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Review of Biogas Production from various substrates and Co-substrates through different Anaerobic Reactor

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ABSTRACT: The utilization of sustainable energy sources is gradually essential, when we want to reduce the global warming impacts over world. Biomass is the most well-known type of sustainable energy source, broadly utilized in the Western world. This paper surveys grass based biomethanation process, its improvement and concentration on parameters like temperature, pH, organic loading rate (OLR), hydraulic retention time (HRT), volatile fatty acids (VFA), alkalinity and gas production. A few examinations have indicated ideal biogas creation from grass in mesophilic condition considering HRT around 30 days. Generation of grass biomethane is a coordinated procedure which includes various stages with various changes. Various species of grass are developed with regular cuts by age. The fibrous content of grass increses with the growth of grass. Higher methane potential received in younger age of grass than older age of about 90 days. The percentage of Water-solvent starches (WSC) are superior when cutting obtained at the evening than the morning. The strategy for ensiling significantly affects the total solids substance in the silaging of grass. Pit silage in few countries in southern Europe having total solids matter about 40%; dried in solar temperature provides reduction in volume of grass silage. Biogas formation is recognized with mass of unstable solids as opposed to silage volume; as per the various reviews, 200-300 m^3 of methane obtained from 0.5 to 1 ton of Volatile solids. The total moistureless solids substance of the grass significantly affects the biodigester arrangement. Different pre-treatment techniques may be utilized particularly if arrangement of separate hydrolysis process set up which is completely away from methenogenesis & acidogenesis process.

Keyword: Biogas, Anaerobic Digestion, Energy Crops, Pretreatment, Anaerobic Digester & Reactor.

I. INTRODUCTION

At present exactly 80% global energy demand reach upto 400 Exa Joule per year which is fulfilled by thermal energy sources such as fossil fuels & crude oil. By around 10–15% of this demand is secured by biomass, Fluid biofuels cover just a little part, the most utilized are ethanol and biodiesel. Ethanol is delivered from energy crops, whereas biodiesel is obtained from vegetable oils. At present biogas plays a littler, however relentlessly developing part. Biogas has moved toward becoming a settled energy asset, particularly through the utilization of inexhaustible biomass i.e. "Energy crops" [48]. Since about 1950, biogas generation from energy crops kept on creating as an essential new ranch undertaking. Anaerobic digestion of energy crop in many European countries receiving ultimate production of biogas which is use as vehicle fuel, has gotten considerable enthusiasm for ongoing years [54]. The practise with regards to production and utilization of grass based biogas as a vehicle fuel or as a alternative fuel of natural energy from the beginning period in European contries like Germany & Austria [41]. Most of the conventional biogas reactors from Germany is dependent on digestion & codigestion of various species of grass and its silage with conventional crop like maize, whereas by feeding of municipal solid waste as a cosubstrate shows the significant growth in the biomethanation and improve the biodegradability rate at mesophilic as well as thermophilic range [36]. In Ireland, agriculturists are thinking about the production and commertilization of biogas as an profitable occupation compared to tanning industry, because of the lower economic profit gained in individual cultivation [52]. Grass is the most sustainable substrate and cosubstrate due to higher cultivation & harvesting of horticultural land about 91% in Ireland's declared by various energy economics and agriculturist [12]. This paper audits in detail the different procedures and methods associated with the generation of napier grass & its silage for assimilation and the potential for pretreatment. Napier grass [commonly known as Pennisetum purpureum] is a species developed basically for grazing the cattles in most part of India. Napier grass enhances soil richness and protects dry land from soil disintegration [40].

A. Characterization of Hybrid Napier Grass

For the formation of biomethane species of Hybrid Napier Grass & its silage be able to be used as a useful feedstock, particularly in Indian context, because of its high return (150 MT/Ha/Year), its long-lasting nature, the high volatile solid contents (about 90%), and ultimate biogas production [52,40]. The chemical charcterization of several parameters in napier grass noted in Table 1 [23,44].

Table 1: Chemical Composition Structure.

Parameters	Range (%)
Moisture content	75-80
Lignin	10-20
Crude protein	10-20
Ether extract	1.5-3.5
Nitrogen free extract	40-60
Total ash	10-15

In the tropical region, the grass grows all year along since ideal temperature upto 30℃ and the low rainfall substituted with clear sunlight is incredibly pleasurable and suitable for crop. The maximum rain fall requirement for the energy crop in single year is around 800-1000 mm. even though, they can grow in various natures of soils except heavily flooded land & water logged areas; and the lands light loams and sandy soils are more suitable than the heavy soils. Extra harvests are acquired from productive soil combined with high organic matter. It maintains pH range from 6 to 8.5 crude protein 10-20% and 20-35% crude fibre which represents the better quality of hybrid napier. Hybrid Napier has greeny & wider leaf consisting high water content and ability to grow throughout the year. The best part of hybrid napier is the minimum fibrous content becoming highly acceptable as a fodder & alternate crop. Some species of Napier grass found high oxalate content if cutting interval is more than 60 days. The cultivation & harvesting rate per unit area is always nearly doubled than conventional crops so the cost per unit area relatively half than conventional crops. Hybrid Napier is not able to produce any seeds only steples can be generated by cutting stem part due to its fast growth of leaves.

B. Anaerobic Reactors

The construction of two stage reactor for higher solids feeding of lignnocellulosic biomass resulted faster reaction rate in hydrolysis, acidogenesis & methanation with higher active organic matter [19,37]. Generally Upflow Anaerobic Sludge Blanket (UASB) are worked on faster activation of microorganism in all stages of anaerobic process. A perspective of Nizami *et.al* (2008) is that arrangement of Sequencing Batch Leach Beds (SBLB) & Continuously Stirred Tank Reactors (CSTR) combination with a UASB resulted amazing increase of biogas production in minimum retention time [38]. Anaerobic digestion has for some time been utilized as a energy giving technique, particularly in Asian nations, for example, China and India [42]. Thus, several different setups of digester have been design, created & maintained furthermore, worked for biogas generation. Floating drum, Fixed drum & Plug flow reactor are most acceptable designs for biomethanation process in asian contries specifically India [6,41,44]. In modern wastewater treatment process anaerobic reactors like CSTR, Fluidized Bed digesters and Anaerobic filters & UASB give higher effeciencies in various nature of wastewater with high solid content & Higher solvent material [5]. Most of the researchers have declared that the advancement in existing design of reactors can improve the efficiency of methane recovery also COD removal from waste treatment.

C. Anaerobic digestion & co-digestion of Grass Silage

The lignocellulosic structure is a obstruction for organisms along with proteins into the cellulosic parts [27]. Due to unformed structure; cellulose is impermeable for hydrolysis process while hemicellulose is delicate for hydrolysis, so they are efficiently hydrolyzed by acids also numerous hemicelluloses chemicals [11]. As per the property of nonwater solubility lignin is the most unmanageable portion of the carbohydrates also it create disturbance during microbial process [32,21]. Along these lines, the decomposition capacity of energy crop in a reactor is constrained through fixed fibrous content of cellulose and lignin having high ratio i.e fibre (30%) [28]. The degradable part in case of grass or energy crop during digestion process are protein, lipid and extracted parts of starches whereas the fixed fibrous matter consist of structured carbohydrates of the plant matter, which is non-degradable. Lehtomaki *et al.* (2008) expressed that it is displaced more competently because of solubilisation than decomposition [29] which is in accordance by the observation reviewed by Kivaisi *et al.* (1990) [25]. In the hydrolysis step of grass based digestion lignin and hemicellulose might be effective during the conversion of cellulose transform into the sugar products [38]. Functioning measures & range of loading declared on the basis of initial procedure of hydrolysis. The second largest generation of agro waste in form of wheat straw, which might be preferred feedstock for biomethanation but due to higher range of fibrous content reduce the degradation capacity having low energy output [45]. In an investigation led by Wang *et al.* (2016) suggested that the co-digestion of agro waste such as Wheat straw with animal dung which improved the degradation procedure & improved the biogas generation by 10% [49]. Bah *et al.* (2014) performed the experiments by taking palm pressed fiber blended in animal dung and revealed that at minimum HRT & co-blending obtained better methane recovery as well as enhanced COD removal, also they claimed that whenever hydrolysis process accelerate microorganism actively collabrate with the feedstock [3]. Li *et al.* (2009) suggested that corn stover with cattle dung as cosustrate gives stable & uniform biogas production than alone corn stover feeding as sole feedstock also based on their study comination of these two substrates improved methane content in biogas about 4.9–7.4 [32]. In Germany around 80% Anaerobic reactors operates on codigestion of maize crop & its silage. Kalamaras and Kotsopoulos (2014) has arranged of trials procedure to look at the biomethanation yield from some energy crops like sorghum, cardoon & maize mixed with cowdung from which they confirmed that ultimate methane formation obtained from cardoon crop co-digest with cattle dung compared with different feedstock crops [23]. In case of sugar industry after sugar extraction beet pulp & molasses are the remains which are characterized by higher carbon contents, so it may be ideal co-substrate with animal manure. In another experimentation by Aboudi *et al.* (2015) semi-continous stirred tank reactor operate in mesophilic temperature range by adding sugar beet material and pig manure collabrate with cowdung & resulted 57.5% methane recovery [1]. As the matter of energy crop Switchgrass is a sustainable energy crop having high carbon substances with minimum efforts of cultivation. It has higher yield per acre with less use of chemical fertilizers so, Lehtomaki *et al.* (2007) suggested that feeding of Switchgrass with cattle manure for anaerobic digestion in lab scale reactor improved the methane production by 16–65% on volumetric basis of reactor, they also observed that when manure/crop volume was about 1:3 & increase up to 1.4:3 the ultimate methane range decreased upto 4–12% [30]. Hashimoto (1983) arrange the lab scale experiments on dairy animal dung and harvested wheat straw whereas they would achieve to ultimate methane percentage after expanding the ratio of wheat straw in the feeding, as the C/N proportion was improved [20]. However methane yield was obtained from manure & wheat straw as co-substrate diminished by 31%.

D. Pre & Post Treatment methods

Pretreatment of feedstock is a advance process of converting fibrous, fixed and lignocellulosic substrate for example Cellulose, hemicelluloses & lignin into the dissolved substances [31]. Several Pretreatment strategies such as physical, chemical and biological are practicised in pilot scale and full scale reactors in industries. Sometimes the combination of above three methods might be adopted for better performance of digesters. Diverse treatment strategies are utilized for restriction on hydrolysis step of energy crop silage dependent on biodegradation and solubilization of lignin and hemicelluloses [8,41]. To break the fibrous content in stable substances to simple compounds normally heating & pressurizing method are employed such as use of autoclave chamber for breaking of tough matter from biomass. [16]. Kalamaras and Kotsopoulos (2014) worked on pretreatment with 2% NaOH addition for different energy crops with thermochemical pretreatment about 120 ℃ to the treated substrates. Further they observed that thermal pretreatment did not accelerate solubilisation of tough matter at lowest temperature however the temperature range required to be upto 150℃ [23]. Bauer *et al.* (2009) worked on steam explosion in which they claimed that with thermophilic temperature range posses the devastation of lignocelluloses formation due to this biodegradability increased by 20% in case of of lignocellulosic materials [4]. Risberg *et al.* (2013) carryout experimentation of pretreatment of wheat straw by applying steam blast so that they monitored anaerobic digestion process by adding alone cowdung and another set prepared with cowdung blended with pretreated wheat straw however it gets decline rate of biogas production even if temperatures goes over 160℃ [43]. The common method for pretreatment of fibrous substances is the use of chemicals to converts the nonbiodegradable materials to biodegradable compounds without any high temperature & pressure. The main disadvantage occur in chemical pretreatment could be environmental pollution and the high cost of chemical. Alkali pretreatment utilizing NaOH, KOH, is a financially savvy technique which can proficiently upgrade the rate of degradation of fibrus substances. Cheng and Zhong (2014) found the incomparable variation in methane formation when cotton stalk and swine manure prepared with alkali base solution, they also monitor low methane yield during without pretreatment of substrate. H_2SO_4, HCl, HNO_3, H_3PO_4, $H_2C_2O_4$, $C_4H_4O_4$ and CH_3COOH are the case of inorganic and natural acids [9]. Some studies are explain about efficiency of dilute acid and concentrated acid used for pretreatment of lignocellulosic biomass whereas they mentioned dilute acid pretreatment is better than concentrated acid for achieving 100% hydrolysis [15]. At another experiments carried out by Yu *et al.* (2002) who done the experimentation on digestion & codigestion of waste corn Stover and swine manure. This study present a results of lignin content which is lessened by 78.5%. Less hydraulic retention time, higher methane percent and higher biogas production is the benifits of alkali pretreatment. Organisms creates a protein to corrupt lignin, cellulose and hemicellulose introduce in the lignocellulosic biomass [54]. Low energy requirement, eco-friendliness and no inhibitor generation quality is the most advantageous part of biological pretreatment. In an ongoing report directed by Wang *et al.* (2012) mentioned enzymatic pretreatment of corn straw with cattle manure, wherein improvement in methane yield by 110.79% and 103.20% due to treated by amylase, cellulase and enzymes [50]. One another study carried out by Lopez *et.al*. (2013) on Napier Grass for biomethanation in which they worked on pretreatment of Napier grass with with three microbial substances MC1,WSD-5 and XDC-2 for various times i.e. 3, 7, 13, 17, and 21 days. MC1 contains cellulose-degrading thermophilic organisms namely Clostridium straminisolvens, WSD-5 include fungal bacteria namely Coprinus cinereus and bacteriais Ochrobactrumsp and XDC-2 involves mesophilic bacteria in the genera namely Clostridium, Bac-teroides, Alcaligenes, and Pseudomonas. The above study reveals that the yields for treated grass were higher than for the untreated samles with the exception of the 21 days pretreatment with MC1 and XDC-2 consortia. The most extreme methane yields for MC1, WSD-5 and XDC-2 pretreated tests were 1.39, 1.49 and 1.32 times more prominent than for untreated samples [33].

II. ANAEROBIC DIGESTION PROCESS

Anaerobic digestion implies without oxygen, Active bacteria & microorganism involves in four key biochemical stages, which are hydrolysis, acidogenesis, acetogenesis and methanation (Fig. 1). Anaerobic process represents the complete degradation of organic matter within specified retention of substrates in the reactor also dependent on loading rate of organic matter.

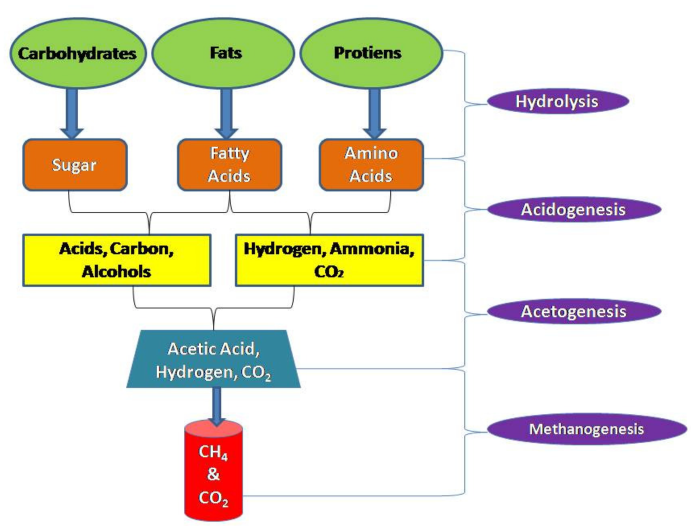

Fig. 1. Anaerobic Digestion Process.

In the environment various groups of microorganisms are involves in every stages of anaerobic processes which have particular requirement of parameters like pH & temperature etc. In the initial stage specifically hydrolysis, the complex organic matter for example carbohydrates, proteins and fats are converted into simple compounds like amino acids, sugars. Some water soluble mixes such as Long-chain sugars, cellulose, hemicellulose and starch also involved in this process. Hydrolases converts long chain sugar into short chain sugars within short period further proteins are transformed into amino acid with the help of proteases and similarly lipases splits fats into fatty acids at specific time requirement. In Acidogenic phase fatty acids are generally obtained by converting simple products getting from hydrolysis. Normally H_2 and CO_2 are formed at lesser partial pressure and lactic acids, organic acids are getting at a higher partial pressure. Methanogenic stage happens under entirely anaerobic condition where acetoclastic converts all above acid formed in two stages is converted into methane.

A. Single-Stage Digestion

The important procedure in anaerobic digestion process is arrangement of reactor in proper design as per requirement [39]. In a single stage digestion all the three stages of microbial process are compiled in two chambers from which energy recovery is carried out from both the chambers at a similar rate. Substrate blending and feeding chamber separately installed at early stage of reactor.

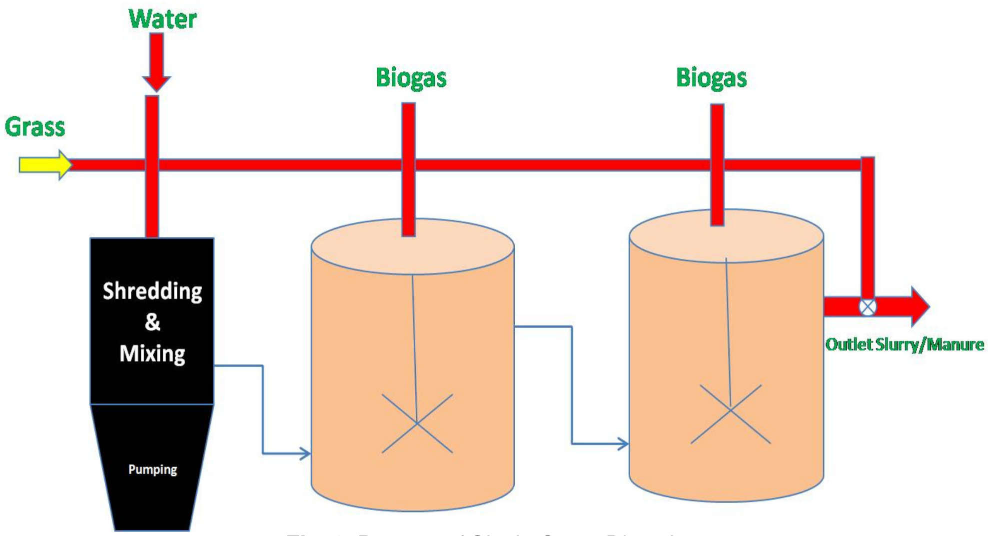

Fig. 2. Process of Single-Stage Digestion.

Fig. 2 indicates single stage digestion process in which complete anaerobic phenomena existed in both chambers.

B. Two-Stage Digestion

In the laboratory scale level Two stage digestion process has possible for monitoring the activity of bacteria at different level of reactors although it was confirmed that each stage may be restricted for a particular feedstock. In the hydrolysis processing of substrates & cosubstrates with high total solids substance and especially more lignocellulosic content is restricted.

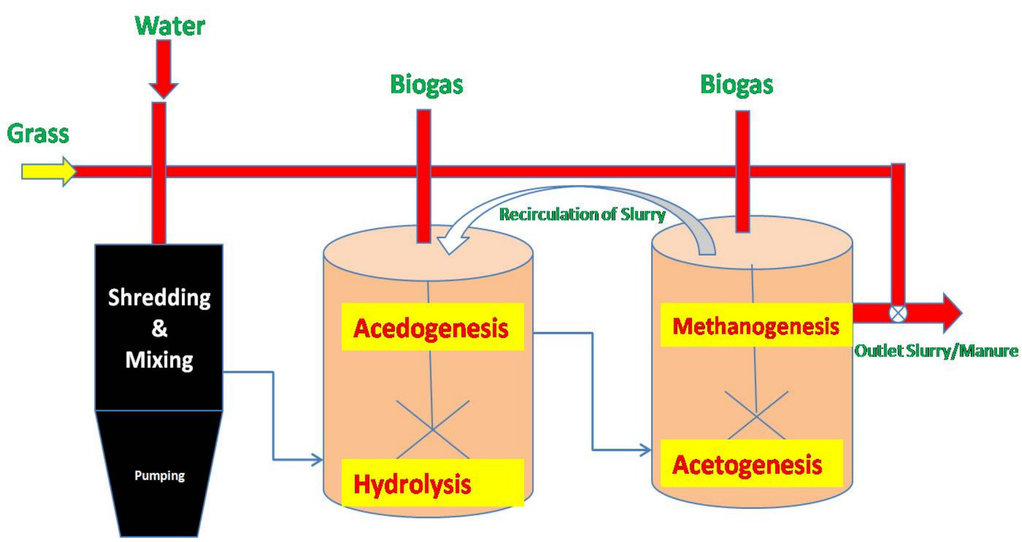

Fig. 3. Process of Two-Stage Digestion.

Fig. 3 features a two-stage framework where the hydrolysis & acidogenesis stages (hydrolytic and fermentative) are secluded from the Acetogenesis & methanogenic stages. The multistage digestion process worked on the concept that first reactor worked on hydrogenic reaction & second reactor worked on methengenic reaction based on the quality of raw substrates feed into the reactor [35].

III. CULTIVATION & HARVESTING FACTORS

A. Climate and soil

In the tropical region, the grass grows all year along since the available ideal temperature at about 31℃ and moderate rainfall with dry weather is suitable for cultivation of energy crop. Hybrid napier grass can grow in different kind of soils except heavy flood zone and water submerge areas even though it require moderate rainfall per year is about 800-1000 mm. While dampness is needed at the root zone; however, stagnation of water there causes decay of the roots. Thus, the lands light loams and sandy soils are more suitable than the heavy soils. Yield of green fodder can be improved by maintaining moderate moisture at deep section with presence of important nutrients & organic matter also range of pH should be within 5 to 8.

B. Land preparation

First and formost, removal of the bushes, thorns, weeds etc. must be done; as the seed bed needed for Hybrid Napier is weed free deep, dense and thorough going. Ploughing of land should be required may be alternated with one, two & three disk. After that levelling of land & removal of existing crop roots such as clods are required. To make irrigation uniform and easy, rideges are prepared across the slop with abundant spacing of 60 cm and hight approximately 25 cm.

C. Manuring

Before ploughing, spreading out the farmyard manure should be done at the rate of 10 MT/Acre. Fertilizers are distributed uniformly on land according to soil characteristics and requirement of nutrients as per soil tesing. For the unfertile land, rate of distribution of N:P:K as per standard suggestion is 8:10:5. The application of fertilizers might be during the removal of weed normally within the 45 days from cultivation.

D. Spacing and seed rate

The energy crops are stron at root level also they are wider in peripheri due to 15 to 20 stems included at single steples after full maturity (Normally 60 days) so the spacing between two steples should be more than 75cm × 75cm to avoid collision between two bunch of green fodder. Around 8000 cutting steples are required for cultivation in one acre.

E. Planting

Cultivation of hybrid napier grass generally carryout at beginning of rainy season. Irrigation facility also require for sustaining the crop in winter as well as summer because of it require irrigation around 30 days interval. Planting of grass is done by cutting of stem portion of grass in such a way that every steples consist of 1 to 2 nodes. These staples rooted vertically in the ground so that nodes can generate new culm. The age of cutting staples normally 3 to 4 months older. Extra soil layer to be added at the root level of staples by cultivaters so that stem improved its standing level as well as improved growth of roots at deep level into the ground.

F. Irrigation and drainage

Provision of water in progressive condition of crop is dependent on water holding capacity of soil and rainfall intensity of that area. Generally water is supplied during the time of staples rooting by furrow method so that abundant water is available during cultivation. After first cycle of irrigation further provision of irrigation can be fulfill by sprinkler or drip method of irrigation. Intensity of irrigation normally within 10 days during summer season also avoid extra water at root level which cause decaying. Weeds can be controlled by removing it by manually or spraying weed control chemicals.

G. Harvesting

Once planting is done, after 60 to 75 days, the first cut is taken; further cuttings can be arrange during 30 to 45 days interval when grass height reach upto 5 feet. Minimum 6 to 8 cuts are possible in single year. for abundant tillering, the fodder should be cut closer to the ground level.

IV. PROCESS CONTROLLERS

A. Temperature

Due to expanded temperature, short-chain parts are framed causing higher natural reasonableness of substrate to microorganisms [34]. There are some deviations from the advantages of mesophilic or thermophilic temperature ranges. When temperature shifts from mesophilic to thermophilic it indicates one essential clarification of these varieties. Approximately 35 to 55 days are needed that can give guarantee if a sufficient microbial production is developed; otherwise it will cause a decline rate of biogas and methane quantity [14]. High microbial quantity requirement is the basic concern in applying thermophilic temperature running in the reactor [7].

B. pH Range

As suggested by Ward *et al.* (2008), the ideal pH for anaerobic digestion is 6.8-7.2. Methanation process affect when pH goes below 6.6 [51]. Moreover ,alkalinity additionally causes some detriments by breaking down of microbial granules [7,45] .In the beginning of second stage, pH tends to vary; and after a while it reaches certain level and get confirmed value as indicated by You *et al.* (2013) [53] & Kim *et al.* (2003) [24]. Although, Dinamarca *et al.* (2003) and Babel *et al.* (2004), have deteriorated fibrous waste; & they observed pH value under 7 without increasing hydrolysis rate [14, 2]. In the second stage, during the anaerobic digestion process the pH needs to be around 7.0. As the pH raises further in the reactor, it results in methanogenesis stage and creates methane [10]. The pH happens to be regulated when cumulative VFA range exceeds 4 g/L [47], A steady pH in two-organize absorption can similarly be retained up by changing the inoculums to nourish proportion [18].

C. Blending

It suggest the mixing of substrate & co-substrate that creates reactor suitability against possible disfunctioning of digester. Similarly, it allows the substrate to get the access into bacteria; and thus methane produced to a great extent [17]. The oxidation of non-degradable ligin is reduced by the blending to a large extent. Blending the digestate with new substrate boosts the bacterial performance [13].

D. Molecule Measure

Molecule size can put its impact on methane production altogether because of the expanded accessibility of surface territory for fibre substraction through hydrolyzing compounds and microorganisms [7]. If the size of grass silage is reduced underneath 1mm in business scale plants [19], it offers abundant amount of energy.

E. Retention Time

Hydroulic Retention Time (HRT) is the time required for total degradation of substrates in the reactor. Normally 6-7 weeks considered as an ideal HRT for lignocellulosic biomass. In pilot scale studies generally 45 days average HRT taken for arganic waste such as Cow dung, food waste etc. Furthermore, the experimentation workout by Lehtomaki *et al.* (2008), on UASB with filter bed digester requires 55 days retention time based on energy crop as a cosubstrate [29].

F. VFA & Alaklinity

Volatile Fatty Acids are the intermediate compounds such as - acetate, propionate, butyrate, lactate produced during the acidogenesis stage. Anaerobic Digestion process is largely affected by the excess quantity of VFA generated in the reactor, as a result the pH value also goes down. Cow dung [46] has a excess of alkalinity; however, during anaerobic digestion if VFA also generated at a large extent, it negatively affects the anaerobic process, thus ultimately the negative effect on the generation of biogas. VFA and alkalinity ratio should be in between 0.05 to 0.15. If the ratio goes beyond 0.15, it causes the serious concern as VFA increases. For its prohibition, proper buffering is needed like adding lime , extra water etc. The methane quantity which is determining factor in the production of biogas is inversely proportional to accumulation of VFA.

G. Codigestion

When any organic waste blend with the main substrate it resulted higher biogas production. Many researchers has included the increased methane content when codigestion carryout with foodwaste, kitchen wate & agro waste. In case codigestion of energy crop minimum ratio (Normally less than 50%) has been chosen with the main substrates like cowdung. Some lab sale studies explain the effect on production of biogas due to highly organic waste such as dairy waste, food waste & industrial waste with addition of supplements like urea, hot water & microorganism. Lignocellulosic biomass affects the methane content when it combine in higher percentage.

H. Supplements, Inoculum, and Restraint

Supplements & inoculums are used for accelerating methane production by improving digestion process or by involving active microorganism in the reactor. Gunaseelan *et.al* (1995 & 1997) worked on biomethanation by adding of nickel (Ni), cobalt (Co), molybdenum (Mo), selenium (Se) & sulphate in the substrate where they found 40 % higher methane production. Similarly, the distinctive added substances can develop the creation rate of methane. In any case, they should be evaluated in the light of money related terms [18,19].

V. CONCLUSION

All-encompassing and extensive approach is needed to examine the generation of biogas from grass to deal with farming and bioenergy generation. At first, some distinction has been observed between production of fodder for domesticated animals and alternate substrate for biodigestion [26]. The rye grasses cut in youthful and blooming stage present ultimate biogas production wherein cutting of green leaves before 45 days gives more biogas production than cutting after full maturity. Extra cutting of grass provide fodder for animal by fulfilling requirement for the reactor. Research facility work would recommend that two-stage absorption offers favourable circumstances than one-stage assimilation. It has been also observed that hydrolysis is important to break the fibrous substances at initial level and lignocellulosic material is increased with the age & maturity of grass [22]. Biogas creation of around 0.4 m^3 CH_4/kg. Volatile Solids is normal from digestion of grass silage as substrate or cosubstrate. This may be enhanced by pretreatment a procedure which is appropriate for energy crop silage, incorporate size decrease, and warm treatment, for example, hot water. Codigestion with slurries is not only more beneficial than mono digestion of either grass or slurry but it offers more steady procedures. Updating biogas to an unlimited gas with 97% or more offers awesome potential as a sustainable petroleum gas. It can be appropriated and managed by means of the existing flammable gas network; equipping the nations, businesses, and establishments to meet their sustainable power source targets especially for transport and Industries [48].

REFERENCES

[1]. Aboudi, K., Álvarez-Gallego, C.J. and Romero-García, L.I. (2015). Semi-continuous anaerobic codigestion of sugar beet byproduct and pig manure: effect of the organic loading rate (OLR) on process performance. *Bioresource Technology*, **194**, 283–90.

[2]. Babel, S., Fukushi, K. and Sitanrassamee, B. (2004) Effect of acid speciation on solid waste liquefaction in an anaerobic digester. *Water Resources*, **38**(9), 2417–2423.

[3]. Bah, H., Zhang, W., Wu, S., Qi, D., Kizito, S. and Dong, R. (2014). Evaluation of batch anaerobic codigestion of palm pressed fiber and cattle manure under mesophilic conditions. *Waste Management*, **34**, 1984–91.

[4]. Bauer, A., Bösch, P., Friedl, A. and Amon, T. (2009). Analysis of methane potentials of steam explodedwheat straw and estimation of energy yields of combined ethanol and methane production. *Journal of Biotechnology*, **142**, 50–55.

[5]. Boe K. and Angelidaki I. (2006). Online monitoring and control of the biogas process, Ph.D thesis, *Institute of Environment & Resources*, Technical University of Denmark.

[6]. Bond, T. and Templeton, M.R. (2011). History and future of domestic biogas plants in thedeveloping world. *Energy Sustainable Development*, **15**, 347–54.

[7]. Bouallagui, H., Touhami, Y., Cheikh, R.B. and Hamdi, M. (2005). Bioreactor performance in anaerobic digestion of fruit and vegetable wastes. *Process Biochemical*, **40** (3-4), 989–995.

[8]. Cecchi, F., Pavan, P., Musacco, A., Mata-Alvarez, J. and Vallini, G., (1993). Digesting the organic fraction of municipal solid waste: Moving from mesophilic (37°C) to thermophilic (55°C) conditions. *Waste Management Resources*, **11**(5), 403–414.

[9]. Cheng, X.Y. and Zhong, C. (2014). Effects of feed to inoculum ratio, co-digestion, andpretreatment on biogas

production from anaerobic digestion of cotton stalk. *Energy Fuels*, **28**, 3157–66.

[10]. Cirne, D.G., Lehtomaki, A., Bjornsson, L. and Blackall, L.L. (2007). Hydrolysis and microbial community analyses in two-stage anaerobic digestion of energy crops. *Applied Microbiology*, **103**(3), 516–527.

[11]. Clavero, T. and Razz, R. (2002). Effects of biological additives on silage composition of mott dwarf elephantgrass and animal performance. *Rev. Cientifica*, **12**(4), 313–316.

[12]. Council regulation. EC/1782/2003. (2003). Establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers. *Off. Journal of European Union*, I.**270**/**1**, 21.10.

[13]. Demirbas, A. and Ozturk, T. (2004). Anaerobic digestion of agricultural solid residues. *International Journal of Green Energy*, **1**(4), 483–494.

[14]. Dinamarca, S., Aroca, G., Chamy, R. and Guerrero, L. (2003). The influence of pH in the hydrolytic stage of anaerobic digestion of the organic fraction of urban solid waste. *Water Science Technology*, **48**(6), 249–254.

[15]. Elgharbawy, A.A., Alam, M.Z., Moniruzzaman, M. and Goto, M. (2016). Ionic liquid pretreatment asemerging approaches for enhanced enzymatic hydrolysis of lignocellulosic biomass. *Biochemical Engg. Journal*, **109**, 252–67.

[16]. Garrote, G., Dominguez, H. and Parajo, J. (1999). Hydrothermal processing of lignocellulosic materials. *European Journal Wood Production*, **57**, 191–202.

[17]. Gomez, X., Cuetos, M.J., Cara, J., Moran, A. and Garcia, A.I. (2006). Anaerobic co-digestion of primary sludge and the fruit and vegetable fraction of the municipal solid wastes – conditions for mixing and evaluation of the organic loading rate. *Renewable Energy*, **31**(12), 2017–2024.

[18]. Gunaseelan, V.N. (1995). Effect of inoculum substrate ratio and pretreatments on methane yield from Parthenium. *Biomass Bioenergy*, **8**(1), 39–44.

[19]. Gunaseelan, V., Nallathambi, S. (1997). Anaerobic digestion of biomass for methane production: a review. *Biomass Bioenergy*, **13**(1-2), 83–114.

[20]. Hashimoto, A.G. (1983). Conversion of straw–manure mixtures to methane at mesophilicand thermophilic temperatures. *Biotechnology Bioengineering*, **25**, 185–200.

[21]. Hendriks, A.T.W.M. and Zeeman, G. (2009). Pretreatments to enhance the digestibility of lignocellulosic biomass, review. *Bioresource Technology*, **100**(1), 10–18.

[22]. Howard, R.L., Abotsi, E., Jansen van Rensburg, E. L. and Howard, S. (2003). Lignocellulose biotechnology: issues of bioconversion and enzyme production. *African Journal of Biotechnology*, **2**, 602–619.

[23]. Kalamaras, S. and Kotsopoulos, T. (2014). Anaerobic co-digestion of cattle manure and alternative crops for the substitution of maize in South European *Bioresource Technology*, **172**, 68–75.

[24]. Kim, J., Park, C., Kim, T. H., Lee, M., Kim, S., Kim, S.W. and Lee, J. (2003). Effects of various pretreatments for enhanced anaerobic digestion with waste activated sludge. J. *Bioscience Bioengineering*, **95**(3), 271–275.

[25]. Kivaisi, A.K., Op den Camp, H.J.M., Lubberding, H. J., Boon, J.J. and Vogels, G.D. (1990). Generation of soluble lignin derived compounds during the degradation of barley straw in an artificial rumen reactor. *Applied Microbiology Biotechnology*, **33**(1), 93–98.

[26]. Surendra, K.C., Ogoshi, R., Reinhardt-Hanisch, A., Oechsner, H., Zaleski, H.M., Hashimoto, A.G., & Khanal, S.K. (2018). Anaerobic digestion of high-yielding tropical energy crops for biomethane production: Effects of crop types, locations and plant parts. *Bioresource technology*, **262**, 194-202.

[27]. Lehtomaki, A., & Björnsson, L. (2006). Two-stage anaerobic digestion of energy crops: methane production, nitrogen mineralisation and heavy metal mobilisation. *Environmental Technology*, **27**(2), 209–218.

[28]. Lehtomaki, A., Huttunen, S., Lehtinen, T.M. and Rintala, J.A. (2008). Anaerobic digestion of grass silage in batch leach bed processes for methane production. *Bioresource Technology*, **99**(8), 3267–3278.

[29]. Lehtomaki, A. (2006). Biogas production from energy crops and crop residues. PhD dissertation, Jyvaskyla studies in biological and environmental science, *University of Jyvaskyla¨*, Finland.

[30]. Lehtomaki, A., Huttunen, S. and Rintala, J. (2007). Laboratory investigations on co-digestion of energy crops and crop residues with cow manure for methane production: effect of crop to manure ratio. *Resource Conservation Recycle*, **51**, 591–609.

[31]. Lewis, N.G. and Davin, L.B. (1998). The biochemical control of monolignol coupling and structure during lignan and lignin biosynthesis. *In Lignin and Lignan Biosynthesis*, Lewis N.G., Sarkanen, S. Eds., *American Chemical Society*,Washington, DC, 334-361.

[32]. Li, X., Li, L., Zheng, M., Fu, G. and Lar, J.S. (2009). Anaerobic co-digestion of cattle manure with corn stover pretreated by sodium hydroxide for efficient biogas production. *Energy Fuels*, **23**, 4635–9.

[33]. López, M.J., Suárez Estrella, F., Vargas García, M.C., López González, J.A., Verstichel, S. and Debeer, L., (2013). Biodelignification of agricultural and forest wastes : effect on anaerobic digestion. *Biomass Bioenergy*, **58**, 34, 3–9.

[34]. Mata Alvarez, J., Mace, S. and Llabres, P. (2000). Anaerobic digestion of organic solid wastes. An overview of research achievements and perspectives. *Bioresource Technology*, **74**(1), 3–16.

[35]. Mata Alvarez, J. (1987). Adynamic simulation of a two-phase anaerobic digestion system for solid wastes. *Biotechnology Bioengineering*, **30**(7), 844–851.

[36]. Murphy, J.D. and McCarthy, K. (2005). Ethanol production from energy crops and wastes for use as a transport fuel in Ireland. *Applied Energy*, **82**(2), 148–166.

[37]. Murphy, J.D. and Power, N.M. (2009). An argument for using biomethane generated from grass as a biofuel in Ireland. *Biomass Bioenergy*, **33**(3), 504–512.

[38]. Nizami, A.S. and Murphy, J.D. (2008). What is the Optimal Digester Configuration for Producing Grass Biomethane? *Renewable Energy*, Submitted December.

[39]. Nzila, C., Dewulf, J., Spanjers, H., Tuigong, D., Kiriamiti, H. and Van Langenhove, H. (2012). Multicriteria sustainability assessment of biogas production in Kenya. *Applied Energy*, **93**, 496–506.

[40]. Petersson, A., Thomsen, M.H., Hauggaard Nielsen, H. and Thomsen, A.B. (2007). Potential bioethanol and biogas production using lignocellulosic biomass from winter rye, oilseed rape and faba bean. *Biomass Bioenergy*, **31**(11-12), 812–819.

[41]. Qi, B.C., Aldrich, C., Lorenzen, L. and Wolfaardt, G.W. (2005). Acidogenic fermentation of lignocellulosic

substrate with activated sludge. *Chemical Engg. Communication*, **192**(7-9), 1221–1242.
[42]. Rajendran, K., Aslanzadeh, S. and Taherzadeh, M.J. (2012). Household biogas digesters—A review. *Energies*, **5**, 2911–42.
[43]. Risberg, K., Sun, L., Levén, L., Horn, S.J. and Schnürer, A. (2013). Biogas production from wheat straw and manure–impact of pretreatment and process operating parameters. *Bioresource Technology*, **149**, 232–7.
[44]. Rosch, C., Raab, K., Sharka, J. and Stelzer, V. (2007). Sustainability of bioenergy production from grassland concept, indicators and results. *15th European Biomass Conference and Exhibition*, 7-11 May 2007, Berlin, Germany.
[45]. Sandberg, M. and Ahring, B.K. (1992). Anaerobic treatment of fish-meal process wastewater in a UASB reactor at high pH. *Applied Microbiology Biotechnology*, **36**(6), 800–804.
[46]. Siegert, I. and Banks, C. (2005). The effect of volatile fatty acid additions on the anaerobic digestion of cellulose and glucose in batch reactors. *Process Biochemical*, **40**(11), 3412–3418.
[47]. Singh, A., Smyth, B.M. and Murphy, J.D. (2009). A biofuel strategy for Ireland with an emphasis on production of biomethane and minimization of land take. *Renewable Sustainable Energy Reviews*, doi:10.1016/j.rser. **07**.004.
[48]. Smyth, B., Murphy, J.D. and O'Brien, C. (2009). What is the energy balance of grass biomethane in Ireland and other temperate northern European climates? *Renewable Sustainable Energy Reviews,* doi:10.1016/j.rser.**04**.003.
[49]. Wang, X., Li, Z., Zhou, X., Wang, Q., Wu, Y. and Saino, M., (2016). Study on the bio-methaneyield and microbial community structure in enzyme enhanced anaerobic codigestion of cow manure and corn straw. *Bioresource Technology*, **219**, 150–7.
[50]. Wang, X., Yang, G., Feng, Y., Ren, G. and Han, X. (2012). Optimizing feeding composition and carbon–nitrogen ratios for improved methane yield during anaerobic co-digestion of dairy, chicken manure and wheat straw. *Bioresource Technology*, **120**, 78–83.
[51]. Ward, A.J., Hobbs, P.J., Holliman, P.J. and Jones, D.L. (2008). Optimization of the anaerobic digestion of agricultural resources, review. *Bioresource Technology*, **99**(17), 7928–7940.
[52]. Weiland, P. (2006). Biomass digestion in agriculture: a successful pathway for the energy production and waste treatment in Germany. *Engineering Life Science*, **6**, (3).
[53]. You, Z., Wei, T. and Cheng, J.J. (2013). Improving anaerobic codigestion of corn stover usingsodium hydroxide pretreatment. *Energy Fuels*, **28**, 549–54.
[54]. Yu, H.W., Samani, Z., Hanson, A. and Smith, G. (2002). Energy recovery from grass using two-phase anaerobic digestion. *Waste Management*, **22**(1), 1–5.

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