Understanding Mercury Throughfall and Litterfall Deposition in Great Smoky Mountains National Park

Suzanne Fisher and Mark Wolfe, Tennessee Valley Authority, Knoxville, TN (lsfisher@tva.gov) or (mhwolfe@tva.gov)

Introduction

Abstract

Mercury emissions from coal-fired power plants together with other various worldwide sources are primary contributors of mercury to the environment. It is thought that regional high elevation sites are potentially affected more than low elevation sites. This study is designed to generate some baseline information that may provide some basic understanding of mercury inputs to the terrestrial ecosystem of the GSMNP. Two major mercury input and pathways were sampled at three elevations in the Great Smoky Mountain National Park (GSMNP) between April and October during both 2008 and to date in 2009. Throughfall (TF) which is precipitation that reaches the forest floor after falling through and interacting with the forest canopy and litterfall (LF) which are pieces and fragments of leaves, twigs, bark etc. that fall to the forest floor are two pathways which comprise the bulk of the mercury that reaches the forest floor. Bulk throughfall and litterfall were collected under the canopy at three elevations from 6,653 to 1,953 feet above sea level.

Study area and methods

Study sites

The 3 locations in the Great Smoky Mountains National Park selected for this study represent an elevation and vegetation gradient are;

Clingmans Dome – (CD) Elev. 6643 ft. The low stature canopy (25-30ft) is composed of primarily spruce and fir with a small deciduous component of mountain ash.

Noland Divide – (ND) Elev. 5578 The canopy here is composed of primarily of large red spruce (60-90ft) with an understory component of Birch mountain ash and other deciduous shrubs.

Noland Creek – (NC) Elev. 1945 ft. This a deciduous stand comprised of mixed hardwoods mainly oaks, red maple, tulip poplar and some hemlock.

Litterfall Collection

At each of the study sites 3 - 40cm x 40cm (0.16 m^2) litterfall (LF) traps were placed under the canopy. The traps consisted of a square wood frame with nylon mesh bottom and were raised off the forest floor 40-50 cm. The traps were spread 4-6 meters apart in a triangular pattern. LF deposition expressed on dry weight basis.

Throughfall collection

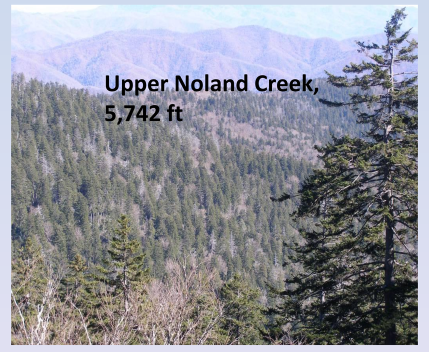
Three throughfall (TF) collectors were setup at each site in a similar triangular pattern as used for LF. Throughfall collectors used a 10.16 cm diameter borosilicate funnels coupled to 1 liter brown borosilicate glass bottles by straight section of 50-60cm long Teflon tube. Ten milliliters of 0.10 n preservative made up from trace metals grade HCL was added to the bottles at the start of each new collection period. A small piece of acid washed glass wool was placed in the neck of funnels to prevent clogging. At the CD site one open TF collector was located near the MDN12 monitor.

Collection Periods

Collections of TF and LF were made ever two to three weeks from mid-April for all sites to late-October at the CD and ND sites and early November at the NC site. During the process of collection clean lab grade vinyl gloves were used when changing out TF bottles or collection of LF. All samples were placed on ice after collection and refrigerated at our lab until analysis.

Analysis

All samples were analyzed total mercury by Frontier Geosciences of Seattle WA.

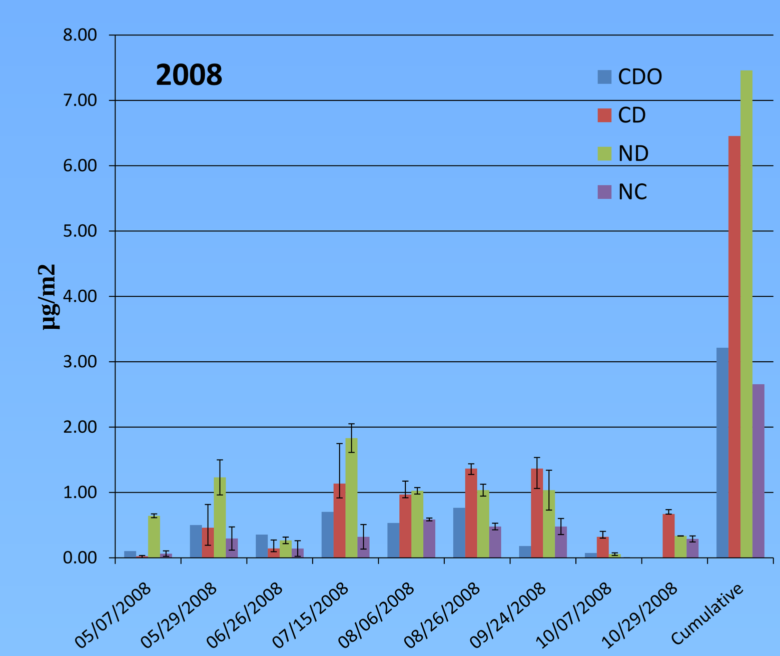


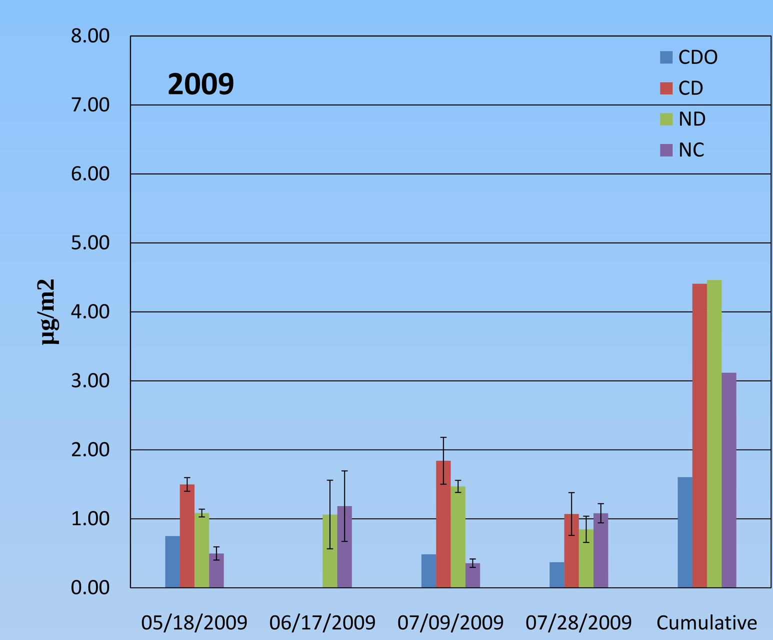
Throughfall collector

Litterfall trap

Results

Throughfall (TF) deposition for collection season (May-October) in 2008 and 2009.





2008

Total Hg deposition by bulk TF followed an elevational trend with the high elevation sites CD and ND having more than a 2-fold greater deposition than at the low elevation site NC during the April to October period.

Total Hg in bulk TF deposition at CD exceeded open collected TF (CDO) by 2-fold. No open collected TF was sampled at ND and NC.

Through much of 2008 TF total Hg flux was greater at the ND site possibly an effect of greater foliar surface deposition area in the larger ND canopy as compared to CD.

2009

Total Hg deposition by TF in 2009 shows a similar elevation pattern to that observed in 2008. Cumulative difference among sites is however somewhat less.

Throughfall Hg concentration (ng/l) Apr.21 - Oct. 31 2008

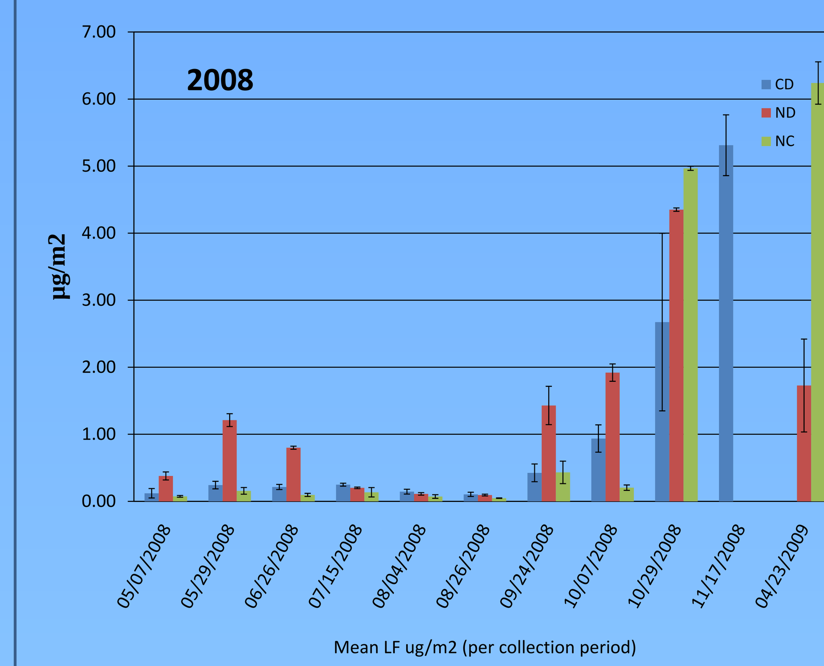
Site	n	mean	stdev	median
cdo	7	5.06	1.97	4.66
cd	23	19.89	12.13	15.11
nd	23	19.30	4.83	18.63
nc	20	12.98	8.05	9.12

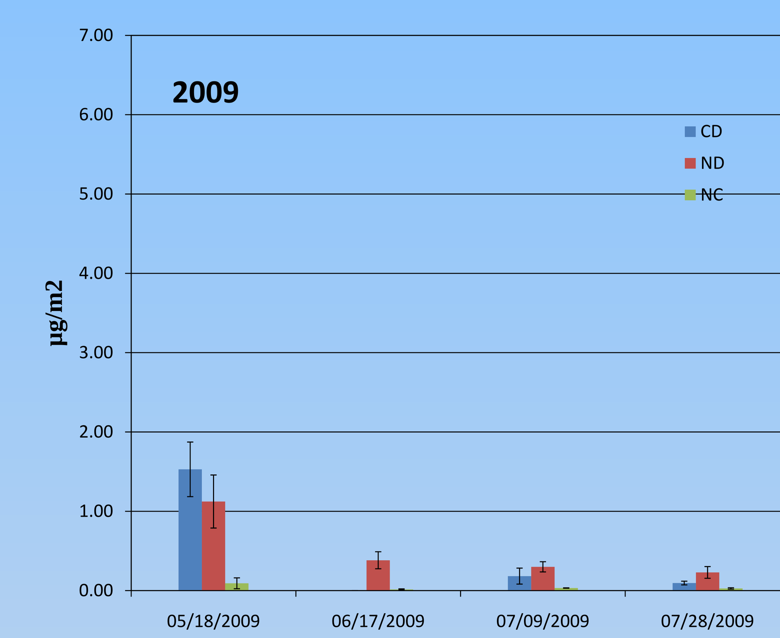
Throughfall THg concentration (ng/l) May 7 - July 28, 2009

Site	n	mean	stdev	median
cdo	3	4.43	1.24	3.75
cd	9	17.17	6.26	18.27
nd	12	15.04	10.24	12.48
nc	12	13.53	5.99	11.76

Average total Hg concentrations in open and bulk TF 2008 and 2009 are similar at the CD and NC sites. Total Hg at both high elevation sites are slightly higher than at the low elevation NC site. Open TF at CD is about 75% lower than mean TF in both years.

Litterfall (LF) deposition for collection season (May-October) in 2008 and 2009.





2008

Total Hg inputs by LF follow seasonal patterns of LF mass with a small peak in spring and a large pulse in the fall. Fall LF input dominates overall total Hg inputs over the growing season. Generally litterfall total Hg inputs are greater at CD and ND through the growing season until the fall when NC total input is greatest.

A significant input of LF Hg occurred during the winter from October 2008 to April 2009 at CD and ND.

2009

Total Hg input in LF at ND and in particular CD were similar to inputs in 2008 during the same time period.

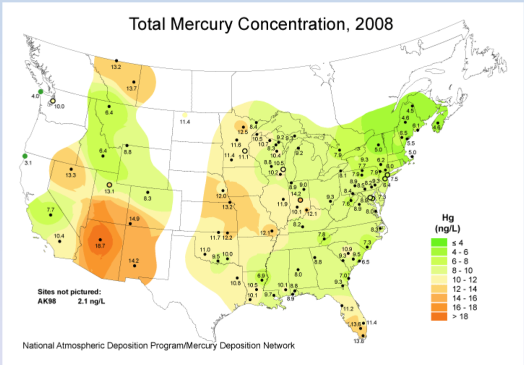
Litterfall THg concentration (ng/g) April 21-October 31, 2009

Site	n	mean	stdev	median
	n			
cd	27	33.87	16.29	35.60
nd	27	34.81	16.47	38.50
nc	25	20.49	13.91	15.40

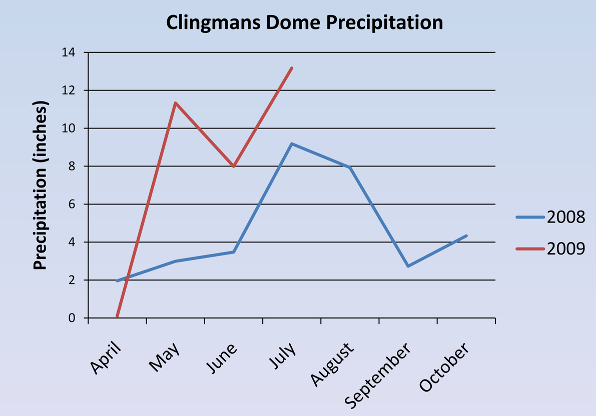
Litterfall THg concentration (ng/g) May 18- July 28, 2009

Site	n	mean	stdev	median
cd	9	31.67	25.50	25.5
nd	12	30.58	15.93	27.55
nc	12	11.71	6.36	5.825

Average total Hg concentrations in litterfall were greater at CD and ND in both 2008 and so far in 2009 as compared to NC.



CDO open throughfall mean concentration was 5.06 ng/l in 2008 for the collection period (April-October). Low elevation MDN-11 annual Hg concentration was 7.8 ng/l.



Precipitation amount in 2009 has exceeded precipitation in 2008 by four-to-eight inches from mid-April to late-June. Cumulative rainfall in 2008 was 17.6 inches through July. For the same period in 2009, cumulative rainfall was 32.6 inches.

Summary

LF input of total Hg was greater than TF input at NC and ND by 1.4 to 2.3 times in 2008. At the highest elevation CD site, however TF was slightly more than LF. TF inputs through July 2009 have greatly exceeded LF inputs primarily due to dramatically greater rainfall in 2009 at all sites. Total Hg TF and LF concentrations are greater at the high elevation CD and ND sites than at the low elevation NC site. LF flux is however, greatest at the NC site due to it higher litterfall mass, occurring in the fall. Overall the LF and TF deposition are within the range of those reported in literature (5-15 ug m^{-2} yr^{-1} and 5-20 ug m^{-2} yr^{-1}, respectively reported by Grigal, 2002).

The limited extent of the LF and TF networks used at the three elevation site provides some insight into the general effect of elevation and vegetation on total Hg inputs. However the lack of multiple plots within elevation prevents understanding how consistent the trends may be.