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Short Communication

Bioenergy 2019- Investigation of biogas generation from the wastes of a vegetable market in single and double chamber reactors

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This paper presents the results of two sets of laboratory experiments on biogas generation from the wastes of a rural vegetable market of Bangladesh under daily victual condition. The quotidian average composition of facilely biodegradable wastes was utilized as the substrate for biogas generation. Cow dung, cauliflower stick, papaya and potato were the major biodegradable wastes. The average total solids (TS) and volatile solids (VS) concentrations of the substrate were tenacious and found to be 18.90% and 15.10% respectively. The experimental setups were placed in an astronomically immense closed chamber containing a room heater. It was operated at 35oC to maintain an auspicious condition for anaerobic digestion. In the first setup, 750 g waste and required amplitude of inoculum were integrated initially to a single chamber reactor to make the efficacious volume of 2 L, and a double chamber reactor (middle interconnection) was initially alimented with 750 g wastes (350 g in each chamber) and inoculum was integrated to make the efficacious volume of 1 L for each chamber. Both the reactors were operated for 39 days. Considering the HRT as 40 days, from the 2nd day of operation, each reactor was alimented daily with a coalescence of 18.75 g wastes and required volume of tap dihydrogen monoxide to make the total volume of 50 mL after dispensing equal volume of slurry from the reactor. The results of the experiments revealed that the temperature varied from 30 to 35oC and it did not affect the rate of biogas generation. For the OLR of 1.42 gVS/L/d, the quotidian stable biogas generation rate was 0.39 and 0.32 m3/kg of VS integrated for the single chamber reactor and the double chamber reactor respectively.

Keywords: Anaerobic digestion, Biodegradable waste, Biogas, Hydraulic retention time (HRT), Single chamber reactor, Double chamber reactor, Organic loading rate (OLR)

Introduction:

The PhD project was initiated due to the desiderata for both energy engenderment and waste treatment. The energy carrier in focus, in this project, was biogas, which is among the alternatives to fossil fuels. The biomass used to engender biogas was victuals-processing industrial wastes. By anaerobic digestion, the wastes could be treated to minimize the environmental impact and at the same time converted into methane energy.

Nowadays both energy crisis and climate change are key issues all over the world. There will be astringent energy shortage in the coming 50 years. According to current research and future presages, the crude oil will run out within 40 to 70 years, and natural gas will be culminated within 50 years (Courtney and Dorman, 2003). Ecumenical average temperature is presaged to increment 1.4 to 5.8 °C by year 2100 and perpetuate to ascend long after that (Dow and Downing, 2006). Several investigations point out that this will ineluctably lead to drought, flooding, increases in hurricanes and tornadoes and possibly widespread crop failures. Ecumenical warming as the result of climate change is an established fact. It is now widely accepted that it is caused by the expeditiously incrementing concentrations of greenhouse gas (CO2 and others) in the atmosphere, which is emitted mainly by the combustion of fossil fuels containing carbon like coal, oil, and natural gas. Security of energy supply, especially sustainable energy, and truncation of CO2 emission are priorities on agenda ecumenical. The utilization of biogas and biomass as an energy source is regarded as CO2 neutral, because the CO2 relinquished during combustion of the biogas is identically tantamount CO2 that the plants have assimilated during photosynthesis to engender organic biomass. Renewable energy is politically injuctively authorized. The European Community has concurred targets for 2020 on renewable energy, which established a high standard for all Member States, aiming a 20% quota of renewable energy by the year 2020 (European Commission. Biogas is one of the most efficient and efficacious options among the sundry other alternative sources of renewable energy currently available. It is engendered through anaerobic digestion processes where the microorganisms convert intricate organic matter into a coalescence of methane and carbon dioxide. The anaerobic digestion of biomass requires less. The Capital investment per unit engenderment cost compared to other renewable energy sources, such as hydro, solar and wind energy. It has been early demonstrated that biogas engenderment from crop residues is economically feasible on a farm-scale level (50–500 kW). Biogas can be engendered from variety of substrates, such as animal manure, energy crops, industrial wastes etc. Biogas. There is inhibited competition with pabulum by utilizing industrial wastewater and residues to engender biogas. The effluent from the biogas process supplies essential nutrients which can withal

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be utilized as fertilizer. The main objective of this PhD project was to investigate the potential of biogas engenderment from aliment-processing industrial wastes in batch assays and perpetual reactor operations with different reactor configurations, for instance, desugared molasses (DM) and sugar beet pulp (SBP) utilizing perpetually stirred tank reactor (CSTR); potato juice, palm oil mill effluent (POME) and deoiled POME utilizing up flow anaerobic sludge blanket (UASB) reactor and expanded granular sludge bed (EGSB) reactor. Supplemental studies of different operating conditions i.e. temperature and organic loading rate (OLR), have been carried out to ameliorate the biogas engenderment. Co-digestion has been addressed to surmount the inhibitory effect from DM. The biogas engenderment from SBP and empty fruit bunch (EFB) has been incremented by co-digesting with manure and POME, respectively. Furthermore, different pre-treatment methods have been applied to EFB in order to ameliorate its biodegradability.

Improvement of the biogas process:

Biogas process optimization through better monitoring and control is one way of amending process efficiency. Other ways can be through pretreatment of the substrate to relinquish more biodegradable compounds, or codigestion with different wastes and/or with animal manure. This will inhibit the inhibition from the substrate and enhance the biogas engenderment.

Oil palm mill plants engender astronomically immense amplitudes of solid wastes such as EFB (23%), mesocarp fibers (12%) and shells (5%) for every ton of fresh fruit bunch been processed in the mills. Astronomically immense quantity of oil palm biomass, especially 17.1 million tons of EFB was engendered by the Malaysia oil palm industry in year 2005.

Chemical treatments include acid, base and oxidant treatments. Acid treatment can significantly amend the reaction rate of the subsequent process of cellulose hydrolysis, while treatment with base increases the internal surface by swelling; decrease of polymerization degree and crystallinity; eradication of links between lignin and other polymers; breakdown of lignin. Alkaline hydrolysis with NaOH has been prosperously applied to treat lignocellulosic materials by Sun and Cheng. Pre-treatment of EFB in this study was investigated on NaOH additament and the methane yield in batch experiment was amended by 37% compared to non-treated EFB, and reached 52% of the theoretical value of 422 mL-CH4/gVS-integrated.

Hydrothermal, additionally called steam treatment, is performed at high temperature and pressure. During pre-treatment, the biomass is often commixed with dihydrogen monoxide and heated to around 180-200 °C for 5-15 minutes in order to ravage the forefending lignin structure and make the cellulose available for the enzymes. It is proved that the hydrothermal pre-treatment can significantly ameliorate biodegradability by achieving ample solubilization of the lignocellulose to enhance hydrolysis in the AD process, which results in the incrementation in biogas engenderment.

Conclusion:

This thesis has mainly fixated on biogas engenderment from victuals-processing industrial wastes, including desugared molasses (DM), sugar beet pulp (SBP), sugar beet top (SBT), sugar beet leaves (SBL), potato juice, palm oil mill effluent (POME), deoiled POME and empty fruit bunch (EFB) by anaerobic digestion. The co-digestion strategy in between sugar processing wastes themselves or with animal manure was applied to surmount inhibition and amend the biogas process. Coalesced pretreatment with co-digestion was investigated in palm oil processing wastes. The major contributions of this thesis work are summarized as follows:

- Methane potentials of pabulum-processing industrial wastes, such as DM, SBP, SBT, SBL; potato juice, potato pulp; POME, deoiled POME and EFB were tenacious in batch assays. All of them are captivating substrates for biogas engenderment.
- DM, SBP, potato juice, POME and deoiled POME were culled as model wastes to run the perpetual reactor experiments in the perpetually stirred tank reactor (CSTR), up flow anaerobic sludge blanket (UASB) and expanded granular sludge bed (EGSB) reactors. The latter four substrates were proved facilely degradable substrates, with good methane potential. However, dilution was obligatory to evade organic overload.
- Co-digestion was applied to DM, SBP with animal manure. DM contains more than 2-3 times higher concentration of ions than mundane molasses, especially sodium and potassium, which could vigorously inhibit the biogas process. In order to minimize the inhibition, codigestion with manure was applied and resulted in maximum methane yield of DM of 300 mL-CH4/gVS-integrated in the CSTR reactor. Prosperous anaerobic digestion of a cumulation of 5% DM with cow manure was achieved and a stable methane engenderment could be obtained at concentrations lower than 15% DM. The average methane yield of 280 mL-CH4/gVS-integrated was achieved in a thermophilic reactor, co-digesting 50% SBP with cow manure. Manure proved to be a very good substrate for co-digestion with sugar processing industrial wastes, as it avails diluting the concentrated substrates and withal provides buffer capacity and nutrients.
- High-rate reactor configurations, i.e. an UASB and an EGSB reactor, were introduced to potato juice, POME and deoiled POME. HRT of 5 days with OLR 5.1 gCOD/L-reactor.d and methane yield of 240 mLCH4/gVS-integrated in the UASB reactor and HRT 8 days with OLR 3.2 gCOD/L-reactor.d and methane yield 380 mL-CH4/gVS-integrated in the EGSB reactor were obtained in steady state when treating potato juice. Both UASB and EGSB are capable of engendering biogas at mesophilic conditions; UASB is more abide to VFA concentrations, while engenders lower methane yield than EGSB. The effluent from the UASB and EGSB reactors could be treated by ammonia retainment method and virtually 100% of ammonia has been retained by decrementing pH below 5. Utilizing POME and deoiled POME

as feedstock, the UASB and the EGSB reactors were reliably operated at the same HRT of 5 days, OLR 5.8 and 2.6 gVS/L-reactor.d respectively. Both reactors achieved commensurably high COD abstraction efficiencies above 90%.

- Pre-treatment of EFB by NaOH presoaking and hydrothermal treatment, co-digested with POME, at commixing ratios of 6.8:1 on VS substructure, corresponding to 1:1 on volume substratum, had a high synergetic effect with highest methane potential of 392 mL-CH4/gVS-integrated corresponding to 82.7 m3 CH4/m3 cumulation. Considering an energy content of 36 MJ per m3 CH4, the energy content in the engendered methane from pre-treated EFB co-digested with POME was 2977 MJ/m3.

Note: This work is partly presented at 5th World Bioenergy Congress during April 15-16, 2019 held at Tokyo, Japan