VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Md. Moudud Hasan**

The public defense will take place on **Tuesday, 11th October 2022 at 5:00pm** in room **D.2.01** (Building D, Brussels Humanities, Sciences & Engineering Campus)

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IN-SITU METHODS FOR HIGH RESOLUTION MAPPING OF RADIOACTIVE SOIL CONTAMINATION

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Abstract of the PhD research

Every country with older nuclear installations or NORM-related industries, including Belgium, suffers from problems related to radioactive soil contamination, usually with large volumes of contaminated soil involved. For radiological impact assessment of a site and environmental decommissioning and remediation, an accurate estimate of the three-dimensional distribution of radioactive contamination and its uncertainty (measurement and spatial) is of crucial importance. Uncertainties of such estimates in the context of remediation are sometimes very large, and further methodological developments are needed to reduce them. The main objective of this thesis is to develop new in situ measurement techniques and improve existing techniques for the determination of the distribution of radioactive contamination at affected sites.

A key step in any measurement of radioactivity is the calibration of the detector efficiency. Monte Carlo simulation was used to calculate the efficiency of the detector used in this study. In situ gamma spectrometry above the soil surface, conducted on a predetermined grid using a $LaBr_3$(Ce) detector based portable measurement setup, can be used to map the level of radioactive contamination in the soil. However, the field of view of a gamma detector can be tens of meters depending on the height of the detector above the soil surface, the source energy and the density of the soil and air. The Tikhonov regularization-based 2D inversion methodology was used to disentangle the contribution of the adjacent area. The method performed well in assessing the ^{133}Ba and ^{137}Cs surface-source activity distributions.

The depth distribution of radioactive contaminants (e.g., ^{137}Cs) is also a critical piece of information for characterizing a contaminated site. An in situ borehole gamma logging method was studied in a ^{137}Cs-contaminated field. The activity-depth distribution was calculated using different inversion methods, such as least squares optimization, Tikhonov regularization and Bayesian data inversion. The calculated activity-depth profiles were in good agreement with those obtained from the soil samples analysis. A dosimetric approach to measuring the activity-depth distribution using Thermoluminescence Dosimeters (TLDs) was also developed, which is a novelty in borehole measurements for radiological site characterization. The developed dosimetry-based method is less destructive and requires no inspection during measurement.

The methods studied in this thesis are particularly useful for collecting data at a contaminated site using relatively few resources. More data can help to improve the spatial resolution in contamination mapping, thus reducing the global uncertainty related to a surveying campaign, which leads to greater confidence in the estimation of the contaminated volume, a crucial parameter in a remediation plan.