VERSITA

Chemical Papers 67 (11) 1376–1385 (2013)
DOI: 10.2478/s11696-013-0399-4

ORIGINAL PAPER

Variability of total and mobile element contents in ash derived from biomass combustion‡

[a]Jiřina Száková*, [a]Pavla Ochecová, [b]Tomáš Hanzlíček, [b]Ivana Perná, [b]Pavel Tlustoš

[a]*Department of Agroenvironmental Chemistry and Plant Nutrition, Czech University of Life Sciences, Kamýcká 129, CZ-165 21 Prague 6, Czech Republic*

[b]*Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic, V Holešovičkách 41, CZ-180 00 Prague 8, Czech Republic*

Received 30 November 2012; Revised 16 January 2013; Accepted 21 February 2013

Seven samples of the ash derived from biomass, representing both fly and bottom ash, were analysed for a wide spectrum of total and mobile contents of nutrient and potentially risk elements. Several techniques, X-ray fluorescence (XRF) spectrometry, instrumental neutron activation analysis (INAA), proton-induced gamma-ray emission (PIGE) and proton induced X-ray emission (PIXE), inductively coupled plasma–atomic emission spectrometry (ICP-OES), and flame atomic absorption spectrometry (F-AAS) were compared. The results showed fairly good agreement between the XRF and INAA results, where the correlation coefficients (r) varied between 0.96 and 0.98. Lower contents documenting insufficient dissolution of the ash samples in the applied acid mixture were observed for both ICP-OES and AAS. In this case, weaker correlation with the INAA results not exceeding $r = 0.7$ were obtained. Therefore, the sample decomposition step is a bottleneck of the accurate analysis of this type of materials. For the assessment of plant-available portions of the elements in the ash samples, the Mehlich III extraction procedure and the extraction with a 0.11 mol L^{-1} solution of CH_3COOH were applied. The results showed relatively low mobility of the elements (especially micronutrients) in the ash samples regardless of their source and composition, suggesting limited immediate effect of direct ash application as a fertilizer.

Keywords: biomass combustion, fly ash, bottom ash, element contents

Introduction

Biomass, such as wood chips or straw, is an increasingly applied alternative to fossil fuels world wide. Simultaneously, possible recycling of ash from biomass combustion to be used as a source of macro- and micronutrients for forests or agricultural land is widely discussed. Different plant species growing under exactly the same natural conditions displayed different uptake characteristics. Plant species dependency and individual differences in the reaction of the plant leaves with different element sources lead to a very limited value of the investigated species as bioindicators of anthropogenic activities (Pitman, 2006; Jenkins et al., 1998). Wood ashes are rich in many essential plant nutrients. Pöykiö et al. (2009) reported the enrichment factors for total metal concentrations in the fly ash varying between 1.3 (potassium and sodium) and 34.5 (sulphur). However, wood is also known for its ability to strongly enrich certain heavy metals from the underlying soils, e.g. Cd, without any anthropogenic input. Because of the high variability of plant materials used for the combustion, their nutrient contents and plant-availability need to be described as they affect the combusted material and combusting conditions. Moreover, the levels of the risk elements

*Corresponding author, e-mail: szakova@af.czu.cz
‡Presented at the XXth Slovak–Czech Spectroscopic Conference, Tatranská Lomnica, Slovakia, 7–12 October 2012.