Metabonomics for Detection of Nuclear Materials Processing

Sandia National Laboratories

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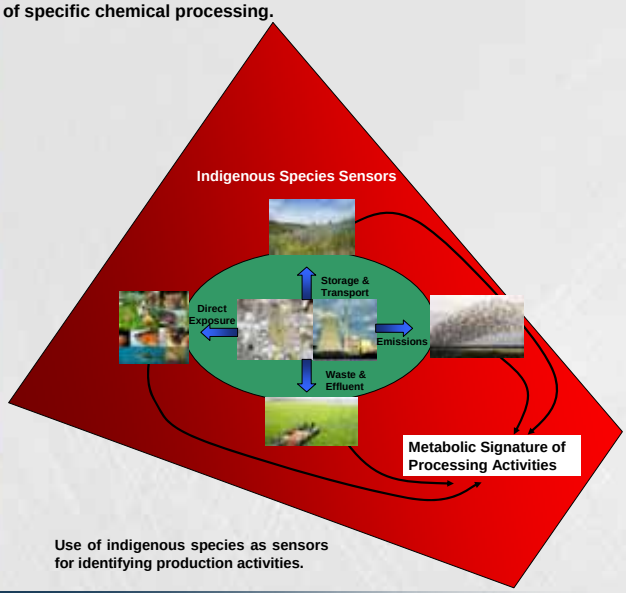
LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Problem

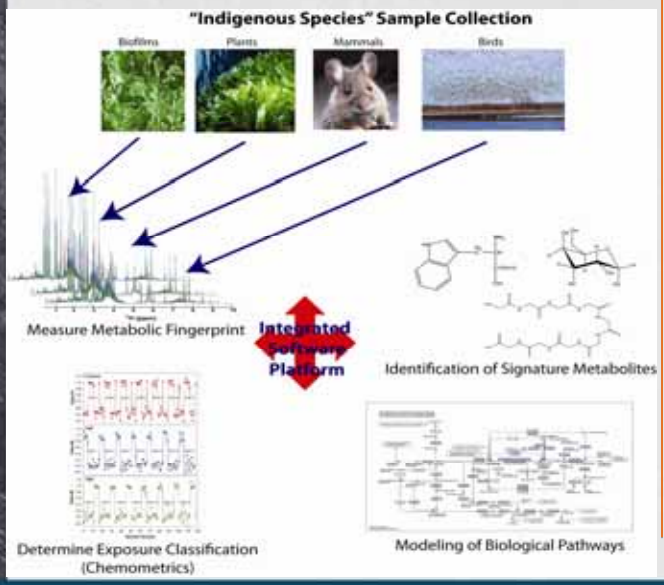
- Tracking Nuclear Materials production, especially covert operations, is a critical problem for nations worldwide. Model Additional Protocol now allows environmental sampling under certain conditions.
- Existing methodology relies heavily on isotope analysis. New methods that could detect chemical exposure, including chronic low-level environmental exposure are desired.
- This project demonstrates the use of metabolic response (metabolic fingerprinting) within indigenous species as a possible tool for detection of specific chemical processing.



Use of indigenous species as sensors for identifying production activities.

Approach

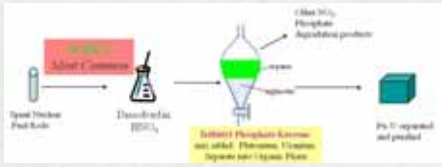
- By monitoring the metabolic response of different organisms, nuclear magnetic resonance (NMR) spectroscopy is used to provide unique metabolic fingerprint that allows identification and tracking of exposure to chemicals used in nuclear materials processing activities.

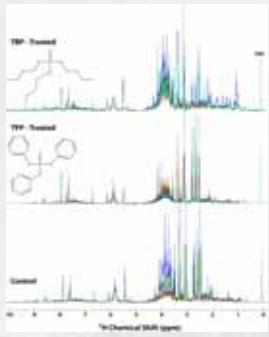


Results

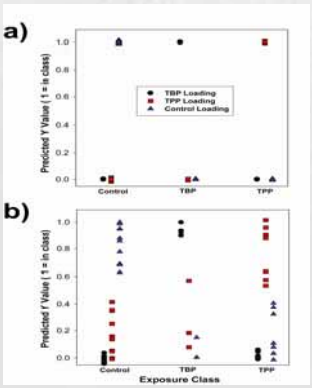
NMR spectroscopy in combination with chemometrics provides a method for detecting environmental exposure.

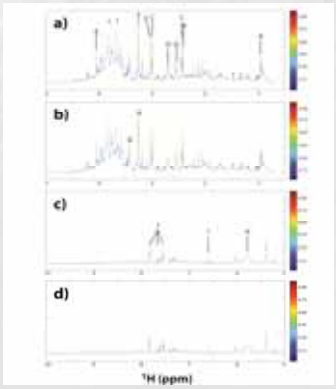
Schematic of the PUREX process from which we have targeted tributyl phosphate (TBP) as a signature of nuclear processing.





Experimental exposure of rats to different doses of TBP followed by collection of the urine and subsequent NMR and chemometric analyses. Control animals and animals exposed to the common industrial chemical triphenyl phosphate (TPP) were also evaluated.





Classification results (Left) clearly identify TBP exposure from control and other background phosphate exposure. New chemometric tools (right) such as Orthogonal Partial Least Squares Discriminate Analysis (O-PLSDA) combined with Variable Importance in Projection (VIP) score weighting, provide the spectral signature responsible for this exposure classification.

Significance

- Detection of covert nuclear materials processing facilities is of paramount importance.
- Metabolic profiling allows indigenous species, such as plants, animals or microbes to be used as sensors, allowing hundreds of possible sensors, if not more, always available to provide monitoring data.
- The method of metabolic profiling can be extended or applied to other chemicals of interest.

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