THE UNIT INTREGRATED APPROCH FOR OFMSW TREATMENT

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In the last decade, in the Department of Civil and Environmental Engineering, University of Trento, Italy, both wastewater and solid waste biological treatments were studied in researches generally based in the group of Sanitary Engineering. In particular, an integrated approach has been adopted for treatment of the organic fraction of municipal solid waste and sewage sludge by Anaerobic Co-Digestion technology. Anaerobic Digestion is a process known from a long time. In spite of that its performance can be still improved working also in the pre- and post-treatment stages. The technology transfer related to these optimization strategies requires an adequate context.

Keywords: OFMSW, co-digestion, biodegradability, nitrogen removal.

1. Introduction

The Anaerobic Digestion (AD) of organic waste offers a great potential for the proper disposal of the organic fraction of municipal solid waste (OFMSW). AD is a biological process accomplished by a consortium of microorganisms and used to treat and stabilize organic matter in the absence of oxygen and occurs under hydrolysis, acidogenesis, acetogenesis, and methanogenesis phases [1, 2]. During anaerobic treatment, organic matter is converted to *stabilized sludge* (anaerobic digester effluent, named also digestate) and *biogas*.

AD technology has been applied to treat both liquid and solid waste. It is typically used in wastewater treatment plant (WWTP) for sludge degradation and stabilization. Furthermore, AD is widely applied throughout the world to a wide variety of wastewater streams and biomass in order to recover energy through methane production. Nowadays, anaerobic digester plants are often promoted by government policy and incentives for producing or using energy from renewable sources. In this frame, the objective of this paper is to present the evolution of the

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research on AD of OFMSW of the Sanitary Engineering group and to give some advices on the application of this process in other countries.

2. Methods

In order to optimize the Anaerobic Digestion of OFMSW several aspects have been taken into account implementing the treatment of OFMSW in the WWTP scheme. Both waste and wastewater process improvements are taken into account.

It is recognized that ***hydrolysis*** is one of the rate limiting steps in AD especially for the presence of organic complex substrates and particulate materials. Results of our studies and others indicate that an acceleration of hydrolysis step could greatly improve the anaerobic digestion process. The main pre – treatment options adopted for improving the OFMSW biodegradability and consequently AD process are mechanical, thermal, chemical, electrolytic, enzymatic and wet oxidation.

Fig. 1 shows the different pre-treatment of OFMSW investigated in our studies. The effect of mechanical, chemical and thermo-chemical pre-treatment on anaerobic digestion will be presented.

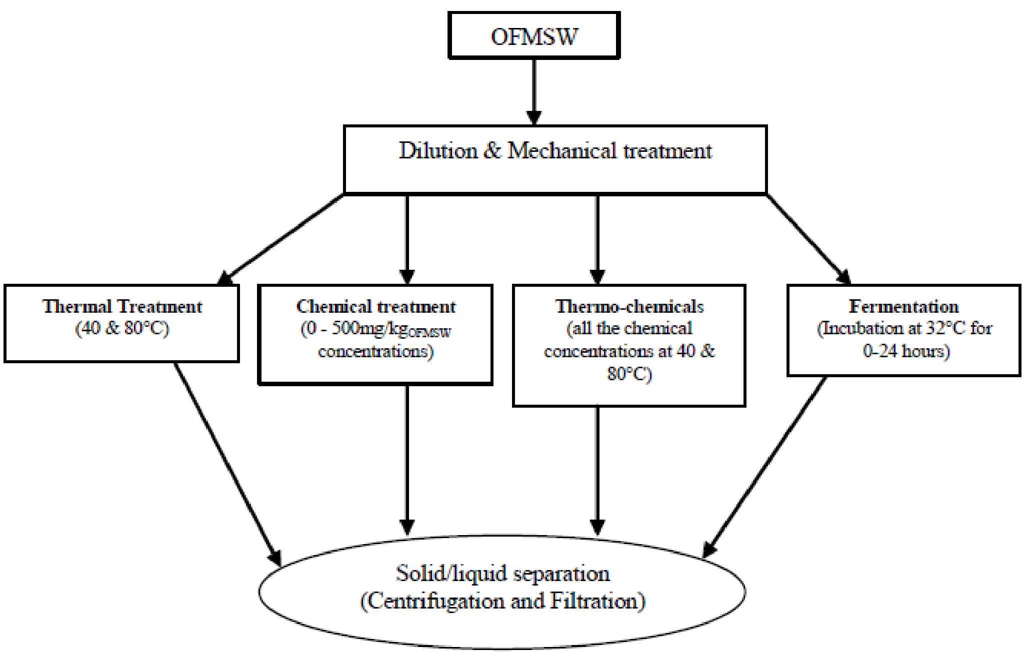

Fig. 1. Schematic diagram of the different pre-treatment investigated

OFMSW is characterised by a high presence of organic biodegradable fraction, thus it is clearly suitable for AD, producing significant amount of biogas.

Furthermore, the ***co-digestion of OFMSW and sewage sludge*** presents the advantages that the macro and micro nutrients, C/N ratios, dry matter and biodegradable organic matter content balance each other very well [3]. Another advantage of co-digestion is the possibility of higher organic load rates (OLRs) and total solid (TS) concentrations.

This paper presents an experience concerning the effects that can be obtained using co-digestion of centrate OFMSW with sewage sludge, for increasing biogas production and using underutilized anaerobic reactor which are currently treating sewage sludge. The positive effect of the co-digestion of OFMSW and sewage sludge is hypothesized to come from the fact that introducing the easily biodegradable fraction of the waste will actually increase the amount of biogas obtained from the plant.

Ammonium

Ammonium is not removed in the AD process and therefore digester effluent generally yields an ammonium-rich effluent, low in biodegradable COD [4, 5]. Anaerobic digester effluent is generally considered a fertilizer. According to legislation and to new standards for nitrogen pollution, the application of the digester effluent of OFMSW and/or sewage sludge (after a mechanical dewatering process) to agricultural field is strictly limited in Italy. The effluent of anaerobic process requires further treatment to remove the ammonium [3, 6,7]. The low COD/N ratios makes digester effluent difficult to treat by the conventional way of nitrogen removal via the nitrification–denitrification processes. Furthermore, techniques for nitrogen recovery, such as ion exchange, struvite precipitation and ammonia stripping, are energetic and economical sustainable only for streams which have a significant ammonium concentration (above 5 kg_N m^{-3}). An alternative approach [8] to the conventional biological treatments and to chemical methods is the use of autotrophic nitrogen bacteria such as (***Anammox*** - ANoxic AMMonium-OXidizing), which require less energy but grow relatively slowly. This paper presents a lab experience related to anaerobic digester effluent treatment.

3. Results

The effects of mechanical, chemical and thermo-chemical pre-treatment on anaerobic digestion show that higher biogas generation rate and/or shorter process times can be obtained.

According to our study, the mechanical treatment (diluition with tap water at 1:1.5 ratio, homogenized with the kitchen garbage disposer and mechanically pre-treated) and the thermo-chemical pretreatment with 500 mg_{NaOH} kg^{-1}_{OFMSW} at 40°C resulted in an increase in biogas volume compared to the untreated samples. Fig. 2 shows the results of anaerobic treatment of the NaOH treated centrate. Different slopes of the biogas production velocity can be observed if compared to the single noticeable slope of untreated samples.

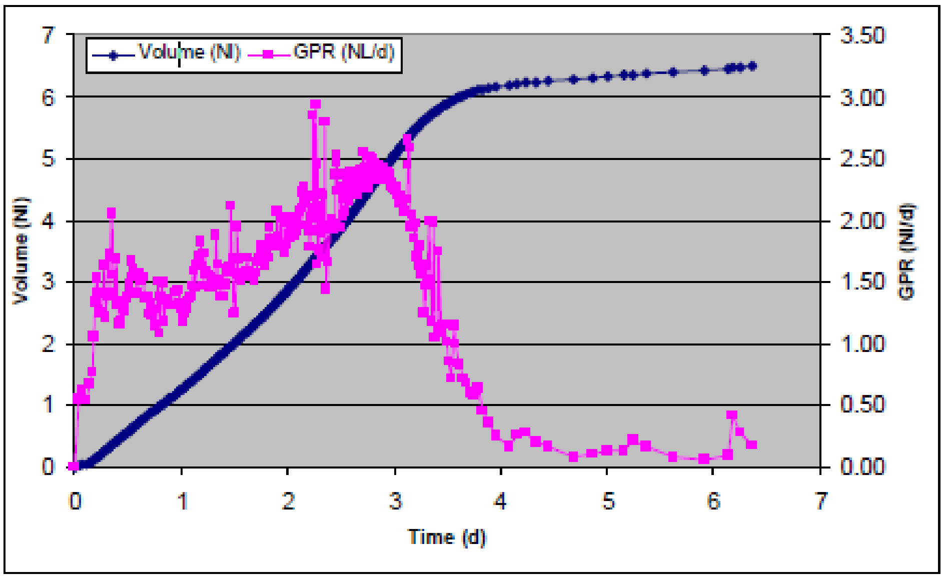

Fig. 2. Anaerobic treatment of the NaOH treated centrate at 6 g_{COD} L^{-1} d^{-1} [9]

The co-digestion showed to have a positive effect on the biogas volume and production velocity (see Fig. 3). The addition of the centrate mechanical and the thermo-chemical pre-treated to the sewage sludge increased the biogas volume produced even at low organic loading. This positive effect on biogas volume increased with the increase in centrate concentration. The specific production rate is increased from 0.236 until 0.434 NL g_{VS}^{-1} $_{added}$ for 3.537 g_{COD} L^{-1} d^{-1} of sewage sludge and 11.537 g_{COD} L^{-1} d^{-1} of a mixture (3.537 g_{COD} L^{-1} d^{-1} + 8 g_{COD} L^{-1} d^{-1}) respectively.

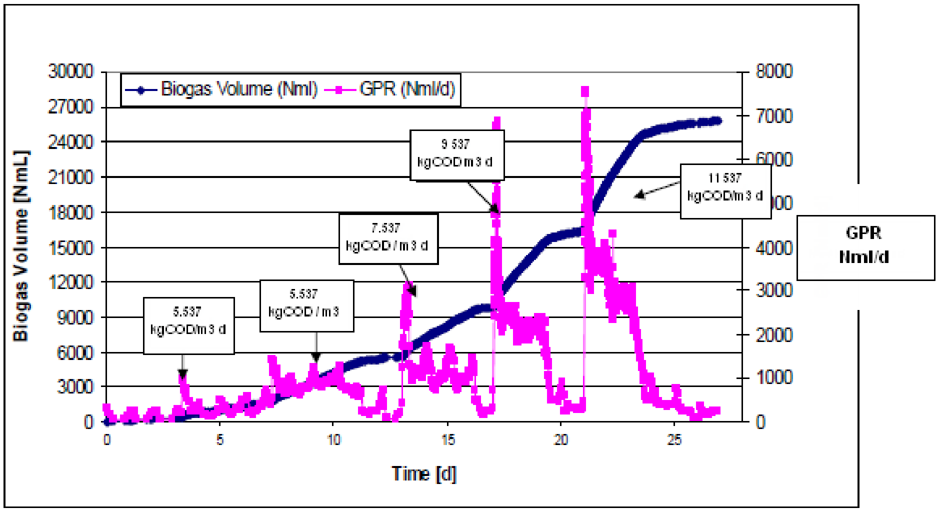

Fig. 3. The biogas production with increasing centrate/sewage sludge concentration

This means an increased in the plant biodegradation efficiency. Also the biogas production rate increased with the increase in loading rate resulting in slightly insignificant difference in 9.537 and 11.537 g_{COD} L^{-1} d^{-1} loading rate. This slightly difference between the two loading rates might be interpreted as either the presence of inhibition effect with increase in loading rate or the maximum co-digestion ratio was reached.

Further, during this increasing co-digestion ratio experiment, it was also observed that the HRT tended to decrease with the increase in time. This was shown by the decrease from 8.9 days for 5.537 g_{COD} L^{-1} d^{-1} to 6.3 days for 11.531 g_{COD} L^{-1} d^{-1} loading concentration. So we can conclude that for sewage sludge the anaerobic process required 4.8 days to biodegradade 3.537g_{COD} $L^{-1}d^{-1}$, while only 6.3 days were required for 11.537 g_{COD} L^{-1} d^{-1} co-digestion.

Looking at this, it can be assumed that the introduction of the centrate to the sewage sludge not only allowed increased in biogas volume, but also increased the microbial activity and thus lowered HRT.

A lab experience related to anaerobic digester effluent treatment demonstrates that alternative solutions for managing the problem of Nitrogen in the effluent are viable.

The characteristics of the anaerobic digester effluent used for the study is tabulated in Table 1. The values are similar to those reported by Derbal et al., 2009. First results showed a stable and high ammonium removal efficiency of 98% - 99% (Fig. 4 and Fig. 5)

Table 1

Characteristics of incoming sewage sludge

COD $_{tot}$ (mg L^{-1})	COD $_{sol}$ (mg L^{-1})	NH_4 (mgN L^{-1})	Norg (mgN L^{-1})	P (mg L^{-1})	pH	Alc mg $CaCO_3L^{-1}$
265.4	146.3	367	70	20	7.7	1492

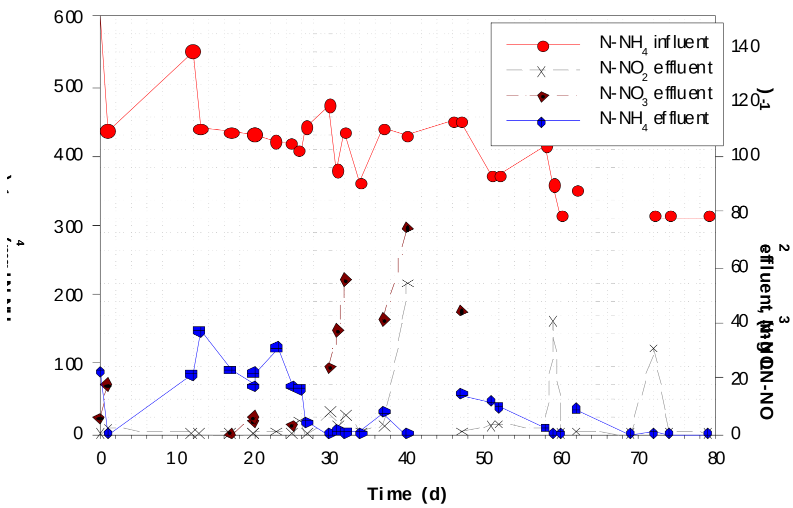

Fig. 4. Concentrations of N-NH_4^{+},N-NO_3-and N-NO_2-over time in the SNAD

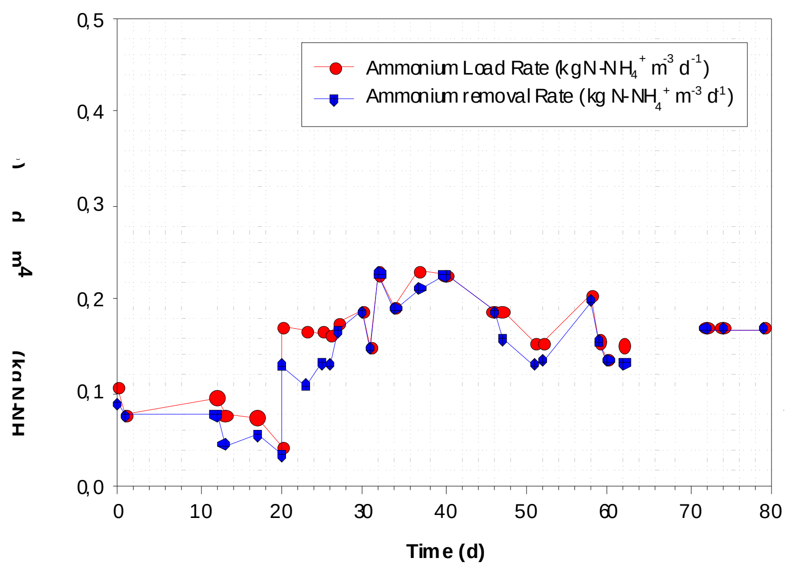

Fig. 5. Efficiency of the SNAD process reactor

4. Conclusions

The performance of AD can be improved working both on the anaerobic biological process and on the pre- and post-treatment stages [10, 11, 12, 13,14]. The integrated approach for treatment of the organic fraction of municipal solid waste (OFMSW) and sewage sludge by Anaerobic Co-Digestion technology is challenging.

Implementing the treatment of OFMSW in the WWTP scheme and working on pre- and post –treatment could maximize energy production from organic compounds through anaerobic co-digestion and minimize energy consumption for nitrogen removal not only in the main stream of wastewater treatment plants (WWTPs) but also in the secondary streams such as anaerobic digestion effluents.

Furthermore, the co-digestion option also offers the possibility of treating OFMSW and sewage sludge within a single plant and further decreasing the management costs.

The configuration proposed in this study consists in mechanical pre-treatment of the OFMSW with the washing of the waste, the thermochemical pre-treatment with 500 mg_{NaOH} $kg^{-1}{}_{OFMSW}$ at 40°C for 30 min and a centrifugation, followed by a codigestion of sewage sludge and OFMSW and by a post-treatment of liquid fraction produced in a dewatering stage after the anaerobic one with an innovative biological process, CANON [15] or SNAD- like.

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