Use of Hyperspectral Imaging to Detect Trichloroethylene and Per- and Polyfluoroalkyl Substances in the Environment

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Background/Objectives. The use of hyperspectral imaging and plants for the detection of environmental contamination provides the ability to collect leaves from the suspect site, scan the leaves with the hyperspectral sensor and perform analysis to determine if the plant has been exposed to a contaminant. Spectral instruments, such as hyperspectral sensors, measure electromagnetic reflectance from objects. Hyperspectral image data sets contain information from many wavelength bands, permitting inspection of subtle spectral features. The data sets contain differences in spectra at various wavelengths that potentially can be used to uniquely identify some characteristics of the scanned object and identify changes in those objects. Plants are known to take up a wide range of contaminants from groundwater and soil. Leaves from poplar trees exposed to trichloroethylene (TCE) which are scanned with a hyperspectral imager show the light reflected from an exposed plant leaf differs from the light reflected from a control plant. This change in light reflectance can create a quick and inexpensive alternative to drilling wells, sampling, and laboratory analysis to detect environmental contamination.

Approach/Activities. Poplar trees were grown in a greenhouse and dosed with TCE at 5, 50, and 100 ppb; and 1 and 100 ppm. The poplars were also dosed at 100 ppm for 1, 2, 4, and 10 weeks. Chemical analysis verified trichloracetic acid (TCAA), a TCE metabolite, in leaf samples. Leaves were scanned using a hyperspectral image radiometer and the scans analyzed for a statistical correlation related to changes in reflectance due to TCE exposure. Statistical correlations of light signature changes to TCE exposure were investigated by drawing pixels from dosed plants and control plant images to train a statistical classifier. The ability of the statistical classifier to identify TCE-exposed plants was tested using pixels from dosed and control plant data not involved in training the classifier. Results showed a set of wavelength changes consistent with TCE exposure as low as 85 ppb. Other analyses showed no effects from removing the leaves up to 15 minutes before scanning, leaf maturity, or leaf position on the plant.

This work is expanding to analyze plants that were exposed to per- and polyfluoroalkyl substances (PFAS). Poplars, willow, and wetland grasses were grown in soil and were irrigated with polyfluorooctanesulfonic acid (PFOS). Additionally, poplar cuttings were grown hydroponically in different concentrations of PFOS. The plant leaves were scanned with a hyperspectral leaf radiometer and collected for laboratory analysis to determine uptake and distribution of PFOS within the plants. Scan data are being analyzed to evaluate if PFOS exposure causes a change in spectra signatures.

Results/Lessons Learned. A set of wavelengths corresponding to TCE exposure has been identified and the goal of the research is to develop a spectral database corresponding to TCE exposure. It is expected that the database will be used to develop sampling protocols to guide field sampling with the hyperspectral leaf radiometer. Supervised classifications using hyperspectral images of poplar leaves dosed with TCE at 85 ppb and control leaves consistently resulted in accuracy assessments greater than 70%. Research is continuing with

PFOS-exposed plants. Preliminary results show reasonable accuracies for identifying exposed plants.