Heavy metals in deposition, soil and runoff

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Data evaluation and data collection in Sweden: *Åkerblom, S., Lundin, L., Rönnback, P., Löfgren, S., Bovin, K., Pihl Karlsson, G., Moldan, F. and Thunholm, B*

Funded by: the Swedish Environmental Protection Agency

Outline

Heavy metals in Annual Report 2020:

- Temporal trends of heavy metals in runoff water
- Budgets of heavy metals in Swedish catchments

Heavy metals to scientific manuscript:

- Data available in international database
- Catchments budgets in Sweden
- Temporal trends of metals in soils in Sweden
- Temporal trends of Hg, Cd, Pb in runoff waters

ICP IM Annual Report 2020

Karin Eklöf[1], Stefan Löfgren[1], Pernilla Rönnback[1], Kleemola Sirpa[2], Lars Lundin[1], Staffan Åkerblom[1,3], Gunilla Pihl-Karlsson[4], Filip Moldan[4] and Ulf Grandin[1]

Who more should be included?

[1]Swedish University of Agricultural Sciences

[2] Finnish Environment Institute (SYKE)

[3]Statistics Sweden

[4]IVL Swedish Environmental Research Institute

Annual report 2020: Objectives

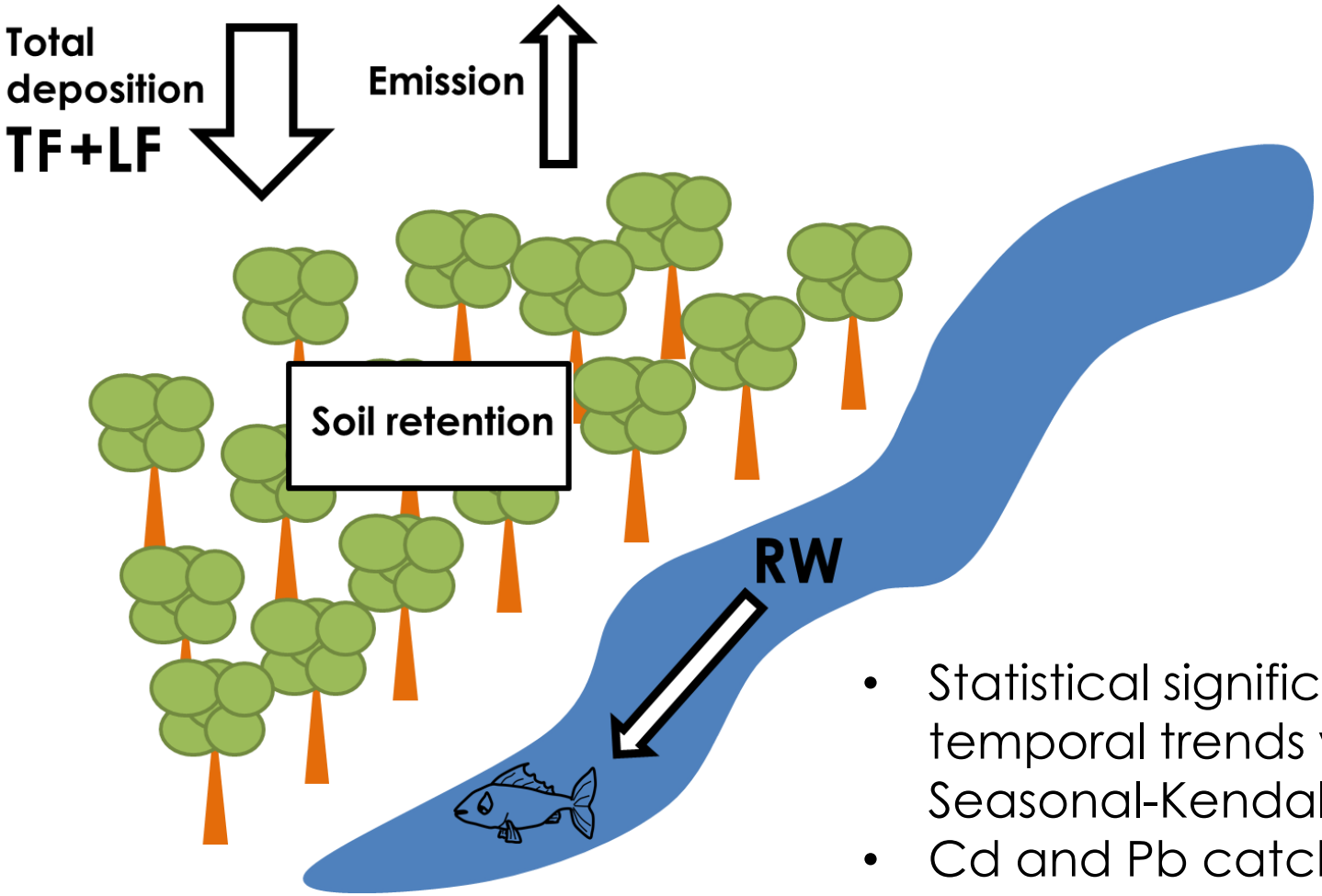
- Declining deposition of Cd, Pb and Hg over Europe in recent decades
- less mobilization of metals from terrestrial soil to surface waters as a result of recovery from acidification

Are declining trends in metal and acid deposition reflected in temporal trends of Cd, Pb and Hg in runoff waters?

How much metals are retained in catchments according to input-output budgets?

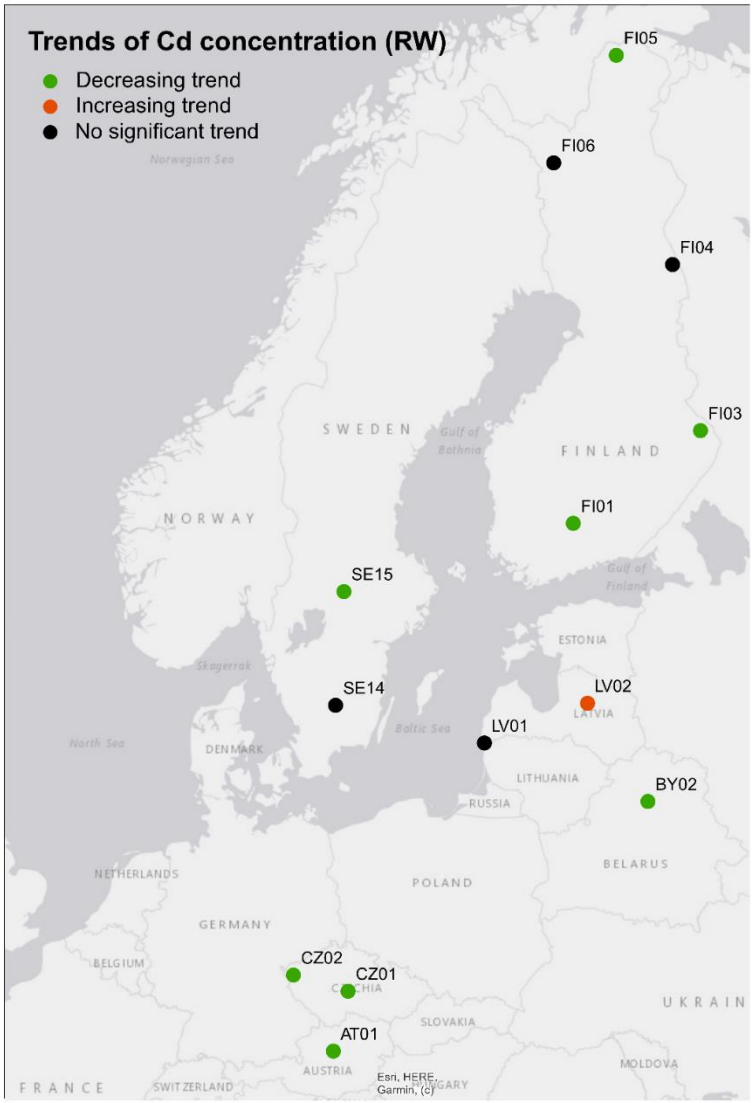


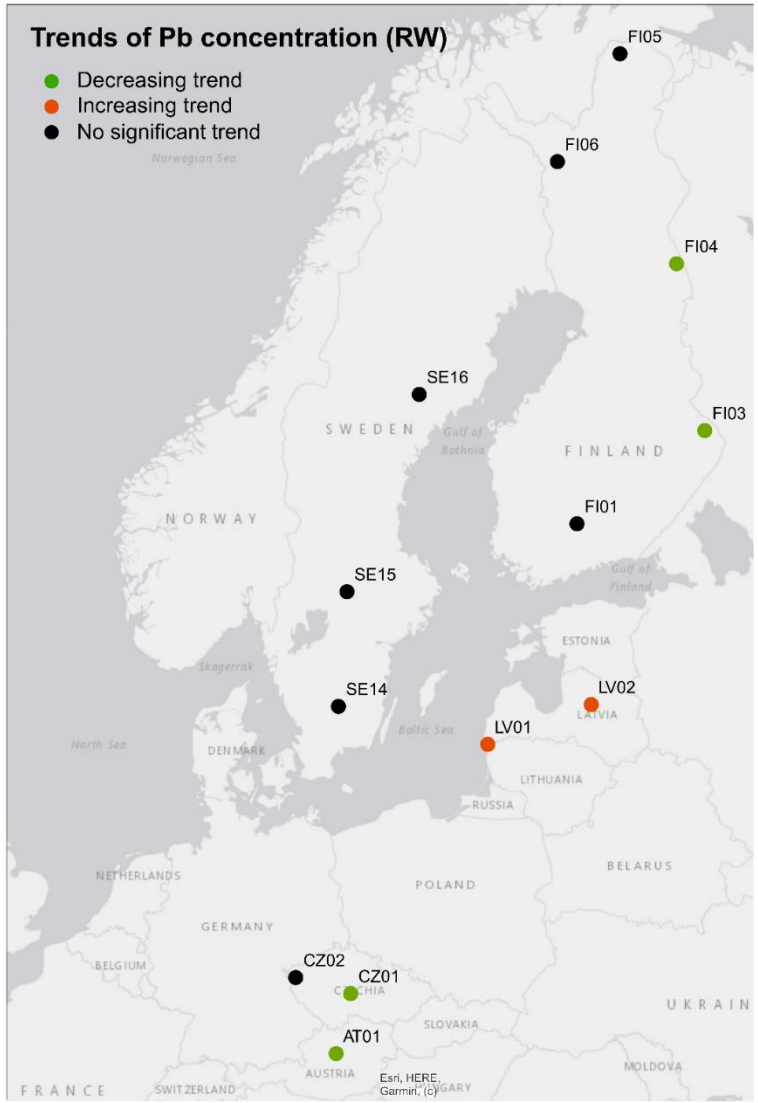
Annual report 2020: Method



- Statistical significance of the temporal trends were tested by Seasonal-Kendall tests
- Cd and Pb catchment budgets in Swedish ICP IM sites

Temporal trends in runoff waters





Temporal trends of cadmium (left) and lead (right) concentration in runoff water from ICP IM sites between 1988 (at earliest) and 2018 (at latest).

Budget of metals in Swedish ICP IM sites

Metal	Site	Open field (BD)	Through fall (TF)	Litter fall (LF)	Runoff (RW)	Total deposition (TF+LF)	% RW of TF+LF
Cd	Aneboda	0.01 (7)	0.02 (7)	0.1 (18)	0.01 (18)	0.1	13
	Gammtratten	0.01 (3)	0.01 (3)	0.02 (14)	0.01 (14)	0.03	29
	Gårdsjön	0.03 (13)	0.03 (13)	0.1 (12)	0.03 (12)	0.1	30
	Kindla	0.03 (3)	0.02 (3)	0.02 (18)	0.03 (18)	0.04	70
Pb	Aneboda	0.9 (7)	0.4 (9)	0.5 (18)	0.3 (18)	0.9	33
	Gammtratten	0.5 (3)	0.3 (4)	0.2 (14)	0.1 (12)	0.5	20
	Gårdsjön	1.0 (13)	0.4 (4)	0.5 (10)	0.5 (3)	0.9	56
	Kindla	0.6 (3)	0.5 (5)	0.5 (18)	0.2 (11)	1.0	21

Catchment budget of Cadmium (Cd) and Lead (Pb) from the Swedish ICP IM sites; Aneboda, Gammtratten, Gårdsjön and Kindla. All numbers are given in ***mg m^{-2} y^{-1}****. Median values from annual fluxes between 1997 and 2018 are presented. Numbers (n) of years that make up the median values is given in parentheses.*

Heavy metals/mercury manuscript

Karin Eklöf[1], Stefan Löfgren[1], Pernilla Rönnback[1], Kleemola Sirpa[2], Lars Lundin[1], Staffan Åkerblom[1,3], Gunilla Pihl-Karlsson[4], Filip Moldan[4] and Ulf Grandin[1]

Who wants to participate?

[1]Swedish University of Agricultural Sciences

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[3]Statistics Sweden

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Recent advances and knowledge gaps on Hg cycling

Hg deposition and re-emission

- Wet deposition rates are generally well quantified, but Hg^0 dry deposition and land Hg^0 re-emission is still uncertain
- Litterfall generally accounts for 65-90% of total deposition in terrestrial ecosystems
- Since the onset of industrialization, deposition of atmospheric Hg has increased Hg concentration in the upper organic soil layers by 20% (Smith-Downey et al. 2010)
- Recent stable Hg isotope studies have confirmed that Hg retained in the organic-rich layers is predominantly derived from atmospheric Hg^0

From a review paper by Bishop et al. 2020 STOTEN

Recent advances and knowledge gaps on Hg cycling

Hg catchment budgets and stream concentrations

- Hg export as a percentage of total atmospheric deposition are generally low in undisturbed forest systems (~4–8%) (Hsu-Kim et al. 2018), and higher in undisturbed systems with high sediment loads (13%, Shanley et al., 2008; 19%, Riscassi and Scanlon, 2013), boreal and alpine tundra (Shanley and Bishop, 2012) boreal peatlands (33%, Osterwalder et al., 2017), and subtropical forest (10%, Ma et al., 2016)
- Decreasing temporal trends of Hg in stream water have been observed during a 12-year period in North America (Gerson and Driscoll, 2016), while others show no trends although DOC concentrations are generally increasing (Eklöf et al. 2012)

From a review paper by Bishop et al. 2020 STOTEN

Data from database at ICP IM Programme Centre

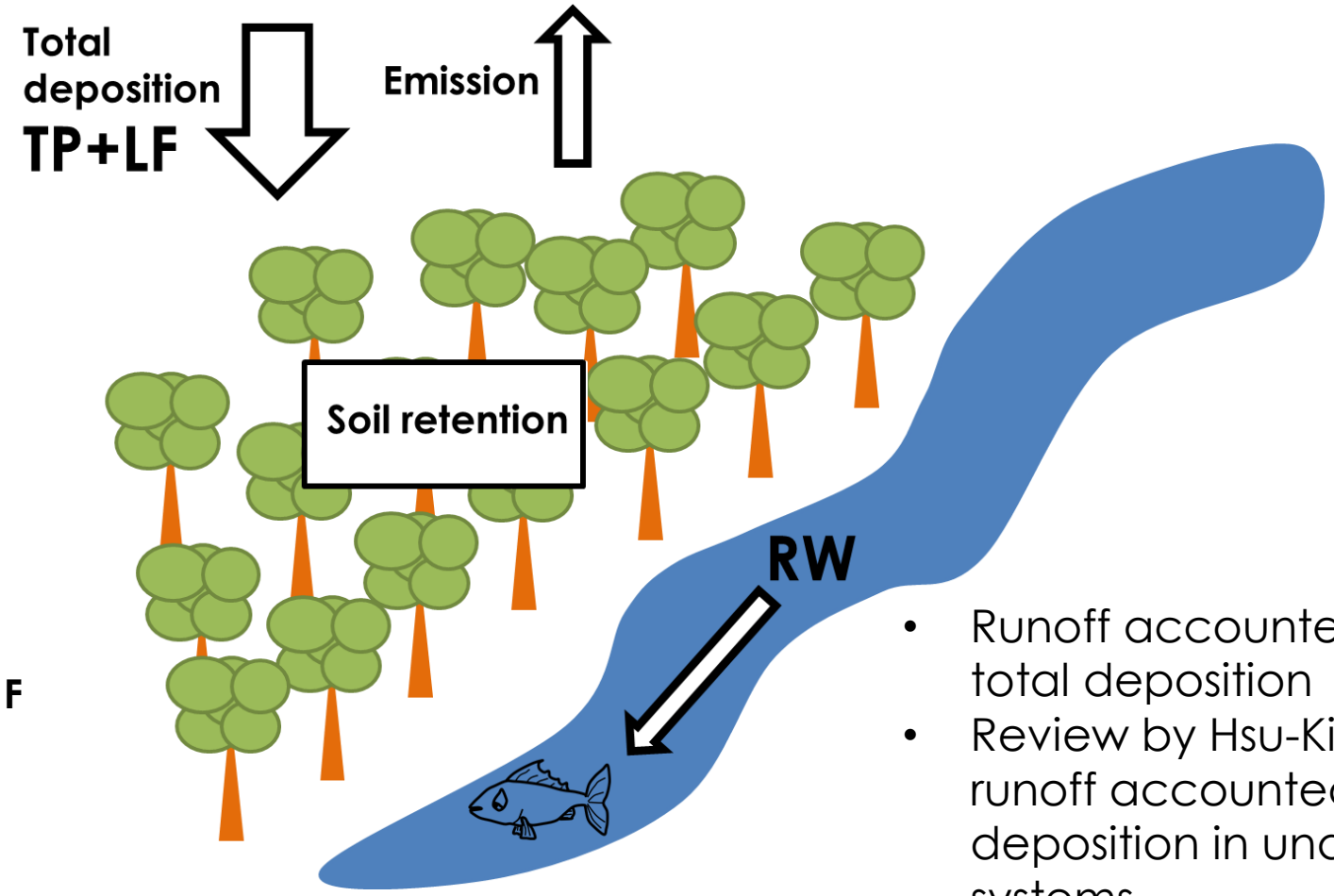
acode	Hg data available	Missing parameters for Hg budgets
AT01	PC (n=27), RW (n=8), TF (n=16)	LF
BY02		PC, LF, TF, RW
CA01		PC, LF, TF, RW
CZ01		PC, LF, TF, RW
CZ02	RW (n=26)	PC, LF, TF
DE01		PC, LF, TF, RW
DE02	PC (n=21)	LF, TF, RW
EE01	PC (n=78), TF (n=8)	LF, RW
EE02	LF (n=8)	PC, TF, RW
ES02		PC, LF, TF, RW
FI01	RW (n=226)	PC, TF, TF
FI03	RW (n=256)	PC, TF, TF
FI04	RW (n=14)	PC, TF, TF
FI05*		PC, LF, TF, RW
FI06		PC, LF, TF, RW
IT01		PC, LF, TF, RW
IT02		PC, LF, TF, RW
LT01		PC, LF, TF, RW
LT03		PC, LF, TF, RW
LV01	PC (n=33)	LF, TF, RW
LV02	PC (n=32)	LF, TF, RW
NO01		PC, LF, TF, RW
NO02		PC, LF, TF, RW
PT01		PC, LF, TF, RW
SE04	LF (n=11), PC (n=4), TF (n=12)	RW**
SE14	LF (n=37), PC (n=7), TF (n=24)	RW**
SE15	LF (n=38), PC (n=8), TF (n=23)	RW**
SE16	LF (n=33), PC (n=10)	RW**, TF**

**Apart from mercury data, also discharge, precipitation amounts, LF amounts is missing*
***Data is available at a national level*

Catchment budgets of Hg could only be calculated in Swedish sites

Runoff concentrations of Hg only in Swedish and Finnish sites

Hg budget of Swedish ICP IM sites 1997-2018



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- Runoff accounted for 5-10% of total deposition
- Review by Hsu-Kim et al. 2018: runoff accounted for 4-8% of total deposition in undisturbed forest systems
- Total deposition measures can be refined by calculating the tree cover percentage in catchments

Temporal trends in runoff waters

Concentrations of total **Hg** decreased significantly in 3 of the 24 sites

Length of times series:

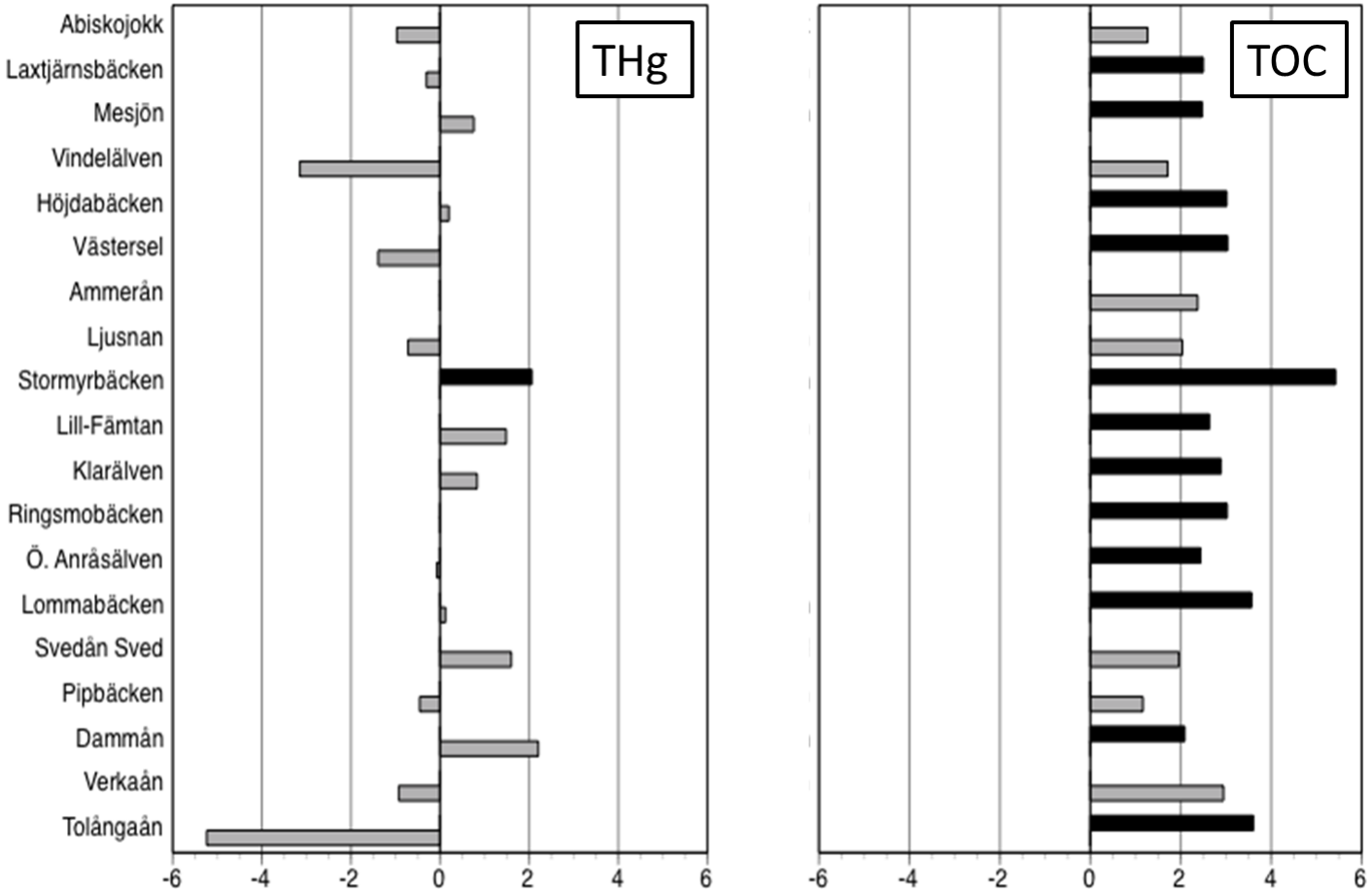
Swedish Environmental monitoring data: 2000-2020

Aneboda (SE14): 1997-2001
Gårdsjön (SE04): 2005-2011
Kindla (SE15): 1998-2000

FI01: 2003-2018
FI03: 2006-2018
FI06: 2004-2018

Temporal trends in runoff waters

Temporal trends of Hg (2000-2010) did not follow these of TOC, although strong relation between these variables were observed (Eklöf et al. 2012)



Temporal trends in runoff waters

Concentrations of **Cd** decreased significantly in 16 of the 28 sites and increased in 1 site

Length of times series:

Swedish Environmental monitoring data: 1996-2020

ICP IM sites:
Starting between 1988-2004
Ending between 2009-2018

Temporal trends in runoff waters

Concentrations of **Pb** decreased significantly in 11 of the 28 sites and increased in 3 sites

Length of times series:

Swedish Environmental monitoring data: 1996-2020

ICP IM sites:
Starting between 1988-2004
Ending between 2009-2018

What to include in a manuscript?

Alternative 1: Only focus on Hg; mass-balances, soil concentrations and temporal RW trends

Alternative 2: Focus on Hg but use Pb and Cd to compare with; mass-balances (Hg, Pb, Cd), soil concentrations (Hg, Pb, Cd) and temporal RW trends (Hg, Pb, Cd)

Alternative 3: Equal focus on Hg, Pb and Cd; mass-balances (Hg, Pb, Cd), soil concentrations (Hg, Pb, Cd) and temporal RW trends (Hg, Pb, Cd)

Do you want to contribute? With data or scientific expertise.
Email: Karin.eklof@slu.se


Thank you!
Questions?