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Spatio-temporal optimization of groundwater monitoring network at Pickering Nuclear Generating Station

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CANada Deuterium Uranium (CANDU) reactors have been in operation since the 1950s. Nowadays, CANDU Owners Group (COG) is actively pursuing Strategic Research and Development to improve CANDU decommissioning and remediation activities. As part of this initiative, optimization of sampling optimization and characterization methods for soil and water are being pursued, as these can significantly reduce decommissioning costs. The adequacy of current approaches in distributed screening networks is questioned by calling statistical and geostatistical criteria. Opportunities for improvement have been identified to support optimization of the number and location of sampling points at CANDU nuclear sites in a safe enclosure or undergoing active decommissioning, by considering the special site conditions, e.g., subsurface buildings or structures. As a case-study, soil and groundwater monitoring measurements at the Pickering Nuclear Generating Station (PNGS) have been investigated. Subsurface geology of the site was investigated, and the geologic materials beneath the site were found to be primarily considered to be aquitard, except sand and gravel. Besides, four main hydrostratigraphic units were distinguished in the sediments.

Quarterly groundwater tritium concentration from the PNGS site data was reviewed, and the maximum tritium value was interpolated and mapped across the site using (logarithmic) kriging system of equations. The current study is a spatiotemporal geostatistical analysis on the tritium concentration, acquired over the last 18 years. This study is divided into three parts: **(i) 2D spatial:** comparing successive tritium concentration 2D spatial maps. **(ii) Spatiotemporal:** applying spatiotemporal variography analysis and kriging to improve the spatial resolution of the interpolations by conditioning to the additional samples in the temporal neighborhood. **(iii) Sampling optimization:** using the cross-validation method of leave-one-out iteratively to find out the best combination of monitoring wells.

The first step aims at meeting the groundwater monitoring objectives, i.e., contaminant migration rate, direction, and potential discharge pathway. The second step is a spatiotemporal case-study. As temporal variography revealed high temporal correlation, the temporal neighborhood is used to improve the interpolations when a well is not sampled in a specific year. In this part, the ratio of spatial correlation (SC) to sampling spacing (SS) is introduced and compared to its equivalent in the temporal domain, i.e., the ratio of temporal correlation (TC) to sampling rate (SR). Since the latter (SC/SS) is larger than the former (TC/SR), it is discussed that for a spatiotemporal study, samples should be added in spatial dimension and reduced in a temporal dimension other than if there are any post-incident/accident situations. Finally, the goal of the third step is to optimize spatial and temporal sampling, thus proposing to add, to replace or to remove some samples in the spatial or in the temporal dimension.

Keywords:

Tritium monitoring, undergoing active decommissioning, time-space characterization, sampling optimization, groundwater surveying, temporal correlation