



# Do Living Green Roofs Reduce Total Mercury in Stormwater Runoff?

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## Introduction

Living "green roofs" are installed to reduce storm water runoff, mitigate heat island effects, remove atmospheric carbon, and insulate buildings. Although green roofs have been demonstrated to reduce the total runoff volume from a roof, there are few published studies of the impact on pollutants in the runoff and none on mercury (Berndtsson et al, 2006). Mercury could be reduced in runoff if the plants or roof materials adsorb mercury. Alternatively, mercury in runoff may be higher from a green roof if the plants act as surfaces for dry deposition of mercury, as has been found in forest canopies, or if mercury is leached from the roof materials.

## Methods

Fifteen experimental roof plots were built on the campus of Virginia Wesleyan College with a completely randomized design using 5 roof types with 3 replications (Fig 1 & 2). Runoff from select rain events was captured in a 1 L acid-washed Teflon bottle, with additional runoff overflowing into a bucket for volume determination by mass. Precipitation was manually collected following Dvonch et al. (1998). Mercury samples were analyzed using cold vapor atomic fluorescence spectrometry. Total nitrogen and phosphorus were analyzed by UV-Vis spectroscopy following persulfate digestion.



Figure 1. Test roof plots.

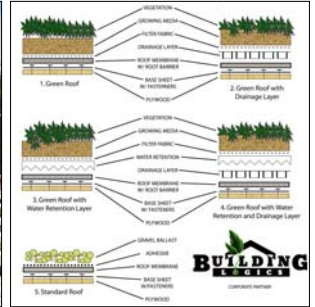


Figure 2. Experimental roof plot configurations.

## Results & Discussion

### Volume

Green roofs decreased the volume of runoff by 35-100% versus conventional gravel roofs (Fig 3). There was no significant difference in runoff volume among green roof types.

### Mercury

The concentration of mercury was typically higher in the runoff from the green roofs than the gravel roofs. Despite the higher concentrations, the reduced runoff volume resulted in a reduction of total Hg load washing off the green roofs. As a result, the total load of Hg was significantly less from the green roofs than the gravel roofs for three of the four rain events sampled (Fig 4 & 5).

### Leaching experiment

To investigate the possible sources of Hg to runoff from green roofs, rainwater was poured over each roof component and collected for analysis (Fig 6). The compost contributed the most total Hg.

### Nitrogen and Phosphorus

Previously it has been assumed that reduced runoff volume would reduce runoff of all pollutants. We found that this was not true for N and P (Fig 7). All green roof plots released significantly more N and P than gravel roof plots, probably due to fertilizers. This study demonstrates that excessive fertilizer application during planting and establishment can be detrimental to local water quality.

### Recommendations

Green roofs can provide clear benefits (energy savings, reduced runoff, heat-island effect) but their potential negative impact on water quality needs to be addressed. This can largely be accomplished by reducing or eliminating fertilizer application during construction and maintenance of the roof. A different source of compost or a reduction in compost amount could reduce the runoff of Hg from green roofs.

We are currently installing a green roof on a dormitory building for a roof scale study. We will evaluate the feasibility of no and low fertilizer additions and pollution reduction technologies which could be installed around roof drains. Further sampling will be required to determine if the trends continue as roofs age. Testing in urban areas impacted by high rates of dry deposition may show even higher concentrations of pollutants in runoff from green than gravel roofs due to the larger surface area of the plants.

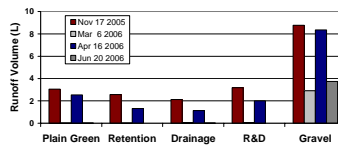


Figure 3. Average runoff volume by roof type. Green roofs had significantly less runoff than gravel roofs ( $p < 0.001$ ).

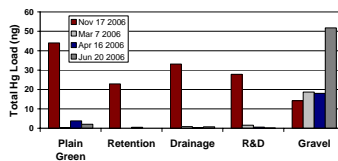


Figure 4. Average total Hg in runoff from each roof type. Hg Load was significantly less from green roofs for March, April, and June ( $p < 0.001$ ).

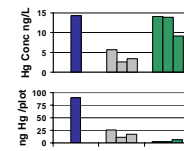


Figure 5. Concentration & load of Hg for April 17, 2006 rain event. Rain load is the ng of Hg deposited to a roof plot. Although concentrations of Hg in runoff were higher from green roof plots, the reduced runoff volume resulted in a reduction of total Hg load washing off the green roofs compared to gravel roofs.

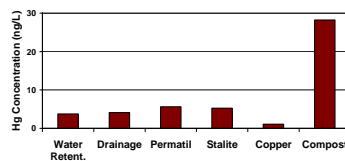


Figure 6. Leaching of total Hg from green roof components.

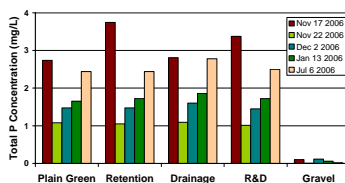


Figure 7. Average concentration of total phosphorus in runoff from each roof type. Green roof runoff was significantly higher on all dates ( $p < 0.001$ ).

## References

Dvonch JT, Graney JR, Marsik FJ, Keeler GJ, Stevens RK. 1998. An investigation of source-receptor relationships for mercury in South Florida precipitation. *Environmental Science and Technology*, 33:4522-4527.

Berndtsson, JC, Emilsson T, and Bengtsson L. 2006. The influence of extensive vegetated roofs on runoff water quality. *Science of the Total Environment*. 355:48-63.

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