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Emissions of C&D refuse in landfills: A European case

Ana López *, Amaya Lobo

Environmental Engineering Group, Department of Science and Techniques of Water and the Environment, University of Cantabria, Avd. Los Castros s/n, Santander 39005, Cantabria, Spain

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ABSTRACT

A field study was developed in a new landfill for refuse from construction and demolition (C&D) material recovery plants of small size (4 Ha.) in Europe, with the aim of evaluating the liquid and gas emissions in this type of facility at a large scale. It included characterization of the materials, monitoring leachate and gas quantity and composition. Besides thermometers, piezometers and sampling ports were placed in several points within the waste. This paper presents the data obtained for five years of the landfill life. The materials disposed were mainly made up of wood and concrete, similar to other C&D debris sites, but the amount of gypsum drywall (below 3% of the waste) was significantly smaller than other available studies, where percentages above 20% had been reported. Leachate contained typical C&D pollutants, such as different inorganic ions and metals, some of which exceeded other values reported in the literature (conductivity, ammonium, lead and arsenic). The small net precipitation in the area and the leachate recirculation into the landfill surface help explain these higher concentrations, thus highlighting the impact of liquid to solid (L/S) ratio on leachate characteristics. In contrast to previous studies, neither odor nuisances nor significant landfill gas over the surface were detected. However, gas samples taken from the landfill inside revealed sulfate reducing and methanogenic activity.

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1. Introduction

The construction industry has a large economic and social role in numerous countries. Traditionally, its development entails an increase in the production of construction and demolition (C&D) waste, with the subsequent loss of resources and environmental impact. In order to avoid these effects, specific standards have been promulgated recently to regulate the generation and management of this waste, promoting recycling and seeking the reduction of the landfilled quantities (i.e. Gobierno de España, 2008). As a result, numerous plants for C&D recovery have been opened (i.e. in Spain the plants under operation increased from 61 in 2006 to 130 in 2010, according to MMAMRM (2011)).

The refuse from C&D recovery plants constitutes a particular case of C&D waste. Several characteristics, such as the particle size or the proportion of materials making up the waste mixture, vary since recyclable fractions are separated from the original stream. Depending on the collected waste materials, organic matter (wood, paper, cardboard and others) can be a significantly great fraction among the rejects. Therefore, biodegradation processes become relevant when this kind of waste is landfilled and thus organic pollution in the leachate and gases can be problematic, like in other types of non hazardous waste landfills.

Several authors have studied the leachability of hazardous compounds from C&D waste in the last years. Roussat et al. (2008) found that one of the most troublesome components with regard to the leachate generation is wood, particularly treated and painted wood. Jambeck (2004) studied the leachability of Chromated Copper Arsenate (CCA)-treated wood as a single element and in contact with municipal solid waste (MSW) and C&D waste in lysimeters. The results regarding arsenic were presented in Khan et al. (2006), while those corresponding to the mixture with other C&D waste were compiled in Jambeck et al. (2008). Dubey et al. (2009) compared the leachate from CCA-treated wood and Alkaline Copper Quaternary (ACQ) treated wood combined with C&D waste in lysimeters. On the other hand, Wadanambi et al. (2008) analyzed the lead leachability of lead-based paint in MSW and C&D landfills environments.

Other researchers have characterized different C&D waste materials with a view to their reuse. Delay et al. (2007) performed leaching tests to measure the release of inorganic pollutants in recycled C&D waste. Jang and Townsend (2001), in turn, analyzed the sulfate and dissolved solids leached from C&D debris fines. In this area, Musson et al. (2008) developed a method to approach the gypsum content in these fines and Townsend et al. (2004)

* Corresponding author. Tel.: +34 942202285; fax: +34 942201703.
E-mail addresses: lopezan@unican.es (A. López), loboa@unican.es (A. Lobo).

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studied their heavy metal leachability. Other authors have studied the influence of CCA-treated wood on the composition of mulch (Mercer and Frostick, 2012; Townsend et al., 2003).

Laboratory studies, like those mentioned above, are essential to gain detailed knowledge about the processes involved in this kind of landfills. However, in order for these results to contribute to the progress of technology, of the landfill engineering in this case, it is also essential to develop and publish data obtained in full scale facilities. Field data can show how experimental observations transfer to reality, where interactions among processes take place that cannot be reproduced in the laboratory. Nonetheless few data have been reported about landfills receiving C&D refuse, probably because of their recent appearance, associated with C&D recovery plants. Existing reports about C&D landfills, with or without a previous recycling facility, focus on characterizing the leachate quality or quantifying the generated sulphidric acid, as main responsible for odor nuisances, which are one of the principal social impacts of these facilities. The Environment Protection Agency of US published in 1995 a comprehensive study about the potential impacts of C&D waste landfills, including the characterization of waste and leachate in 21 landfills in the US (USEPA, 1995). Melendez (1996) compiled and compared the leachate generated in different C&D landfills. Townsend et al. (1999), in turn, studied the leachate generated by some of the materials included in this type of waste under saturated and non-saturated conditions, through several experiments in leaching columns. On the other hand, Weber et al. (2002) analyzed the leachate generated in four test cells built in a C&D debris landfill. These studies highlight the high sulfate and dissolved solid content of leachate, coming fundamentally from the breakdown of gypsum drywall (calcium and sulfate are the predominant ions observed in the leachate). Moreover, these leachates present elevated concentrations of heavy metals which, in some cases such as cadmium and lead, could seriously damage human health and the environment (Melendez, 1996).

An important issue in C&D landfills results from the deposited gypsum. Owing to the biological reduction of sulfate from gypsum, a variety of reduced sulfur compounds (primarily H_2S) is generated in C&D debris landfills, causing odor problems in many occasions, and possible health concerns (Eun et al., 2007; Lee et al., 2006; Reinhart et al., 2004). Trying to characterize the problem, Lee et al. (2006), published the gas composition of samples taken from the inside, the waste/cover interface and the ambient air in 10 C&D debris landfills. The most recent reports have focused on the search of cover materials that attenuate the emission of these compounds (Plaza et al., 2007; Sungthong and Reinhart, 2011; Xu et al., 2010).

These studies, the same as those about leachate mentioned above, have all been developed in American landfills. Further information is needed about the emissions of this kind of facilities in other locations, where not only the local but also the waste characteristics may be different.

This paper provides field data from a full-scale C&D landfill called Corral Serra in Spain (Europe). It presents the results of a five-year-study which included waste, leachate and landfill gas characterization as well as other variables measured in situ. In a first section a general description of the studied landfill and its associated C&D waste recovery plant is provided. Then, the study approach is described, including the analytical methodology and instrumentation plan. Finally, the obtained results are presented and discussed in contrast to data reported in other cases.

2. The studied landfill

The new landfill of Corral Serra was built in 2005 to hold the residues from several C&D recovery plants and transfer stations in a Mediterranean region of Europe. The aim of these facilities is to generate recycled aggregate. They receive waste not only from building and civil construction works but also from demolition and building restoration. The typical recovery line starts screening, separating and grinding materials with a size bigger than 400 mm. Then, there is a separation of ferric metals and undesired materials such as plastics, metals, wood, hazardous materials, paper-cardboard, wires, glass and other materials. Finally, the sorted aggregates are crushed and divided into different sizes (normally considering three fractions: under 8 mm, under 15 mm and between 8 and 40 mm). The rest (except the recovered ferric metal) are sent to a landfill.

The studied landfill has a total surface of 140,000 m^2, of which 40,900 m^2 have been used for C&D waste disposal. It has a bottom lining system according to Directive 1999/31/EC (CEU, 1999). The leachate collection system consists of a 50-cm-thick layer of gravel placed on a geotextile that protects the bottom liner. A 250 mm slotted PE collection pipe receives the leachate along the South–North axis of the landfill and conveys it to the collection sump.

From the beginning of operations, in March 2006, until July 2009, 303,738 T of C&D materials were disposed of, including 218,697 T of waste and 85,041 T of recycled granular material used as intermediate cover. Fig. 1 shows the different operation stages. During the first six months, in which 33,342 T were received, waste was spread in approximately 2.5-m-high layers, without intermediate cover. During the following four months 33,142 T were disposed of, in-2-m layers with 35-cm-intermediate cover. At the end of this stage there was an average waste thickness of 5 m in Vessel 1. In the second stage 73,107 T were buried in 1.8-m-high cells with 55-cm-weekly cover during eleven months, up to an average thickness of 14 m in Vessel 1. At that time the Vessel 1 surface was at the level of the Vessel 2 bottom. Since December 2007 until July 2009 93,040 T of waste were spread in 2.1-m layers with 20-cm-intermediate cover. The final average thickness was 17 m in Vessel 1 and 6 m in Vessel 2.

Based on topographical data, a global average density (waste and cover) of 0.83 T/m^3 was reached in the landfill; the average apparent density of waste was 0.60 T/m^3. This value is quite higher than the reference range for mixed construction waste [0.18–0.36 T/m^3], reported by Tchobanoglous et al. (1993). This difference corresponds to the type of waste. The residues received in Corral Serra come from a recovery plant that rejects the smallest fractions, which are easier to compact than the conventional C&D waste mixture.

The yearly net precipitation in the area is negative. Taking advantage of this fact, leachate is stored inside the landfill and in external ponds, from where it is recirculated to promote evaporation by irrigation on the waste when there is no rain.

3. Experimental study

3.1. Work plan

In order to take advantage of the new landfill as a pilot experiment to characterize the emissions in this kind of facilities located in similar climatic areas in Europe, a study was planned. It included a detailed record of the operational practices, waste, leachate and gas samples characterization, in situ monitoring of several variables (temperature, leachate head on the bottom liner and settlement) and gas/liquid samples extraction from several points inside the waste body. This study was as a part of a Collaboration Research Project between TIRME S.A. and the Environmental Engineering Group of the University of Cantabria (GIA-UC), to gain knowledge about processes occurring inside the landfill and help understand the consequences of leachate recirculation, which is not a common practice in this kind of landfills. It supplements

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