Radioisotope Chemistry

Age-dating of sediment cores is an essential tool in environmental forensic studies and an integral component of the information needed for remediation and restoration. Forensic study age-dating is used to determine the time at which contaminant deposition occurred and can be used to evaluate trends, measure sedimentation rates, and trace the history of an area in terms of environmental change.

Sample Collection

Sediment cores are collected from areas of interest using a variety of methods, such as gravity or piston coring. To determine accurate sedimentation rates, it is important to collect a core long enough to provide about 100 years of history. Depending on the expected sedimentation rates, a typical core might be 1 to 3 meters long. The cores are collected in plastic or metal sheaths, extruded and sectioned. Sections are normally collected at 1- to 2-cm intervals; some sections are analyzed immediately and others are archived if more analytical detail is needed.

Battelle has experience with age-dating marine and freshwater sediments for forensic studies, remediation projects, and dredging activities. We have successfully age-dated sediment from difficult locations such as rivers and sandy lakes.

Battelle has over 30 years experience in conducting analyses of sediment cores through radionuclide dating and other methods.

Applications

- Age-Dating Sediment
- Environmental Forensics
- Determination of Sedimentation Rates
- Evaluation of Mixed Layer
- Change & Trends Analyses
- Remediation
- Restoration

Instruments

- Liquid Scintillation Analyzer (Beta Counter) (Packard 1900 CA Tri-Carb) (^{14}C analysis)
- Gamma Counter (Princeton) (cesium, beryllium, and other isotopes)
- Alpha Counter (Canberra) (^{210}Pb analysis)

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Applications

Age-dating Sediment Cores: The activity of a naturally occurring radioisotope, ^{210}Pb, is used to calculate sedimentation rates in lakes, rivers, and marine environments. A typical profile is shown in Figure 1. The most useful profile will show decreasing activity to a low and stable level, which would be indicative of the background activity. The method relies on two simplifying assumptions about the sediment: 1) a relatively uniform grain-size distribution with depth, and 2) a relatively constant historical deposition rate.

Sedimentation Rates and ^{210}Pb: Alpha spectroscopy is ideal for analyzing sediments for ^{210}Pb because it is sensitive and provides high resolution. Gamma spectroscopy is sometimes used, but frequently, the resolution is too low and the background level of ^{210}Pb is not detectable. Determination of the background level of activity is very important to calculate accurate sedimentation rates. The procedure involves homogenizing, weighing, and then freeze-drying wet sediment from core segments. Subsamples of the dry sediment are subjected to acid digestion followed by plating onto silver disks for ^{210}Po analysis using alpha counting. The use of this isotope yields improved sensitivity. Sample results are reported as ^{210}Pb activity in units of disintegrations per minute per gram (dpm/g).

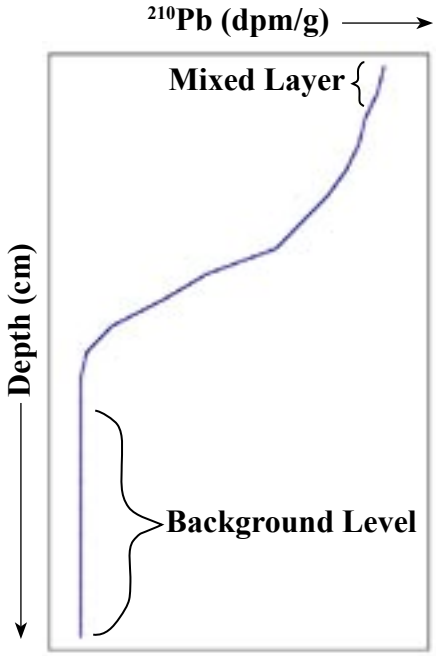

Figure 1. Typical ^{210}Pb Profile

^{137}Cs and ^{7}Be—Validating Sedimentation Rates and Evaluating the Mixed Layer: Results obtained by gamma spectroscopy for these isotopes can be a useful interpretive tool in conjunction with ^{210}Pb data. Because ^{7}Be has a short half-life (53 days), it can be used to determine the sediment mixed layer. ^{137}Cs was deposited on the earth's surface between 1957 and 1965 as a fission product from nuclear testing. Analysis of sediment sections provides the depth at which ^{137}Cs is detected that can be equated to the original years of deposition. This information can be used to verify the sedimentation rates calculated from ^{210}Pb. Verification with ^{137}Cs is extremely useful for situations in which the basic assumptions for sedimentation rates cannot be supported.

Project Examples

Coring and Dating of Sediment Samples—Wyckoff/Eagle Harbor Superfund Site: This investigation focused on the distribution and fate of sediment contaminated with creosote at a former wood-treatment facility.

Reference: Brenner RC, VS Magar, JA Ickes, JE Abbott, SA Stout, EA Crecelius, and LS Bingler. 2002. "Characterization and Fate of PAH-Contaminated Sediments at the Wyckoff/Eagle Harbor Superfund Site." *Environmental Science & Technology* 36(12):2605-2613.

Lake Hartwell, SC—Sediment Core Dating to Evaluate Long-Term Recovery: This study evaluated recovery as a result of natural capping of surface sediments contaminated with polychlorinated biphenyls (PCBs).

Reference: Brenner RC, VS Magar, JA Ickes, EA Foote, JE Abbott, LS Bingler, and EA Crecelius. 2004. "Long-Term Recovery of PCB-Contaminated Surface Sediments at the Sangamo-Weston/Twelvemile Creek/Lake Hartwell Superfund Site." *Environmental Science & Technology* 38(8):2328-2337.

Geochemistries of Metals in Puget Sound, WA: This study determined distributions of arsenic, antimony, mercury, chromium, and cobalt in surface sediments and arsenic in sediment cores from Puget Sound, and related the distributions to sources, transport paths, and associated geochemical reactions.

Reference: Crecelius, EA, MH Bothner, and R Carpenter. 1975. "The Geochemistries of Arsenic, Antimony, Mercury and Related Elements in Sediments of Puget Sound, Washington." *Environmental Science & Technology* 9:325-333.

For more information, contact:

Linda Bingler
1529 West Sequim Bay Road
Sequim, WA 98382
Phone: (360) 681-3627
Fax: (360) 681-3699
E-mail: l.bingler@pnl.gov

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