Metals in Contact with Tree-Root Surfaces: Investigations of the Rhizosphere Using X-ray Fluorescence

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Introduction

The soil in immediate contact with plant roots, the rhizosphere, is the medium from which metals entering plant tissue are generally transported. The region is extremely complex and is dominated by plant extrudates and symbiotic bacteria. Not surprisingly, it is poorly understood. The object of this study was to establish the feasibility of using micro-x-ray fluorescence (XRF) to map the metal distribution in the rhizosphere of aspen roots collected near a copper smelter in Northern Quebec, Canada.

Methods

Dr. Francois Couchesne supplied aspen roots with intact soil clinging to the root surface. The samples were fixed in 4% paraformaldehyde at room temperature for 2 h, then rinsed in distilled water. Following dehydration in a graded acetone series, samples were infiltrated overnight in a 1:1 mixture of Spur's (hard) and acetone, then infiltrated in pure Spur's for 72 h. After the samples were transfered to fresh Spur's, they were placed at 55º C for 24 h to polymerize the resin. Embedded root tissue was randomly chosen and hand sectioned to 20-50 microns using a razor blade, providing a root cross section approximately 1 mm across with the rhizosphere largely intact.

X-ray fluorescence intensity maps were taken at beamline 20-ID-B (PNC-CAT) of the Advanced Photon Source (APS), located at Argonne National Laboratory. A pair of Kirkpatrick-Baez mirrors were used to focus the x-rays to a spot size of 1.5 microns at the sample. A 13-element Ge detector was used to monitor the emitted fluorescence x-ray intensities for Ca (Kβ), Fe (Kα), Cu (Kα) and Mn (Kα). A step size of 3 microns was used, the total image size was 140 x 300 microns. The incident photon energy was set to 9000 eV.

Results and Discussion

The four intensity maps taken simultaneously are shown in the figures. The center of the root is at the top of each image. The most intense metal intensities all occur in a ring around the root.

Some of the maps show structure within the root itself, Fig 1, 3 and 4 for example. Note, that Mn forms a second ring just under the root surface.

Conclusions

We have successfully used micro-XRF to map the rhizosphere of an aspen root. The maps show that the metals examined (Ca, Fe, Cu, Mn) all concentrate around the surface of the root. More detailed studies are needed to determine the physiological significance of the pictures. Micro-x-ray absorption near edge structure may help determine the chemical nature of the metal deposits seen.

Acknowledgments

The authors wish to thank; Ron Smith (UWO), Steve Heald and Robert Gordon (PNC-CAT) for their technical assistance. This work was supported by a Major Facilities Access grant from NSERC, Canada. Work at APS is also supported by the U.S. DOE under contract # W-31-109-Eng-38. Use of PNC-CAT is supported by the U.S. DOE under contract # DE-FG03-97ER45628.

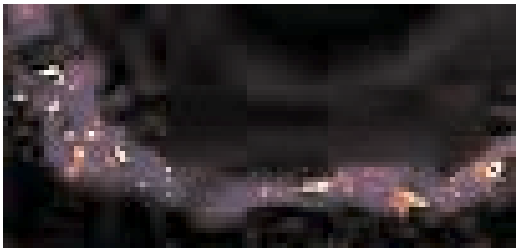

FIG 1. Ca Kβ fluorescence intensity map.

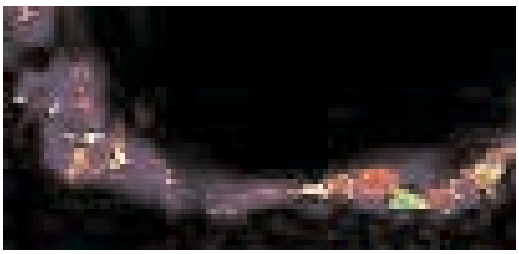

FIG 2. Fe Kα fluorescence intensity map.

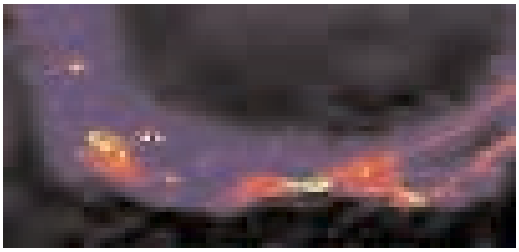

FIG 3. Cu Kα fluorescence intensity map.

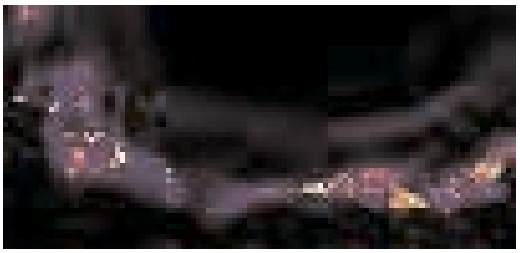

FIG 4. Mn Kα fluorescence intensity map.