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Biomonitors of Environmental Contamination from the Nuclear Industry: Implications for monitoring the Growth of Nuclear Energy

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Abstract

We have investigated the use of tree bark and lichen as tracers of the source, nature, and extent of environmental contamination from the nuclear industry using two test cases in southwest Ohio: the former Miamisburg Mound Laboratories site (MML) and the former Fernald Feed Materials Production Center (FFMPC). Although these facilities were primarily dedicated to the nuclear weapons industry during the Cold War, similar sampling and analytical approaches could be applied towards environmental monitoring associated with the nuclear energy industry.

Results from tree bark transects in the vicinity of, and emanating from, the FFMPC show that tree bark serves as a long-term archive of particulate matter leaked to the atmosphere from the nuclear industry. Increasing uranium concentrations, and the increasing presence of non-natural (depleted and enriched) uranium (DU and EU, respectively) in tree bark as the FFMPC is approached, preserves a time-integrated record of the source, nature, and extent of uranium contamination to the environment. Furthermore, our results show that the presence of ^{236}U, an essentially non-naturally occurring isotope of U that is produced in nuclear reactors, is a highly sensitive tracer that can be diagnostic of environmental contamination even in cases for which perturbations in the relative abundances of the major isotopes of uranium, ^{235}U and ^{238}U, cannot be resolved. These data are consistent with historically documented major releases of uranium dust to the environment from the FFMPC (Conte et al., in review).

The MML, in contrast, represents a site for which there is no previously documented evidence for off-site contamination. Nevertheless, results from both uranium and thorium isotopic analysis of lichens from the vicinity of the MML reveal the presence of actinide contamination in the environment surrounding the former MML site. Despite natural $^{235}U/^{238}U$ ratios, the presence of measureable ^{236}U provides unequivocal evidence for a component of anthropogenic uranium related to the nuclear industry. Furthermore, a positive correlation between $^{236}U/^{238}U$ and $^{230}Th/^{232}Th$ in the lichen samples suggests the presence in the environment of contaminant ^{230}Th, an isotope previously identified as one of several significant on-site contaminants (McHugh et al., in prep).

Given the projected increase in demand for electricity and expansion of nuclear power capacity globally (IAEA 2016), and associated increase in nuclear fuel production and reactors, there is a need for monitoring programs that evaluate present day background levels of actinides in the environment, as well as past, present, and future contamination of the environment in the vicinity of facilities related to nuclear energy production. We propose that techniques similar to those demonstrated in our FFMPC and MML studies can be used to monitor baseline actinide levels in the environment, and to monitor both inevitable, and often "stealth" leaks to the environment, as well as to evaluate the degree and areal extent of contamination resulting from catastrophic events.

References:

Conte, E., Widom. E. and Kuentz, D. (in review), Uranium isotopes in tree bark as a spatial tracer of environmental contamination near former uranium processing facilities in southwest Ohio. Journal of Environmental Radioactivity.

IAEA (2016), Energy, electricity and nuclear power estimates for the period up to 2050. Reference Data Series No. 1, 2016 edition.