US Environmental
Protection
Agency

Field-Portable X-ray Fluorescence

Introduction

Field-portable X-ray fluorescence (FPXRF) is a site-screening procedure using a small, hand-held portable instrument (2.5 lbs.) that addresses the need for a *rapid* turnaround (~2 min./sample), *low-cost* method for the in situ analysis of inorganic contaminants. Traditional Contract Laboratory Program (CLP) methods of analysis may take 20 - 45 days per site to complete and cost much more than FPXRF. FPXRF can measure inorganic elements when used with the proper radioisotope source and the appropriate standards. FPXRF is capable of the simultaneous analysis of up to 25 elements.

Some FPXRF instruments have multiple radioisotope sources allowing the researcher to expand the list of analytes and to select the source which will provide the best quantitation of the element(s) of concern.

FPXRF is useful at various levels of analysis, with data quality dependent upon the extensiveness of the survey, the type of standards used, and the reinforcement of data by other collaboratory methods. FPXRF can be used for periodic monitoring as remediation proceeds. The following table includes the elements that are on the EPA's Inorganic Target Analyte List, with asterisks designating the ones quantifiable by FPXRF. Though detection limits are highly matrix dependent and site specific, the detection limits have been in the 10-60 mg/Kg range. Analyses can be performed on any surface, making FPXRF particularly useful for soil and paint analysis (e.g., for lead).

The Survey

An FPXRF survey is a combined effort of field scientists and geostatisticians. Ideally, it is a pre-survey aerial photographic evaluation of the site, a screening on-site to collect site-specific calibration standards, an off-site calibration of the instrument, and a final on-site visit for data collection and quality control. Then geostatistical interpretation is done and a site screening report is published.

Typically a field survey is requested by an EPA region. Remedial project managers (RPMs) can contact local contractors with the equipment and expertise to do an FPXRF survey. When special help is needed, the RPM may contact the ESD for expert advice. The team that responds is equipped with an FPXRF instrument and all of the necessary supporting equipment to adequately assess the site. Using the calibration curve that has been generated from site-specific standards, if available, the X-ray responses of the routine samples are regressed against this curve and an analytical result is generated. Geostatistics, an interpretive method which allows for the similarity between neighboring samples, is used to optimize the sampling design prior to the survey. After the sampling, geostatistics is used to analyze the data and to produce concentration isopleth maps.

Instrumentation

The principle of X-ray fluorescence is based on the fact that each element will fluoresce in a unique and characteristic way when "excited." When an atom of a given element is bombarded with energy of sufficient strength, an electron will be displaced within the element's electron shell leading to an atomic instability (i.e., excitation). This instability is very short-lived as other electrons rapidly move to replace the vacancy left by the expelled electron. As these electrons jump from energy shell to energy shell to fill the vacancy, a characteristic radiation with unique wavelengths and energies will be released.

The released characteristic radiation then passes into the instrument's detector system which is capable of distinguishing between these energies. Each energy detected is then assigned to a specific element. The greater the number of "hits" for a given energy level, the equal greater the content of that contaminant that is present in the sample. Quantitation can be done against a calibration curve that was generated by the analysis of site-specific (or other similar) standards or using the fundamental parameters approach which mathematically corrects for interferences based on X-ray fluorescence theory.

X-ray fluorescence has been a standard laboratory method for years and the recent availability of portable instruments now allows this method to be taken into the field for use at hazardous waste sites.

How a Field Survey is Conducted

To effectively use FPXRF, the field scientist must ask a few questions. What is the objective of the survey? What data are needed? What is the most efficient sampling scheme? What are the data quality objectives?

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A complete FPXRF analysis is based on calibration of standards that are specific to the site. These standards are collected on the initial site-screening visit and are analyzed by a complete CLP procedure in order to calibrate the FPXRF instrument. Numerous in situ measurements are made on the hazardous waste site. QA/QC is integrated into the program. The resulting data are not only quantitative, but of known quality.

Advantages and Limitations

Advantages

- Low cost analyses
- Ease of operation
- Portable, moves to any site
- Rapid results - real time
- Surface sampling

Limitations

- Complex data interpretation - for geostatistical investigations
- Matrix variability
- Type of soil influences results
- Interelement interferences
- Less sensitive than a complete CLP analysis

Reference

Raab, G. A., R. E. Enwall, W. H. Cole, III, M. L. Faber, and L. A. Eccles, July 1990, X-Ray Fluorescence Field Method for Screening of Inorganic Contaminants at Hazardous Waste Sites. In: *Hazardous Waste Measurements*, M. Simmons, Ed., Lewis Publishers, Chelsea, MI.

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