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

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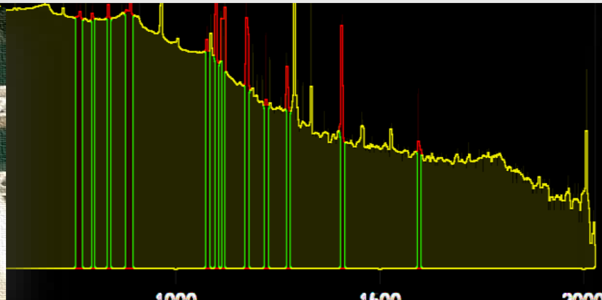
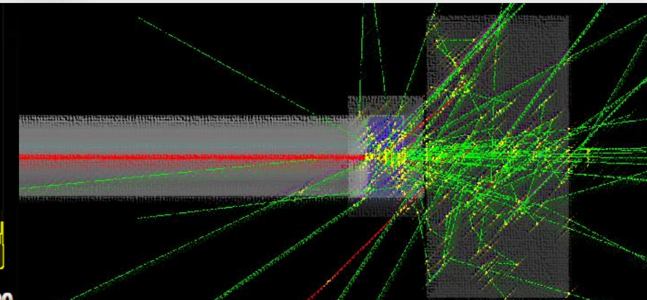



Overview

- Introduction
- Sample Collection
- Sample Irradiation
- Sample Counting
- Preliminary Results

Purpose

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.

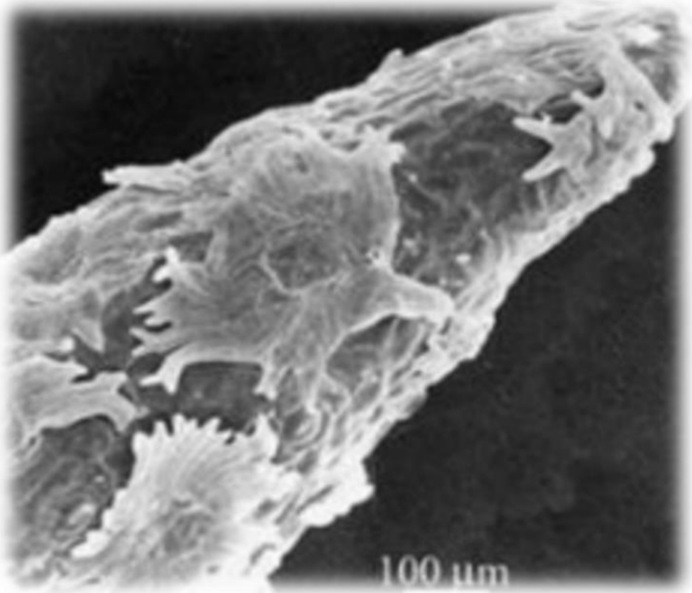
Introduction

- 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

Deadly legacy: Savannah River site near Aiken one of the most contaminated places on Earth | News | postandcourier.com

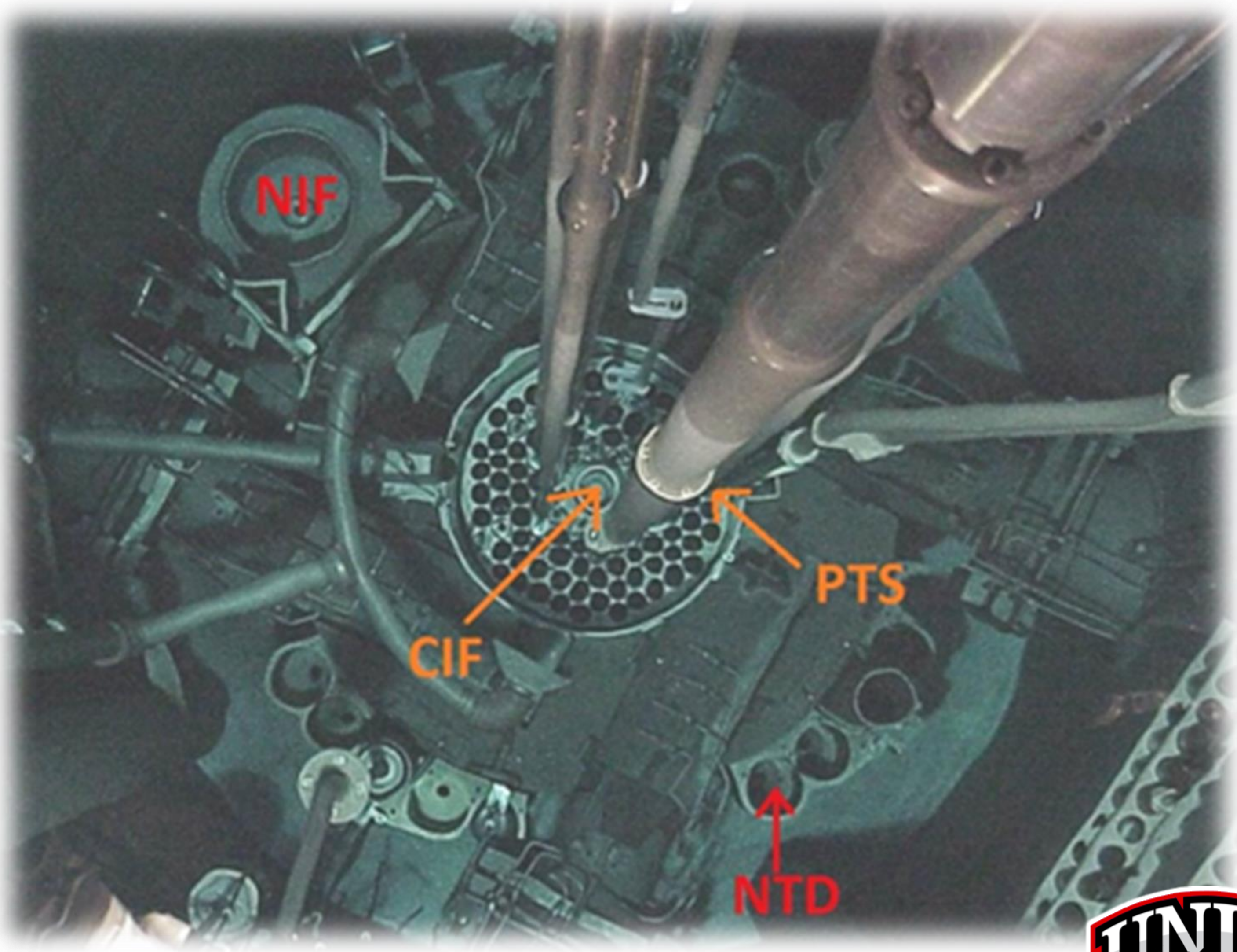
Why Spanish Moss?

- 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
  - $n + {}^{A}_{Z}M \rightarrow {}^{A+1}_{Z}M + \gamma$
- Short-lived isotopes
  - Pneumatic Transfer System (PTS)
  - Irradiation time: 25s
  - Thermal neutron flux:
    - $4.6 \times 10^{12} cm^{-2} s^{-1}$
  - Decay for 10 min. prior to counting
- Long-lived isotopes
  - Neutron Transition Doping position (NTD)
  - Irradiation time: 8hr
  - Thermal neutron flux
    - $2.2 \times 10^{11} cm^{-2} s^{-1}$
  - Decay for 4 days prior to counting

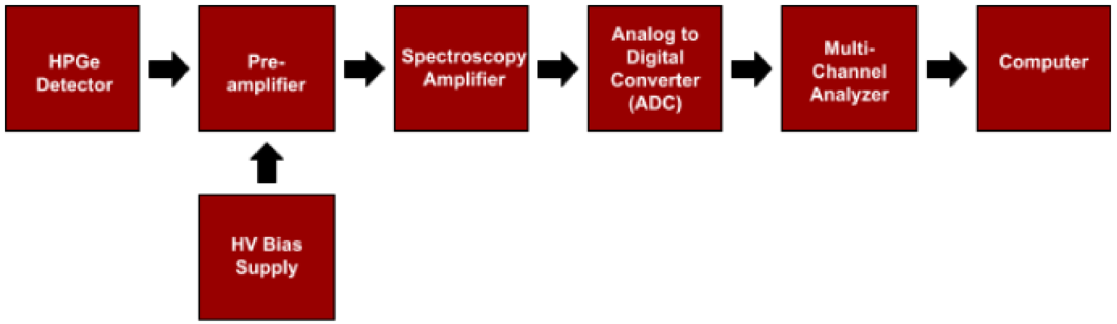


Sample Counting

- 2 Canberra HPGe detectors
  - 50% efficiency
  - 99% efficiency
- Maintain deadtime below ~ 20%
- Short-lived count time:
  - 600 s
- Long-lived count time:
  - 3600 s

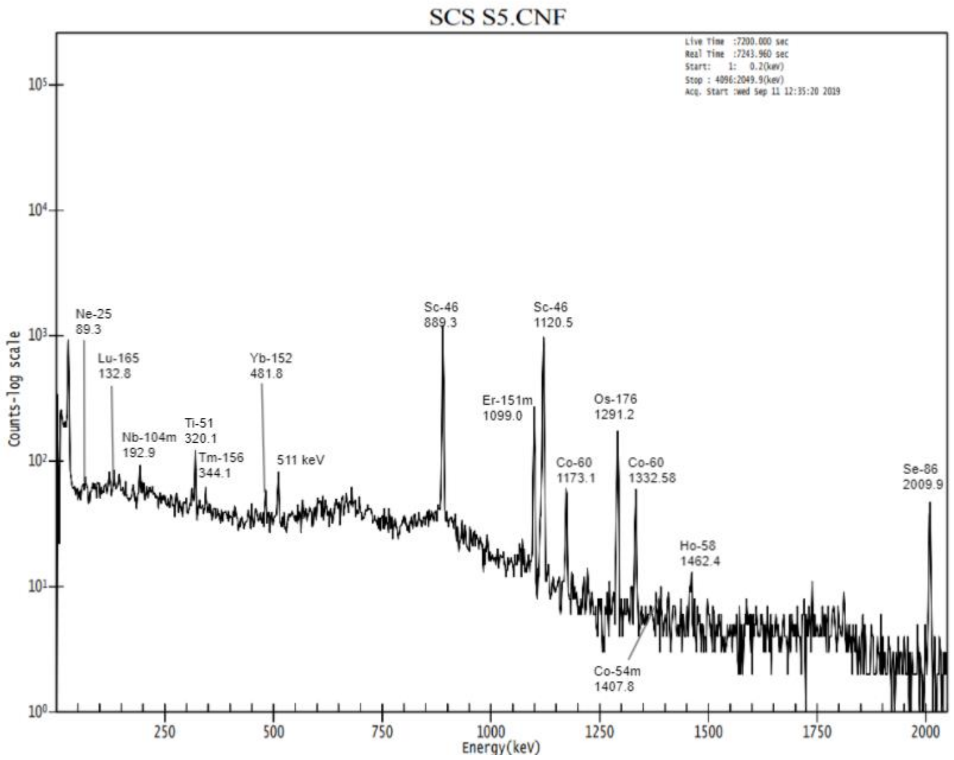
- Lynx system
  - All-in-one digital system
    - Bias high voltage
    - ADC
    - MCA

- Genie 2k software



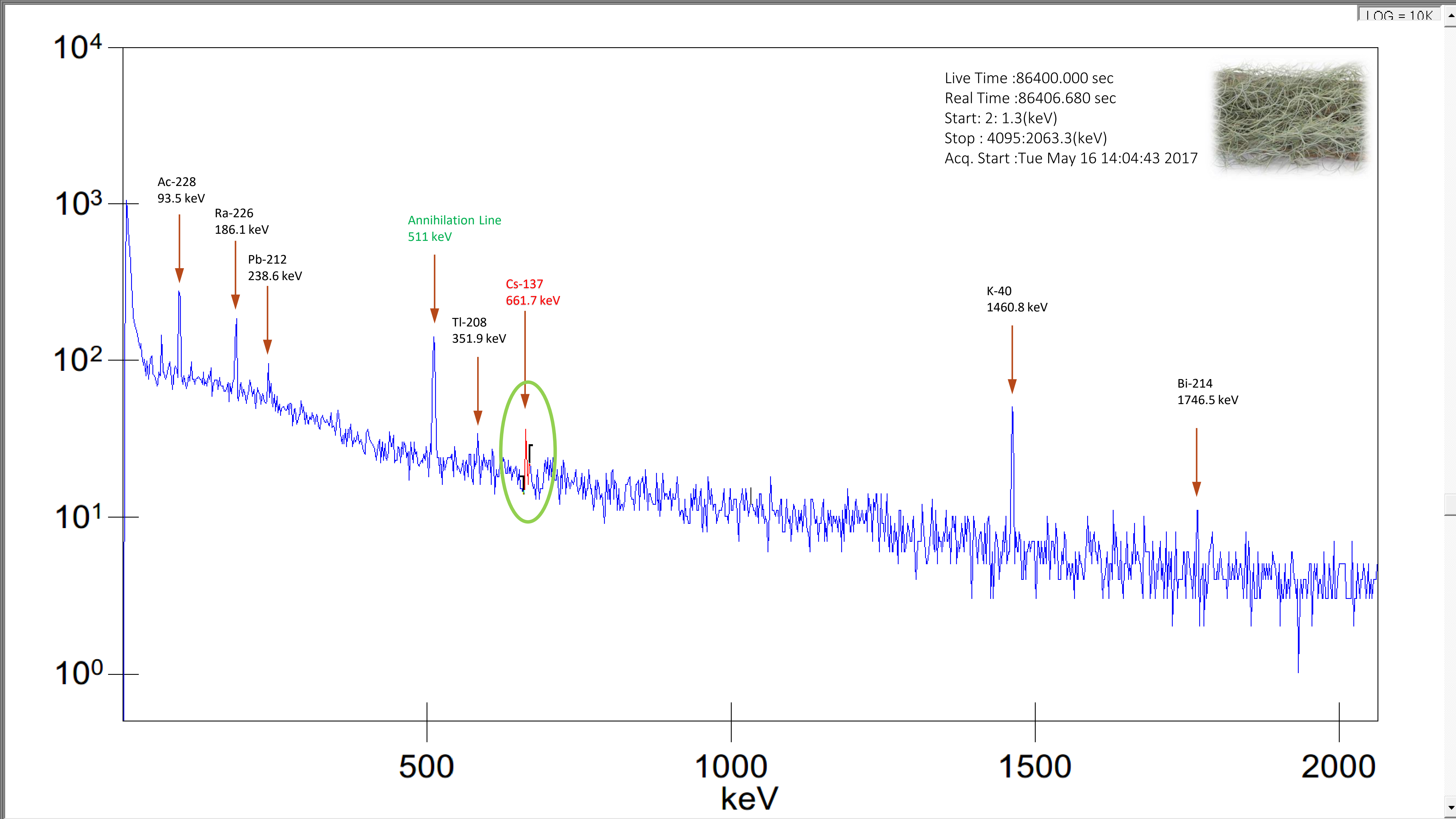
Sample Analysis

- Net counts [C] in a photopeak in a spectrum corresponding with a photon energy is approximately:
    - $C = \Delta N \gamma \varepsilon = \varphi_{th} \sigma_{eff} \frac{N_{AV} \theta m_x}{M_a} (1 - e^{-\lambda t_i})(e^{-\lambda t_d}) \frac{(1 - e^{-\lambda t_m})}{\lambda} \Gamma \varepsilon$
        - Θ isotopic abundance of the target isotope
        - m_x mass of the irradiated element
        - M_a [g/mol] atomic mass
        - Γ [photons/disintegration] probability of the disintegration nucleus emitting a photon of a specific energy E_γ
        - ε 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_γ)



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

- Mass of unknown element using Direct comparator method
    - $m_{unk} = m_{cal} \cdot \frac{\left(\frac{N_p}{t_m \cdot e^{-\lambda t_d} \cdot (1 - e^{-\lambda t_m})} \right)_{unk}}{\left(\frac{N_p}{t_m \cdot e^{-\lambda t_d} \cdot (1 - e^{-\lambda t_m})} \right)_{cal}}$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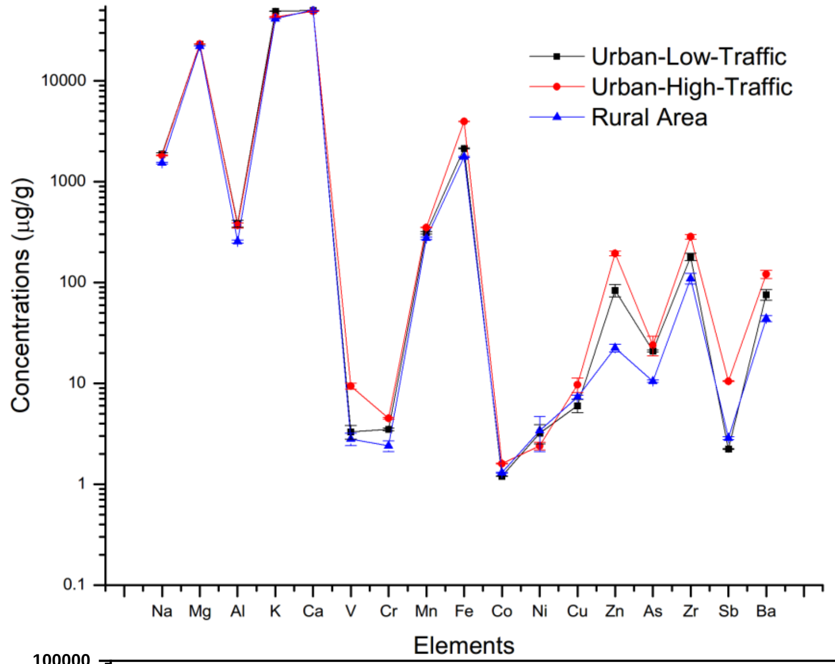
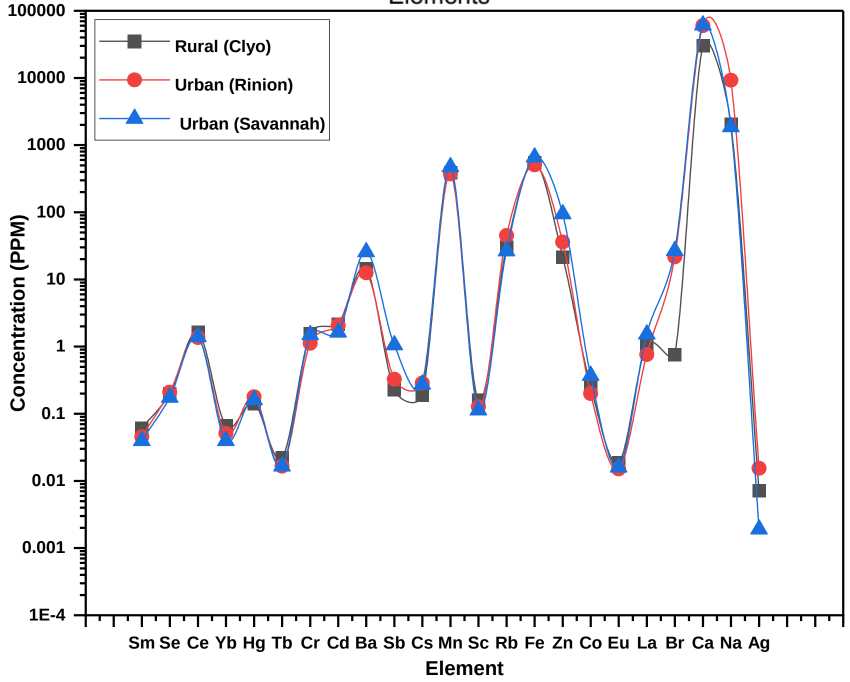
Ac-228
93.5 keV
Ra-226
186.1 keV
Pb-212
238.6 keV
Annihilation Line
511 keV
Tl-208
351.9 keV
Cs-137
661.7 keV
K-40
1460.8 keV
Bi-214
1746.5 keV
10^4
10^3
10^2
10^1
10^0
500
1000
1500
2000
keV

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

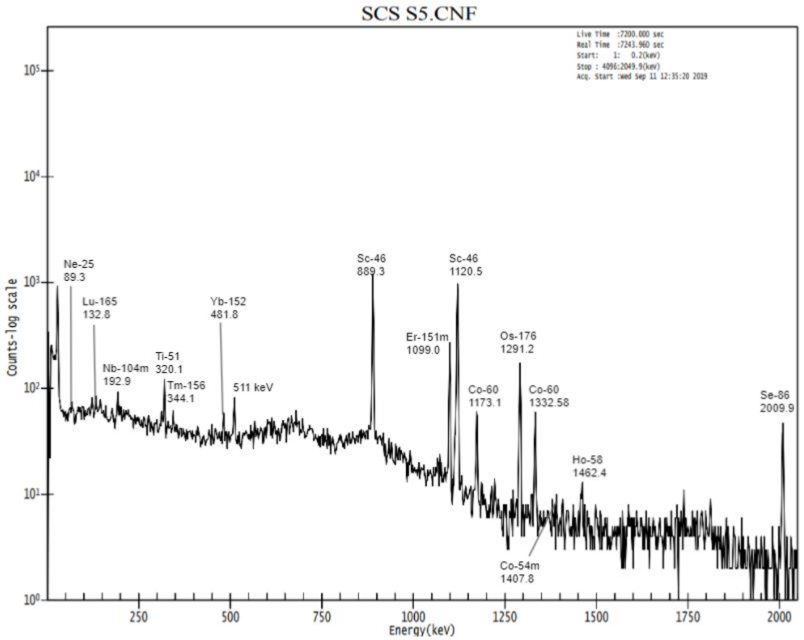




Preliminary Results

- 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.



Acknowledgement

- Students from the HERD group:

  Peter Dimpfl, Robert Gentile, Christina Hall, Nafisat Isa, Amelia Manhardt, Gianni Nelson

- Dr. Wesley Frey at the McClellan Nuclear Research Center of UC DAVIS;

- This research is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Evans-Allen project number SCX312-07-20.

USDA

United States Department of Agriculture
National Institute of Food and Agriculture

Questions?