Global Cycles of Metals and Minerals

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The consumption of most metals and minerals continues to rise because of population growth, increased affluence, and technological development. Since the beginning of the 20th century, humanity has built up sizeable socioeconomic material stocks and continues to do so. There is also a growing concern about whether we can mine metals fast enough to switch to net-zero carbon technologies on a global scale. This material demand for metals and minerals causes a substantial share of global greenhouse gas emissions, water use, and deforestation, among other environmental impacts. Social implications for workers and local communities and potential scarcity and supply dependency cause additional concern. Therefore, considerations about sustainable material use urge greater resource efficiency and retention of metals in the economy. The global economy needs to use metals and minerals for longer timespans, keeping them in the loop more often. However, in many cases, we are far from closing the material cycles globally in what would be called a Circular Economy. Estimations derived from modeling global material cycles throughout time are that half of the periodic table metals are used for a decade or less before being lost in extraction, production, use, or waste management. While base metals like iron, aluminum, or copper or precious metals like gold, on average, stay in use for up to two centuries, we find that the specialty metals required for a wide range of high-tech products are lost rapidly. Material cycles that are indeed no cycles in practice mean that the need for extraction will stay high or rise even further. This extraction need can be tackled with improved design for better sorting, recycling, and longer-lasting products, combined with improving waste-management practices. Closing material cycles would also make supply chains more resilient and less dependent on countries with either large geological reserves or quasi-monopolistic market positions in material processing. Further research is needed to quantify material-related environmental and social impacts and trace material flows and stocks in the global economy. This information will help in material design, product design, legislation, and regulation and help companies build more resilient supply chains.

Short bio

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Christoph Helbig is a newly appointed Professor of Ecological Resource Technology at the Faculty of Engineering Science of the University of Bayreuth, Germany. His research is on the modeling, simulation, and evaluation of global material cycles from mining to recycling, considering environmental, technic, economic, and social aspects. He specializes in assessments of metals and minerals, infrastructure, energy, and mobility technologies. Previously, Christoph Helbig was a postdoctoral researcher at the University of Augsburg, Germany, where he also did his Ph.D. in industrial engineering. In 2019, he was a visiting postdoctoral researcher at Waseda University, Tokyo, Japan. He holds an M.Sc. degree in physics.