

Micro-PIXE study of *Phyllanthus balgooyi*, nickel hyperaccumulating tree from Sabah (Malaysia)

Antony VAN DER ENT¹, Jolanta MESJASZ-PRZYBYLOWICZ², Wojciech PRZYBYLOWICZ², Alban BARNABAS²

¹ *Université de Lorraine, Nancy, France*

² *iThemba LABS, National Research Foundation, South Africa*

a.vanderent@uq.edu.au

One of the over twenty Ni hyperaccumulator plant species known in Sabah (Malaysia) on the island of Borneo is the tree *Phyllanthus balgooyi* (Phyllanthaceae). This species is remarkable because it attains over 16% of Ni in its phloem sap, the second highest concentration of Ni in any living material in the world (after *Pycnandra acuminata*, Sapotaceae from New Caledonia with 25% Ni in latex). This study focuses on the tissue-level distribution of Ni and other elements in leaves and stems of *P. balgooyi*. Micro-PIXE quantitative elemental mapping of leaves and stems of these species was performed using the nuclear microprobe at the Materials Research Department, iThemba LABS (South Africa). Data were collected in list-mode and processed using GeoPIXE-II software. The results show that in stem sections of *P. balgooyi* Ni is very high in the major vascular bundles, whereas Ca is high in cortex and collenchyma, but low in the vascular bundles. In the leaves Ni preferentially accumulates in the abaxial epidermis extending into the spongy mesophyll, and is also extremely high in the central vascular bundles. Co co-locates with Ni in the leaves, but Mn shows an opposite distribution pattern whereas S or P are present in concentrations orders of magnitude lower than Ni, and hence not implicated in local Ni speciation. Preferential accumulation of Ni in vascular tracts suggests that Ni is present in metabolically active (water-soluble) form. The elemental distribution of *P. balgooyi* contrasts with many other Ni hyperaccumulators from around the world where Ni is preferentially accumulated in (adaxial) leaf epidermal cells. Nevertheless, in *P. balgooyi* Ni is spatially separated from the photosynthetically active palisade mesophyll-layer of the leaf and does not block light from reaching the chloroplasts.

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