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SUPPORT FOR RESOURCE CONSERVATION AND RECOVERY ACT METAL AND AIR STREAM CHARACTERIZATION

TECHNOLOGY NEEDS

MSE Technology Applications (MSE-TA), Inc's., support for the Resource Conservation and Recovery Act (RCRA) Metal and Air Stream Characterization Project is comprised of one task: to select a test bed and evaluate the performance of field transportable technologies in the identification and quantification of RCRA and other heavy metals in soils. The primary objectives of this technology demonstration were to: (1) select and characterize two demonstration sites, (2) select technologies for the demonstration, (3) verify developer claims regarding technology performance, (4) compare field instrument performance to conventional Environmental Protection Agency (EPA) approved laboratory analytical methods and protocols, and (5) determine the logistical and economic resources required to operate each technology demonstrated.

TECHNOLOGY DESCRIPTION

Technology developers involved in the RCRA and Other Heavy Metals in Soil Demonstration were: (1) Los Alamos National Laboratory (LANL), Laser-Induced Breakdown Spectroscopy (LIBS), (2) Meldok, Inc., LIBS, (3) Pacific Northwest National Laboratory (PNNL), Stripping Voltammetry, and (4) PACE Environmental Laboratory, Flame Atomic Absorption.

LIBS is a form of atomic emission spectroscopy in which powerful laser pulses are focused on the soil sample to form a hot micro plasma. Because of high plasma temperature (8,000 to 10,000 K), material in the plasma volume is vaporized, exciting the atoms and inducing atomized, energized, and consequently, characteristic light emission occurs, with unique spectral signatures. Using appropriate calibration, quantitative analysis is possible.

Stripping Voltammetry is a two-step electroanalytical technique for metals concentration measurement. In the first step, the target metal is preconcentrated onto the working electrode, and in the second step, the accumulated metal is stripped by applying an anodic potential scan. The resultant measured peak current is directly proportional to the metal concentration. Alternatively, a constant current is used to strip the accumulated metal and the voltage versus time plot is recorded. Approximately 30 metals can be measured by electrolytic deposition or adsorptive accumulation of a suitable metal chelate onto the electrode surface.

Pacific Northwest Laboratory used three stripping voltammetry systems to measure metals in soils. Adsorptive stripping voltammetry analysis for chromium was performed using an EG&G PAR Model 264A voltammetry analyzer and a PAR Model 303A static mercury drop electrode (SMDE). Stripping potentiometry analysis for Cd, Cu, and Pb was performed using a PSA TraceLab system with a glassy carbon disk or the ETG Metalyzer 3000 system, which has been developed for the determination of Cd, Cu, and Pb in water.

Flame atomic absorption is the process that occurs as a ground state atom absorbs energy in the form of light at a specific wavelength, and is elevated to an excited state. The amount of light energy absorbed at the specific wavelength will increase as the number of atoms of the selected element in the light path increases. The relationship between the amount of light energy absorbed and the concentration of the analyte present in known standards can be used to determine unknown concentrations by measurement of the amount of light absorbed.

BENEFITS

DOE, along with other federal agencies and private industry, are faced with massive soil characterization problems at numerous contaminated sites. It is anticipated that millions of dollars would be required for laboratory analyses to accurately characterize the constituents in the contaminated soil. DOE is attempting to meet the objective of cost-effective field analyses by developing and demonstrating promising field transportable heavy metals in soils measurement technologies.

COLLABORATION/TECHNOLOGY TRANSFER

Organization and execution of the RCRA and Other Heavy Metals in Soils Demonstration was a collaborative effort among the following participants: MSE-TA, of Butte, Montana, a prime contractor of DOE and responsible for operating the Western Environmental Technology Office (WETO); DOE EM-50 CMST-CP; Ames Laboratory (Ames), a CMST-CP support office; Sandia National Laboratories (SNL), DOE's representative to the CMST-CP and under contract to the EPA to provide technology developers with a clearly defined verification pathway; and the technology developers.

The purpose of these demonstrations is to develop and evaluate technologies that can identify contaminants and/or objects of concern in a field application. Potential users of these technologies are widespread across the DOE complex and in the nation. Because the needs are extensive, the technologies would be readily transferable to private entities. Some candidates for these technologies are Superfund sites, existing operating mine sites, and nonoperating mine sites.

Data generated during these demonstrations will result in dissemination of technical and economic information via presentations and/or publications at national meetings, conferences, workshops, seminars, etc.

ACCOMPLISHMENTS

RCRA and Other Heavy Metals in Soils Demonstration was completed in October 1995. The final report has been written and is scheduled to be distributed in June 1996.

Each technology was evaluated individually, and technology analytical field results were compared to the technology developers' claims and averaged analytical results of an on-site analytical laboratory, an off-site analytical laboratory, and an independent analytical laboratory. Analytical laboratories analyzed duplicate soil samples using conventional laboratory methods. Conventional laboratory analysis data was considered confirmatory. All confirmatory laboratories were to abide by the requirements of the project Quality Assurance Project Plan.

Quantitative and qualitative factors were considered in the design and implementation of the technology demonstration. Quantitative factors included accuracy, precision, and sample throughput. Qualitative factors included portability, ease of operation, logistical burden, and robustness.

LANL LIBS technology participated as a Level 1 technology. This was the first field demonstration for this instrument. Precision of this technology was very good, indicating the instrument's ability to duplicate soil sample analyses consistently. However, the accuracy of the LANL LIBS technology when compared to the confirmatory laboratory analyses was generally greater than their performance claim of 20%. Performance Evaluation (PE) samples had Cr and Cd concentrations that were an order of magnitude higher than the demonstration field samples. For the PE samples, the technology detected Cr and Cd within the performance acceptance limits. This technology performed better on lower concentrations of Mn. Sample throughput matched the developer's claim of two samples per hour.

PNNL's static mercury drop electrode (SMDE) technology participated as a Level 1 technology. This was the first field demonstration for this technology. Precision of the SMDE was lower than the developers claim. Accuracy of the technology was acceptable for the PE samples; however, the instrument was less accurate when analyzing the demonstration field samples. SMDE reported results for the field sample were consistently higher than the values reported by the confirmatory laboratories. Sample throughput was 2 samples per hour, while the developer's claim was 4 samples per hour.

Precision of the PNNL, PSA TraceLab was generally below the developer's claim of 40%. Accuracy was generally above the developer's claim of 20% for Cd and Cu, but below 20% in all cases for Pb. Values reported for Cu were

consistently lower than the confirmatory laboratories results, suggesting a possible calibration error. Sample throughput was two samples per hour, while the developer's claim was four samples per hour.

PNNL's Environmental Technology Group Metalyzer 3000 was a hand-held production model prototype Level 1 technology. The developer did not analyze the PE samples or the mandatory duplicate samples, so it was difficult to assess the precision and accuracy of the technology. The developer did perform a duplicate analysis on one sample, then calculated for this duplicate analysis within the developer's claim of 40%. Accuracy of the Metalyzer 3000 did not meet developer's claims for the samples analyzed. Sample throughput was 3.3 samples per hour, while the developer's claim was four samples per hour.

TTP INFORMATION

Support For RCRA Metal and Air Stream Characterization technology development activities are funded under the following technical task plan (TTP):

TTP No. PE153001 "Support For RCRA Metal and Air Stream Characterization"

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BIBLIOGRAPHY OF KEY PUBLICATIONS

None available at this time.