SECTION 1 FACT CHECK ALUMINUM

Aluminum is a silvery-white light metal. After oxygen and silicon, it is the third most common element and the most abundant metal in the earth's crust.

In aluminum smelters, aluminum oxide is produced from the mineral bauxite in the Bayer process. In the subsequent Hall-Héroult process, pure metal is obtained by fused-salt electrolysis

Aluminum is very base and, when freshly cut, reacts with air and water at room temperature to form aluminum oxide. However, this immediately forms a thin layer impermeable to air and water (passivation) and thus protects itself from corrosion. Pure aluminum has low strength; in alloys it is comparable to steel - at only one third of its density.

Aluminum is an all-round metal! It is the second most important metallic material after steel. In 2016, 115 million tons were produced worldwide. The price of aluminum on the world market in 2015 was around the value of 2000 dollars per ton (purity of 99.7%). One of the best known products is aluminum foil. But it is used in many other technical areas.

TASKS

1. Research the material aluminum and its many uses.
2. Complete the table.

Area	**Used in / as...**
Medicine	
Arts and Crafts	
Missile/ Rocket Technology	
Construction, Functional Material	
Lightweight	
E-vehicle construction, Aerospace	
Thermal conductor	
Electrical conductor	
Metrology	
Mirror Coating	

Sales of aluminum are considered a business cycle indicator of the global economy; for example, global aluminum production fell by more than 10 percent the following year as a result of the 2008 financial crisis. In 2016, 115 million tons of aluminum oxide (Al_2O_3) were produced worldwide. From this, 54.6 million tons of primary aluminum were obtained.

SECTION 2 INFO SHEET PRODUCTION OF ALUMINUM

Mining using the example of bauxite deposits in Australia Mining the ore bauxite takes up large areas of land that can only be used again after recultivation. Four tons of bauxite are needed to produce one ton of aluminum. This generates ten tons of overburden. In addition, the production of aluminum oxide by the Bayer process produces about three tons of iron-rich alkaline red mud, which is hardly recycled and whose landfilling or other "disposal" poses major environmental problems.

TASKS

3. Research conditions of bauxite mining in Australia and worldwide.
4. What is meant by the term "red mud"?

Energy requirements The production of aluminum is very energy-intensive. The fused-salt electrolysis alone to extract one kilogram of aluminum requires between 12.9 and 17.7 kWh of electrical energy, depending on the date of construction and the modernity of the plant. It is therefore an endeavor of manufacturers to obtain electrical energy as cheaply as possible.

As criticism of nuclear power has grown, so has criticism of the aluminum it produces. This is the case, for example, in France, where the electricity comes from the national energy pool and thus predominantly from nuclear power plants. The same is true of fossil-fueled power generation, e.g. particularly in Australia, where 90% of electricity is generated from coal and gas. As a result, the use of "coal or nuclear power" is being partially pushed back in favor of more ecologically valuable electricity from hydropower. The generation of electricity for the production of one kilogram of aluminum releases 8.4 kg of CO_2 in the German power plant fleet, compared with a global average of around 10 kg.

The Point Henry aluminum smelter of Alcoa World Alumina and Chemicals Australia at Corio Bay near Geelong in Victoria

Recycling: In Europe, the recycling rate for aluminum is 67%, while worldwide it is around 40%.

In Austria (according to a study from the year 2000), 16,000 tons of aluminum per year end up in consumption via packaging; likewise, 16,000 tons of aluminum end up in household waste without being recycled (this also includes aluminum household foil, which is not considered "packaging"). 66% of packaging in residual waste is aluminum [beverage] cans. These are still present in metallic form in the ash after waste incineration and account for an average of 2.3% of the ash in Europe. In the EU, an average of 70% of the aluminum contained in the bottom ash is recovered.

On the other hand, the good reusability of aluminum is positive. However, the residual materials must be collected and cleaned strictly separately (aluminum recycling, Recycling Code-41 (ALU)). Aluminum is easier to recycle than plastics, but its recyclability is somewhat poorer than steel due to downcycling if it is not collected by type. Aluminum recycling requires only 5% of the energy used in primary production.

SECTION 3 Pollutants and impact parameters

Against a backdrop of increasing resource scarcity, environmental pollution and global climate change, sustainable production technologies and changes in consumer behaviour are becoming increasingly important to all economic, social and political sectors. Life Cycle Assessment (LCA) is a methodological framework to analyse products, materials and services to determine their impacts on health, environment and resource consumption.

The three influencing variables mentioned represent the endpoints of the LCA. They result from eleven damage categories, which consider the relevant environmental compartments (living organisms, soil, water, air) with the pollutant inputs (substances, radiation, noise) and their migration. Mineral and fossil resources as well as land and water requirements are taken into account, as is the emission load of all subsystems examined.

These damage categories are calculated in the LCA (Life Cycle Inventory; LCI) with the help of the material data, the applied processing steps, the energy inputs and the disposal route. By means of material flow analyses with the SimaPro5 tool, an ECOBALANCE succeeds.

TASK:

5. Using the metal aluminum as an example, the environmental impact is to be determined for the quantity of 0.1 kg if (1) the metal is extracted from bauxite rock or (2) 100 % recycled aluminum.

The table lists on the one hand the elements, substances and radiation responsible for a pollutant effect, and on the other hand further influencing factors relating to the consumption of raw materials and land areas. In some cases, pollutant classes affect more than one endpoint. For example, the gases carbon dioxide, methane and nitrous oxide affect both human health and the environment. Heavy metals are toxic to all living organisms.

Impact Categories	Aluminum	
	virgin (1)	100% recycled (2)
	mPt	mPt
Carcinogens	1.4	0.05
Resp. Organics	0.33	0.9
Resp. Inorganic	46.5	0.05
Climate Change	11	0.6
Radiation	0.6	0.05
Ozone Layer	0.7	0.1
Ecotoxicity	1	0.1
Acid./Eutroph.	1.1	0.05
Land Use	1.4	0.1
Minerals	9.1	0.1
Fossile Fuels	37.1	3.9
Sum [mPt]	110	6

The impact categories are colour-coded. They are reflected in the two staggered bars of the diagram.

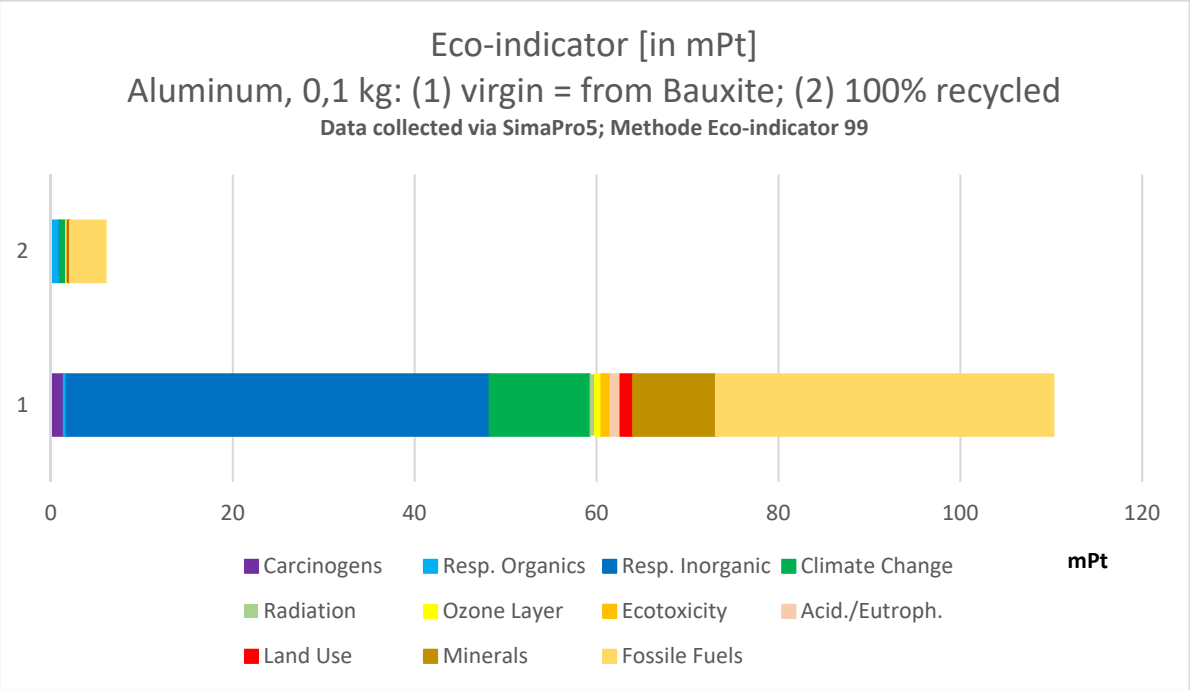
The data collected were compiled using the Eco-indicator 99 method.

The unit is expressed in Eco-Point **Pt.**

1 Pt is 1/1000th of the annual environmental impact of an average European.

SECTION 4 Interpretation of the LCA-results

The mineral and energy resource consumption and the negative health effects during raw material extraction, transport and processing of the rock of the aluminum extracted from the bauxite are well recognizable.



The comparison to recycled aluminum is significant.

CONCLUSION: Collecting used aluminum cans, tea light sleeves and foils is worthwhile!