SECTION 1 FACT CHECK GOLD

Gold is a yellow shiny metal and forms with silver and copper the group of coinage metals. For at least 6 millennia, it has been used as ritual jewelry and as a means of payment. The greed for gold gives rise to raids and war. In nature, copper forms either in the form of "copper-red", metallic shiny nuggets or in branched structures, so-called dendrites. Copper is often associated with other metals in copper minerals and copper ores (cuprite, malachite, copper glance).

Gold is found on earth predominantly in the form of dross, i.e., in elemental, metallic form. The proportion of gold in the continental earth's crust is 4 ppb, or about 4 grams per 1000 tons of rock. The proportion varies by region - in deposits that are mined, the gold content is often several grams per ton. It is found in primary raw material deposits as gold-bearing rock (gold ore) and in secondary deposits, for example in soap deposits.

Around 43% of the gold mined in 2017 came from China, Australia, the USA, Russia and Canada. The deepest gold mines in the world are located in South Africa. There, gold is mined almost 4,000 meters below the earth's surface. The mining company AngloGold Ashanti is constructing shafts at depths of up to 5000 meters.

In 2016, around 17% of the gold mined was a by-product of the refining of other metals such as copper, nickel or the other precious metals, so that it may only be the extraction of gold as a by-product that makes the exploitation of other deposits economically viable.

As an inert metal, gold is resistant to corrosion. It is particularly ductile and can therefore be drawn out into extremely thin foils. In 2020, about 3500 tons were mined - 50% is used as a financial investment, 40% was processed into jewelry and 8% was demanded by industry. But it is used in many other technical fields. Also important are the numerous gold alloys with other metallic elements (lead, copper, platinum, etc.) which are widely used according to their properties.

TASKS

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

Area	**Used in / as...**
Jewelry, Decoration	
Medicine	
Food industry	
Investment	
Electronics	
Nanotechnology	
Mirror coating	
Metrology	
Jewelry, Decoration	
Medicine	

SECTION 2 INFO SHEET PRODUCTION OF GOLD

Mining using the example of the gold mine at Karibib in western Namibia, Africa.

In contrast to most other metals, the chemically inert gold occurs mostly in the solid state. It does not have to be extracted from ores by reduction. It is first dissolved mechanically from the rock. However, since gold is hardly reactive chemically and can only be converted into soluble compounds with difficulty, special processes are required for gold extraction.

There are already very old copper mines worldwide whose copper grades are decreasing significantly over time, by about a third since the end of the 1990s. Since much more earth has to be moved to obtain the same amount of copper, the operation of existing mines is continuously becoming more expensive. The mining of copper ore takes up large areas of land that can only be used again after recultivation.

TASKS

3. Research the processes used to extract the gold.
4. Explain the terms ductile, native, troy ounce and nugget. 5.
5. What was the "gold rush" all about?

Environmental impact Many of today's mines contain almost only trace amounts of gold. As a result, up to 20 tons of debris are generated to produce a single gold ring. This leads to the destruction of entire landscapes. Considerable amounts of highly toxic mercury, already washed out during gold extraction or knowingly released into the environment during evaporation, also permanently poison large areas and river courses. Because gold mining is often improvisational and far removed from effective regulatory oversight, environmental concerns are often subordinated or ignored. Conflicts often arise between gold prospectors and the local population. However, there are first projects of ecological gold mining, like the Oro Verde in Colombia. In February 2011, the Fair Trade seal was awarded for the first time for bars whose gold comes from this mine.

Recycling Gold is highly recyclable. Through urban mining (including electrical equipment from recycling stations, dental and jewelry processing waste, electroplating and sewage sludge ash (containing up to 0.3 grams of gold per ton of sewage sludge), shredder fines, catalysts, etc.), the metal-bearing scrap enters secondary cycles. Through various recycling processes, mainly the valuable metals gold, silver, PGM, copper and the so-called strategically important metals (which are important for e-mobility and digitalization) are recovered. Reprocessing represented around 30% of the total gold supply in 2016. Multi-metal recovery, which is carried out by Degussa, Umicore, ESG and Aurubis AG, among others, combines mechanical, pyro- and hydrometallurgical processes to separate complex secondary raw materials, such as slags, dusts, conductors and blanks, in order to recover the elements that are particularly valuable. Gold is often recovered from anode slimes left over from the refining of other metals, especially copper. The anode slimes produced during the electrolysis of copper, for example, have a silver content of 45 to 50%. The silver is purified and in turn cast into electrolysis anodes. When these are refined, gold, platinum and palladium precipitate in the sludge that accumulates under the anode. This slurry is further processed in a precious metal processing plant by electrolytic refining to the maximum yield and purity of gold. Copper ores often contain so much precious metal that copper producers earn significant ancillary revenues from them.

SECTION 3 Pollutants and influencing 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: Using the metal gold as an example, the environmental impact is to be determined for the quantity of 0.1 kg if (1) the metal is extracted from rock or (2) 100 % recycled gold scrap from e-scrap.

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	Eco Balance for 0,1 kg Gold Refinery
Carcinogens/Toxicity	0.016
Resp. Organics/Inorganic	0.0101
Climate Change	0.0000573
Radiation	0.0000181
Ozone Layer	0.00000121
	0.000000737
	0.00564
Ecotoxicity	0.00000396
	0.000000703
	0.000000164
Acidification	0.000000226
Eutrophication	0.000000749
Land Use	0.00000258
	0.00000993
	0.00000315
Metal depletion	692
Fossile Fuels	318
Sum [in kPt]	**1010**

Impact Categories	Eco Balance for 0,1 kg Gold electronic scrap
Carcinogens/Toxicity	0.00116
Resp. Organics/Inorganic	0.000209
Climate Change	0.00000118
Radiation	0.000000129
Ozone Layer	1.17E-08
	2.33E-08
	0.000042
Ecotoxicity	1.85E-08
	3.58E-09
	1.29E-09
Acidification	1.94E-09
Eutrophication	6.3E-10
Land Use	1.43E-08
	4.32E-08
	2.04E-08
Metal depletion	0.166
Fossile Fuels	3.7
Sum [in Pt]	**3.9**

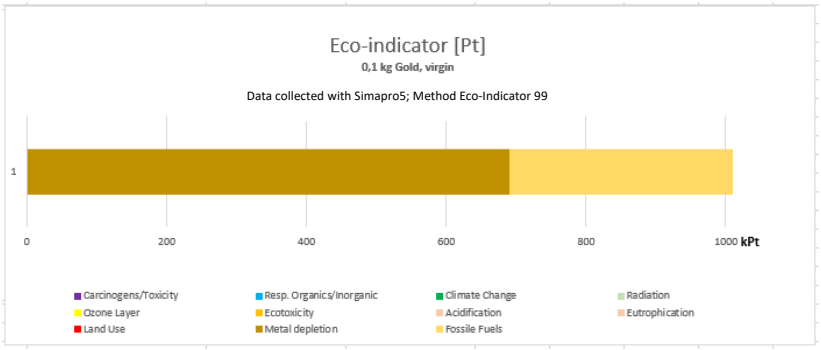
The impact categories are colour-coded. They are reflected in the two staggered bars of the diagram.

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

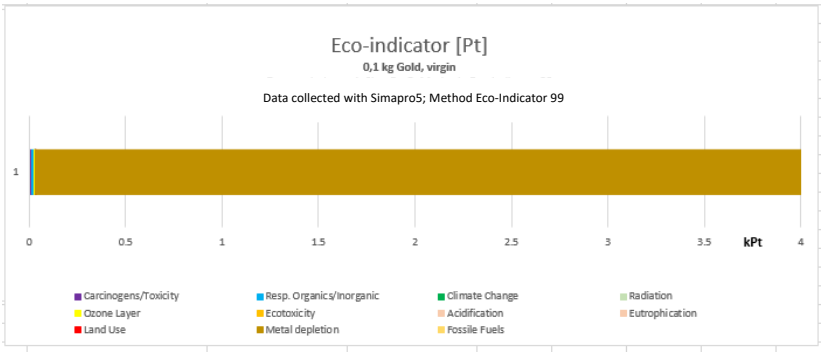
The unit is expressed in Eco-Point **Pt.** 1 Pt is 1/1000th of the annual environmental impact of an average European.

SECTION 4 Interpretation of the results

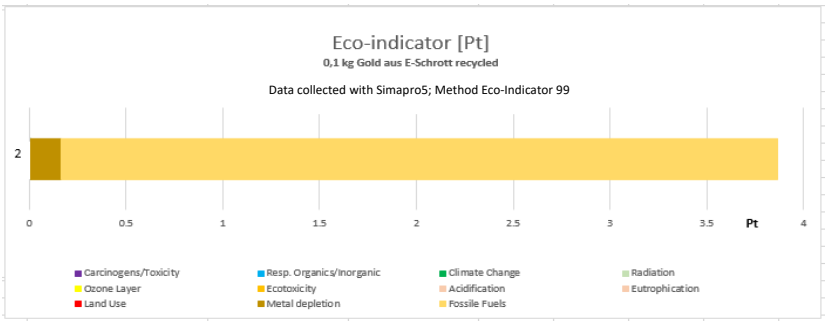
Clearly visible are the mineral and energy resource consumption and the negative health effects during raw material extraction, transport and processing of the rock when gold is extracted from mines. The resource consumption of mineral and fossil fuels dominates the life cycle assessment.



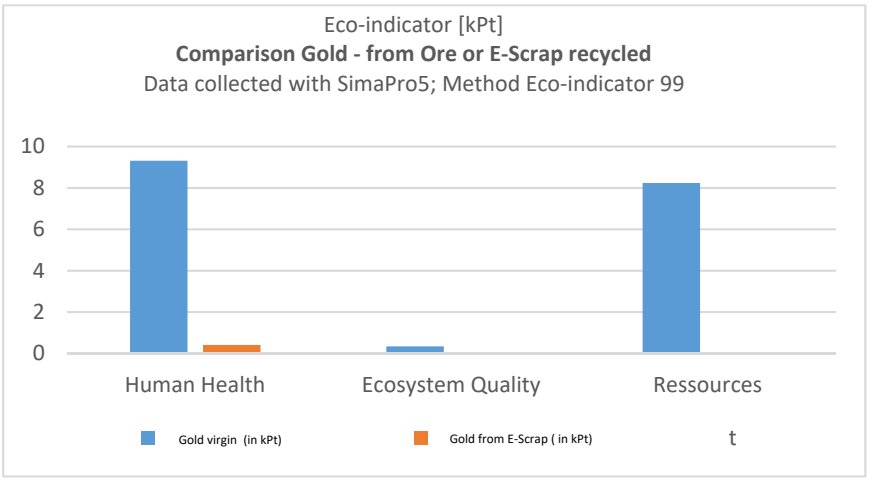
The scaling is in the kPt range in the case of gold!



Even in the detailed view for a better representation of the other impact categories, they are hardly recognizable.



By contrast, the eco-balance for recycled gold is much more favorable. However, the processing of the e-scrap also entails considerable health risks due to the dust load, as it contains other metal components, some of which are toxic.



CONCLUSION: Collecting jewelry, dental crowns and old coins is worth it!But urban mining with the processing of even complex e-scrap is very worthwhile!