Climate change impact on the environmental risk of technology-critical elements (TCE)

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Collaborators: Dr Tamzin Blewett, University of Alberta; Dr Farhan Khan, NORCE, Bergen, Norway.

Case Partner : Dr Chris Cooper, International Zinc Association.

Project Highlights:

- To establish the environmental risk of technology-critical elements
- To determine at a regional scale (in the Arctic) how climate change influences technology-critical elements toxicity
- To better understand the regional, European, and Global regulatory drivers for technology-critical elements via a policy-placement with our Case partner

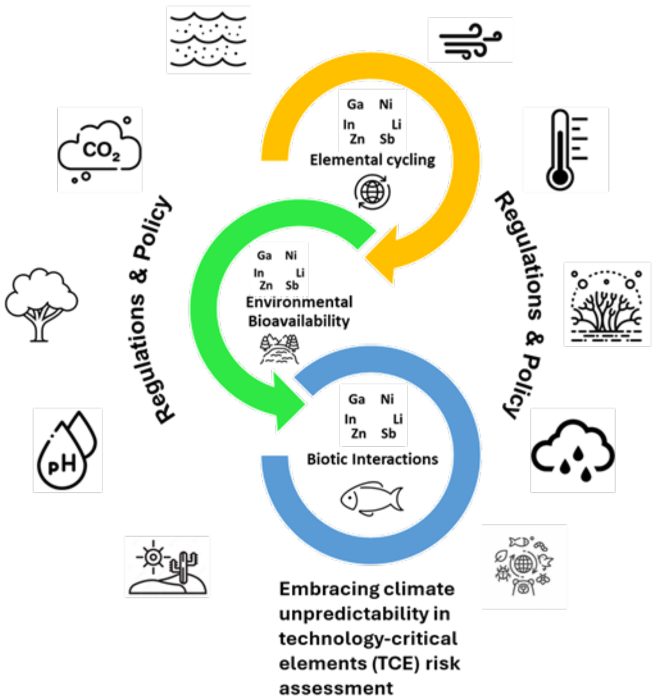
Overview:

Many of the technologies that are essential for the reduction in global carbon dioxide emissions and necessary if the UK is to meet its Net Zero targets are dependent on trace elements. These technology-critical elements include the rare earth elements, platinum group elements, and transition metals such as cobalt, copper and zinc. Paradoxically, the technologies that use these elements aim to reduce the impact of major global climate change (ocean acidification, wildfires, permafrost and glacial thawing and erratic weather patterns), but for many of these elements we lack basic knowledge on their toxicity to humans and wildlife, particularly under changing climatic conditions. This includes their environmental fate, bioavailability and toxic mode-of-action. The Brundtland Commission in 1987 defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs.” Thus, for industries to meet their sustainability goals is good practice to establish the hazards of the compounds it produces or uses and the risks to human and environmental health once released into the environment.

Many of the mining operations for these technology-critical elements occur in regions of the world where we have yet to describe the species present or understand the complex ecosystem structures that maintain environmental health, such as the deep sea. In addition, some of these regions, e.g. the Arctic, are predicted to experience three times the rate of change in comparison to southern latitudes. Regional impacts of climate change may have drastically different effects on local biogeochemical cycles (e.g. inputs from mine tailings) and metal speciation (e.g. pH and sources of dissolved organic matter). A warming world also effects organismal physiology and metabolism associated with temperature acclimation as well as influence metal uptake, accumulation, and detoxification processes.

What is clear is that climate change parameters do not often follow simple linear patterns and unpredictable events are likely the norm. The project aims to understand the cycling, bioavailability, and biotic interactions of these technology-critical elements at a regional scale and assess the potential changes in these factors, and risk to human and environmental health, under near-future climate change scenarios.

Figure for advertisement:



Methodology:

The questions to be addressed are:

How is the environmental availability of technology-critical elements affected by changes in physico-chemical parameters which are likely to be affected by a changing climate?

What is the potential uptake and toxicity technology-critical elements using state-of-the art *in vitro* (non-animal) bioavailability tests?

To answer these the project will include both field and laboratory components. Field based studies will analyse trace element compositions of water, sediment, and biota in Greenland or the Canadian Arctic (depending on availability). We will use state of art trace metal analysis such as Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and laser-ablation Time-of-Flight Mass spectrometry (TOF-MS) as well as BGS' metal bioavailability and bioaccessibility methods. Laboratory based studies will assess the impact of these elements on organism physiology under different climatic conditions. There will also be an opportunity for policy-placements with the International Zinc Association to understand the regulatory requirements on industry.

Possible Timeline

Year 1: Literature review of current understanding of technology-critical elements toxicity and the impact of climate drivers. Field work – samples collection and clean lab trace element metal analysis.

Year 2: Laser-ablation TOF-MS and trace element bioavailability, speciation and toxicity studies under different climate scenarios.

Year 3: Potential field work at the Canadian High Arctic Research Station, sample analysis and policy-placement.

Training and skills:

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study,*
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study,*
- a number of one-day workshops,
- additional online events and in-person workshops attached to relevant conferences,
- tissue and environmental trace-metal analysis,
- environmental fate analysis,
- Multi-element laser-ablation TOF-MS,
- Human bioaccessibility testing,
- organismal physiology experimental design,
- in silico metal speciation analysis,
- industry perspective on metal regulations (policy-placement).

Partners and collaboration (including CASE):

TARGET partners - Southampton supervisor Dr Nic Bury and co-supervised by Prof Andy Cundy and Dr Darren Beriro (BGS). The student will join weekly lab meeting and monthly meetings with all project & Case partners.

Collaboration – Dr Tamzin Blewett, University of Alberta (https://www.blewettlab.com/) has recently received funding from the Canadian Government to assess the environmental impacts of mining in the Arctic. The successful candidate will undertake a research placement with Dr Blewett's at CHARS (https://www.canada.ca/en/polar-knowledge/CHARScampus.html) or University of Alberta.

Dr Farhan Khan, NORCE Norwegian Research Centre AS, Bergan, Norway, has led recent work on impact of climate change on metals and is involved in the Norwegian initiatives in metal research, focusing on bioaccumulation models (i.e. biodynamic modelling approaches)

Industry Case Partners – Dr Chris Cooper, International Zinc Association advise their members, mining organisations and downstream users, on environmental issues, EU policy and regulatory requirements and are part of the wider group International Council on Mining and Metals (ICMM) and members of Eurometaux (https://eurometaux.eu/).

Further reading:

Zitoun, R., Marcinek, S., Hatje, V. et al. Climate change driven effects on transport, fate and biogeochemistry of trace element contaminants in coastal marine ecosystems. Commun Earth Environ 5, 560 (2024). https://doi.org/10.1038/s43247-024-01679-y

Adeel, M., Lee, J.Y., Zain, M et al. Cryptic footprints of rare earth elements on natural resources and living organisms. (2019). Environ Int 127, 785-800. doi: 10.1016/j.envint.2019.03.022.

Gauthier, P.T., Blewett, T.A., Garman, E.R., Schlekat, C.E., Middleton, E.T., Suominen, E.M. and Cremazy, A. 2021. Environmental risk of nickel in aquatic Arctic ecosystems. Sci. Tot. Environ., 797, 14891.

Further details:

Please visit https://target.le.ac.uk/ for additional details on how to apply.

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Websites:

https://burylabs.co.uk/

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