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RELEASE OF ELEMENTAL MERCURY BY INTACT HAWAIIAN *METROSIDEROS*: FIRST *IN SITU* MEASUREMENTS

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Key Word Index—*Metrosideros*; Myrtaceae; tree; heavy metal; mercury; vapour release; rate of emission.

Abstract—Intact Hawaiian *Metrosideros* trees *in situ* release mercury vapour from their branches at rates as high as 5–6 μg/kg/hr (dry wt). This compares well with the emission of mercury from detached leaves or shoots of woody perennials *Aleurites*, *Leucaena* and *Pandanus*. The emission rates appear to be related to soil mercury content.

INTRODUCTION

Arsenic, selenium, mercury and other toxic or potentially toxic elements are known to undergo transformation by micro-organisms into volatile methyl derivatives [1–5]. The subsequent escape of these alkyls into the open air environment may serve as a detoxification mechanism. Cells of the green alga *Chlorella* convert aqueous mercury into the element [6–8] which, like methyl mercury, is sparingly soluble in water and volatile.

Intact lichens and mosses are also known to release elemental mercury as the vapour [9], but among vascular plants this ability has heretofore been known only for detached leaves or leafy branches under laboratory conditions [10], leaving open the possibility that mercury vapour release is an artefact rather than a natural phenomenon.

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RESULTS

The present report, using the native 'Ōhi'a tree of Hawaii, *Metrosideros collina* var. *polymorpha*, shows that the rates of mercury vapour release from intact branches of plants in the field are comparable with those seen previously in a variety of woody species.

The field measurements summarized here, although limited in number, demonstrate clearly and consistently that 'Ōhi'a trees in the natural state emit elemental mercury at substantial rates: 0.26–5.03 μg/kg/hr (Table 1). The release rates found at the Mauna Loa roadside may

Table 1. Mercury content and mercury release from leaves of *Metrosideros collina* var. *polymorpha* on intact branches *in situ*

Location	Elevation (m)	Branch No.	*Metrosideros* mercury analyses: Soil (μg/kg)	Leaves (μg/kg)	Rate of release (μg/kg/hr)
Honolulu*					
Lyon Aboretum	170	1	272 ± 29	95 ± 2	1.20 (354)†
		2	n.d.	69 ± 2	3.73 (156)
		3	458 ± 0	58 ± 4	0.83 (161)
		4	n.d.	59 ± 4	1.25 (100)
Hawaii Volcanoes National Park					
Mauna Loa Strip Road‡	1800	1	41 ± 3	31 ± 9	0.29 (278)
		2	43 ± 2	46 ± 4	0.26 (270)
Puhimau Thermal Dieback Area	1300	1	670 ± 2620	491 ± 201	3.17 (60)
		2	546 ± 190	439 ± 200	1.16 (80)
		3	3701 ± 1600	369 ± 269	5.63 (80)
		4	7450 ± 1305	330 ± 229	4.43 (75)

*Young trees, *ca* 2 m tall.
†Leaves on the branch.
‡Older trees, 15–16 m tall, 10 and 15 cm diameter at breast height.
§12–18 cm shoots on old stumps.
n.d., Not determined.

Table 2. Mercury content and mercury release from detached leaves of *Metrosideros* and other woody plants

Species	Collection site	Mercury analysis		
		Soil (μg/kg)	Leaves (μg/kg)	Rate of release (μg/kg/hr)
Aleurites moluccana	Foster Garden, Honolulu	68 ± 10	54 ± 7	0.68 ± 0.07
Leucaena leucocephala	Manoa Valley, Honolulu	116 ± 16	68 ± 8	3.05 ± 0.30
Metrosideros collina	Kilauea East Rift, Hawaii	105 ± 14	147 ± 21	1.76 ± 0.21
Pandanus odoratissimus	Foster Garden, Honolulu	122 ± 16	46 ± 5	1.59 ± 0.39
Persea americana	Manoa Valley, Honolulu	101 ± 21	133 ± 18	4.13 ± 0.22
Rhizophora mangle	Kailua, Oahu	n.d.	78 ± 8	1.61 ± 0.28

n.d., Not determined.

reflect not only a low soil mercury concentration, but also a thin substratum insufficient to cover the roots. Otherwise, emission rates of 1–5 μg/kg/hr appear to be associated with soil mercury concentrations of 272–7450 μg/kg, a 25-fold range.

These rates compare well with those previously reported for detached leaves of other woody perennials, for example *Aleurites*, *Leucaena* and *Pandanus* [10], and *Metrosideros* itself (Table 2). If these rates are representative of 'Ōhi'a mercury release, the extensive native forests of Hawaii may be responsible for the transfer of sizeable quantities of mercury from the soil to the atmosphere.

EXPERIMENTAL

In our expts, entire leafy branches were enclosed in 3 l., 20 ml polyethylene bags containing 1 cm × 3 cm strips of gold foil which had been freshly washed in nitric acid. Within the bag, a battery operated pump circulated contained air at 1–2 l./min to ensure mixing. Sampling time was 2–4 hr. Gold strips were rapidly sealed in individual polyethylene containers and subsequently analysed by standard flameless atomic absorption spectrophotometry. The foils were stripped of their mercury in hot HNO_3 for analysis. Leaves, soils and air samples were analysed by standard methods already described [11–13]. Data for soil and leaf mercury content are means of replicates, but the measurements of release rates for individual branches are presented individually (Table 1). Similar considerations apply to detached leaves of *Metrosideros* in the present study except that they were pooled.

At the Honolulu and Mauna Loa sites, air temps. of 24–28° were found around leafy clusters on the branches measured at *ca* 1.5 m above ground. Soil temps. were in the same range. At Puhimau, however, the branches were regenerated shoots on old stumps of an original thermally killed 'Ōhi'a forest. Here, soil temps. reached 63° and the air temps. among the leaves *ca* 30 cm above the soil reached 30–35°. All field measurements were made at midday.

During the sampling and measurement period, 6 December 1985 to 16 January 1986, air mercury levels (Hg^0 by gold foil) ranged from 0.06 to 0.24 μg/m³, quantities too small to constitute a source of error in our closed system release measurements.

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