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Project Summary

An X-Ray Fluorescence Survey Of Lead Contaminated Residential Soils in Leadville, Colorado: A Case Study

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Concern over the adverse impacts to human health due to exposure to lead has prompted characterization efforts at numerous sites across the United States. One of the primary exposure routes to man is through the ingestion and inhalation of lead contaminated soils. This problem can be of concern at old mining and smelting locations, such as the California Gulch Superfund Site.

The California Gulch site is a historic lead mining and smelting site that was added to the National Priority List (NPL) in 1983. During the summer of 1991, at the request of the Remedial Project Manager, personnel from the U.S. EPA's Environmental Monitoring Systems Laboratory at Las Vegas participated in a survey that included the design, collection, and analysis of soil samples from this site.

The objective of this survey was three fold: to gather sufficient data that would permit the use of geostatistics to determine optimal sample size and spacing; to identify geographical distribution of soil lead levels in specific concentration ranges; and to demonstrate the ability of field portable X-Ray Fluorescence (FPXRF) instrumentation to generate quantitative data of sufficient and known quality. Satisfying the objectives of this survey required the development of a sampling and analysis plan and a quality assurance project plan that addressed the identification and quantification of error associated with the sampling, sample handling, and analytical methods.

Both field portable and laboratory XRF instruments were used for the survey. The three field portable instruments used were X-Met* 880's marketed by Outokumpu Electronics. For measurement correlation purposes, the laboratory grade Kevex 770, marketed by Fisons Instruments was utilized.

The case study details the XRF monitoring approach, sample collection, preparation, and analysis procedures, and the database management and Quality Assurance/Quality Control measures that were implemented for this survey. This survey demonstrated that field portable XRF instrumentation can produce large quantities of acceptable quality data in a timely, cost-efficient manner.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, NV, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Leadville is about 100 miles southwest of Denver. It is situated on the western slope of the Mosquito Range, just east and upslope of the Arkansas River, at an elevation of approximately 10,200 feet.

* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Mining activity occurred predominantly on the eastern side of Leadville, along the drainages of California, Evans, Stray Horse, Oregon, Malta and Georgia Gulches. Mining in this area was traced to the discovery of placer gold in California Gulch. During 1874, a heavy mineral that interfered with the placer gold operations was identified as silver-bearing lead carbonate. Eventually, the mining and processing turned from the oxidized, carbonate ores to the less desirable sulfide ores, of lead and zinc.

The dispersion of lead occurred from natural processes, such as wind and water; however, in Leadville, the problem was exacerbated by human impacts, ranging from smelter stack emissions to slags that were crushed and spread on icy roads and used for railroad ballast. Tailings and mine waste rock were thoroughly mixed into local soils by over a century of mining and commercial activities in which these materials were often used for fill material. Many homes were built among the waste rock/tailings piles or immediately adjacent to them. The use of these mining generated materials and their close proximity to human habitation raises a health concern and a need to identify the concentrations and the geographical distribution of soil lead within and in the immediate vicinity of Leadville.

Survey

Initially, two major issues had to be addressed. The first issue was to determine if a single matrix model for the XRF instruments would be adequate for analyzing all of the soils within the area to be surveyed. The second issue, stemming from access difficulties, involved determining whether samples collected at the edge of the public easement of alleyways and from nearby residential yards were of a single population.

Assessment of XRF and CLP data obtained from the same samples indicated that a single matrix model could be used. Data assessment to determine the existence of a single soil population was accomplished by using the nonparametric Kolmogorov-Smirnov procedure and the paired-wise sample t-test. The results of these tests showed that no significant differences existed between alley easements and yard soils.

The portable X-Met 880 field units were energy dispersive spectrometers, self-contained, battery powered and microprocessor based, weighing 8.5 kg. The surface analysis probe of these units contained an Americium-241 and a Curium-244 source and a proportional tube counter specifically designed for field use. The Kevex contained a 198 watt, Rh anode, liquid-cooled X-Ray tube and a cryogenically cooled lithium drifted silicon solid state detector.

To achieve the objective of the survey, a Quality Assurance Project Plan and a sampling and analysis plan were developed. The approach identified in these plans called for the collection and analysis of over 3,700 soil samples. The samples were collected along transects at 25-foot intervals. At each sampling location, a volume of soil six inches in diameter and four inches deep was collected. To reduce heterogeneity, the sample was turned onto itself seven times in situ. After mixing, all samples were containerized, labeled, and maintained under chain-of-custody.

Samples were analyzed field moist by an X-Met 880 field instrument three separate times. Each sample was mixed prior to and between each of the three analyses. Following these initial measurements, the sample was dried overnight at 100° C.

After drying, the sample was passed through a 10 mesh sieve onto a 3 x 3 ft piece of paper where the sample was rolled onto itself 20 times to reduce heterogeneity. After mixing, approximately 6 gm taken in 10-12 subsamples were placed into a 31 mm diameter polyethylene X-Ray cell and sealed with 0.2 mil polypropylene film. The capped sample was then analyzed by the Kevex and once again by one of the X-Met 880 field instruments.

Data Assessment

Correlations between the Kevex and the X-Met 880 measurements were identified and documented. The correlations between the instruments were excellent throughout the survey. Monitoring instrument stability was accomplished by quality control check samples measured before and after each block of 10 samples on the X-Met 880 instruments and 13 samples on the Kevex instrument.

Documentation of the correlation between combined X-Met 880 and CLP measurements and between Kevex and CLP measurements are presented.

Conclusions

The lead concentration data obtained by field portable XRF instruments on residential soils in Leadville was optimal for producing concentration isopleth maps that depict gross contamination patterns across the surveyed area. The large number of samples analyzed minimized errors in estimating values at unsampled points, yielding representative depiction of lead distribution.

The utilization of XRF technology was instrumental in analyzing large number of samples over a three month period, thereby allowing the cost- and time-effective determination of spatial patterns of contamination distribution.

The initial assumption that residential soils in Leadville were of a very similar matrix with respect to XRF measurements was verified. The close agreement between XRF results and randomly chosen samples analyzed by CLP methods indicate that the single matrix model used with the X-Met 880 instruments was a reasonable approach in dealing with a soil matrix whose initial components were distinctly different but presumably well mixed by residential and mining activities over a long period of time.

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The complete report, entitled "An X-Ray Fluorescence Survey of Lead Contaminated Residential Soils in Leadville, Colorado: A Case Study," (Order No. PB93-203156/AS; Cost: $35.00; subject to change) will be available only from:
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