ENHANCING THE SLUDGE REDUCTION POTENTIAL OF DAIRY WASTE ACTIVATED SLUDGE BY VARIOUS PHYSICO-CHEMICAL PRETREATMENTS

ABSTRACT

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ABSTRACT

Dairy industry is one of the prime sectors in India. Studies say that Indian dairy industries have a growth at more than 15% and are estimated to cross 150 million tons per annum. Water management in the dairy industry is well documented, but effluent production and disposal remain a problematic issue for the dairy industry. Anaerobic digestion is of particular interest in sludge treatment since it can reduce the overall amount of sludge to be disposed, while producing an energy-rich biogas that can be valorized energetically. However, it is hampered due to the rate limiting step of hydrolysis. To improve the rate of hydrolysis and its performance, sludge disintegration was developed as a pretreatment process to accelerate the process and to increase the degree of stabilization. This study presents the findings obtained from laboratory scale experiment of a series of three different sludge disintegration methods like low temperature thermo-alkaline (LTTA), disperser-alkaline and sonication-alkaline, an assessment of pretreated sludge biodegradability and the performance of semi continuous anaerobic reactors of pretreated sludge.

The samples were collected from a dairy effluent treatment plant at Tirunelveli in South Tamil Nadu (India) and characterized for various physico-chemical parameters. Firstly, the laboratory scale feasibility studies

on LTTA pretreatment was investigated and it was carried out at 50 to 80°C during 6 to 48 hrs, in order to enhance solubilization of particulate material, as well as enzymatic hydrolysis. At optimized condition (60°C with pH 12), COD solubilization and suspended solids reduction was 23% and 22% higher than that of control. Besides, protein and carbohydrate hydrolysis was also performed successfully and it was found that increase in temperature doesn't play a major role, i.e., the solubilization rate increases linearly with temperature only till 60°C, after which the rise is nearly flat. Thus, 60°C with pH 12 is significant for protein and carbohydrates release. Biochemical Methane Potential (BMP) assay results of pretreated sludge confirmed that the observed solubilization led to an increase in sludge biodegradability, nearly 51% higher biogas production than control. Thus, 60°C with pH 12 was chosen for semi continuous Reactors.

Two identical laboratory scale semi continuous reactors with a working volume of 4L were used at mesophilic temperature (35°C). Among the two, one is designated as Control Semi Continuous Anaerobic Reactor (CSCAR) which acts as control and another is designated as Experimental Semi Continuous Anaerobic Reactor (ESCAR), where sludge reduction was carried out. Sludge retention times (SRTs) of 20, 15 and 12 d were sequentially tried to investigate the performance of the anaerobic digestion of the pretreated sludge. A control reactor fed with untreated sludge was operated at same SRTs. During the total period of 310 d, the first SRT (20 d) was started at

digestion run time of 60 d until 150 d, then second SRT (15 d) until 240 d, and finally, the third SRT (12 d) until 310 d. With three operated SRTs, the SRT of 15 d was found to be most appropriate for economic operation of the reactor. Combining pretreatment with anaerobic digestion led to 47% and 50% of Suspended Solids (SS) and Volatile Solids (VS) reduction respectively, with an improvement of 75% in biogas production.

Secondly, an investigation into the influence of combined alkaline and disperser pretreatment on sludge disintegration was studied. The effects of four variables, alkalines (NaOH, KOH, $Ca(OH)_2$), treatment time (15-180 mins), pH (8-11) and rpm (4000-24000) were investigated. The effect of sludge pretreatment was evaluated by COD solubilization, SS reduction and biogas production. The best performances, in terms of COD solubilization, SS reduction and biogas production, were the ones that occurred for specific energy (SE) input of 4544 kJ/kg TS for NaOH at pH10, were found to be 24%, 23.3% and 76%, higher than the control, respectively. Subsequently, during the total period of 310 d in semi continuous anaerobic reactors, the first SRT (20 d) was started at digestion run time of 80 d until 160 d, then second SRT (15 d) until 250 d, and finally, the third SRT (12 d) until 310 d. Combining pretreatment with anaerobic digestion at 15 d SRT led to 49% and 51% of suspended solids and volatile solids reduction respectively, with an improvement of 76% in biogas production.

Lastly, this study tested the effectiveness of soniation-alkaline method using different alkaline agents (NaOH, KOH, $Ca(OH)_2$), pH (8-11) and sonic reaction times (5-30 mins) for the first time in literature.. The final optimal parameters were obtained based upon the SE input for the corresponding pH and sonic reaction time with COD solubilization as the response. In this, 4172 kJ/kg TS of supplied energy for NaOH with pH10 were found to be efficient for sludge disintegration. With the optimal condition, COD solubilization, suspended solids reduction and biogas production can be improved by 59%, 46% and 80% higher than that of control. During the total period of 310 d in semi continuous anaerobic reactors, the first SRT (20 d) was started at digestion run time of 90 d until 180 d, then second SRT (15 d) until 250 d, and finally, the third SRT (12 d) until 310 d. Combining pretreatment with anaerobic digestion at 15 d SRT led to 58% and 62% of suspended solids and volatile solids reduction respectively, with an improvement of 83% in biogas production.

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