# APLICATION OF ANAEROBIC CO-DIGESTION TO THE COUPLED TREATMENT OF SLUDGE FROM URBAN WASTEWATER AND OTHER BIODEGRADABLE WASTES

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## Abstract

Anaerobic sludge from urban treatment plants and organic matter wastes generate disposal problems. To prevent this problem and convert the sludge and organic matter wastes into a source of income, the mesophilic anaerobic co-digestion of appropriate mixes of waste should be investigated. The organic matter should be easily biodegradable. This parameter can be determined by the use of the biodegradability index obtained by the biological oxygen demand/chemical oxygen demand ratio (BOD/COD). Values of this parameter higher than 0.4-0.59, among 0.2-0.4 and below 0.2-0.1 correspond to effluents that are considered totally biodegradable, partially biodegradable and non biodegradable, respectively. Using adequate solid wastes, the biogas production during the biological treatment can increase and provide economic benefits for the treatment plant, if the biogas is employed to produce electricity. In many countries, as in Spain, the electricity produced from biogas is financially supported by the government. Therefore, the coupled anaerobic treatment (co-digestion) for the degradation of sludge and biodegradable solid waste may represent an alternative to enhance biogas production. The aim of this work is to test the potential of an advanced oxidation process to treat landfill leachate and to favour the subsequent anaerobic process.

Keywords: anaerobic, biogas, co-digestion, coupled treatment.

## Introduction

Landfill leachate (LL) generated from municipal solid wastes (MSW) can vary on quality and characteristics, depending on the type of solids, the microbiological activity, type of soil, precipitation and landfill age. It contains large number of different organic compounds at high concentration, which can be a risk for the environment if they are not adequately treated. As the leachate gets older, the ratio degradable/non degradable material gets smaller. Despite the large number of LL treatments methods such as physical-chemical, chemical oxidation, adsorption, chemical precipitation, air stripping, sedimentation, flotation and biodegradation, the problem is not solved yet.

Both, chemical and biological processes of wastewater treatment have inherent limitations in applicability, effectiveness and cost. Compounds that are toxic, inhibitory or refractory to biological degradation could, therefore, be pretreated by a chemical process to produce biodegradable intermediates, which increases its global removal efficiency. Chemical treatments based on physical-chemical processes that are able to produce changes on the chemical structure of contaminants are the so-called advanced oxidation processes (AOPs). Those generate the highly reactive hydroxyl radical ($HO^{\cdot}$), which is used to degrade recalcitrant chemicals. The reactivity depends on the type of oxidant added, catalyst loading and the intensity of radiation energy. One of the most studied processes among advanced oxidation technologies is the photo-oxidation of contaminants by means of UV-light irradiation with the presence of $TiO_2$ as catalyst. However, using this as a unique process to treat the whole waste is rather costly.

To improve cost-efficiency, we propose for LL treatment the integration of photochemical oxidation, followed by an adsorption process and a subsequent biological treatment, using catalysts and sorbent materials that are industrial by-products ($WTiO_2$ and CV-Z zeolite) (Poblete *et al.*, 2011, Querol *et al.*, 2002).

Anaerobic degradation is a biological suitable process for the treatment of industrial wastewaters that contain large amount of organic matter as well as for the stabilization of sludge from urban treatment plants, since it has many advantages compared to the aerobic treatment. Anaerobic processes consume less energy, produce less waste sludge and produce biogas that may generate energy that is financially supported by the Spanish government (RD 661/2007). However, the coupled treatment is more suitable for water with recalcitrant compounds that are not amenable to conventional biological treatment.

The aim of this work was to evaluate the potential of the coupled AOP-adsorption process to convert complex recalcitrant chemicals present in high-load water as it is the LL, in more biodegradable material. Both, the effluent and the sludge generated in the AOP-adsorption process could then be treated through the subsequent anaerobic treatment.

## Methods

Landfill leachate was treated in a continuous pilot plant, whose schematic diagram is shown in Figure 1. The landfill leachate influent ($F_0$) flow rate employed for this study was 5,220 mL $h^{-1}$, while the continuous process was performed at a hydraulic retention time (HRT) of 60 min. The AOP was performed in a photo-reactor AREUS (Germany). The irradiation system was provided with an immersion UV-A lamp (TQ 150 W) with a long wave of 365 nm.

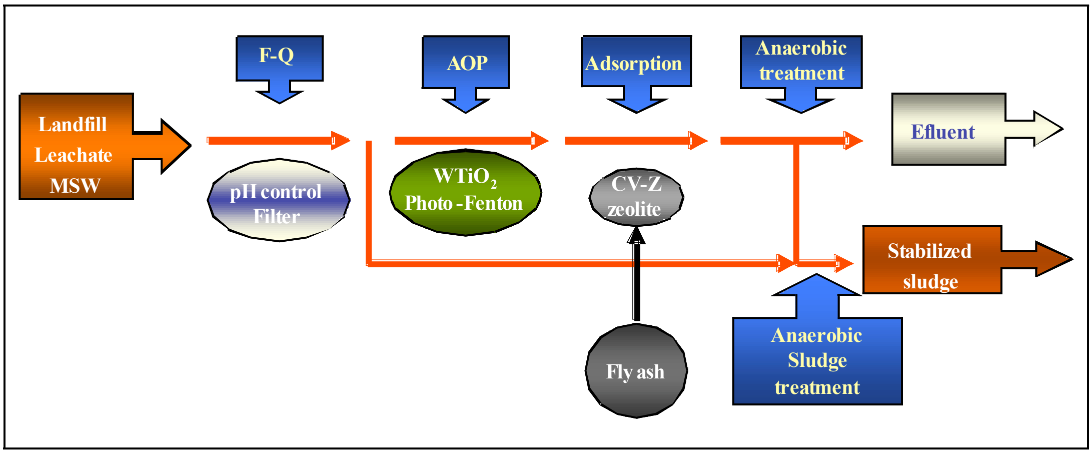


*Figure 1. Schematic representation of the experimental process.*

The anaerobic biodegradability potential of influent, the effluent and the generated sludge produced in the pilot plant, was tested in multi-batch anaerobic reactors, according to the UNE-EN-ISO 11734. Characterization of the samples is shown in Table 1.

*Table 1. Characterization of the samples used in the anaerobic biodegradation test.*

| Parameter | Landfill | Efluent | Sludge |
|---|---|---|---|
| pH | 8.3 | 2.14 | 2.38 |
| SS (mg.L$^{-1}$) | 680 | 800 | 21,000 |
| ST (mg.L$^{-1}$) | 19,960 | 6,320 | 6,680 |
| TOC (mg.L$^{-1}$) | 3,600 | 200 | 1,371 |

## Results and discussion

Figure 2 shows the TOC and TN kinetics over the experiment and the variations of methane generated with time for TOC initial concentration of 160.6 mg/L (PEG 400), 165.3 mg/L (Landfill leachate), 216 mg/L (effluent) and 52.8 mg/L (sludge). TOC removal in the final effluent of the integrated process was very high 84.4 %, while COD reduction was only 50 %. This small removal on COD may be attributed to the $H_2O_2$ that remain after the AOP. The variation of the TOC, TN and the gas generated with digestion time, for the samples studied, shows that the process is operating favourably. The anaerobic test of effluent and landfill leachate showed even better degradability than the PEG 400 used as the reference compound.

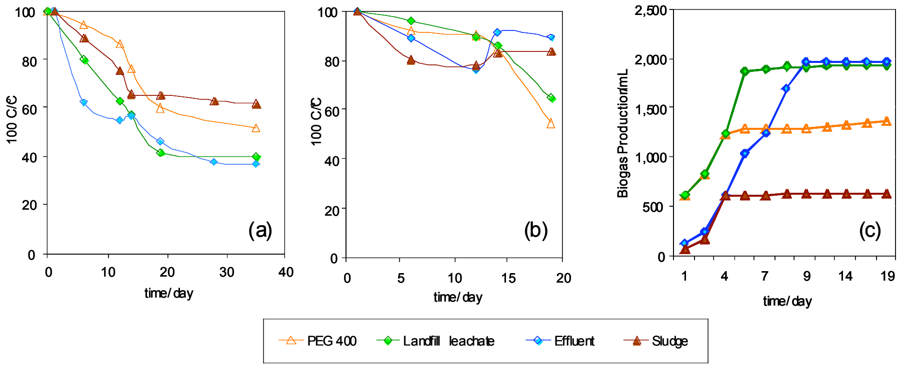


*Figure 2, kinetics of (a)TOC, (b) TN and, (c) Biogas production.*

## Conclusions

Photocatalysis using by-products as catalyst ($WTiO_2$) and as adsorption reagent (CV-Z zeolite) may be a potentially efficient process to eliminate many hazardous organic pollutants and nitrogen compound present in landfill leachate. AOP by the Photo-Fenton and Photocatalytic methods seems to synergize the advantages of the individual options. The results of this study demonstrate the adequate stability of the batch mesophilic anaerobic digestion process for landfill leachate and the effluent of the pilot plant in comparison to the reference compound.

## Acknowledgements

This research was supported by the Spanish Ministry of Science and Innovation, under the project FOXMORE (CTM2006-05114).

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