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Study of start-up of a continuous digester on a laboratory scale treating the sludge issued from wastewater treatment plant in Adrar city (south west of Algeria)

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Abstract – *A continuous digester type was designed at the laboratory scale with an aim to studying and improving anaerobic digestion of organic wastes. The results obtained can be extrapolated at large scale pilot plant.*
To study the digester start-up we have chosen as a substrate the sludge issued from the wastewater treatment plant located in Adrar city (south west of Algeria).
Different parameters have been measured such as pH, VFA, COD, and biogas volume generated during the digestion process.

***Keywords**: continuous digester; anaerobic digestion, sludge, COD, VFA*

I. Introduction

Evacuation, treatment and general municipal wastes management in developing countries (DCs) are crucial. Demographic change and urbanization made the amount of waste released to grow, until becoming a major concern, faced by these countries representatives.

Local authorities, thanks to international assistance, have engaged comprehensive waste management policies, to define a path of treatment best suited to local conditions. Waste treatment mode retained in developing countries is most often directed towards landfill, but now most of the waste is disposed of on the outskirts of cities in landfills or sewage treatment plants more or less controlled. Waste loses a potential recovery in terms of recycling materials and energy and organic fertilizers production.

Anaerobic digestion (AD) of biodegradable wastes has the potential to achieve efficient pollution reduction and the additional advantage of conserving energy, thus providing opportunities for ecological and economic benefits from these waste streams **[1]** and **[2]**.

Anaerobic digestion is the degradation of complex organic matters under the absence of oxygen. This process is time consuming as bacterial consortia responsible for the degradation process requires time to adapt to the new environment before they start to consume on organic matters to grow **[3]** (Poh et Chong). These reactions are carried out in bioreactors; there are many kinds of these bioreactors. High-rate anaerobic bioreactors have been applied in laboratory-scaled such as up-flow anaerobic sludge blanket (UASB) reactor and up-flow anaerobic filtration **[4]** ; fluidized bed reactor and up-flow anaerobic sludge fixed-film (UASFF) reactor **[5]**. Anaerobic contact digester **[6]** and continuous stirred tank reactor (CSTR) have also been studied for treatment of palm oil mill effluent POME **[7]**.

In this context, we launched anaerobic digestion program by focussing on the start-up of a continuous digester, treating sludge issued by wastewater treatment plant in Adrar city.

II. Materials and methods

The experiments were carried out using a continuous digester. The laboratory scale reactor was made using PVC tube with an internal diameter of 200 mm and an overall height of 500 mm. The active volume was 12 l (Fig 1), the digester was maintained at mesophilic temperature range (35 ± 2°C) **[8]**. The digester was equipped with inlet and outlet ports for feeding and effluent discharge. A plastic tube connected the vial to an inverted Marriotte flasck of 0.25 l that contained an alkaline solution (2.5% NaOH), so CO_2 was absorbed into the alkaline solution and the volume of CH_4 generated was measured as the displaced liquid volume **[9]**.

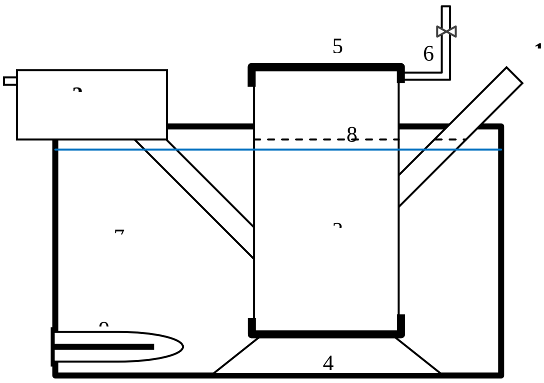

Figure 1. (1) inlet – (2) outlet – (3) Digestion tank – (4) Digester base – (5) Lid – (6) Collecting biogas pipe – (7) water bath – (8) substrate level – (9) electric resistance with thermostat.

The substrate used for this experiment was sludge collected in Adrar city municipal wastewater treatment plant. The Organic Loading Rate (OLR) was 16 g/l of total solids (TS), was fermented in a continuous digester of twelve litters capacity under anaerobic conditions, in order to avoid the medium acidification during the start-up period, cause the acids accumulation could hamper anaerobic digestion process **[10]**. After this, the Organic Loading Rate was increased until 30g/l TS. 50 ml of waste obtained from the slaughterhouses were used as incolum. The waste characteristics were presented in Table 1 below.

TABLE I. INOCULUM CHARACTERISTICS

Inoculum	COD (mg/l)	T.S. %	V.S.%
slaughterhouses wastes	1000	28	90

II.1. Analytical techniques

pH was measured using phmeter HANNA 8141. Volatile Fatty Acids (VFA) and Total Alkalinity (TA), concentrations have been achieved according to the method described by **[11]**. Chemical Demand in Oxygen (COD), Total Solids (TS), Volatile Solids (VS) their concentrations were carried out according to **[12]**.

III. Results and discussion

pH variation recorded during anaerobic digestion (AD) process presented a slight decrease during the first ten days (from 7.4 to 7.1) (Fig.2) when the organic loading rate was 16 g/l TS.

In contrast, dropped drastically from 7.1 to 5.6 after the 17 th days when the Organic Loading Rate was increased to 30 g/l TS, that enabled us to deduce that the amount of acid produced during the hydrolysis and acidogenesis phases was proportional to the organic matter rate introduced into the digester. This was in conformity with the findings achieved by **[13]** and **[14]**. **[2]** explain this decrease of pH value by the conditions created probably resulted in the biochemical thermodynamics within the microbial populations favouring the fermentative acidogenic phase of AD. From the 25 th day until the end of the digestion process the pH increased and remained stable in the vicinity of 7.

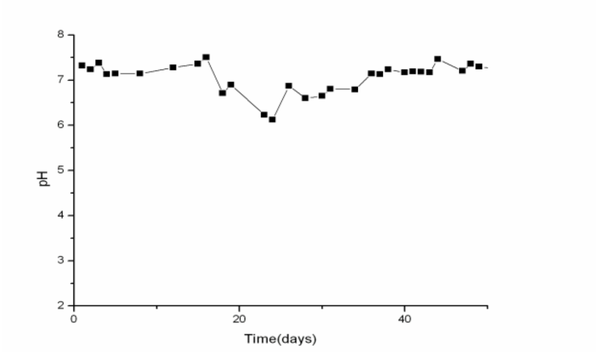

Figure 2. pH variation during the time

The Total Alkalinity in the digester increased from 550 mg/l at an OLR of 16g/l to 4780 mg/l at an OLR of 30 g/l(fig.3). Alkalinity is known to be a critical buffering factor for neutralizing VFA during methanogenesis**[15]**

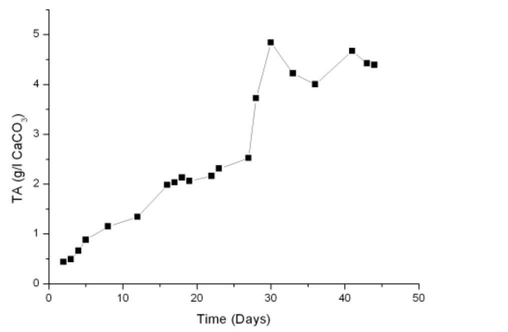

Figure 3. TA variation during the time

During the anaerobic acid-phase stage of complex organic substrates, mainly constituted by carbohydrates, proteins and lipids, these are converted basically to volatile fatty acids (VFA) and to a lesser extent to other low molecular weight compounds **[16]**.

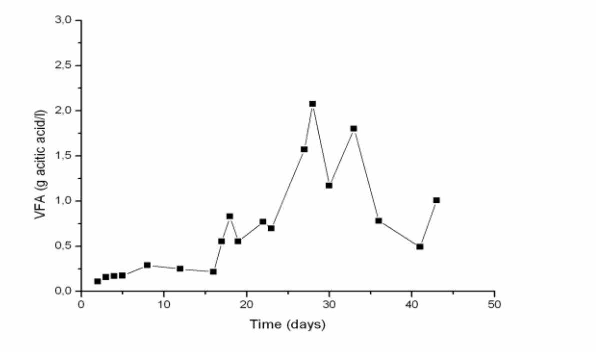

Figure 4. VFA variation during the time

As can be seen in Fig.4, the VFA concentration in the effluent at the initial OLR of 16 g/l TS was in the range of 250-500 (mg acetic acid /L) during the first 17 days of the digestion, after that, the curve showed an increase in VFA up to 2000 mg of acetic acid/l. This VFA production phase corresponded to the hydrolysis acidogenesis phase identified by **[17]** and **[18]**. The decrease in VFA after the 28 day was due to the consumption of VFA by bacteria which could correspond to the acetogenesis phase.

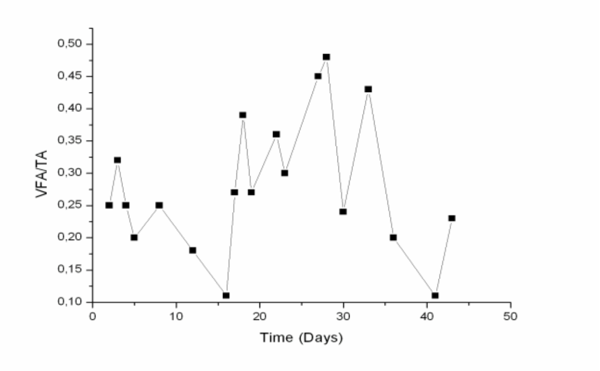

Figure 5. VFA/TA variation during the time

In Fig 5 we illustrated the report of VFA/TA variation and showed that this report was for all the digestion process lower than 0.5. This value, was quoted by **[19]** and **[20]** which indicated the feasibility of the process in spite of the significant VFA production. The presence of these latter could inhibit the anaerobic digestion process . **[21]**.

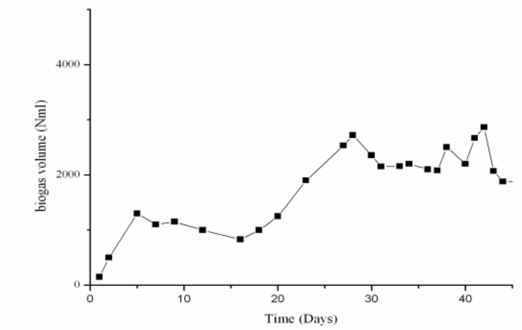

Figure 6. Volume variation during the time

On Fig. 6 we presented the produced biogas volume variation during the digestion. We noted a weak production during the first 17 days, just after, the volume of gas increased considerably, reaching an average value of 2500 nml/d. The total volume of biogas produced during this period was 45l.

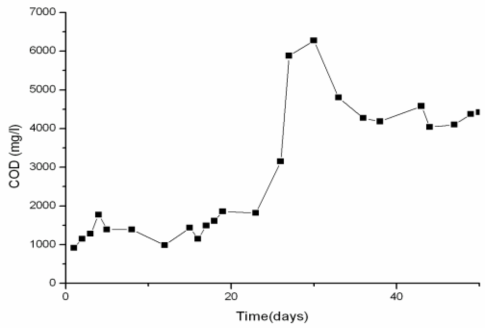

Figure 7. DCO variation during the time

Fig 7 showed a small increase in the value of COD for the first five days, after that we observed a slight decrease of COD, due to the organic matter degradation. The sharp increase in the value of COD from 17th days was due to substrate addition. Then there was a rapid decline from 30th day of 6000 mg / l to a mean value of 4000 mg / l. This decrease is explained by the high bacterial activity.

IV. Conclusion

Continuous digester start up study has been achieved. We found that the methanisation phase starting was based on the amount of total solid introduced. The pH variation of the medium and the volume of biogas produced were also proportional to the amount of organic matter introduced. The process of digestion has been boosted by the VFA presence and a TA which the report did not exceed 0.5. Anaerobic digestion also enabled significant cleanup of organic matter. In our conditions it was 2000 g / l (COD) removed for a period of 15 days only.

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