

Fractionation of the organic matter contained in leachate resulting from two modes of landfilling: An indicator of waste degradation

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Abstract

Three experimental pilots were set up at the semi-industrial scale to assess the impact of leachate recirculation and Mechanical Biological Pre-treatment (MBP) before landfilling on the biological degradation of landfilled wastes. The organic matter contained in leachates resulting from these pilots has been used as an indicator of waste degradation. Fractionations were carried out (i) using XAD resins in order to divide the organic matter into several fractions according to the hydrophobic character of the molecules and (ii) using an ultrafiltration protocol to divide the organic matter into several fractions according to the apparent molecular weight of molecules. Three phases of degradation are determined according to the distribution of the organic matter and according to the humification rate. The humification process seems to be more rapid for MBP leachates than for Bioreactor leachate. These results were confirmed by the ultrafiltration results indicating that, to date, MBP leachates contain more molecules with a high molecular weight than Bioreactor leachate. However, this could be explained by an interruption of waste degradation due to an accumulation of volatile fatty acids.

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1. Introduction

Landfilling remains nowadays the most widely used MSW treatment in many European countries. At the same time the 1999 EU Landfill Directive sets targets to substantially reduce the amount of biodegradable MSW going to landfill. This Directive results from the former landfills (no controlled landfills) which do not guarantee sufficient technical and environmental performances. In France, the targets set in the EU Landfill Directive must be reached at a national level. Contrary to Germany and Austria, the French regulation (adopted on 9th Septem-

ber, 1997 and strengthened in 2006) does not set standards for landfilled wastes (for example, on biological activity, ...). It imposes, in particular, the recovery and the treatment of the leachate and the biogas produced during site exploitation and for the period of post-30-year exploitation. However, the end of the post-exploitation period does not inevitably mean that any risk of pollution has been isolated.

That is why the conventional landfill is led to evolve in order to improve the stabilization of landfilled wastes and thus to limit the environmental impacts. Technological solutions are developing in order to accelerate the biological degradation of wastes outside and/or within landfills. It should be the Mechanical Biological Pre-treatment (MBP) prior to landfilling or the Bioreactor concept.

MBP is coming from Germany and Austria; it aims at reducing the biodegradable organic matter contained in waste going to landfill to limit biogas and leachate production and to reduce the landfill aftercare [1,2]. At the moment, only four full scale plants are operating or under construction in France.

The bioreactor consists in collecting generated leachate to reintroduce it into the landfilled waste. Reinhart et al. [3] specify that leachate recirculation reduces of 2–3 years the time

Abbreviations: AT₄, respiratory activity at the end of 4 days; BMP, biochemical methanogene potential; BOD₅, biological oxygen demand at the end of 5 days; DOC, dissolved organic carbon; DS, dry substances; HS*, humic-like substances; FA*, fulvic-like acids; HA*, humic-like acids; HPI*, hydrophilic-like substances; HPO*, hydrophobic-like substances; MBP, Mechanical Biological Pre-treatment; MSW, municipal solid waste; OM, organic matter; SUVA, specific ultraviolet absorbance; TOC, total organic carbon; TPH*, transphilic-like substances; VFA, volatile fatty acids.

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necessary to reach the stabilization of a landfill, as it supplies additional moisture which is crucial for organic matter degradation [3,4]. The leachate recirculation was used a long time by experimental way in France but since January 19, 2006, this technique is registered in the French regulation.

Indicators of degradation and stabilization are necessary to determine the impact of these techniques on waste degradation. Many authors have tried to characterize a waste considered as “stabilized” without an only and common definition has been given. So, researchers must use one or more global parameters to define a stabilized state. The study described in this paper thus concentrates on the fractionation of the organic matter contained in leachates which appears such as a relevant indicator of waste degradation and stabilization.

The organic matter and more especially humic-like substances represent the major part of organic compounds contained in leachate. Organic matter can be classified into three fractions (Fig. 1):

- Simple compounds like carbohydrates, organic acids (mainly volatile fatty acids), amino acids and alcohols which are identifiable by specific analysis. They are easily biodegradable and present low molecular weights.
- Humic-like substances which include humins and humic-like acids which are characteristic of the humification stage and composed of high aromatic and high molecular weight cellulosic compounds, and fulvic-like acids with medium to high molecular weights. They are relatively rich in carboxylic and hydroxylic groups.
- Non humic-like substances which represent the dissolved organic carbon that belongs neither to the humic nor to the fulvic-like acids. This fraction is usually called hydrophilic acids and is expected to constitute a substantial fraction of the dissolved organic carbon content [5].

According to its complexity and heterogeneity, a common approach for the Humic-like Substances (HS*) is to isolate functionally different fractions because there is no single analytical method which allows to define them directly. The relation between the high percentage of humified compounds (humic-

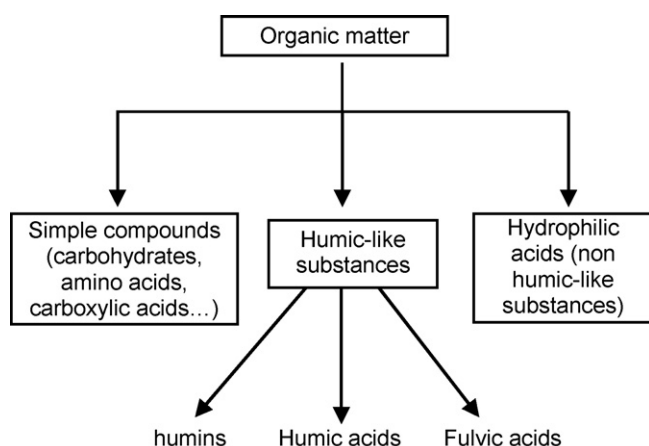


Fig. 1. Composition of the organic matter.

Table 1

Composition of input fresh Municipal Solid Wastes

Composition	%
Organic waste	55
Plastic	14
Textile	7
Metal	2.6
Hazardous waste	0.4
Glass	11
Other	10

like and fulvic-like acids, noted down HA* and FA*), the apparent molecular weight of molecules and the state of the stabilization of a landfill has been established: the highest degree of humification corresponding at the most stable state. Several authors have compared the percentage of humic and fulvic-like acids in leachates resulting from landfills of different ages [6–8].

A CRPE long-term research program named ELIA (Environmental Landfill Impact Assessment) aims at comparing on the environmental, technical and economical levels leachate recirculation and MBP before landfilling. The impact of the duration of the MBP has been also studied by using wastes which were more or less pre-treated (12 and 25 weeks according to the composting stage). A CRPE long-term research program named ELIA aims at comparing on the environmental, technical and economical levels leachate recirculation and MBP before landfilling. The impact of the duration of the MBP has been also studied by using wastes which were more or less pre-treated (12 and 25 weeks). For that, experimental pilots were set up at the semi-industrial scale by the CRPE which has studied the economical and technical impacts of these two methods and the biogas quality and quantity.

2. Material and methods

2.1. Experimental cells

Four experimental cells were set up in October 2003: a test cell with conventional landfilling, a bioreactor cell with leachate recirculation and two MBP cells with pre-treated wastes. Results of test cell are not discussed in this paper because they don't give relevant and supplementary information for this study. Each cell of 23 m³ contains around 11 tonnes of wastes. Fresh MSW were collected from a sorting and composting plant in France; Table 1 gives the mass composition of MSW.

Cell 1 (Bioreactor cell) was filled with fresh MSW which were coarsely ground with an industrial high-speed hammer shredder for the homogenisation of waste and to open the plastic bags. This cell is exploited according to the bioreactor concept. Four phases of recirculation have been applied (Table 2). Until approximately the 16th month, 1347 L/t_{DS} of leachate was recirculated. However leachate analysis have been realized and showed an accumulation of volatile fatty acids (Fig. 2) which blocked the waste degradation. Yuen [9], showed that the degradation of the easily biodegradable organic matter could involve a significant salting out of volatile fatty acids and consequently

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