# UNIVERSITI TEKNOLOGI MARA

# ASSESSMENT OF NATIVE POTENTIAL HYPERACCUMULATOR AND THEIR RELATIONSHIP WITH MACRONUTRIENTS AND TRACE ELEMENTS IN SABAH

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# ABSTRACT

Hypernickelophores is a unique group of plants that may accumulate above 10,000 mg $kg^{-1}$ of nickel (Ni) in their aboveground tissues. These plants are being used for Metal Farming (MF), a sustainable metal recovery method in tropical ultramafic environments. Their ability to absorb and translocate Ni may be affected by macronutrients and trace elements (Ca, K, Na, Mn, Co) and environmental conditions including soil pH. However, their nutrient–metal interactions are poorly known, especially in Malaysia. Due to limited fundamental research, Ni distribution, elemental behaviour and cellular localisation information in potential hypernickelophores in Sabah is not much known. The aim of this study is to suggest a Ni hypernickelophore that can accumulate Ni up to 10,000 mg $kg^{-1}$ in its aboveground tissue as tropical metal crop candidate for (MF) through evaluation of macronutrients and trace elements such as sodium (Na), calcium (Ca), potassium (K), nickel (Ni), cobalt (Co) and manganese (Mn) in identified hyperaccumulators by using Atomic Absorption Spectrophotometer (AAS). All samples for AAS analysis were digested using wet acid digestion method. Then, determination of Ni at cellular level of a selected hypernickelophore using SEM-EDX was carried out on flash frozen fresh samples. The correlation analysis was performed by using Statistical Package for Social Sciences (SPSS). Translocation factor (TF) and Bioaccumulation Factor (BAF) of Ni was also determined. 8 species of identified hyperaccumulating plants (*Psychotria sarmentosa, Glochidion* sp. 'bambangan', *Rinorea, bengalensis, Rinorea javanica, Actephila alanbakeri, Walsura pinnata, Xylosma luzonensis* and *Mischocarpus sundaicus*) were collected from serpentinite area in Kinabalu Park Reserved Forests for this study. 4 hypernickelophores were found in this study which are *G.* sp. '*bambangan', R. bengalensis, R. javanica* and *P. sarmentosa* with uptake of Ni as much as 10 784 mg.$kg^{-1}$ (TF = 40, BAF = 10.20), 13 196 mg.$kg^{-1}$ (TF = 17, BAF = 8.04), 13 780 mg.$kg^{-1}$ (TF = 3, BAF = 13.75) and 17 085 mg.$kg^{-1}$ (TF = 7, BAF = 8.37) mg $kg^{-1}$, respectively. *G.* sp. 'bambangan' was chosen to be further studied by analysing the content of Ni at the cellular level by using SEM-EDX as the other hypernickelophore identified in this study have been studied up to the cellular level. Nickel was found in the leaf, stem and leaf with Ni content of 6400 mg.$kg^{-1}$, 2200 mg.$kg^{-1}$ and 1900 mg.$kg^{-1}$, respectively. The correlation between Ni and Mn, Ni and K, Ni and Co as well as Ni and Na is not statistically significant. In contrast, the correlation between Ni and Ca as well as pH of soil and Ni concentration are statistically significant with p value less than 0.05. These findings suggest that nutrient interaction and soil pH are crucial in regulating Ni absorption in hypernickelophores. Knowledge of these interactions provides important knowledge for improving agronomic conditions including nutrient enrichment and pH regulation, enabling the cultivation and utilisation of hypernickelophores as potential Metal Crops in Metal Farming specifically in Sabah.

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# INTRODUCTION

## 1.1 Research Background

Research in plant that possess the ability to accumulate extraordinarily high concentrations of trace elements in their living biomass has gained attention worldwide. It involves unique plants that grow in their habitat without suffering any phytotoxic effects which are known as hyperaccumulators. The term was introduced in 1976 when the French research group found *Sebertia acuminata* which can accumulate up to 25.74% Ni on a dry weight basis in its latex. *S. acuminata* which is the fourth Ni hyperaccumulator discovered globally after *Hybanthus austrocaledonicus, Homalium guillainii* and *Psychotria douarrei* were found at the same location, Riviere Bleue in Quebec with concentration of Ni 5.52 % in trunk bark, 0.69 % in leaves and 1.38 % in leaves, respectively.

According to Jaffré et al. (1976), a plant must accumulate more than 1000 $mg.kg^{-1}$ of Ni in any of its aboveground tissue in order to be classified as Ni hyperaccumulator. In addition, a Ni hyperaccumulator that can accumulate more than 10,000 mg.kg of Ni in its aboveground tissues is known as hypernickelophore (Jaffré & Schmid, 1974). According to Reeves et al. (2017), there are around 700 species of hyperaccumulators worldwide where Ni hyperaccumulating plants composed 70% of it. However, the percentage of Ni hypernickelophore plants formed only 10% which is less than 100 species around the world (Nkrumah et al., 2018). Subsequently, the term hyperaccumulator was more precisely defined by Brooks and Wither (1977) to describe plants that possess Ni concentrations greater than 1000 mg $kg^{-1}$ in their dried leaf tissues. This definition was initially applied to Ni accumulators but was later extended by Baker and Brooks (1989) as well as van der Ent et al. (2013) to include plants that accumulate various other metals such as Mn, Co, Cu and Zn. Each metal has its own specific concentration thresholds for classification as a hyperaccumulator, reflecting the diverse capabilities of plants to accumulate different elements.

Although these plants thrive in Ni-rich environments, the biochemical and physiological consequences of Ni buildup require further investigation. Accumulation