UMEÅ UNIVERSITET

Metals take flight
Transport and effects across ecosystems

Johan Lidman

Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av filosofie doktorsexamen framläggs till offentligt försvar i Triple Helix, Universitetsledningshuset,
Fredagen den 19 februari, kl. 09:00.
Avhandlingen kommer att försvaras på engelska.

Fakultetsopponent: Doktor Brendan Mckie,
Institutionen för vatten och miljö, Sveriges lantbruksuniversitet,
Uppsala, Sverige.

Institutionen för Ekologi, Miljö och Geovetenskap

Organization
Umeå University
Department name

Document type
Doctoral thesis

Date of publication
19 February 2021

Author
Johan Lidman

Title
Metals take flight - Transport and effects across ecosystems

Abstract
Metal contamination can have severe toxic effects in the ecosystems, resulting in loss of biodiversity, reduced abundance of organisms, and loss of ecosystem services. Traditionally, aquatic ecosystems have been regarded as a sink of metal contamination. However, lakes could also act as a source, as metals can be transported by emerging aquatic insects from the aquatic to the terrestrial ecosystem. The consequence of this transport for terrestrial organisms has previously gained little focus. In this thesis, I study metal contamination transport and toxic effects on metal exposed aquatic invertebrates and the terrestrial insectivorous bird, pied flycatcher (*Ficedula hypoleuca*), in aquatic and terrestrial environments contaminated by metals from a closed lead (Pb) and zinc (Zn) mine. Studied lakes adjacent to the mine all displayed elevated metal concentrations from the start of the mining operation, but with different temporal and spatial patterns with lakes used as part of the mining activity even more affected. Factors affecting metal toxicity, such as organic matter concentration in lakes, varied during the mining and post-mining period, indicating fluctuating toxicity despite similar metal concentrations. The contamination level and toxicity risk are still high 15 years after closure of the mine, but ecosystems are starting to recover. Despite high metal concentrations in lake water and sediment, no effect on invertebrate abundance or composition of aquatic invertebrates was observed. However, when focusing on metamorphosis, proportionally fewer insects emerged from more contaminated lakes. In contrast, in lab mesocosm was no effect on metamorphosis observed of non-biting midges (*Chironomus riparus*), although larval survival decreased, and emergence was delayed at higher metal concentrations in sediments. Emerging adult insects transported a significant amount of metals to terrestrial ecosystems, observed both in the lab and in the field. Emerging aquatic insect and ants were major dietary metal exposure routes for pied flycatcher's nestlings. Thus, aquatic-derived metals can influence terrestrial consumers, especially in riparian zones of contaminated lakes where availability of aquatic insects is high. Increasing accumulation of Pb has been observed to reduce hemoglobin (Hb) levels in birds. Despite elevated Pb concentrations in nestling blood in contaminated environments, nestling Hb levels, used also as indicator of nestling health, was more affected by availability of different prey than Pb levels in the blood, where availability of aquatic insects and aerial terrestrial insect had positive impact on nestling health. Overall, this thesis show that metal contamination of aquatic ecosystems also influences terrestrial organisms by decreasing their food availability and increasing metal exposure via diets. Thus, potential effects on terrestrial systems should to larger extent be included when studying aquatic contaminants. Further, indirect effects and metal bioavailability could alter the toxic effects on metal-exposed organism and should be included to accurately estimate direct toxic effects.

Keywords
Metal contamination, aquatic insects, passerines, aquatic subsidies, cross-ecosystem impact, multiple stressors, sediment toxicity

Language
English

ISBN
978-91-7855-447-8

Number of pages
32 + 5 papers