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Study WWTP in Butarque (Madrid)

Biological treatment to increase the performance of Anaerobic Digestion

and reduce the volume of dehydrated sludge increasing the performance of cogeneration

and increasing the production of biogas

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1.- INTRODUCTION.

Anaerobic processes are fundamentally processes of digestion of organic matter and nutrients (primarily N and P) that can be applied to liquid and solid waste and usually include separation and exploitation of the gas produced. The transformation of organic matter into methane and CO2 is carried out in three fundamental and consecutive stages, the hydrolysis-acidogenesis, homoacetogenesis-acetogenesis and Methanogenesis, which involves different groups of bacteria with acid acetic, propionic, butyric, lactic, formic, formation of CO_2, N_2, H_2, to finally reach methane, CO_2, H_2, N_2, H_2O.

Microbial populations involved in these anaerobic processes are usually a very complex mixture of different types and species of bacteria, fungi and protozoa. The concentration of the biological components of these populations is far from being constant, since there are fluctuations in time which can be very drastic. Although biological treatment processes can tolerate some variations, there are limits to them which produce failures in the process when they are exceeded.

Main interactions that occur between different microbial species are: competition, which refers to a competition for the use of a particular nutrient. Predation, which occurs when an organism feeds on another as Amoeba or a Protozoan that swallows cells of yeasts and algae. Parasitism, where one takes advantage or lives at the expense of another who usually dies. Commensalism, when two organisms live simultaneously without benefit not to bother. Mutualism, when two organisms benefit each other, and Amensalismo, which refers to the case of the excretion of a substance by a body, which is harmful to another. The study of these interactions reveals the complexity that can present the biological relationships in a treatment process and the need of knowledge of them for a better control of the said process.

Micro-organisms produce waste substances depending on the species under consideration and environmental conditions. The substances most desirable are gases like CO_2, N_2, and CH_4, which can be easily separable. Other gases such as SH_2, NH_3, and amines are toxic smelly or undesirable.

Biological treatment that we propose consists of inoculated a group of bacteria obtained from the natural environment, selected and subsequently freeze-dried with your exo and endoenzimas, with a concentration greater than 7 x 10^9 cfu/g, which allows structured digestion of organic matter via metanifera...

The implementation of a new biocenosis with a large stable microbial population, characterized by its interrelation of mutualism, by displacing other undesirable microorganisms by competition (by the number of individuals introduced and their greater affinity for the substrate) and modify the environment in which it is inserted (pH 7.0 and its great power buffer) along with the additions of periodic to keep such biocenosiswith a predominance of the bacteria metaniferas against the acidogenas, allows ensuring stability of anaerobic digestion and increase its performance since the vast majority of microorganisms present dedicated its activity to perform specific metabolic processes without that therefore they do not alter the other individuals with whom they live. As a result you get higher performance in the digestion process, great stability of the process and use optimized in the dehydration of sludge and the biogas produced.

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2.- TECHNICAL CHARACTERISTICS

2.1.- Works of digesters. Dimensions.

2.1.1.- Primary digesters (assets) 3 units.

Unit volume: 10.078 m^3 x 3..... Total 30.234 m^3

Volume reduction (sand 5%) ..... 1.510 m^3

Total useful volume..... 28.724 m^3

Primary digesters (standing)... 3 units
Unit volume: 4.900 m^3 x 3 ..... 14.700 m^3 in stock

2.1.2.- Secondary digesters (active): 2 units

Unit volume: 7.687 m^3 x 2 ..... 15.374 m^3

Secondary digesters (standing)... 2 units.
Unit volume: 3.613 m^3 x 2 ..... 7.226 m^3 in stock

3.- PERFORMANCE DATA.

3.1.- Loads of primary digestion:

™ Volum of Input slurry daily in... 1,640 m^3 fresh sludge.
- MST dry matter 5.20 % , 52 kg/ m^3 x 1,640 m^3 = 85,280 kg.
- MV volatile matter 72.30% = 85,280 kg x 0.723 = 61,657 kg.
- MM mineral matter 27.70% = 85.280 kg x 0,277 = 23,623 kg

™ Specific charge kg MV/ m^3/day = 61,657 kg / 28,724 m^3 = 2.15 kg

3.2 .- Physical and chemical properties of primary digestion.

™ **Retention time 28,724 m^3 / 1,640 m^3./day= 17.51 days= 17d 12 h**
™ TAC (alkalinity rate) in $CaCO_3$ = 3,796 mg/l average level
™ pH = 7.16
™ Residual volatile acidity in CH_3COOH = 472 mg/l
™ Temperature 35 ºC

3.3.- Loads of secondary digestion.

Volume introduced sludge / day = 1,640 m^3

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Retention time 15,374 m^3/ 1,640 m^3/day = 9,37 days = 9 days 9 hours.

Total retention time Dig Prim+Dig Sec =26.88 days = 26 days 21 hours

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3.4.- Performance of digestion (primary plus secondary).

According to the analysis of digested sludge:

MST = 30.38 g/L = 30.38 kg/ m^3 x 1,640 m^3/day = 49,823 kg
MV = 15.86 g/L = 15.86 kg/ m^3 x 1.640 m^3/day = 26,010 kg.
MM = 14.52 g/L = 14.52 kg/ m^3 x 1.640 m^3/day = 23,813 kg.

Gross performance with direct calculation of the reduction:

MV (Volatil matter) input 61,657 kg - MV (volatil matter) output 26,010 kg = 35,647 kg

$$\frac{35{,}647 \times 100}{61{,}657} = \textbf{57.80 \%}$$

NET performance with specific formula

$$1 - \frac{M1 \times (100 - M2)}{M2 \times (100 - M1)} = k \times 100$$

where M1 = mineral matter of fresh sludge
M2 = mineral matter of digested sludge
100-M1 = volatile matter of fresh sludge
100-M2 = volatile matter of digested sludge

$$1 - \frac{23{,}623\ (MMLF) \times 26{,}010\ (MVLD)}{23{,}813\ (MMLD) \times 61{,}657\ (MVLF)} = 0.418 \times 100 = \textbf{41.8}\ \%$$

PERFORMANCE: 100 – 41.80 = 58.20 %

Note: There is a good correlation between net and gross performance, but there is a contradiction between these yields and the % of MV (volatil matter) residual in digested sludge is 52.20%. It should be less than 50%.

3.5.- Biogas production

Current production: 27,764 m^3 /day

Current specific production:

Per kg de MV (volatil matter) introduced $\frac{27{,}764}{61{,}657}$ = **0.450 m^3 /kg MVI (volatil matter introduced)**

Per kg de MV (volatil matter) destroyed $\frac{27{,}764}{35{,}647}$ = **0,780 m^3/kg MVD (volatil matter distroyed)**

Note: These specific data do not seem to correspond to the high yields of the digestion. For many WWTP the % yield is equal or less than 51 - 50% with a specific production of more than 500 L/kg of MVI (volatil matter introduced).

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Biogas production provided with treatment E-Z.

Expected biogas production: 0.560 m^3/kg MVI

61,657 kg MVI x 0.560 m^3/kg MVI = 34,530 m^3/day

Increase (without considering the increase of the % of CH_4 estimated at 2-3% with E-Z):

34,530 – 27,760 = **6,770 m^3/day 24-25 %** more

Calorific value of biogas: 65.24% of CH_4: PCI methane per Nm^3 = 8,550 kcal / m^3

8,550 kcal/ m^3 x 0.6524 = 5,578 kcal / m^3 o sea 5,580 thermias

Energy value of the increment of gas produced = 5,580 th x 6,770 m^3 = 37,776 th/day

per month 37,776 th/day x 30.5 days/month = **1.152.180 th/mes.**

In 30% of electricity production: 1,152,180 x 0.30 = 345,654 th/month.

1 thermia = 1.163 kw x 345,654 = 401,995 kwh.

For year 12 months - 1 month of maintenance of engines.

402,000 x 11 = **4,422,000 kwh/year**

3.6.- Sludge production.

Data from current production and informed weight verification

MS (dry matter) of digested sludge 30.38 kg/ m^3 x 1,640 m^3 = 49,823 kg.

49,823 kg / 1,000 = 49.82 Tm /day x 30.5 días = 1,520 Tm / month.

Weight of digested sludge with 24.6 % MS $\frac{1,520}{0.246}$ = 6,179 Tm

6,179 Tm with 75.40 % of H_2O. **(151 Tm difference)**

Weight dehydrated sludge indicated/month = 6,028 Tm

Sludge reduction required with the treatment E-Z

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Weight of the supplement of biogas produced corresponding to the supplement of digested

MV: Weight of 1 m^3 of biogas by indicated composition of CH_4 = 65.24% and CO_2 = 33.76%

Specific weight of CH_4 = 0.728 g/L y del CO_2 = 1.9768 g/L a 0ºC.

0.728 g/L x 0.6524 L = 0.475 g
+ = **1.1424 g/l**
1.9768 g/L x 0.3376 L = 0.6674 g

Weight of supplement of the produced biogas / day:

1.1424 g/l = 1.1424 kg/ m^3 x 6,770 m^3 = **7,734 kg/day**

6,770 m^3 of biogas are theoretically equal without correction of vapor pressure of H_2O, pressure and temperature to 7,734 kg of destroyed additional MV.

New production of sludge with reduction of MV.

Weight of MV / day in currently digested sludge = 26,010 kg

MV reduced by treatment with A-Z = 7,730 kg
New weight of MV in digested sludge 18,280 kg

New composition of digested sludge:
MV 18,280 kg / 1,640.000 L (1,640 m^3) = 0.0111 kg = 11.14 g/L

MM (mineral matter) 23.813 kg / 1,640,000 L = 0.1452 kg = 14.52 g/L

MST (total dry matter) per litre 25.66 g/L

New MS weight in digested sludge:

25.66 g/L = 25.66 kg/m^3 x 1,640 = 42,082 kg = 42.08 Tm/day x 30.5 d = **1,283 Tm/mes.**

Weight of digested sludge with 30% of MS instead of 24.60% and 70% of H_2O instead of 75,40%.

1,283 / 0.30 = 4,278 Tm/month instead of 6,028 Tm/month.

Reduction in weight of dehydrated sludge 6,028 - 4,278 = 1,750 Tm/month.

3.7.- Reduction in the consumption of flocculants.

Effect obtained by improvement of filterability of the sludge obtained by reduction of the residual VM, which translates into an increase in the coefficient of filtration due to the development of the interstitial spaces between the particles of the mineral matter and reduced organic matter

Reduction in the consumption of flocculants estimated between 20 and 25% approximately.

75,000 kg/year x 0.20 = 15,000 kg

Average of 16,800 kg /year

75,000 kg/año x 0.25 = 18,750 kg

4.- OVERVIEW OF THE EFFECTS OF BIOLOGICAL TREATMENT WITH E-Z St. 1.1.1.

4.1.- Physical effects:

Increased production of biogas

6,770 m^3 /d x 365 d = **2,471,050 m^3 /year**

Increased production of electricity

402,000 kwh/month x11 = **4,422,000 kwh/year**

Reduction of the weight of dewatered sludge

1,750 Tm/month x 12 = **21,000 Tm/ year**

Reduction in the consumption of flocculants

Media del 22.5 % / year : 75,000 Tm x 0.225 = **16,875 kg**

Induced effects:

Increased in the TAC (alkalinity rate) to more than 4,000 mg/l $CaCO_3$, reduction of volatile acids less than 400 mg/l of CH_3COOH

4.2.- Economic results of exploitation with treatment E-Z

Increased of production of electricity / year:

4,422,000 kwh x 0.054 €/ kwh = **€ 239,190**

Reduction of weight of dehydrated sludge:

1,750 Tm/mes x 12 meses x 23,897 €/Tm = **€ 501.837**

Reduction in the consumption of flocculants: price average € 3.1 /kg

16,800 kg x 3.1 €/kg = **€ 52.080**

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Total economic results ……,,….. **€ 793.107**

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5.- BIOLOGICAL TREATMENT WITH E-Z St. 1.1.1

5.1.- Initial treatment in primary digesters. Unit dose and Total.

0.035 kg/ m^3 x 30,234 m^3 = 1,060 kg

equivalent to 1,060 kg / 28,700 m^3 useful = 0.037 kg/m^3

1,060 kg / 3 = 353 kg/digester

5.2.- Treatment of normal maintenance. Unit dose and Total:

0.030 kg/ m^3 x 30,234 m^3 = 900 kg/ year

900 / 3 = 300 kg/digester / 12 = 25 kg/ month = 6 kg per week and digester

6.- PROTOCOL OF COMPARATIVE CONTROLS

1.- Before treatment:

Analysis of fresh sludge MST, MV,
MM, pH, . Analysis of digested sludge
MST, MV, MM, pH, . TAC, AGV (fat
volatil acids) in primary digesters.

Perform 15-20 analysis to have a reliable

average value. Trials and complementary

controls:

Trials of filterability with pressure cylinders Pont - a - Muussan with pressure between 1 and 15 bars. Drying of sludge digested to the output of centrifuges.
Production of biogas, total volume day and specific per kg
MVI and MVD Composition of biogas
Consumption of flocculants
Production of electricity, hours of engine operation.

2.- Within 30 days of the start of treatment: Perform the same analysis of control and tests

3.- 60 days after the start of treatment: Perform the same analysis of control and testing.

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4.- 90 days after the start of treatment: Perform the same analysis of control and testing. Final report of the results of biological treatment in anaerobic digestion of sludge.

Technical direction

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