IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 7.301
Volume 3, Issue 1, February 2023

Utilization of Biomass for Production of Biogas – An Overview

Dr. Nitin W. Ingole[1], Vaibhav R. Dhawale[2], Waman P. Bhave[3]
Professor & Dean (R&D), Department Civil Engineering[1]
Research Scholar, Department of Civil Engineering[2]
Student, M.E. Environmental Engineering, Department of Civil Engineering[3]
Prof. Ram Meghe Institute of Technology and Research, Badnera, Amravati, Maharashtra, India

Abstract: *India is a developing country comprising more than one-sixth of the world's population. Solely due to this reason there is a large dependence on energy resources for meeting the daily requirements particularly the fossil fuels which are generally regarded as undesirable for several reasons. Among the various other energy resources available, biogas has emerged as a promising fuel for the future with numerous advantages. This paper throws light upon the progress of biogas technology in India, suggesting how this valuable potent resource can be used for future sustainability. This study can be helpful in implementing biogas technology in many rural areas across India thereby establishing social and economic stability. Biogas is produced by anaerobic digestion of manure, energy crops (mainly maize), wastewater treatment sludge and organic waste. Biogas is a renewable energy source. Sustainability requirements are increasingly important. As a greenhouse gas, methane is 25 times stronger than carbon dioxide, so small leakages of biogas have a strong negative effect on the total greenhouse gas performance of the energy production pathway. This chapter covers an overview from the literature concerning methane emissions from different steps in the biogas production chain with reference to relevant selected articles.*

Keywords: Renewable energy, Anaerobic digestion, Biomass, Biogas, Energy crops.

I. INTRODUCTION

The renewable energy sources are one of the essential for the sustainability of the globe. India is the sixth largest fossil fuel consumer. The dependence of other countries for fossil fuels creates barriers in implementing unbiased political strategies. So biogas and other renewable energy sources have their relevance. The cost factor is one of the advantages of biogas. The government is in right direction for the implementation of biogas as fuels. But India has an infinitely extensible canvas synchronising with agricultural sector. Biogas has been found to be an eco-friendly fuel which can cater all the requirements of the present scenario in India. From being an easily producible fuel to an eco-friendly one, it can be used for cooking, heating, lighting and running small I.C engines. This is eligible in fulfilling the basic needs of an Indian household to managing waste from society [1] Biogas is a renewable energy source. Sustainability requirements are increasingly important. One of the requirements is the greenhouse gas performance of the energy production pathway. For AD, three greenhouse gases are important in this: carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O).Since biogas contains about 60% methane, this gas is especially important in biogas production pathways. As a greenhouse gas, methane is 25 times stronger than CO2 so small leakages of biogas have a strong negative effect on the total greenhouse gas performance of the energy production pathway.[2] The main objective of this review is to give an insight and update of the state of biogas technology research in some selected Indian states in peer reviewed literatures by highlighting the production of Biogas, Factors affecting its generation from various organic matters like food wastes, kitchen wastes, municipal wastes and also strengths and weaknesses in biogas research and development capacity. In Modern age the extensive demand for fossil fuels becomes a threat to the environment and a challenge for researchers. Some alternative renewable sources like Methanol, Ethanol, Hydrogen, Natural Gas, LPG, CNG, LNG, Biogas and Biodiesel, plastic fluids, etc which may be produced at a reasonable cost from various wastes. The fuels extracted from refused food wastes may be used either for running IC engines or cooking purposes at a very low cost. [3] Due to the increase in population, both developed and developing countries are facing mainly issues surrounding the future energy security and a better use of natural resources. Such present and future energy problems can be solved by the use of renewable energy sources. Among several renewable energy sources is a sustainable means of anaerobic digestion (AD) for production of gases. In the past, AD as a source of biogas was used mainly for degradation of waste materials or toxic compounds. However, recently, there has been great interest in producing biogas from energy crops. This paper presents an overview of state-of-the-art and future viewpoints related to the AD process for biogas production.[33]The prospectus and problem of bioenergy have many ramifications. Each and every component of biomass can prove an exhaustible resource of energy provided the same is tapper properly. Full understanding of nature and depth of bioenergy can make it a potent instrument for social and economic development of a particular region.[22] Many countries are adopting environmental policies promoting the production and consumption of alternative, sustainable and renewable energy sources. Among these sources is green energy production through the anaerobic digestion of agricultural feedstock, like animal manure and food industry by-products, mainly aimed at producing biogas. Nevertheless, only a very small part of the biogas potential is currently used, while many European countries are facing huge problems caused by the overproduction of organic waste from industry, agriculture and households. Biogas production is an excellent way of using organic waste for energy generation, followed by the recycling of the digested substratum (digestate) as fertiliser. Many factors, like chemical composition and pH of raw materials, environmental temperature and microbial composition, influence the efficiency and reliability of the anaerobic digestion process.[29]

II. BIOMASS CHARACTERISTICS

Sunil Kumar Srivastava [2020] The review suggests solid waste can be used as an economical and sustainable source of renewable energy. It can effectively replace an existing source of energy in significant proportions. In the primary stage, the characterization of solid waste should be carried out, followed by the removal of contaminants just before pre-treatment of organic solid waste. Various techniques of pre-treatment invented by the researcher can be used for the pre-treatment of segregated organic solid waste. These pre-treatment techniques improve the putrescibility of organic solid waste caused by enhancement in the efficiency of an anaerobic digester. The putrescibility of solid waste along with residence time plays a major role in biogas production.[18]SeyedehAzadehAlavi-Borazjani, Luís A. C. Tarelho, Isabel Capela (2021) investigated on Utilization of Biomass Ash in Biogas Production and Purification.Biomass ash is a complex solid matter remaining after the combustion of biomass under laboratory or industrial conditions. The ash content or ash yield of different biomass groups varies in the range of 0.1–67%wt. (mean 7.2%wt.), which usually decreases in the following order: animal and human biomass wastes>aquatic biomass>contaminated biomass and industrial biomass wastes (semi-biomass)>herbaceous and agricultural biomass> wood and woody biomass. Typically, the ash content of biomass sources is much lower than for coal (mean around 21%wt.).The raw biogas obtained from the AD process of organic matter contains some impurities such as water vapour, dust, hydrogen sulfde (H2S), CO2, siloxanes, hydrocarbons, NH3, carbon monoxide (CO), nitrogen (N2), oxygen (O2), and halogenated volatile organic compounds. The presence of these impurities in biogas may have various detrimental effects such as clogging, corrosion, reducing the biogas calorifc value, and environmentally hazardous emissions .Therefore, it is essential to remove biogas impurities prior to any final utilization.[30]K Sivabalan, Suhaimi Hassan, HamdanYa and JagadeeshPasupuleti (2020)Biomass can be sorted from various sources such as municipal solid waste (MSW), agricultural crops, crop residues, and forest residues. The clear cut of biomass characteristics in proximate analysis and ultimate analysis makes it possible to produce reliable energy resources. Biomass is multi-faceted fuel; thereof, it produces biofuel, which can be used in transportation and bioenergy to generate cleaner and affordable electricity throughout the world. In that sense, in this article, the characteristics and functionality of different thermochemical processes such as direct combustion and gasification have been discussed, and the reliability and new findings in various aspects in the bioenergy field.[40]

III. BIOMASS AND SUSTAINABILITY

Moses Jeremiah Barasa Kabeyi and Oludolapo Akanni Olanrewaju (2022) on Biogas Production and Applications in the Sustainable Energy Transition. This study presents the pathways for use of biogas in the energy transition by application in power generation and production of fuels. Diesel engines, petrol or gasoline engines, turbines, microturbines, and Stirling engines offer feasible options for biogas to electricity production as prme movers. Biogas fuel can be used in both spark ignition (petrol) and compression ignition engines (diesel) with varying degrees of modifications on conventional internal combustion engines. In internal combustion engines, the dual-fuel mode can be used with little or no modification compared to full engine conversion to gas engines which may require major modifications. Biogas can also be used in fuel cells for direct conversion to electricity and raw material for hydrogen and transport fuel production which is a significant pathway to sustainable energy development. Enriched biogas or biomethane can be containerized or injected to gas supply mains for use as renewable natural gas.[26]Azeem Hafiz P, Rashid Ahamed, Muhamed S, Sharukh (2016) Study of Biogas as a Sustainable Energy Source in India. Biogas is a gaseous fuel which is obtained from biomass by means of fermentation of wet organic matters. Biogas is clean as it does not release additional carbon into the atmosphere on burning and reduces greenhouse effect. Therefore it is eco-friendly and less polluting. All these factors effectively convey how biogas can become a sustainable source of energy in India.[1] Kamrun Nahar (2012) on Biogas Production from Water Hyacinth Sustainability generally depends on the socio-economic development of a country and the availability and consumption of energy. The available sources of energy can be classified into non-renewable and renewable. In the renewable account, the energy is being deposited everyday whereas the non- renewable energy deposits are continuously depleted by our withdrawals. Due to continuous depletion in the natural resources by an increased consumption of the energy, alternatives of fossil fuels must be searched out. Bioenergy is the only alternative and cheap source of energy which can be made available especially for the rural agricultural people of Bangladesh. This paper describes the various uses of an important energy crop, Water hyacinth and the production of biogas using it as a feedstock, which could be collected from the water body and converted to gas, fertilizer and many other useful products [20] Moses Jeremiah Barasa Kabeyi and Oludolapo Akanni Olanrewaju (2022)on Biogas Production and Applications in the Sustainable Energy Transition. This study presents the pathways for use of biogas in the energy transition by application in power generation and production of fuels. Diesel engines, petrol or gasoline engines, turbines, microturbines, and Stirling engines offer feasible options for biogas to electricity production as prme movers. Biogas fuel can be used in both spark ignition (petrol) and compression ignition engines (diesel) with varying degrees of modifications on conventional internal combustion engines. In internal combustion engines, the dual-fuel mode can be used with little or no modification compared to full engine conversion to gas engines which may require major modifications. Biogas can also be used in fuel cells for direct conversion to electricity and raw material for hydrogen and transport fuel production which is a significant pathway to sustainable energy development. Enriched biogas or biomethane can be containerized or injected to gas supply mains for use as renewable natural gas. Biogas can be used directly for cooking and lighting as well as for power generation and for production of Fischer-Tropsch (FT) fuels. Upgraded biogas/biomethane which can also be used to process methanol fuel. Compressed biogas (CBG) and liquid biogas (LBG) can be reversibly made from biomethane for various direct and indirect applications as fuels for transport and power generation. Biogas can be used in processes like combined heat and power generation from biogas (CHP), trigeneration, and compression to Bio-CNG and bio-LPG for cleaned biogas/ bio methane [26] Peter Weiland (2010) on Biogas production Biogas production in the agricultural sector is a very fast growing market in Europe and finds increased interest in many parts of the world. In the next few decades, bioenergy will be the most significant renewable energy source, because it offers an economical attractive alternative to fossil fuels. The success of biogas production will come from the availability at low costs and the broad variety of usable forms of biogas for the production of heat, steam, electricity, and hydrogen and for the utilization as a vehicle fuel. Many sources, such as crops, grasses, leaves, manure, fruit, and vegetable wastes or algae can be use, and the process can be applied in small and large scales. This allows the production of biogas at any place in the world [28]

IV. ENVIRONMENTAL ISSUES OF BIOMASS

Amir Izzuddin Adnan, Mei Yin Ong, Saifuddin Nomanbhay, Kit Wayne Chew and Pau Loke Show (2019) studied on Technologies for Biogas Upgrading to Biomethane .The environmental impacts and high long-term costs of poor waste disposal have pushed the industry to realize the potential of turning this problem into an economic and sustainable initiative. Anaerobic digestion and the production of biogas can provide an efficient means of meeting several objectives concerning energy, environmental, and waste management policy. Biogas contains methane (60%) and carbon dioxide (40%) as its principal constituent. Excluding methane, other gasses contained in biogas are considered as contaminants. Removal of these impurities, especially carbon dioxide, will increase the biogas quality for further use.

Integrating biological processes into the bio-refinery that effectively consume carbon dioxide will become increasingly important. Such process integration could significantly improve the sustainability of the overall bio-refinery process. The biogas upgrading by utilization of carbon dioxide rather than removal of it is a suitable strategy in this direction. The present work is a critical review that summarizes state-of-the-art technologies for biogas upgrading with particular attention to the emerging biological methanation processes.[17] Dr Nitin W Ingole (2015) studied on Development and Design of Biogas Plant for Treatment of Kitchen Waste One of the main environmental problems of today's society is the continuously increasing production of organic wastes. In many countries, sustainable waste management as well as waste prevention and reduction have become major political priorities, representing an important share of the common efforts to reduce pollution and greenhouse gas emissions and to mitigate global climate changes. Uncontrolled waste dumping is no longer acceptable today and even controlled landfill disposal and incineration of organic wastes are not considered optimal practices, as environmental standards hereof are increasingly stricter and energy recovery and recycling of nutrients and organic matter is aimed [19]Emma Lindkvist Magnus Karlsson and Jenny Ivner (2019) on systems Analysis of Biogas Production. Biogas production has the potential to recover nutrients and energy from organicby-products, as well as to substitute fossil fuels in the energy system. Resource efficiency relates to the economic, energy and environmental performance of the system studied. A comprehensive research design for assessment of the resource efficiency of biogas production systems is described in this paper. The research design includes the following parts: identification of cases, defining scenarios, system development, evaluation perspectives and systems analysis. The analysis is performed from three perspectives; economy, energy and environment.[27] Ali Kasap, RamazanAktas , EmreDulger (2012) Studied on Economic and Environmental Impacts of Biogas . As a result, biogas can be an alternative for closure of our country's energy deficit, keeping the national capital in the country, and preventing the emission of greenhouse gases into the atmosphere. It should be seen fertilizer as a source of energy, not a waste. Biogas, which is produced by the decomposition of animal and vegetable waste, is possible to use as a source of domestic, clean and alternative energy instead of natural gas or LPG gas for all needs by storing. Biogas for villages and farms and natural gas for our cities will be became future source of energy after a certain period of time.[21]

V. BIOMASS BASED ENERGY PRODUCTION

Nagy Valeria, SzaboEmese (2011) investigated the biogas is one of renewable energy. In fact the biogas is the indirect conversion of some solar energy stored in natural organic matter to gaseous energy carrier by anaerobic fermentation. So the biogas is the end product of the microbiological fermentation (metabolic product of the methane bacteria). It is a mixture, which consists of methane gas and carbon dioxide. Its energy content can be determined from methane quantity. Biogas and methane quantity getting from organic matter per volume depend on quality features of organic matter and also the technological parameters of the biodegradation. [5] Emma Lindkvist , Magnus Karlsson, and Jenny Ivner,(2019)Studied in Systems Analysis of Biogas Production has the potential to recover nutrients and energy from organic by-products, as well as to substitute fossil fuels in the energy system. Resource efficiency relates to the economic, energy and environmental performance of the system studied. [4] N.W. Ingole and Dr A. G. Bhole (2000) carried out work on biogas production from dried water hyacinth plant by digestion process. In this study, the raw material 'water hyacinth' the aquatic weed, is considered as a biomass for the generation of biogas because of its abundance, ready available and nuisance value. The prospects and problem bioenergy have many ramifications. Each and every component of biomass can prove an exhaustible resource of energy provided the same is tapper properly. Full understanding of nature and depth of bioenergy can make it a potent instrument for social and economic development of a particular region.[1] Yadvika , Santosh, T.R. Sreekrishnan , Sangeeta Kohli,Vineet Rana(2003) reviews on the various techniques, which could be used to enhance the gas production rate from solid substrates. Biogas technology offers a very attractive route to utilize certain categories of biomass for meeting partial energy needs. In fact proper functioning of biogas system can provide multiple benefits to the users and the community resulting in resource conservation and environmental protection. [06] Subodh Kumar Sau, Prasanta Kumar Nandi, ApurbaGiri, Tapas Kumar Manna (2013) investigated on Huge amount of tea waste is wasting from tea shop and pumpkins from the market. Human urine is unhygienic to the open environment, whereas it can be utilized as a biocatalyst for the enhancement of production of biogas from these wastes. In this study predigested tea and pumpkin wastes were treated with human urine to enhance the biogas production by improving the C: N ratio. India is an agricultural based country. Huge amount of vegetable and other organic wastes pollute the environment due to formation of natural and marsh gas known as greenhouse gas having greater global warming potential. However, this biogas is the only cheap alternative renewable source of energy. It is composed mainly of CH_4 and CO_2 .Methane has potential uses viz. as fuel, electricity generation, urea production etc. Anaerobic digestion is the process which breaks down organic matter to simple chemical component using four different stages. These are hydrolysis, acidogenesis, acitogenesis and methanogenesis. In the fourth stage acetate is converted to CH_4 and CO_2. Various works have been done by using agricultural and animal wastes to produce biogas [7] Ashenafi Tesfaye Bicks (2020) investigated under this study, daily food waste that is dropped at the backyard of the university student cafeteria is used for biogas generation. Biogas is produced when anaerobic digestion of organic matter like food waste, kitchen waste, and other biodegradable waste is digested under anaerobic condition. Biogas mainly consists of methane and carbon dioxide with a small quantity of gas such as hydrogen. It is colorless but while cooking it has a blue burning flame. The feed stoke used for conversion of biomass waste to biogas can be different depending on the availability of the waste at the local site, but the rate of methane yield depends on the property of the biomass type and digester type used. [8] Gregor D. Zupancic and Viktor Grilc (2012) Studied Most organic wastes produced today originate in municipal, industrial and agricultural sector. Municipal waste (as well as municipal wastewater sludge) is generated in human biological and social activities and contains a large portion of organic waste readily available for treatment. Agricultural waste is common in livestock and food production and can be utilised for biogas production and therefore contribute to more sustainable practice in agriculture. Industrial wastes arise in many varieties and are the most difficult for biological treatment, depending of its origin. Namely, many industries use chemicals in their production in order to achieve their product quality and some of these chemicals are present in the waste stream, which is consequently difficult to treat. [9] Sagor Kumar Pramanik , FatihahBintiSuja , Biplob Kumar Pramanik and Shahrom Bindi MdZain (2018) studied on Solid organic wastes create potential risks to environmental pollution and human health due to the uncontrolled discharge of huge quantities of hazardous wastes from numerous sources. Now-a-days, anaerobic digestion (AD) is considered as a verified and effective alternative compared to other techniques for treating solid organic waste. The paper reviewed the biological process and parameters involved in the AD along with the factors could enhance the AD process. Hydrolysis is considered as a rate-limiting phase in the complex AD process. The performance and stability of AD process is highly influenced by various operating parameters like temperature, pH, carbon and nitrogen ratio, retention time, and organic loading rate. Different pre-treatment (e.g. mechanical, chemical and biological) could enhance the AD process and the biogas yield. Co-digestion can also be used to provide suitable nutrient balance inside the digester [10] Gudina Terefe Tucho, Henri C. Moll, Anton J. M. Schoot Uiterkamp and Sanderine Nonhebel (2016) investigated on problems with biogas implementation in developing Countries from the perspective of labour requirements. Most households in rural developing countries depend on firewood from public forests or agricultural bio-wastes for cooking. Public forests, though, are declining due to an increasing population and inefficient use of wood. Use of agricultural wastes on the other hand involves loss of soil nutrients since these resources are used as a substitute for inorganic fertilizers. Biogas energy can be an alternative in providing clean energy for cooking as well as improving soil fertility with the slurry. However, the labour spent on producing biogas can limit its use as a source of energy and fertilizers. Therefore, this study aims to determine the labour requirement of different mono and co-digestion biogas energy systems. The assessment is made by using simple models involving different schemes of resources collection and transportation based on reported relevant literature.[11]Tatiana Nevzorova, Vladimir Kutcherov (2019) review on barriers to the wider implementation of biogas as a source of energy. Many countries have realised that biogas as a source of energy is an important component for sustainability transition. However, the total production volume of biogas is still relatively low. Such slow development raises a fundamental question—what are the current barriers hindering the wider uptake of biogas as a source of energy? In order to answer the question, a systematic state-of-the-art review of the barriers was conducted based on the Scopus database. The results of the review were summarised by country and were divided into two broad categories: developed and developing economies. Each group was analysed separately according to six types of barriers: (1) technical, (2) economic, (3) market, (4) institutional, (5) socio-cultural, and (6) environmental barriers. By analysing the barriers through different contexts, the most frequent and crucial constraints the biogas industry currently faces were identified and integrated into a systematic classification. In addition, possible solutions on how to overcome the most critical barriers were added. In that research work The distinguishing feature between research in developed and developing economies with respect to the implementation of biogas is that the former focus mostly on the transport sector while the latter mainly focus on domestic and agricultural biogas plants. Currently, developing countries have more barriers for biogas uptake. [12] Azeem Hafiz P, Rashid Ahamed, Muhamed S, Sharukh M (2016) Studied on Biogas as a Sustainable Energy Source in India. This paper reviews the status to biogas implementation in India. The renewable energy sources are one of the essential for the sustainability of the globe. India is the sixth largest fossil fuel consumer. The dependence of other countries for fossil fuels creates barriers in implementing unbiased political strategies. So biogas and other renewable energy sources have their relevance. The cost factor is one of the advantages of biogas. The government is in right direction for the implementation of biogas as fuels. But India has an infinitely extensible canvas synchronising with agricultural sector. The paper proposes the future strategies to be adopted by India for empowerment of biogas as a fuel.[14] Raveendran Sindhu, Parameswaran Binod, Ashok Pandey, Snehalata Ankaram, YuminDuan, Mukesh Kumar Awasthi(2019) investigated on Biofuel Production From Biomass: Toward Sustainable Development. Biogas production is an eco-friendly strategy for energy production from biomass and the residue can be used as a soil conditioner. Biogas is produced by the anaerobic biological breakdown of organic matter. It primarily consists of methane and carbon dioxide. Flammable methane is the main component of biomass (50%e85%), representing the main energy source. It can be used in boilers for heat generation. Upgraded biogas can be directly used in boilers. Biogas production from local agricultural waste using a laboratory-scale digester was evaluated. Various process variables affecting biogas production, like the nature of the feedstock and carbon-to-nitrogen ratio, were evaluated. Among the different agro-residues screened, wheat stalk, soybean straw, and black gram stalk were found suitable for biogas production.[13] Peter Jacob Jorgensen, PlanEnergi (2009) reported in biogas – green energy manual. All organic matter, with the exception of lignin, can be decomposed anaerobically to produce biogas, although the time taken to do so differs greatly. How long it takes depends on the composition of the biomass – the more complicated the molecules, the longer it takes a microorganism to break it down. Sometimes a biomass consists of a number of different substances that have an impact on the gas yield. Biogas and methane yield when carbohydrates (cellulose), proteins and fats are completely digested. [15] GudinaTerefeTucho , Henri C. Moll, Anton J. M. Schoot Uiterkamp and Sanderine Nonhebel (2016) Problems with Biogas Implementation in Developing Countries from the Perspective of Labor Requirements. The present biomass energy use in developing countries involves many aspects related to long distance traveling, indoor air pollution, soil nutrient losses, and deforestation. These factors are severe in Sub-Saharan Africa where the majority of rural households depend on common forests for the cooking energy in a traditional setting. Biogas energy can be an alternative option to provide clean energy, save time, and provide slurry enriched with soil nutrients. However, the extent to which a biogas system can save time and reduce labor also depends on the time spent on its resources collection and transportation. Biogas energy can save the time spent on firewood when all the biogas resources are available nearby and slurries are converted to compost or applied on nearby lands.[21]

VI. ANAEROBIC TRANSFORMATION OF ORGANICS WASTE

Amirhossein Malakahmad, Syazana Nasrudin, Noor Ezlin Ahmad Basri and Shahrom Md Zain (2013) Studied on Anaerobic biodegradation of Organic Fraction of Municipal Solid Waste (OFMSW) produces methane gas and useful by-product in form of slurry. The methane gas is a precious source of energy and the slurry can be used as soil amendment and crop growth improvement agent. In addition, application of anaerobic transformation techniques in any waste management system reduces considerable waste volume transported to the landfill. This volume reduction will resulted in decrease of capital costs for waste transportation, disposal as well as lands acquisition. Although the anaerobic biodegradation is a promising method for management of biodegradable waste and has many advantages over land filling and incineration, it is a complex technique and its operational conditions should be monitored well by experts throughout the process. Also quality of the gas stream and its further treatment as well as trading of the slurry in some regions would be challenging. Even though anaerobic transformation of waste is been distinguished in this study, it is an obvious fact that an integrated solid waste plan accomplished by all management and engineering tools, techniques and technologies from source reduction to waste disposal.[34] Amirhossein Malakahmad and Noor Ezlin Ahmad Basri, Shahrom Md Zain (2011) investigated on Production of Renewable Energy by Transformation of Kitchen Waste to Biogas, Case Study of Malaysia. Malaysia is still struggling to select the most appropriate method to dispose municipal solid wastes with various available alternatives such as incineration, gasification, composting and landfilling. Biological process such as anaerobic digestion could provide a vital element in an integrated solid waste management system for a community in a developing country while preserving the natural ecosystem within an acceptable cost. It was found in this study that an anaerobic system with organic loading rate of up to 20 kg/m3 d with 40 g/L slurry concentration is able to produce up to 0.6 m3 /kgVS of biogas daily. Organic waste is a resource that needs to be tapped and not to be wasted into landfills or reduced to ashes and dust in incinerators. The renewable energy produced from anaerobic digestion process can be seen as a good reason for many communities to start transformation of our valuable resources.[35] Amirhossein Malakahmad, SyazanaNasrudin, Noor Ezlin Ahmad Basri and Shahrom Md Zain on Anaerobic Transformation of Biodegradable Waste; Simultaneous Production of Energy and Fertilizer. Anaerobic biodegradation of Organic Fraction of Municipal Solid Waste (OFMSW) produces methane gas and useful by-product in form of slurry. The methane gas is a precious source of energy and the slurry can be used as soil amendment and crop growth improvement agent. In addition, application of anaerobic transformation techniques in any waste management system reduces considerable waste volume transported to the landfill. This volume reduction will resulted in decrease of capital costs for waste transportation, disposal as well as lands acquisition. Although the anaerobic biodegradation is a promising method for management of biodegradable waste and has many advantages over landfilling and incineration, it is a complex technique and its operational conditions should be monitored well by experts throughout the process. Also quality of the gas stream and its further treatment as well as trading of the slurry in some regions would be challenging. Even though anaerobic transformation of waste is been distinguished in this study, it is an obvious fact that an integrated solid waste plan accomplished by all management and engineering tools, techniques and technologies from source reduction to waste disposal.[34]

VII. TYPES OF BIOMASS AND THEIR POTENTIAL

Biomass can be any type of organic matter and it is a source/feedstock. The fuel form obtained after the processing or preparation of this biomass is called biofuel, biogas or bio-solid and the energy output is called bioenergy, which is a measure of the energy capability of the biomass used.

C. Bonechi, M. Consumi, A. Donati, G. Leone, A. Magnani, G. Tamasi, C. Rossi (2017) studied on different biomas. The term biomass indicates organic matter of plant or animal origin, spontaneous or cultivated by humans, terrestrial and marine, produced directly or indirectly through the process of photosynthesis involving chlorophyll. In general, biomass can be defined as anything having an organic matrix. Thus, the term biomass identifies a great variety of heterogeneous materials and matrices. In order to limit the range of the present analysis, we consider only biomass of plant origin and specifically agricultural and agro-industrial residues and wastes, energy crops, and forestry residues and wastes. We do not consider the problems related to land use and how energy crop production competes for land with food production. Indeed, the concept of energy from biomass regards biomass as a renewable energy product obtained as a side product of a primary product, for example, fruit tree prunings or straw as a by-product of cereal production. The potential global availability of unexploited biomass alone could provide 10%–20% of the primary energy demand of the planet.[36]

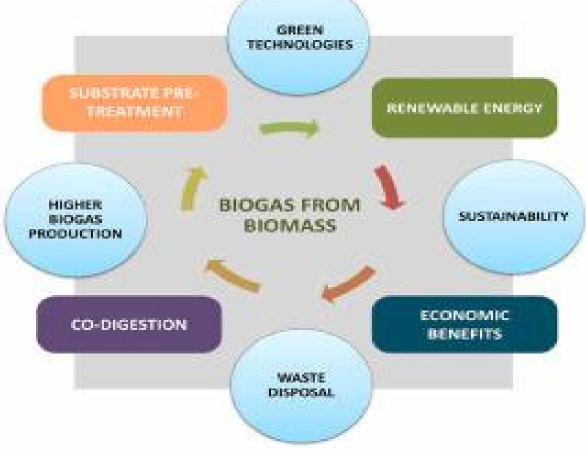

Figure 1: Biogas Production from Biomass

Archana Kasinath , Sylwia Fudala-Ksiazek , Malgorzata Szopinska , Hubert Bylinski Wojciech Artichowicz , Anna Remiszewska-Skwarek , AnetaLuczkiewicz (2021) studied on Biomass in biogas production. Biogas can be produced from agricultural residues, municipal/industrial biowastes, and sustainable biomass, especially materials that are locally available. However, in many cases, the methane yields obtained from the conventional Anaerobic Digestion process are regarded as having limited profitability. This paper summarizes the recent knowledge regarding the different strategies that are used to enhance Anaerobic Digestion efficiency and the methods to strengthen the existing incentives to overcome today's barriers to biogas production.[38]

Dr. A. G. Bhole and N. W. Ingole (2000) investigated on comparative study of Production of biogas from water hyacinth by single phasic and diphasic digestion process. Problem associated with weed growth have worsened because of water becoming enriched by fertilizer runoff and from nutrients derived from human and agricultural wastes. The concept of utilization of water hyacinth not only brings the nuisance under control but also provides energy. The present paper deals with comparative study of biogas production by using single phasic and diphasic digestion process [25] Seyedeh Azadeh Alavi-Borazjani, Luís A. C. Tarelho·Isabel Capela on the Utilization of Biomass Ash in Biogas Production and Purification. A review of the literature demonstrated that biomass ash can be successfully used to improve the two important processes of biogas production and purification. The main mechanisms involved in increasing biogas production by adding biomass ash to anaerobic digestion reactors were found to be: (i) Supplying the necessary nutrients; (ii) providing alkalinity and improving the buffering capacity of the system; and (iii) adsorption of inhibitory compounds. Also, possible mechanisms for the purification of biogas with biomass ash, depending on the type of impurities present in the biogas, were either attributed to chemical reactions that mainly result in the formation of compounds with low solubility or to physical absorption. However, despite the wide range of published results on the usage of biomass ash in various contexts, such as soil amendment and agricultural use, environmental remediation, construction and ceramic industry, and catalytic applications, little has been done on the utilisation of biomass ash in biogas technology.[30] Abdeen Mustafa Omer(2016) on Biomass and Biogas for energy generation. Biogas from biomass appears to have potential as an alternative energy source, which is potentially rich in biomass resources. This is an overview of some salient points and perspectives of biogas technology. The current literature is reviewed regarding the ecological, social, cultural and economic impacts of biogas technology. This communication gives an overview of present and future use of biomass as an industrial feedstock for production of fuels, chemicals and other materials. However, to be truly competitive in an open market situation, higher value products are required. Results suggest that biogas technology must be encouraged, promoted, invested, implemented, and demonstrated, but especially in remote rural areas. [31] Abdeen Mustafa Omer (2012) investigated on biomass and biogas for energy generation: recent development and perspectives. Biogas from biomass appears to have potential as an alternative energy source, biomass resources being available worldwide. This is an overview of some salient points and perspectives of biogas technology. The current literature is reviewed regarding the ecological, social, cultural and economic impacts of biogas technology. This article gives an overview of present and future use of biomass as an industrial feedstock for the production of fuels, chemicals and other materials. To be truly competitive in an open market situation, higher value products are required. Results suggest that biogas technology must be encouraged, promoted, invested in, implemented and demonstrated, especially in remote rural areas.[32] P. Manonmani1, R.Elangomathavan2, Mukesh Goel3 and Lurwan Muazu (2016) on Biogas Production Potential Of Different Substrate Various Combinations. The quantitative analysis of biogas production from 12 different substrates mixtures showed that the water displacement has been gradually increased from 0th to 30th day, which indicated the production of biogas in respective bio digester. There was maximum total solid and volatile solid removal in all of different substrate combinations through co-digestion. The increased pH of 30th day revealed that appropriate degradation occurred throughout the process. The maximum biogas production was achieved in food waste and cow dung (1:1) mixture in contrast to the other combination of Jatrophaand cow dung. This study concluded that the food waste + cow dung is the potential substrate mixture which could be effectively used for biogas production, which offers further advancements in biogas production technology through co-digestion in course to commercialise biogas in future.[39] N. W. Ingole and A. G. Bhole (2002) investigated on utilization of water hyacinth relevant in water treatment and resource recovery with special reference to India These varied uses of water hyacinth strengthen its claimto be regarded as a crop, and its eradication can be a profitable proposition if plants, on collection, are suitably employed. Financial outlay is moderate and it can be undertaken by either state or private enterprises. Persistent removal of water hyacinth followed by sowing with Trapanatans or Lotus sp. for a few successive years would soon result in the replacement of the water hyacinth population by the latter plants and lead finally to its extermination or controlled growth.[14]

VII. ENHANCEMENT OF BIOGAS PRODUCTION.

Mathieud Umont, Nl, L Uchienluning I SmAilyildiz, Klaa S Koo P,(2016) Studied in Methane emissions in biogas production In this chapter, emissions have been converted to a percentage of the methane that is actually utilized. These relative emissions from storage of substrates, however, depend on the feedstock mix that is applied at the AD plant. For manure, methane emissions from storage are significant, but potential biogas production is low leading to high relative emissions. For other co-substrates, the opposite is true. Since the specific biogas production from co-substrates is generally much higher than for manure, the relative emissions from the combined feedstock are much lower than for manure alone.[2] Muhammad Rashed Al Mamun and Shuichi Torii (2017) investigated on laboratory scale combined absorption and adsorption chemical process to remove contaminants from anaerobically produced biogas using cafeteria (food), vegetable, fruit, and cattle manure wastes. Iron oxide (Fe_2O_3), zero valent iron (Feo), and iron chloride ($FeCl_2$) react with hydrogen sulfide (H_2S) to deposit colloidal sulfur. Silica gel, sodium sulfate (Na_2SO_4), and calcium oxide (CaO) reduce the water vapour (H_2O) and carbon dioxide (CO_2). It is possible to upgrade methane (CH_4) above 95% in biogas using chemical or physical absorption or adsorption process. The removal efficiency of CO_2, H_2S, and H_2O depends on the mass of removing agent and system pH. The results showed that $Ca(OH)_2$ solutions are capable of reducing CO_2 below 6%. The H_2S concentration was reduced to 89%, 90%, 86%, 85%, and 96% for treating with 10 g of $FeCl_2$, Feo (with pH), Fe_2O_3, Feo, and activated carbon, respectively. [4] KhuthadzoMudzanani, Esta van Heerden, RynethMbhele and Michael O. Daramola (2021) investigated on Enhancement of Biogas Production via Co-Digestion of Wastewater Treatment Sewage Sludge and Brewery Spent Grain: Physicochemical Characterization and Microbial Community A common problem usually encountered in biogas production is low biogas yield due to the use of single feedstock, i.e., sewage sludge. Too often, sludge is either recalcitrant to digestion or has a low or high C/N ratio. This can be improved by co-digesting the sludge with a co-substrate that increases the conversion of organic solids to biogas, thus increasing the production of methane.[37] Federica Liberti, Valentina Pistolesi, Mawaheb Mouftahi, Nejib Hidouri, PietroBartocci, Sara Massoli, Mauro Zampilli and Francesco Fantozzi (2019) This study reports the results of experimental tests of anaerobic digestion on a laboratory and industrial scale, aimed at verifying and quantifying the increase in the biological efficiency of the anaerobic digestion process, in terms of biogas production and/or methane content, deriving from the use of a mix of nutrients and sucrose in an incubation pre-treatment plant. The main results show an increase of 12 v% in methane production from the industrial biogas plant when coupled with the anaerobic digester. This improvement can have significant economic advantages. In fact, this work shows that the net present value of the plant can increase about 30%. [23] Yadvika, Santosh , T.R. Sreekrishnan, SangeetaKohli, Vineet Rana (2004)Enhancement of biogas production from solid substrates using different techniques .Biogas, a clean and renewable form of energy could very well substitute for conventional sources of energy which are causing ecological-environment problem and at the same time depleting at a faster rate. This paper review the various techniques, which could be used to enhance the gas production rate from solid substrates [6] M.S. Miah , Chika Tada, Yingnan Yang Shigeki Sawayama (2005) Analysis on The enhancing effect of aerobic thermophilic (AT) bacteria on the production of biogas from anaerobically digested sewage sludge (methanogenic sludge) was investigated. Sewage sludge (5%, w/w) was incubated at 65°C with shaking for a few months to prepare the AT seed sludge. AT sludge was prepared by incubation of the AT seed sludge (5%, v/v) and sewage sludge (5%, w/w) at 65°C with shaking. The addition of this AT sludge (1.2% 0.5% of total volatile solids) to methanogenic sludge enhanced the production of biogas.[24] S. Abanades ,H. Abbaspour, A. Ahmadi, B. Das· M. A. Ehyaei, F. Esmaeilion · M. El Haj Assad, T. Hajilounezhad8 , D. H. Jamali , A. Hmida ,· H. A. Ozgoli , S. Safari , M. AlShabi , E. H. Bani-Hani(2022) Studied The resources of biogas production along with treatment methods are presented. The effect of different governing parameters like feedstock types, pretreatment approaches, process development, and yield to enhance the biogas productivity is highlighted. Biogas applications, for example, in heating, electricity production, and transportation with their global share based on national and international statistics are emphasized. Reviewing the world research progress in the past 10 years shows an increase of ~ 90% in biogas industry (120 GW in 2019 compared to 65 GW in 2010). Europe (e.g., in 2017) contributed to over 70% of the world biogas generation representing 64 TWh. Finally, different regulations that manage the biogas market are presented. Management of biogas market includes the processes of exploration, production, treatment, and environmental impact assessment, till the marketing and safe disposal of wastes associated with biogas handling.[27]

VIII. CONCLUSION

A critical analysis of literature review that there is a strong possibility to enhance the biogas production under field conditions. Biomass is a potential for energy production varies in relation to the process used, which may involve elementary or highly sophisticated technologies. Biomass is a major future sustainable energy resource of the planet. This study provides a novel contribution to the literature by analysing the existing knowledge about the possibility of enhancing the biogas. However, there are many local and national factors and site-specific experiences, which cannot be underestimated, and the improvement of AD technology should be sought with codigestion and the development of new pretreatment methods. Implementation of proper monitoring and control systems is crucial for effective biogas production with the available biomass and improved cost performance. For this reason, laboratory-scale studies followed by pilot-scale in situ studies are needed to properly evaluate the type of substrate, co-substrate and the effectiveness of feedstock pre-treatment in terms of the Anaerobic Digestion process and final digestate disposal.

National and regional strategies should stimulate further growth of biogas technology by applying biodegradable waste streams and/or sustainable biomass that does not deplete local resources, which would lead to ecological problems. The future use of biomass should be focused more on the local market and pre-treatment/codigestion to enhance biogas production via Anaerobic Digestion. The economic and energy aspects of the appropriate use of biomass and pre-treatment should be also considered.

ACKNOWLEDGEMENT

The authors are very much thankful to Principal Dr. G. R. Bamnote and Dr. P.S. Pajgade, Head, Department of Civil Engineering, Prof. Ram Meghe Institute of Technology and Research, Badnera-Amravati for providing the library facilities. The authors also express acknowledgements to SantGadge baba Amravati University, in Maharashtra, India, whose support for permission to collect literature from the library of related research has lead to the knowledge presented here.

REFERENCES

[1]. Azeem Hafiz P, Rashid Ahamed, Muhamed S , Sharukh M," Study of Biogas as a Sustainable Energy Source in India," International Journal of Research in Mechanical Engineering Volume 4, Issue 3, May-June, 2016, pg. 58-62.

[2]. Mathieu Dumont, LuchienLuning, I SmailYildiz, KlaasKoop ,"Methane emissions in biogas production " page no 248-266 DOI: 10.1533/9780857097415.2.248.

[3]. Amar Kumar Das, Shovan Nandi, Subrat Kumar Patra , "Scope of Biogas generation from Kitchen wastes and its economical adoptability," International Journal of Latest Engineering and Management Research, Volume 02 - Issue 05, May 2017 , pg :. 49-53.

[4]. Emma Lindkvist , Magnus Karlsson and Jenny Ivner, " Systems Analysis of Biogas Production—Part I Research Design," Energies 2019, 12, 926; pg :-1-12 doi:10.3390/en12050926

[5]. Nagy Valeria, SzaboEmese," Biogas from organic wastes', Seriastiintele Vietii ,Vol. 21, issue 4, 2011, pg :. 887-891

[6]. Yadvika, Santosh , T.R. Sreekrishnan, SangeetaKohli, VineetRana "Enhancement of biogas production from solid substrates using different techniques–a review,"(2004) Pg:1-10. doi:10.1016/j.biortech.2004.02.010

[7]. Subodh Kumar Sau, Prasanta Kumar Nandi, ApurbaGiri, Tapas Kumar Manna, "Enhancement of Methane Production from Tea Waste and Pumpkin Waste using Human Urine," International Journal of Science, Engineering and Technology Research (IJSETR) Volume 2, Issue 12, December 2013

[8]. Ashenafi Tesfaye Bicks "Investigation of Biogas Energy Yield from Local Food Waste and Integration of Biogas Digester and Baking Stove for Injera Preparation: A Case Study in the University of Gondar Student

Cafeteria," Journal of Energy ,Volume 2020, Article ID 8892279, 11 pageshttps://doi.org/10.1155/2020/8892279

[9]. Gregor D. Zupancic and Viktor Grilc "Anaerobic Treatment andBiogas Production from Organic Waste'', Institute for Environmental Protection and Sensors,Slovenia page 1-28.

[10]. Sagor Kumar Pramanik, FatihahBintiSuja, Biplob Kumar Pramanik and Shahrom Bindi MdZain,"Opportunity of Biogas Production from Solid Organic Wastes through Anaerobic Digestion,'' ICCEE 2018 E3S Web of Conferences 65, 05025 (2018) https://doi.org/10.1051/e3sconf/20186505025

[11]. GudinaTerefeTucho, Henri C. Moll, Anton J. M. SchootUiterkampandSanderineNonhebel,"Problems with Biogas Implementation inDeveloping Countries from the Perspective ofLabor Requirements," Energies 2016, 9, 750; Pg:1-16doi:10.3390/en9090750

[12]. Tatiana Nevzorova , Vladimir Kutcherov, " Barriers to the wider implementation of biogas as a source of energy: A state-of-the-art review," Energy Strategy Reviews 26 (2019) 100414, pg:- 1-12 https://doi.org/10.1016/j.esr.2019.100414.

[13]. [13]RaveendranSindhu, ParameswaranBinod, Ashok Pandey,SnehalataAnkaram, YuminDuan, Mukesh Kumar Awasth,"Biofuel production From Biomass: TowardSustainable Development," Current Developments in Biotechnology and Bioengineering. Pg -79-92https://doi.org/10.1016/B978-0-444-64083-3.00005-1,

[14]. N.W. Ingole and A.G. Bhole," Utilization of water hyacinth relevant in water treatment and resource recovery with special reference to India," IWA Publishing 2002 Journal ,283-296, 4 December 2001 of Water

[15]. Peter Jacob Jorgensen, Plan Energi, "Biogas – green energy," pg -1-36.

[16]. Muhammad Rashed Al Mamun and Shuichi Torii, "Enhancement of Methane Concentration by Removing Contaminants from Biogas Mixtures Using Combined Method of Absorption and Adsorption," Hindawi International Journal of Chemical Engineering Volume 2017, Article ID 7906859, pg :1-10 https://doi.org/10.1155/2017/7906859

[17]. Amir Izzuddin Adnan, Mei Yin Ong ,SaifuddinNomanbhay, Kit Wayne Chew andPau Loke Show," Technologies for Biogas Upgrading to Biomethane:A Review, Bioengineering 2019, 6, 92Pg -1-23; doi:10.3390/bioengineering6040092.

[18]. [18] Sunil Kumar Srivastava,"Advancement in biogas production from the solid waste by optimizing the anaerobic digestion," Waste Disposal & Sustainable Energy (2020) 2:pg85–103,https://doi.org/10.1007/s42768-020-00036-x

[19]. Dr Nitin W Ingole, " Development and Design of Biogas Plant for Treatment of Kitchen Waste," International Journal of research in engineering, and Science and technology,Vol-01,no-05,(2015).

[20]. Kamrun Nahar, "Biogas Production from Water Hyacinth(EichhorniaCrassipes)," Asian Journal of Applied Science and Engineering, Volume 1, No 1 (2012)pg : 9-13.

[21]. Economic and Environmental Impacts of Biogas ,"Economic and Environmental Impacts of Biogas ",Journal of Agricultural Machinary Science ,2012,8(3),271-277

[22]. Dr. Nitin W. Ingole, "Biogas from water hyacinth by triphasic digestion process," Journal of the Institution of Engineers (India): Environmental Engineering Division, Volume No.81,pg :13-16.

[23]. Federica Liberti, ValentinaPistolesi , MawahebMouftahi, NejibHidouri ,PietroBartocci, Sara Massoli , Mauro Zampilli and Francesco Fantozzi ," An Incubation System to Enhance Biogas andMethane Production: A Case Study of an ExistingBiogas Plant in Umbria, Italy,"MDPI, Processes 2019, 7, 925; doi:10.3390/pr7120925

[24]. M.S. Miah · Chika Tada · Yingnan Yang Shigeki Sawayama," Aerobic thermophilic bacteria enhance biogas production," J Mater Cycles Waste Manag (2005) 7:48–54 , DOI 10.1007/s10163-004-0125-y

[25]. Dr.Nitin W. Ingole, "Comparative study of production of biogas from water hyacinth by single phasic and diphsic digestion process"Journal of indian water work association,(2000) pg :-137-140.

[26]. Moses Jeremiah BarasaKabeyi and OludolapoAkanniOlanrewaju," Biogas Production and Applications in the Sustainable Energy Transition" Journal of Energy Volume 2022, Article ID 8750221, 43 pages https://doi.org/10.1155/2022/8750221

[27]. S.Abanades ,H. Abbaspour, A. Ahmadi, B. Das· M. A. Ehyaei, F. Esmaeilion · M. El Haj Assad, T. Hajilounezhad8 , D. H. Jamali , A. Hmida ,· H. A. Ozgoli , S. Safari , M. AlShabi , E. H. Bani-Hani,"International journal of envoirnmental science and technology (2022) 19:3377–3400, https://doi.org/10.1007/s13762-021-03301-6

[28]. Peter Weiland," Biogas production: current state and perspectives,''ApplMicrobiolBiotechnol (2010) 85:849–860 DOI 10.1007/s00253-009-2246-7

[29]. A. Comparetti, P. Febo, C. Greco and S. Orlando, "Current state and future of biogas and digestate production," Bulgarian Journal of Agricultural Science, 19 (No 1) 2013,pg : 1-14.

[30]. Seyedeh Azadeh Alavi-Borazjani1 · Luís A. C. Tarelho1 · Isabel Capela," Waste and Biomass Valorization" 1 April 2021 https://doi.org/10.1007/s12649-021-01461-7

[31]. Abdeen Mustafa Omer," An overview of Biomass and Biogas for energy generation: Recent development and perspectives "Journal of Bioscience and Biotechnology Discover Volume 1(3), pages 42-58, August 2016 https://doi.org/10.31248/JBBD2016.010

[32]. Abdeen Mustafa Omer,"An Overview Of Biomass And Biogas For Energy Generation: Recent Development And Perspectives "Cellulose Chem. Technol., 46 (7-8), 477-492 (2012)

[33]. Nathaniel Sawyerr, Cristina Trois, TilahunWorkneh,VincentOkudoh," An Overview of Biogas Production: Fundamentals, Applications and Future Research, International Journal of Energy Economics and Policy, 2019, 9(2), 105-116. DOI: https://doi.org/10.32479/ijeep.7375

[34]. Amirhossein Malakahmad, Syazana Nasrudin, Noor Ezlin Ahmad Basri and ShahromMdZain Anaerobic," Transformation of Biodegradable Waste; Simultaneous Production of Energy and Fertilizer ," American Journal of Environmental Science, 9 (2): 113-119, 2013

[35]. Amirhossein Malakahmad, Noor Ezlin Ahmad Basri, ShahromMdZain," Production of Renewable Energy by Transformation of Kitchen Waste to Biogas, Case Study of Malaysia," 978-1-4577-1549-5/11/2011IEEE

[36]. C.Bonechi,M.Consumi.A.Donati,G.Leone,A.Magnani,G.Tamasi,C.Rossi,"Biomass:AnOverview"Bioenergy systems for the Future. http://dx.doi.org/10.1016/B978-0-08-101031-0.00001-6

[37]. Khuthadzo Mudzanani ,Esta van Heerden , RynethMbhele , and Michael O. Daramola ,"Enhancement of Biogas Production via Co-Digestion of Wastewater Treatment Sewage Sludge and Brewery Spent Grain:Physicochemical Characterization and Microbial Community "Sustainability 2021, 13, 8225. Pg:1-16 https://doi.org/10.3390/su13158225.

[38]. ArchanaKasinath, SylwiaFudala-Ksiazek, MalgorzataSzopinska, Hubert Bylinski,WojciechArtichowicz, Anna Remiszewska-Skwarek, AnetaLuczkiewicz," Biomass in biogas production: Pretreatment and codigestion", Renewable and Sustainable Energy Reviews, Renewable and Sustainable Energy Reviews 150 (2021) 111509 https://doi.org/10.1016/j.rser.2021.111509.

[39]. P. Manonmani, R.Elangomathavan, MukeshGoel and LurwanMuazu Biogas Production Potential Of Different Substrate In Various Combinations," International Journal of Advanced Research in Biology Engineering Science and Technology (IJARBEST) Vol. 2, Issue 6, June 2016.

[40]. K Sivabalan, Suhaimi Hassan, HamdanYa and JagadeeshPasupuleti,"A review on the characteristic of biomass and classification of bioenergy through direct combustion and gasification as an alternative power supply," International Conference on Robotics and Artificial Intelligence,1831(2021) 012033 doi:10.1088/1742-6596/1831/1/012033

BIOGRAPHY

I am Dr. Nitin W. Ingole working as a Professor and Dean (R&D), Department of Civil Engineering, PRMIT & R Amravati. I am the PG teacher and Approved PhD guide in SantGadge Baba Amravati University, Amravati and North Maharastra University, Jalgaon. My research area is Wastewater engineering, SWM, Phytoremediation, Process design etc. I am having 33 years of teaching as well as administrative experience including 20 years of experience in research. Conferred with many academic and research awards. Presently working as Professor and Dean. Teaching Environmental Microbiology, Ad. Wastewater Treatment, Industrial Wastewater Treatment, Impact Assessment to PG. Six scholars completed their PhD and 05students are working for their doctoral thesis. Filed 8 patents and till date awarded 3 Patents

I am Vaibhav Ramkrishna Dhawale Research scholar in PRMIT&R Badnera, I am also working as a Assistant Professor in Prof. Ram Meghe college of Engineering and Management, Badnera. My research area is Biogas, Phytoremediation, Water and wastewater Engineering, I am having 13 years of teaching as well as 06 years industrial experience in various civil field.

I am Waman Pandurang Bhave, Retired Superintending Engineer (PWD) Gov. of Maharashtra. I am M.E.(Environmental Engineering) Student of PRMIT&R Badnera Amravati(Maharashtra). I am also having 30 years of experience in PWD government of Maharashtra.