Life Cycle Assessment

Aluminium oxide

Results Summary

Version	4.0
Date	16.04.2025

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1. General Information

Client	Aluminiumoxid Stade GmbH Johann-Rathje-Köser-Straße 21683 Stade Germany
Life Cycle Assessor	Ramboll Deutschland GmbH Jürgen-Töpfer-Straße 48 22763 Hamburg Germany
Report Date	16.04.2025
Reviewed	No
Reference to standards	The study was conducted in accordance with the requirements of DIN EN ISO 14040 and 14044
Disclaimer	Liability claims caused by the use or non-use of the information provided or by the use of incorrect or incomplete information are excluded as a matter of principle, unless there is evidence of wilful intent or gross negligence.

2. Scope of the study

2.1 Declared Unit

The declared unit is 1 kg of unpacked aluminium oxide at gate of the production site.

2.2 System Boundaries

A cradle to gate approach was selected.

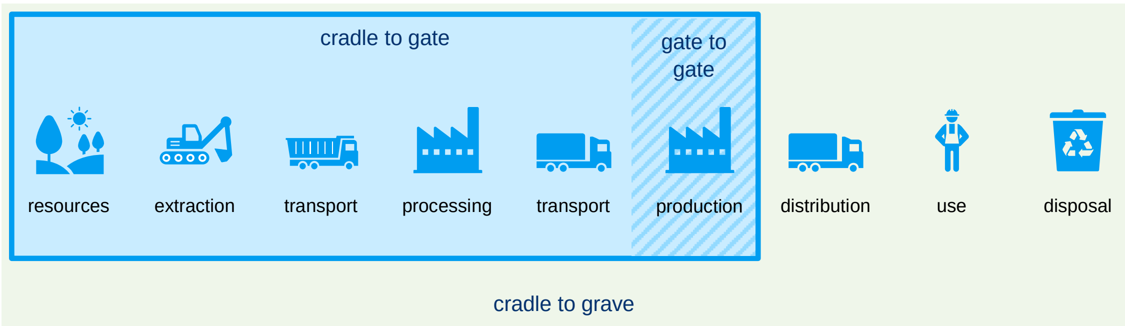

Figure 1: System boundary of AOS product system

The system boundaries of the AOS product system include the provision of raw materials and energy consumption needed for the manufacturing of aluminium oxide. The system boundary ends at the aluminium oxide ready for transport.

All processes included or excluded from the system are summarized in Table 1.

Table 1: Summary of covered aspects

Included	Excluded
Raw material provision	Packaging material
Energy production and utilization	Transports after gate
Fuel for machinery	Use phase and end of life of aluminium oxide
Production waste treatment	Capital goods
Production of operating materials	Infrastructure
	Human labour and employee commutes

2.2.1 Time coverage

The LCA is based on AOS consumption data for the calendar year 2021. The background data used was selected for a high level of temporal representativeness.
Data for transportation processes refer to the recent emission standards. All background data sets used are the most recent available in the Sphera database.

2.2.2 Technology coverage

Since the entire manufacturing process was investigated, the technological representativeness can be classified as high. For the raw materials used, LCA data sets were used that reflect their production as precise as possible from a technological point of view.

2.2.3 Geographical coverage

The production of aluminium oxide by AOS is exclusively carried out in Germany. For the majority of raw materials and energies, background data with Germany as the geographical reference were selected. Where this was not possible, data with a European reference (EU28) was used.

2.3 Data quality

For all material and energy flows directly involved in the production process, the quantities purchased or consumed in the reference year were available as primary data. Secondary data for upstream and downstream processes and for the calculation of the LCA results were obtained from the Sphera Professional Database.
For the LCA modelling, the software “LCA for Experts” from Sphera, version 10.9.0.31 was used. All background data sets used were taken from the Sphera LCA database version 2024.1.

3. Description of the production process

Figure 2: Production process of aluminium oxide

The bauxite processed in 2021 originates in Guinea, from where it is delivered to the port of AOS over a distance of around 6,000 km in ocean-going vessels.

For the production of aluminium oxide, the bauxite is first crushed and wet ground, with caustic soda being added to break it up. The break-up takes place at AOS in the so-called pipe digestion. The suspension is pumped through the reactor pipes by high-pressure pumps and heated up in stages. As the temperature rises, almost exclusively the aluminium compounds dissolve from the raw material.

After leaving the pipe digestion, a highly supersaturated solution of aluminium hydroxide in caustic soda is present. It contains the insoluble components such as iron oxides and titanium dioxide. In large clarification tanks, these mineral residues are separated by sedimentation.
The residues of adhering caustic soda are washed out in a multi-stage purification process. The remaining residue ("red sludge”) is pumped via pipelines to the nearby landfill and stored there.

The purification process used at AOS for the red sludge allows for extraordinarily low sodium hydroxide losses compared to the rest of the world. The aluminium hydroxide dissolves to form sodium aluminate, while other components such as iron and titanium oxide precipitate undissolved and are separated as red sludge.

To obtain the product from the pure lye, the supersaturation must be removed. This is achieved by adding seed crystals, by intensive stirring and by further cooling of the solution. At the end of the agitation, the hydroxide crystals are filtered off on vacuum filters. A part of the material flow is returned to the preparation as inoculant. The remaining part is washed out as a product and processed.

In a final calcination process, the aluminium hydroxide is converted to aluminium oxide at temperatures of approx. 1000°C by splitting off water.

4. Results of the Impact Assessment

Table 2 shows the overall results of the conducted LCA study done via the evaluation method of Environmental Footprint 3.1, developed by the European Union Joint Research Centre.

Table 2: EF 3.1 results for 1 kg aluminium oxide

Impact Category	Aluminium Oxide	Unit
Climate Change, total	8,47E-01	kg CO_2-eq.
Climate Change, biogenic	1,61E-03	kg CO_2-eq.
Climate Change, fossil	8,45E-01	kg CO_2-eq.
Climate Change, LU and LUC	1,01E-04	kg CO_2-eq.
Eutrophication, freshwater	3,11E-07	kg P-eq.
Eutrophication, marine	8,83E-04	kg N-eq.
Eutrophication, terrestrial	9,66E-03	mole N-eq.
Acidification	3,48E-03	mole H+-eq.
Photochemical ozone formation	2,56E-03	kg NMVOC-eq.
Resource use, fossils	1,24E+01	MJ
Resource use, minerals & metals	1,16E-07	kg Sb-eq.
Water use	4,50E-03	m^3 world eq.
Particulate matter	5,41E-08	disease incident
Land use	4,80E-01	Pt

Table 3: ISO 14067 results for 1 kg aluminium oxide

PCF results	Aluminium Oxide	**Unit**
Sum of partial PCFs (Fossil and biogenic GHG emissions and removals)	8,47E-01	kg CO_2-eq.
Fossil GHG emissions	8,45E-01	kg CO_2-eq.
Aircraft GHG emissions	5,33E-08	kg CO_2-eq.
Biogenic GHG emissions	1,19E-02	kg CO_2-eq.
Biogenic GHG removals	-1,02E-02	kg CO_2-eq.
Emissions from land use change (dLUC)	1,01E-04	kg CO_2-eq.
Biogenic carbon in product	0	kg C

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