Confocal X-Ray fluorescence imaging on cucumber hypocotyls

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Plant phytotoxicity caused by environmental pollutants such as heavy metals (lead, nickel etc.) is of increasing interest in various environmental studies. Different tissues in plants sometimes strongly accumulate certain heavy metals and store these in inactive chemical forms. The roots take up organic and inorganic compounds from the soil and the xylem, phloem sap transports them towards the other parts of the plant body. These compounds may influence essential metabolic processes, however, some plants developed biochemical tolerance mechanisms against phytotoxicity. This may in turn constitute a risk factor for human health when the accumulated toxic elements enter the food chain. A specific motivation related to this general toxicology problem is that the groundwater of Eastern Hungary has a high level of As contamination of local geological origin. This groundwater is generally used in the agriculture for irrigation, although As concentration levels in some cases exceed the level recommended by the European Union for drinking water (10 $\mu g/dm^3$) by three to five times. The uptake of arsenic by different plants can be used as indicators on the bioavailability of arsenic in the soil. The determined concentration levels and the distributions of toxic elements within the internal structure of biological samples having micrometer to mm sizes will contribute to the better understanding on how different plants and biomonitoring species take up and accumulate toxic chemicals.

In order to study this type of bio-accumulation effects the (quantitative) distributions of elements within cucumber roots and hypocotyls were determined by confocal micro-XRF imaging at HASYLAB Beamline L. The hypocotyls of cucumber samples were lyophilized before the measurements, which procedure provided a stable form of the samples throughout the entire measurement.

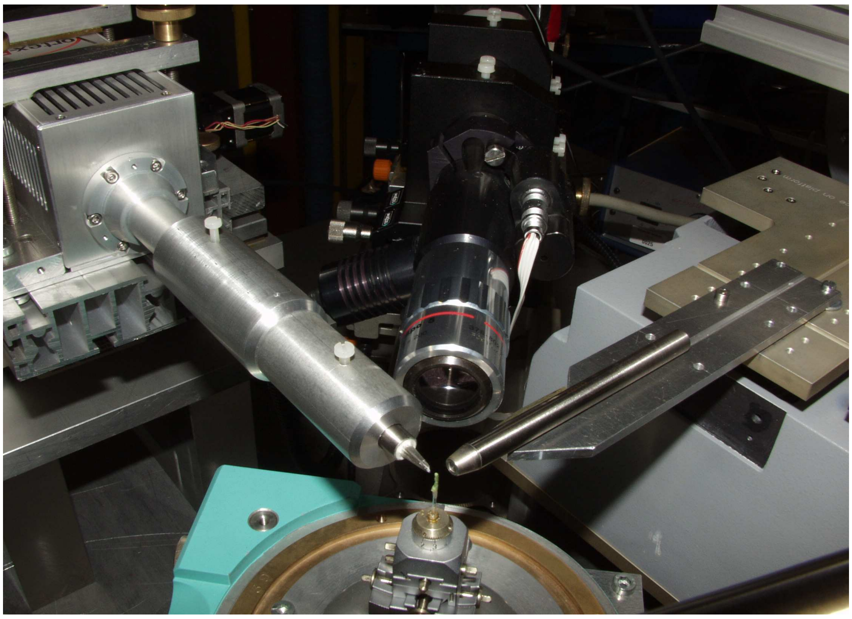

Figure 1: Experimental set-up used for the confocal micro-XRF measurements on cucumber hypocotyls.

In-vivo measurements of the samples resulted in a serious degradation of the irradiated tissues, indicating the need to use cryogenic conditions. In order to provide a suitable positioning of the sample the hypocotyls were mounted on a glass capillary that was fixed on a 5-axis goniometer head (see Figure 1.).

The applied confocal micro-XRF imaging technique is based on the use of two polycapillary lenses for (1) focusing the incoming X-ray beam and (2) for collecting the emerging X-ray fluorescence radiation and guiding this to the detector [1,2]. The confocal micro-XRF provides an elegant possibility of determining the elemental distributions of interest *in-situ* in given virtual cross-sections. Other advantage of the technique is that the measurement does not require sample rotation.

The measurements were performed in continuous scanning mode, reducing considerably the total measuring time required. The size of the X-ray microbeam was determined to be approximately 20 µm, having an energy of 23.5 keV.

A typical result for As analysis is shown in Figure 2., showing the optical image (a) and illustrating the As distribution in a given cross section in hypocotyls (b). The figure illustrates that most of the arsenic is concentrated in the phloem and xylem channels and along the outer skin of the sample with a notable similarity between optical and confocal XRF images.

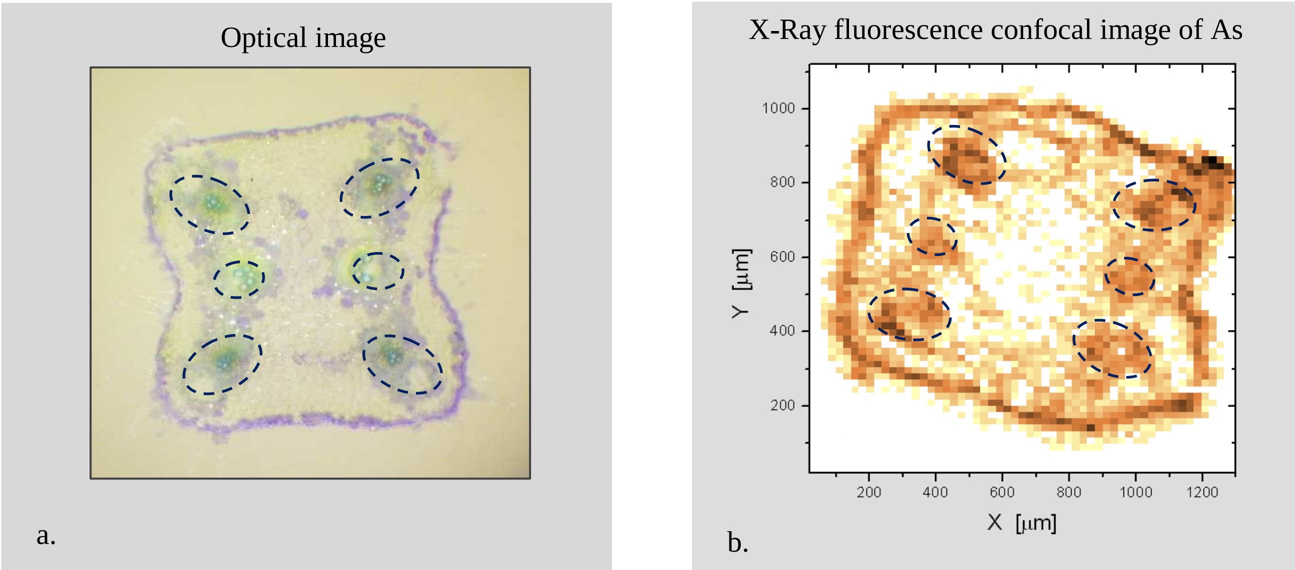

Figure 2: Comparison of optical image (a) and As X-ray fluorescence distribution (b) from a given cross section of cucumber hypocotyls.

References

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