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Comparison between laboratory and field leachability of MSWI bottom ash as a road material

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The leaching properties of bottom ash from municipal solid waste incineration (MSWI) used as an aggregate substitute in unbound pavement layers are evaluated. The mechanical behaviour of bottom ash is acceptable for this application, but the potential environmental consequences constitute the most important limitation on the use of bottom ash as a road material. The environmental properties of bottom ash are assessed by means of the Dutch availability test NEN 7341 and the single-batch and two-stage batch European EN 12457 laboratory leaching tests. Furthermore, an experimental unbound pavement stretch is constructed to provide information on leaching behaviour under field conditions. In this high infiltration scenario, the results from predicted (based upon laboratory leaching tests) and measured releases (under field conditions) are compared, evidencing that predictions based on compliance leaching tests may be highly realistic. The depletion period of the extractable fraction of a number of elements in these field conditions is also quantified.

1. Introduction

Bottom ash is the main by-product from municipal solid waste incineration since it accounts for about 90% (in weight) of the solid by-product (Chandler et al., 1997). Incineration reduces the volume of waste by about 90% and its mass by about 70% (Chimenos et al., 1999). The current annual production of bottom ash in Catalonia (NE Spain) reaches 150,000 tonnes, produced in five municipal solid waste incineration (MSWI) plants. Nowadays, bottom ash in Catalonia is mainly landfilled although the proportion destined for engineering purposes is progressively increasing. The Catalan Autonomous Government levies landfilling taxes on this material in order to promote valorisation. Owing to its characteristics, bottom ash could be used as a road material replacing natural aggregates.

Experimental data have shown that MSWI bottom ash meets the physical and mechanical requirements established by Spanish Road Regulations for granular layers, as well as the Catalan Specifications for MSWI bottom ash valorisation, which are environmental requirements based on leachability of Cu, Pb, Zn, As, Cd and Cr according to DIN 38414 leaching test (Izquierdo et al., 2002). Nevertheless, these environmental standards may be considered permissive given that: 1) only the above mentioned elements are regulated, and 2) tolerant limit values compared with other environmental standards from different EU state members are required.

MSWI has proved to be successful as an unbound road material from a technical and mechanical point of view (Rogbeck and Hartlén 1996; Pihl, 1997; Reid et al., 2001; Arm, 2003). The leaching properties are considered to be the main limitation barrier that could restrict the valorisation opportunities of bottom ash.

Leaching tests yield information on environmental properties of bottom ash to support decision taking on waste management. However, the leaching behaviour of the environmentally relevant elements under field conditions may differ from the predicted behaviour based on results provided by laboratory leaching tests (Schreurs et al., 2000; Reid et al., 2001).

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Such a possible lack of correlation between predicted and actual releases must be evaluated in order to correctly assess the potential environmental impact of the use of bottom ash. For this reason, it is of considerable scientific and environmental interest to compare the leachability of bottom ash deduced from laboratory leaching tests with that occurring under field conditions. To date, only a few studies comparing laboratory and field data regarding certain bottom ash elements have been performed, obtaining a relatively good agreement between laboratory predictions and field results (Schreurs et al., 2000; Bruder-Hubscher et al., 2001; Åberg et al., 2006; Lidelöw and Lagerkvist, 2006; Hjelmar et al., 2007).

The main objectives of this study are: 1) to evaluate the mobility of a number of elements under field conditions, 2) to quantify the depletion period of the soluble fraction, and 3) to determine the degree of correlation between predicted and measured leachable concentrations of a number of elements, highlighting those of main environmental relevance to MSWI bottom ash.

2. Materials and methods

2.1. Materials

MSWI bottom ash used in this study proceeded from the Mataró incineration plant (NE Spain). After quenching and air drying, the quality of the material was improved at the Pedreres Rusc treatment plant, where large particles and a high proportion of the metallic fraction and unburned material were removed. The treatment included a weathering for several months. The material was sampled from the stockpiles at the treatment plant and characterized prior to the field application.

The field test, located in a rural area in Tagamanent (NE Spain), consists of an experimental road stretch of 200 m in which MSWI bottom ash was applied as a granular road base replacing natural aggregates to study the mechanical performance (Izquierdo, 2005). The road section was completed with an unbound granular layer of compacted limestone aggregates on the top of the bottom ash layer. In a small transect of this field test, drainage channels of 5 m long × 3.7 m wide were constructed (Fig. 1), impermeabilized with a geotextile and filled with compacted bottom ash. A PVC tube (10 cm diameter) with drilled holes (3 mm diameter) was placed across the channels to collect the percolation water and connected to a sampling tank. The tube was covered with a layer of coarse bottom ash (particles >20 mm) to retain fine particles and help the filtration. Field leachates were sampled with a 4-month periodicity, except for two extractions sampled consecutively at the beginning. Seven field extractions were obtained.

As a reference material, a channel filled with a typical limestone aggregate currently used as a road material was also constructed. The results obtained allowed us to distinguish the proportion of the field releases corresponding to the leaching of the upper limestone layer.

After a period of 15 months, a number of core samples from the field bottom ash channel were extracted to determine the total leached amounts of some elements. About 15 kg of bottom ash were sampled and subsequently mixed and quartered to supply subsamples for the determination of the leaching potential.

2.2. Characterization methods

Milling of quartered fractions was carried out for the chemical characterization. Major, minor and trace element concentrations were determined in bottom ash. Samples were acid-digested by using a special two-step digestion method devised for the analysis of trace elements in coal and combustion wastes by Querol et al. (1995). A standard reference material (a municipal waste incinerator fly ash) was used to test the accuracy of the analytical determination. A relative error <3% was obtained for most elements with the exception of K and P (<10%). Major, minor and trace element concentrations in acid digestions were determined by means of inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma atomic emission spectrometry (ICP-AES), whereas silica contents were determined by X-ray Fluorescence (XRF) on the bulk solid samples. Analyses were performed in duplicate with the exception of core samples from the field test, carried out in triplicate in order to obtain more reliable data given that this parameter will be useful for further calculations.

2.3. Laboratory leaching tests

Since the results from laboratory leaching tests were correlated with field data obtained from the experimental road, it should

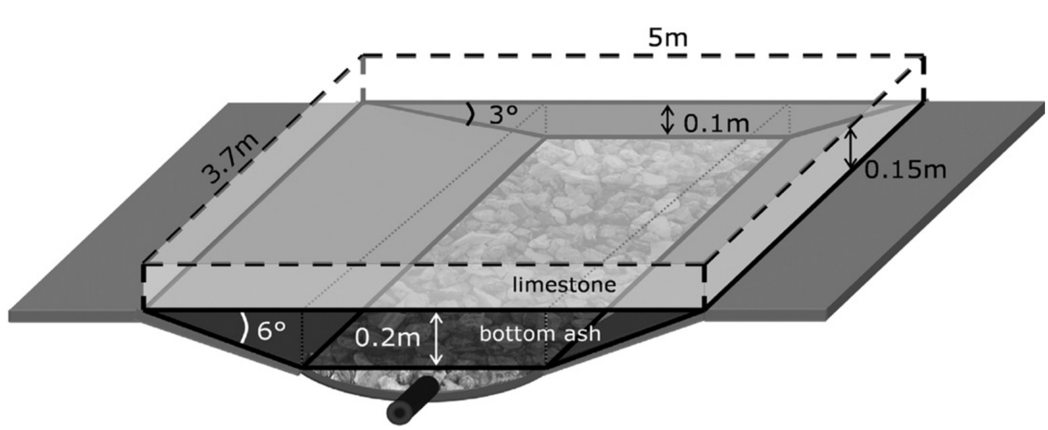

Fig. 1 – Cross section of a bottom ash channel and location of leachate collection and sampling devices (not in scale).