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Additives For Scum Reduction In Biogas Plant : A Simplified Testing Methedology

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Abstract: ***Scum formation is a major operational problem in anerobic biodigestor. A simple, convenient and inexpensive testing methodology for scum reduction has been developed during span of project. In these research work the effect of canola oil, coconut oil and ENO studied on scum and foam reduction. Canola oil is found out to be the promising and most suited for reducing level of scum compared to the ENO and Coconut oil.***

Keywords : Scum, anaerobic, Canola oil, methane.Methedology

I. INTRODUCTION

Scum can be defined as combination of mainly gas and metastable viscous liquid inorganic waste. Scum is concoction of slow decomposing constituents of food waste which floats on top of digester slurry and mostly dark brown in colour. Several investigations in biodigester studies reveals that the most important drubbing factor contributing to scum formation are servicable parameters of digesters that is organic overload, temperature changes and improper mixing, heavy raw material concentration and presence of precise microorganisms. Methods to avoid scum formation are divided into four categories as Physical, Mechanical, Biological and chemical methods. The mechanical, thermal and electric energy inputs utilized in this methods. Mechanical method reduces scum formation by implanting mechanical devices such as agitators. Biological methods aimed to avoid scum formation by limiting the scum causing biological microbes. For instances by lowering the loading rate of the scum causing microbes in the organic waste. The chemical methods best on operational practices of utilizing the defoamers [7]. Extremely large scum and foam formation leads to operational interference e.g. declination in plant performance[29-32], undesirable pipe blockages [23], declination in transfer of oxygen [24], incorrect measurements by data acquisitions and monitoring modules [25] and unenviable essential solid lost from activated sludge of biogas plant [26-28].

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II. FINDINGS OF THE LITERATURE

A research on foaming in biogas plants fed with agro-industrial wastes was performed. The concrete causes of foaming were organic loading rate of digester and incorrect chemical composition of mixture. Research concluded that protein rich substrates and lipid rich substrates can result in persistent foam. Finally, analysis found out that operational taxonomix unit which is very first species. After foam formation it's content was increased in all digesters. Similar microorganism foam forming bacteria (Nocardia and Desulfotomaculum) was found. From this specific research it is found rapeseed oil as best possible solution to avoid scum formation[1]. Anti-foaming agents destroy the foam and replacement of completely different type of film occurs on foam inducing surface film. Rapeseed oil, which is a type of plant oil, is recommended as a cheap anti-foaming agent by the experimentation [2]. Foam content was reduced by Soyabean oil in all foaming tests. In case of barley lowest foam content reduction (45%) was achieved with the 29% of without Soyabean oil v/s 16% with Soyabean oil. The foam reduction in remaining tests were between 59% for wheat and 64% for triticale. After addition of Soyabean oil, no foam was detected in case of 4mm triticale, while, in case of grain without plant oil 13% of foam content was found means a foam reduction of 100%.In case of coarse grain, the presence of Soyabean oil had a positive effect on foam reduction in digester [3]. The defoaming chemicals lower the elasticity of the surface and inhibit the generations of the foam [6]. The foam phenomenon occurred due the combination of elasticity of the surface and surfactants.Foam establishes the equilibrium among the surfactants and elasticity of surface. Breaking of the foam occurred due to phenomenon of foam to achieve the chemical equilibrium among the surfactants and surface elasticity[34]. The defoaming effectiveness of defoamers is different. The defoaming potency of various chemical defoamers dependent on the compound reactivity, factors causing foam formations and characteristics of foam. Defoaming chemical additives breaks the equilibrium of foam forming films by different mechanisms for instance forms aquaphobic bridges among foam forming films. For Successful operation of these mechanism the smaller droplets of chemical additives should break in the foam forming films. Hence, the diameter of chemical additive droplet should be smaller than the thickness of the foam forming film. The Defoaming chemical additives should be mixed as an emulsion. A convex curved surface formed as a results of contact of aquaphobic chemical additive in the foam forming films. The pressure build up below these convex curved surface and repels the liquid.

Finally equilibrium disturbs and foam forming film collapses. The defoamers should be added adequately to maintain the elasticity of the surface [6]. Vegitable oils beneficial than the chemical defoamers. The vegitable oils are abundantly available in agricultural crops and improve the production of biogas. Vegitable oils have different viscosities and defoaming potential.

The defoaming potential of vegetable oils is poor because they dispel suddenly. Vegetables oils are aquaphobic compounds of the esters i.e. triglycerides of glycerin.Foam suppression by adding antifoaming agents were Oleic acid and octanoic acid at different concentrations and compared with tendency of foaming of raw manure. Decrease of foaming in case of octanoic acid was greater as compared to oleic acid. Antifoam injection has two methods, namely, injection at top and bottom of reactor. The defoaming found out to be better with the bottom injection technique. Whereas, in case of where foam was created very rapidly and when it cannot suppress immediately, so in those cases injection of defoaming agents from the top of digester plays vital role [7]. Antifoaming agents such as oleic acid or rapeseed acid reduces foaming which was caused by proteins in the biogas digester and lipids. Various antifoaming agents are used but without scientific approach it can harm the mesophilic reaction. Carboxylic ends of lipids were responsible for increasing foam production or counteracting foam. So it is concluded that oils and fatty acids could reduce or suppress foam whereas foaming was generated by salts of fatty acids. Rapeseed oil stimulated methane production and oleic acid showed immured effect. [8]

III. METHODOLOGY

The testing methods for the evaluation of the effectiveness of additives to reduce scum formations were costly and time consuming. Existing tests were not providing promising findings [19-20] .The simple testing method developed and implemented in this research work. The samples used in the experiments were obtained from digester of Biogas plant (K2 plant) at katraj waste disposal depot maintained by Mailhem IKOS Pvt. Ltd having capacity of 5TPD municipal solid waste.

A. Precautions taken for the Sample Extractions

The sampling bottle and equipments kept clean and free from atmospherics contaminations. The sampling equipments were rinsed with the Nitric Acid 70 % volume / volume. The bottles filled in a such away that little space kept unfilled to compensate for expansion of sample during transport. The sample site selection was based on the objectives of the study from scum affected sites. These samples were initially extracted in the standard plastic bottles and stored in the dark place at normal room temperature (27°C).The sample extracted for study utilized for treatments within 24 hours to maintain its reactivity. The samples were kept away from excessive heat sources [21-22].

B. Additives constituents

Canola Oil (contents per 200 gm)

Saturated fats 14g, monosaturated fats 126g, Polysaturated fats 62g, omega 3 acid 15g, vitamin E 120mg.

Virgin Coconut oil

Fatty Acids, Moisture

ENO (contents per 10g)

Swarjiksara 5.82g, Nimbukamlan 4.08 g, Sodium Saccharin 10mg

C. Defoaming Potency and calculations formulae

Based on the Volume after 24 hrs of additive addition the defoming potency calculation formulae is developed [33]

$$Defoaming\ potency = \frac{(Volume\ before\ additive\ addition - Volume\ after\ additive\ addition)}{Volume\ after\ additive\ addition} \times 100$$

If the value comes negative, the defoming potency is not satisfactory.

D. Experimentations

For experiments 500 ml of sample is taken in a conical glass flask. Then chemical additives in ratio (v/v) are added to the sample. The mixture is then stirred with a glass stirrer to replicate the conditions in the digester. The conical glass flask is then sealed with a rubber cork having a hole. Glass tube is inserted in the hole at one end and at other end sealed with a rubber inflammable balloon. This is to store and measure the methane gas formed during the process. Readings were taken after 1hrs, 5hrs, 18 hrs and 24hrs of a day respectively.

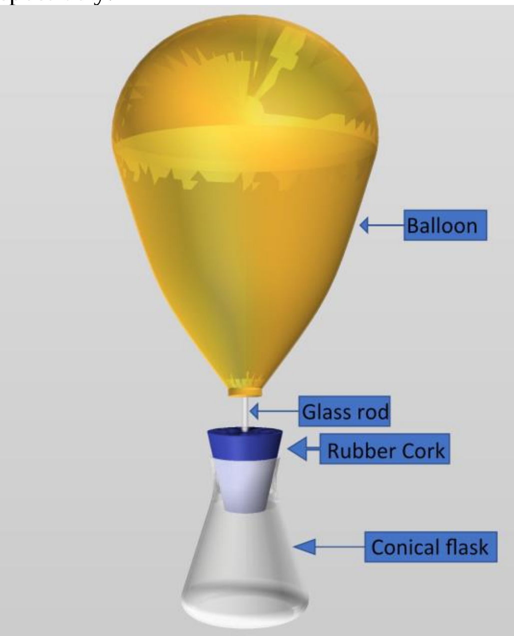

Fig. 1. Apparatus of test.

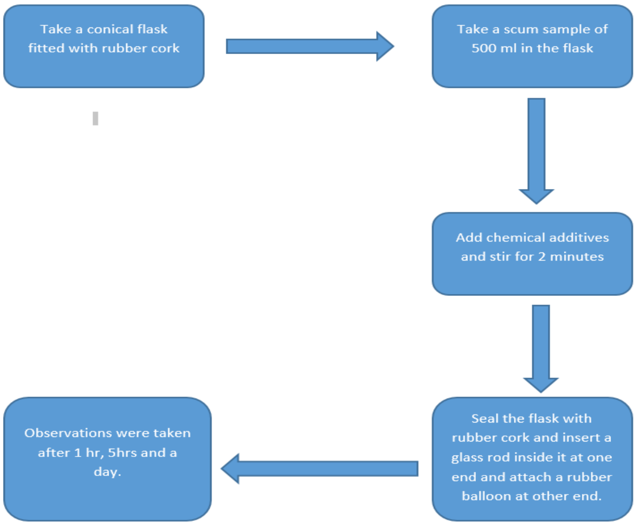

Fig. 2. Procedure for experimentation

IV. RESULTS AND DISCUSSIONS

A. Comparison of Defoaming Potency performance of Additives canola oil, Coconut oil and ENO.

Chemical defoaments used in these experiments were edible canola oil, coconut oil and ENO. The experiments were conducted for a one cycle of a day as the condition of samples will deteriorate after it.

The scum sample of 500 ml volume was taken in a conical flask. Then above chemical additives in ratio 0.5% (v/v_{sample}) are added to the sample. It was then stirred with a glass stirrer and then the flask is sealed tight with a rubber fork. The experimentations were repeated on scum samples from different biogas plants to obtain accurate results. The defoming potency of Canola Oil, Coconut oil and ENO after 24 hrs is found out to be 14 %, 1% & -2.67% respectively. The readings were taken after an hour, 5hrs, 18hrs, and 24 hrs of the additive addition. The additive does not showed accountable change at the observation of 18hrs readings. The defoaming potency of the canola oil additive was found out to be the best as represented in figure 3. The canola oil successfully controls the rapid volume expansion of foam while the results of Coconut oil and ENO were not satisfactory. Canola oil reduced the level of scum without triggering the bacterial reaction and hence the scum layer has been controlled. The validation of the experimental results obtained from the tests conducted using different chemicals additives were compared with the one without using any additives. The sample was kept without additive addition in flask and the reading of volume reductions were taken. It was evident that the after one hour the sample had reduced by just 2 ml, the sample after 24 hours is reduced to 5 ml only and some slurry is formed. In further observation the sample drastically deteriorate after 72 hours the scum and foam layer had drastically increased almost till the cap due to gas entrapment. This happened due to bacterial action which catapulted the reaction.

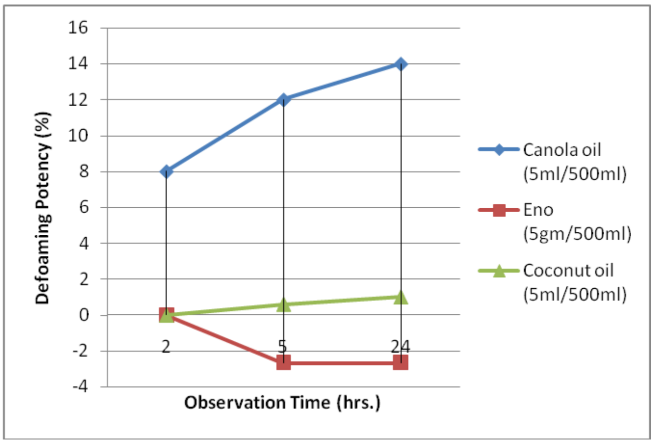

Fig.3. Scum Reduction Vs Observation Time in Hrs after different additive additions canola oil, ENO and Coconut oil.

B. Defoaming Potency of Canola Oil

The further experimentations were conducted with additive canola oil in ratio 0.25%, 0.5%, 0.7% and 1% (v/v_{sample}) were added to the sample to obtain the optimum result as showed in figure 4.

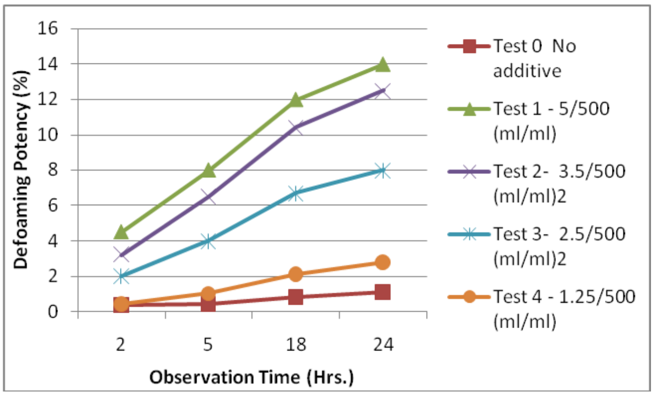

Fig. 4. Scum Reduction Vs Observation Time in Hrs for different Canola oil concentrations.

The experimentation clearly concludes that the suppression of the foam enhanced after increasing the concentration of canola oil. The foam reductions were directly proportional to amount of the addition of canola oil. After 24 hours of canola oil addition the maximum defoaming potency of canola oil found to be up to 14%.

V. CONCLUSIONS

It is found that canola oil as most efficient additive to decrease scum level compared to ENO and coconut oil. It is found out that vegetable oils can be a good solution to decrease scum level. Brief literature review concludes that in the coarse grain the presence of soyabean oil reduce foam in digester, the rapeseed oil stimulated methane production and oleic acid showed slight inhibitory effect and antifoam injection at the bottom of the digester showed good results as compared to the headspace injection method. The defoaming potency of canola oil is found out to be in direct proportion to the concentration of addition of canola oil.

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