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Leachate recirculation effects on waste degradation: Study on columns

V. Francois [a], G. Feuillade [a,*], G. Matejka [a], T. Lagier [b], N. Skhiri [b]

[a] *Laboratoire des Sciences de l'Eau et de l'Environnement, ENSIL, 16 rue Atlantis, 87060 Limoges Cedex, France*
[b] *CReeD, Zone Portuaire de Limay, 291 avenue Dreyfous Ducas, 78520 Limay, France*

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Abstract

The purpose of this study is to determine the impact of leachate recirculation on the degradation of municipal solid wastes (bioreactor concept). The study was carried out using columns containing approximately 50 kg of waste, in order to follow waste degradation over a limited time. Three types of waste were studied: fresh waste of standard composition, fresh waste of fermentable composition and some 8-yr-old waste extracted from a site in France. Measurement of the global parameters, such as chemical oxygen demand (COD), volatile acidity, alkalinity, leachate conductivity, methane potential of the wastes and biogas production monitoring (volume of CO_2 and CH_4 produced), were carried out. The quantity of oxydizable matter and biogas production was increased by the leachate recirculation, and the duration of the first degradation phases was reduced in all cases. Chloride, ammonium and organic pollution accumulation was observed according to the duration of recirculation. After 400 days of degradation, waste stabilization seemed to be reached for all of the recirculated columns (COD < 300 mg/L O_2, and methane potential reached).
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1. Introduction

Sanitary landfills are designed to limit water entry, in order to reduce their environmental impact. This type of design can, however, slow down waste degradation processes, which are strongly dependent on moisture. Indeed, one then witnesses a progressive draining of moisture from waste, which results in a lengthening of degradation time and, consequently, in an increase in management costs. In contrast, the bioreactor concept aims at supporting waste degradation, while providing the necessary moisture. One of the principal techniques used is leachate recirculation in the solid waste mass.

Leachate recirculation tests on waste were progressively put in place as pilots (waste columns) (Stegmann, 1997; Chugh et al., 1998; Rodriguez Iglesias et al., 2000; Youcaï et al., 2002; Sponza and Agdag, 2004) or on sites in England (Reinhart and Al-Yousfi, 1996), and particularly in the United States. The main results indicated that the quantity of pollution produced on-site was consistently greater than that produced with the columns. When the studies were carried out using small columns (less than 50 cm) and low quantities of waste, the results were not indicative of what happens on-site. When the quantity of waste was great enough (at least approximately 10 kg), the evolution was the same; nevertheless, it was not possible to define a correlation between the results obtained with the columns and the results at the site, where the waste degradation is not controlled (Kylefors et al., 2002).

A research programme was launched in France by the Environment Energy and Waste Research Center (CreeD), in collaboration with the French Agency for Environment and Energy Management (ADEME), to describe the principal effects of leachate recirculation on waste degradation, in order to understand better the phenomena brought into play and to optimize the installation of such a concept. The first stage of this programme was a laboratory study aimed at studying certain parameters influencing degradation, such as composition, age, waste quantity, volume and

* Corresponding author. Tel.: +33 05 55 42 36 70; fax: +33 05 55 42 36 80.
E-mail address: feuillade@ensil.unilim.fr (G. Feuillade).

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recirculated leachate quality using a column (1 m height) containing approximatively 50 kg (the waste mass great enough to be significant).

On the one hand, the study presented in this paper brings together the methodology applied to setting up the columns of leachate recirculation waste. All of the columns were instrumented to allow the waste parameters, leachate and biogas, to be controlled. A characterization of the wastes was carried out before their introduction into the columns and their methane potential was estimated according to the BMP tests.

On the other hand, it gave the analytical results obtained from the various columns during the monitoring of leachate and biogas produced over a period of time. The global parameters of leachates such as pH, E_H, chemical oxygen demand, volatile acidity, alkalinity, conductivity or more specific parameters as nitrogen (organic and mineral species), cations (Ca^{2+}, K^+, Na^+), anions (Cl^-, SO_4^{2-}) were determined. The production of biogas (volume and quantity of CO_2 and CH_4) was measured.

The analytical monitoring of leachate and biogas composition on waste columns made it possible to highlight the principal phases of anaerobic degradation and their characteristics over a limited period of time. The advantages and disadvantages of leachate recirculation on waste degradation were then underscored.

2. Materials and methods

2.1. Experimental column device

The waste columns were designed in order to reproduce landfill conditions, while controlling the principal factors taking place during waste degradation. The experimental device was thus selected in order to respect, as much as possible, the following criteria:

- anaerobic medium (closed system),
- optimal degradation temperature (operational temperature range of 35–40 °C, (Yuen et al., 1995)),
- precipitation-simulating and leachate-recirculation system,
- leachate recovery (drainage layer (gravels) and sampling system),
- biogas recovery (collected on top of the column),
- gas removal in the event of overpressure (valve).

In order to estimate the leachate recirculation effects on waste degradation, column couples (3 couples) were used simultaneously: a column undergoing recirculation and another without recirculation (Figs. 1 and 2).

The first type of waste column (two column couples) (Fig. 1) was entirely instrumented to allow the waste

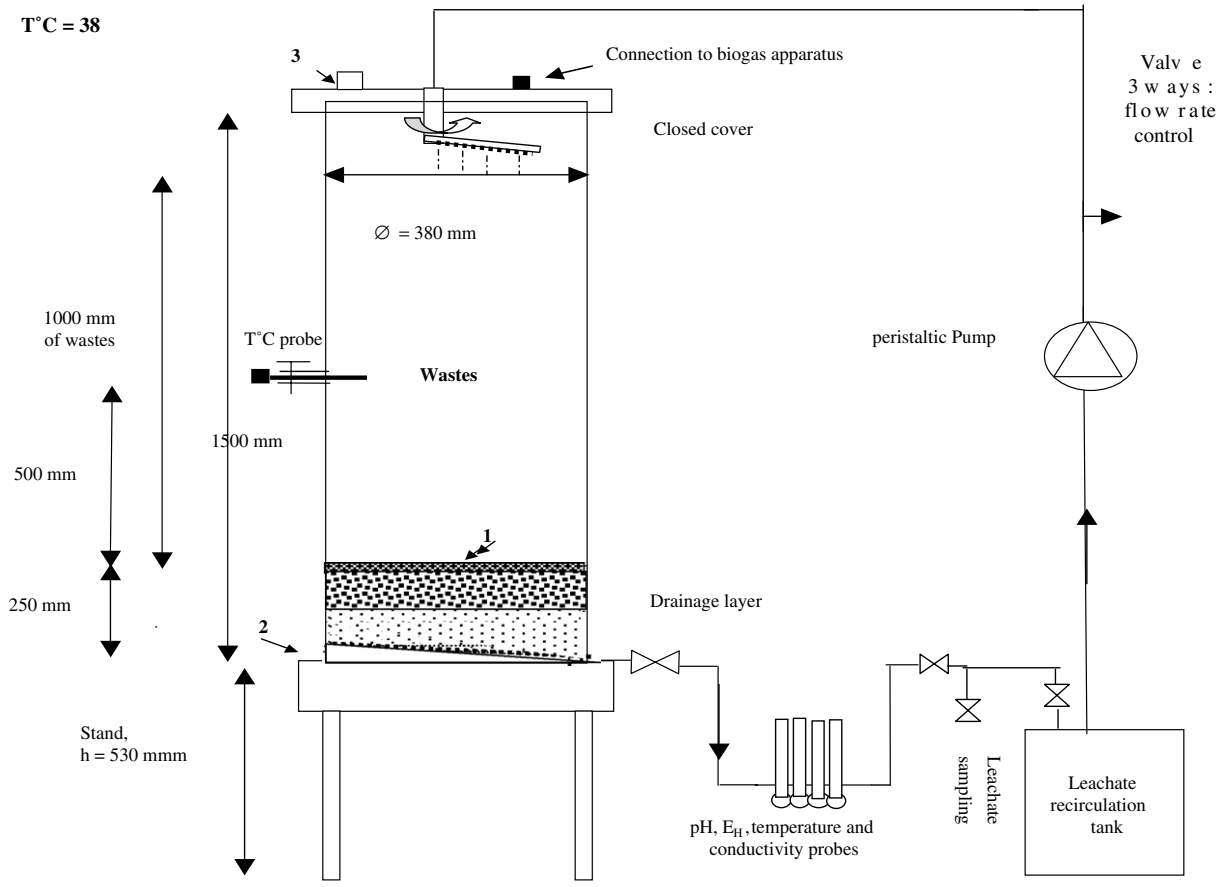

Fig. 1. First type of column (transparent PVC) with leachate recirculation. (1) PVC screen; (2) PVC screen of low thickness covered with a filter fabric (500 μm–1 mm); (3) safety valve.

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