

Mercury deposition through litterfall in an Atlantic Forest at Ilha Grande, Southeast Brazil

Emmanuel V. Silva-Filho^{a,*}, Wilson Machado^a, Rogério R. Oliveira^b,
Silvia M. Sella^c, Luiz D. Lacerda^a

^a *Depto de Geoquímica, Universidade Federal Fluminense, Niterói, RJ 24020-007, Brazil*

^b *Depto de Geografia, Pontifícia Universidade Católica do Rio de Janeiro, RJ 22453-900, Brazil*

^c *Depto de Química Analítica, Universidade Federal Fluminense, Niterói, RJ 24020-007, Brazil*

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Abstract

Atmospheric Hg transfer to the forest soil through litterfall was investigated in a primary rainforest at Ilha Grande (Southeast Brazil) from January to December 1997. Litter mass deposition reached $10.0 \text{ t ha}^{-1} \text{ y}^{-1}$, with leaves composing 50–84% of the total litter mass. Concentrations of Hg in the total fallen litter varied from 20 to 244 ng g^{-1} , with higher concentrations during the dry season, between June and August ($225 \pm 17 \text{ ng g}^{-1}$), and lower concentrations during the rainy season ($99 \pm 54 \text{ ng g}^{-1}$). This seasonal variability was reflected in the Hg flux through litterfall, which corresponded to a Hg input to the forest floor of $122 \mu\text{g m}^{-2} \text{ y}^{-1}$, with average Hg deposition of $16.5 \pm 1.5 \mu\text{g m}^{-2} \text{ month}^{-1}$ during and just after the dry season (June–September) and $7.0 \pm 3.6 \mu\text{g m}^{-2} \text{ month}^{-1}$ in the rest of the year. The variability in meteorological conditions (determining atmospheric Hg availability to foliar scavenging) may explain the pulsed pattern of Hg deposition, since litterfall temporal variability was generally unrelated with such deposition, except by a peak in litterfall production in September. Comparisons with regional data on Hg atmospheric deposition show that litterfall promotes Hg deposition at Ilha Grande two to three orders of magnitude higher than open rainfall deposition in non-industrialized areas and approximately two times higher than open rainfall deposition in industrialized areas in Rio de Janeiro State. The observed input suggests that atmospheric Hg transfer through litterfall may explain a larger fraction of the total Hg input to forest soils in Southeast Brazil than those recorded at higher latitudes.

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1. Introduction

Among the trace metal contaminants of greater environmental interest, mercury (Hg) has received an increasing attention in atmospheric, aquatic and terrestrial environmental studies, since it is recognized as a highly toxic, globally distributed pollutant, which may accumulate in organisms, including humans (Mason et al., 1994; Morel et al., 1998; Grigal, 2002). In spite of Hg being a rare element

in the terrestrial crust, it shows high vapor pressure and high residence time in the atmosphere, implying in an atmospheric transport of both natural and anthropogenic derived Hg far away from emission sources (Mason et al., 1994).

Many studies dealing with the main pathways of Hg deposition in forested ecosystems (i.e., wet and dry open atmospheric deposition, throughfall and litterfall), suggest that interactions between atmospheric Hg and the forest canopy may be a key process influencing Hg input to forested watersheds (e.g., St. Louis et al., 2001; Hintelmann et al., 2002; Rea et al., 2002). Some of these studies suggest that the role of litterfall in transferring atmospheric Hg to soils may be particularly important in temperate areas.

* Corresponding author. Tel.: +55 212 6292205.

E-mail address: geoemma@vm.uff.br (E.V. Silva-Filho).

Notwithstanding the scarcity of data from tropical regions, which makes comparisons difficult, it may be expected that Hg deposition through litterfall in tropical forests be greater than the observed results from temperate and boreal areas, where deciduous vegetation is frequently dominant, since there are evidences that Hg accumulates with increasing foliar age (Guentzel et al., 1998; Fleck et al., 1999; Rea et al., 2002) and canopies of tropical forests tend to be more efficient filters of atmospheric Hg than temperate forests canopies (Jordan et al., 1980; Kolka et al., 1999). While a review of twenty-one literature studies on Hg deposition through litterfall from temperate and boreal forests indicated an average deposition of $21 \mu\text{g m}^{-2} \text{y}^{-1}$ (Grigal, 2002), preliminary studies reported for tropical forests indicated Hg annual deposition through litterfall of $30\text{--}34 \mu\text{g m}^{-2} \text{y}^{-1}$ extrapolated from a six-month period at urban and rural areas in Southeast Brazil (Fostier et al., 2003). Mélières et al. (2003) using average litterfall production and average Hg content in forest canopy leaves estimated $45 \pm 10 \mu\text{g m}^{-2} \text{y}^{-1}$ as the annual transfer of Hg to the forest soil through litterfall in French Guiana remote areas.

In Brazil, most research efforts have been conducted to understand Hg cycling in the Amazon region, mainly due to concerns with gold mining and deforestation (e.g., Lacerda, 1995; Cordeiro et al., 2002; Wasserman et al., 2003; Almeida et al., 2005). On the other hand, information on other ecologically important biomes, is scarce, such as the 'Mata Atlântica' (Atlantic Forest) (e.g., Fostier et al., 2003), which originally covered about one million square kilometers ($\sim 12\%$ of country area; de Oliveira-Filho and Fontes, 2000), but has become one of the most important examples of radical destruction of tropical forests ever witnessed (de Carvalho et al., 2004).

This study presents data on Hg deposition through litterfall in an Atlantic rainforest within a law-protected reserve at Ilha Grande Island, located at Southeastern Brazilian coast. This region has witnessed intense land use changes during the past century, conversing forested areas for urban, agricultural and industrial development, which resulted in atmospheric trace metal contamination, including Hg (Marins et al., 1996; Silva-Filho et al., 1998a; Lacerda et al., 2002; Lacerda and Ribeiro, 2004).

In order to contribute to our knowledge on the Hg cycling in tropical forests, where the role of litterfall is suspected to be critical, the Hg transfer from the atmosphere to the forest floor was investigated in a stand where the structure and composition of vegetation are known, in which the seasonal pattern of Hg input through litterfall was evaluated.

2. Location and methods

The study area was established in the Atlantic Forest located at Ilha Grande, a 190 km^2 island in the Brazilian Southeastern coast (Fig. 1), 150 km far away from Rio de Janeiro city. In spite of been considered a pristine area without pollutant point sources (De Paula and Mozeto,

2001), this island receives contaminants via atmospheric deposition from two of the most urbanized and industrialized centers of Brazil, São Paulo and Rio de Janeiro (e.g., Kjerfve et al., 1997; Molisani et al., 2004). This anthropogenic input is reflected in concentration profiles of sediment cores, as recorded for zinc and cadmium in the southeastern side of the island (Silva-Filho et al., 1998b).

Ilha Grande bedrock is pre-Cambrian, with high to medium metamorphic rocks (migmatites, gneisses and charnockites), and basic intrusives represented by diabase, basalt and gabbro dikes (De Paula and Mozeto, 2001). Regional climate is tropical, hot and wet, with a mean annual temperature close to 23°C . Regional rainfall data were obtained from Departamento Nacional de Meteorologia (DENEMET) for the 1915–1988 period, indicating that a relatively intense rainfall occurs through the year. A lower average rainfall is recorded between June and August ($83.6\text{--}92.8 \text{ mm month}^{-1}$) and a higher average rainfall is recorded between December and March ($258.8\text{--}278.8 \text{ mm month}^{-1}$). During sampling period the driest month was June (11 mm) and the wettest was March (388 mm). The total annual rainfall (2400 mm) was slightly higher than that from mean historic period. Rainfall temporal variability in the Ilha Grande area may be affected by sharp polar cold fronts, which predominantly occurs in June through August (Kjerfve et al., 1997), and intense orographic rains, apart from the cold fronts (Lacerda et al., 2002).

The sampling station (located 280 m above m.s.l., with a slope of about 25°) is a primary forest stand, on which litterfall was collected from January to December 1997. Such stand presented 134 tree species from 41 families, with an average height of 11 m , average DBH of 12.2 cm and basal area of $58 \text{ m}^2 \text{ ha}^{-1}$ (Oliveira, 2002). Ten species dominated forest composition (*Rustia formosa*, *Mabea brasiliensis*, *Calyptanthes lucida*, *Vochysia bifalcata*, *Pradosia culmanii*, *Faramea pachyantha* var. *mandiocana*, *Eclinusia ramiflora*, *Heisteria silvianii*, *Psychotria nuda* and an unidentified species), accounting for 32.4% of tree density (Oliveira, 2002).

Twenty-six sampling plots ($10 \text{ m} \times 10 \text{ m}$) were established within the stand, composing a sampling area of 2600 m^2 . Two 0.25 m^2 litter traps made of 1 mm plastic meshes were placed in each plot, 70 cm above the forest floor. Litter samples were collected monthly, packed into paper bags and transported to the laboratory. There, the material was manually separated in leaves, twigs (below 2 cm diameter), reproductive materials and trash (miscellaneous plant debris), in order to characterize the deposited material. All litter fractions were dried to constant weight at 60°C . Then composite samples were prepared by mechanically grinding all fractions, using a stainless steel grinder, and then by careful homogenization of the powder.

For the determination of total Hg concentrations, homogenized 1.0 g samples of the total deposited litter (composed of all litter fractions) were submitted to an acidic extraction in a $\text{H}_2\text{SO}_4/\text{HNO}_3$ solution. Glass and plastic ware were decontaminated by immersion during 2 days in 10% (v/v) Extran[®] solution (MERCK), followed

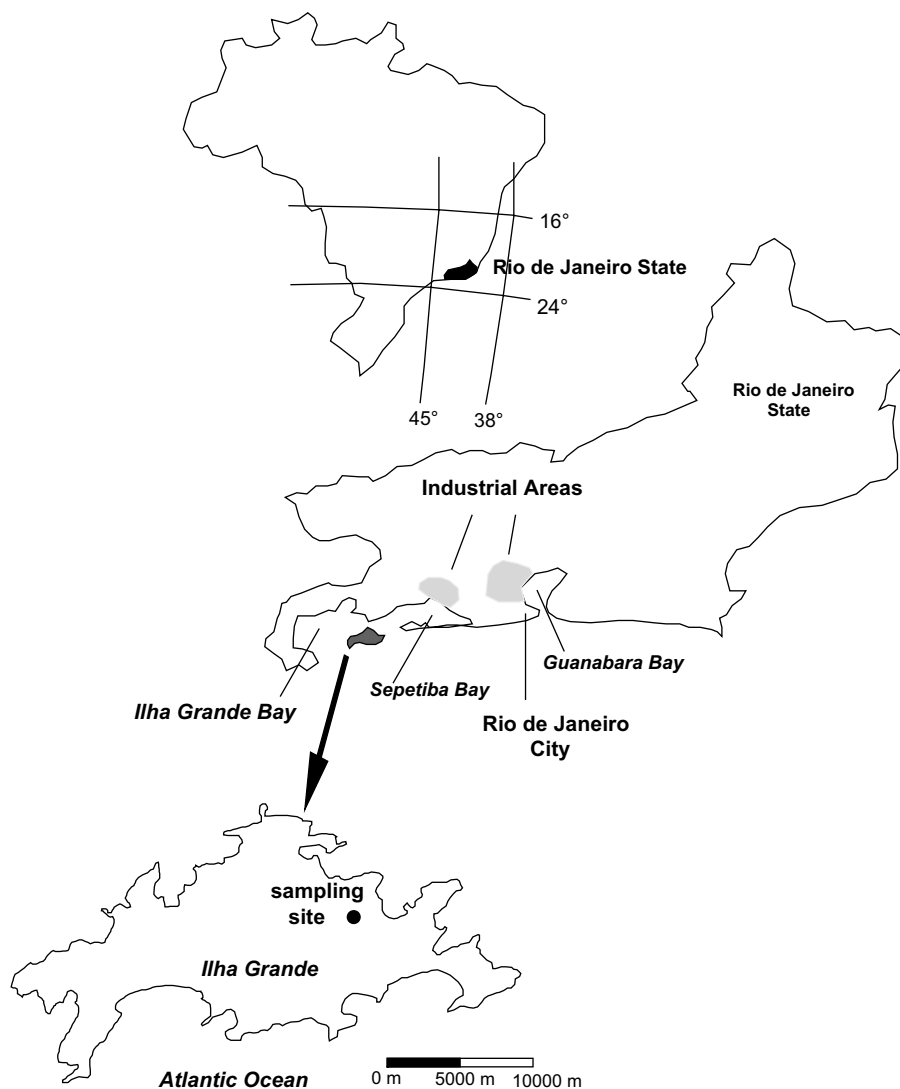


Fig. 1. Location of sampling station at Ilha Grande, Rio de Janeiro State, Southeastern Brazil.

by immersion during 3 days in diluted HNO_3 (10% v/v) and final rinsing with Milli-Q water. All chemical reagents used were of at least analytical grade.

Cold Vapor Atomic Absorption Spectrophotometry (CVAAS) was used for Hg determination, after Hg^{2+} reduction with SnCl_2 . All samples were analyzed in duplicates, showing reproducibility within 9.5%. The analysis of a standard reference material (NIST SRM 1515 – Apple Leaves) provided an average recovery of 92%. Reagent blanks were carried on in parallel with all sample analysis. In all cases blank signals were lower than 0.5% of sample analysis. The concentration values obtained was not corrected for the recoveries found in the certified material.

3. Results and discussion

3.1. Litterfall deposition

Total litterfall deposition in the study site ranged from $0.55 \text{ t ha}^{-1} \text{ month}^{-1}$ (May) to $1.26 \text{ t ha}^{-1} \text{ month}^{-1}$ (Sep-

tember), resulting in a total litter input to the forest floor of $10.03 \text{ t ha}^{-1} \text{ y}^{-1}$. This was similar to the upper extreme of the annual litterfall deposition range compiled by Vitousek and Sanford (1986) for thirty-two tropical forests ($3.6\text{--}12.4 \text{ t ha}^{-1}$). Leaves were the major fraction composing the deposited litter, corresponding from 50.3 to 83.7% of such deposition, while twigs corresponded to 3.7–38.8%, and other fractions (reproductive material and trash) presented a lower contribution (<15%) to the total litterfall. A substantial temporal variability in total litterfall deposition was recorded (Fig. 2), mostly due to leaf litter variation, showing higher values between September and December. Peaks in litterfall are related to the presence of deciduous species among the canopy trees (Santiago and Mulkey, 2003).

3.2. Mercury concentrations and deposition through litterfall

The Hg concentrations in total litterfall varied by a factor of 12 during the period studied, ranging from 20 to

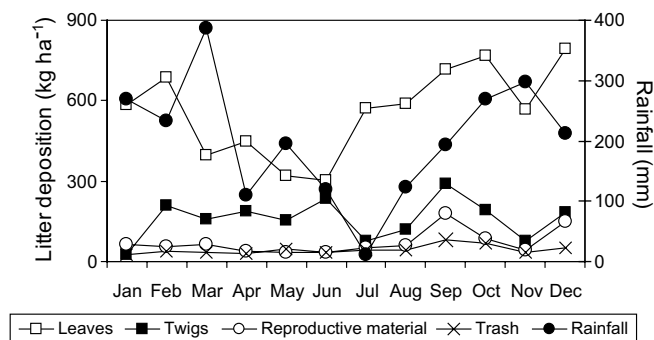


Fig. 2. Annual rainfall distribution and litter deposition variation in the studied site at Ilha Grande, SE Brazil.

244 ng g⁻¹ (131 ± 74 ng g⁻¹), with higher concentrations observed during the lower rainfall period, between June and August (225 ± 17 ng g⁻¹). The lower Hg litterfall concentrations were observed between December and May (99 ± 54 ng g⁻¹) (Fig. 3). This seasonal two-fold enrichment in Hg concentrations was reflected in the Hg litterfall flux, which presented a Hg deposition of 16.5 ± 1.5 μg m⁻² month⁻¹ during and just after the period of lower rainfall (June–September) and 7.0 ± 3.6 μg m⁻² month⁻¹ in the other periods (Fig. 3), resulting in high Hg input to the forest floor via litterfall deposition of 122 μg m⁻² y⁻¹. The variability of Hg concentrations in litterfall is partially associated with changes in Hg concentrations in the bulk atmospheric deposition over the region. Concentrations of Hg in bulk deposition over the adjacent Sepetiba Bay area also show high variability during the year. Marins et al. (1996) reported higher Hg concentrations (160 ng l⁻¹) at the industrialized area of Sepetiba

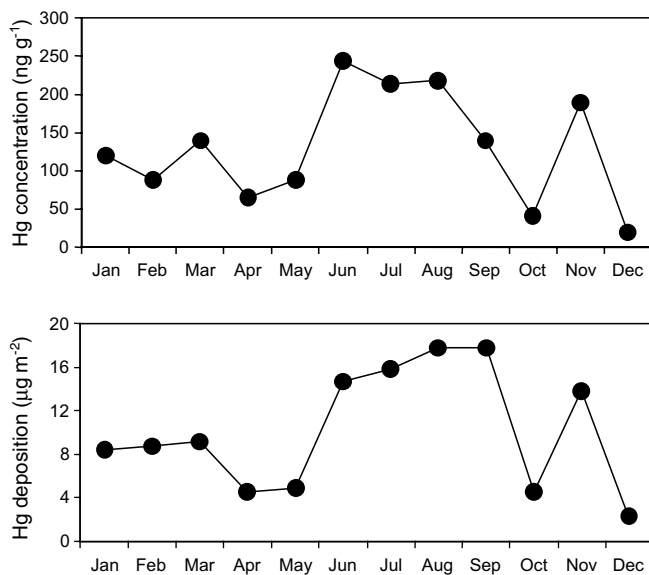


Fig. 3. Annual variation of Hg concentration and deposition in litterfall from the studied area at Ilha Grande, SE Brazil.

basin in January, February and September while in the rest of the year mean Hg concentrations observed was 30 ng l⁻¹. Unfortunately these authors did not provide concentrations in June and July. Lacerda et al. (2002) reported Hg concentration in pristine forested areas in the same region to triple between September to November (2.2–3.0 ng l⁻¹) relative to the period between February to May (<0.8 ng l⁻¹).

Mercury concentrations and deposition in litterfall in the studied site are one order of magnitude higher than Hg concentrations and fluxes generally reported for temperate and boreal forests. Representative examples of Hg concentrations in the litterfall of temperate and boreal trees affected by different levels of atmospheric Hg input varied from 33 to 79 ng g⁻¹ in Canada (St. Louis et al., 2001), 29.7–105 ng g⁻¹ in USA (Lindberg, 1996; Rea et al., 1996; Grigal, 2002; Grigal et al., 2000; Rea et al., 2002), and 33–88 ng g⁻¹ in Germany (Schwesig and Matzner, 2000). On the other hand, Hg concentrations in leaf litter of Amazonian forests under variable levels of Hg input may range from 56 to 140 ng g⁻¹ in French Guiana and Brazil (Roulet et al., 1999), while for two Atlantic Forest sites in Southeastern Brazil, Fostier et al. (2003) reported Hg concentrations in litterfall varying from 72 to 100 ng g⁻¹. Even considering the scarcity of data, litterfall Hg concentrations seem to be higher in tropical forests. In our studied site at Ilha Grande Atlantic Forest, Hg litterfall concentrations are up to two-times higher than the maximum values generally observed in temperate and boreal forested ecosystems.

3.3. Factors affecting Hg deposition in litterfall

The results suggest that the canopy of the highly productive primary rainforest studied at Ilha Grande may efficiently contribute for the Hg input to the underlying soil. The present study found higher Hg concentrations in litterfall than those previously reported sites in other regions, in particular from temperate and boreal ecosystems and suggest that high atmospheric Hg inputs coming from surrounding industrialized and urbanized areas (Marins et al., 1996, 1998) may influence Ilha Grande Forested ecosystems. However, besides the atmospheric transport of anthropogenic Hg, other processes may contribute to determine the elevated values observed.

Plant uptake from soils in tropical forests is of minor importance on the elemental composition of canopy leaves (Jordan, 1989; Mélières et al., 2003). Diverse mechanisms at the canopy level result in high efficiency of element scavenging from the atmosphere. Among them, colonization of leaf surfaces by epiphylls, including algae, lichens, liverworts and bacteria (Jordan, 1989). Translocation of nutrients from leaf to twig before leaf abscission has been demonstrated in different tropical sites (Jordan et al., 1980) and may also occur in the case of Hg. The high diversity and density of epiphylls, such as bromeliads and orchids typical of tropical forests canopies may also

increase the scavenging capacity of Hg from the atmosphere (Nadkarni, 1984).

The amount of litterfall may determine the relative importance of Hg litterfall input between different sites. The higher Hg input found in the study site in comparison with other forests in a worldwide scale may also be partly attributed to the high annual litterfall production recorded for the sampling period at the Ilha Grande Forest. For example, Waring and Schlesinger (1985) showed that litter input in forests increases with decreasing latitude and increasing productivity from boreal to tropical forests. Schwesig and Matzner (2000) concluded that high litterfall rates explain the large relevance of litterfall for the Hg accumulation in soil of a German Forest. St. Louis et al. (2001) suggested that Hg flux via litterfall was driven primarily by the annual biomass flux of litter, despite differences in Hg concentrations among different litter types, in a comparison between upland and wetland forested areas.

Besides the effect of the variability in litterfall quantity, there are evidences that different plant species may have contrasting abilities to ‘filter’ atmospheric Hg, and consequently to determine Hg inputs to forested soils via throughfall and litterfall. For example, Mélières et al. (2003) showed that Hg concentrations in canopy leaves from diverse Amazon species reached moderate to high values (32–114 ng g⁻¹), varying by a factor close to four, which probably reflects the coupling of diverse leaf age/life-spans and specific leaf areas involved in the removal of atmospheric Hg. On the other hand, very low values (1–40 ng g⁻¹) reported by Guentzel et al. (1998) may be related to a trend displayed by the single tree species sampled by them at the Everglades. The processes determining the leaf absorption of atmospheric Hg are a function of both meteorology and leaf surface characteristics, such as leaf hairs, waxes and roughness and the presence of epiphytic organisms (Jordan et al., 1980; Rea et al., 2002).

The variability in meteorological conditions that determine the atmospheric Hg availability (elemental Hg⁰, reactive gaseous Hg (RGM) and aerosol Hg) and the rainfall washout of forest canopies may also partly explain patterns of Hg deposition via throughfall and litterfall (Grigal, 2002; Hintelmann et al., 2002; Rea et al., 2002). The temporal variability of litterfall, however, was unrelated with Hg litterfall deposition in the study site, whereas a highly significant correlation ($r = 0.88$; $p < 0.001$) was observed between Hg concentrations in litter and Hg flux through litterfall (Fig. 4). This pattern suggests that litterfall amount variability does not play a major role in determining Hg litterfall deposition, when compared to other forest sites in temperate and boreal regions reported in the literature. Rather, our results support the assumptions that other processes that determine Hg concentration in litterfall are responsible for the observed Hg input. These probably include atmospheric Hg availability (i.e., amount and chemical form of Hg in the atmospheric deposition) during regionally drier months (June–August), which showed a comparatively low litterfall amount (Fig. 2). However, it

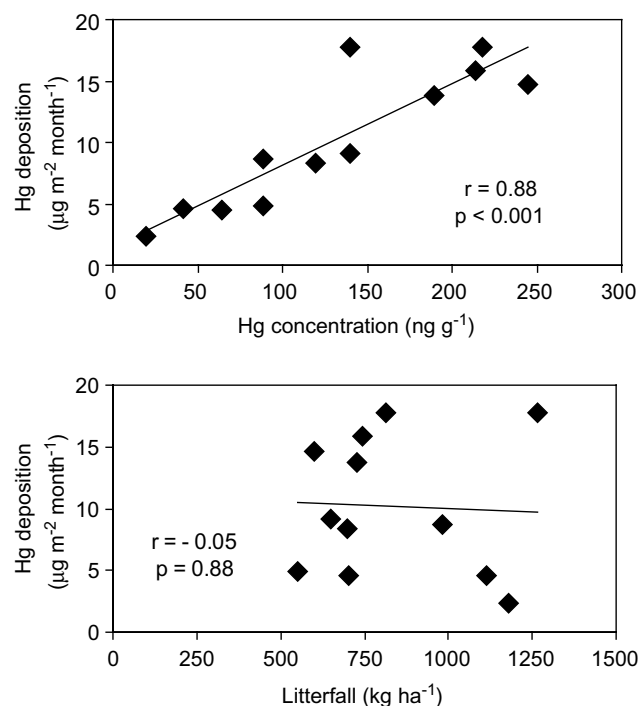


Fig. 4. Relationship between Hg deposition and Hg concentration in litter and between Hg deposition and litter production in the studied site at Ilha Grande, SE Brazil.

is interesting to note that the main period of high Hg litterfall deposition to the studied forest floor extended to September (Fig. 3), at the end of the regional dry season, when a peak in litterfall production (1.26 t ha⁻¹), probably associated with dry-season deciduous species, coupled with an intermediate Hg concentration (140 ng g⁻¹), promoted the maximum Hg input through litterfall. This suggests that while the period with higher Hg concentration in litter occurred, a high Hg flux through litterfall was sustained, even with comparatively lower litterfall flux, but when litterfall flux increased just after this period, such increase counterbalanced the comparatively lower Hg concentration.

Unfortunately, no data exist on Hg concentrations in the local atmosphere. However, bulk atmospheric deposition of Hg has been measured in many sites within the Sepetiba bay area (including Ilha Grande), based on direct bulk deposition collection of estimation by analysis of ombrotrophic lake sediment profiles. These results suggest relatively high Hg atmospheric deposition rates ranging from 1 to 30 µg m⁻² y⁻¹ in pristine sites and 50–90 µg m⁻² y⁻¹ in areas close to industrial emissions at Sepetiba basin (Marins et al., 1996, 1999; Silva-Filho et al., 1998a,b; Lacerda et al., 2002; Lacerda and Ribeiro, 2004). Therefore, high concentrations of Hg in the forest canopy and consequently in litterfall are expected.

An additional mechanism of increasing Hg concentrations in litterfall could be the re-emission of Hg from soils, which could be trapped in the forest canopy causing litterfall enrichment, as suggested by modeling and gradient

analysis of Hg concentrations in some temperate forests (e.g., Lindberg et al., 1992). Data on Hg degassing from Atlantic Forests soils are not reported. However, in upland tropical forests in the Amazon, Margarelli and Fostier (2005) measured very low emissions from forest soils with an average maximum of $0.6 \text{ ng m}^{-2} \text{ h}^{-1}$ in comparison with a deforested site, where mercury emissions were higher ($3.2 \text{ ng m}^{-2} \text{ h}^{-1}$ maximum). Moreover, Almeida et al. (2004) measured peak Hg emissions from an Amazon Forest soil of about $8.4 \text{ ng m}^{-2} \text{ h}^{-1}$, which were lower than those measured in pasture soils ($46 \text{ ng m}^{-2} \text{ h}^{-1}$). According to these results, it may be expected a lower soil mercury emission in preserved Atlantic Forests compare to the ones from deforested areas.

3.4. Comparisons with other inputs

The relative importance of litterfall to the total Hg input to forested ecosystems at higher latitudes is frequently estimated through comparisons of litterfall deposition with open rainfall deposition and net throughfall deposition (i.e., throughfall less open rainfall input), but there is a lack of this information for tropical forests. Comparisons with regional data on Hg atmospheric deposition in the studied area may provide some insights on this issue. Regional data on annual Hg deposition in open rainfall indicated a range of $0.4\text{--}3.4 \text{ } \mu\text{g m}^{-2} \text{ y}^{-1}$ in three contrasting coastal areas in Rio de Janeiro State (Lacerda et al., 2002), for which the upper extreme was recorded in an urban site within Rio de Janeiro conurbation area (about 80 km from Ilha Grande) and the lower extreme was recorded in a site out of urbanized and industrialized areas, closer to Ilha Grande (about 20 km from Ilha Grande). In an area affected by industrial activities in Sepetiba Bay (about 30 km from Ilha Grande) an extremely high annual rainfall Hg input was recorded, $76 \text{ } \mu\text{g m}^{-2} \text{ y}^{-1}$ (Marins et al., 1996). Other measurements of Hg atmospheric deposition in Rio de Janeiro State have used dated sediment profiles in Itatiaia Mountains (about 150 km from Ilha Grande), showing a maximum annual input of $120 \text{ } \mu\text{g m}^{-2} \text{ y}^{-1}$ during the 1960s, and a recently lower input of $20 \text{ } \mu\text{g m}^{-2} \text{ y}^{-1}$ after the 1970s (Lacerda and Ribeiro, 2004). This context indicates that litterfall promotes Hg deposition in Ilha Grande Forested soils that is of one to three orders of magnitude higher than in open rainfall deposition from non-industrialized areas, and approximately two-times higher than in open rainfall deposition from industrialized areas of the Rio de Janeiro State. Such data indicate that canopy in the studied forest is able to produce a large increase in total Hg input to underlying soils in comparison with the magnitude expected for open rainfall deposition.

Unfortunately, to our knowledge there is no data about regional Hg deposition in throughfall that could allow us such comparisons. In a larger spatial scale, data reported by Fostier et al. (2000) indicated that canopy from an Amazonian Forest promoted a total Hg input via throughfall of $72 \text{ } \mu\text{g m}^{-2} \text{ y}^{-1}$, in contrast with a total open rainfall

deposition of $18.2 \text{ } \mu\text{g m}^{-2} \text{ y}^{-1}$. A comparison between these results indicates that dry deposition of atmospheric Hg on the forest foliage and its wash-out by rain water plays a significant role to determine Hg input to underlying soils. This Hg deposition enrichment by forest canopy was significantly affected by the occurrence of dry periods of a few days just before sampling, evidencing the importance of Hg dry deposition to the forest studied. The authors also indicated that their throughfall estimation is higher than those reported for temperate and Nordic regions.

3.5. Implication for Hg cycling in tropical forests

The results presented here provide an additional evidence for the role of tropical forests in atmospheric Hg transfer to soils. A coupling between the long distance Hg atmospheric transport and its accumulation by forests canopy (predominantly during dry periods; e.g., Rea et al., 1996), appears to increase Hg deposition via throughfall and litterfall in areas free of anthropogenic Hg point sources (e.g., Fostier et al., 2000) similar to Hg atmospheric deposition in areas affected by gold mining and industrial point sources (e.g., Mason et al., 1994; Marins et al., 1996).

Roulet et al. (1999) indicated that cumulative anthropogenic atmospheric deposition accounted for less than 3% of Hg burdens in the upper 20 cm soil from Brazil and French Guiana Amazon Forest. Based on the principle that throughfall Hg input represents Hg total atmospheric deposition in soils, Fostier et al. (2000) estimated that if total Hg throughfall ($72 \text{ } \mu\text{g m}^{-2} \text{ y}^{-1}$) would be incorporated in the upper 10 cm of Brazilian Amazon soils, the atmospheric deposition would account for a maximum of 3% of the Hg burden in lateritic soils. Both studies, however, did not taken into consideration the contribution from litterfall. Therefore, considering that total Hg flux to forest floor can also be increased by litterfall inputs (Lindberg, 1996), it is possible that the atmospheric inputs of Hg to tropical forest ecosystems have been underestimated. Our findings strongly suggest that Hg litterfall input may be even more important to the total Hg atmospheric deposition to tropical forests than usually considered in the literature (e.g., see Grigal (2002) for a review).

Considering the results discussed above, the fate of Hg within tropical forested ecosystems is probably dependent on the high Hg scavenging capacity of tropical forests canopy proportion as well as the amount of litterfall proper, which appear to be greater than those generally recorded at higher latitudes. The high Hg flux to soil from litterfall and the low re-emission of deposited Hg showed in other studies (e.g., Almeida et al., 2005; Margarelli and Fostier, 2005) results in a high Hg accumulation capacity, and therefore, relatively high concentrations, in tropical forests soils. Recent studies (Roulet et al., 1999; Fostier et al., 2000; Lacerda et al., 2004; Almeida et al., 2005) showing high Hg remobilization from tropical soils following deforestation may be partially a result of the high atmospheric

Hg scavenging capacity of tropical forests canopy and further transfer to soils through litterfall.

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