Using Spanish Moss as a Bio-indicator for Air Pollution in the Low Country of Savannah River Basin

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Overview

- Introduction
- Sample Collection
- Sample Irradiation
- Sample Counting
- Preliminary Results
In this study, we collected samples of Spanish moss along the Savannah river, near some industrial sites and superfund sites from Aiken, SC to Savannah, GA, in order to seek the relationship of heavy metals in the Spanish moss and the air pollution in the low country of Savannah River Basin.
Introduction

• The Savannah River Site (SRS)
  • 310 square miles
  • Borders the Savannah River
  • 1950s produced materials used to create nuclear weapons
  • 5 nuclear reactors
• 1989 - added to the EPA’s National Priorities list
• Contaminated by:
  • Organic compounds
  • Heavy metals
  • Radionuclides
  • Misc. Chemicals
Why Spanish Moss?

- Spanish Moss (Tillandsia Usneoides)
- Epiphytic bromeliad
  - Air plant
  - Uptake nutrients from surrounding aerial environment
- Native to tropical and subtropical climates
  - Southeastern US
- Passive bioindicator
- Benefits
  - Cost effective
  - Large accumulation capacity
  - Allows for longer monitoring periods
  - More sites can be monitored simultaneously
Neutron Activation Analysis

- McClellan Nuclear Research Center
  - University of California Davis
  - 2.0 MW TRIGA Mark II
- Neutron Capture
  \[ n + \frac{2}{3}M \rightarrow A + \frac{1}{3}M + \gamma \]
- Short-lived isotopes
  - Pneumatic Transfer System (PTS)
  - Irradiation time: 25s
  - Thermal neutron flux:
    - \( 4.6 \times 10^{12} \text{ cm}^{-2} \text{s}^{-1} \)
  - Decay for 10 min. prior to counting
- Long-lived isotopes
  - Neutron Transition Doping position (NTD)
  - Irradiation time: 8hr
  - Thermal neutron flux:
    - \( 2.2 \times 10^{11} \text{ cm}^{-2} \text{s}^{-1} \)
  - Decay for 4 days prior to counting
### Sample Counting

- 2 Canberra HPGe detectors
  - 50% efficiency
  - 99% efficiency
- Maintain deadtime below ~ 20%
- Short-lived count time:
  - 600 s
- Long-lived count time:
  - 3600 s
- Lynx system
  - All-in-one digital system
    - Bias high voltage
    - ADC
    - MCA
- Genie 2k software
Sample Analysis

- Net counts \( C \) in a photopeak in a spectrum corresponding with a photon energy is approximately:
  \[
  C = \Delta N \gamma \varepsilon = \varphi_{th} \sigma_{eff}^{N_{Av}} \Theta m_x (1 - e^{-\lambda t_i}) (e^{-\lambda t_d}) (1 - e^{-\lambda t_m}) \frac{\Gamma \varepsilon}{\lambda} M_a.
  \]
  - \( \Theta \) isotopic abundance of the target isotope
  - \( m_x \) mass of the irradiated element
  - \( M_a \) [g/mol] atomic mass
  - \( \Gamma \) [photons/disintegration] probability of the disintegration nucleus emitting a photon of a specific energy \( E_\gamma \)
  - \( \varepsilon \) the full energy photopeak efficiency of the detector (the probability that an emitted photon of a given energy will be detected and contribute to the photopeak at energy \( E_\gamma \))

- Mass of an element measured
  \[
  m_x = C \frac{\lambda}{(1 - e^{-\lambda t_i}) (e^{-\lambda t_d}) (1 - e^{-\lambda t_m}) \varphi_{th} \sigma_{eff}^{N_{Av}} (\Theta \varepsilon \Gamma)} M_a.
  \]

- Mass of unknown element using Direct comparator method
  \[
  m_{\text{unk}} = m_{\text{cat}} \cdot \frac{N_p}{(t_m e^{-\lambda t_d} (1 - e^{-\lambda t_m}))_{\text{unk}}} \cdot \frac{N_p}{(t_m e^{-\lambda t_d} (1 - e^{-\lambda t_m}))_{\text{cat}}}
  \]
Live Time : 86400.000 sec
Real Time : 86406.680 sec
Start: 2: 1.3(keV)
Stop : 4095:2063.3(keV)
Acq. Start : Tue May 16 14:04:43 2017

Annihilation Line
511 keV

Cs-137
661.7 keV

K-40
1460.8 keV

Ac-228
93.5 keV

Ra-226
186.1 keV

Pb-212
238.6 keV

Ti-208
351.9 keV

Bi-214
1746.5 keV

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Environmental Monitoring Along the Savannah River

- Urban-Low-Traffic
- Urban-High-Traffic
- Residential
- Rural Area
- Traffic-related elements:
  - Cd, Cr, Zn, Sb, and Ba are significantly higher
Preliminary Results

• Neutron activation analysis can determine the level of elements in Spanish moss with high accuracy and extreme sensitivity. It is an appropriate tool for conducting multi-element analysis in biological samples.

• The concentrations of heavy metals in the samples has clear correlations with the pollution sources in the Savannah River Area, which proves that Spanish moss can serve as an efficient bio-indicator of air pollution.
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Questions?