Evaluation of outer bark and inner bark of *Ginkgo biloba* Linn. as indicators for mercury pollution

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Abstract

The outer bark, inner bark and xylem of *Gingko biloba* Linn. collected in urban, suburban and rural sites, Japan were analyzed for mercury (Hg) by cold vapor atomic adsorption spectrometry. Outer bark showed higher Hg concentration than inner bark at the outermost part and decreased exponentially, showing a minimum Hg concentration at the boundary of the inner and outer bark. Inner bark had higher Hg concentration than the adjacent xylem. This distribution indicated that atmospheric Hg was accumulated by (1) direct deposition to the bark surface and (2) foliar uptake followed by phloem transport in preference to accumulation from soil via roots. So origin of Hg in outer bark may be atmospheric deposition and that of inner bark may be atmospheric elemental Hg (Hg(0)). Both outer and inner barks collected in urban sites showed higher Hg concentrations than the other sites. Hg concentrations in the bark pockets of *G. biloba* trunks were also determined to monitor the change of Hg deposition over time.

Keywords: Outer bark; Inner bark; Deposition; Airborne pollution; Hg

1. Introduction

Tree bark serves as a passive biomonitor of environmental contamination. The analysis of bark enclosed within the tree trunk (bark pocket), especially, can provide information on historical change of pollution (Satake et al., 1996). Tree accumulates environmental pollutants directly from the atmosphere, by deposition on the leaves or bark, or indirectly following deposition on the soil and subsequent root uptake (Lepp, 1975). In particular, atmospheric Hg can be assimilated as Hg(0) through leaf stomata (Lindberg et al., 1992) and may be transported to the tree via the inner bark. The aim of this study was to evaluate Hg concentration in outer bark, inner bark and xylem and compare total Hg concentration of leaves and internal Hg concentration of leaves to show pathway of accumulation, and to show the confidence of monitoring Hg pollution with tree bark.

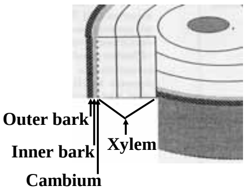

Fig. 1. Diagram of tree trunk (Satake, 1996).

2. Materials and methods

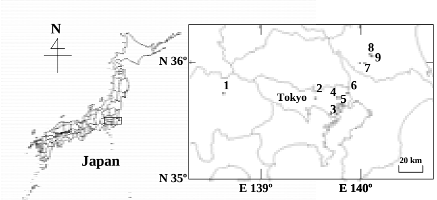

Fig. 2. Sampling locations.

The samples of *Ginkgo biloba* Linn. were collected at urban (St.2, St.3, St.4, St.5 and St.6), suburban (St.8 and St.9) and rural (St.1 and St.7) sites.

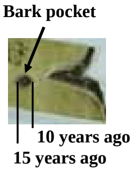

Photo 1. Bark. **Photo 2. Bark pocket.** **Photo 3. Leaf.**

2.1 Radial distribution of Hg concentration in outer bark, inner bark, xylem
Sample: St.1, St.4, St.7, St.8 and St.9
The samples were sub-divided into thin sections of outer bark, inner bark and xylem layer and bark pockets with approximately 2 mm thickness and 15✕15 mm^2 area using a scalpel.

2.2 Comparison of the total concentration and internal concentration of leaves.
Sample: St.7
Total concentration: unwashed leaves
Internal concentration: CH_3Cl-washed leaves

2.3 To show the confidence of monitoring Hg pollution with outer barks.
Sample: St.2, St.3, St.5 and St.6
Outer barks in 5 adjacent trees were removed at each sampling location.

Hg concentration was determined by cold vapor atomic absorption spectrometry.

3. Results and discussion

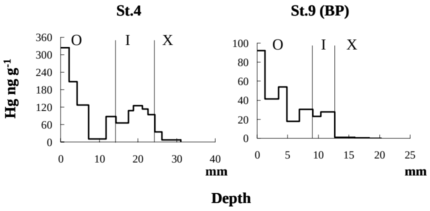

Fig. 3. Radial distribution of Hg concentration in outer bark, inner bark and xylem (O: Outer bark, I: Inner bark, X: Xylem, BP: Bark pocket).

Table 1 Total concentration (unwashed) and internal concentration (CH_3Cl-washed) of Hg in leaves.

Total concentration		Internal concentration	
Sample ID	Hg (ng g^{-1})	Sample ID	Hg (ng g^{-1})
1	95.1	1	53.4
2	79.0	2	62.0
3	86.2	3	50.1
4	61.4	4	64.4
5	81.3	5	74.7
Average	80.6	Average	60.9
STD	12.4	STD	9.7
RSD(%)	15.4	RSD(%)	15.9

76% of Hg distributed in the inside of the leaves and 24% distributed at the outside of the leaves. Translocation of Hg from soil to leaves is usually believed to be negligible (Rea et al., 2002). Inner bark probably contained atmospheric Hg(0) accumulated by the leaves and subsequently translocated.

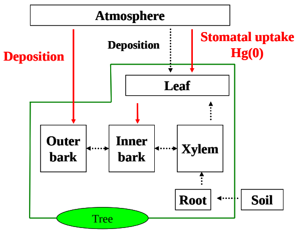

Fig. 4. Hg accumulation of outer bark and inner bark.
† Red lines are main routes.

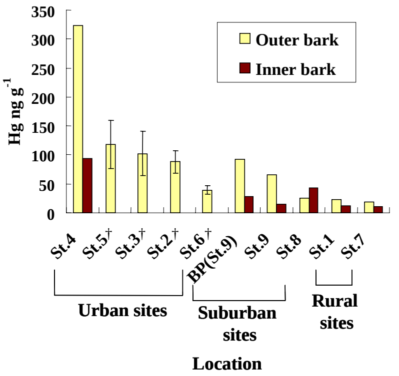

Fig. 5. Hg concentrations (Mean ± S.D.) of outer barks and inner barks (BP: Bark pocket).
† Sample of inner bark was not collected.

4. Conclusions

1. **Both outer bark and inner bark can be indicators for Hg pollution.**
2. **Inner bark probably contained gaseous atmospheric Hg(0) accumulated by the leaves and subsequently translocated.**
3. **Atmospheric Hg was accumulated by deposition to outer bark.**
4. **Bark pocket may be employed as historical monitor of Hg pollution.**

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