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Investigation of radionuclides and anthropic tracer migration in groundwater at the Chernobyl site

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Following the reactor 4 explosion of the Chernobyl Nuclear Power Plant (ChNPP), at least 10^{19} Bq of radionuclides (RN) were released in the environment. In order to protect workers and prevent further atmospheric RN dispersion in the area adjacent to the ChNPP, contaminated wastes including fuel particles, topsoil layer and forest remains were buried in approximately 800 shallow trenches in the sand formation in the Red Forest waste dump site [1]. No containment measures were taken, and since then RN have leaked to the unsaturated zone and to the groundwater. Since 1999, migration of RN in the vicinity of the trench 22 at Red Forest site has been investigated within the frame of the EPIC program carried out by IRSN in collaboration with UIAR and IGS [2, 3]. A plume of ^{90}Sr was shown downgradient from the trench 22 with activites reaching 3750 Bq/L [2]. In 2008, further studies were initiated through the TRASSE research group, based on a collaboration between IRSN and CNRS. These programs aim at combining groundwater dating with RN migration monitoring studies in order to constrain RN transport models [3].

Groundwater residence time was investigated based on ^{3}H/He and CFC. Both tracers led to ages ranging from modern (1-3 y) at 2 m depth below the groundwater table to significantly higher apparent ages of 50-60 y at 27 m below the groundwater table [3]. ^{36}Cl/Cl ratios 2 to 4 orders of magnitude higher than the theoretical natural ratio are measured in groundwater. Similarly, SF_6 shows concentrations as high as 1200 pptv while natural concentrations are in the order of 6-7 pptv. Based on apparent groundwater ages, both contaminations are linked to the Chernobyl explosion. Hence those tracers show excellent potential to constrain conservative and reactive transport, respectively. In contrast, ^{238}U/^{235}U ratio down gradient from trench 22 remains similar to the natural ratio. This suggests that either most of the U contained in the trench is in a non soluble form, associated with U-Zr matrix fuel particles [5] and/or that migration of U is limited due to redox processes and/or microbial activity.

The above described experience of post-Chernobyl studies shows that a combined analysis of radionuclides, natural and anthropogenic tracers provides an efficient research tool to better understand and quantify contaminant transport processes in the geo-sphere. Similar approaches can be applied to the study transport of RN in the subsurface, issued from both, diffuse (contaminated watersheds) and point (damaged NPP and fuel storage units) radioactive sources produced by the Fukushima accident.

References

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