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A Review on Production of Biogas from Kitchen Waste by Anaerobic digestion process

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Abstract: *Facing energy crisis and climate change, the world is in need of a green, efficient, carbon- neutral energy source to replace fossil fuels. The search for energy alternatives involving locally available and renewable resource is one of the main concern of governments, scientists, and business people worldwide. In India, Large amount of kitchen waste, vegetable waste, bagasse, garden waste are obtained which is given in municipal solid waste which adds to waste management. If it can be utilized for better purposes it can reduce load to municipal solid waste management. This waste being organic in nature can be used for biogas production. Biogas, formed by anaerobic digestion of organic wastes, makes sustainable, reliable and renewable energy possible. There is potential for biogas production from kitchen waste, and at the same time the waste itself can be treated to minimize the environmental impact and provide nutrient rich organic fertilizer. In this paper a review of experiment work by different researchers for generation of biogas from organic waste produced from kitchen has been outlined. This paper even opens new avenue of waste to energy method of disposal of kitchen waste. These waste if treated in proper method can be utilize for integrated solid waste management. This paper leads to finding out most effective ways for biogas production and study of various methodologies of kitchen waste utilization.*

Keywords: *Anaerobic digestion, Organic waste, Solid waste management, Kitchen waste, Organic fertilizer*.

I. Introduction

Everything, in essence, is about energy. There is no doubt now that energy is fundamental for our development. Energy is vital for the internal and external security of a country and energy issues are at the core of social, environmental and economic security challenges. The world is experiencing an economic downturn and in these dire times, individuals and institutions are more likely to consider options for renewable energy or other measures that help the environment. As the demand for the world's fossil fuel increases and with their price increase, interest has rightly begun to be given to the development of renewable energy sources. The search for energy alternatives involving locally available renewable resources is one of the main concerns of governments, scientists and business people worldwide [1].

One of the problems faced by the world today is management of all types of waste and energy crisis. Rapid growth of population, uncontrolled and unmonitored urbanization has created serious problems of energy requirement and solid waste disposal. In response to these problems the need for alternative renewable energy sources from locally available resources cannot be over emphasized. Biomass such as agricultural wastes, municipal waste, and green waste (kitchen waste) present a promising renewable energy opportunity. Kitchen waste comprises high fraction of organic matter which causes environmental and health risks, hence the need for a strong appropriate management system. Inadequate management of waste like uncontrolled dumping has several consequences, it is not only polluting surface water and ground water through leachates it also promote the breeding of flies and other diseases bearing vectors, and emits unpleasant odor and methane which is a major greenhouse gas contributing to global warming. Biological conversion of biomass to methane has received an increasing attention in recent years. There are many technologies such as incineration and Refuse Derived Fuel (RDF) for producing energy from solid waste. Among them anaerobic digestion has become a promising technology particularly for recovery of energy from organic fraction of solid wastes. Anaerobic digestion is a potential environmental friendly technique, producing energy in form of biogas and residue, which can be used as soil conditioner [2].

Waste minimization and energy generation is the recent emerging concepts. The conventional energy resources are declining now a days, hence a suitable substitute for conventional resources are being explored. Resource recycling and energy saving systems for processing organic solid waste in urban areas need to be established. The advantages of such processes over conventional aerobic processes are low energy requirement for operation, a low initial investment cost and a low sludge production. Food waste (falls into a broader category of biodegradable waste) means all sorts of food wastes coming from restaurants, catering facilities and as well as home kitchens. Kitchen waste makes up a significant part of biodegradable waste and thus it should be further processed [3].

Organic matter present in wastes and in sludge can be degraded biologically by using anaerobic bacteria. Anaerobic digestion has been used for stabilizing waste water sludge for over 60 years. However the process is unreliable. The lack of sufficient training has contributed to the unsatisfactory use of the anaerobic digestion process. The key to efficient anaerobic digestion is to develop and maintain a large stable, viable population of methane forming bacteria. It is necessary to provide: (1) Adequate contact between the bacterial population and appropriate nutrient sources in the substrate (i.e. efficient mixing) ; (2) a suitable uniform environment; and (3) sufficient bacterial retention time. Most problems encountered in anaerobic digestion are associated with no uniform, unstable, or other unusual conditions in the feed or in the reactor itself. Proper attention to these three key factors will minimize such problems. To begin the discussion of process fundamental, it is useful to formulate a check list of key factors that govern bacterial growth. Favourable condition relative to all of the following factors will maximize the chances for achieving optimum design and efficient operation:(1) pH (2) Temperature control (3) Homogeneous mixing (4) Concentration of proper nutrients (5) absence (or assimilation) of Toxic materials (6) Feed characteristics (7) Retention time. The Bio-gas (mainly mixture of methane and Carbon dioxide) is produced / generated under both, natural and artificial conditions. However for Techno-economically-viable production of biogas for wider applications the artificial system is the best and convenient method [4].

Biogas refers to a gas made from anaerobic digestion of kitchen waste. Methane is a clean energy one of the constituent of biogas which has a great potential to be an alternative fuel. Abundant biomass from various institutions could be a source for Methane production where combination of waste treatment and energy production would be an advantage [5].

Among the many bio-energy related processes being developed, those processes involving microorganisms are especially promising, as they have the potential to produce renewable energy on a large scale, without disrupting strongly the environment or human activities. Anaerobic digestion (AD) is a technology widely used for treatment of organic waste for biogas production. Anaerobic digestion that utilizes manure for biogas production is one of the most promising uses of biomass wastes because it provides a source of energy while simultaneously resolving ecological and agrochemical issues. The anaerobic fermentation of manure for biogas production does not reduce its value as a fertilizer supplement, as available nitrogen and other substances remain in the treated sludge [6].

Characteristics of Kitchen Waste

The production of methane during the anaerobic digestion of biologically degradable organic matter depends on the amount and kind of the material added to the system. Kitchen waste (KW) is organic matter which discarded from restaurants, hotels and house. Generally KW is not segregated from other solid waste from the source. KW is disposed along with Municipal Solid Waste (MSW) which is generally dumped. Dumping of such waste can cause fire hazard in landfill site due to generation of methane and other inflammable gases. KW along with other MSW causes public health hazard and other issues like flies, air pollution etc. Kitchen waste can be best utilized for waste to energy process as it is having high calorific volume. Many researchers have worked in different types of kitchen waste from residence, vegetable market etc. [7][8][9]. The vegetable waste is also organic matter which leftover from vegetable markets, restaurant, house, hotel. Vegetables are source of proteins, vitamins, minerals, dietary fibers, micronutrients, antioxidants, carbohydrates. The vegetable waste is a very serious issue. The vegetable waste disposal methods include dumping in municipal landfills, spreading on land and by feeding to animals. These methods results in many issue like dieses (cholera, malaria, and typhoid), insect, hazards, water pollution, air pollution and land pollution [10][11].

Characteristics of Biogas and Cow Manure

Biogas is an odourless and colourless gas. It burns with pale blue flame. Biogas is about 20% lighter than air, has an ignition value 750^0C, it burns with blue flame similar to liquefied petroleum gas its caloric value is 20 mega joules per cubic metre (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, LGP, diesel, and electricity depending on the nature of the task, and local supply condition. Anaerobic digestion effluent has superior nutrient qualities over normal organic fertilizer; 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 [12]. Some characteristics of Cow Manure reported by different researchers include: 16% TS [13], 77% moisture content [14], 9.3% TS and 80.3% VS [15].

II. Methods of Kitchen Waste Degradation

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), and Sulphur (S) to form variety of organic compounds such as carbohydrates, proteins and lipids. In nature microorganisms, through digestion process breaks the complex carbon into smaller substances. There are 2 types of digestion process:

i. Aerobic digestion.

ii. 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" 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/m3 which when burned at normal room temperature and presents a viable environmentally friendly energy source to replace fossil fuels (non-renewable).

There are two types of processes for anaerobic fermentation, 1stone is the Continuous and 2ndone is batch. A continuous process is suitable for the material which is free-flowing and for the batch process is used for light materials. Biogas digester 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. Biogas technology is particularly valuable in agricultural residual treatment of animal excreta and kitchen refuse (residuals) [12].

Gujalwar et.al. (2014) has studied generation of biogas in combination of kitchen waste and cow dung. They have used 20 liters air tight anaerobic digester for digestion of kitchen waste. The digester was installed in Environmental Engineering laboratory of Civil Engineering, Department, at Jagadambha College of Engineering and Technology, Yavatmal, India. Potato chips used as kitchen waste and cow dung used as an inoculums. They concluded that mixing of extra bacterial seed improves digestion of kitchen waste and production of bio gas, generation of biogas increased by stirring of the mixture for homogeneous mixing of substrate with bacteria present in anaerobic bacteria. They concluded that biogas produced for 500 ml food slurry has increased by about 70 ml for successive twelve days, biogas has increased with maximum use of cow dung in food slurry with use of lab stirrer than without use of lab stirrer [4].

Reddy et.al. (2017) has studied Bio Gas Generation from Biodegradable Kitchen Waste**.** Kitchen waste like vegetable peelings, fruit peelings, and Food waste collected from Siddartha Nagar, Kandivili East at Radha Residence CHS of 300 families with a population about more than 1200 people living in Mumbai city**.** From the house hold Survey and from the society office registers it has been investigated that on an average 400 kg of organic waste is collected from house to house. The fresh kitchen waste is mixed with cow dung and water to prepare slurry. The ratios are 40% kitchen waste plus10% cow dung and 50% water. They concluded that 75:25 Ratio of food waste and cow dung will provide more efficient gas. Fulfill the demand and supply for energy sources can be reduced by converting Bio degradable kitchen waste into a biogas [16].

Tanimu et.al. (2014) completed a study on effect of carbon to nitrogen ratio of food waste on biogas methane production in a anaerobic digester. Food wastes were collected from Taman Sri Serdang, Selangor, Malaysia. Food waste (raw chicken meat/ beef (5%), kitchen wastes such as rice and noodles (77%), leafy vegetables/ salad (7%), soup (6%) cooked meat/fish (5%)),vegetable waste (baby corn (5%), lettuce (24%), carrot (5%), broccoli (18%) and green leafy vegetables (48%)), fruit waste (papaya (27%), orange (19%), pineapple (39%), watermelon (11%) and berries (4%)) was collected for produce biogas. They concluded that methane composition of biogas increased with increasing C/N ratio with the highest methane composition of 85% obtained during the digestion of feedstock 3 with C/N ratio of 31. Similarly, the treatment efficiency of food waste during the digestion also increased from 69% to 74%, for C/N ratio of 17 to 26, respectively and to the highest value of 85% at C/N ratio of 30. It can be resulted that increase in C/N ratio of food waste resulted to better pH stability and enhanced methanogenic activities [17].

OjikutuAbimbola O, OsokoyaOlumide O (2014) has studied Biogas production from kitchen waste. Food waste includes yam peels, plantain peels, orange rind and fish waste was collected for bio gas production. Mixture of these waste were carried out in batch type digester for 70 days digestion period. They resulted that the food waste type had significant($P \leq 0.05$) effect on substrate temperature and pH but had no significant ($P > 0.05$) effect on biogas production. The mean value of biogas production was in the range of 1090 ml/day and 8016.67 ml/day. The study concluded that anaerobic digestion of the mixture of the FW enhanced biogas production although not significantly ($P > 0.05$) [9].

Dhanalakshmi Sridevi V and Ramanujam R.A. (2012) has studied Biogas Generation in a Vegetable Waste Anaerobic Digester**.** Nine reactor of 500 ml capacity lab scale batch reactors are used for generation of biogas at koyembedu, Chennai, India. Carrot, beans and brinjal having pH 5.4, 5.8 and 5.7 and moisture content 89.8%, 90.29% and 89.4% respectively were chosen for the study of generation of bio gas. Daily generation of biogas was measured by water displacement method. It can be concluded that vegetable waste contain high carbohydrates are responsible to anaerobic digestion process and maximum gas production occurred during 5 to 10 days of digestion. Carbohydrates have been broken down much faster than protein and fats present in the vegetable waste and produced gas [10].

Patil V.S, Deshmukh H.V.(2015) has studied Anaerobic digestion of Vegetable waste for Biogas generation. They concluded that VW have high carbohydrate and high moisture content. It is a good substrate for the production of biogas through biomethanation**.** Biogas yield reported is in the range of0.360 L/g of VS to 0.9 L/g VS added. The biogas yield is affected by temperature, pH, organic loading rates and design of reactor. Biomethanation process reduces the load of organic pollutants in reduction of total solids, volatile solids, bio chemical oxygen demand and chemical oxygen demand [11].

Muhammad Rashed Al Mamun, Shuichi Torii (2015) has studied Production of Biomethane from Cafeteria, Vegetable and Fruit Wastes by Anaerobic Co-Digestion Process. The study was conducted to determine the optimal mixing ratio of cafeteria, vegetable waste and fruit waste in generation of biogas and methane yield using batch type anaerobic digester at mesophilic temperature. The higher methane contents and yields were obtained from the Cafeteria waste: Vegetable Waste: Food Waste (1.0:1.0:1.0) mixture ratio than those from the Cafeteria waste: Vegetable Waste: Food Waste (1.5:0.5:1.0, 1.0:1.5:0.5, and 0.5:1.0:1.5). it can be Concluded that maximum yield within 35 days hydraulic detention time without inoculums added [18].

Authors	**Year**	**Parameters Studied**	**Methodology**	**Reference**
S. Sharada et al.	2016	Effect of percent solids on biogas yield	Anaerobic digestion	[19]
Ogur et al.	2013	Active slurry volume and slurry displacement in digester	Anaerobic digestion in concrete underground tank	[1]
P.A.Gadge et al.	2014	Size of biogas plants based on availability of biodegradable materials and Consumption of Biogas	Anaerobic digestion	[20]
Rama Dhanariya et al.	2015	Effect of pH and temperature on Biogas production	Anaerobic digestion	[3]
Shrinvasa Reddy N. et al.	2017	Effect of ratio of food waste to cow manure on biogas production	Anaerobic digestion Experimental method	[16]
Amarkumar das et al.	2017	Temperature, Pressure, Solid Concentration and Loading Rate, pH	Anaerobic digestion Theoretical Method	[21]
N. H. S. Ray et al.	2014	Different techniques for CO, H_2S scrubbing, biogas production from organic wastes, its' composition and properties for use in C.I Engines	Anaerobic digestion	[22]
Aisha abubakar et al.	2017	Biogas Potential of some selected kitchen waste Parameters like pH, total solids (Ts), volatile solids (Vs), moisture content and Ash content are studied	Anaerobic digestion	[2]
A. Apte et al.	2013	Moisture content Ash Content Volatile Matter Calorific Value	Analytical method The Questionnaire	[8]
Jasleen Bhatti at el.	2015	pH Ammonia (NH_3) C/N Ratios Water Hyacinth kitchen waste	Anaerobic Digestion	[23]
Laxman Lama et al.	2012	pH, C/N Ratios, Burn time	Anaerobic digestion of Kitchen waste using modified ARTI Model	[24]
Mh. Rashed al mamun et al.	2015	Cafeteria, vegetable and fruit wastes and their different ratios for fermentation slurries	Anaerobic co-digestion process	[18]
Ziana Ziauddin et al.	2015	Temperature, Solid Concentration, pH	Analytical method and Anaerobic method	[12]
Rajib Bosu et al.	2016	human waste, kitchen waste and sun-shine for Biogas and its impact on energy cost on a university campus	Analytical method	[25]
V. D. Gujalwar et al.	2014	Different proportions of food waste and cow dung, effect of mixing and bacteria addition rate	Experimental anaerobic digestion method	[4]
S. Mohan et al.	2013	pH, BOD, COD acidity and alkalinity.	Experimental anaerobic digestion method Upflow Anaerobic Sludge Blanket (UASB) Reactors	[5]

L. Deressa et al.	2015	Fruit and vegetable wastes mixed with different wastes Total solids (TS) Volatile solids (VS)	Anaerobic digestion	[26]
N. Riar et al.	2013	pH, temperature & TS%, and treatability of kitchen wet waste and biogas production	Anaerobic digestion	[27]
Ms Awasif Saadi et al.	2016	Temp, no of days, Methane Gas Produced from Grain, Fruit and Vegetable wastes	Anaerobic digestion	[28]
R. P. Agrahari et al.	2014	pH, slurry temp, ambient temp and utilization of organic waste	Anaerobic digestion	[29]
Kumar V.N.S.V. et al.	2016	pH, temperature & TS%,	Anaerobic digestion	[30]
Tamrat Aragaw et al.	2013	cattle and rumen fluid as in columns, pH, TS, VFA	Anaerobic Co-digestion	[6]

III. Conclusion

The gap between demand and supply for energy sources can be reduced by converting Bio degradable kitchen waste into a biogas. It is a source of renewable green energy. Anaerobic digestion is a proven technology for processing source-separated organic wastes and has experienced significant growth. The anaerobic digestion is the excellent opportunity to produce an alternative fuel, which can be used for the local purposes like cooking, lighting, and generation electricity, managing the waste accumulation and to obtain organic fertilizer. As well as, it is a good way to reduce the waste from our society, hence, reduce the radiation of the harmful gases that affects the atmosphere and cause many environmental problems such as global warming. Even though AD is effective, there are problems associated with the application of this technology in diverting organics from the landfills and composting facilities. Additional difficulties in the operation of AD plants are due to the problem of getting fairly clean feedstock what on the other side is crucial factor for the compost quality and the overall efficiency of the AD process. It is therefore, very important to exercise the discipline required to minimize contamination of source-separated organic wastes and for the AD process to include extensive pre-treatment for contaminant separation. Further research is necessary to collect additional data on the use of the Anaerobic Digester using kitchen wastes.

Also, further experiments should be performed for identifying the optimum operating parameters for producing higher concentrations of VFAs in the liquid product of an acetogenesis reactor. In addition, technical and economic feasibility studies of the environmental and economic aspects of the industrial application of this process alternative should be carried out.More research in the field of biogas production is required and its sustainability must be considered in the global renewable scenario. The operational conditions and parametric stabilization imparts a vital role for its vast productivity. There is need, further to investigate the cost economics and utility returns to establish the plant and running the unit for 365 day a year at residential community level.

References

[1]. Ogure E. O. and Mbatia S., "Conversion of kitchen waste into biogas", The International Journal of Engineering and Science, Vol. 02, 11, 70-76, 2015.

[2]. Abubakar Aisha Aliyu, "Biogas potential of same selected kitchen waste", American Journal of Engineering Research, Volume-6, Issue-5, pp-53-63, 2017.

[3]. Rama Dhanariya, Dr. Sarita Sharma**,** Dr.Sharma,A,Dr.Verma,S, "A study of biogas production from different kitchen waste", International Journal of Chemical and Physical Sciences, 04, 01, pp-21-25, 2015.

[4]. Gujalwar V. D., M. Iqbal, "Innovations in Generation of Bio-Gas From Kitchen Food Waste And Cow Dung"**,** IOSR Journal of Mechanical and Civil Engineering, 29-31, 2014.

[5]. S. Mohan and K. Jagadeesan, "Production of Biogas by using food waste", International Journal of Engineering Research and Applications, Vol. 3, Issue 4, Jul-Agu 2013, pp. 390-394, 2013.

[6]. T. Aragaw, M. Andargie, A. Gessesse, "Co-digestion of cattle manure with organic kitchen waste to increase biogas production using rumen fluid as in columns",International Journal of Physical Science, Vol. 08(11), 443-450, 2013.

[7]. Suyog Vij, "Biogas Production From Kitchen Waste", Department of Biotechnology & Medical Engineering, 2011.

[8]. 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, 2013..

[9]. Ojikutu Abimbola O., Osokoya Olumide O., "Evaluation of Biogas Production from Food Waste"**,**The International Journal of Engineering and Science (IJES), 3, 1-07, 2014.

[10]. Dhanalakshmi Sridevi V. and Ramanujam R. A., "Biogas Generation in a Vegetable Waste Anaerobic Digester: An Analytical Approach", Research Journal of Recent Sciences, 1(3), 41-47, 2012. ,

[11]. Patil V. S. and Deshmukh H. V., "Anaerobic digestion of Vegetable waste for Biogas generation: A Review", International Research Journal of Environment Sciences, 4(6), 2015, 80-83.

[12]. Ziana Ziauddin, Rajesh P., "Production and Analysis of Biogas from Kitchen Waste", International Research Journal of Engineering and Technology (IRJET), Volume: 02 Issue: 04 | July-2015, 622-632.

[13]. Nusara W. J. Environ. Sci. 2007, 19, 1025-1027.

[14]. Graunke R., "Food and Fuel; Biogas Potential at Broward Dinig Hall", Soil and Water Science Department University of Florida-IFAS. 2007.

[15]. Chua, K. H. Yip, C.H and Nie, W. L. S. "A Case Study on the Anaerobic Treatment of Food Waste and Gas Formation", 2008.

[16]. Srinvasa Reddy N., Satyanarayana. S. V. and Sudha. G, "Bio Gas Generation from Biodegradable Kitchen Waste", International Journal of Environment, Agriculture and Biotechnology (IJEAB), 2, 2017

[17]. Musa I. Tanimu, Tinia I. Mohd Ghazi, Razif M. Harun, and AzniIdris, "Effect of Carbon to Nitrogen Ratio of Food Waste on Biogas Methane Production in a Batch Mesophilic Anaerobic Digester", International Journal of Innovation, Management and Technology, 5, 2014.

[18]. Muhammad Rashed Al Mamun and Shuichi Torii, "Production of Biomethane from Cafeteria, Vegetable and Fruit Wastes by Anaerobic Co-Digestion Process", Journal of Clean Energy Technologies, 3, 2015, 5

[19]. Sharada S., Hemalata K., "production of biogas from kitchen waste",International Journal of Scientific Development and ResearchIJSDR,01,07,218-221,2016

[20]. Gadge P.A., Dr.Waghmare A.C.,Ninave, V.R., "Biogas Generation Plant based on Kitchen waste material",International Journal of Engineering Trends and Technology,08,03,154-158,2014.

[21]. Amar Kumar Das, Shovan Nandi, Subrat Kumar Patra,"Scope of biogas from kitchen waste", International Journal of Latest Engineering and Management Research, 02, 05, pp 49-53, 2017.

[22]. Ray N.H.S., Mohanty M.K., Mohanty.R.C., "Anaerobic Digestion of kitchen waste: Biogas production, purification and Application in IC Engine", International Journal of Latest Trends in Engineering and Technology, 03,03,100-106,2014.

[23]. Bhatti J., G. N. Tiwari, "Biogas production by using kitchen waste", Journal of Basic and Applied Engineering Research, 02, 23, 2015,pp2026-2029.

[24]. Laxman Lama, Sunil Prasad Lohani, Ram Lama, and Jhalak Raj Adhikari "Production of biogas from kitchen waste", Rentech Symposium Compendium,02,pp14-18,2012.

[25]. Bosu R.,Talukdar S. K., Md. Abu Zahed, "Biogas Utilization from Biomass and Kitchen waste and its Impact on Energy cost on a University campus", AJER,05,11,150-157,2016

[26]. Daressa L.,Libsu S.,Chavan R.B., Manaye D.,Dabassa A., "Production of Biogas from fruit and vegetable wastes mixed with different wastes", HRPUB, 65-71, 2015.

[27]. Riar N., Dr. Khitoliya R. K. and Dr. S. Kumar, "A study of treatability of kitchen wet waste and Biogas production", International Journal of Computational Engineering Research, 03, 06, 62- 65, 2013.

[28]. Ms Awasif J. M., Al Saddi and Dr. Rao, L. N.,"Design and Production of methane gas from food waste using Anaerobic Digestion", GRD Journals- Global Research and Development Journal for Engineering, 01, 08, 77-82, 2016.

[29]. Agrahari R. P., Tiwari G. N., "Comparitive study of biogas production: Utilization of organic waste", International Journal of Environment and Resource, 03, 01, 01-06, 2014.

[30]. Kumar V. N. S.V., "The production of Biogas using kitchen waste", IJSER, 07, 09, 528-534, 2016.