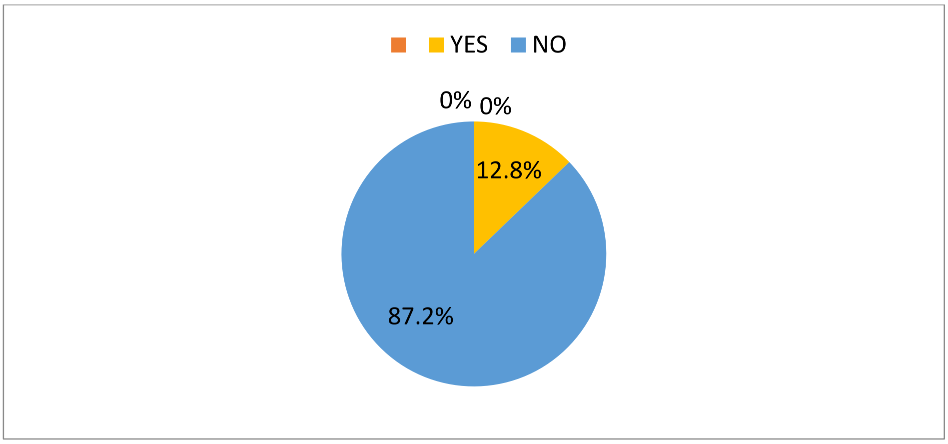

Figure 6

Figure 6 shows that 68 respondents representing 87.2% confessed that they don't recycle and 11 respondents representing 12.8% also confirm that they recycle waste. The main findings suggest that majority of the respondents don't recycle.

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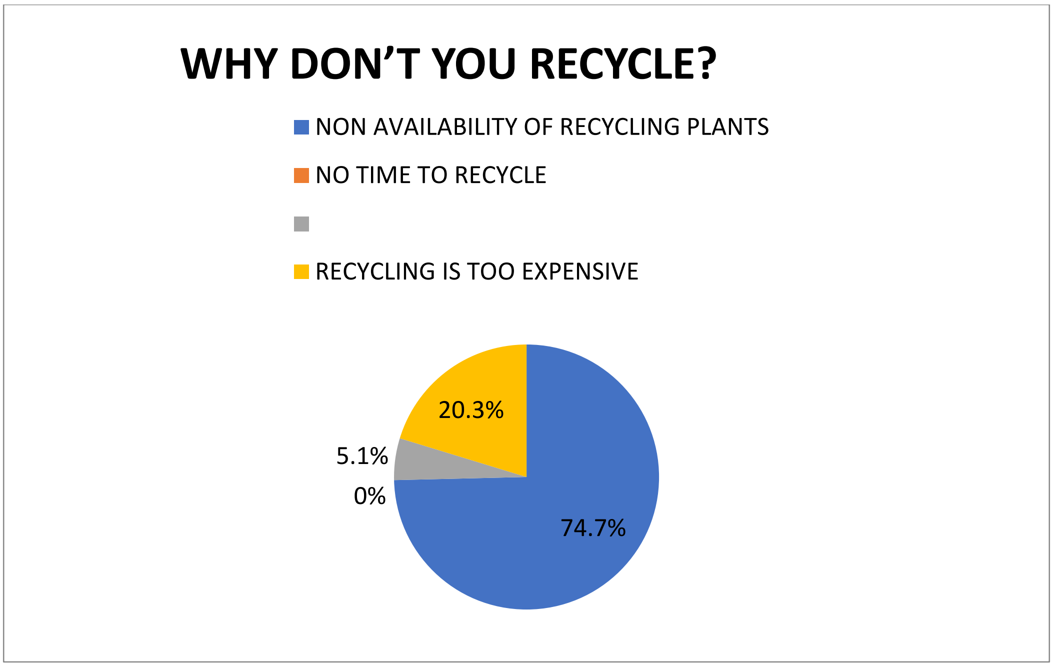

Figure 7

According to figure 7, 59 respondents representing 74.7% confirmed that non availability of recycling plants is the main reason why they don't recycle, 16 respondents representing 20.3% said that recycling is too expensive and 4 respondents representing 5.1% said that recycling is too expensive. The main findings suggest that majority of the respondents confirmed that non availability of recycling plants is the main reason why they don't recycle.

WHAT MATERIALS DO YOU RECYCLE?

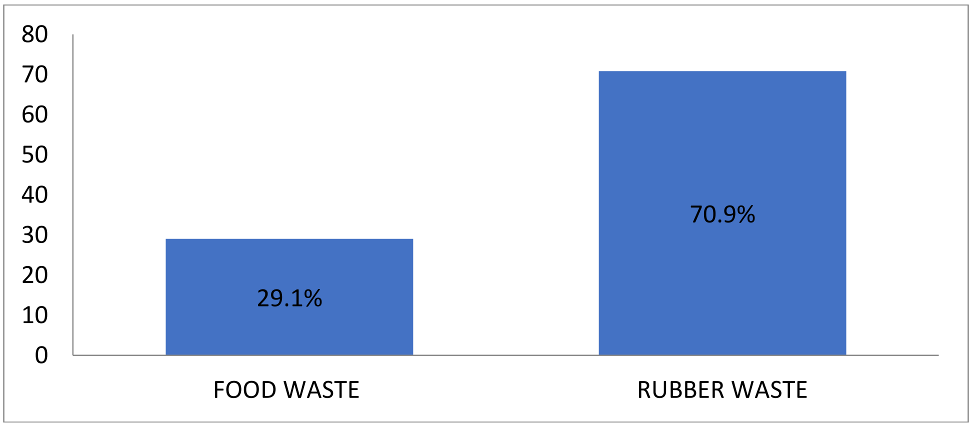

Figure 8

According to figure 8, 56 respondents representing 70.9% said that they recycle rubber waste and 23 respondents representing 29.1% recycle food waste. The main findings suggest that majority of the respondents recycle rubber waste.

HOW DO YOU RECYCLE?

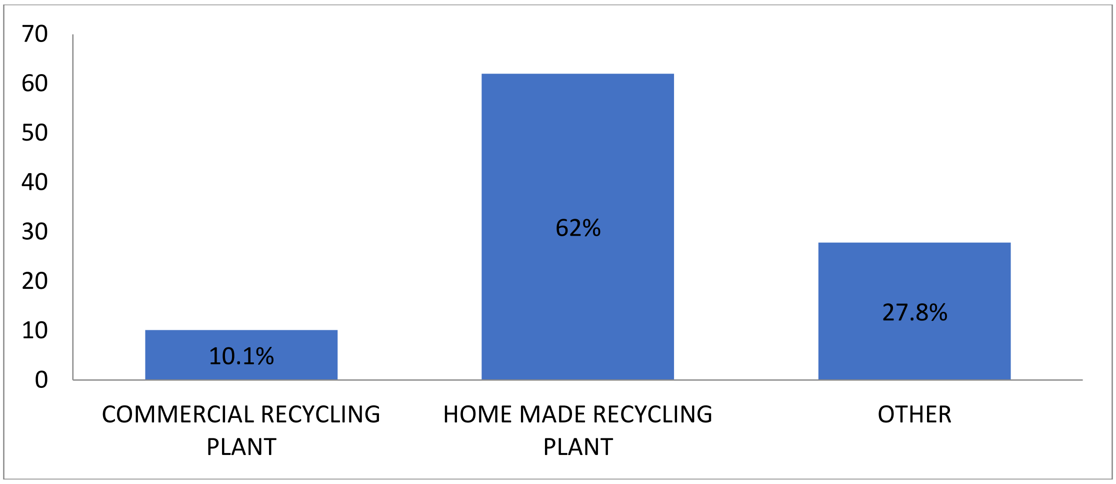

Figure 9

According to figure 9, 49 respondents representing 62% say they use home made recycling methods, 22 respondents representing 27.8% use other means to recycle and 8 respondents representing 10.1% use commercial recycling plant. The main findings suggest that majority confirmed that they use home made recycling methods.

DO YOU GET PAID FOR RECYCLED MATERIALS?

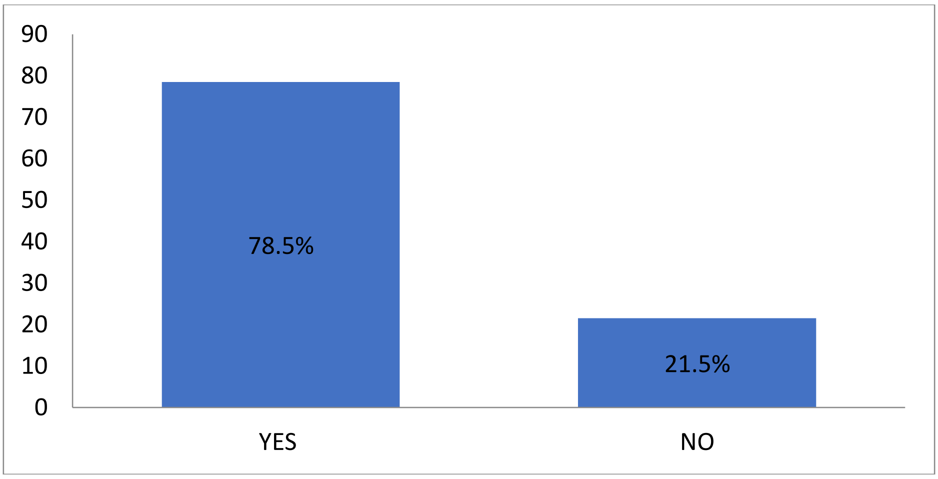

Figure 10

According to figure 10, 62 respondents representing 78.5% confirmed that they get paid for recycled materials and 17 respondents representing 21.5% said they don't get paid. The main findings suggest that majority of the respondents get paid for recycled materials.

HOW MUCH TIME IS DEVOTED TO RECYCLING EACH DAY OF THE WEEK?

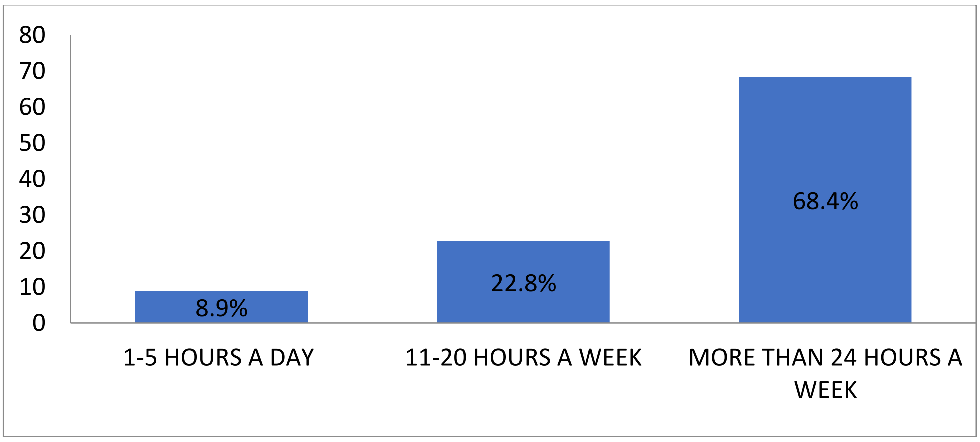

Figure 11

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Figure 4.11 shows that 54 respondents representing 68.4% confirmed that they do recycle materials more than 24 hours a week, 18 respondents representing 22.8% recycle 11-20 hours a week and 7 respondents representing 8.9% recycle 1-5 hours a day. The main findings suggest that majority of the respondents recycle more than 24 hours a week.

DO YOU THINK YOU COULD RECYCLE MORE?

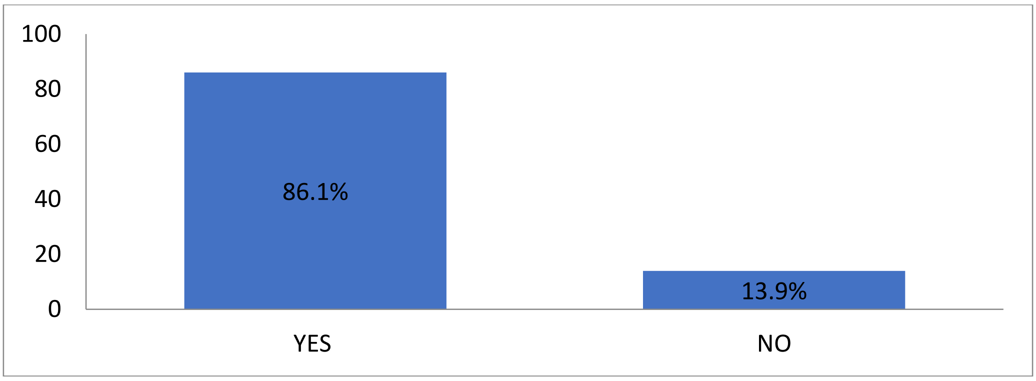

Figure 12

According to figure 12, 68 respondents representing 86.1% confirmed that they could recycle more if the necessary recycling equipment are available and 11 respondents representing 13.9 % think they could not recycle more. the main findings suggest that majority of the respondents think they could recycle more.

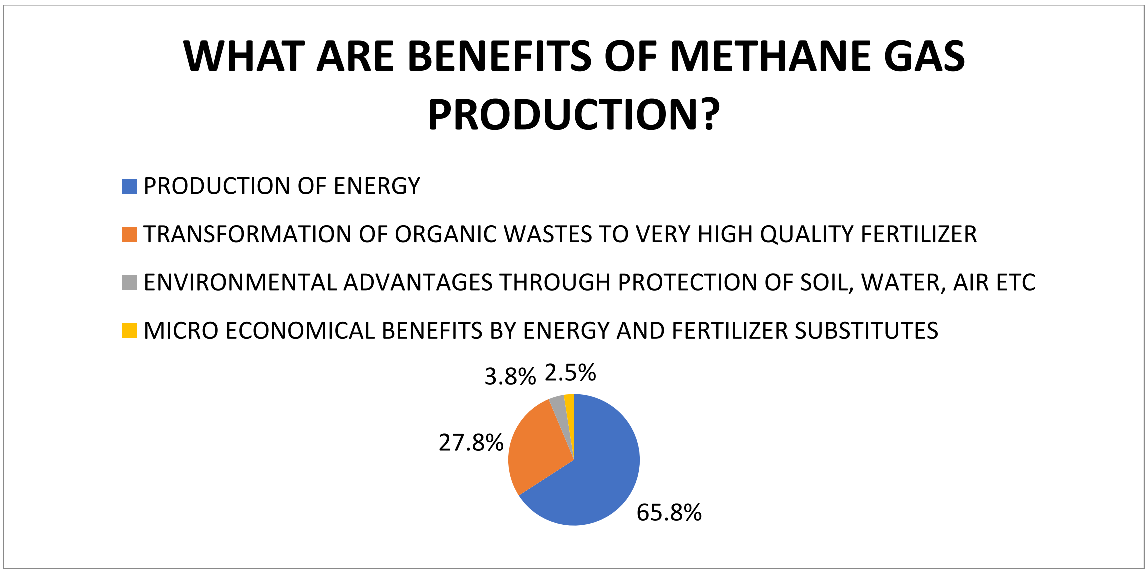

Figure 13

According to figure 13, 52 respondents representing 65.8% confirmed that the benefits of methane gas production is the production of energy for consumption, 22 respondents representing 27.8% said that transformation organic wastes to very high quality fertilizer is the benefits of methane gas production, 3 respondents representing 3.8% confirmed that environmental advantages through protection of soil, water, air etc is the benefit of methane production. The main findings suggest that majority of the respondents confirmed that production of energy is a benefit of methane production.

VII. DISCUSSION OF FINDINGS

This section deals with discussion of main findings. The discussions of main findings were concerned with the transformation of waste products to methane gas in the Takoradi Metropolis.

According to figure 4, 57 respondents representing 72.2% confirmed that they know the meaning of recycling and 22 respondents representing 27.8% don't know what recycling means. The main findings suggest that majority of the respondents are aware of recycling. [8] completed a study on a biogas operation to increase the total biogas yield from 50% available biogas to 90% using several treatments including: a mesophilic laboratory scale continuously stirred tank reactor, an up flow biofilm reactor, a fiber liquefaction reactor releasing the bacteria *Fibrobacter succinogenes* and a system that adds water during the process. These methods were sufficient in bringing about large increases to the total yield; however, the study was under a very controlled method, which leaves room for error when used under varying conditions.

According to figure 5, 77 respondents representing 97.4% confirmed that it is important to recycle and 2 respondents representing 2.5% said it is not important to recycle. The main findings suggest that majority of the respondents think it is important to recycle. [9] outlined the economic, and social benefits of biogas production.
The economic benefits were as follows:
1. Treatment of solid waste without long-term follow-up costs usually due to soil and water pollution

2. Increased local distribution of fertilizer, chemical herbicides, and pesticide demand

3. Generation of income through compost and energy sales (biogas/electricity/heat) to the public grid

4. Improved soil/agriculture productivity through long-term effects on soil structure and fertility through compost use

5. Reduction of landfill space and consequently land costs
The social and health effects associated with biogas include:
1. Creation of employment in biogas sector

2. Improvement of the general condition of farmers due to the local availability of soil-improving fertilizer

3. Decreased smell and scavenger rodents and birds.

THE GENERAL BENEFITS OF BIOGAS TECHNOLOGY
Production of energy. Transformation of organic wastes to very high quality fertilizer. Improvement of hygienic conditions through reduction of pathogens. Environmental advantages through protection of soil, water, air etc. Micro-economical benefits by energy and fertilizer substitutes.

Macro-economical benefits through decentralizes energy generation and environmental protection.
Figure 6 shows that 68 respondents representing 87.2% confessed that they don't recycle and 11 respondents representing 12.8% also confirm that they recycle waste. The main findings suggest that majority of the respondents don't recycle.[10] studied the Effect of Total Solids Concentration of Municipal Solid Waste on the Biogas Produced in an Anaerobic Continuous Digester. The total solids (TS) concentration of the waste influences the pH, temperature and effectiveness of the microorganisms in the decomposition process. They investigated various concentrations of the TS of MSW in an anaerobic continuously stirred tank reactor (CSTR) and the corresponding amounts of biogas produced, in order to determine conditions for optimum gas production. The results show that when the percentage total solids (PTS) of solid waste in an anaerobic continuous digestion process increases, there is a corresponding geometric increase for biogas produced. A statistical analysis of the relationship between the volume of biogas produced and the percentage total solids concentration established that the former is a power function of the latter, indicating that at some point in the increase of the TS, no further rise in the volume of the biogas would be obtained.

According to figure 7, 59 respondents representing 74.7% confirmed that non availability of recycling plants is the main reason why they don't recycle, 16 respondents representing 20.3% said that recycling is too expensive and 4 respondents representing 5.1% said that recycling is too expensive. The main findings suggest that majority of the respondents confirmed that non availability of recycling plants is the main reason why they don't recycle.[12] investigated the reactivity of methane. They concluded that it has more than 20 times the global warming potential of carbon dioxide and that the concentration of it in the atmosphere is increasing with one to two per cent per year. The article continues by highlighting that about 3 to 19% of anthropogenic sources of methane originate from landfills.

According to figure 8, 56 respondents representing 70.9% said that they recycle rubber waste and 23 respondents representing 29.1% recycle food waste. The main findings suggest that majority of the respondents recycle rubber waste.[11], appropriate rural technology of India ARTI, has developed a compact biogas plant which uses waste food rather than any cow dung as feedstock, to supply biogas for cooking. The plant is sufficiently compact to be used by urban households, and about 2000 are currently in use – both in urban and rural households in Maharashtra. The design and development of this simple, yet powerful technology for the people, has won ARTI the Ashden Award for sustainable Energy 2006 in the Food Security category.

According to figure 9, 49 respondents representing 62% say they use home made recycling methods, 22 respondents representing 27.8% use other means to recycle and 8 respondents representing 10.1% use commercial recycling plant. The main findings suggest that majority confirmed that they use home made recycling methods.[13], Composition of biogas depends upon feed material also. Biogas is about 20% lighter than air has an ignition temperature in range of 650 to 750 ^{0C}. An odorless & colourless gas that burns with blue flame similar to LPG gas. Its caloric value is 20 Mega Joules (MJ) /m3 and it usually burns with 60 % efficiency in a conventional biogas stove. This gas is useful as fuel to substitute firewood, cow-dung, petrol, LPG, diesel, & electricity, depending on the nature of the task, and local supply conditions and constraints.

According to figure 10, 62 respondents representing 78.5% confirmed that they get paid for recycled materials and 17 respondents representing 21.5% said they don't get paid. The main findings suggest that majority of the respondents get paid for recycled materials. [12] investigated the reactivity of methane. They concluded that it has more than 20 times the global warming potential of carbon dioxide and that the concentration of it in the atmosphere is increasing with one to two per cent per year. The article continues by highlighting that about 3 to 19% of anthropogenic sources of methane originate from landfills.

Figure 11 shows that 54 respondents representing 68.4% confirmed that they do recycle materials more than 24 hours a week, 18 respondents representing 22.8% recycle 11-20 hours a week and 7 respondents representing 8.9% recycle

1-5 hours a day. The main findings suggest that majority of the respondents recycle more than 24 hours a week. Dr. Anand Karve (ARTI) developed a compact biogas system that uses starchy or sugary feedstock (waste grain flour, spoilt grain, overripe or misshapen fruit, non edible seeds, fruits and rhizomes, green leaves, kitchen watse, leftover food, etc). Just 2 kg of such feedstock produces about 500 g of methane, and the reaction is completed with 24 hours. The conventional biogas systems, using cattle dung, sewerage, etc. use about 40 kg feedstock to produce the same quantity of methane, and require about 40 days to complete the reaction. Thus, from the point of view of conversion of feedstock into methane, the system developed [14], is 20 times as efficient as the conventional system, and from the point of view of reaction time, it is 40 times as efficient. Thus, overall, the new system is 800 times as efficient as the conventional biogas system. According to figure 12, 68 respondents representing 86.1% confirmed that they could recycle more if the necessary recycling equipment are available and 11 respondents representing 13.9 % think they could not recycle more. the main findings suggest that majority of the respondents think they could recycle more. Biogas digestor systems provides a residue organic waste, after its anaerobic digestion(AD) that has superior nutrient qualities over normal organic fertilizer, as it is in the form of ammonia and can be used as manure. Anaerobic biogas digesters also function as waste disposal systems, particularly for human wastes, and can, therefore, prevent potential sources of environmental contamination and the spread of pathogens and disease causing bacteria. Biogas technology is particularly valuable in agricultural residual treatment of animal excreta and kitchen refuse (residuals).[13].

According to figure 13, 52 respondents representing 65.8% confirmed that the benefits of methane gas production is the production of energy for consumption, 22 respondents representing 27.8% said that transformation organic wastes to very high quality fertilizer is the benefits of methane gas production, 3 respondents representing 3.8% confirmed that environmental advantages through protection of soil, water, air etc is the benefit of methane production. The main findings suggest that majority of the respondents confirmed that production of energy is a benefit of methane production

VIII. CONCLUSIONS

As regards the main findings of the study, the following conclusions were made:

Respondents from age group 36-45 years highly responded to the study. Buying and selling is the main business that goes on at the Takoradi market circle. Diploma holders dominated the sample for the study. The awareness of recycling is high in the Takoradi metropolis. Recycling is very important to the economy of Ghana. Residents of Takoradi don’t recycle. Non availability of recycling plants is the main reason why they don’t recycle. Rubber waste is the main material the minority residents recycle. Homemade recycling methods are widely used. Residents get paid for recycled materials. Most resident recycle more than 24 hours a week. Production of energy is a benefit of methane production.

IX. RECOMMENDATIONS

Based on the conclusions made the following recommendations were made:

Market women and food vendors must be encouraged to further their education and create more public awareness about the importance of recycling and methane production. There is the need to elaborate the importance of recycling waste materials to the residents of Takoradi metropolis. Residents of Takoradi must be encouraged to recycle waste materials. The government, NGOs and other stakeholders must help to provide recycling plants to facilitate the productions of methane at Takoradi metropolis.

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