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Task

The company Lynas Malaysia Sdn. Bhd. processes ore from Lynas's Australian Mt.Weld mine for Rare Earth Elements. As a result of this process, the natural Thorium and Uranium content that was part of the original ore, is concentrated in a waste stream called WLP (Water-Leach-Process) residue. Because the concentration of Thorium in this waste stream exceeds internationally defined exemption levels for larger amounts of this, this waste has to be handled, treated and disposed as radioactive waste to protect man and the environment from its hazards. Lynas decided to dispose this waste in a Permanent Disposal Facility (PDF) and selected a site in the wider Kuantan area for this.

As a pre-stage of an Environmental Impact Assessment (EIA) Lynas has commissioned the company AGV Environment with the definition of Terms of Reference (TOR) for this project.

I was requested by the NGO SMSL Kuantan to go through the TOR document[1] and formulate critique, if necessary and appropriate. The following summarizes my view on this document.

1. **The TOR confuses and misuses terms**

In a long-standing effort Lynas tries to confuse inappropriate waste terms to psychologically downplay the hazards, that is associated with their waste. The TOR continues this tradition.

The TOR uses the term „Very Low Level Waste" for the WLP. It therefore cites IAEA's Waste Classification Scheme for that:

> *"waste that does not necessarily meet the criteria of exempt waste, but that does not need a high level of containment and isolation and, therefore is suitable for disposal in near surface landfill type facilities with limited regulatory control. Such landfill type facilities may also contain other hazardous waste".*[2]

But, the complete citation of the original document is contradicting and has been skipped from the TOR's citation. In the original publication, the last sentence shows why WLP waste is not at all VLLW:

> *"(3)Very low level waste (VLLW): Waste that does not necessarily meet the criteria of EW, but that does not need a high level of containment and isolation and, therefore, is suitable for disposal in near surface landfill type facilities with limited regulatory control. Such landfill type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low levels of activity concentration.* ***Concentrations of longer lived radionuclides in VLLW are generally very limited."*** [3]

Even though IAEA does not specify nearer, how small "very limited" concentrations have to be to fall under VLLW, but the exemption level of 1 Bq/g for Thorium is a good approach for the interpretation of this sentence.

Factually, the term Very-Low-Level-Waste is only used in France. And here it is for wastes only, that result from the decommissioning of nuclear power plants and here for the bulky metall and concrete

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[1] AGV Environment: Terms of Reference: Proposed Development of a Dedicated Permanent Disposal Facility for the Water Leach Purification Residue at Bukit Ketam in Mukim Kuala Kuantan, Daerah Kuantan, Pahang Darul Makmur, Project Proponent: Lynas Malaysia Sdn. Bhd.. - Petaling Jaya (Malaysia), September 2020

[2] ibid.: page 1

[3] IAEA: Classification of Radioactive Waste; No. GSG-1 General Safety Guide, IAEA Safety Standards Series, Vienna 2009, GSG-1, para 2.2, page 5

masses during demolition of majorly uncontaminated machinery and building materials. These wastes can contain small concentrations of the two artificial radio-nuclides Cesium-137 and Strontium-90 in concentrations slightly above or around the exemption limit. To avoid enhanced measuring efforts, their concentration is not really measured but simply detected with dose counters (that can detect Cesium-137). Both radio-nuclides have a half-life in the order of 30 years. They therefore decay within a limited time period of approximately less than 500 years, for which a site has been prepared where those metal and concrete materials are disposed in shallow trenches and covered with clay and an earthen cover. To term this simple technology as "engineered barriers" would be inappropriate and simply misleading. The term "limited regulatory control" is overall guiding this: the materials to be disposed require no radiation protection measures any more when they leave the decomissioned site.

In all other countries the term VLLW is not used. The terms NORM- or TENORM-wastes or wastes from Uranium mining and milling (tailings) are commonly in use. In case of the WLP waste the correct term would be "Rare-Earth Water-Leach-Process waste with enhanced long-lived Thorium concentrations" would be the appropriate term. As the handling of this waste requires Radiation Protection measures (shielding, exposure time limitations, dose measurements, etc.) to limit radiation exposure hazards it cannot at all compared with the VLLW definition in France.

The mentioning of the longevity in case of the WLP waste, because it does not include any short-lived artificial radio-nuclides but contains natural ones with much longer half-lives in the order of some billion years. IAEA therefore leaves it open, if the necessary safety level in a surface-near setting can be fulfilled or not:

> *"In general, for waste containing naturally occurring radionuclides, acceptable levels of activity concentration will be expected to be lower than those for waste containing artificial radionuclides, in view of the long half-lives of naturally occurring radionuclides. Depending on site factors and the design, it may still be possible to demonstrate the safety of waste with higher levels of activity concentration."*[4]

In case of NORM and TENORM wastes it makes no sense to try to use waste terms that were defined and applied for purposes in the nuclear industry.

Conclusion:

- The term VLLW is inappropriate for WLP waste due to the long-lived nature of the hazardous components.
- The correct term would be "Very-Long-lived Low-Level-Waste" (VLLLLW or VL4W), which describes the properties of these kind of wastes and makes clear which safety features a disposal facility needs to have.

Requirements for disposing NORM-/TENORM wastes

The following applies to the WLP wastes instead:

- The Thorium and Uranium content of the WLP wastes results from their natural occurrence in the processed ore (Naturally Occurring Radioactive Material, NORM), that stems from Mt. Weld in Australia.
- Within the ore, before mining and milling took place, the Thorium and Uranium was completely geo-chemically fixed to the material, practically no Thorium and Uranium left the site there (e.g. by any leaching or by erosion processes). Consequently, there was no hazard posed to man and the environment, because the decay occurred only within the ore body itself.

[4] ibid, *para 2.19, page 11*

- When the ore was technically mined and processed, this solid, reliable and complete geo-chemical fixation was disturbed, the radio-nuclides were brought to the surface and into a geo-chemically mobile form. Their existence at the earth's surface can now pose radiation doses to persons that are in close vicinty to those materials, e. g. by gamma-radiation exposure.
- Disturbing the stable and safe containment of Thorium and Uranium in the ore body by mining and milling hands over the responsibility to avoid associated hazards to the company that initiated such mining and milling.
- As the radioactive material content does not decay this transferred responsibility (from nature to the miner/miller) to protect people and the environment from those hazards is never-ending. No matter if people come into direct contact with this material nowadays or after 100, 1,000 or after 1 Mio. years, the hazards posed remain the same. That special property makes the material special. Mixing this kind of hazards with those in the nuclear industry, where most of the hazards are time-depending, is therefore misleading and inappropriate.
- As the transferred responsibility for protection is never-ending, and mankind has no technologies to safely and completely ensure that, the safe enclosure has to be at least guaranteed over times for which that is technically achievable, even knowing that the hazards are not time-limited. So any solution for NORM waste has to be As-Long-Reliable-As-Technically-possible (ALRATP).
- Current time-frames for this ALRATP are defined in the US (in the Uranium mill tailings regulation) as 1,000 years, other countries do not have such strict values set-up in their regulation, but apply similar time-frames (e. g. in Germany). But completely inacceptable are times below 200 years or to not define this ALRATP at all. The latter means to reject the responsibility for the long-term hazards posed nearly completely (which is in-acceptable).
- That means that the central requirement of any disposal facility of this type is
    - to firstly define the As-Long-As-Technically-Reliable period (based on current technical standards and available technologies),
    - secondly to derive site selection criteria from this (and to compare their longevity properties),
    - to design and layout the properties of the technical solution for that.

None of this has been done in the TOR. It seems that the authors were not even aware that this is a central task. This lack of responsibility in the TOR can be demonstrated on several occasions. it can be best seen on the front page. Controlling leakage protection with a 2 mm-HDPE plastic sheet can be reliable – assumed that appropriate quality control during installation has been performed - for 20 years, because HDPE is a short-lived material which degrades within decades. Nothing you can garantee performance over the longer term with.

Conclusion:

It is surprising that the term "Permanent" in the PDF abbreviation has not yet triggered the authors to even think about that. If you use words, you'll have to have an understanding of those words.

The complete TOR lacks any thoughts about longevity. Each chapter in the TOR should have a three-fold extension: one on the short-term issues (0 .. 10 years), one on the mid-term issues (10 .. 100 years) and one on the long-term issues (100 .. 1,000 years). If the third part concludes "We are currently not knowing enough to answer that reliably", the authors should go deeper into those.