INNOVATIONS IN NEXT GENERATION CB THREAT CHARACTERIZATION AND ASSESSMENT FOR DECISION SUPPORT

Leveraging The Outdoor And Built Environment Microbiota For Threat Signature Detection And Decision Support

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Detection of nuclear fuel cycle, enrichment, and weapon development activities is critical for supporting warfighter preparation in chemical, biological, radiological, nuclear, and explosives (CBRNE) operations, nuclear compliance, and clandestine activities. Disadvantages of conventional radiation monitoring and detection systems of being easily identifiable, mandatory placement near a radioactive source for detection, and capacity to report radioactivity at a specific moment in time diminish their applications in the field. In the event of source relocation and contamination, the ability to detect trace amounts of ionizing radiation is a paramount concern for CBRNE operations and prevention of clandestine activities. Microbes in the environment experience behavioral and morphological changes in response to environmental stress, including low-dose ionizing radiation. These responses are known to sometimes persist even after the stress is removed. We hypothesized that these responses can be monitored through transcriptional changes and could be harnessed for biosensors capable of discerning radionuclide type have the potential to monitor and report on nuclear fuel cycle, enrichment, and weapon development activities in diverse environmental conditions.

Transcriptomic profiling through mRNA sequencing analysis revealed unique responses of microorganisms after exposure to acute and chronic radionuclides representative of the nuclear fuel cycle. After quantitative PCR verification, genes with high abundance and overexpression were selected as candidates for biosensor development. Key differences in gene expression were seen in Pseudomonas putida and Escherichia coli after acute and chronic exposure to plutonium-239, tritium, and iron-55 at a dose rate of 8.7 mGy/d. Importantly, these differences do not appear to be overlapping other well-known stress signatures. Substantial differences in differentially expressed genes were noted between acute and chronic exposures datasets indicating the potential presence of a radiation-induced time signature.

In a complementary body of work, we have been studying the core microbes of indoor microbiomes to identify taxa that could host robust programs for airborne threat detection. Analysis of different rooms from different geographical locations indicate a major influence from human and soil microbiomes. We have sought to reduce the burden of engineered microbes to enable their use in environmental and competitive scenarios, taking three approaches. First, we pick microbes from that particular ecological niche. Second, we split the sensing program into two hosts. Third, we reduce other metabolic burden in these engineered cells.
Together, our combine projects suggest the use of both natural microbial responses and engineered microbial response to drastically improve threat Signature Detection and Decision Support

Work described in this abstract has been funded by DTRA (HDTRA1-17-1-0002) and a DARPA YFA award (N66001221400).

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