Investigation and Development of New Techniques in Response to a Nuclear or Radiological Emergency

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FST-51200.65.17.24 Year 2 of 3

Objective:

To address gaps in current emergency response capabilities by developing three new methodologies/technologies as follows:
1. Identify radiation induced biomarkers using genetic methods, for the rapid identification and quantification of accidental exposures following a radiological or nuclear emergency.
2. Develop advanced source reconstruction and dose modelling techniques applied with data assimilation for accurate prediction of field dose maps.
3. Decontamination of people and equipment and development of a delivery system.

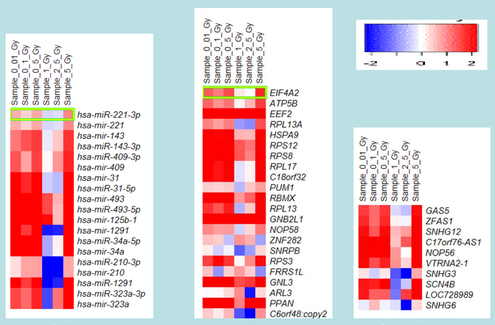
Radiation Biomarkers

Previous Work Completed

- Exosomes were purified from the plasma of healthy donors, exosomes were verified using exosomal markers.
- miRNA was then purified from exosomes
- Several potential exosomal miRNA biomarkers were identified following reverse transcription, RT-PCR array
- RNA Sequencing and mass spectrometry (by SBI company) was performed on the exosomes of the plasma.

Work completed 2019/2020

- With the help of the Bioinformatician of SBI, high throughput RNA sequencing was analysed, identifying several potential radiation induced biomarkers.
- Ordered antibodies for western blot and designed primers for real time PCR, for the validation of potential biomarkers.
- Established the low throughput validation assays
- Collected and irradiated the blood of second batch of donors, and collected the plasma.



miRNA mRNA lncRNA

Expected Outcomes

- Identified several potential biomarkers
- Established low throughput assays

Achievements and successes

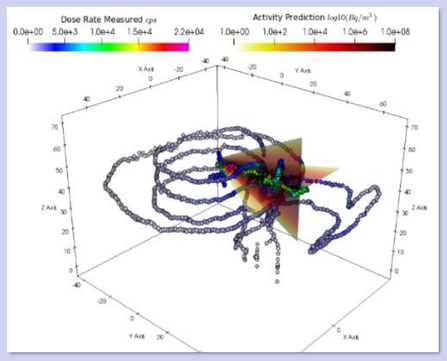
- Identified several potential biomarkers
- Presented at International Congress of Radiation Research August 2019

Future Work

- To validate the potential biomarkers using blood of new donors
- A manuscript will be prepared for peer review publication submission

Source reconstruction and dose mapping

Previous Work Completed

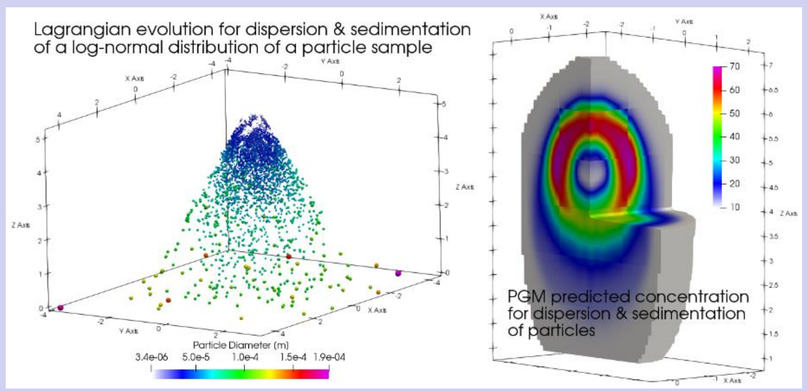


Reconstructed source and dispersion parameters

$$Q[Bq/s] = 3.47 \cdot 10^{8}$$

$$\sigma_y[m] = \frac{0.11x}{(1 + 1 \cdot 10^{-4}x)^{0.5}}$$

$$\sigma_z[m] = \frac{0.09x}{(1 + 1.5 \cdot 10^{-4}x)^{0.5}}$$



Current and Future Work

- Further investigate the properties of a polydisperse Gaussian model (PGM) for Eulerian multiphase flows in which particles can exhibit a range of diameters and velocities at a single location (JCP2019)
- Advance the development of PGM for performing 3D modelling of atmospheric dispersion of radioactive plume in the near field and meso-γ scale range
- Advance the data assimilation procedure of field measurements for accurate source reconstruction and dose mapping

Expected Outcomes

- Dose mapping evaluation completed in a report.
- Report and/or publication documenting efficiency of rapid update of dose mapping

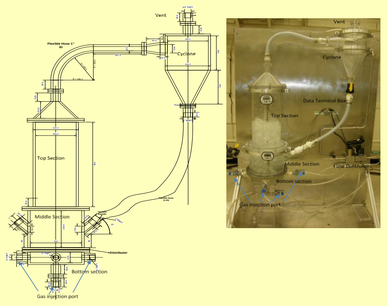
Achievements

- Presentation at International Congress on Industrial and Applied Mathematics 2019
- Presentation at the European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery (NERIS) 2019
- Paper “A Gaussian Moment Method for Polydisperse Multiphase Flow Modelling” accepted in the Journal of Computational Physics, July 2019

Decontamination

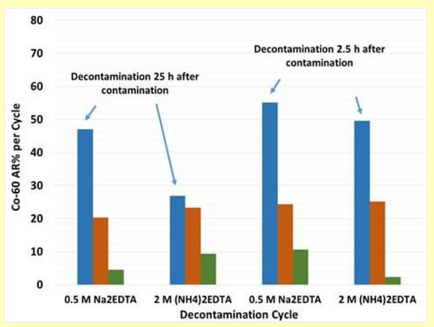
Previous Work Completed

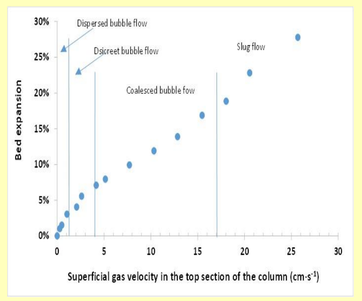
- A diffusion cell was used to test the effectiveness of wet and dry decontamination processes for removal of ^{60}Co and ^{137}Cs from pig skin (simulating human skin).
- A fluidization apparatus was constructed in-house for decontamination of small tools.

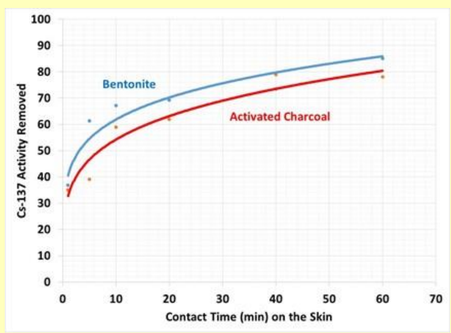


Current Work

- Wet processes assessed (reagent type and concentration, pH, ageing of radionuclide on skin, no. of cycles)
- Dry processes assessed (type of adsorbent, particle size, adsorption time, permeation of radionuclide through skin)
- Fluidization apparatus commissioned; tests in progress







Expected Outcomes

- Wet and dry processes for the removal of radioactivity from skin developed and optimized.

Achievements

- Increased reagent concentration or number of decontamination cycles not beneficial; decontamination as soon as possible after contamination is the key
- Common materials are effective for dry skin decontamination. ^{137}Cs permeates through skin faster than ^{60}Co

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Stakeholders: Health Canada (primary), CNSC, Environment Canada, Public Safety, Defense Research and Development Canada

*PL – Project Lead
*TL – Technical Lead