Nuclear Waste Disposal

Subjects: Chemistry, Inorganic & Nuclear
Contributor: Michael I. Ojovan

Nuclear waste (like radioactive waste) is waste that contains, or is contaminated with, radionuclides, at activity concentrations greater than clearance levels set by the regulators, beyond which no further use is foreseen. Disposal is the emplacement of waste in an appropriate facility without the intention to retrieve it.

Keywords: nuclear waste ; radioactive waste ; nuclear waste management ; disposal ; disposal facility

Radioactive waste (which is the same as nuclear waste), is material that contains, or is contaminated with, radionuclides, at activity concentrations greater than the clearance levels established by the regulatory body, beyond which no further legal or regulatory purpose is foreseen [1][2]. The radioactive (nuclear) waste results as a byproduct of nuclear energy utilization, as well as from the processing of some naturally occurring radioactive materials (NORM), e.g., within oil and gas production and ore beneficiation. Indeed, nuclear energy has numerous applications, such as medical diagnostics and treatment, and it also has massive power generation, with 422 nuclear power reactors, with a total capacity of 378,314 MW(e) and a total span of 19,399 reactor-years of operation [2], currently in operation. Additionally, another 57 new nuclear power reactors are currently under construction, which will add 58,858 MW(e) of installed capacity worldwide [2]. The utilization of nuclear energy is inevitably accompanied by the generation of some byproducts, in the form of radioactive or contaminated materials for which no further use is foreseen, including a part of used (spent) nuclear fuel (SNF) that is not intended for reprocessing [3][4][5]. The total amount of such unneeded materials is orders of magnitude smaller compared with the waste materials generated by non-nuclear activities. For example, a typical 1 GW(e) nuclear power plant (NPP) produces about 25 tonnes of SNF annually, which can be declared as waste (SNFW), or stored for future reprocessing. It also annually generates a few hundred cubic meters of low and intermediate radioactive waste (LILW). In comparison, a typical 1 GW(e) coal-fueled power station annually produces ~6.5×10^6 tonnes of gaseous CO_2 pumped into the atmosphere; >300×10^3 tonnes of solid waste in the form of ash residue containing about 400 tonnes of toxic heavy metals, including radioactive uranium and thorium; and also >5×10^3 tonnes of noxious gases [6][7]. The nuclear industry acknowledges the need to plan for nuclear waste management (NWM) well in advance, and it integrates NWM at the country level, aiming also to convince stakeholders and populations, which in many cases perceive nuclear waste as a problematic issue that either has uncertain solutions, or no solutions at all, to trust it [8][9][10][11]. Sustainability of nuclear energy cannot be assured without demonstrating to the public that nuclear waste is manageable and does not leave any burden to future generations, as to do otherwise would otherwise contradict the very fundamental safety principles of nuclear energy [12]. This entry briefly describes the final disposal step of NWM.

References

1. IAEA. Nuclear Safety and Security Glossary; IAEA: Vienna, Austria, 2022.
2. IAEA. PRIS, Power Reactors Information System. Available online: https://pris.iaea.org/pris/home.aspx (accessed on 4 January 2023).
3. IAEA. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards; Safety Standards Series GSR Part 3; IAEA: Vienna, Austria, 2014.
4. IAEA. Selection of Technical Solutions for the Management of Radioactive Waste; TECDOC-1817; IAEA: Vienna, Austria, 2017.
5. Ojovan, M.I.; Lee, W.E.; Kalmykov, S.N. An Introduction to Nuclear Waste Immobilisation, 3rd ed.; Elsevier: Amsterdam, The Netherlands, 2019; 497p.
6. Chapman, N.; Hooper, A. The disposal of radioactive wastes underground. Proc. Geol. Assoc. 2012, 123, 46–63.
7. Yudintsev, S.V.; Nickolsky, M.S.; Ojovan, M.I.; Stefanovsky, O.I.; Nikonov, B.S.; Ulanova, A.S. Zirconolite Polytypes and Murataite Polysomes in Matrices for the REE—Actinide Fraction of HLW. Materials 2022, 15, 6091.

8. IAEA. Policies and Strategies for Radioactive Waste Management; IAEA Nuclear Energy Series, NW-G-1.1; IAEA: Vienna, Austria, 2009; 68p, Available online: http://www.pub.iaea.org/MTCD/publications/PDF/Pub1396_web.pdf (accessed on 4 January 2023).
9. Pershukov, V.; Artisyuk, V.; Kashirsky, A. Paving the Way to Green Status for Nuclear Power. Sustainability 2022, 14, 9339.
10. Drace, Z.; Ojovan, M.I.; Samanta, S.K. Challenges in Planning of Integrated Nuclear Waste Management. Sustainability 2022, 14, 14204.
11. Yang, J.; Wang, J.; Zhang, X.; Shen, C.; Shao, Z. How Social Impressions Affect Public Acceptance of Nuclear Energy: A Case Study in China. Sustainability 2022, 14, 11190.
12. IAEA. Fundamental Safety Principles; IAEA Safety Standards Series No. SF-1; IAEA: Vienna, Austria, 2006.