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#08-243 An advanced blind-tube monitoring instrument to improve the characterization of subsurface radioactive plumes

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Nuclear legacy waste storage facilities, such as ponds, tanks and silos, at nuclear waste management facilities or waste disposal sites, often contain radioactive waste under water. Some of these structures in the UK were not lined and, over time, cracks and slits have occurred providing paths for egress of radioactivity to the environment. Consequently, a mixture of radionuclides and water, defined as liquor, can leak into the subsurface dispersing downward and outward in the unsaturated ground from the waste source, contaminating the soil and sediment during its path.

The scenario on which this research is focussed concerns the potential for nuclear material to have leaked into the ground beneath the Magnox Swarf Storage Silo (MSSS), which was built in the 1960s at Sellafield (UK). In the main, solid waste from the reprocessing of nuclear fuel is stored in the MSSS underwater but it also contains residual material held within the water that is highly mobile and thus has the propensity to migrate into the ground. Sellafield Ltd. is in the process of retrieving the waste and decommissioning the MSSS facility, which requires radiological surveillance of the ground. The current techniques of measurement of the subsurface radioactivity generally involves periodic campaigns to collect soil and groundwater samples from several boreholes, and subsequent laboratory analysis. In addition, ground surveys employing geophysical logging probes have also been deployed in specific boreholes/blind-tubes, in preference to the laboratory analysis. The available radiometric sensors operate at only relatively low dose rates, have low radiation resistance and have low spectroscopy potential. Thus, they are not satisfactory for deployment in a high dose rate environment and constitute only a short-term solution. Therefore, an innovative technological solution is necessary to achieve increased resolution and better understanding of soil and groundwater contamination around the MSSS building. It will also allow to identify and predict spatial migration pathways and guide site remediation programs.

A design for a resilient radiometric logging probe developed in this research will be presented that fulfils these requirements for down-hole rapid monitoring of long-lived contaminants, such as caesium-137 and strontium-90 (and hence yttrium-90). The device (Figure 1) holds a CeBr3 scintillator detector and a digital data transmitter (MCA), in a resistant and waterproof housing. The probe is then connected to a cable and lowered down in the blind-tube by means of a winch system, and the position in the hole calculated by a depth encoder. The logging cable has usually three functionalities: transmit electrical signals to recording instruments at surface, provide power, and support the lower and raise of the probe. The assessment of caesium-137 and strontium-90 in the surrounding soil formation (but closed to the borehole), is done by detecting the high penetrating gamma-ray photons and Bremsstrahlung photons, emitted by the deceleration of the energetic beta particles in the steel blind tubes, respectively. Moreover, it is anticipated that the extension of a single detector to a blind-tube string network will provide 3D spatial arrangement in order to characterize radioactivity in the ground system, at interim storage sites for high-level radioactive waste. Modelling and laboratory experiments are underway to validate the concept and calibrate the system in a soil-filled phantom arrangement that replicates the in-ground blind-tubes set on site which will be reported on in this work. The ultimate goal is to achieve a validation of the complete system in the existing blind-tube network at the Sellafield site.

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