

ROOFING CONTRIBUTIONS TO URBAN RUNOFF POLLUTION

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ABSTRACT

Development in sensitive watersheds continues to pose environmental problems for receiving waters. Materials, such as galvanized metal, concrete, asphalt and wood products, may release pollutants into urban runoff and snowmelt; however, the long term effect of commonly-used roofing materials on the environment has not been quantified. This lack of long-term testing poses a particular problem because roofing is ubiquitous in the urban environment and covers a comparatively large amount of the surface area available to generate runoff.

The ongoing research project involves testing a variety of construction materials (roofing materials, treated and untreated woods) to determine their long-term pollutant release after typical installation and exposure to the weather. The goal is to develop a better understanding of how the aging and exposure processes will impact the release over time. Initial field testing at two sites with different climates showed that nutrient concentrations were elevated early in the materials' life, as were the metals. Now, over two years of monitoring has occurred. For many of the pollutants, the concentrations have leveled off to much lower concentrations. For most pollutants, especially nutrients, periodic spikes in runoff concentrations can be correlated to noticeable degradation in the material itself. Preliminary metals results show that lead concentrations are just above the detection limit, while copper releases are much greater for many materials.

INTRODUCTION

Laboratory studies of common construction materials (Pitt *et al.*, 2000; Clark 2000) have demonstrated the potential for many construction materials to leach pollutants into the environment. Other studies have confirmed the important role played by roofs, paved surfaces, treated woods, and other construction materials to wet weather flow pollutant contributions.

METHODOLOGY

The two categories of materials investigated during the laboratory-scale survey were the following:

- Roofing materials (galvanized metal, asphalt/tar shingles, cedar shingles, plastic/vinyl/fiberglass roofing panels, fake slate roofing, and roofing sealers)
- Woods (treated with CCA and with an alternative water-proofing compound [organic-CCA combination])

For the outdoor “pilot-scale” installations, the materials were purchased at Lowes in Harrisburg, PA, and Home Depot and Lowes in Birmingham, AL. The field tests began in the summer of 2005 with the construction of identical sets of test frames (and materials) at PSH and UAB. Samples from each storm for the first two months were collected and analyzed for pH, conductivity, chemical oxygen demand (COD), nutrients and heavy metals. COD is used as a surrogate for the organic contribution since the laboratory testing showed that the contribution of specific semi-volatile organic compounds was negligible. The field results presented in this paper focus on the testing performed by the research team at PSH.

RESULTS AND DISCUSSION

A prior laboratory analysis of these roofing panels showed that metals are still being released from materials that are well into their lifespan, and indicate that measurable quantities of pollutants may continue to be released throughout the material’s useful life. Given the large quantity of these materials installed in the environment, the overall contribution may be significant and deserves further investigation.

Long-Term Field Evaluation. The test frames were constructed at slopes similar to those used in residential pitched roofs. The test panels were purchased and installed intact (panels were not cut to fit the frames at PSH, but were cut in half at UAB because of the limited space on top of the roof where these panel frames were installed) and installation techniques matched those used by roofers to the maximum extent practicable. The panels were uncovered just before the first rain event. Samples were collected for every storm for the first two months, with periodic sampling thereafter. The data shown below are for just over one year of testing at the PSH site.

The pH of the rainfall was measured periodically over the time frame. Rainfall pH has varied between 3.9 and 5.5. The roofing materials have been inspected at least monthly and degradation has been noted. Visible degradation was noted on the galvanized metal panels within two weeks of installation, particularly near the fasteners attaching the panel to the frame. Runoff pH from the materials has, in general, been slightly elevated compared to the rainfall pH – indicating a slight buffering of the rainwater. The exceptions to this are the cedar shakes (runoff pH always below 5.0); the roofing felt; and the rubberized roofing.

Nitrogen results showed elevated concentrations early in the testing process. Periodic spikes in the runoff concentration of these nutrients have been seen throughout the test period. In the case of the first spike in the concentration of the nitrogen compounds, visible degradation in many of the panels was noted. In all cases, the contribution of nitrogen-based contributions to the runoff was higher from the wood-based products than from the metals and plastics.

Phosphorus had elevated runoff concentrations during the first few storm events, but these concentrations leveled off to a low background concentration within the first few storm events. This trend, with a few exceptions, has held for the metal- and plastic-based roofing materials. However, the wood products and roofing felt have had periodic spikes in runoff concentration

Metals analysis is still ongoing. Lead concentrations are near background for all materials (in most cases, lead concentrations in the runoff are just above the method detection limit of 1 µg/L). Copper has been analyzed for samples collected at days 10 and 41 of exposure (from the 3rd and 6th storm post-installation). Copper concentrations from the runoff of the 3rd storm are very high for the treated wood products and the asphalt shingles. This was not unexpected since copper is an active ingredient in both materials as a preservative and preventer of biological degradation/growth. It is unknown if these early elevated concentrations are due to the washoff of excess material from the surface of the panels or if it is the release of materials bound near the surface. Copper concentrations for the treated woods and shingles exceeded 0.5 mg/L for the 3rd and 6th storm samples.

For several storms, multiple samples are being collected for each material. These results will be analyzed to determine if there is a first-flush phenomenon occurring and if a first-flush (which is the bulk of the water in all captured whole-storm samples) could explain the variability in the storm events. Early analyses of two storms indicate that several of the materials are exhibiting a first-flush effect, even after background correction.

CONCLUSIONS

Laboratory testing showed that galvanized metal roofing contributed the greatest concentrations of many of the pollutants of interest – conductivity, cations, metals and nutrients. In addition, the metals analysis showed that the pressure-treated and waterproof wood contributed a significant metals load. COD was also elevated in the leachate from the waterproof wood. Other roofing materials appeared to be leaching phthalate esters from the plasticizers.

The two year of testing has shown that most of these materials (except for the ‘plastic/vinyl’ roofing) contribute measurable concentrations of nutrients and COD, with elevated concentrations early in their useful life and leveling off to lower concentrations as the surface coatings and deposition during storage are washed off. In addition, pH analysis has demonstrated that the rubberized roofing, roofing felt and cedar shakes have lowered the runoff pH, even in an area of the U.S. where the

rainfall pH is very acidic compared with most of the country. Preliminary metals analysis indicated elevated copper concentrations in the earliest storms, possibly due to the release (or washoff) of excess preservative. It is anticipated that these pollutant concentrations will increase at some point due to the excess wearing of the materials during their lifespan.

In general, nutrient leaching from construction materials has not been investigated. The preliminary results of this project demonstrate that nutrient leaching may be significant in the right environmental conditions. Potential testing for environmental compatibility should include a wide range of potential pollutants, rather than simply focusing only on the expected organic and metallic pollutants.

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Recent Relevant Publications

Clark, S.E.; K.A. Franklin; J.M. Hafera; J.T. Kirby. (2007). "Roofing as a contributor to urban runoff pollution." *World Environmental and Water Resources Congress 2007*. ASCE/EWRI, Tampa, FL, May 15 – 19, 2007. CD-ROM.

Clark, S.E.; J.M. Hafera; J.C. Elligson; J.B. Mikula; B.V. Long; M. Lalor. (2006). "Pollutant potential from building materials: Laboratory and field evaluations." *World Environmental and Water Resources Congress*. ASCE/EWRI Omaha, NE, May 2006. CD-ROM.

Clark, S.E.; M.M. Lalor; R. Pitt; R. Field. (2005). "Stormwater Pollution from Common Building Materials." *WEFTEC 2005 Conference Proceedings*. Water Environment Federation. 30 pages. CD-ROM.

Hafera, J.M.; J.C. Elligson; S.E. Clark; J.B. Mikula; M.M. Lalor; S. Johnson. (2005) "Wet-weather pollution from commonly-used building materials." *Proceedings of the 2005 Pennsylvania Stormwater Management Symposium*. Villanova Urban Stormwater Partnership. CD-ROM.

In addition to the publications listed above, a summary of this research has been submitted to the *Journal of Irrigation and Drainage Engineering* for publication.