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TOXIC ARSENIC COMPOUNDS REMAIN IN NATIVE PLANT SPECIES FROM ARSENIC POLLUTED SOILS

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ABSTRACT

Arsenic is considered a toxic element for plants. However, the discovery of arsenic resistant and hyperaccumulating plant species has increased the interest in understanding the distribution of arsenic species in these environmental matrices. Plants are able to take up both arsenate (As(V)) and arsenite (As(III)) from soils, via phosphate transporters and some aquaporin channels, respectively, but both forms of arsenic are toxic to cellular metabolism of plants. Methylated arsenic species can be taken up by plants from soils as well, but generally less efficiently than inorganic species. Some authors have suggested that the synthesis of phytochelatins (PCs) is involved in As(III) detoxification in terrestrial plants. The chelating properties of these peptides lead to arsenic complexes which are less reactive and therefore less toxic for plants than the free arsenic ions [1]. Arsenic can also be present in plants as non-extractable arsenic species, strongly bound to lipids or to cell wall constituents. Nevertheless, the arsenic remained in plants as free inorganic or methylated ions has a greater interest due to its higher mobility and toxicity, and therefore, its ecological impact and risk to health.

The aim of this work consisted on the determination of the fraction of arsenic present as toxic forms (inorganic and methylated species) present in native terrestrial plants from polluted soils by former mining activities (Mónica mine, NW Madrid, Spain), with high total arsenic concentration levels (up to 3,500 μg g^{-1}) [2], due to their higher mobility and the risk associated to their reintegration into other environmental compartments. For this purpose, roots and aboveground parts were analysed separately, to assess possible transformations from translocation processes. Extractions were carried out with deionized water by microwave-assisted extraction, at a temperature of 90 °C and three extraction steps of 7.5 min each. Total extracted arsenic concentrations were determined by ICP-AES, showing extraction percentages from 9 to 39%. Speciation studies were performed by HPLC-(UV)-HG-AFS [3], and they showed the main presence of As(V) (up to 350 μg g^{-1}), followed by As(III), in both plant parts. Monomethylarsonic acid (MMA) and trimethylarsine oxide (TMAO) were also found only in some plants. On the other hand, the use of 0.5 mol L^{-1} acetic acid as extractant led to higher extraction percentages (33-87%), but lower column recoveries, probably due to the extraction of arsenic compounds different to toxic free ions studied, which may come from biotransformation mechanisms carried out by plants to reduce arsenic toxicity. However, As(V) concentrations increased up to 800 μg g^{-1} in acid medium, indicating the probable release of As(V) from organoarsenic compounds and therefore a higher potential risk for the environment [4].

From the easily soluble, water-extractable arsenic species concentration levels, it can be drawn that between 70 and 89% of the total arsenic in plants must have been biotransformed, so it is present under the form of different arsenic compounds. Some of these compounds are likely to be extracted with acetic acid, which seems to induce the release of As(V) from organoarsenic compounds, showing a higher potential risk for the environment. This high level of biotransformation of most part of arsenic could explain the survival capacity of the plant species studied, despite their high total arsenic concentrations. Still, elevated arsenic concentration levels remain as toxic forms, predominantly as arsenate, reaching up to 190 μg g^{-1} considering roots and aboveground parts separately, and 350 μg g^{-1} considering the sum of both plant parts (more than double in acid medium), which may constitute an environmental risk due to its possible reintegration to the environment. Therefore, the study and control of native plants growing in arsenic polluted soils is a relevant factor for environmental safe.

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