Research Project 3

Geochemical Weathering Reactions in Granular Byproduct Materials

Recycled Materials Resource Center

University of New Hampshire

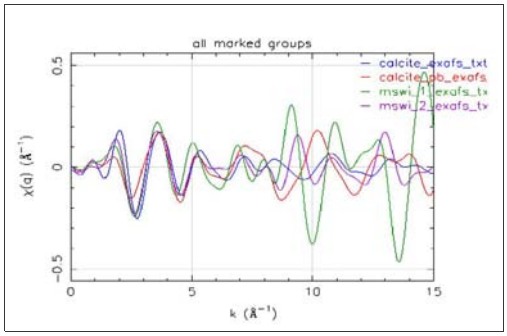
Federal Highway Administration

Project Objectives

The primary objective of this research is to characterize the long term leaching behavior of granular byproduct materials with respect to trace heavy metal constituents, and identify the controlling mechanism in these leaching characteristics to elucidate environmental implications of reuse of these materials.

Project Progress

This research project was developed to test the hypothesis that metal contaminants are incorporated into the crystal structure of minerals that form during geochemical weathering of granular by-products. Early on in this project, it was shown that materials such as municipal solid waste incinerator (MSWI) ash and coal combustion products had significantly decreased leaching of heavy metals as a result of weathering (aging). This project has also demonstrated that accelerated aging techniques such as elevated temperature and pressure, as well as carbonation, can create artificially aged ash samples that are similar to naturally aged materials. Dr. Gardner and graduate student Bob Carter then began testing both naturally and artificially aged materials to determine the specific geochemical reactions that bind the heavy metals. X-ray absorption spectroscopy (XAS), x-ray absorption near-edge spectroscopy (XAFS) and extended x-ray absorption fine-structure spectroscopy (EXAFS) techniques were employed to determine if an isomorphic substitution of lead for calcium in calcite crystals was immobilizing the lead. X-ray diffraction would not be able to detect small changes in the calcite composition, and thus not detect lead in the mineral structure. Samples of standard materials (Pb-foil, aragonite, calcite, $PbCO_3$, $PbCl_2$, PbO_2, and $PbSO_4$) and samples of preserved, carbonated, and artificially aged MSWI bottom ash were tested at the Center for Advanced Microstructures and Devices (CAMD) at Louisiana State University. At this point, the results are inconclusive as the data lacks coherent edge and near-edge structures, so further testing at CAMD is planned. On a separate track, Fourier transform infrared spectroscopy (FTIR) was used to verify the existence of amorphous minerals that form during weathering. Preliminary data collection by FTIR suggested development of amorphous aluminosilicate clays in ash samples of varying age. Subsequently, empirical standards of allophane and halloysite were analyzed and compared to fresh, artificially aged, and carbonated samples that had been artificially aged. The aged samples were found to have more peaks in common with the allophane and halloysite than the fresh ash. The results of FTIR concur with preliminary results, demonstrating increased development of amorphous clays in weathered ash materials.



An overlay of EXAFS scans of two different MSWI ash samples, a calcite standard and a lead doped calcite standard. The results suggest that lead may be undergoing isomorphic substitution for calcium in calcite crystals forming in the ash due to weathering, but the results are inconclusive. Further advanced testing is planned to resolve this data.

Project Partners

New Hampshire DES, Public Service of New Hampshire, Kyushu University

End Products

This project will result in a framework that describes the geochemical reactions that take place in by-product materials as a result of weathering and determines how those reactions change leaching behavior of the material. A second product will be a list of recommendations for testing protocols that are particularly relevant for this type of leaching behavior. The specifications are from Europe and other sources and may not be well known in the United States.

Further Information

The Recycled Materials Resource Center (RMRC), a cooperative agreement between the University of New Hampshire and the Federal Highway Administration, is a national center that promotes the appropriate use of recycled materials in the highway environment. Its focus is on the long-term performance and environmental implications of using recycled materials.

For detailed quarterly progress reports for Project 3/4, as well as all RMRC-funded research projects, please see: http://www.rmrc.unh.edu/Research/researchlevel2.asp.

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