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Numerical study of 3He, BF3, and NaI Detectors using compensated neutron log method for porosity measurements at the abandoned well of limestone formation for potential deep borehole disposal candidate

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The increasing generation of disused sealed radioactive sources (DSRS) in Indonesia has created an urgent need for sustainable and secure disposal solutions. Deep borehole disposal (DBD) in limestone formations, especially from abandoned wells, presents a promising approach due to their high structural stability and low porosity, which effectively limit radionuclide migration. This study investigates the optimization of neutron-based porosity measurement methods using ^{3}He, BF_3, and boron-lined NaI detectors in abandoned wells, addressing the impacts of variables including salinity, wax deposition, and porosity.

Simulations performed using Particle and Heavy Ion Transport code System (PHITS) revealed that ^{3}He detectors provide the highest sensitivity to porosity changes and remain effective across a broad range of salinity levels, followed by BF_3 and boron-lined NaI detectors. Sensitivity was observed to increase with porosity but decline significantly with salinity levels of 5% to 30%, attributed to neutron absorption by chlorine ions in saline water. Wax deposition, modelled as a 3 mm layer, also reduced detector sensitivity, with ^{3}He detectors showing the least impact (0.36%-16.12%), making them the most suitable for complex borehole environments. Boron lining improved thermal neutron capture efficiency but introduced detection sensitivity fluctuations, particularly in BF_3 detectors. Validation through PHITS simulations demonstrated accurate gamma energy spectra alignment with IAEA standards and consistent near-to-far detector count ratios when compared to reference datasets.

These findings highlight the need for advanced detection technologies and simulations to improve reliability of porosity measurements in DBD applications. The integration of such systems addresses critical challenges posed by salinity, wax deposition, and neutron interactions, supporting the efficient and secure management of radioactive waste. This research provides a significant contribution to the practical implementation of DBD, enhancing its viability as a sustainable disposal solution for radioactive waste in Indonesia and global.

Technical Track

Fuel Cycle and Waste Management

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