

## **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 *Ginkgo biloba* Linn. collected in urban, suburban and rural sites, Japan were analyzed for mercury (Hg) by cold vapor atomic adsorption spectroscopy. Outer bark showed higher Hg concentration than inner bark with 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 mercury 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. Internal concentration of leaves was 76% of total concentration of leaves. Origin of Hg in leaves may be gaseous Hg(0). So origin of Hg in outer bark may be atmospheric deposition and that of inner bark may be gaseous Hg(0). Both outer and inner barks collected in urban sites showed higher Hg concentrations than the samples collected in the other areas, indicating that both barks can serve as indicators of Hg pollution. Hg concentrations in the bark pockets of *G. biloba* trunks were also determined to monitor the change of Hg deposition over time.

**Key words:** Outer bark, Inner bark, Deposition, Airborne pollution, Hg

### **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 gaseous elemental mercury (Hg(0)) through leaf stomata (Hanson et al., 1995) and may be transported to the tree via the phloem.

The aim of this study was to compare 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.

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## Materials and methods

The samples of *Ginkgo biloba* Linn. were collected from 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. (Fig. 1). A section of tree trunk containing a bark pocket collected at St.9 also was formed around 10-15 years ago. The samples at St.1, St.4, St.7, St.8 and St.9 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<sup>2</sup> area using a scalpel. Leaves were collected at St.7. The Hg analyses were on unwashed leaves and on leaves from which the surface waxed (and hence any adhering particles) had been removed by stirring 2 g of leaves in 20 ml of chloroform (CHCl<sub>3</sub>) for 15 seconds. The term “total concentration” is used in the following to refer to the concentration determined on unwashed leaves and “internal concentration” for the concentration determined on CHCl<sub>3</sub>-washed leaves. To show the confidence of monitoring Hg pollution with outer barks, outer barks in 5 adjacent trees were removed at St.2, St.3, St.5 and St.6 and were divided into approximately 2 mm thickness and 15×15 mm<sup>2</sup> area using a scalpel.

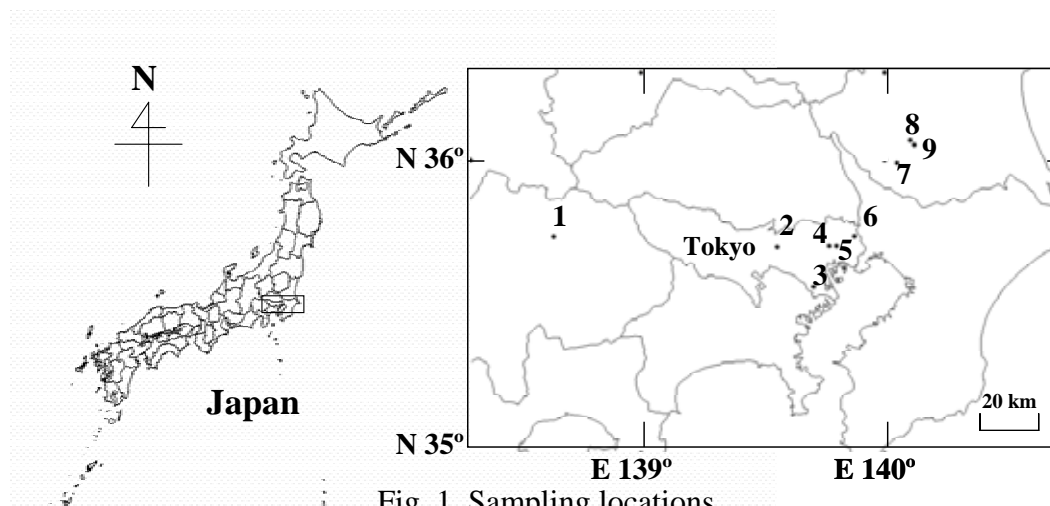


Fig. 1. Sampling locations.

Hg released from the samples (approximately 50 mg) by thermal decomposition was collected by a two-stage gold amalgam process and measured by cold vapor atomic absorption (SP-3D, Nippon Instruments).

## Results and discussion

Fig. 2 shows the radial distribution of Hg concentration in outer bark, inner bark and xylem. The outer bark showed higher concentrations of Hg than those inside. Inner bark had higher Hg concentration than the adjacent xylem. This distribution indicated that Hg was accumulated by (1) direct deposition to the bark surface and (2) foliar uptake followed by phloem transport in preference to accumulation from the soil via the roots. Hg in leaves usually originates from atmospheric deposition (dry and/or wet deposition), stomatal uptake of Hg(0) and translocation (transfer of Hg from soil to leaves through the roots of the tree). Total concentration (unwashed) of leaves and internal concentration (CH<sub>3</sub>Cl washed) of leaves were  $80.6 \pm 12.4 \text{ ng g}^{-1}$  (n=5) and  $60.9 \pm 9.7 \text{ ng g}^{-1}$  (n=5) respectively.

$\text{g}^{-1}$  ( $n=5$ ), respectively. Internal concentration was 76% of total concentration. Translocation of Hg from soil to leaves is usually believed to be negligible (Rea et al., 2002). Origin of Hg in leaves may be gaseous Hg(0). So origin of Hg in outer bark may be atmospheric deposition and that of inner bark may be gaseous Hg(0).

RSD of Hg concentrations in St.3, St.4, St.6 and St.7 were 22.2% ( $87.9 \pm 19.5 \text{ ng g}^{-1}$ ,  $n=5$ ), 37.7% ( $102 \pm 38 \text{ ng g}^{-1}$ ,  $n=5$ ), 35.1% ( $118 \pm 35 \text{ ng g}^{-1}$ ,  $n=5$ ) and 19.1% ( $39.4 \pm 7.5 \text{ ng g}^{-1}$ ,  $n=5$ ), respectively. The cause of the variation may be due to the depth of sampling, the surface texture of bark, stem-flow (funneling of rainwater collected in crown) and so on.

Both outer and inner bark collected in urban areas showed higher Hg concentration than the samples collected in other areas (Fig. 3). There are many municipal waste incinerator in these urban areas. The results were generally consistent with the likely magnitude and sources of airborne Hg pollution,

indicating that both barks can serve as indicators of Hg pollution.

## Conclusions

This study showed origin of Hg in outer bark was atmospheric deposition. Inner bark probably contained gaseous atmospheric Hg(0) accumulated by the leaves and subsequently translocated. Both outer and inner bark collected in urban areas showed higher Hg concentration than other the samples collected in other areas, indicating that

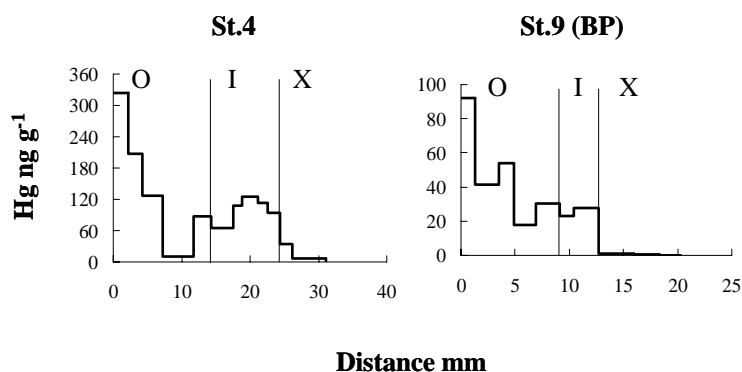


Fig. 2. Radial distribution of Hg concentration in outer bark, inner bark and xylem (O: Outer bark, I: Inner bark, X: Xylem, BP: Bark pocket).

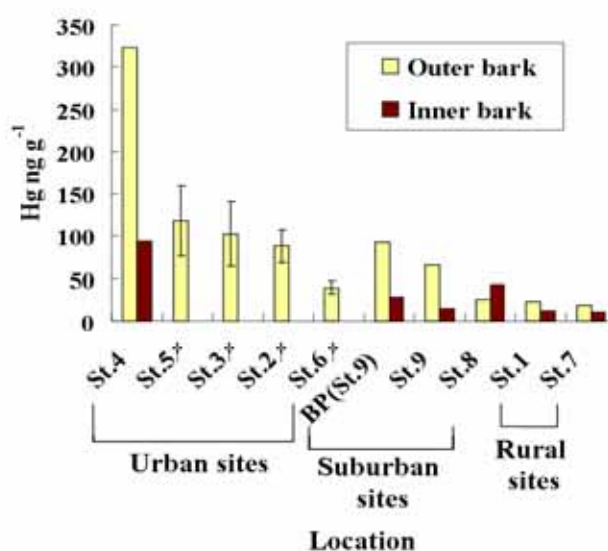


Fig. 3. Hg concentrations (Mean  $\pm$  S.D.) of outer barks and inner barks.

<sup>†</sup>: No sample of inner bark

both barks can be indicators of Hg pollution. Hg concentration was also determined in the bark pockets of *G. biloba* trunks to monitor the change of Hg pollution over time.

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