DRONE-BASED HYPERSPECTRAL IMAGING FOR RAPID QUANTIFICATION OF LEAD IN SURFACE OIL

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Background/Objectives:

Mining and industrial operations can cause large-scale contamination of surface soils with lead and other metals. This can include the aerial deposition of particulates or stormwater runoff, tailings releases, and other mechanisms that can result in contamination extending for several miles. Determining the lateral extent of contamination in surface soil by collecting surface soil samples and sending them to an off-site laboratory for analysis can be time consuming in terms of field work, can under or over delineate the extent of contamination, and offers low resolution data density with discrete results provided only at the sample locations. Hyperspectral imaging has been shown in the academic literature to be capable of quantifying metals in soils, including lead. When mounted on a drone, hyperspectral imagery may be acquired over large areas relatively quickly.

Approach/Activities:

To evaluate the potential use of drone-based hyperspectral imaging to quantify lead in surface soils, Parsons mounted a short wave infrared hyperspectral camera on a drone and flew the drone over a closed mine in northern Canada. The flight height was selected to provide a pixel size of approximately 2 inches x 2 inches. Imagery was acquired from 450 acres in approximately 4 days. The hyperspectral camera acquired data over 245 bands. To decrease the large number of bands and speed up processing time, principal component analysis (PCA) was used to reduce the dimensionality of hyperspectral data while also maintaining the variance and trends in the data. After performing PCA, shadow correction was performed to normalize the reflectance values using a digital surface model and the azimuth of the sun at the time of image acquisition. Fifty soil samples were acquired throughout the site and the concentrations of metals in those samples were determined using x-ray fluorescence (XRF). The XRF measurements were used as training data in machine learning random forest (and similar) models to construct surface maps of predicted lead concentrations.

Results/Lessons Learned:

Overall, this study confirmed hyperspectral imaging can perform rapid screening level characterization of metal concentrations in surface soils over a large area with a fine resolution. Key results and lessons learned are as follows:

- Hyperspectral imaging, supported by machine learning models, can characterize lead concentrations in surface soils
- Drone-based imaging provides high resolution mapping capabilities for lead in surface soil
- Several post-acquisition data processing techniques were evaluated, with the Savitzky-Golay filtering identified as optimal for lead
- Several challenges associated with drone-based hyperspectral imaging were identified in this study including:
    - Illumination variability can affect the model accuracy (e.g., cloud cover, time of day)
    - Highly reflective soils (e.g., silt) can bias the predictions high.
    - The large amount of data generated (i.e., several gigabytes) can present logistical difficulties, especially when local data processing is not possible.
    - Drone-based hyperspectral imaging cannot characterize metals in soils with considerable cover (e.g., vegetation, debris, etc.)

Future work will apply this methodology to other metals (i.e., arsenic, zinc).

About The Author

Dr. Rigby is risk assessor and project manager working for Parsons in Salt Lake City. He has worked at sites across the US since 1999. Dr. Rigby has degrees from the University of California, University of Alberta in Canada, and ETH in Switzerland.