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Critical aspects of biomass ashes utilization in soils: Composition, leachability, PAH and PCDD/F

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ABSTRACT

Bottom and fly ashes streams collected along a year in several biomass thermal plants were studied. The bulk composition of ashes and other chemical characteristics that may impact soil application showed a high variability depending on the ash stream, combustion technology and ash management practice at the power plants. The acid neutralization capacity (ANC) and metal's availability for leaching at fixed pH 7 and 4 was performed according with EA NEN 7371, as a quick evaluation method to provide information on the long-term behavior of ashes, regarding heavy metals and also plant nutrients release. Also the pH dependence leachability study was performed according to CEN/TS 14429 for predicting the leaching behavior under different scenarios. Leachability profiles were established between pH 3 and 12, allowing to distinguish different solubility control phenomena of toxic heavy metals (Cu, Cr, Mn, Ni, Zn, Pb) as well as other salts (Ca, K, Mg, Na, Cl). The ANC of fly ashes at pH 4 (3.6–9.6 molH$^+$/kg) were higher than that observed for the bottom ashes (1.2–2.1 molH$^+$/kg). Ashes were also characterized for persistent organic pollutants (POP), such as polycyclic aromatic hydrocarbons (PAH) and paradibenzodioxines and furanes (PCDD/F). Contents were found to be much higher in fly ash than in bottom ash streams. None of the PAH levels did reach the current national limit value of sewage sludge application in soils or the guide value for ash in north European countries. However, PCDD/F contents, which are not regulated, varied from non-detectable levels to high amounts, regardless the level of loss on ignition (LOI) or unburned carbon content in fly ashes. Given the current ash management practices and possible use of blends of bottom and fly ash streams as soil conditioners resembles clear the urgent need to regulate ash utilization in soils, incorporating limit values both for heavy metals, PAH and PCDD/F.

1. Introduction

Due to increasing environmental concerns related with the use of fossil fuels, new solutions to limit the greenhouse gases emission and related environmental effects are continuously sought. Among the available alternative energy sources, biomass is considered a renewable energy source with high potential to contribute to satisfy energy needs of modern society for both the industrialized and developing countries worldwide (Dermibas et al., 2009; Khan et al., 2009; Insam and Knapp, 2011; Swaaij et al., 2015). The main technologies used for energetic conversion of biomass still involve thermochemical conversion (TC) processes, mostly the combustion processes. The most efficient technology used at industrial scale is fluidized bed (FB), both bubbling fluidized bed (BFB) and or circulating fluidized bed (CFB) alternatives that uses a hot sandy bed to support biomass combustion, as opposed to grate furnace. This technology is characterized by a process operating at relatively low temperature, isothermal operating conditions and high fuel flexibility, presenting good combustion efficiencies (Loo and Koppejan, 2008; Khan et al., 2009; Tarelho et al., 2011; Swaaij et al., 2015). Grate furnaces work with more variable temperatures and are appropriate for biomass fuels with varying particle sizes (with a downward limitation concerning the amount of fine particles in the fuel mixture) and high ash content (Loo and Koppejan, 2008). In Portugal there is a set of industrial thermal power plants and cogeneration plants in operation based on biomass combustion, and most of those units include BFB combustors (Tarelho et al., 2013). Many industries, like pulp and paper or thermal power plants use forest and agricultural residual biomass from their activities of forest maintenance/thinning, wood processing, and forestry maintenance as solid biofuels (Emilsson, 2006). However, it is recognized that thermochemical conversion (TC) of

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