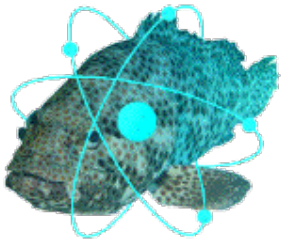

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Radiochemistry and Monte Carlo integrated approach to radiological characterization for nuclear facilities decommissioning

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In the last decades, hundreds of nuclear reactors have been shut-down and have experienced decommissioning operations. This is also the case of L-54M Politecnico di Milano nuclear research reactor. Since shut-down in 1979, the plant has been managed according to deferred dismantling strategy. Following National and International well-established guidelines, several activities, such as spent nuclear fuel removal and primary circuit decontamination, have already been performed to guarantee facility safe storage as well as safety of workers and public. Recently, preliminary radiological characterizations have been launched, even though a more extended campaign would be necessary to implement facility decommissioning and restore unrestricted reuse status.

In the framework of the IAEA irradiated GRAphite Processing Approaches (GRAPA) collaborative research project, a general radiochemistry and Monte Carlo integrated approach has been developed to study materials activation and support radiological characterization campaign. First of all, the system physical model has to be created in the Monte Carlo code, by including all geometrical and material composition structural features as well as the complete neutronic history of the plant. Some input script limitations need to be overlooked by a careful simplification process that guarantees the best model accuracy and point-to-point mass conservation. In case of uncertainties, a sensitivity analysis should be carried out. Afterwards, in order to verify the model accuracy, several system properties described by the code are selected and compared with the available experimental values. For sake of example, criticality data and neutron fluxes could be used to verify the Monte Carlo model of a nuclear reactor. Thereafter, the main radionuclides of interest for decommissioning purposes have to be selected, along with their production reactions and impurity activation precursors in virgin materials. Finally, the Monte Carlo output can be properly processed to produce a 3D activation map for each simulated radionuclide. In order to obtain the ultimate model validation, the simulated activity concentrations are point-to-point compared with the available radiometric measurements. A sufficient number of irradiated samples should be collected and analyzed to determine γ-emitting and pure β-emitting radionuclides, so as to complete the model validation and strengthen its trustworthiness.

This integrated method, thanks to its general principles, could be applied to any nuclear reactor or facility undergoing decommissioning, thus helping reducing the characterization efforts and, possibly, the associated costs.

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