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Effect of Canola Oil to Reduce the Scum Formations

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Abstract*: The scum is a colligation of slow degrading substrate formed on topmost portion of digester with its gas, metastable liquid and foam contents it impacts seriously on biogas plant economically, environmentally and biologically. Scum formations hamper the yield of biogas generation, methane contents, slows the degradation process and stops the burnable biogas formation. The operational plant performance drops rapidly. The experimentations were conducted with canola oil, natural Coconut oil and ENO to evaluate the defoaming potentials on lab scale model. The research concluded that the canola oil is best chemical additive which reported better defoaming potential of 32% at peak, higher yield of biogas, improves methane contents and stabilizes the pH for better biomethanation.

Keywords: Canola oil, Additives, defoaming, Methane content

I. INTRODUCTION

Scum is a layer of slow degrade organic food formed on topmost portion of the digester slurry which is usually dark brown in colour. Scum events eventually occurred during summer and winter seasons due to fluctuation in temperature. Scum is mostly gas and metastable viscous liquid.

Scum events disturb the biogas power plants and leads to many serious problems. Scum events leads to physical, biological and economical failures of biogas plants. Scum comes out of digester, blocks the pipes, reduce the surface area and losses of inoculums. Scum productions inhibits the methanogenic bacteria microbes formations. Scum interferences with the mixing equipments and blocks the pumps and auxiliaries. Scum produces on topmost portion of digester slurry where methane is presents in dome of the digester. The methane is hot gas at about 50°c which heats the scum top layer and hardened. The hard cover responsible for the blockage of the production of biogas.

To overcome the operational difficulties of the scum deep-rooted study of the causes of scum production is essential. Scum formations causes due to the Organic Overloading, Temperature fluctuations and Improper mixing, increase of scum forming microbes and feeding of the slow degrade fibrous and cellular food waste.

Scum can be reduced by physical, chemical, Mechanical and biological methods. The physical and mechanical methods include proper mixing, implementations of agitators and recirculation through the pumps which consume electric and mechanical power sources.

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Chemical methods include the additions of chemical additives which codigested with input waste and favor the biogas productions. Biological methods include the limiting of the feeding of scum causing microbes to digester. The scum formations can be reduce by the maintaining the operational functionalities, mitigations and adaptations, design practices and implementations of recent up gradations techniques [1].

The experimentations conducted by the L. Moeller , F. Krieg , A. Zehnsdorf , R. A. Muller the experimentations concluded that the use of soybean oil reduce the foam formation upto 45% and co digested with the substrate[2]. The research conducted by the P.G Kougias, P.Tsapekos, K. Boe and Angelidaki addition of oleic acid octanoic acid reduces the scum and foam formations. Injection of additive from bottom is preferred by these researchers [3].

H. Wu, R. Dong, S. have experimented with alkaline agents to maintain the PH level as PH drops means more acidity which leads to scum and foam formations. Experimentations includes CAO and NAO alkaline agents. These method not beneficial due to residual alkaline contents and financial considerations in ammonia stripping process[4]. Fazilet Vardar-Sukan experimented with several defoamers to break equilibrium of surfactants and elasticity of surface to reduce foam and scum formations by lowering elasticity of surface. Experimentations suggested for vegetable oils which easily co-digested with the substrate [5]. Ignasi Rodríguez-Roda, Maria Casellas, Elvira César, Laura Pastor, Eduard Moliné, Bonmatí, Bhargavi Subramanian and Krishna Pagilla favored the chemical defomers, operational and design modifications and sludge breakup (disintegration) process [6].

The Literature suggested implementation vegetables oil is beneficial and preferable and strong bases helps to maintain the PH of digestion process which encourage the biogas generation.

II. MATERIALS AND METHODS

A. Feedstock selections and properties

The literature suggested the natural oil are beneficial and co-digested with the input raw material and encourage the biogas production. Therefore, the canola natural oil and coconut oil is selected for the experimentations. The strong bases also showed the good results and fascilates the PH adjustment so, for experimentation easily available ENO is selected for the experimentations.

Canola Oil (contents per 500 gm) monosaturated fats 315g, Polysaturated fats 155g, Saturated fats 35g, vitamin E 260 mg, omega 3 acid 36g. Natural Coconut oil Free Fatty Acids and contents of Moisture ENO (constituents per 100 gm) Nimbukamlan 42.8 g, Swarjiksara 59g, Sodium Saccharin 110mg.

B. Experimentation Plagiarism Check

Lab Scale model with scale 1:250 is prepared

i. 20L cylindrical container with black cover
ii. Cavlar Balloon for gas storage.
iii. Pipings done by PVC pipe (inlet and outlet)
iv. Simple Connecting tube.
v. Piston valves and Flow control valve.

All the equipment were properly cleansed and treated with nitric acid to avoid any type of contaminations. The experimental setup were kept similar as per the actual atmospheric conditions of biogas plant. The cylindrical container used as a biodigester to do the experimentations. The Biodigester covered and kept in surrounding. Dead weight is kept at the top of biodigester to maintain the required pressure for biogas genetrations.The flow control valves are used to maintain the flow of biogas from digester to balloon unit. The input and manure output are monitored as per the standard operating procedures.

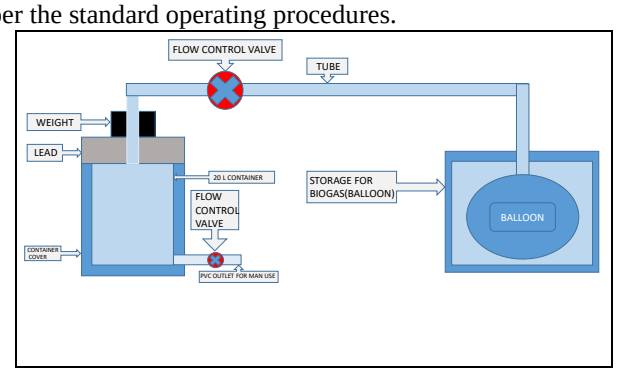


Fig.1. Experimentation Setup

C. Protocol for the Experimentations

The Samples of Municipal Solid Waste were collected from katraj biogas plant maintained by the Mailhem Ikos environment pvt.ltd. The organic fraction of MSW was segregated from sample. The crushing of segregated samples was done. It was feeded with equal amount of water to the digester. The various additives were added as an emulsion to the biodigester. The retention time maintained to achieve the stability. The yield of biogas, methane contents of biogas and PH is strictly monitored during the experimentations. Tests were performed with following combinations of additives.
Combinations 1: MSW + Canola oil.
Combinations 2: MSW + Coconut oil.
Combinations 3: MSW + ENO.
The rigorous experimentations were repeatedly performed to validate the results

D. Analytical methods

The properties of feedstock were analyzed by APHA2005. The biogas content and methane yield were checked on gas chromatography machine.

E. Defoaming and Scum Reduction Potential (%)

The scum and foam reductions is calculated as the ratio of the change in volume to the original volume of the mixture [7].

Fig.2. Protocol for Experimentations

III. RESULTS AND DISCUSSIONS

A. Scum Reductions potentials of canola oil, ENO and Coconut oil additives.

The municipal solid waste and equal amount of water along with three different additives in proportion 1% Volume on volume basis is feeded to three separate digesters for experimentation. The additives were added as an emulsion for better mixing. The experimentations were repeated to obtain accurate results. The volumetric change (scum and foam reduction), biogas yield and methane contents were analyzed. The defoaming potential of canola oil, ENO and Natural Coconut oil depicted in Fig.3. The defoaming potential of Canola oil, Natural Coconut oil and ENO were found out be 32%, 4% and -12%. The canola oil showed best results for scum and foam reductions. The coconut oil showed negligible change while ENO showed adverse effects for scum and foam reduction.
The validation of results obtained by adding different additives was compared with the one containing without any additives. The separate fourth digester is build to confirm that there any change on scum reduction of time interval without adding any additive and kept for 30 days. The readings were systematically taken and assessed. After one day of feeding the scum and foam started to form, the volume of biodigester was increase by 60 ml and after every day the volume increases due to scum formation. The highest value of change in volume was noted as 680 ml. The scum and foam formation increases on time interval which is adverse effect. The addition of additives showed decrease in Volume which is a positive effect of addition.

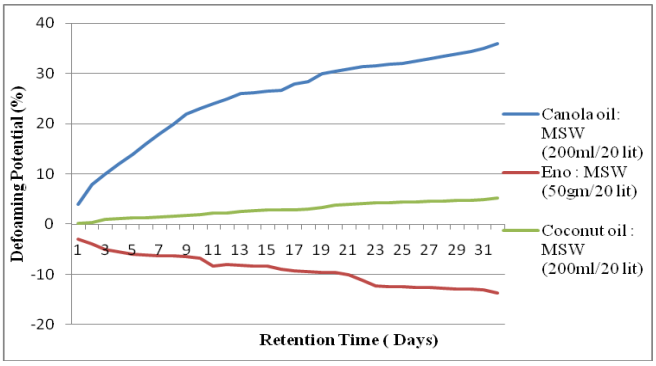


Fig.3. Defoaming potential of Canola oil, Eno and Coconut oil

The scum and foam layer formed on top level of digester due to the equilibrium of Surfactants and surface elasticity as well foam causing films. After addition of the chemical defoamers the droplet of defoamers is smaller than thickness of foam causing films. It enters into the foam causing films and produces the aquaphobic bridges among this foam causing films by building convex curved surface. The pressure below convex curved surface is more which repels the liquid molecules and inhibits the formation of foam films. Moreover, such surfaces lower the elasticity of surfaces and break the equilibrium between the surfactants and elasticity of surface and reduce the foam and scum formation.

B. Biogas Yield obtained from different additives.

The yield of biogas was measured for each biodigester. The biodigester with canola oil as additive showed best results with max yield and burnable biogas formation at 21 day in retention time. The Coconut oil as an additive for biogas formation showed moderate results while ENO inhibits the biogas formations.

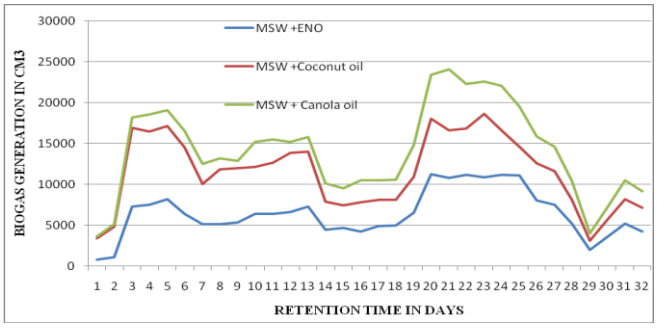


Fig.4.Biogas Generation potential by different additives

The canola oil is best additive for scum reduction which decreases the scum and favored the biogas formations. The canola oil reduces the scum at top level of digester due to which more surface area exposure to act for methanogenesis. The recently formed biogas comes at topmost part of digester and clears path for fresh biogas generations. The scum was responsible for the blocking and mixing of substrate previously which was reduced by addition of canola oil and easily co-digested with substrate. The ENO increases the pH of digester and residual alkaline product disturbs the methanogenesis process and resulted in poor yield of biogas formations.

C. Comparison for the Improvement in Methane Contents by Additives.

The generated biogas was analyzed on Gas Chromatography Machine for the contents of methane in biogas. The methane contents enhanced by using canola oil as an additive. The experimentations conducted for the canola oil, coconut oil and ENO as an additive the methane contents were found out to be 58%, 53% and 42 % respectively at the end of four weeks.

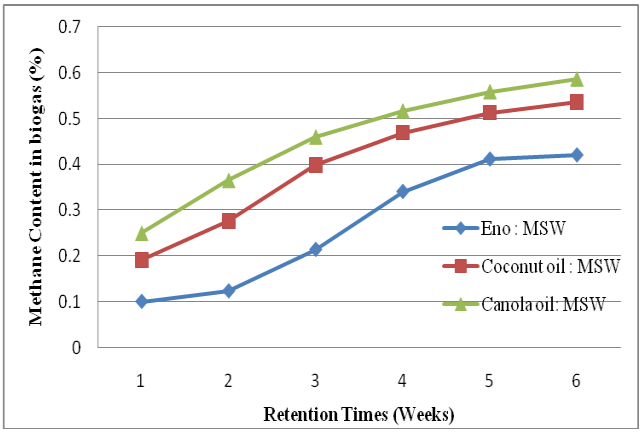


Fig.5. Improvement in Methane contents by different additives

The digestion process called methanogenesis mainly affected by the scum and foam formations. The canola oil was found out to the best additive for scum and foam reductions which improves the digestions and enhances the methanogenesis. The Canola oil forms a top layer on the digester which replaces the scum and foam causing films which helps to degrade faster the slow degradable substrates and enhanced stage 1 called hydrolysis of digestion and results into better digestion.

D. pH adjustment by additives addition.

The pH plays vital role in scum and foam formations. The decrease in pH level 6 leads to more acid formations and enhances the scum and foam formations and inhibits the biogas generations. The pH above 7.6 leads to alkalinity and again retards biogas generation. The pH behaviour with addition of different additives was plotted against No. of days in fig.6.The Graphs clearly concludes that the pH stabilizes after three weeks of additive addition. The alkanality reported higher with the ENO as it is a strong base. Coconut oil showed moderate Normal pH range during complete process.

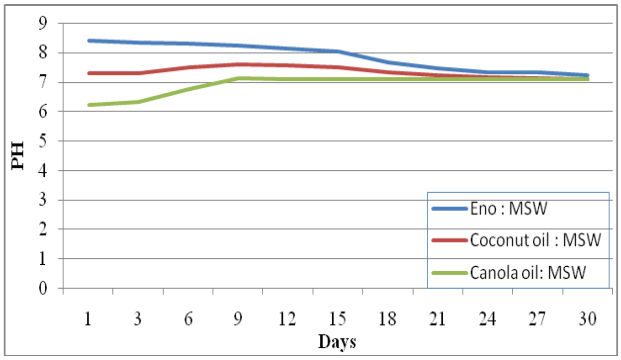
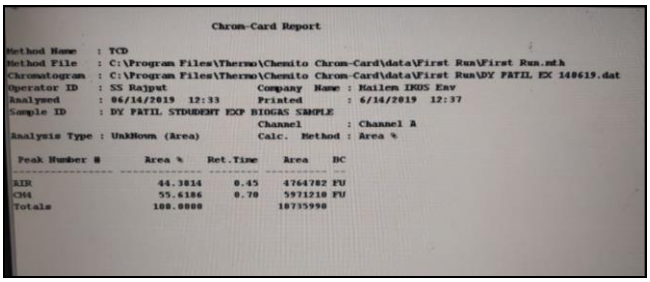


Fig.6. PH for the process of biogas by additive addition.



Chrom-Card Report

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Chromatogram : C:\Program Files\Thermo\Chemito Chrom-Card\data\First Run\DY PATIL EX 140619.dat
Operator ID : SS Rajput Company Name : Mailem IKUS Env
Analysed : 06/14/2019 12:33 Printed : 6/14/2019 12:37
Sample ID : DY PATIL STUDENT EXP BIOGAS SAMPLE
Channel : Channel A
Analysis Type : UnkNown (Area) Calc. Method : Area %

Peak Number #	Area %	Ret.Time	Area	BC
AIR	44.3814	0.45	4764782	FU
CH4	55.6186	0.70	5971210	FU
Totals	100.0000		10735990	

Fig.7. Sample of Result on Gas chromatograph

IV. CONCLUSION

The research concludes that the

The canola oil showed best results for scum and foam reductions. The coconut oil showed negligible change while ENO showed adverse effects for scum and foam reduction. The defoaming potential of Canola oil, Natural Coconut oil and ENO were found out be 32%, 4% and -12% at the peak of biogas production which slightly increases with further retention time. The biodigester with canola oil as additive showed best results with max yield and burnable biogas formation at 21 days in retention time after feeding which was better as compared to normal 30 days of retention time for development of first culture of methanogenic microbes. The Coconut oil as an additive for biogas formation showed moderate results while ENO inhibits the biogas formations. The methane contents enhanced by using canola oil as an additive. The research concluded that the canola oil, natural coconut oil and ENO as an additive the methane contents were found out to be 58%, 53% and 42 % respectively at the end of four weeks. The experimentations conclude that the pH stabilizes after three weeks of additive addition to substrate.

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