Assessment of environmental aspects of using biomass bottom ashes as stabilising agent of expansive clays.

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1. Introduction

All decisions that affect the environment, such as resource consumption or waste generation are beginning to be a priority in the policies of the European Union. Engineering and construction sectors are the main cause of the consumption of natural aggregates that involves the construction of any structure and they are causative of high emissions during the construction material manufacturing. Green initiatives are essentials in both sectors.

These initiatives are extendable in the stabilization of soils: Could we substitute chemical agents for residues that present stabilizing potential? The aim of the present research is the environmental assessment of waste (biomass bottom ashes) when they are used as soil stabilisers. Although, physical and mechanical properties of these ashes applied in engineering infrastructures have been evaluated by studies as Cabrera et al. (2014) or Hinojosa et al. (2014), it is necessary to extend the study toward the environmental risk derived from their use.

2. Material and methods

2.1-Materials

The present work analyses an expansive soil, bottom ashes and mixtures of both materials (stabilised soil).

The soil studied (ES) is a clayey soil, a blue marl with a powerful formation of carbonated clays that was found at the site of the construction works of a motorway. It presents a liquid limit of 59.2 being classified as high plastic clay "CH" according to ASTM D2487–11 of Unified Soil Classification System: USCS. The tested bottom ashes come from the combustion of different biomass mixtures: seed grape and oil cake for GB ash, and olive oilcake and wastes from olive oil industries for OB ash. The tested materials are listed in Table 1:

Table 1. Tested materials: expansive soil (ES), biomass bottom ashes and mixtures of stabilised soil.

Code	Definition	Code	
GB	Bottom ash from grape	OB	Bottom ash from grape
ES-8G	ES stabilized with 8% of GB	ES-8O	ES stabilized with 8% of GO
ES-12G	ES stabilized with 12% of GB	ES-12O	ES stabilized with 12% of GO
ES-16G	ES stabilized with 16% of GB	ES-16O	ES stabilized with 16% of GO

2.2-Experimental methods

This research is focused on the study of the pollutant release of heavy metals and anions indicated by EU Landfill Directive on leachates obtained according to three different methodologies that represent different phases of study as it can be observed in Figure 1:

a) The *Compliance Batch Test (UNE-EN 12457-3:2003)* for basic characterisation of leaching levels for liquid to solid ratios (LS) of 2 and 10 l/kg. These data are compared with the legal limit established by the Landfill Directive.

b) The *Column test (NEN 7343:2004)* for estimation of the leaching behaviour in the short, medium and long term of aggregates without density alteration. It is performed at liquid to solid ratios of 0.1, 0.2, 0.5, 1, 2, 5 and 10 l/kg.

c) The *under-compaction leaching test (UCLT)* is an experimental test designed with the purpose of analysing the contaminating potential of granular materials, considering the real conditions of material used in engineering´s infrastructures: high density due to compaction. Data will be compared with the data from the standardized tests.

By the UCLT procedure, the material will be tested inside a stainless-steel rectangular tank designed according to Figure 1. The tank is composed by a smaller compartment to collect the leachate drained. Materials are compacted at 90% maximum density obtained in the Modified Proctor Compaction Test, and several rain episodes were applied to reach the same LS ratio than column test and after each one, leachates were drained into PE containers.

At the end of each test, eluates were separated, filtered and analysed by inductively coupled plasma mass spectrometry (ICP-MS). This analysis quantified the heavy metals specified by the European Landfill Directive: Ni, Cr, Sb, Se, Mn, Hg, As, Pb, Cd, Cu, Ba and Zn, and the anions fluoride, chloride and sulphate.

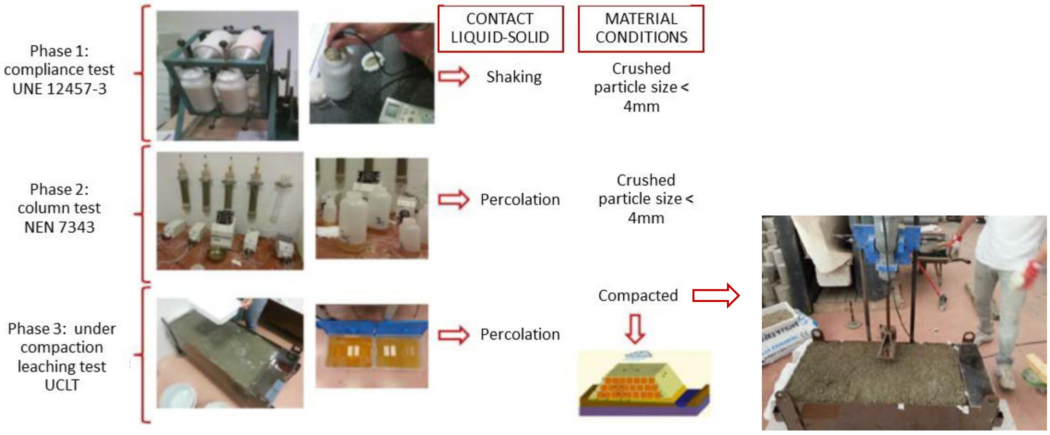

Figure 1. Experimental methods and phases of study developed.

4.Results and discussion

4.1. Base characterisation: compliance test data and pollutant potential

From compliance test can be deduced the elements released in higher levels. Concentrations obtained can be compared with the legal limits of the Landfill Directive, and the data summary is showed in Table 2.

Table 2. Summary of pollutant elements released in higher levels according to compliance test (in mg/kg).

Material	Element that exceed the non-hazardous limit	Material	Element that exceed the non-hazardous limit
ES	sulphate		
Grape bottom ash and stabilised mixtures		Olive bottom ash and stabilised mixtures	
BG	Cr, Cu, Se and sulphate	BO	Cr, Cu, Se, Hg, fluorate and sulphate
ES-16G	Cr, Se and sulphate	ES-8O	Se and sulphate
ES-8G and ES-12G	Se and sulphate	ES-12O	Se, Hg and sulphate
		ES-16O	Se, Hg, Cr and sulphate

Based on data, it is observed that the higher the percentage of ash in the stabilized soil mixtures, the higher the level of contaminant. This is because the ashes BG and BO presented the highest pollutant levels.

4.2. Comparison between the normalised test NEN 7343 and the designed leaching procedure UCLT.

When both procedures where compared, it was deduced that under compaction, release levels were lower than the obtained by the normalised column test (see Figure 2 in the case of sulphate and Se).

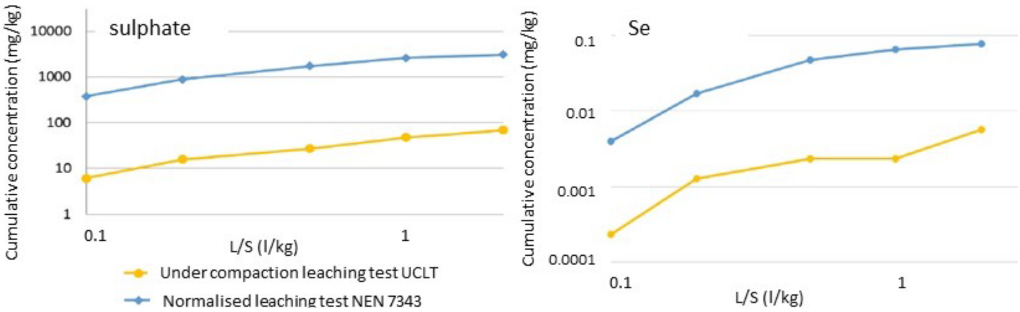

Figure 2. Comparison between release levels between column test NEN7343 and UCLT test.

Figure 2 shows higher release levels in the normalized test curve than in UCLT curve, what was observed for both stabilizing ashes. When material is compacted, changes in its physical properties are playing a key role and the higher density is producing a lower percolation factor causing a lower release.

5-Conclusions

The present investigation confirms the need to test stabilised soils that will be used in civil infrastructures under work conditions. The contempt of these physical conditions during experimental procedures in laboratory can lead to overestimate their pollutant potential and limit their reusing in a second life cycle.

6-References

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