Feasibility Study of Gallium Recycling by Phytoextraction with *Lemna minor*

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Gallium is used in a lot of electrotechnical devices and light sources like light emitting diodes (LED), transistors, photodetectors, and electronic integrated circuits. Additionally, it is applied in solar cells, and in high dilution in some other semiconductors. [1] Appearing in bauxite with an amount of 30 to 80 ppm [2], its mining and production is a tedious and cost-intensive process. Moreover, the low geological deposits and the rising future demand bear a high supply risk of gallium in the long term (Figure 1) [3]. Thus, the investigation and development of a recycling process is an important step to prevent this supply shortfall.

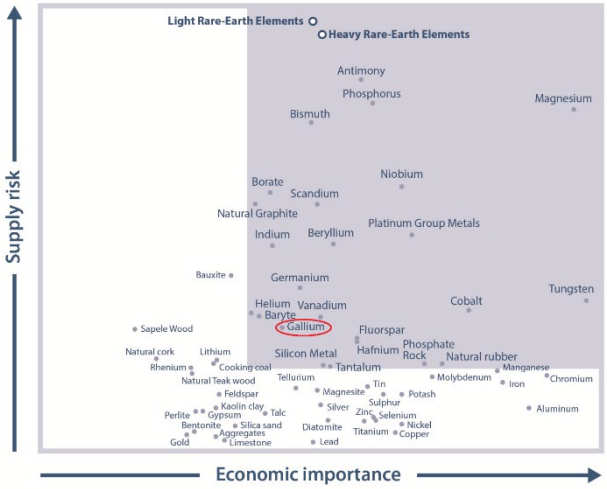

Figure 1: Criticality screening of resources for the EU (2017) (amended from [3])

One potentially applicable recycling method could be a phytoextraction process which employs the ability of algae or higher plants to remove contaminants from soil or water into harvestable plant biomass. In this context, it is well known that the duckweed *Lemna minor* is capable of accumulating aluminum which belongs to group 13 of the periodic table also comprising gallium. The advantage of duckweed is mainly based on the high potential for installing a continuous extraction process as it is easily cultivated and harvested in hydroponic systems.

At the department Chemical Engineering of the FH Münster, the accumulation of gallium with duckweed was successfully investigated. A culture solution for duckweed was spiked with gallium chloride or gallium nitrate; pH was set to 5 - 6, and added citrate prevented the precipitation of gallium hydroxide. After a 7-day growing period with 16/8 h light/dark cycles, the plants were harvested, dried and ashed. Ga was analyzed by ICP-MS. The results show a Ga^{3+} fraction of up to 10 % which is 100 to 1000 times higher compared to the mineral bauxite or the Bayer liquor. This figure is sufficiently encouraging to follow this path of recycling by phytoextraction.

[1] Mineral Commodity Summaries, „Gallium," U.S. Geological Survey, 2012.

[2] J. F. Greber, „Gallium and Gallium Compounds," Wiley-VCH, Weinheim, 2012.

[3] New-Mine, „EU Training Network for Resource Recovery Through Enhanced Landfill Mining," 2018. [Online]. Available: https://new-mine.eu/eu-raw-materials-week/. [Zugriff am 01 03 2021].