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The complexity of sediment contamination in backwaters of the Elbe River - what can we learn from it and does it matter?

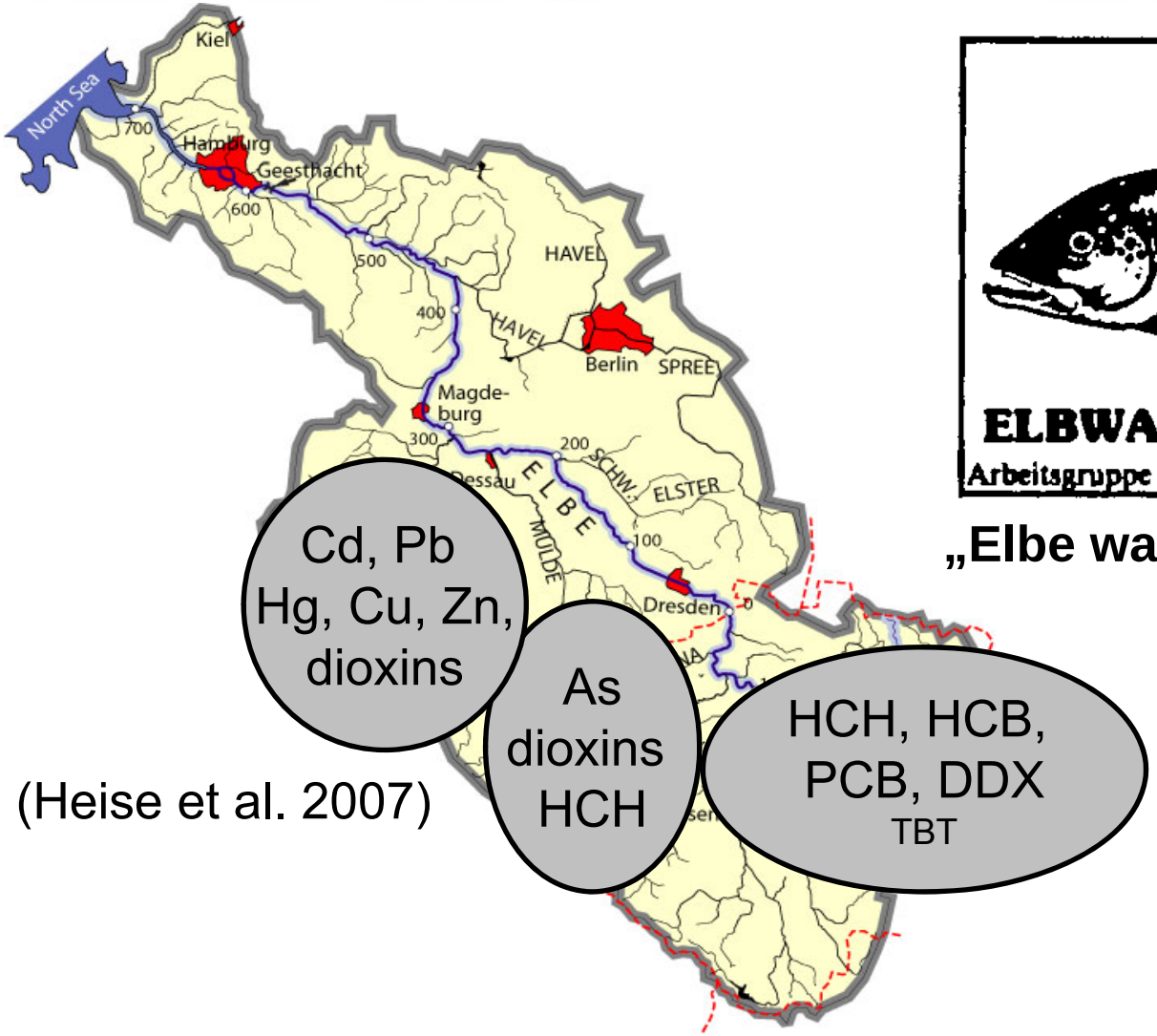
SedNet conference, Krakow 2015

Backwaters are water bodies that have no or restricted connection to the major river, but which can be flooded under elevated discharge conditions and potentially exchange sediment with the river.

Why may they be important: THE NUMBER

1000 backwaters in the Elbe floodplain

Why may they be important: The Contamination?



(Heise et al. 2007)

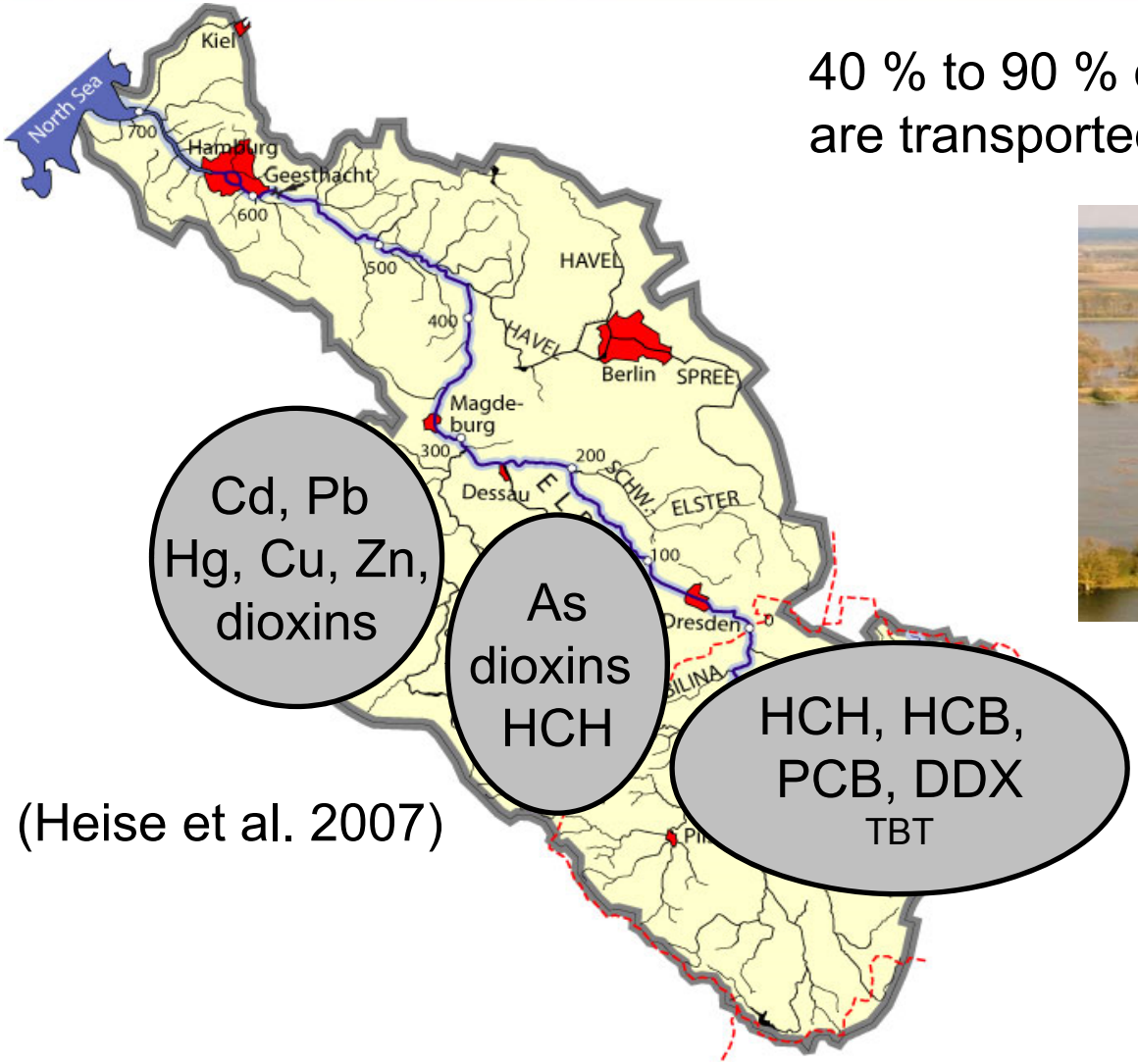
„Elbe waters make you slim!“ (1990)

Legacy of the past:

Industrial emissions

Mining

Why may they be important: The Contamination?



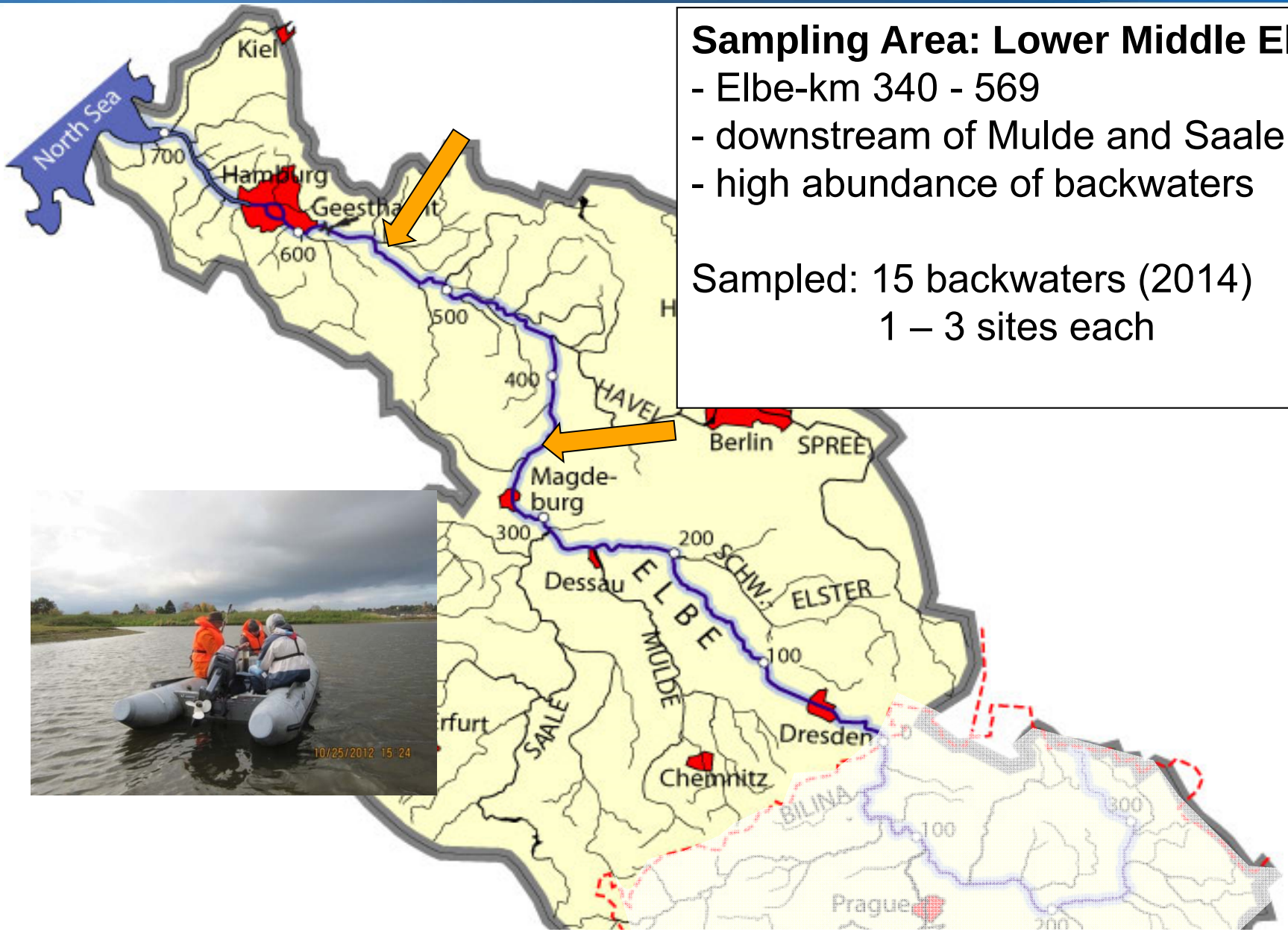
(Heise et al. 2007)

40 % to 90 % of the annual contaminant load are transported during high water discharges.

Why may they be important: Impact on the WFD?

Source
Or
Sink?

Backwater-Study 2014



Sampling Area: Lower Middle Elbe:

- Elbe-km 340 - 569
- downstream of Mulde and Saale
- high abundance of backwaters

Sampled: 15 backwaters (2014)
1 – 3 sites each

The investigation in detail

On site measurement of **erosion stability**

Dating of sediment cores
HM-profiles (XRF-Analysis)
Cs^{137}-profiles (γ-Detector)

Ecotox tests

With algae, bacteria;
in elutriates & direct contact

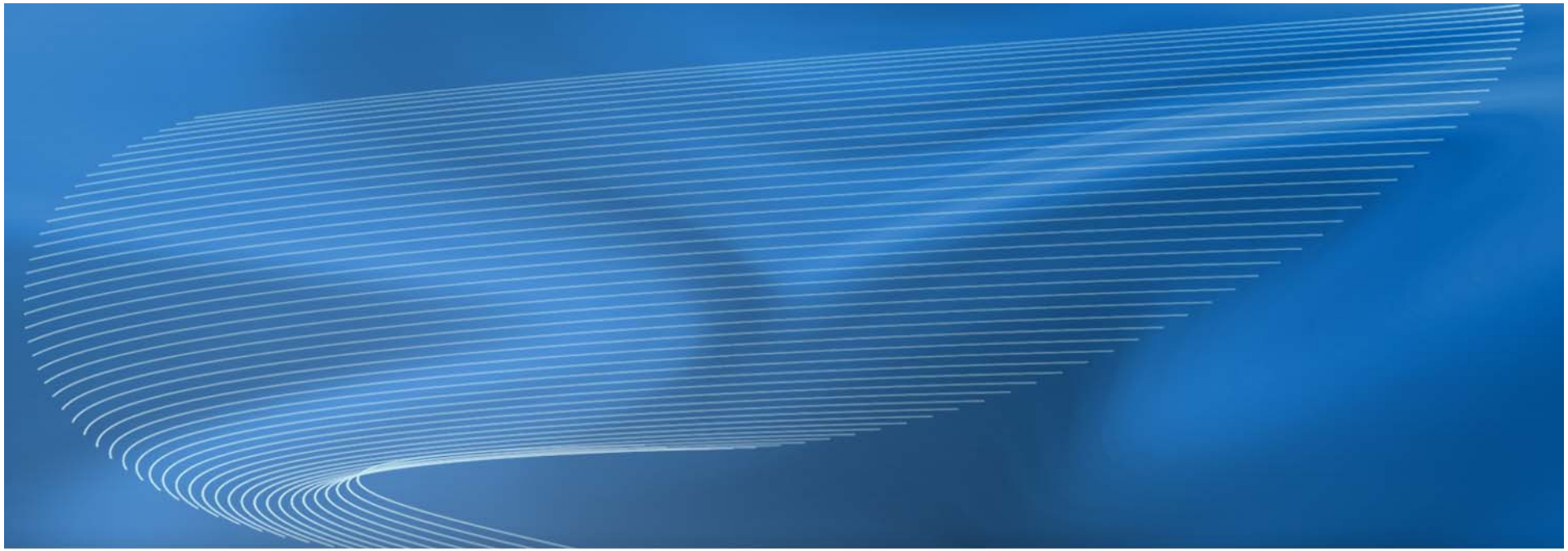
Chemical analysis

0-10 cm

10-20 cm

Analysis of historic substances (HM, HCB, PAH, PCB)

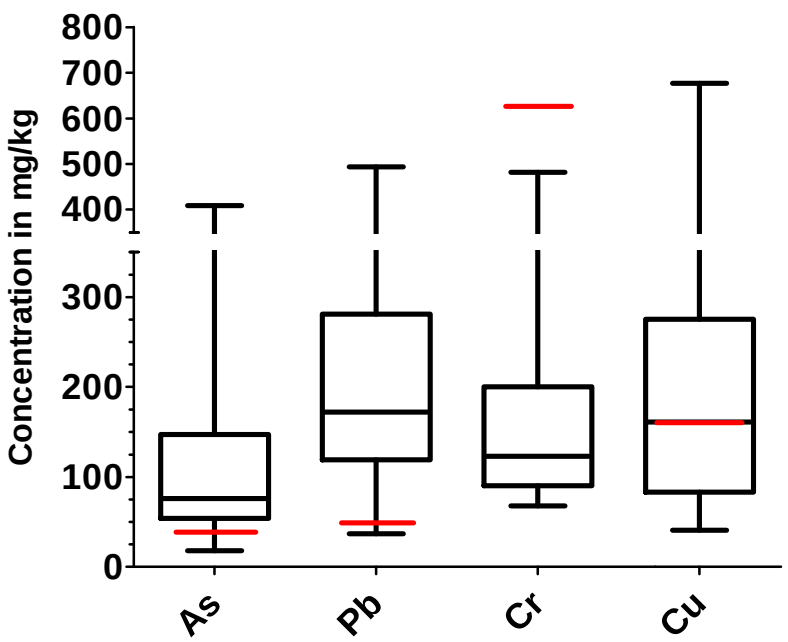
Deep sample with multicorer

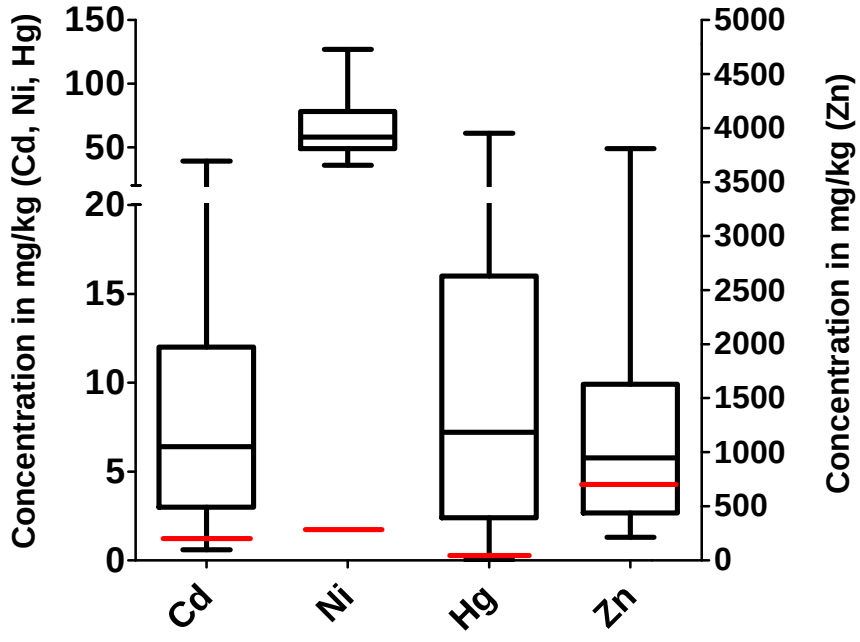


How contaminated are backwater sediments?

Chemical contamination of sediments: Trace metals and As

Upper treshold value for sediment quality, acc. to EQS of WFD (International Commission for the Protection of the Elbe)



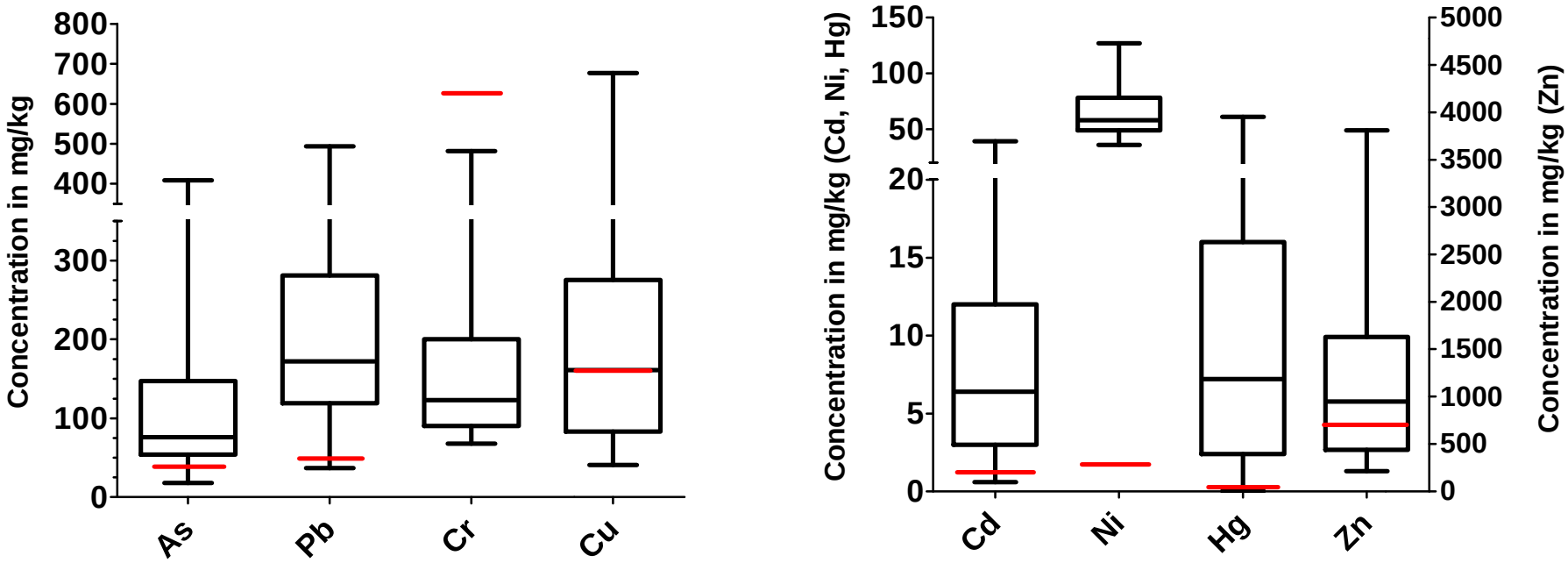


90 sediment samples, 15 side structures (2014) (<20 µm fraction)

Chemical contamination of sediments: Trace metals and As

Up to 51 mg/kg mercury
Up to 25 mg/kg cadmium
Up to 400 mg/kg arsenic
Up to 500 mg/kg lead

U quality, acc. to EQS of WFD
(rotection of the Elbe)

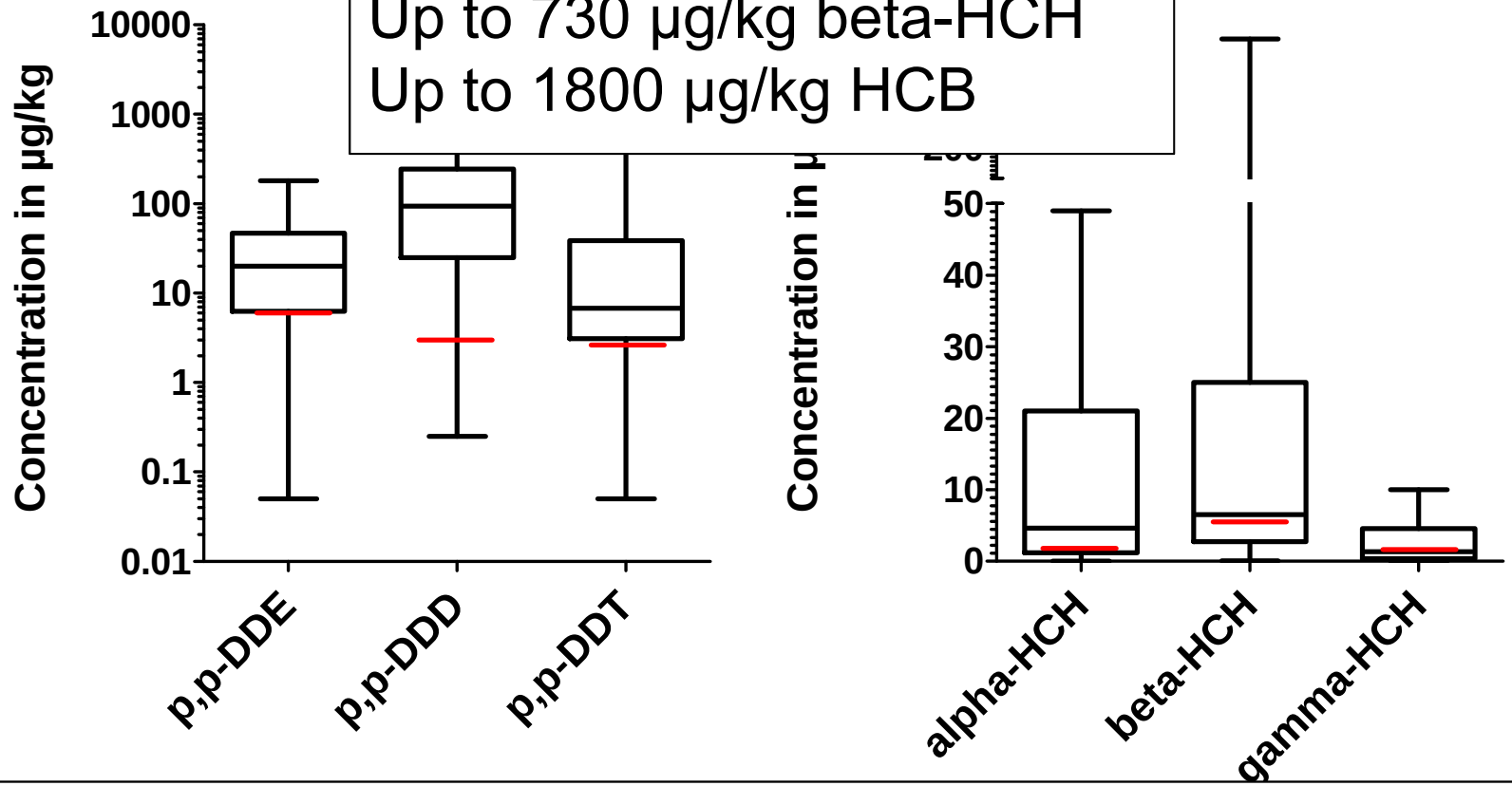


75 % of all samples exceeded criteria for As, Pb, Cd, Hg, Ni

Chemical contamination of sediments: DDX and HCH-isomers

Upper tres… …c. to EQS of WFD
(Internatio… … of the Elbe)

Up to 760 µg/kg p,p´DDT
Up to 2200 µg/kg p,p´DDD
Up to 730 µg/kg beta-HCH
Up to 1800 µg/kg HCB



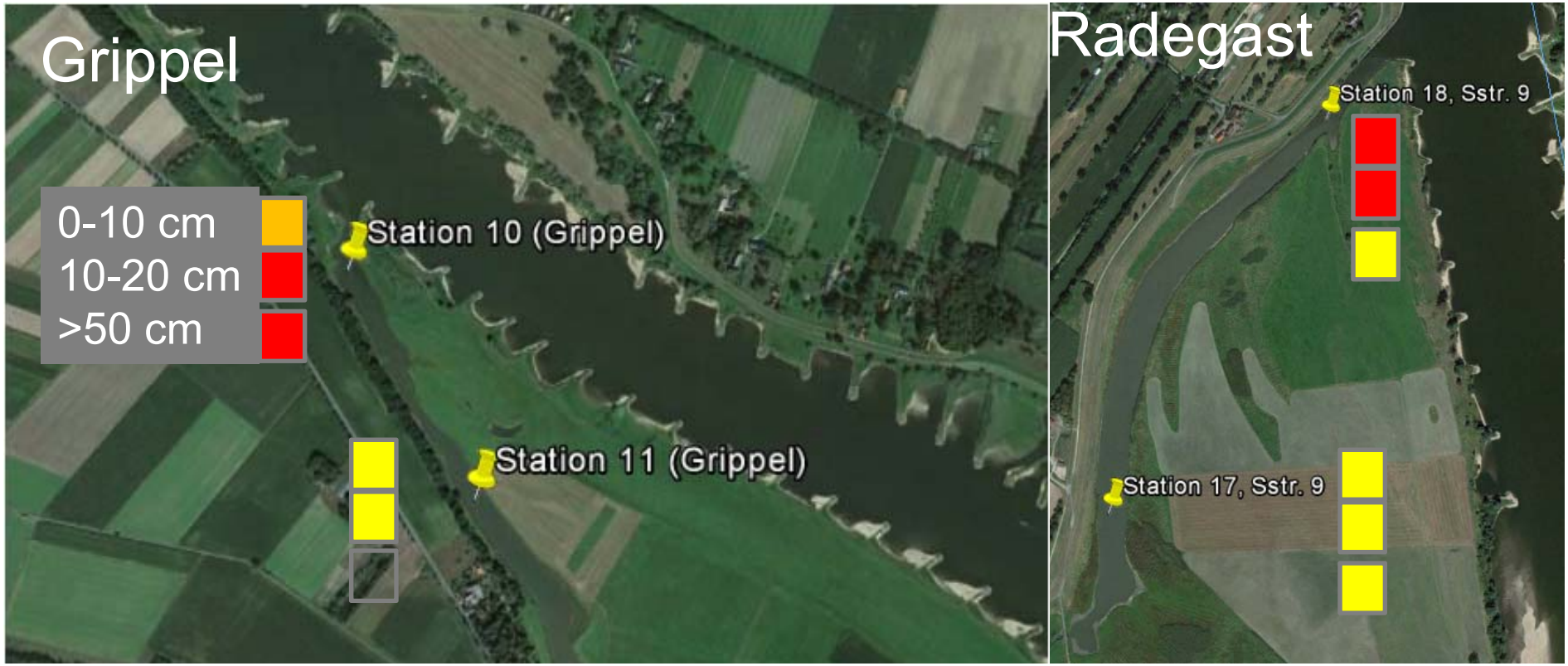
75 % of all samples exceeded criteria of p,p´DDX
>50 % exceeded criteria for HCH-isomers

Chemical contamination: Trends?

Partly very high contamination with „historic“ substances

- No correlation with depth

Increasing chemical contamination

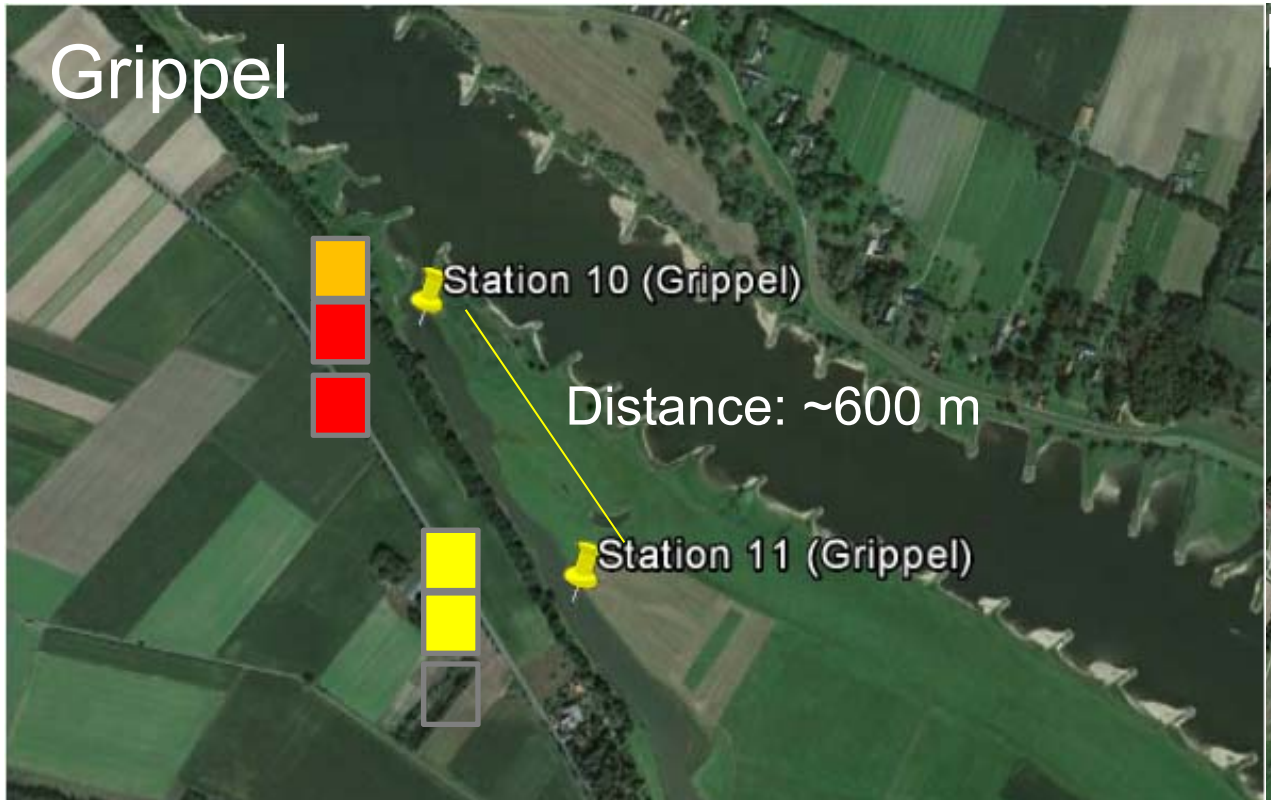


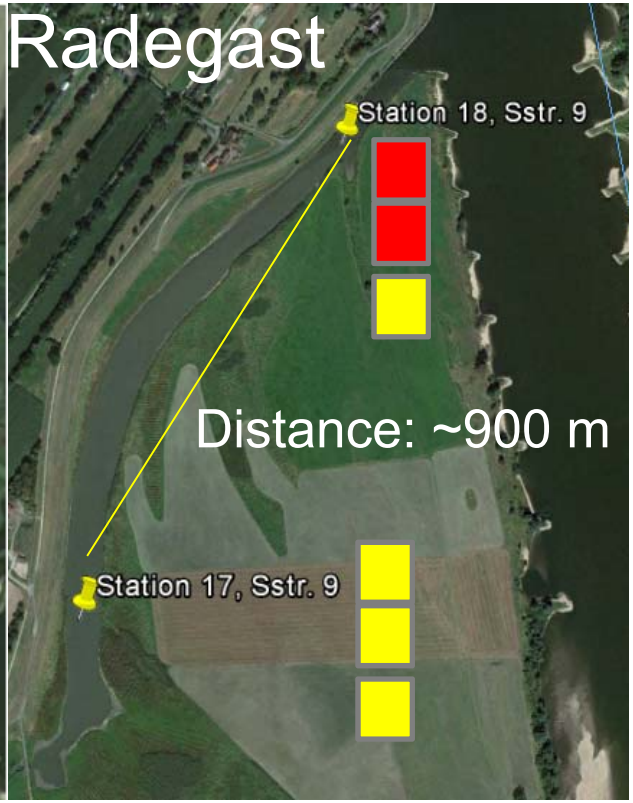
Chemical contamination: Trends?

Increasing chemical contamination

Partly very high contamination with „historic“ substances

- No correlation with depth
- Contamination decreases with distance from the Elbe River
- Backwaters with large „mouth“ at slip-off slope more affected?





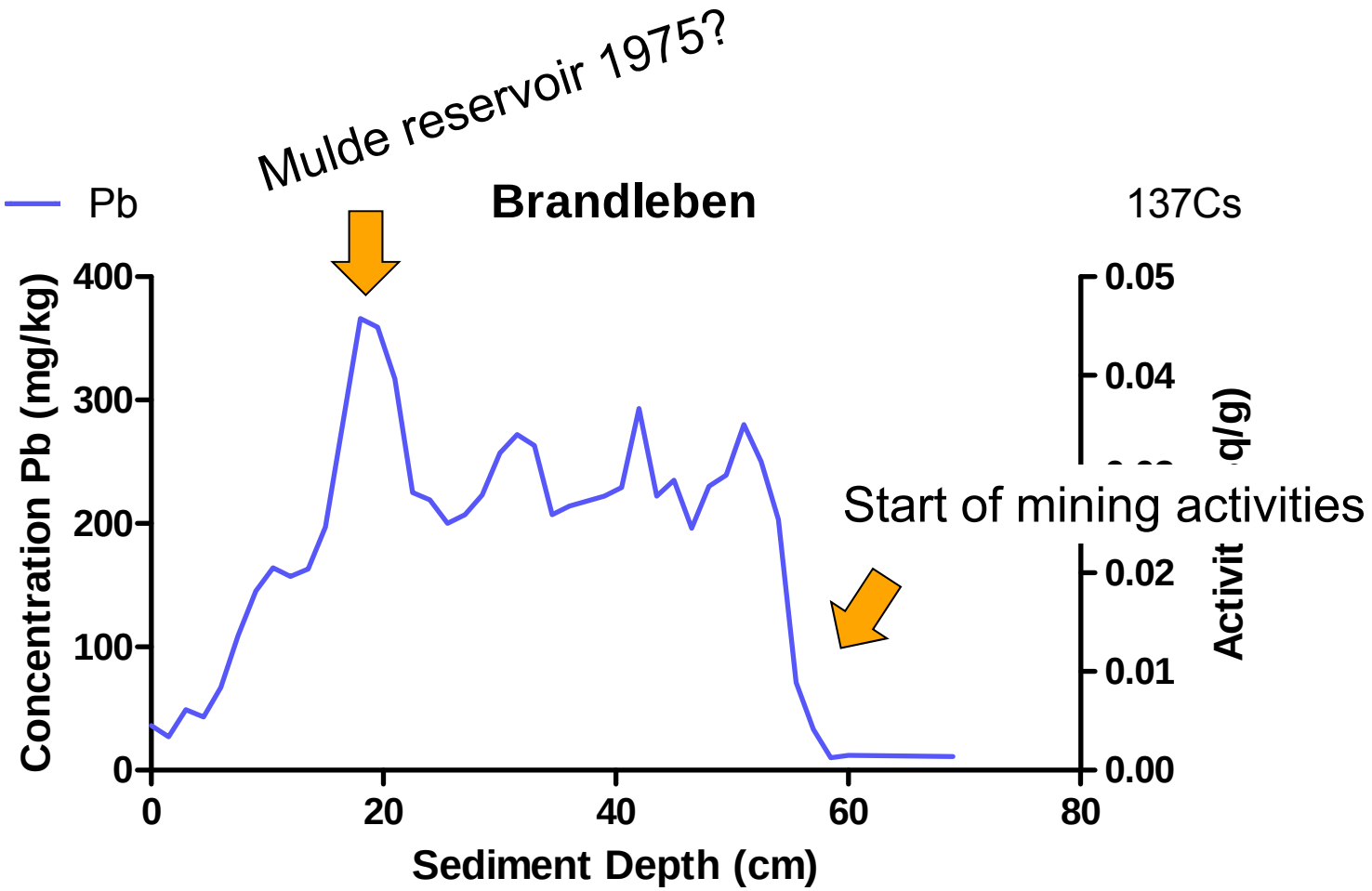
Backwaters – sinks or sources?

EITHER …New material: SPM from the Elbe deposited close to the confluence

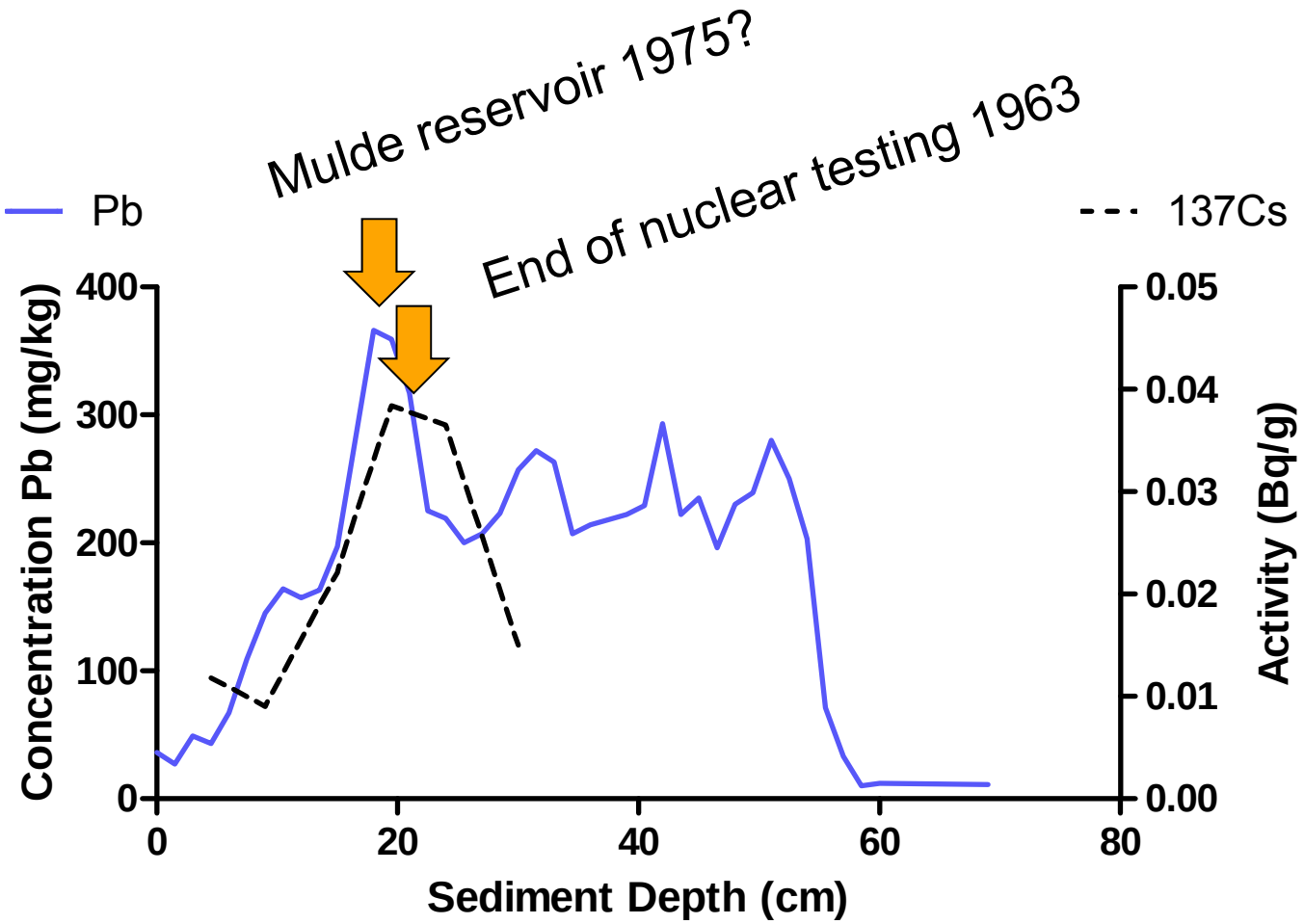
OR Historic contamination: Exposed due to erosion close to the confluence

→ Dating of sediment cores (^{137}Cs, HM-profiles)

Pb-contamination profile with depth, Brandleben



Pb-contamination profile with depth, Brandleben

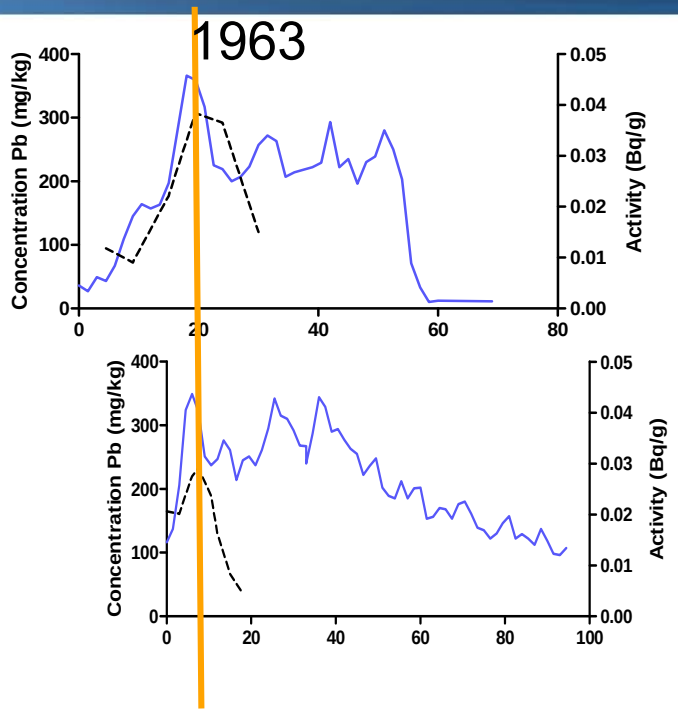


Chernobyl-Peak?

^{137}Cs and Pb-Profiles: Examples

Pb

---- ^{137}Cs



Brandleben,
Elbe km

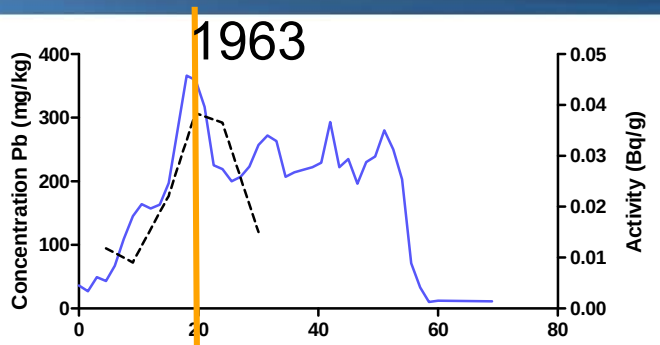
Damnatz,
Elbe km 509

From 6 sediment cores, 4 did not have any Chernobyl-Peak (1986)
Partly contamination right to the top
Sediments from up to 40 years are missing

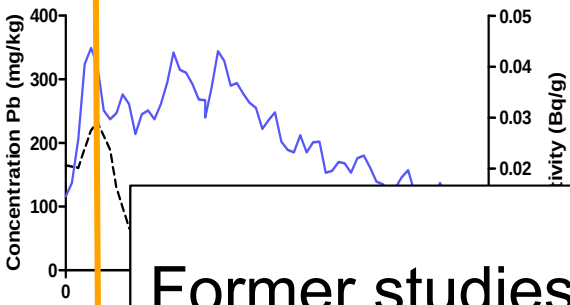
^{137}Cs and Pb-Profiles: Examples

Pb

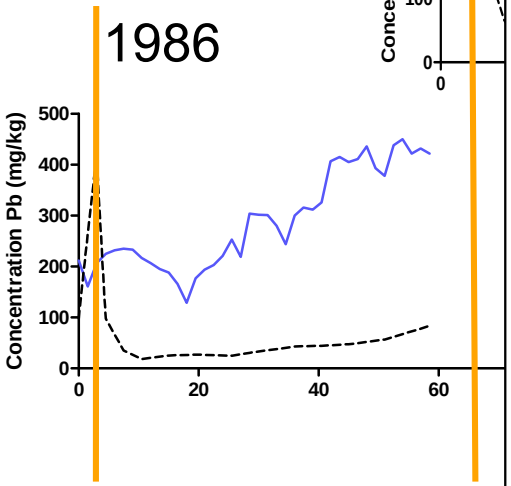
^{137}Cs



Brandleben,
Elbe km



Damnatz,
Elbe km 509



Former studies still found
the Chernobyl-Peak

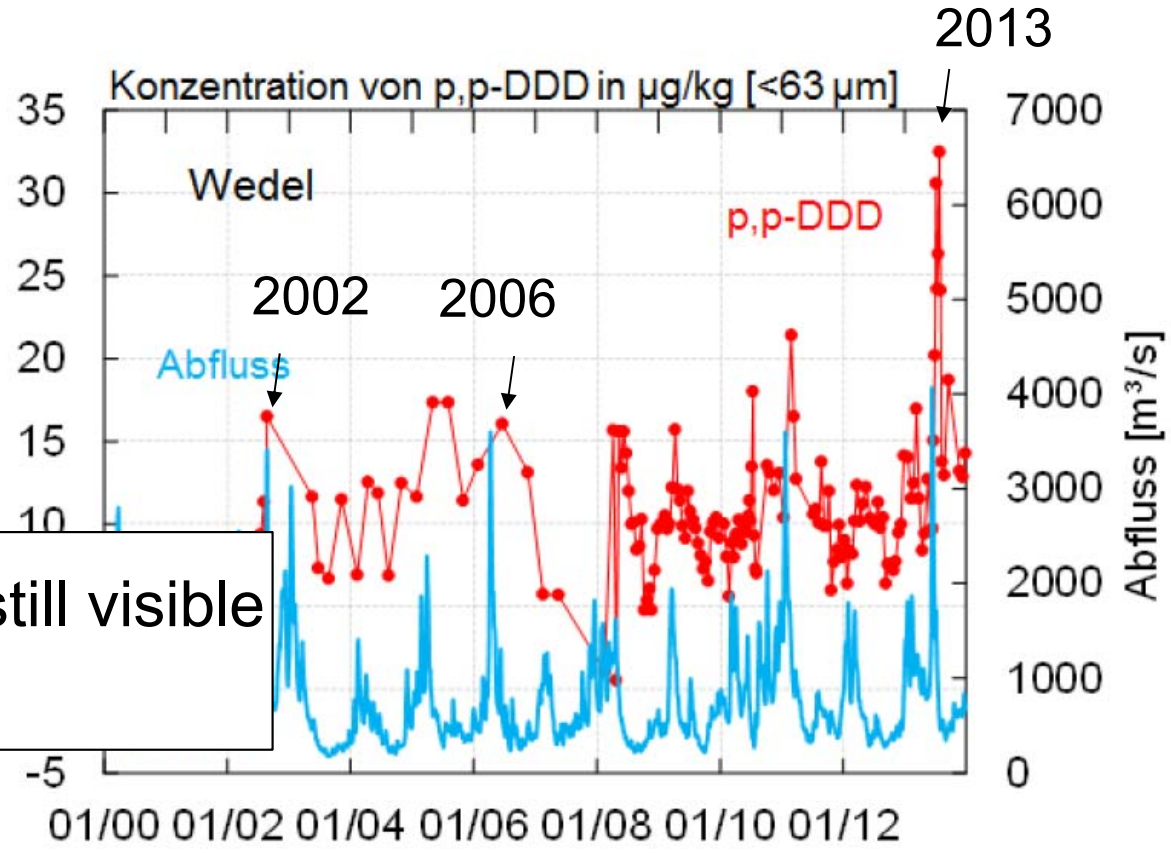
- prior to 1993 (Prange et al. 1997)
- 1997/98 (Zachmann et al. 2013)
- 1998 (Krüger et al. 2006)

→ Erosion since 1998?

Impact of high water discharges?

Extreme high water discharges affecting the whole river basin since 1998:

- 2002
- 2006
- 2013



Contamination signal still visible in the Elbe estuary

Concentration of pp-DDD in the **Elbe Estuary** between 2000 and 2012 (from BfG 2014)

Conclusions so far

- Sediments in Elbe-backwaters are mostly highly contaminated (>>EQS)
- Backwaters seem to be more contaminated towards the opening to the river
- Large volumes of sediments have gone missing (no 1986-peaks)

→ Extreme flood events since 2002 possibly eroded the sediments near the confluences, exposing deeper historic contaminated material

Does it matter?

Overall estimated area of backwaters in the Elbe river: 50 km^2

→With an erodible sediment layer of 60 cm depth, 18 mio m^3 of contaminated material could be „on the move“.

Conclusions so far

- Sediments in Elbe-backwaters are mostly highly contaminated (>>EQS)
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→ Extreme flood events since 2002 possibly eroded the sediments near the confluences, exposing deeper historic contaminated material

Doe

Over

→W inated

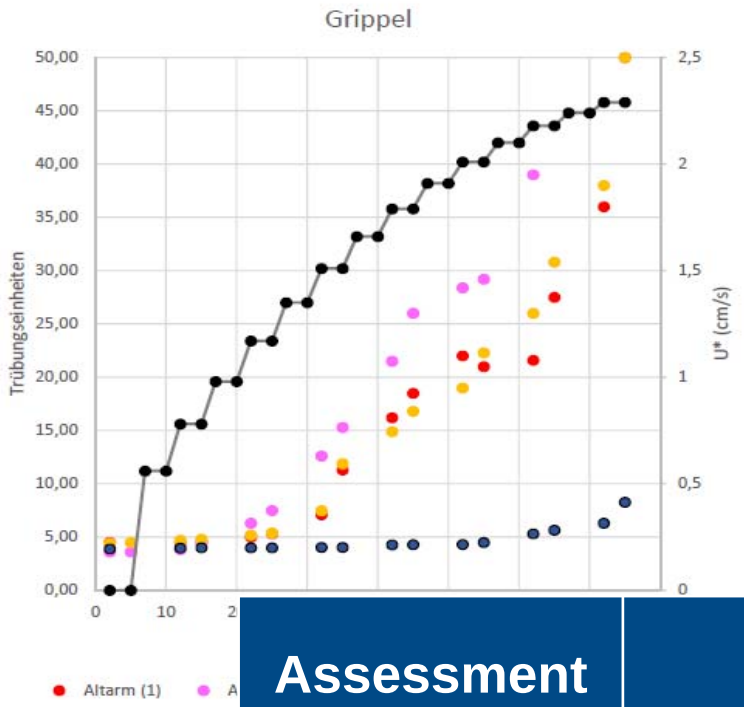
ma

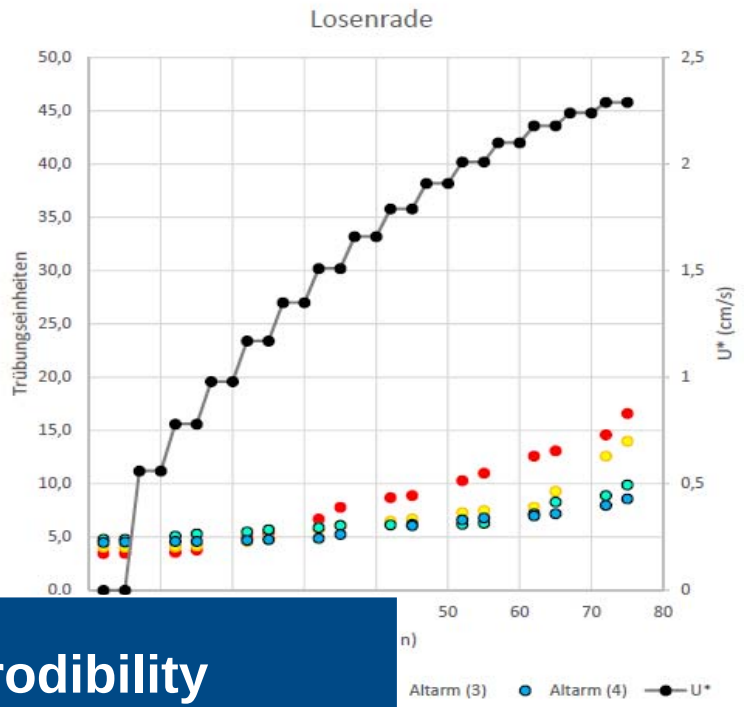
1000 backwaters in the Elbe -
what could be done about it??

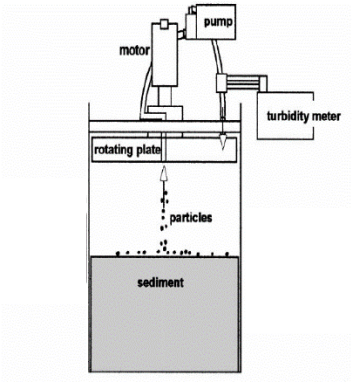
→ Prioritization:

- Are the sediment surfaces stable or easily eroded?
- How toxic is the material when resuspended?

Erodibility measurements of surface sediments



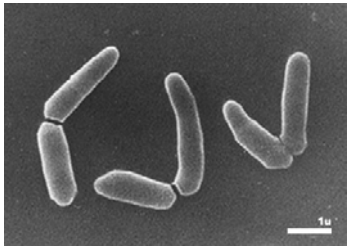




Assessment	Erodibility
	high u_{crit} (>2 cm/s), low mass erosion
	medium u_{crit} (1 to 2 cm/s), moderate mass erosion
	low u_{crit} (<1 cm/s), high mass erosion

Measurement of Ecotoxicity

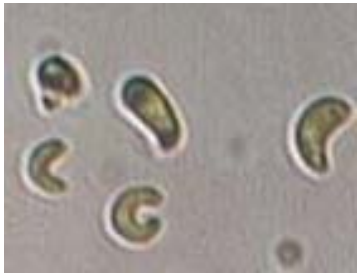
Sediment bacteria



Sediment Contact

Arthrobacter globiformis

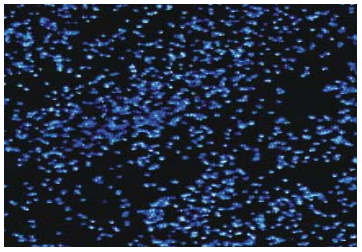
Green algae



Elutriate

Raphidocelis subcapitata

Luminescent bacteria



Elutriate
and Methanol-extract

Allovibrio fischeri

Integrated assessment:
(based on Ahlf and Heise 2005)

Test: 1	2	3		Tox.class
				1 – not toxic
				1 – not toxic
				2 – slightly toxic
				3 – moderately toxic
				4 - toxic
				5 – very toxic
				5 – very toxic
				4 - toxic
				3 - moderately toxic
				2 - slightly toxic

Integrated Assessment (WoE-Approach)

4 sediments with high or very high contamination showed high ecotoxic responses and were easily resuspendable.

One sediment would be of no concern.

Sampl. site	Backwater	Chemical contam.	Eco-toxicity	Erodibility
1	1			
2	1			
3	2			
4	3			
6	4			
7	5			
8	6			
9	6			
15	7			
16	8			
17	9			
18	9			
19	10			
20	10			

→ Need for prioritization of sites on RB scale on the basis of

- Size of backwater
- Location towards the river

  (large opening at slip-off slope of the river?)
- Depth of sediment layer
- Contamination
- Erodibility
- Toxicity of resuspended material

Thanks for your attention

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Henning Tien
Kamelia Samet
Silvia Materu

And thanks to ELSA for funding

Report soon available at
http://www.elsa-elbe.de/dokumente.html
(German)

Referenzen

Heise S, Krüger F, Baborowski M, Stachel B, Götz R & Förstner U (2007) Bewertung der Risiken durch Feststoff-gebundene Schadstoffe im Elbeeinzugsgebiet. 349. Im Auftrag der Flussgebietsgemeinschaft Elbe und Hamburg Port Authority, erstellt vom Beratungszentrum für integriertes Sedimentmanagement (BIS/TuTech) an der TU Hamburg-Harburg, Hamburg.

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