

**Note: Reference may contain copyrighted material
and is therefore not published in its entirety.**

ELSEVIER

journal homepage: www.elsevier.com/locate/envres

Toxic elements in arctic and sub-arctic brown bears: Blood concentrations of As, Cd, Hg and Pb in relation to diet, age, and human footprint

Boris Fuchs^{a,*}, Kyle Joly^{b,**}, Grant V. Hilderbrand^c, Alina L. Evans^a, Ilia Rodushkin^{d,e}, Lindsey S. Mangipane^f, Buck A. Mangipane^g, David D. Gustine^f, Andreas Zedrosser^{h,i}, Ludovick Brown^j, Jon M. Arnemo^{a,k}

^a Department of Forestry and Wildlife Management, Inland Norway University of Applied Sciences, Campus Evenstad, 2480, Koppang, Norway

^b National Park Service, Gates of the Arctic National Park and Preserve, 99709, Fairbanks, Alaska, USA

^c National Park Service, Alaska Regional Office, 99501, Anchorage, Alaska, USA

^d Division of Geosciences, Luleå University of Technology, 97187, Luleå, Sweden

^e ALS Scandinavia AB, 97187, Luleå, Sweden

^f U.S. Fish and Wildlife Service, Marine Mammals Management, 99503, Anchorage, Alaska, USA

^g Lake Clark National Park and Preserve, National Park Service, 99501, Anchorage, Alaska, USA

^h Department of Natural Science and Environmental Health, University of South-Eastern Norway, 3800, Bø in Telemark, Norway

ⁱ Institute for Wildlife Biology and Game Management, University of Natural Resources and Life Sciences, 1180, Vienna, Austria

^j Département de Biologie, Université de Sherbrooke, J1K 2R1, Sherbrooke, Québec, Canada

^k Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences, 901 83, Umeå, Sweden

ARTICLE INFO

Handling Editor: Robert Letcher

Keywords:

Boreal
Contaminants
Grizzly bear
Pollution
Ursidae
Trace elements

ABSTRACT

Contamination with arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb) is a global concern impairing resilience of organisms and ecosystems. Proximity to emission sources increases exposure risk but remoteness does not alleviate it. These toxic elements are transported in atmospheric and oceanic pathways and accumulate in organisms. Mercury accumulates in higher trophic levels. Brown bears (*Ursus arctos*), which often live in remote areas, are long-lived omnivores, feeding on salmon (*Oncorhynchus* spp.) and berries (*Vaccinium* spp.), resources also consumed by humans.

We measured blood concentrations of As, Cd, Hg and Pb in bears (n = 72) four years and older in Scandinavia and three national parks in Alaska, USA (Lake Clark, Katmai and Gates of the Arctic) using high-resolution, inductively-coupled plasma sector field mass spectrometry. Age and sex of the bears, as well as the typical population level diet was associated with blood element concentrations using generalized linear regression models.

Alaskan bears consuming salmon had higher Hg blood concentrations compared to Scandinavian bears feeding on berries, ants (*Formica* spp.) and moose (*Alces*). Cadmium and Pb blood concentrations were higher in Scandinavian bears than in Alaskan bears. Bears using marine food sources, in addition to salmon in Katmai, had higher As blood concentrations than bears in Scandinavia. Blood concentrations of Cd and Pb, as well as for As in female bears increased with age. Arsenic in males and Hg concentrations decreased with age.

We detected elevated levels of toxic elements in bears from landscapes that are among the most pristine on the planet. Sources are unknown but anthropogenic emissions are most likely involved. All study areas face upcoming change: Increasing tourism and mining in Alaska and more intensive forestry in Scandinavia, combined with global climate change in both regions. Baseline contaminant concentrations as presented here are important knowledge in our changing world.

* Corresponding author.

** Corresponding author.

E-mail addresses: boris.fuchs@inn.no (B. Fuchs), kyle.joly@nps.gov (K. Joly).

<https://doi.org/10.1016/j.envres.2023.115952>

Received 9 March 2023; Received in revised form 16 April 2023; Accepted 18 April 2023

Available online 26 April 2023

0013-9351/© 2023 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).