Accumulation & Translocation of Heavy Metals in *Avicennia marina* at Mai Po

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Abstract

Mai Po Reserve is a Ramsar site in Hong Kong, with its mangrove habitat influenced by polluted waters of the Deep Bay. Despite its ecological and environmental significance, there is a paucity of recent research on the level of heavy metal pollution in Mai Po and the mechanisms of how local mangroves tolerate the pollution. Understanding how mangroves at Mai Po interact with heavy metals allows for understanding their role in affecting the fate of pollutants, which facilitates better conservation of the mangrove habitat and its related ecosystem functions. This study investigated the level of bioaccumulation and translocation of a variety of essential and non-essential in *Avicennia marina* trees at Mai Po.

Introduction

- Potential toxicity of heavy metals in mangroves
- No recent data for extent of heavy metal pollution at Mai Po (important mangrove ecosystem), despite pollution from Deep Bay[1;2].
- *A.marina* – primary mangrove in Hong Kong: reported as relatively tolerant species, but extent of accumulation & translocation depends on type of element (non-essential VS essential)
- Aim: updated investigation of how *A.marina* at Mai Po is responding to the heavy metal pollution

Methods & Materials

The overall methodology is largely based on Butler[3] and Wolswijk[4].

- **Field Sampling & Sample Sizes**: At each of the three stations (Figure 1), young and mature leaves (5 leaves per replicate) and 6 surface bark pieces were sampled from 10 trees. The main roots (mainly pneumatophores) and fine nutritive roots (with fine hairs) were dug up and cut from six trees. **Laboratory Processing:** The samples were rinsed in MiliQ water, freeze-dried for 48hrs and then manually homogenized using ceramic mortar and pestle. Samples then underwent microwave digestion and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analysis.
- **Data Interpretation:** Element concentrations (µg g^{-1} dry sample weight) were used to derive bioaccumulation factors (BAF) and translocation factors (TF) for each plant part.

$$\text{BAF} = \frac{\text{Element concentration in plant tissue}}{\text{Element concentration in sediment}}$$

$$\text{TF} = \frac{\text{Element concentration in above-ground plant tissue}}{\text{Element concentration in fine or main roots}}$$

Figure 1: Sampling stations within Mai Po Reserve; from Google Earth. Sampling took place at three areas ("stations") at Mai Po, which were: 22°29'42"N 114°01'48"E (Station A), 22°29'40"N 114°01'43"E (Station B), and 22°29'54"N 114°01'42"E (Station C), as shown in Figure 1.

Results

- BCF > 1: Only in fine roots (Cd = 7.6; Cu = 2.5; As = 2.1). Mn BCF = 1.0.
- TF > 1: None for fine roots; for main roots: Mn has highest values on the overall (young leaves = 1.0; mature leaves = 3.1; bark = 1.2), followed by Ni (young leaves = 1.1; mature leaves = 1.2; bark = 1.1). Cu (young leaves = 1.0; mature leaves = 0.9; bark = 2.3).

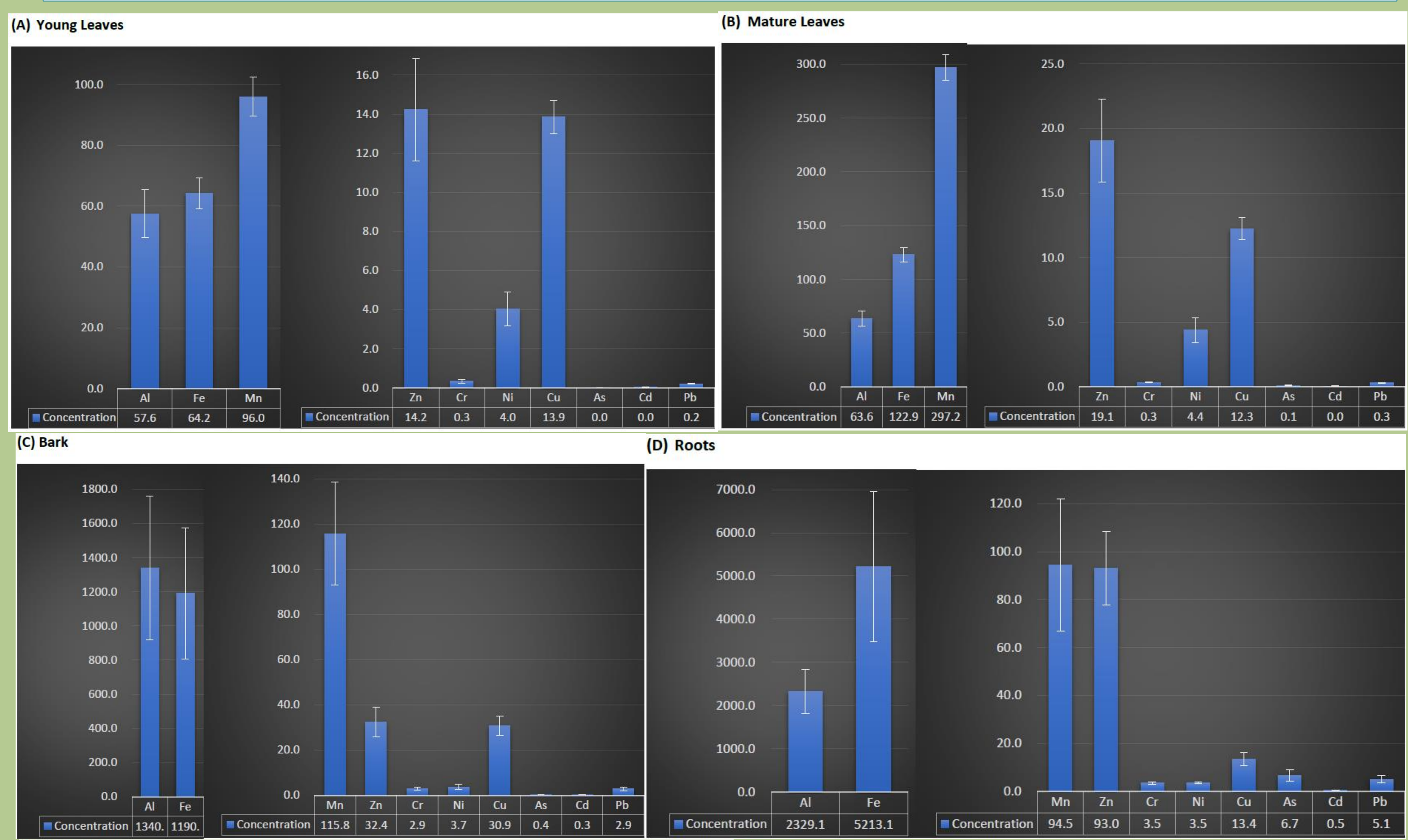

Figure 2: Concentrations of elements in (A) young leaves; (B) mature leaves; (C) bark ; (D) roots; (E) fine roots
(unit = µg / g dry weight of respective tissue)

Table 1: Bioaccumulation Factor (BCF) & Translocation Factor (TF) of Tested Elements in *A.marina* Tissues

		Al	Cr	Mn	Fe	Ni	Cu	Zn	As	Cd	Pb
BAF	Young leaves	0.0006	0.0	0.1	0.0	0.1	0.2	0.03	0.0002	0.05	0.0
	Mature Leaves	0.0006	0.0	0.4	0.0	0.1	0.2	0.04	0.0	0.05	0.0
	Bark	0.01	0.03	0.2	0.03	0.1	0.6	0.06	0.02	0.3	0.07
	Root	0.02	0.04	0.1	0.1	0.1	0.2	0.2	0.3	0.6	0.1
	Fine Root	0.04	0.09	**1.0**	0.6	0.3	**2.5**	0.9	**2.1**	**7.6**	0.6
TF Fine Roots	Young Leaves	0.01	0.04	0.1	0.0	0.4	0.10	0.03	0.0001	0.0	0.0
	Mature Leaves	0.02	0.04	0.4	0.0	0.4	0.09	0.04	0.0	0.0	0.01
	Bark	0.3	0.4	0.2	0.05	0.4	0.2	0.07	0.0	0.04	0.1
TF Main Roots	Young Leaves	0.02	0.1	**1.0**	0.01	**1.1**	**1.0**	0.2	0.0005	0.08	0.0
	Mature Leaves	0.03	0.1	**3.1**	0.02	**1.2**	0.9	0.2	0.01	0.1	0.06
	Bark	0.6	0.8	**1.2**	0.2	**1.1**	**2.3**	0.3	0.05	0.6	0.6

Discussion & Conclusions

- *A.marina* excluded non-essential elements (Cr, As, Cd, Pb) by accumulation in the root zone and showed higher translocation for essential elements (Al, Mn, Fe, Ni, Cu, Zn).
- Strong accumulation processes in fine nutritive roots of *A.marina* → roots of *A.marina* can effectively exclude non-essential elements from entering the translocation system.
- Possible mechanisms:
  - Root epidermis & endodermal Casparian strips acting as barriers to prevent (non-essential) metals from moving into the stele for further translocation[5].
  - Gas exchange (in pneumatophores) → formation of iron plaques on root surfaces → accumulation of (trace) metals in the root zone[2;6-8].

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