

RENO-TITAN: From black to white.

Radiation protection in the mining and processing of heavy mineral sands in Vietnam

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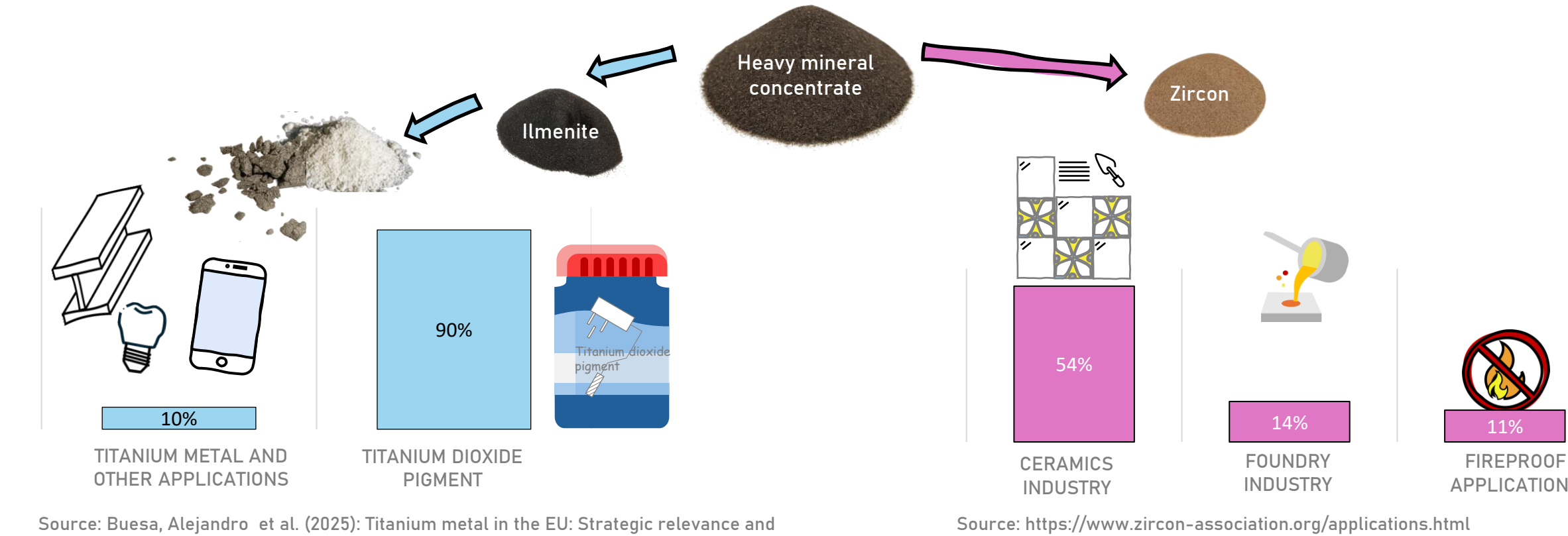
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Abstract

The German-Vietnamese CLIENT II collaborative project RENO-TITAN, which ran from April 2023 to March 2026 and was led in Germany by Magdeburg-Stendal University of Applied Sciences, focused on improving the management of mining residues from Vietnam's titanium industry, in which naturally occurring radionuclides can accumulate, as well as on issues related to responsible mining. The provinces of Lâm Đồng and Quảng Trị served as reference regions. On the one hand, material streams were systematically recorded and characterised in order to establish a sound basis for radiation and environmental protection. On the other hand, safe recovery and disposal options were assessed and, on that basis, the technical and regulatory conditions under which reuse (e.g. in construction materials) could be implemented responsibly were examined.

What are heavy mineral sands mined for?

Heavy mineral sands are mined primarily for the extraction of titanium-bearing minerals such as **ilmenite** (FeTiO₃) and **rutile** (TiO₂). These minerals are used mainly for the production of high-purity titanium dioxide (TiO₂), the most important white pigment (e.g. for paints and coatings, paper, and plastics), and of titanium metal (e.g. for applications in aviation, the chemical industry, and medicine). **Zircon**, which is often recovered as a co-product, is used in ceramics and in refractory high-temperature applications. These raw materials commonly occur in placer deposits in coastal and fluvial sediments.



In three sentences ...

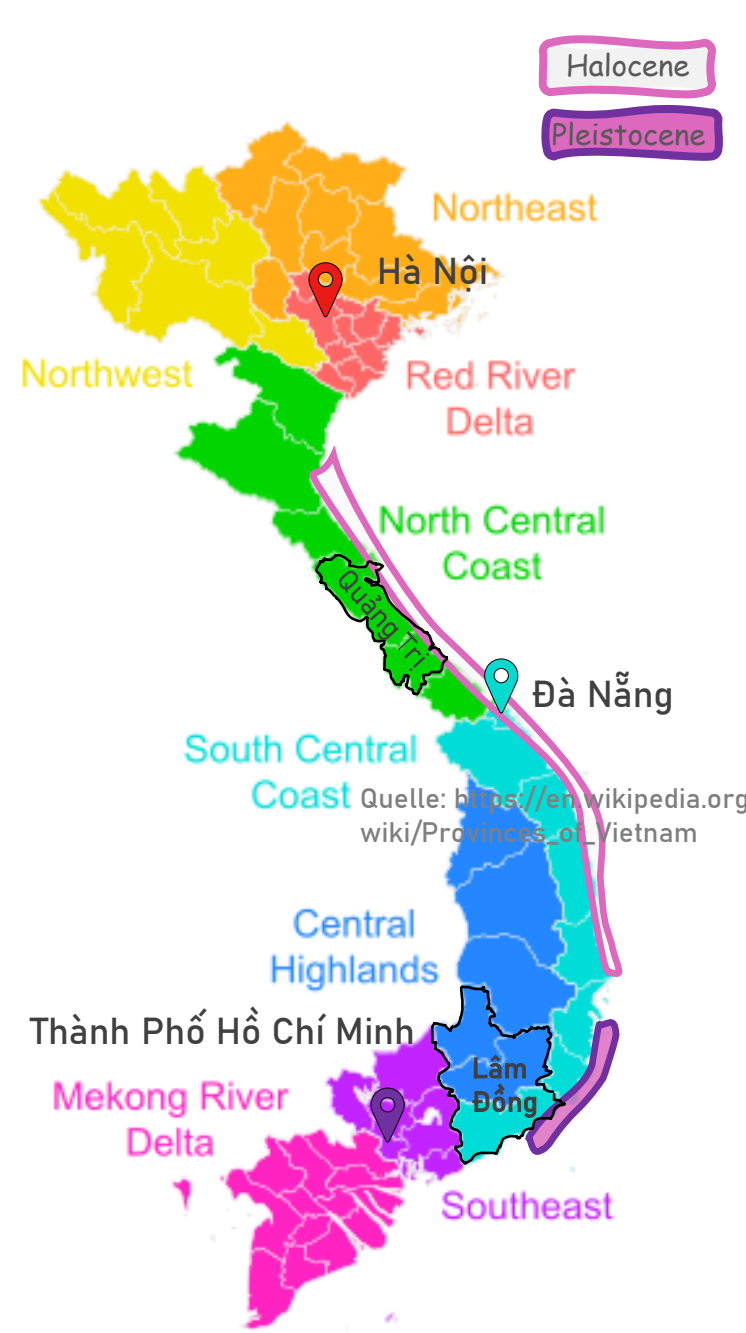
Heavy mineral sands are a source of ilmenite and rutile for the production of TiO₂ pigment and titanium metal.

During processing, naturally occurring radionuclides may become concentrated, leading to the formation of NORM.

The CLIENT II project RENO-TITAN examined the management of NORM residues arising from heavy mineral sands mining and downstream processing, as well as potential options for their reuse.

Heavy mineral sand mining in Vietnam

In Vietnam, heavy mineral sands mining is concentrated in selected stretches of the coastline in central and southern Vietnam, including Quảng Trị Province and Lâm Đồng Province (the coastal area of the former Bình Thuận Province) Vietnam's Master Plan on mineral exploration, mining, processing and use for the period 2021–2030, with a vision to 2050, seeks to increase value addition along the value chain, from the production of concentrates and downstream processing through to the manufacture of titanium dioxide pigment.



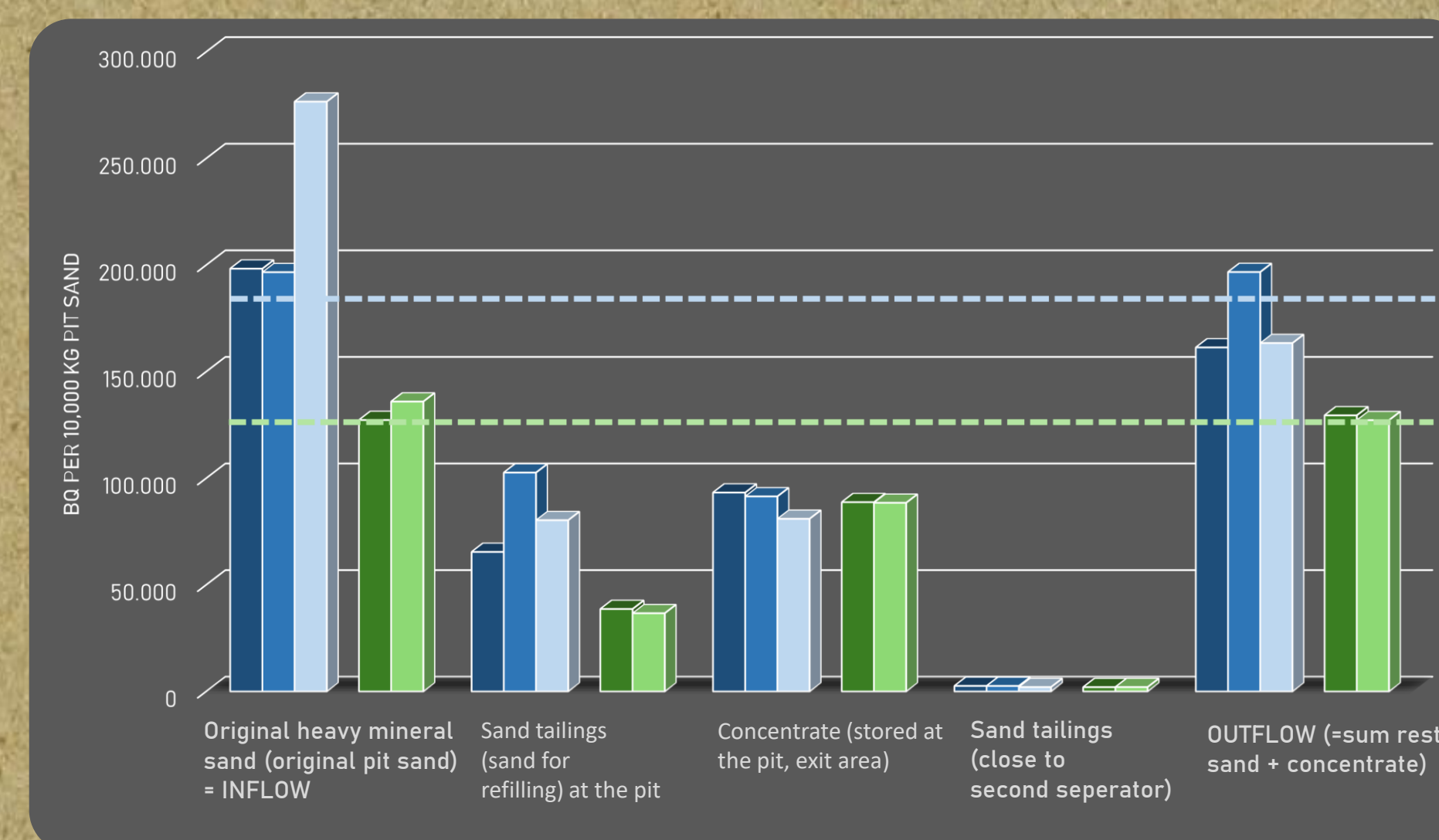
Results

Process overview: Radiological and geotechnical measurements covering the process chain from open-cast extraction to processed minerals in Vietnam, based on case studies from two companies in the provinces of Quảng Trị and Lâm Đồng.

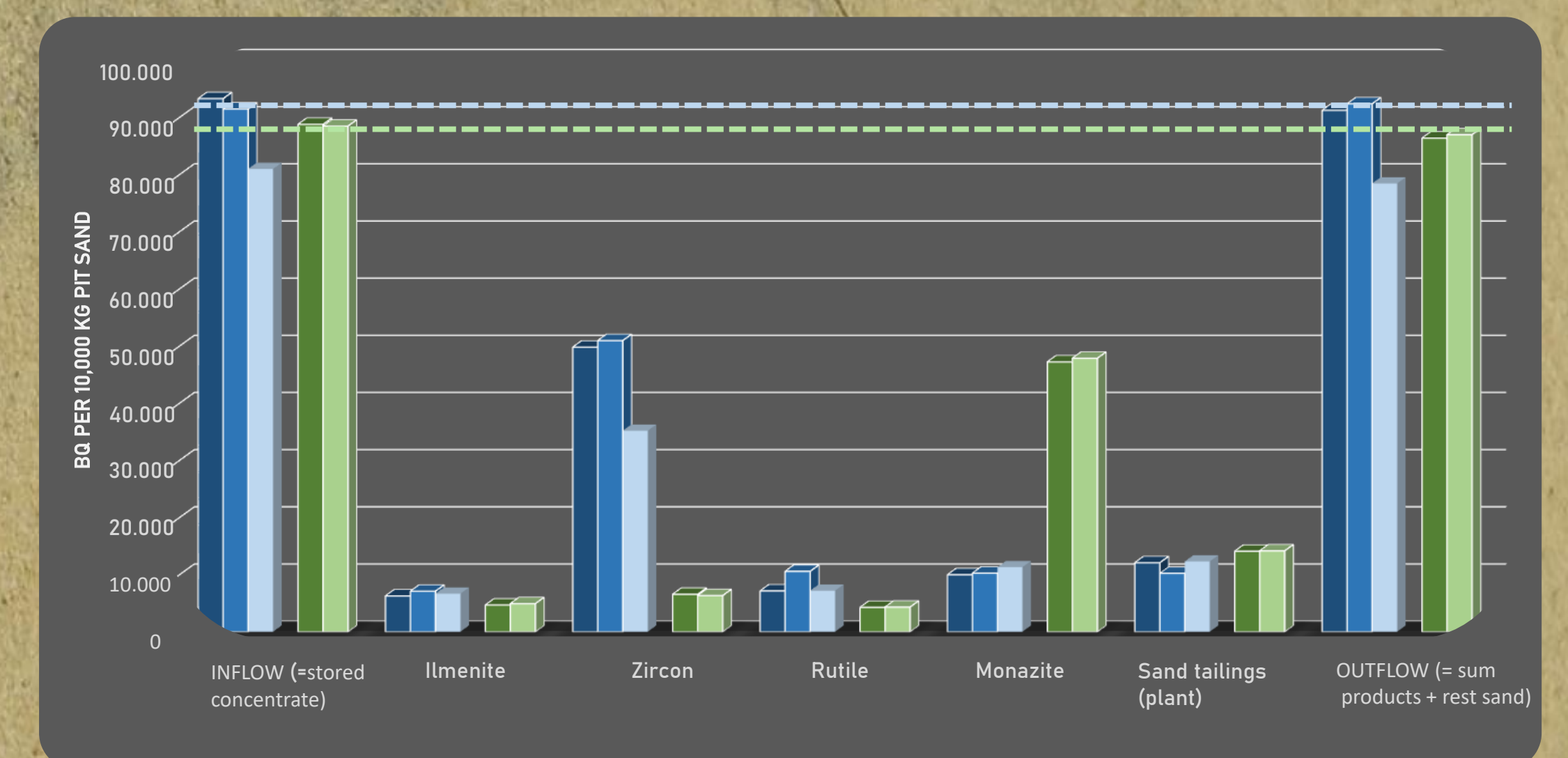
Process Step	Grain Density [g/cm ³]	Ambient Dose Rate (nSv/h)	Enrichment (compared to the initial sand)	
			U-238	Th-232
Heavy mineral sands (sedimentary placer deposits)	2.64–2.66	100–190	1	1
Wet mining (using suction dredgers)	2.64–2.65	100–110	1	1
Wet processing (using spiral separators)	2.64	130–160	0.3	0.3
Residual sand after 1st mechanical separation in open-cast mining	2.64	75	0.4	0.6
Residual sand after 2nd mechanical separation in open-cast mining	3.04	240–250	6	8
Heavy mineral concentrate	3.68–3.78	700–1,900	50–80	70–120
Ilmenite	4.30	700–1,700	90; Staub 270	100; Staub 560
Zircon sand (min 65%)	4.55; Staub 4.24	n.d.	10	12
Rutile	4.60	1,500	30	50
Pseudo-rutile	4.64	2,000	350	70
Monazite	3.95	2,300	450	90
	n.a.	1,900 (90%)	40	35
	n.a.	n.a.	n.a.	n.a.
	n.d.	1,300	n.d.	n.d.
	4.8–5.3*	16,000 (57%)	2,400	17,000
	3.11–3.51	10,000 (80%)	n.d.	n.d.
	n.d.	300–1,100	7–70	10–130
	n.d.	n.d.	n.d.	n.d.

* range from literature n.a. = not applicable n.d. = no data

Radionuclide balance: [U-238, Ra-226, Pb-210 / Ra-228, Th-228]



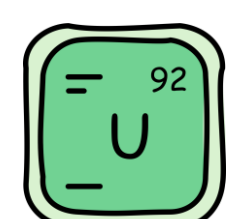
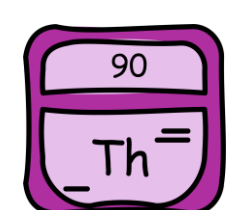
Upstream radionuclide activity balance in heavy mineral sands mining (from feed sand to concentrate)



Downstream radionuclide activity balance during processing from concentrate to mineral products

Why does NORM matter?

The extraction and processing of heavy minerals inherently give rise to process streams in which naturally occurring radionuclides may become concentrated, resulting in naturally occurring radioactive material (NORM) in both products and residues.



In heavy mineral sands mining, this is due in particular to certain accessory minerals, such as monazite and zircon, which contain radionuclides from the uranium and thorium decay series. Depending on the mineralogical characteristics of the feed material and the way in which the process is operated, these radionuclides become concentrated in specific fractions.

What is a radionuclide balance?

A radionuclide balance is the systematic comparison of the incoming and outgoing material-bound activity streams (solid, liquid, gaseous) of a single node within a technological or industrial process, or within a system defined in space and time, on the basis of the respective mass flows of each partial stream and the associated specific activity (activity concentration) of the relevant radionuclides. Its purpose is to verify whether all relevant material streams have been accounted for with regard to the activity introduced into and removed from the process, and to identify redistributions and accumulations of individual radionuclides.

Recommendations

- A consistent, risk-based approach to radiation protection in heavy mineral sands mining and processing in Vietnam is needed in order to enable technically sound, proportionate, and legally robust assessments and to avoid over- or under-regulation at the provincial level.
- Monitoring should comprise regular measurements of gamma dose rate, radon, and dust-borne radionuclides, together with groundwater monitoring focused on radium-226 and radium-228, so that dose estimates can be derived on a transparent and traceable basis and control measures can be defined in a targeted manner.
- Residues: The environment and water resources should be protected through sealed storage areas with leachate control.
- Residues: Reuse as a construction material is possible in several applications, provided that the material is technically suitable for construction purposes and that the Vietnamese building standard TCXDVN 397:2007, Natural Radioactivity of Building Materials – Safety Levels and Test Methods, is applied, particularly in view of the existing shortage of construction sand in the country.