CASE STUDY

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BOC DISSOLVES LIPOPROTEIN (EPS) CONCENTRATION IN A DIGESTER REDUCING VISCOSITY, BALANCING BIOLOGY AND ENHANCING DIGESTABILITY

April 4th, 2020

1. ABSTRACT
During 2019 a staged trial was carried out on a co-digestion site in Leicester. It included supermarket waste, swine waste, dog food and oil washing as feedstock. Careful attention to daily Dry Matter (DM) feeds with daily sampling, as well as the DM, FOSTAC, pH and temperature.

BOC (Bio-Organic Catalyst, a proprietary liquid formulation consisting of a surfactant and protein synergist) was used as a stand-alone pre-treatment and trialled to understand the effect it would have on Biogas production, Organic Loading Rate and Odour. The results of the first stage (Controlled Batch Reactor, (BR) were promising, increase consumption of 3.1kg VS was seen in the treated BR, 25% greater than the control BR, see Figure 1 for this. The Treated Reactor, when decantated, showed less viscosity and was not characterised by a fungal layer at the surface of the soup.

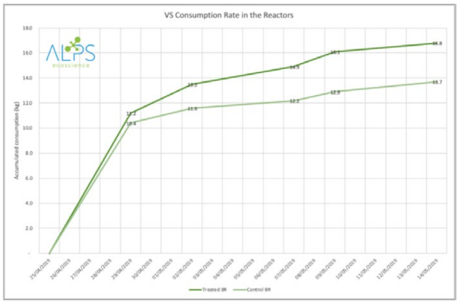

Figure 1 Rate of VS degradation in the Batch Reactor

Full-scale treatment began on July 15th and ran for 70 days. OLR before treatment was 5.81g DM/L/d, during treatment, this increased to 7.57g DM/L/d. By the end of September, treatment had stopped, and by early 2020 the process was experiencing difficulties from foaming and increased viscosity. The OLR had not reduced to previous levels remaining at 7.09g DM/L/d per its standard Organic Loading capacity (OLR) of between 5.5 and 6g DM/L/d. By late February the pasteurisation was no longer able to carry the required heat. Viscosity tests showed it 3 times higher than is considered normal. BOC treatment was started again on February 5th and has reduced viscosity by 42%, biological indicators have returned to normal, and the digester is on the mend.

2. THE SITE
The site has two primary digesters, each 3,000M3 in size, fed by a day tank via a hydrolysis tank. The feedstock consists of predominately food waste mixed with swine effluent and waste dog meal, a total annual feed of 50,000T.

The site is located in Leicester, UK and can preselect food waste, ensuring an ODM loading is consistent. Power generating capacity is 1.5MWh, generated through two 750kWh CHP engines fed by 7.685M M3 of biogas and an average of 57.95% CH_4 content.

Table 1 Technical details of the operation

PLANT TECHNICAL DATA	
Year of plant construction	
Year in service	
Plant size	1.5MW
Digester volume	4,500M^3
HRT	25 to 30 days
Process Temperature	40°
Feedstock	Co-digestion of food waste, pig slurry and dog food

3. CONCEPT

Anaerobic Digestion of Solid Organic Wastes (SOW) involves four steps, Hydrolysis, Acidogenesis, Acetogenesis and finally Methanogenesis. Fermentative bacteria first hydrolyse high molecular weight substrates into low weight molecular weight and water-soluble organic intermediate products such as glucose, fatty acids and amino acids. This initial process sets up the rest of the digestive process and production can be maximised by enhancing this process. Particulate size and Interfacial tension (IFT) ensure the fermentative bacteria have an easily digested food source.

Of the four stages of Anaerobic Digestion (AD), the Hydrolysis step is often the limitation. Hydrolysis is the conversion of particulate and bound biopolymers to simple biodegradable organic compounds. Pre-treatment of the feedstock enhances the performance and efficiency of the AD through cell wall rupture and release of intracellular components.

BOC, with its protein/surfactant synergist, first aid by modifying the surface-active properties in the liquid phase as well as provide similar protein to the fermentative process. Studies have shown upwards of 75% increased biogas generated in some co-treatment studies and up to 30% in stand-alone treatment.

The BOC enhances the lysing and destruction of microorganisms (Biofilm). It modifies the cell structure by building cell materials; this leads to improved acidification of substrate and hydrolysis. BOC can dissolve certain extracellular polymeric substances (EPS) and ensure digester stability with slightly higher pH and proper viscosity levels.

BOC in the hydrolysis step enhances the solubility of COD into liquid phase, again many studies prove this, a study carried out by Aqua Enviro showed an increase of 1,240% Fats solubilisation. It is then very quickly stripped out as Methane.

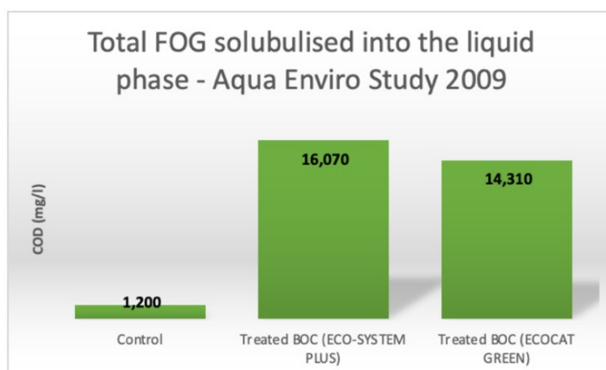

Figure 2 BOC and its effect on dissolving COD to liquid phase, results as reported by AquaEnviro in 2009

4. METHODOLOGY

Accumulation of Biofilms in the soup formed through secretion of extracellular polymeric substances (EPS). Bacteria come together and formed sessile aggregates to produce EPS, or more commonly known as slime; it is a matrix containing DNA, proteins, lipids and polysaccharides. This phenomenon is normal; however, when a sudden change to the food-stock or overloading, the bacteria increase the secretion of these EPS as a protective strategy, a little like a feast/famine strategy.

In this particular digester, the EPS identified as a Lipoprotein (see Figure 2), the digestate is loaded with fat and protein lending itself to this. Samples were drawn before treatment and again 22 days later. The results of which discussed below.

5.RESULTS

BOC can dissolve the lipoprotein molecule; the results of the treatment thus far are.

Table 2 Viscosity resultsfromthree weeks into BOC treatment at different shear rates

	Dig 1	Dig 3	Dig 1	Dig 3	Dig 1	Dig 3
05/03/2020	2184	1808	3756	3110	4217	3586
27/03/2020	1296	1271	2156	2078	3387	3157
% decrease in viscosity	40.7	29.7	42.6	33.2	19.7	12.0
Shear rate	4.314		2.576		1.288	

We expect to see further reductions in April when the digesters reach approximately 1,500mPas at a shear rate of 2.567 we will then reduce the dosing concentration of BOC.

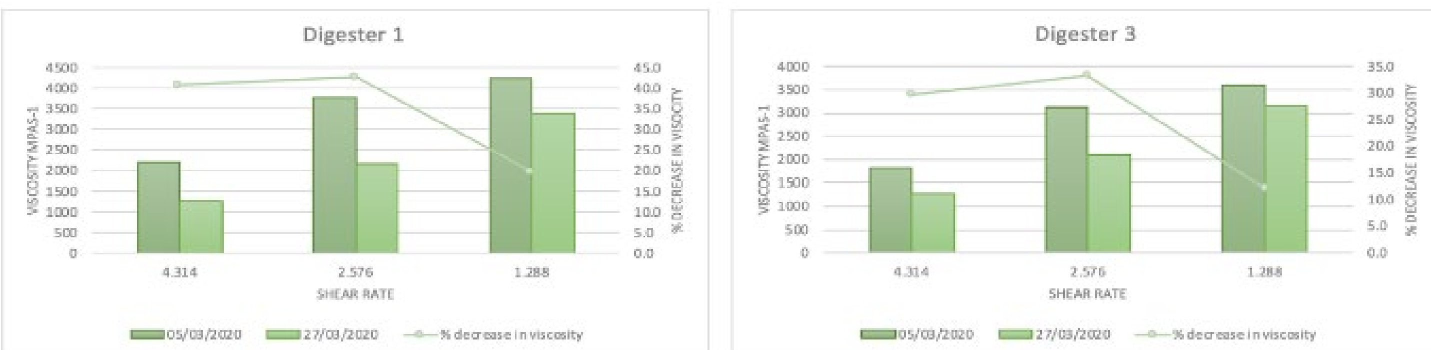

Figure 3 Representing the viscosity reduction in the digestate based on the results in Table 2

Below show results from the initial samples as reported by the laboratories.

A portion of the second sample was bench tested for COD reduction; the results showed a 25% reduction in COD after 2 hours of stirring and heating from 88,000mg/l to 65,900mg/l. It is further evidence of the BOC capability in enhancing the stripping out soluble COD to gas.

AC Shropshire Digestate, mixing at 78 rpm for 2 hours (starting temperature around 30 degrees, final temperature around 50 degrees)

1 ml of ECO CAT was added to 500 ml of digestate

Column1	Initial Vol. (ml)	Final Vol. (ml)	COD (ppm) diluted 1 in 10	Actual COD (ppm)	COD Reduction (%)
Digestor 1 Blank	500	350	8,800	88,000	
Digestor 1 with BOC	500	350	6,590	65,900	25%
Digester 3 Blank	550	400	8,940	89,400	
Digester 3 with BOC	550	350	7,790	77,900	13%

Sugars in extract polymeric	Wet weight basis %									
	Total Sugars	Glucose	Xylose	Mannose	Arabinose	Galactose	Rhamnose	Klason Lignin/undigested protein	Acid Soluble Lignin/UV absorbing protein	Ash
Mix of 1 & 3 digester	0.86	0.54	0.15	0.04	0.08	0.04	0.01	1.15	0.60	1.86

* It seems that the exopolysaccharide is protein-lipopolysaccharide as the mass balance does not add up with the protein and sugars data

Sugars in extract monomeric	Dry weight basis %						
Sample name	Total Sugars	Glucose	Xylose	Mannose	Arabinose	Galactose	Rhamnose
Mix of 1 & 3 digester	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sugars in extract monomeric	Wet weight basis %						
Mix of 1 & 3 digester	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* There are no monomeric sugars in the extract. Indicating that the viscosity is caused by polysaccharide

Exopolysaccharide					
	Dry EPS% in the liquid	Wet EPS% in liquid	Dry EPS% in the total sample	Wet EPS% in the total sample	Water holding capacity g/g dry EPS
Mix of 1 & 3 digester	0.81	6.054	0.57	4.06	6.47

Sugars in extract polymeric	Dry weight basis %										
Sample name	Total Sugars	Glucose	Xylose	Mannose	Arabinose	Galactose	Rhamnose	Klason Lignin/undigested protein	Acid Soluble Lignin/UV absorbing protein	Ash	Mass Balance
Mix of 1 & 3 digester	12.35	7.77	2.14	0.56	1.14	0.60	0.13	16.57	8.58	26.73	64.22

Figure 4 Lab results as reported identifying the EPS (Extracellular Polymeric Saccharide)

6. RECOMMENDATIONS

Continuation of treatment will offer the operators peace of mind the biological process is in balance and is resilient now to any potential changes to the process. As the digestate returns to lower viscosity through the dissolving of the lipoprotein EPS, we will slowly reduce the dosage concentration and increase the OLR.
It is scientifically proven and accepted a surfactant will benefit AD either as a stand-alone or in combination with a mechanical pre-treatment (Kavitha et al., 2012). The protein synergist, the proprietary technology, in the BOC will turbocharge the biochemical process and will do this at a commercially competitive rate. Cost of treatment is approximately 0.3p/kg DM.

While offering operators resilience and peace of mind on the digestibility and biological balance within his digester, it also offers enhanced organic loading capacity, in some cases able to increase OLR by 20 to 30%.

7. PERFORMANCE OF DIGESTER THROUGH PRE-TREATMENT, TREATMENT AND POST-TREATMENT

Column1	Pre-treatment	Treatment	Post-treatment
From	01/01/2018	15/07/2019	01/10/2019
To	14/07/2019	22/09/2019	30/11/2019
Total Days:	559	69	60
OLR (g DM/L day)	5.81	7.33	7.09
Total DM (kg):	13,517,421	2,383,479	1,946,721
DM/Day:	24,181	34,543	32,445
CH_4 (%)	57.95	59.96	59.39
Biogas (M^3)	9,966,549	1,715,183	1,318,360
Biogas yield (L/kg DM)	737	720	677
Fostac (Dig1)	0.34	0.3	0.3
Fosatc (Dig 2)	0.39	0.29	0.3
pH (Dig 1)	7.64	7.31	7.32
pH (Dig 2)	7.61	7.32	7.33