Uranium Uptake for *Capsicum Annuum* in Various Growing Conditions

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### Abstract

Uranium is naturally radioactive and commonly found in water, soil, and rock. It can occur in elevated concentrations due to the presence of ore bearing bodies and be concentrated through human activities. This thesis focuses on uranium uptake for *Capsicum annuum* for three growing conditions. These include a set of plants grown in hydroponic systems, and two traditionally grown, one with a single acute spike and the other with constant contamination. In addition to the dose scenarios there are two controls, a hydroponic and a traditionally grown. The commercially grown pepper plants were cropped to remove mature seed pods. The plants were then allowed to grow (uncontaminated) until new peppers were just forming. At that point, uranium as uranyl acetate was added. Uranium concentration ratios (soil to plant) were developed for the different growing conditions. While uranium concentrations were larger in traditionally contaminated plants than hydroponic systems, uranium concentrations in soils were larger than in hydroponic; thus, concentration ratios for hydroponic systems were larger than traditionally contaminated systems.

### Materials and Methods

Plants were grown in the Nuclear Engineering and Radiation Health Physics (NERHP) due to the use of radioactive materials in the experiment.

- Three growing conditions were chosen:
  1. Hydroponic
  2. Constant Contamination
  3. One-time Spike
- A concentration of 50 µg/mL uranium for hydroponic and constant contamination.
- A concentration of 700 µg/mL uranium for one-time spike.
- Prior to contamination, existing peppers were clipped for analysis. Contamination continued for 34 days. The following steps were taken for analysis:
  1. Samples were dried.
  2. Pepper samples were ground using SPEX Sample Prep Mixer/Mill 8000M.
  3. Hydropon samples were ground by hand.
  4. Samples were encapsulated in a 2.5 dram vial and then encapsulated in a 2 dram vial.
  5. Standards and Reference Material were prepared and encapsulated.
  6. Samples were irradiated in the OSU TRIGA Reactor.
  7. Analysis was performed using HPGe for Np-239's 106.1 and 277.6 keV peaks.

### Neutron Activation Analysis

Since uranium is an alpha emitter, it cannot be measured using conventional detectors. Instead, neutron activation analysis needs to be performed. As the sample is present in the reactor, there will be a decrease in uranium atoms due to absorption of neutrons and being fissioned and a proportional increase in daughter atoms. It is thus desired to measure a daughter product of uranium that undergoes radioactive decay that can be measured using conventional detectors. One such interaction is the absorption of a neutron from U-238, resulting in the following decay chain:

\[
{\text{238U}}(n,\gamma)^{239}\text{U}{\text{239U}}(\beta^-)^{239}\text{Pu}(\alpha)^{235}\text{Np}+4n
\]

In this decay chain, the nuclide of interest is Np-239. As Np-239 decays it emits a beta particle as well as several gammas. In this analysis, the gammas of energies 106.1 and 277.6 keV are of interest. These gammas can be detected using a high Purity Germanium (HPGe) Detector. The actual activity of the sample can be calculated using standards that are irradiated with the samples in the group.

A standard is also irradiated that has a known weight of Uranium. The irradiation facility and irradiation time, will have an expected activity of the sample. This expected activity is compared to the actual activity, such that:

\[
\text{Weight of } U \text{ in sample} = \frac{(\text{Counts of Np239} - \text{Background Counts})_{\text{sample}}}{(\text{Counts of Hp239} - \text{Background Counts})_{\text{standard}}} \times \text{Weight } U
\]

### Results

The uptake of uranium into pepper plants before contamination was measured. In these cases, Uranium content averaged between 0.5 to 1.7 ppm. The resulting pepper plant uptake was up to 0.4 ppm. Negative values on the graph indicate that values were below detectability limits. One thing to note is that the pepper plants were more likely grown for a longer period than the 34 day period of this study: starting as seed and progressing to mature pepper plants. This would have caused a larger uptake of uranium over the plant's cumulative life.

After uranium contamination, uranium content in soils varied from 350 to 460 ppm for constant contamination, 560 to 860 ppm for one-time spike, and only 2 to 2.5 ppm for hydroponic systems. While the pepper concentrations were more comparable, varying between 0.25 and 0.07 ppm. However, due to the smaller concentrations in the hydroton of the hydroponic systems, this yielded larger concentration ratios.

### Conclusions

While uranium uptake into the plant was comparable for each condition, the uranium uptake into the hydroton for the hydroponic systems was considerably less, yielding a lower concentration ratio. This could be due to the larger amounts of drainage in the hydroponic system or due to the inherent properties of the hydroton. This suggests that for hydroponic systems, the concentration ratio may not be appropriate for comparison with traditional systems.

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