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Indicating the parameters of the state of degradation of municipal solid waste

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Abstract

This study related to the analysis of the physical (granulometry and composition) and chemical (organic matter, organic carbon and nitrogen contents) characteristics, as well as those relating to release (leaching tests and determining the methanogene potential) of several domestic wastes, with an aim of evaluating stabilization indicators. Values thresholds for a known stabilized waste were thus deduced by correlation (% paper-cardboard = 0–1; % volatile solid (VS) = 18–19; % OC = 5–6; % fines = 44–45; % degraded components = 75–76, COD of leachate = 141–155 mg O_2/L; DOC from leachate = 45–49 mg C/L and 0.9–1 m^3 CH_4/t of dry waste). However, these values thresholds remain specific to the method employed for the analyses. The results obtained represent a considerable advance in the definition of a waste stabilized state and propose the importance of certain parameters, such as the paper-cardboard content and the measurement of leachates by using the SUVA index for determining a stabilization state.

Keywords: Waste; Stabilization; Physicochemical indicators; Leachate; Leaching tests; Methanogene potential

1. Introduction

Landfilling is carried out in order to reduce environmental impacts to the minimum. Regulations (adopted on 9 September, 1997) impose, 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.

The final quality of waste thus becomes an indispensable criterion for ensuring that there is no risk of environmental pollution.

The definition of a waste stabilized state, and the ways of making it possible to reach this state quickly, are currently the highest priority. The stabilization criteria are mainly directed towards following-up leachates and biogas produced.

Morris et al. [1] indicated, for example, a stabilized state for a total gas production corresponding to 95% of the estimated theoretical gas production. However, the analysis of the pollution released by waste is not always representative of the potential waste pollution [2].

Recent studies [3–6] try to determine more relevant criteria to represent the state of waste degradation by analysing, for example, their biodegradability and their release potential. According to Kelly [4], the best parameters of waste stability are the organic matter content, the cellulose content and the measurement of waste methanogene potential. However, little data are available and it remains difficult to validate. The study described in this paper thus concentrates on the physicochemical characterization (granulometry, composition, organic matter content, organic carbon and nitrogen contents) of several domestic wastes of different ages, such as measuring total parameters of the leachate and biogas released in order to define the value thresholds of a stabilized state.

Abbreviations: BMP, biochemical methanogene potential; BOD_5, biological oxygen demand at the end of 5 days; COD, chemical oxygen demand; DOC, dissolved organic carbon; OC, organic carbon; PC, paper-cardboards; PCA, principal component analysis; SUVA, specific ultraviolet absorbance; VS, volatile solid; VSS, volatile suspended solids

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Table 1
Type of waste studied and analyses carried out

Age of wastes	3 Years	8 Years	8 Years	8 Years	20 Years	30 Years
Site	A	B	C	D	D	E
Name of wastes	A_3	B_8	C_8	D_8	D_{20}	E_{30}
Site surface cover	Clay layer	Clay layer	Clay layer	Clay composed of compost	Clay layer	Clay layer
Type of analysis carried out	Physical characteristics Chemical characteristics Release (leachate and biogas)	Physical characteristics	Physical characteristics	Physical characteristics Chemical characteristics Release (leachate and biogas)	Physical characteristics Chemical characteristics Release (leachate and biogas)	Physical characteristics Chemical characteristics Release (leachate and biogas)

2. Materials and methods

2.1. Choice of domestic wastes

The solid wastes were collected from sanitary landfill. In order to see a significant progression of the measured parameters, wastes of different ages were studied (Table 1).

These wastes were selected more because of their accessibility than their intrinsic characteristics. Their disparate sources make it difficult, however, to take the factor age in the results into account. For the 8-year-old wastes, study as been mainly carried out with D_8 (covered by clay composed of compost) because the mass of this waste was the more important and then the more significant. However, it will be necessary to realize the same study with B_8 and C_8 wastes to confirm the impact of the type of cover.

Waste masses, ranged from 40 to 150 kg and were collected from 2 to 3 m depth.

Waste samples were preserved on plastic bags, and then they were studied in the following 48 h.

Fresh waste, reconstituted according to ADEME specifications, was called F and was also characterized. It is used as a reference. This waste composition is given in Table 2.

Table 2
Composition of reconstituted fresh waste F [19]

Waste category	National average of reference (in % of wet mass)
Putrescible waste	28.6
Papers	16.1
Cardboards	9.3
Packaged papers	1.4
Textiles	2.6
Medical textiles	3.1
Plastics	11.1
Wood	3.3
Glass	13.1
Metals	4.1
Inert material	6.8
Special waste	0.8
Total	100

2.2. Physical characteristics of waste

Wastes were characterized in a wet state so as to be closer to the characteristics of the waste in the landfill.

2.2.1. Granulometry

The MODECOM ADEME Method (1993) was applied to each rough waste:

$$\textbf{COARSE}\text{–}/10\,\text{cm}/ \rightarrow \textbf{MIDDLE}\text{–}/2\,\text{cm}/ \rightarrow \textbf{FINE}$$

2.2.2. Composition

Middle and coarse fractions were sorted according to the waste categories given in MODECOM [7]: paper-cardboards, plastics, wood, inert material, metals, special waste (batteries, cigarette butts, dirty sponges, medicines), textile, glass and a form of degraded wastes. The form of degraded wastes represent wastes in a state of degradation, so that it is not possible to associate them with a specific waste family.

This sorting stage proves to be difficult for the rather wet fractions, like degraded compounds, which tend to be linked to other waste categories.

2.3. Chemical characteristics

To be representative, the analysis to determine the chemical characteristics must be carried out on a homogeneous and fine sample. The grinded waste is thus necessary for these measurements. It is necessary to carry it out as a dry waste, in order to facilitate the operation. Therefore, a drying stage must be carried out before the grinding operation.

2.3.1. Waste preparation before analysis

2.3.1.1. Drying. The waste was dried under a stream of nitrogen (micronitrogen generator 90) in a glove box, in order to limit their oxidation.

This drying operation lasts approximately 3 weeks for a 50 kg quantity of waste.

2.3.1.2. Grinding of all sorted and dried fractions. The sorted and dried waste fractions were grinded to an approximate size