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ENERGY RECOVERY AND SOLID ORGANIC WASTE MANAGEMENT USING DRY ANAEROBIC DIGESTION

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ABSTRACT:

Anaerobic digestion has always been regarded as a feasible course decreasing carbon-based matter and improving Hydrogen and Methane as renewable energy sources from organic carbons, and has managed to the overall gasification of biodegradable organic wastes further more. Although misty anaerobic assimilation has been well developed, it is a challenge to adapt this type fermentation technology for carbon-based unwanted with excess of solid contents. In such condition, arid methane fermentation would be an appropriate approach. Arid methane fermentation is a ground-breaking anaerobic digestion method of recycling solid organic backwoods for energy retrieval and releasing nutrient-rich fertilizer without dilution of substrate. This technology helps in Waste controlling in a country like Nepal, where municipal wastes, hospital wastes, domestic wastes, farm wastes, and livestock manure are existed in abundance. Though the assembly of biogas over anaerobic absorption is not a new knowledge, anaerobic digestion procedures are frequently worked at well below their best performance due to numerous influences. The feasible and advantage of arid fermentation process for treating solid organic wastes are deliberated. While the optimization of environmental situations inside the digester such as temperature, pH, buffering capacity and fatty acid concentrations etc. are investigated with a least retention time in this paper.

KEYWORDS: Anaerobic Digestion, Wet Fermentation, Dry Fermentation, Solid Organic Waste, Biogas, Energy recovery.

1. INTRODUCTION:

Anaerobic digestion is the procedure of disintegration of organic matter via microbial consortia in an oxygen-free surroundings to produce clean energy (Hydrogen and Methane) and carbondioxide and reclaim nutrientrich manure [1]. It can stay useful to digest a wide variety of nourish stocks including industrial, domestic, municipal, hospital, agricultural, and farm organic wastes. The rapid increase and buildup of compact waste in major cities of low income developing countries like Nepal and its associated risk to human health and environment is a basis of principal concern.

Joint dense waste controlling preparation in best of the communities in the developing world includes having the whole components of the waste mixed together and placed in bins or on a simple ground at localities within communities and next hauled to the dumpsite via the waste expert. The unrestrained breakdown of organic solid trashes be able to result in extensive uncleanness of topsoil, water, then air [2] due to releasing of leachate into groundwater and emission of potential green house gases into the atmosphere. Disintegration of one metric ton of organic solid waste can potentially release 50 – 110 m^3 of carbon dioxide and 90 – 140 m^3 of methane into the atmosphere [2]. Besides, diseases like cholera, diarrhoea, intestinal worms and upper respiratory diseases etc. causing bacteria and foul odor are also spreader. Thus, damping and land filling will constitute very huge environmental consequences both now and in the near future. In addition, it becomes more and more exertion in

finding suitable localities owing to a fast decrease in landfill or dumpsite spaces and also receiving public support. Incineration for energy retrieval can be a expensive capital asset and stance social and environmental health hazards e.g., burning toxic wastes causes harmful air pollution. With regards to composting, to obtain high quality compost, would produce greenhouse gases and no energy recovery. It is so
Vital to look for and appliance long-term waste controlling method that ensures a viable method for waste managing amenities.

The digested waste is stabilized by anaerobic ingestion with little environmental consequences. As known, misty anaerobic fermentation of fertilize and extra carbon-based wastes aimed at methane and hydrogen manufacture has been well developed by now [3]. In agriculture-based countries, some farmers have aided from manure to biogas household technology. For example, in Nepal, 172,858 biogas plants are constructed by the end of 2008 (BSP Nepal, 2008). They are small scales (mainly 4 m^3, 6 m^3, 8 m^3 and 10 m^3), domestic, single stage continuous wet fermenter. For this process, waste or manure should be diluted with appropriate proportion of water to reduce total solids content but the high dilution rate would lead to increased volume handling problems involving both the storage during fermentation and effluent disposal. On contrary to this, the dry anaerobic fermentation procedure stabilizes the wastes in its produced method. Therefore, the making of biogas over arid anaerobic digestion proposals important advantages over other forms of waste action like scorching, composting, terrestrial filling, deduction sites and misty anaerobic ingestion etc. In order to develop feasible dry fermentation process for potential energy recovery, it is important to review the optimization techniques and suggested possible areas where improvements could be made, including the reactor configuration, mixing, feed stocks, codigestion and pretreatment. Optimization of environmental situations within the digester such as temperature, pH, buffering capacity and fatty acid concentrations should also be considered for make the maximum of the biogas production in a least retaining time.

2. DRY FERMENTATION PROCESS AND ITS PROGRESS:

Though misty anaerobic ingestion is the familiar technology in best of the developing countries for energy production, there are more or less remarkable problems with the practice, such as operating below optimal performance, large digester size, constraint of liquid basis, slurry handling and high retention time etc. Some factors like less land and no source of water have also restricted the promotion. Furthermore, farmers cannot utilize effluent properly in line for to conduct problem of the liquid slurry. Although arid fermentation is scarcely used so far, it would be a likely excellent another to the conservative procedure to extravagance the manures and wastes. Arid fermentation is an advanced anaerobic action approach to treat high solid contents bio-wastes without dilution. It bids great benefits like use of wastes in its formed form, no constraint of liquid source, high organic loading rate, minor digester, no liquid overflow, and no requirement of purification of waste etc. It would stay more feasible for semiarid climates and places where no easy access of water [4]. The process has attracted an increasing attention everywhere the sphere with a view to reduce cost of digesters by way of slurry handling problems [5].

The biochemical process for arid fermentation is like to misty fermentation. The biogas making as of anaerobic fermentation of undiluted and diluted manure at 35^0C is similar [5]. The biodegradation of unmixed as well as adulterated manures do not vary noticeably [5]. The ratio of methane is approximately same in biogas whether it is generated through arid fermentation or misty fermentation. Dry fermentation of cow dung is larger to misty fermentation in terms of hydrogen making on per reactor size [6]. Some studies show that nearby is no possibility of survival of pathogenic micro organisms under dry fermenting process. Inactivation rates in lot systems might ensue at a higher rate related with constant systems, as there is no nonstop arrival of fresh material, even fiery fatty acid absorptions are much lesser [4].. There are no arid anaerobic plants in Nepal and other developing countries significantly. As dry anaerobic digestion has more benefits compared to other skills, research on arid fermentation has great importance to make a more efficient and feasible practice to solve multi-layered and dreadful waste problematic.

3. DEVELOP AND OPTIMIZATION OF DRY FERMENTATION PROCESS:

There are massive biomass resources in Nepal that have good biogas likely. In arid fermentation method, the undiluted substrate is pretreated and fed into air tight digester under specified environmental situations. In the nonappearance of oxygen, anaerobic bacteria ferment biodegradable material into biogas. Biogas usually contains 60–70% methane and 30–40% carbon dioxide along with drop quantities of hydrogen sulfide, watervapour, ammonia, Hydrogen, Nitrogen, carbon monoxide, oxygen and siloxanes. It is actually a process by which composite organic macromolecules are former hydrolyzed and fermented into simpler soluble molecules which are then transformed by acid forming bacteria into instable fatty acids (like acetic acid, propionicacid, butyricacid and ethanol), Carbon dioxide and hydrogen. Methane is designed by methanogenic bacteria, moreover by breaking down the acids to methane and carbondioxide, or by dipping carbondioxide with hydrogen.

The solid waste group in Kathmandu is growing rapidly and is expected to be 1091m^3/d (245 tons/day) and 1155m^3/d (260 tons/day). The same trend is also in other cities. There is more than 2 million possible biogas plants in Nepal (BSP, Nepal). In other side, Nepal is facing 16 hours per day load shedding and scarcity of cooking gas. Biogas can be used for electricity production lighting, space heating; water heating, process heating and fuels for engines and so on. Thus, recovering energy from the waste by arid fermentation procedure can help to solving energy crisis, reduce consumption of fossil fuels and can also earn money through carbon trading. To develop and recover the biogas scheme i.e. to rise the quantity of energy produced per unit waste treated, following factors should be considered.

3.1 REACTOR DESIGN:

The presentation of a reactor depends upon its types, types of feed stocks, maintainable organic filling rate, and small retention time to produce the all-out volume of methane. The batch digestion scheme yields a cost-effective and economically feasible means for the change of wastes to valuable energy [8]. A multi-stage system can recover the solidity of the procedure [9] and have higher act but more exclusive. For instance, in a contrast of one- and two-stage thermophilic reactors giving cattle manure [10], it was found that the two-stage digester had a 6–8% developed exact methane yield and a 9% more effective volatile solids removal [11] and found a 21% increase in methane produce when both working on public compact waste.

3.2 MIXING

In adding to basic reactor project, the contents of greatest anaerobic digesters are gradually mixed for attaining optimal anaerobic-digestion to ensure effectual transfer of organic material for the lively microbial biomass, to release gas bubbles stuck in the medium and to avoid sedimentation of solider particulate material. The process of mixing employed can differ greatly such as automatically, recirculation of biogas finished the bottom of the reactor or hydraulic involvement by recirculation of the dig estate with a pump. A certain degree of collaborating is necessary for giving substrate to the bacteria, but extreme mixing can decrease biogas manufacture. In circumstance of plug flow reactor (PFR) material changes through the pot as a clear plug with no mingling with the prevailing vessel insides in the axial direction while employing an arid solid batch ingestion process, mixing becomes rather challenging and can be very costly.

3.3 TEMPERATURE:

Anaerobic ingestion take place at psychrophilic temperatures under 20^{0}C [8] but maximum reactors work at also mesophilic temperatures or, with targets at 35^{0}C and 55^{0}C, respectively. The biodegradability of manure rises with temperature [5]. The procedure becomes quick at high temperatures [12], becomes more and more unbalanced with increasing temperature, and requires greater rates of heat inputs. Thermophilic bacteria are very subtle to small temperature-changes and so maximum of digesters work on mesophilic temperature. Through batch digestion of vegetable waste and wood chips, more quick deprivation of fatty acids was initiate at 55^{0}C than at 38^{0}C, and also 95% of the methane yield was understood after 11 days below thermophilic conditions compared to 27 days below mesophilic conditions [13]. Similarly, the net energy output from 18 l thermophilic digesters was 427 kJ/day higher than that produced by mesophilic digesters [14]. It must be remembered that an increase in methane yield from a thermophilic process has to be balanced against the enlarged energy necessity for maintaining the reactor at the advanced temperature.

3.4 PH AND BUFFERING CAPACITY:

The difference in pH secret reactor moves the digestion procedure because hydrogen-ion concentration has straight influence on microbial development and ideal pH range is 6.8–7.2. The development rate of methanogens is greatly reduced under pH 6.6 [15] and optimum pH for hydrolysis and acid genesis is between pH 5.5 and 6.5, whereas an overly alkaline pH can lead to disintegration of bacterial granules and subsequent letdown of the procedure. That's why hydrolysis/acidification and gametogenesis/ methanogens procedures are separated in the two-stage procedures. Safeguard volume, equilibrium of carbon dioxide and bicarbonateions, provides confrontation to significant and quick changes in pH and is relative to the attentiveness of bicarbonate. Adequate alkalinity has to be available at all periods, up to a level of approximately 3000 mg/l, for adequate buffering to be preserved. Cumulative a small buffer capacity is best proficient by reducing the organic loading rate, though a more rapid method is the addition of strong bases or carbonate salts to eliminate carbondioxide from the gas space and change it to bicarbonate or direct totaling of bicarbonate. To quicken the start-up of the arid digestion process, $NaHCO_3$ gives the best results when the buffer/ substrate solids proportion amounted to 0.06 [16]. It has also been established that the inoculum-to-feed ratio can be adapted to maintain a constant pH. Small chain fattyacids, intermediate products, are also accomplished of inhibiting methanogens in great concentrations. Fermentation of glucose is reserved at total VFA concentrations overhead 4 g l_1 [17]. Acetic acid is typically present in higher concentrations than extra fatty acids during anaerobic digestion, but propionic and butyric acids are inhibitorier to the methanogens. Inhibitors of methanogens such as excessive fatty acids, hydrogensulphide, and ammonia are toxic only in their non-ionized forms. The comparative proportion of the ionized and non-ionized forms and toxicity is pH-dependant. Ammonia is toxic above pH 7; volatile fatty acids and hydrogensulphide are toxic under pH 7. If the ammonia formed can be entirely removed, the dry fermentation of mud can be likely at smaller renewable technology [18].

3. 5 FEEDSTOCKS

The straight contrast of biogas possible of different feed stocks is hard as performance data for specific kinds are often produced under a wide diversity of experimental situations (e.g. mixing regime, pH, temperature, total solids, volatile solids, and retaining time etc). The substrates must have enough moisture content because moisture is vital for the activities of the waste-decomposing anaerobes. For optimal operation, C/N proportion should be about 30:1 in the raw material. While carbon establishes the energy source for the microorganisms, nitrogen serves to recover microbial growth. If the quantity of nitrogen is warning, microbial populations will continue small and it will take lengthier to decompose the obtainable carbon. Excess nitrogen, outside the microbial condition, is often lost from the procedure as ammonia gas [19]. The relatively-small particle sizes rise the whole surface area of the atoms and so improve microbial action. The early substrate concentration belongings anaerobic digestion. An increase of initial organic matter extends the hydrolytic and acidogenic stages. The higher methane manufacture is observed in substrate of 20% TS than 30% TS on arid mesophilic anaerobic ingestion of organic portion of municipal solid waste [20]. Loading rate affects digester's design (particularly the volume), food-to-microbes (F/M) ratio, and truly the overall process-performance. The real loading rate be contingent on the types of wastes fed into the digester since the types of waste determine the equal of chemical action in the digester.

3.6 CODIGESTION:

Codigestion means mingling of changed types of feed stocks beforehand digestion to get good C/N ratio (25–30:1). Codigestion of waste sewage sludge with agricultural wastes or can improve the methane manufacture of anaerobic digestion procedures. The Codigestion of OFMSW and cotton gin waste with cow manure applied intrinsic cellulose demeaning bacteria and the added nutrients in the manure to well digest the fiber in cotton gin waste and the paper section of OFMSW [21]. Hence, codigestion of solid wastes can develop the nutrients and bacterial varieties in various trashes to optimize the digestion procedure.

3.7 PRE-TREATMENTS, PERCOLATION AND ADDITIVES:

Pre-treatment of organized feed shares with optimal proportion (10 to 20 %, [22] of inoculants leachate can rise biogas produce and volatile solids decrease. It also rises solubilisation by giving cellulose or lignin present. The microbial populations existing in rumen liquid have been rummage-sale as a planting material in anaerobic digestion, often to rise the making of fatty acids from lignocellulosic feedstocks. In an aerobic pretreatment, the temperature increase catalyzes the jump of the anaerobic operation because of DE polymerization of complex organic parts but biogas potential is condensed. The waste water heated in a heat exchanger is squirted on stacked biomass over nozzles inside the reactor to keep the temperature; to recruit biogas making; to inspire bacteriological deeds; and to biodegrade the biomass firm. Additives can enhance the making rate of biogas and act of the reactor or rise the speed of start up, but their added cost must always be stable against resulting advances in efficiency.

4. CONCLUSION:

The cumulative sizes of waste being produced would not be a difficult if waste is viewed as a resource and achieved properly through dry fermentation. As utmost of the digesters are running well below their optimal recital, optimization would be answer. Reactors plan needs to rise methane or hydrogen produce from a increasing range of suckle frameworks which can be able using a multi-stage scheme or by refining mixing features without unruly syntrophic action. Thermophilic anaerobic digestion plants frequently have progressive gas outputs and pathogen elimination than mesophilic. Codigestion, pretreatment, count of suitable ratio of inoculum and percolation studies have recognized ways of refining biogas or hydrogen produce. Aerobic pretreatment decreases the retaining time but some percentage of biogas potential is mislaid. It is significant to monitor the parameters like pH, temperature, buffering volume, fatty acid levels to confirm optimal efficacy and exploit gas profit in small retaining time.

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