Anaerobic digestion of Rice Straw for biogas production

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Introduction:

Bioenergy production and efficient waste reduction are major factors to preserve the environment and minimize the reliance on fossil fuels for achieving the goals of sustainable development (Albertson, O. E, 1961). Usage of crop residues is an encouraging and viable option for the meeting the needs of primary energy. Among the crops grown for meeting the food needs of the globe, paddy ranking in third place and is cultivated in area of 161.42 million hectare with a gross grain production of 678.69 Mt in the year 2009 (Xie, S, 2016). One ton of paddy cultivated produces around 290 kg of rice straw (RS) indicating good potential in terms of quantity available. Asia alone accounts for 70% RS produced globally which is around 720 Mt (Zealand, A. M, 2017).

Anaerobic digestion (AD) is a promising technology for converting RS into biogas and digestate. AD is nothing but bio-methanation of organic residues by microorganisms in the absence of oxygen (Pore, S. D, 2016). Several organic residues can be used for anaerobic conversion into biogas and digestate. Among the residues produced globally, residues obtained from food grown crops plays an important role in terms of providing local employment, animal fodder, cooking fuel, making the shelter etc. RS is obtained from paddy crop which is also widely grown in Asia, lignocellulosic in nature, has great potential to be used as the substrate for anaerobic digestion (Pore, S. D, 2016).

AD of Rice Straw and Influencing parameters:

Temperature: In general, temperature ranges for AD of RS is classified as psychrophilic (10-20 °C), mesophilic (30-40°C) and thermophilic (50-60°C) (Kwietniewska, E, 2014). An optimum and sustainable temperature is the basic need for reducing the vulnerability of anaerobic system (Shetty, D. J, 2017). Even though high temperatures in the AD system improves the metabolic rate of microorganisms, thermophilic system is difficult to control and also needs additional energy (Hagos, K, 2017). However in mesophilic temperatures, wide range of microorganisms involves in the digestion and more stable than thermophilic temperature systems (Appels, L, 2008).

VFA and pH: VFA accumulation occurs in AD when acids produced from hydrolysis and acidification process cannot be consumed by methanogenic bacteria, which leads to system destabilization and reduction of pH (Cai, Y, 2017). The predominant volatile acids in AD were propionic acid, acetic acid, lactic acid and formic acid (Cai, Y, 2017). The favourable pH range for AD is 6.8 to 7.2, whereas optimal pH for hydrolysis and acedogenesis is 5.5 to 6.5, while it is around 7.0 for methanogenesis (Shetty, D. J, 2017).

C/N ratio: C/N ratio is a major factor in AD which talks about the nutrient balance in the reactor. A favourable nutrient balance is needed by anaerobic bacteria for their evolution as well as for maintaining a stable environment (Li, Y, 2018). If substrate C/N ratio is less, that represent it is rich in protein and vice versa and It is observed that, a C/N ratio of 20-30 is recommended to be favourable for AD (,Kwietniewska, E, 2014).

Ammonia: ammonia is an essential source of nitrogen for anaerobic microorganisms. Ammonia at high concentration may inhibit methanogenic bacteria in AD which leads to system instability (Cooney, C. L, 1975). It is observed from studies that ammonia concentration below 200mg/l (low concentrations) are favourable to the AD process (Pore, S. D, 2016).

Metal elements: Trace element addition to AD is one of the way to improve methane yield (Cai, Y, 2017). metal elements include heavy metal ions such as Cr, Co, Cu, Zn, Ni, Mo, W, etc and light metal ions such as Na, K, Mg, Ca, Al, etc (Zhang, C, 2014). Certain metals are used as a fraction of the enzyme structure of the anaerobic microorganisms (Chen, Y, 2008). However, some elements may have toxic effect on anaerobic microorganisms in the system (Kwietniewska, E, 2014).

Co-digestion: Co-digestion is a treatment method in which several feedstocks are mixed and treated at a time (Kwietniewska, E, 2014) .Co-digestion can minimize the gap between the peak and valley values of methane yield for stable gas supply (Li, D, 2015). Co-digestion produced more total methane yield than individual mono-digestions (Ye, J, 2013) and is considered to be most economical than pre-treatments for lignocellulosic biomass (Ye, J, 2013).

Pre-treatment: The primary aim of pre-treatment technology on lignocellulosic biomass is to change or alleviate the structural and compositional impediments to hydrolysis (Kaur, K., 2016). There are three types of pre-treatments: 1) physical pre-treatment (milling, grinding, chipping), 2) chemical pre-treatment (acids, alkalis, oxidants), 3) biological pre-treatment. The pre-treatment technology results in chemical and/or physical changes in the lignocellulosic biomass (Phutela, U. G, 2012).

Conclusion: Anaerobic digestion is a feasible technology for digesting the RS for bioenergy production which can be done in both thermophilic and mesophilic temperature ranges. Trace element supplementation in the system is found to be favourable for effective digestion. Co-digestion of RS with nitrogen rich substrates had resulted in improved stability in addition to the production of enhanced biogas. Pre-treatment has improved the digestibility of the substrate in turn enhanced biogas production.

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