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Heavy Metals Phytoremediation Potential of *Hevea brasiliensis* in Bentong, Malaysia

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Abstract. Biomonitoring uses living organisms to assess environmental quality and being preferred over conventional methods that use fully or semi-automatic gauges for its lower cost and practicality. Recently, higher plants are widely used for biomonitoring purposes by means of their species identification simplicity, larger availability of biological substantial, and easy to sample. In this study, samples of *Hevea brasiliensis* (i.e leaves, barks, and latex as well as surrounding soils) from outskirts of Pelangai, Bentong were tested for heavy metals by using inductively coupled plasma optical emission spectroscopy (ICP-OES). Enrichment factor of soils indicated that some metals (B, Ca, Cu, Mn, Pb, Zn, As and Na) were anthropogenic which most likely originated from traffic emissions. In addition, leaves trapped the most heavy metals compared to barks and latex. The accumulation of pollutants in those samples has identified biomonitoring abilities of *Hevea brasiliensis.*

Keywords: *Heavy metals, phytoremediation, ICP-OES, pollutants, Hevea brasiliensis*

INTRODUCTION

The introduction of organic and inorganic pollutants into the atmosphere possesses harmful threats to human health such as allergies, diseases, and death [1]. Direct emissions of particulate matter from road vehicles and heavy metals from various industrial activities have polluted the air significantly [2-3]

Pollutants may enter vegetation through root system or aerial parts [4-5]. Buildup of contaminants in plants, integration over time of the elemental input, and easy sampling over large areas have given brilliant insights for biomonitoring [6]. Recently, higher plants are widely used for biomonitoring purposes by means of their species identification simplicity, larger availability of biological substantial, and easy sampling technique [6-7].

Routes of environmental chemicals to foliage are associated with atmospheric particulates matter, direct pesticides, and surrounding vapor. Hydrophobic chemicals are likely deposited on leaves and bounded on the cuticle while high water solubility chemicals are being diffused into the plant through stomata [4].

Meanwhile, tree barks are useful as a passive medium to sample the quality of air at certain vicinity [8]. They have been used to measure the concentrations of organic and inorganic compounds as well as deciding the pollution source [9]. The structural porosity of tree bark is efficient to accumulate and retain heavy metals [10]. It can accumulate larger particles and retain them for a longer time (more than 10 years) [11]. Tree barks act as lipophilic absorbent for organic compounds as well as recording atmospheric vapor phase [12].

Laticiferous tissue that produces latex in *Hevea brasiliensis* can be found in all parts of the tree; roots to the leaves [13]. Latex, as the cytoplasm of laticiferous cells, has similar organomineral compositions as of ordinary plant cytoplasm except that it contains 30-45% rubber in the form of polyisoprene. A lot of studies have been conducted on the anatomical, cytological, physiological and biochemical aspects of latex [14].

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In this research, samples of leaves, tree barks, and latex of *Hevea brasiliensis* were used to monitor the uptake of surrounding trace metals, therefore enhancing its phytoremediation capability.

MATERIALS AND METHOD

Plant Sampling

Kampung Simpang Pelangai of Bentong district, Malaysia (3°11'36.0"N 102°14'48.0"E) has been chosen as sampling site. In this study area, dominant, matured trees of *Hevea brasiliensis* (i.e readily being tapered) were identified and used for tissue analysis and soil collection. Soils were collected at 2 cm from the top of ground using a steel hand shover. Adult leaf samples were cut off with stainless steel scissor while hammer and chisel were used to obtain 5x5 cm^2 of bark portion (not exceeding 2 mm depth). Meanwhile, 50 mL of latex was collected via tapping followed by coagulation with formic acid to get a solid rubber. All samples (soil, leaves, tree barks and latex) were taken to the laboratory and stored in -5 °C freezer before further analysis.

Sample Preparation

All samples were dried in the oven for 24 h at 60 °C. Next, the samples were put into crucible to be dried into the muffle in the furnace at 500 °C for 24 h until they turned into ashes. The ash was put into sterilin bottles and added with 1 ml of concentrated HNO_3 and 20 ml of deionized water. The sterilins were centrifuged at 60 rpm for 15 min. The liquid from each sterilin was emptied into a new sterilin and thus ready for analysis.

Heavy Metals Analysis

Heavy metal concentrations in plant and soil samples were analyzed using inductively coupled plasma optical emission spectroscopy (ICP-OES, VISTA-PRO; Seiko Instruments Inc.) The accuracy and precision of the analytical procedure were verified through analysis of standard reference material. The recovery range was 95-110%. All analyses were done in duplicate.

Data Analysis

The enrichment factor (EF) was calculated to evaluate the derivation source of heavy metal contents. EF is the relative abundance, with respect to aluminium, of one element (M) in soil compared to its relative abundance (M/Al) as a crustal element. The formula used is as follows:

$$Enrichment\ Factor(EF) = \frac{\left(\frac{M}{Al}\right)soil}{\left(\frac{M}{Al}\right)crust} \quad (1)$$

The concentrations of crustal elements were obtained from Wedepohl [15]. Consequently, EF>1 indicates a certain degree of anthropogenic contamination while EF>10 shows a high contamination of metals that leads to polluted air [16].

The biconcentration factor (BCF) is the ratio of metal concentration (C) in tree samples to the extractable metal concentrations in soils. This value reflects the progressive accumulation of metal in respective samples. The calculation is based on the formula:

$$Bioconcentration\ Factor\ (BCF) = \frac{C_{sample}}{C_{soil}} \quad (2)$$

BCF value of more than 1 indicates high capacity of metal absorption from soils to plant tissues [17].

RESULTS AND DISCUSSION

Heavy Metal Contents in Soils

The heavy metal concentrations in soil and their respective EF are reported in Table 1. The highest heavy metal concentration in soil was Fe (5.427 mg/L) while the lowest heavy metal concentration detected was Ni (0.003 mg/L). Based on EF value, Pb, Zn, and Cu were most likely came from anthropogenic sources (traffic emission) [16, 18]. High value of EF for As and Cu (EF>10) denoted the heavy metal pollution of As and Cu in soil. EF values are 4.7 and 5.9 for Pb and Zn respectively implied a moderate contamination of Pb and Zn in soil. Low value of EF for Cr, Fe, Mn, and Ni (EF<1) indicated that they were naturally present in the soil.

TABLE 1. Metal content in the soil with respective enrichment factor (EF)

Metal	Cr	Cu	Fe	Mn	Ni	Pb	Zn	As
Replicate 1 (mg/L)	0.008	0.127	5.427	0.111	0.003	0.041	0.150	0.052
Replicate 2 (mg/L)	0.008	0.128	5.427	0.111	0.002	0.041	0.160	0.052
Mean concentrations (mg/L)	0.008	0.127	5.427	0.111	0.003	0.041	0.160	0.052
EF	0.4	17.2	0.3	0.4	0.3	4.7	5.9	50.5

Phytoremediation Potential of *Hevea brasiliensis*

Table 2 and Table 3 show the heavy metal concentrations in each plant sample and their bioconcentration factor (BCF), respectively. Of all samples, leaves trapped the most heavy metals followed by tree barks and latex. Based on BCF, Mn and Ni were found to be accumulated in high quantities (BCF>1). Though BCF for Pb and As was less than 1, the accumulation of Pb and As in tree barks and leaves signified heavy metals contamination of Pb and As as they had no beneficial effect on any organisms. Pb and As are not essentially needed by the plant nor naturally present in the environment as they are most likely originated from fuel combustion and vehicular emission [19].

TABLE 2. Heavy metals concentrations (mg/L) in plant samples

Metal	Cr	Cu	Fe	Mn	Ni	Pb	Zn	As
Tree barks	0	0.045	0.230	0.592	0	0.013	0.121	0.003
Leaves	0.003	0.072	0.515	2.856	0.009	0.010	0.142	0.001
Latex	0	0.108	0.152	0.089	0	0	0.082	0

TABLE 3. Bioconcentration factor (BCF) of heavy metals for each sample

Metal	Cr	Cu	Fe	Mn	Ni	Pb	Zn	As
Tree barks	0	0.35	0.04	5.33	0	0.32	0.76	0.06
Leaves	0.38	0.57	0.09	25.73	3.00	0.24	0.89	0.02
Latex	0	0.85	0.03	0.80	0	0	0.51	0

CONCLUSION

Heavy metals content in samples of *Hevea brasiliensis* were evaluated for its ability to biomonitor heavy metals pollution from traffic in outskirts of Bentong, Malaysia. The soils were enriched in severe contamination of Cu and As as well as moderate pollution of Pb and Zn. In addition, leaves accumulated the highest amount of heavy metals with Mn to be the most trapped heavy metal. These results suggested the heavy metals phytoremediation potential of *Hevea brasiliensis*. Biomonitoring of heavy metals using *Hevea brasiliensis* may be conducted at two locations with different traffic activity as well as measuring polyaromatic hydrocarbons (PAHs) concentrations that most probably accumulated in tree samples.

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