ABSTRACT:

Anaerobic digestion offers excellent opportunities to convert organic waste streams into environmentally safe bio-solids and generation of renewable energy through the bio-methane produced by the microbiological populations processing the wastes. Bio-organic catalyst compositions (BOCs) offer improvements in enhancing anaerobic biological activity and raising bio-methane production. The bio-catalytic actions of BOCs act upon the influent waste stream components, accelerating methanogenesis optimization within the anaerobic digestion (AD) unit, improving total solids (TS) and total volatile solids (TVS) reductions, while improving bio-solids’ quality.

KEYWORDS:


INTRODUCTION:

Extensive work in both municipal and food processing anaerobic digesters has shown that BOCs offer great potential in optimizing anaerobic digestion conversion rates, while solving chronic operational challenges of operators in obtaining optimal renewable energy production and high quality bio-solids.

The economics of anaerobic digestion is closely tied to obtaining optimal renewable energy bio-methane yields, which offsets fossil fuel energy purchases. The ability of increasing bio-methane yields directly reduces natural gas and fuel oil purchases, and increasingly, carries values in generating renewable energy or carbon reduction credits.
Accelerating and optimizing the anaerobic digestion rates expands the capacity of anaerobic digester system through enhanced biological vitality, is also tied directly to the capital equipment investment (CAPEX) of combined heat and power (CHP) required to utilize bio-methane production.

Problems encountered in anaerobic digesters generally are tied to the difficulties of various components of the waste stream to be converted in anaerobic digestion, leading often to a decrease in bio-methane yields over time, and reduction of usable renewable energy cash flows.

Most anaerobic digesters are often challenged by these factors that can result in reduced bio-methane yields, and require expensive maintenance cleanings, in addition to decreasing renewable energy production. The organic materials that represent the highest bio-methane values are also the organic components that cause these problems, the volatile organic solids.

BOCs directly act on these high value components of wastes, accelerating the anaerobic digestion processes into more optimized conversion efficiency. Case studies show a much higher yield per pound, or kilo, of organic waste biogas, while clearing the internal blockages that build up over time.

BOCs require little capital equipment expenditure, as installations are simply an injection pumps, along with a reservoir of BOCs. Results become evident relatively quickly, as a faster release of high bio-methane value components of the waste material shifts the internal biomass within the anaerobic digester into the methanogenesis phase, increasing the bio-methane yields and total consumption of volatile fatty acids.

A complete mass balance analysis of using BOCs shows benefits over a number of critical costs of operations, including, 1) lowering bio-solids hauling weight and volumes 2) substantially reducing bio-solids odors 3) reducing aeration energy through recirculation of dewatered liquids 4) total nitrogen reductions and 5) improvements in all discharge values of a facility, including BNR discharges.

CHALLENGES OF ANAEROBIC DIGESTION:

Anaerobic digestion offers both an effective organic waste stream treatment solution that reduces pollution loadings to environmentally safe discharges. The bio-gases produced within the microbial populations of the AD systems contain renewable energy potential from the percentage of bio-methane in the bio-gases that are generated through the biological reactions. These two characteristics comprise the twin pillars of the economic value proposition to the AD system operator/owner.

The operation of anaerobic digestion (AD) systems is dependent upon feeding the four (4) phase anaerobic digestion process.

(See chart below)
The breakdown of more complex lipids (fats, oils, greases) represents the highest value bio-methane components of the organic waste stream, but also represent the most difficult components to optimize their anaerobic digestion processing. Proper management of acid/alkalinity and pH, length of holding periods, and various other strategies, are all critical operating parameters that insure the conversion of total solids (TS) and volatile total solids (TVS). When these operating parameters become compromised through demands of actual waste stream loadings and AD system design limits, the total optimal biological conversions will be effected.

Co-generation packages are designed to capture, clean up, and produce usable renewable energy yields, which are then utilized to off-set purchases of natural gas, or fuel oil, for heating, and can also provide additional renewable energy off-sets when converted to heat or power generation. Matching combined heat and power (CHP) packages to the bio-methane yields is directly a function of the amortization cash flows and credits available.

In many cases, the AD system provides a critical bio-conversion of high wastewater loadings. Overall wastewater treatment discharges, along with infrastructure requirements and operating costs, will be based upon successfully obtaining the most optimum reductions within the AD system.

With the expansion of renewable energy generation from solid waste sources, a great deal of effort is being extended to fully automated AD system operations and biomass blending strategies to provide the complementary balancing of constituents of the organic waste components feeding the anaerobic digestion processes. Nevertheless, there are fundamental challenges inherent in a complex sequential anaerobic digestion processing that are evident in all AD systems.

USE OF BIO-ORGANIC CATALYST COMPOSITIONS:

The mechanism of bio-catalysis of BOCs on the waste stream components sets into motion an accelerated molecular breakdown of the biomass enabling a corresponding acceleration of the anaerobic digestion processes within the AD system. There are numerous aspects that will impact the complete biological conversion of the total organic solids (TS), and most importantly the total volatile solids (TVS).

Food Processing AD Systems:

The use of BOCs evolved out of their use within the aeration channels of a large international food manufacturer professionally managed wastewater treatment facility. These aeration channels were not able to meet desired dissolved oxygen levels in spite of having both surface aerators and fine bubble diffusers working at maximum capacity. Additionally, heavy lipid (FOG) accumulation had covered the aeration channels. There were odor and bio-solids’ management issues as well.

The use of the BOCs worked immediately in raising dissolved oxygen levels, and very quickly solubilized the accumulated FOGs that had covered the entire aeration channels. This allowed the client to meet much higher loadings than their facility was designed, and engendered confidence in its ability to rapidly solubilize lipid molecular wastewater components.

Due to the wastewater loadings having higher actual organic loadings exceeding their design capacity, along with high concentrations of FOG, the advanced AD system required a flow equalization tank and other load balancing procedures to manage the influent loads. They were being challenged during production cycles in far exceeding their AD system design parameters. Over time, the media within their AD system accumulated.
FOG components that reduced the efficiency of the internal microbiological populations to perform optimum biological conversion of the influent biomass loadings.

In starting up introduction of BOCs into the AD system, a reduced dosage level, compared to established aeration channel loadings and dosage levels, was initiated at the beginning of a trial program. In order to provide adequate solubilization of the complete wastewater components, especially the FOGs elements, the BOC was injected into a collection well, prior to the flow equalization tanks. This allowed a threshold-adjusted solubilization of accumulated FOG elements as the BOC was injected into the wastewater influent that was entering their AD system.

Initially, there was a release of concentrated FOG deposits within their AD system that could be observed in their DAF unit that received the discharges from the AD system. Over a few days, the FOG deposits were cleared out of the AD system, and the bio-methane production curves began to show improvements. Since their AD system is highly automated for optimized biological conversion efficiencies, acid/alkalinity ratios and pH adjustments were possible on a real time basis. As they are required to manage high FOG loadings in their industry sector facilities, they were very focused on the challenges of obtaining good biological conversions of volatile fatty acids.

As the acclamation of the internal microbiological populations adjusted to the solubilization of FOGs, and the vitality of their reproduction and biological conversion efficiencies reached a higher zone of methanogenesis, bio-methane yields began to rise over baseline production values. There began to evolve an optimum dosage of BOC that tied to the wastewater loadings and revealed an optimization improvement potential that averaged an improvement range up to 30% over baseline values.

(See chart below of bio-methane optimization in food processing wastewater AD system at maximum yields established a correspondence with the wastewater loadings.)
Municipal AD Systems:

This success lead to additional food processing facilities managed by the wastewater operator that were experiencing difficulties of adequate performance within differently designed wastewater treatment systems designs, in which the AD systems had experienced nearly complete shutdowns of the AD system due to toxic chemical discharges into their wastewater that essentially crashed the anaerobic biological performance of their AD system.

In one very challenging case, restart-up effort were experiencing substantial difficulties getting their AD system to generate the sufficient methanogenesis activity for bio-methane generation. Upon injection of BOC into their flow equalization tanks, the AD system very quickly began to shift into higher anaerobic digestion efficiency and the methanogenesis biological activity and bio-methane yields rose, with corresponding organic loadings reductions to the SBR wastewater treatment system.

These experiences with various food processing operations and their AD systems, lead to the decision to explore the potential to treat municipal AD systems. The use of AD systems within municipal wastewater treatment facilities represent a significant installed base throughout the world, and with the recent new emphasis on cost containment and renewable initiatives by governmental bodies, there is a strong incentive to generate maximum yields from bio-methane potential within the existing installed base of AD systems in order to more fully utilize the availability of co-generation packages.
Extending the applications scope of using BOCs in optimizing AD systems, a 3 MGD municipal WWTF was approached to serve as a site for a one-year evaluation study that would look at the complete mass balance analysis of both AD system optimization, as well as the corresponding impact on aeration energy usage and total water quality of their discharges. This one-year study allowed an evaluation of a four season cycle, with cold Northeastern US winter temperatures, variable spring and fall temperature ranges, and warmer summer temperatures. (Ref: NYWEA 81st Annual Meeting Presentation by Bio-Organic Catalyst, Inc.)

Bio-methane generated in the AD system, provided heating for the AD system in the boilers, and which was supplemented by outside purchases of natural gas to maintain adequate AD temperature for the anaerobic digestion processes. Excess bio-methane gas generation was not utilized, but flared, and now with nearly 70 – 90% greater bio-methane generation after they have reached optimal bio-methane yields per dry weight bio-solids, there is now planning for acquisition options of a co-generation equipment package to more fully utilize the additional excess bio-methane and renewable energy potential they now have available.

Beginning in November 2008, injection of BOC was initiated into the sludge feed line at various dosage levels, prior to the AD system. Average daily volume ran between 25,000 up to 30,000 gals. Daily, with a sludge feed of 2.5% solids. HRT averages 20 days. The following chart shows the rise of bio-methane yields as the dosage rate was raised until there evolved a clear zone of optimal bio-methane yield per gallon of sludge, and there evolved a maximum yield per dry lb. of TVS.

(See following chart)

An analysis was made of the aeration energy reductions due to the recirculation of BOC in the supernatant returning back to the influent wastewater and positively impacting aeration energy usage within the secondary aeration channels. Furthermore, a complete analysis was conducted to evaluate the total effluent discharge levels correspondence to prior baseline values.

Along with energy usage reductions, and total discharge readings, analysis was made of bio-solids transport reductions due to more complete conversion of the TS and TVS within the AD system. The complete mass balance analysis illustrated the overall economic and performance optimization potentials of BOCs. An important, but more subjective observation, was the significant reduction in noxious odor characteristics of the processed bio-solids.
In both of these operating cost areas, the resulted an approximately 25-30% reductions.

(See charts below)

An important and critical metric that showed the optimization of anaerobic digestion performance with BOC was the yield of cubic feet of bio-methane per lb. of dry weight loadings of TVS. The following chart shows that the AD system in reaching maximum optimization potential across TS and TVS loading values shows the increase in cubic feet of bio-methane from a baseline value of approximately 9 cubic feet of bio-methane per lb. of TVS, up to levels of approximately 15 cubic feet per lb. of TVS dry weight.

(See chart below)
CONCLUSIONS:

The bio-catalytic actions of BOCs upon biomass, and more specifically, upon various sludge components, prior to their inflow into various AD systems, produces notable improvements in critical parameters to the operator. There are close correlations between higher TS and TVS conversion rates, pointing towards an acceleration of the phased methanogenesis cycle, and overall enhancement of complete biomass vitality and microbiological population densities.

The combined total mass balance analysis shows improvements in obtaining optimal bio-methane yields on a dry weight generation of cubic feet of usable bio-methane renewable energy that can run between 25 – 100% increase over baseline yields. Bio-methane yields demonstrate a more complete reduction of TS and TVS percentages, and the final biosolids’ quality and total weight reduction provide reductions in noxious odors and transport hauling costs.

Through the recirculation of BOCs within the supernatant discharges from the biosolids post anaerobic digestion, there are significant electrical energy usage reductions, over baseline values, which contribute another economic value in evaluating total mass balance operating parameters. The relative economic cost/benefit analysis will vary depending upon the variations of particular AD system design and overall wastewater treatment facility characteristics.

The use of BOCs bring highly effective attributes to solving chronic degradation of anaerobic digestion efficiencies due to either overloading of total organic loads, and more specifically, the problems encountered with complex lipid molecular structures which, while offerings high value in bio-methane generation, present difficulties in required solubilization within the biomass of the AD system.