Heavy Metal Contamination in Highway Marking Glass Beads

Lisa Axe and Nimrat Sandhu
New Jersey Institute of Technology, NJ

Kauser Jahan, V. Ramanujachary, and
Travis Francis Magdaleno
Rowan University, NJ

Outline

- Background & Motivation
- Objectives
- Methods
- Results
- Conclusions
- Acknowledgement

Background

- Glass Beads
  - Enhance visibility for night driving through *retroreflectivity*.

Roadway with glass beads vs. one without

Motivation

- Recently, As, Pb, and Sb have been observed in glass bead samples.
- Question: What is the environmental risk in using these glass beads?
- To better understand the risk involved, glass bead batches with elevated concentrations of metals and metalloids were procured.

Objectives

- Determine the total concentrations of select metals and metalloids using hydrofluoric acid (HF) digestion followed by inductively coupled plasma mass spectroscopy (ICP-MS) and compare results to field portable X-Ray fluorescence (FP-XRF).

- Conduct batch experiments to determine environmental impact:
  - Abrasion
  - Roadways deicing salts
  - pH
  - Time
  - Ionic strength

- Based on leaching, develop guidance to address potential environmental risk.

Methods

- Total Metal Determination
  - Dissolution
    - Hydrofluoric acid digestion
      - ASTM C169 – hot plate
      - EPA Method 3052 – microwave oven
    - ICP-MS
  - Non-destructive X-Ray fluorescence EPA Method 6200
    - Field portable XRF (FP-XRF)
    - Lab scale XRF

Methods: Environmental Risk

- Assess leachability from one batch to compare results:
  - Toxicity Characteristic Leaching Procedure (TCLP) U.S EPA Method 1311: Simulates leaching at lower pH in a landfill environment.
  - Synthetic Precipitation Leaching Procedure (SPLP) U.S. EPA Method 1312: Simulates acid rain and considers infiltration of contaminants into groundwater used as a drinking water source.
  - Environmentally relevant conditions: time, pH, salt, ionic strength, and particle size.

Results

- Select batches of glass beads exhibited elevated concentrations of As, Pb, and Sb.
- Concentrations were observed with significant variability: 50-83% for Pb, 17-22% for As, and 13-16% for Sb.
- pH and time were observed to be the most significant factors affecting leaching of metals and metalloids from glass beads.

Results

- TCLP and SPLP underestimated the leaching potential from glass beads as compared to the batch studies.
- Further analysis of other batches procured for the study revealed leaching.
- Guidance was provided for As at 100 mg kg^{-1}, Pb at 100 mg kg^{-1}, and Sb at 175 mg kg^{-1}.

Conclusions

- The glass beads procured from the NJDOT and glass vendors may not be representative of the glass beads being used on highways.
- Elevated concentrations of metals and metalloids were observed in the select batches of glass beads with significant variability.
- FP-XRF is a viable a technique that showed a strong correlation with results from HF digestion followed by ICP-MS.

Conclusions

- Leaching studies demonstrated the potential for release of As, Sb, and Pb.
- Results from the TCLP and SPLP tests were not consistent with the batch studies.
- The leachability thresholds are the following: 100 mg kg^{-1} for As, 100 mg kg^{-1} for Pb, and 175 mg kg^{-1} for Sb.

Acknowledgements

This research is funded by New Jersey Department of Transportation utilizing federal State Planning and Research,(SPR) funds. The contents of this presentation reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the NJDOT or the FHWA. This presentation does not constitute a standard, specification, or regulation.