Heavy metal leaching from forest roads reinforced with fly ash

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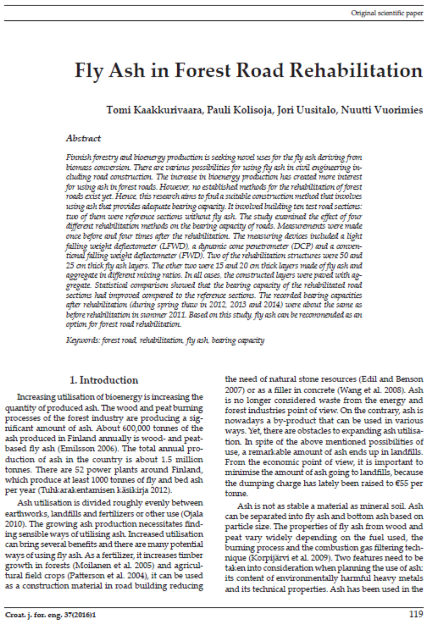
FORMEC-COFE, 6. – 9. Oct. 2019, Sopron

Related studies and presentations

- “Fly ash for forest road rehabilitation” FORMEC 4.10-8.10.2015, Linz, Austria
- “Increased fly ash utilization — value addition through forest road reconstruction” FEC, 16.-19.4.2018, Rotorua, New Zealand


Original scientific paper

Fly Ash in Forest Road Rehabilitation

Tomi Kaakkurivaara, Pauli Kolisoja, Jori Uusitalo, Nuutti Vuorimies

Abstract

Keywords: forest road, rehabilitation, fly ash, bearing capacity

1. Introduction

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ARTICLE

Increased fly ash utilization — value addition through forest road reconstruction

Tomi Kaakkurivaara and Heikki Korpunen

Introduction

First question from audience: how about heavy metals?

Background

- The amount of fly ash which originates from burning of wood and peat has grown to 700 000 tons in Finland (2017)
- Increased forest biomass and peat based fly ash utilization has potential benefits from an economic point of view. Dumping charges have risen lately in Europe, especially in Finland to €70 per ton. As a result of rising dumping charges, new applications or methods for utilizing fly ash have become more relevant.

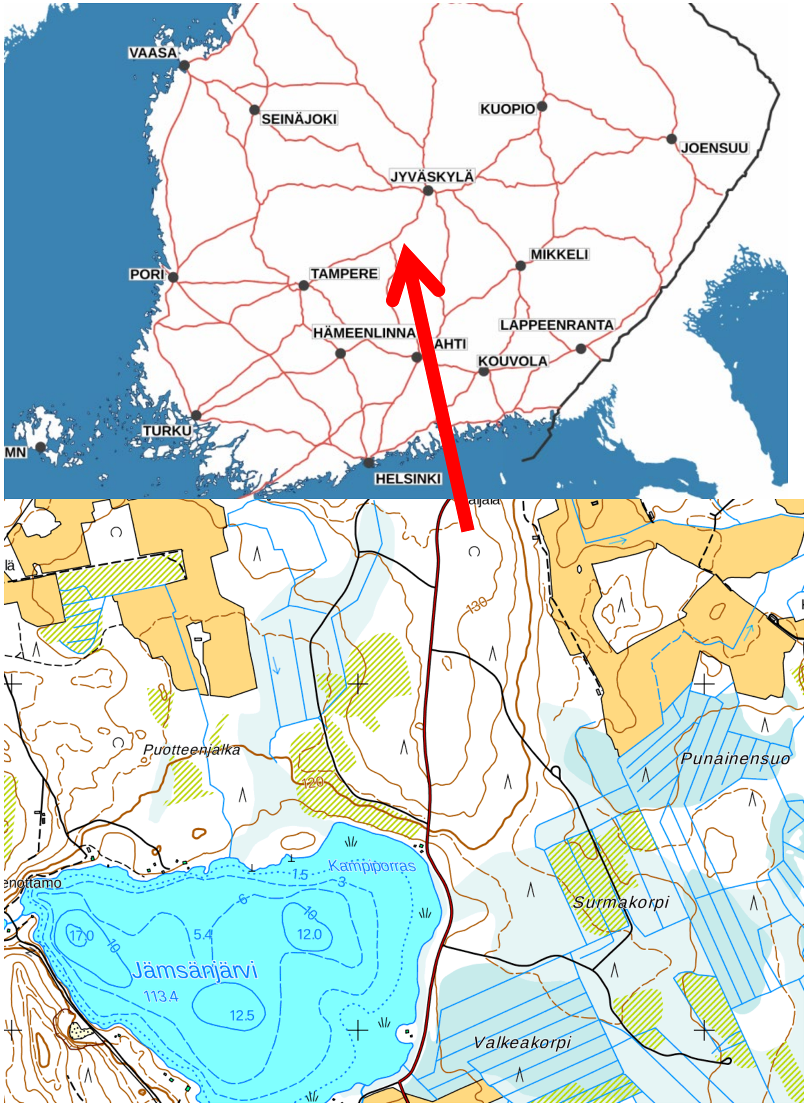
Background

- The situation of ash utilization in forest road construction and rehabilitation has changed recently in Finland. At the beginning of 2018, the same environmental permission procedure covers both the forest roads and public roads
- How about environment aspects? Ash may contain several heavy metals, e.g. Cu, Cd, Cr, Mn, Hg, Ni and Zn, which are toxic in high concentrations

Objectives

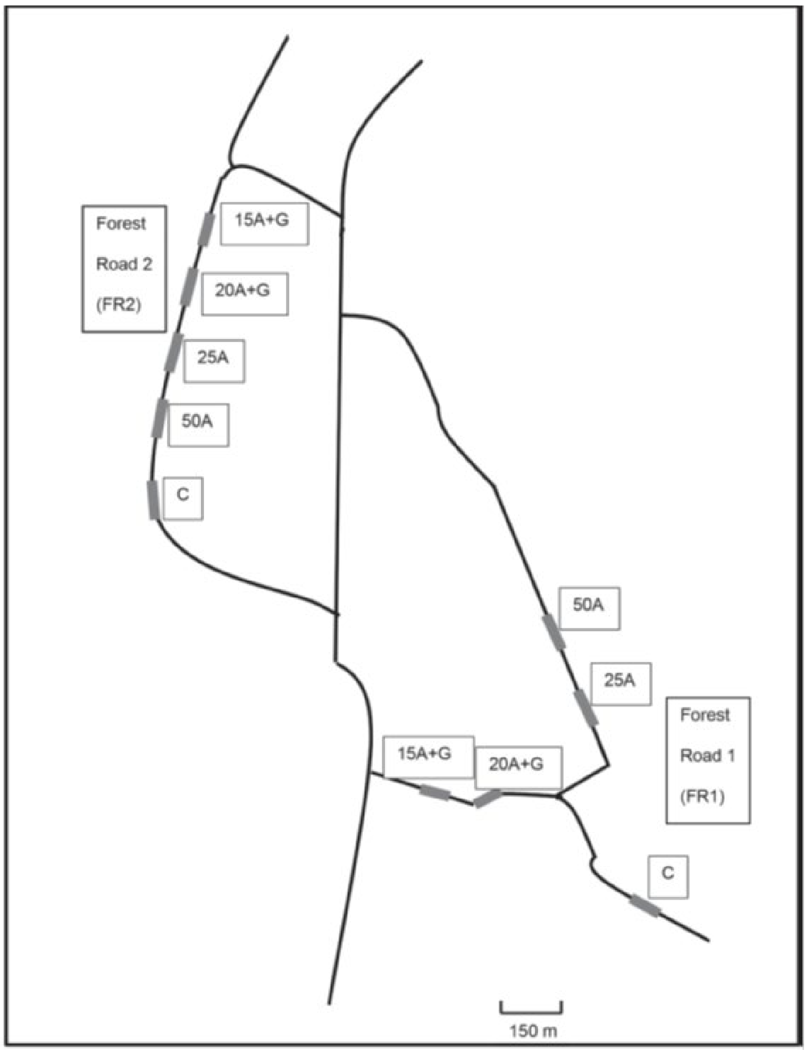
- The aim of this study was to determine the water quality related to the concentrations of dissolved heavy metals and barium (Ba)
- We hypothesized that possible dissolution of heavy metals and Ba from ash layers would be evenly distributed phenomena and similar in all locations from the ash containing road since the homogenous ash layers were constructed inside the forest roads.

Study location



- Experimental area near Jämsä, central Finland.
- Vegetation; Boreal, Forest land; wetlands and upland mineral soils
- Mean annual precipitation 636 mm
- Mean effective temperature sum 1333 degree days
- Mean growing season length 170 days

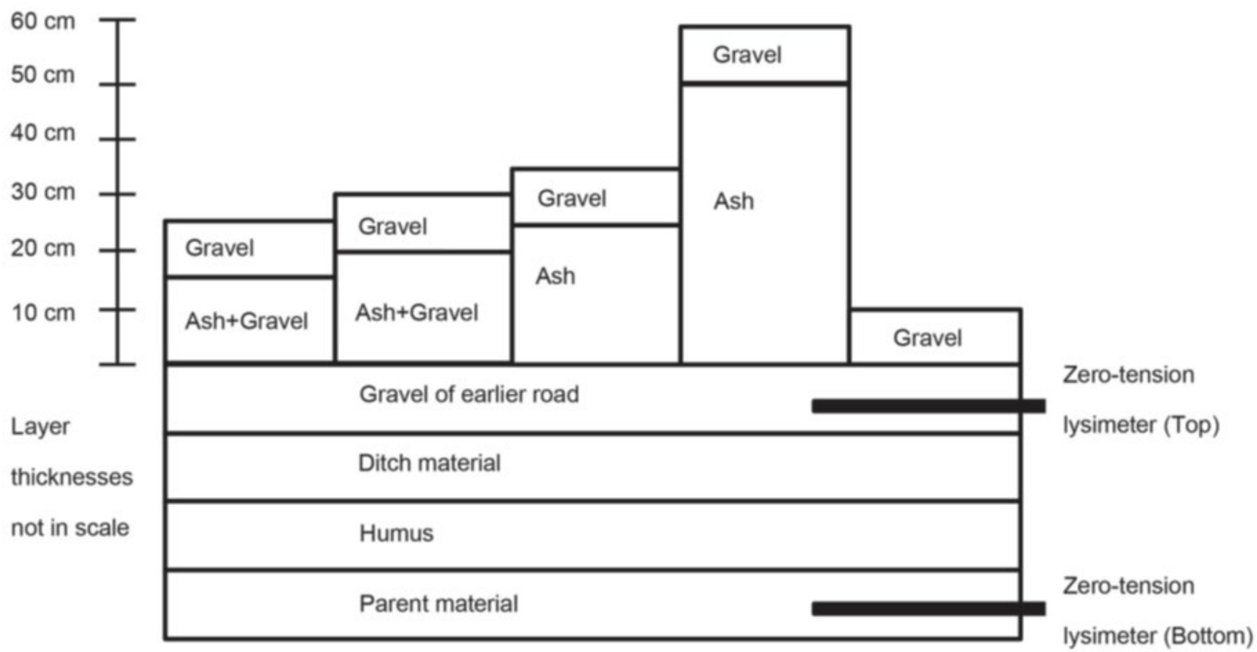
Test structures



Treatments:

- **C** = control (no ash)
- **15A +G** = 15 cm layer of ash + gravel
- **20A + G** = 20 cm layer of ash + gravel
- **25A** =25 cm layer of ash
- **50A** = 50 cm layer of ash

Road structure and lysimeters

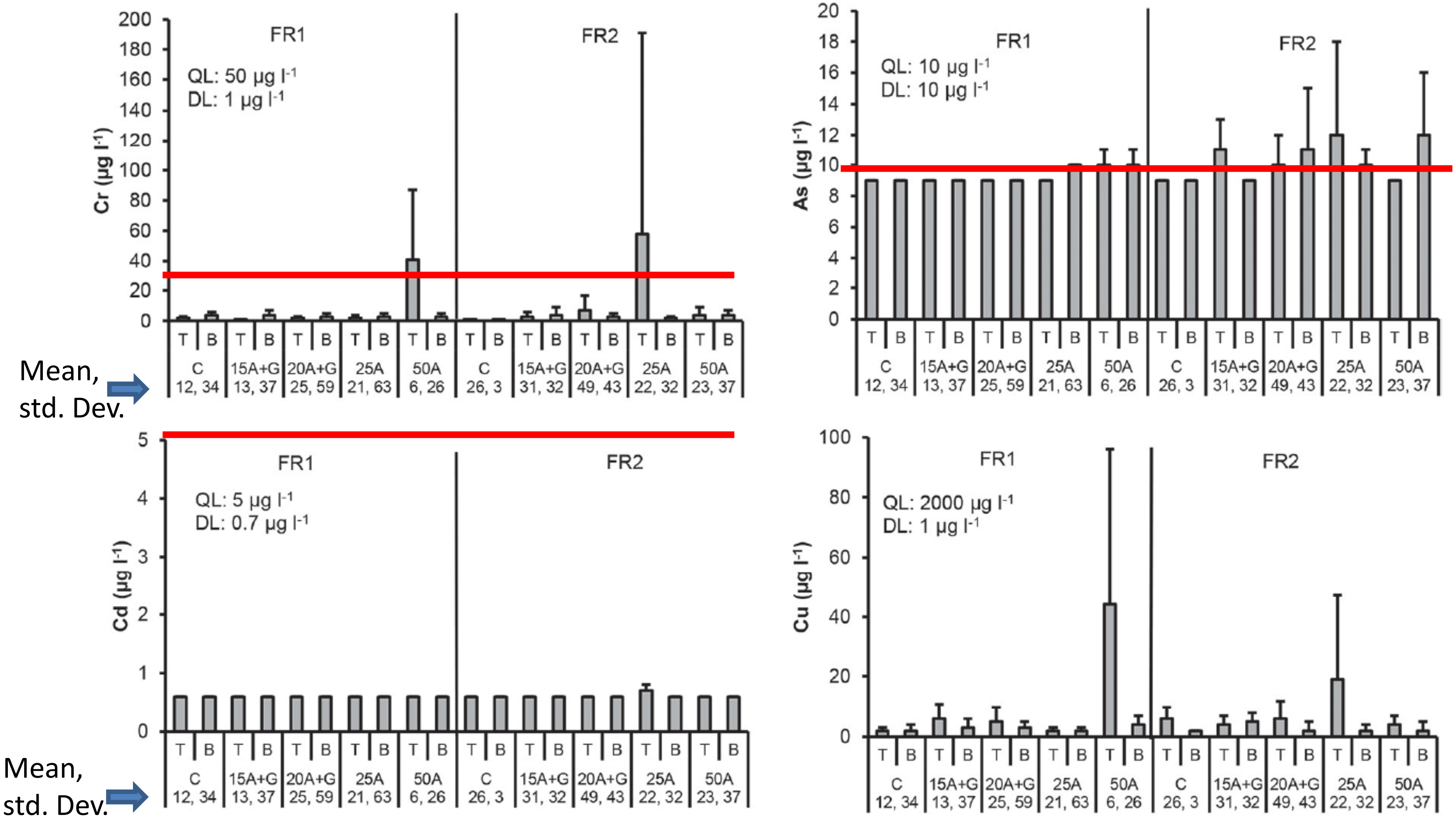


- Percolation water collected by lysimeters (0,1m^2)
- Also ditch water samples collected up and down stream
- Data collecting 2011 – 2014, May–November at about 4-week intervals.

Upper limit concentrations

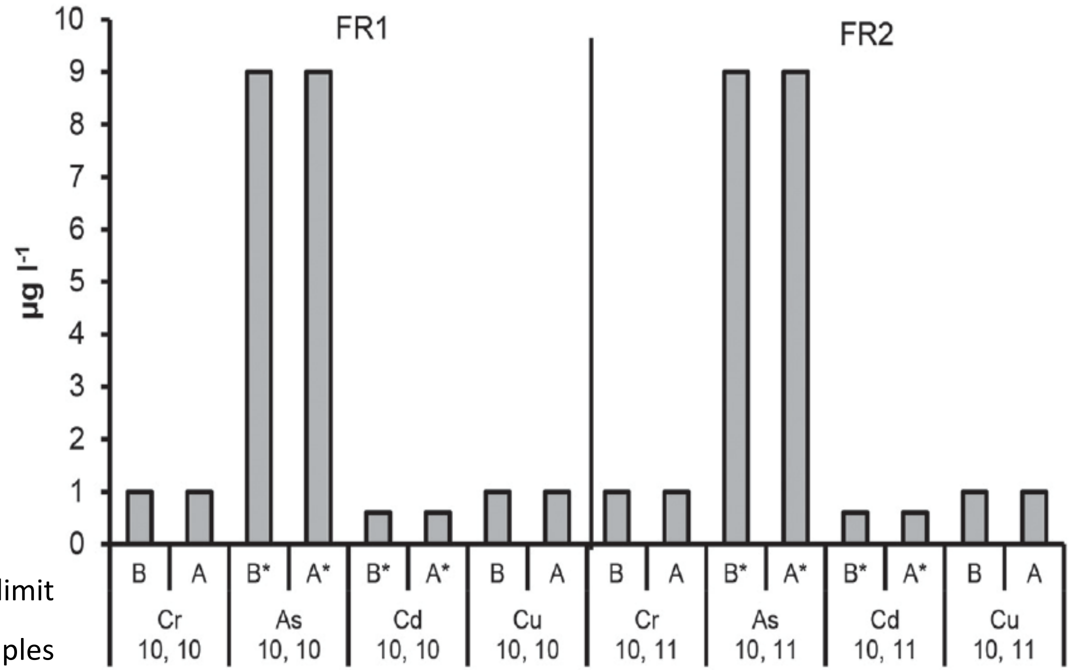
Measured parameter	Density ($kg\ l^{-1}$)	Quality limit (QL)	Source
Heavy metals			
Arsenic (As)	5.72	$10\ \mu g\ l^{-1}$	Finlex (2001)
Cadmium (Cd)	8.65	$5\ \mu g\ l^{-1}$	Finlex (2001)
Cobalt (Co)	8.90	$1\ \mu g\ l^{-1}$	Lahermo et al. (2002)
Copper (Cu)	8.96	$2000\ \mu g\ l^{-1}$	Finlex (2001)
Chromium (Cr)	7.19	$50\ \mu g\ l^{-1}$	Finlex (2001)
Lead (Pb)	11.35	$10\ \mu g\ l^{-1}$	Finlex (2001)
Molybdenum (Mo)	10.22	$70\ \mu g\ l^{-1}$	Lahermo et al. (2002)
Nickel (Ni)	8.90	$20\ \mu g\ l^{-1}$	Finlex (2001)
Zinc (Zn)	7.13	$3000\ \mu g\ l^{-1}$	Finlex (2001)
Earth alkaline metal			
Barium (Ba)	3.59	$700\ \mu g\ l^{-1}$	WHO (2011)

Concentrations in percolation water



- QL = quality limit, DL = detection limit of analytical equipment.

Ditch water

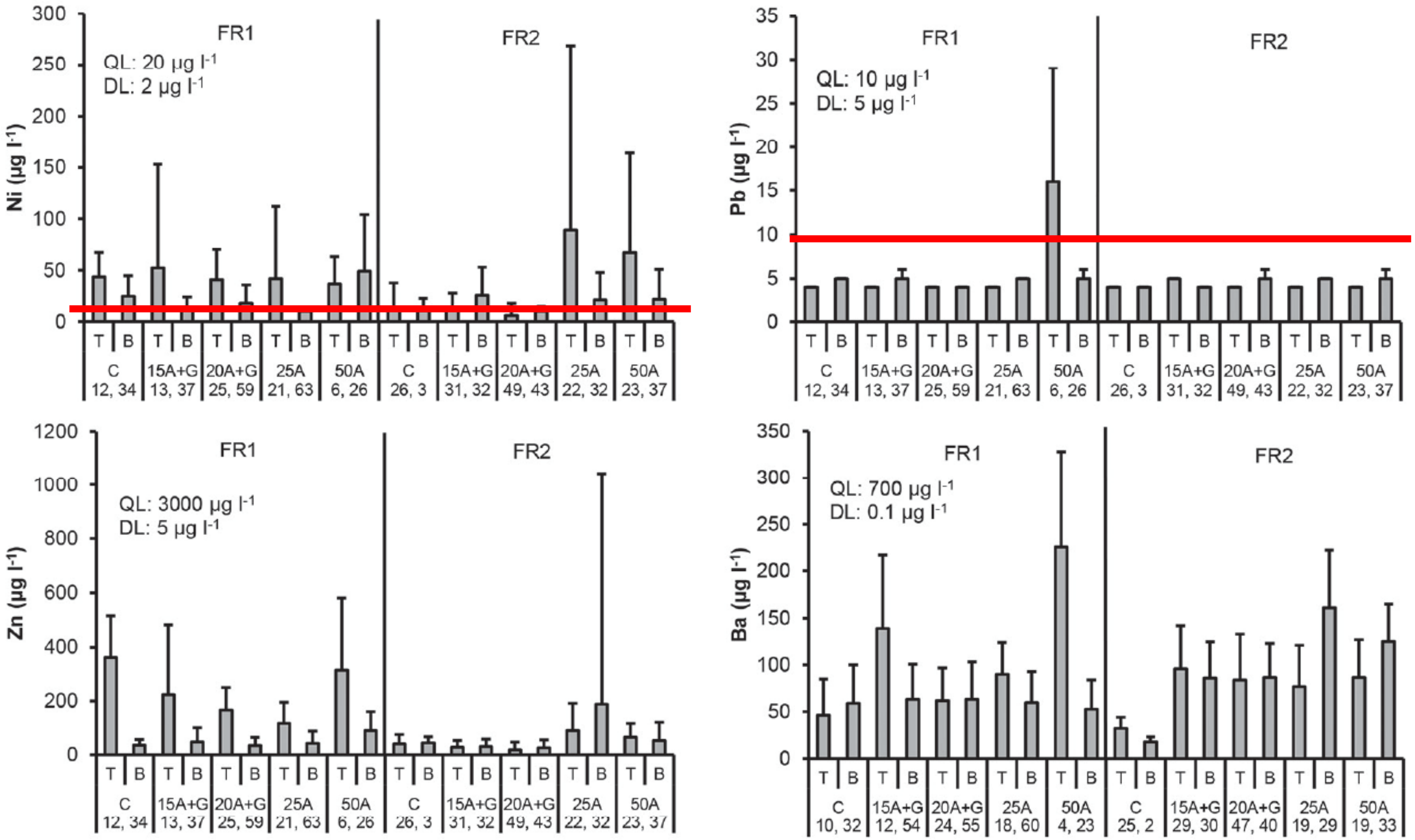


* Below detection limit

N:o samples

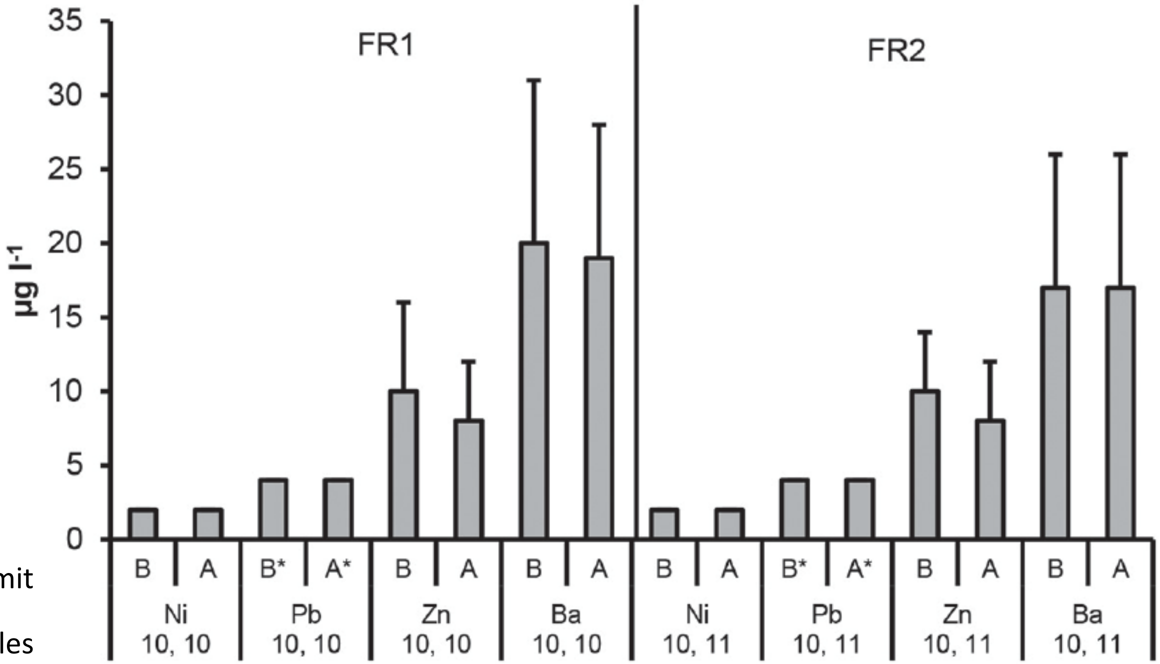
- collected before (B, no ash effect) and after (A, incl. possible ash effect) the ditch crossed the experimental forest road containing ash layers (FR1, FR2).

Concentrations in percolation water



- QL = quality limit, DL = detection limit of analytical equipment.

Ditch water



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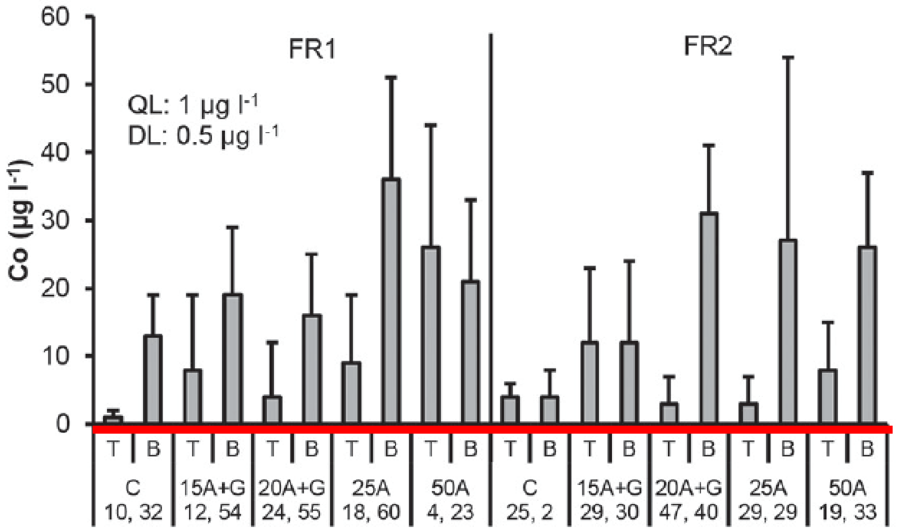
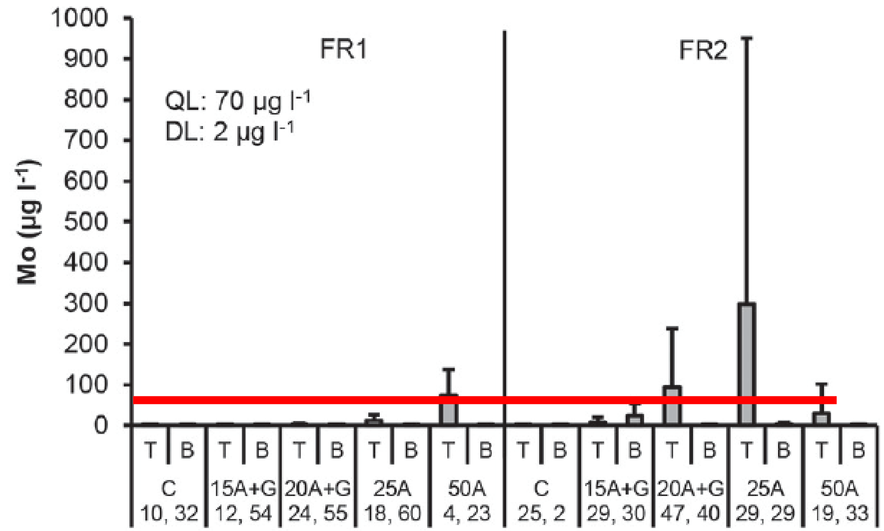
Concentrations in percolation water





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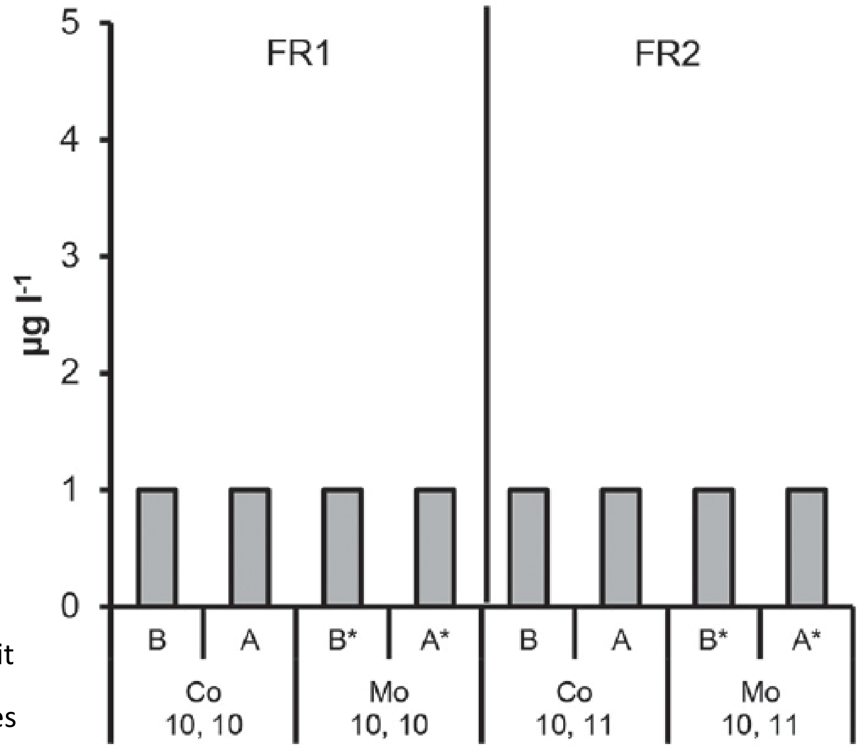
Ditch water



* Below detection limit

N:o samples

- collected before (B, no ash effect) and after (A, incl. possible ash effect) the ditch crossed the experimental forest road containing ash layers (FR1, FR2).

Conclusions

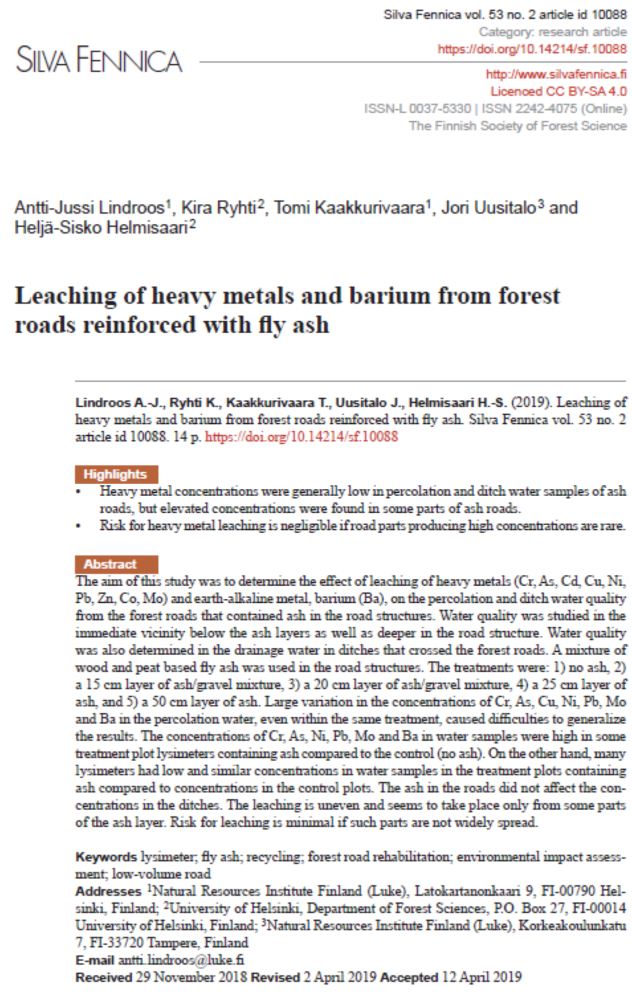
- The mean concentrations of all the measured parameters were low in many treatment plots that contained ash, and the mean concentrations decreased in the road structure from the top to the bottom level of the road.
- Some lysimeters close to the ash layer had elevated concentrations of heavy metals (e.g. As, Ni, Mo) and Ba in percolation water, when others necessarily did not.
- The ash containing forest roads did not negatively affect the concentrations of water in ditches that crossed the forest roads.
- The leaching from the forest roads seems to take place from some points from the ash layer and not evenly from the entire ash layer.
- Risk for leaching should be considered if the points with high concentrations are widely spread in the road, and water from these parts is flowing directly to side-ditches and groundwater without percolation through the soil material of the road structure.
- The risk for leaching of heavy metals and Ba seems to be low.

Thank you!

- Further information:

Lindroos A-J, Ryhti K, Kaakkurivaara T, Uusitalo J, Helmisaari H-S. 2019. *Leaching of heavy metals and barium from forest roads reinforced with fly ash.* Silva Fennica vol. 53 no. 2. https://doi.org/10.14214/sf.10088

- Any questions?



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Leaching of heavy metals and barium from forest roads reinforced with fly ash

Lindroos A.-J., Ryhti K., Kaakkurivaara T., Uusitalo J., Helmisaari H.-S. (2019). Leaching of heavy metals and barium from forest roads reinforced with fly ash. Silva Fennica vol. 53 no. 2 article id 10088. 14 p. https://doi.org/10.14214/sf.10088

Highlights

- Heavy metal concentrations were generally low in percolation and ditch water samples of ash roads, but elevated concentrations were found in some parts of ash roads.
- Risk for heavy metal leaching is negligible if road parts producing high concentrations are rare.

Abstract

The aim of this study was to determine the effect of leaching of heavy metals (Cr, As, Cd, Cu, Ni, Pb, Zn, Co, Mo) and earth-alkaline metal, barium (Ba), on the percolation and ditch water quality from the forest roads that contained ash in the road structures. Water quality was studied in the immediate vicinity below the ash layers as well as deeper in the road structure. Water quality was also determined in the drainage water in ditches that crossed the forest roads. A mixture of wood and peat based fly ash was used in the road structures. The treatments were: 1) no ash, 2) a 15 cm layer of ash/gravel mixture, 3) a 20 cm layer of ash/gravel mixture, 4) a 25 cm layer of ash, and 5) a 50 cm layer of ash. Large variation in the concentrations of Cr, As, Cu, Ni, Pb, Mo and Ba in the percolation water, even within the same treatment, caused difficulties to generalize the results. The concentrations of Cr, As, Ni, Pb, Mo and Ba in water samples were high in some treatment plot lysimeters containing ash compared to the control (no ash). On the other hand, many lysimeters had low and similar concentrations in water samples in the treatment plots containing ash compared to concentrations in the control plots. The ash in the roads did not affect the concentrations in the ditches. The leaching is uneven and seems to take place only from some parts of the ash layer. Risk for leaching is minimal if such parts are not widely spread.

Keywords lysimeter; fly ash; recycling; forest road rehabilitation; environmental impact assessment; low-volume road
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