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Enabling Delta Life

The risks of remobilization of historically polluted sediments in the Meuse

a (case) study by

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Background of the study

- Climate change will probably lead to more extremely high river discharges and floods.
- Several research projects, including EU-projects AquaTerra and Modelkey concluded that these floods and storm flows will remobilize historically contaminated soil or sediment from riverbanks and floodplains.

but:

- Although scientific (and empirical) evidence is overwhelming, it resulted in hardly any policy responses yet (Jos Brils, Meuse Conference 2010).

possible reason:

- A lack of appealing examples of quantified ‘cause-impact relationships’.
  - our challenge!

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Character of the study

- We had a very limited budget, so no expensive experiments or monitoring or even extensive model calculations

  Some indicative model calculations with readily available model and data, for illustrative purposes only.

- Case study of one polluted river bank site being partly eroded by assumed extreme high water event in Meuse river basin

  Our message: this could happen at comparable sites, no evidence this will happen at this specific site!

- Intention (hope) that this example is appealing enough to 'shake up' water managers and policy makers and start anticipating measures.

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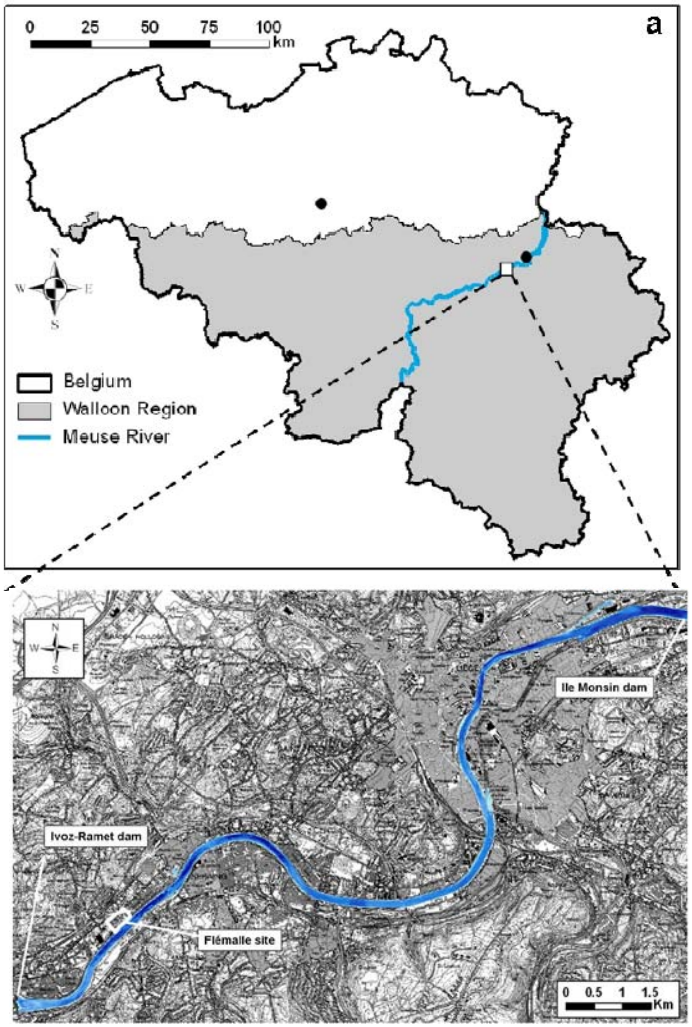
Description of the case study (1)

- Meuse river basin (many polluted sites in upper (Walloon) region;
- Flémalle former coke plant site (BTEX, PAH, heavy metals, oil); Data from PhD thesis Battle Aguilar, J. (2008);
- Benzene, fluoranthene and cadmium chosen as representative pollutants;
- EXPOBASIN model was forced with 1993 hydraulic flood data (3050 $m^3.s^{-1}$ at Eijsden);
- Erosion estimate: 1,4% (10,920 tons) of soil is eroded during 24 hours;



Graphics from: Battle Aguilar, J. (2008), PhD Thesis

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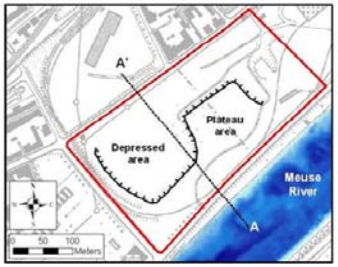
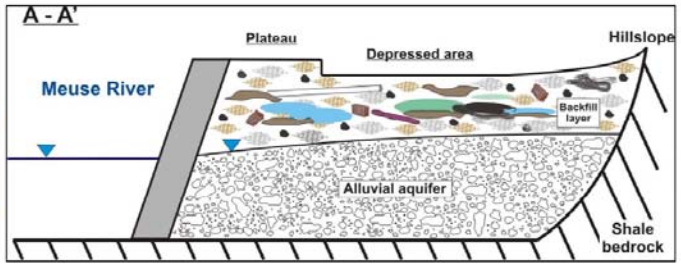
Description of the case study (2)

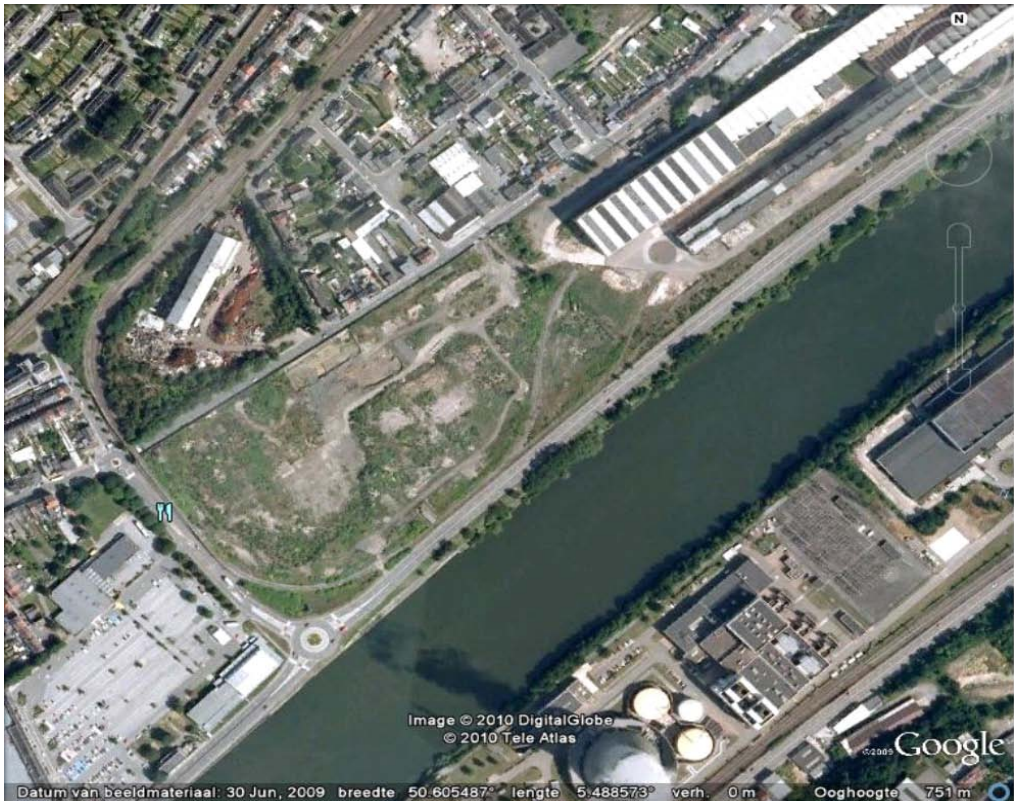
- Median soil quality Flémalle:
  - Benzene 80 mg/kg
  - Fluoranthene 460 mg/kg
  - Cadmium 2.67 mg/kg
    (P_{90} 25 – 60x higher)

- Eroded mass of pollutant:
  - Benzene 874 kg (1.07x ann. av.)
  - Fluoranthene 5023 kg (8x ann. av.)
  - Cadmium 29.2 kg (0.015x ann. av.)

- Annually averaged background concentrations of pollutants and SPM from monitoring point Eijsden;







Graphics from: Battle Aguilar, J. (2008), PhD Thesis

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Results: Water quality

- Calculated maximum concentrations at Eijsden due to erosion event (without backgrond) compared with measured concentrations at Eijsden:

	Calculated total concentration (µg/l)	Calculated dissolved concentration (µg/l)	Measured total or dissolved concentration (µg/l)
Benzene	3.32	3.29	Avg = 0.034 Max = 0.51
Fluoranthene	18.67	1.1	Avg = 0.049 Max = 0.65
Cadmium	0.108	0.004	0.62 = Avg = 0.175 38.8 = Max = 35.2

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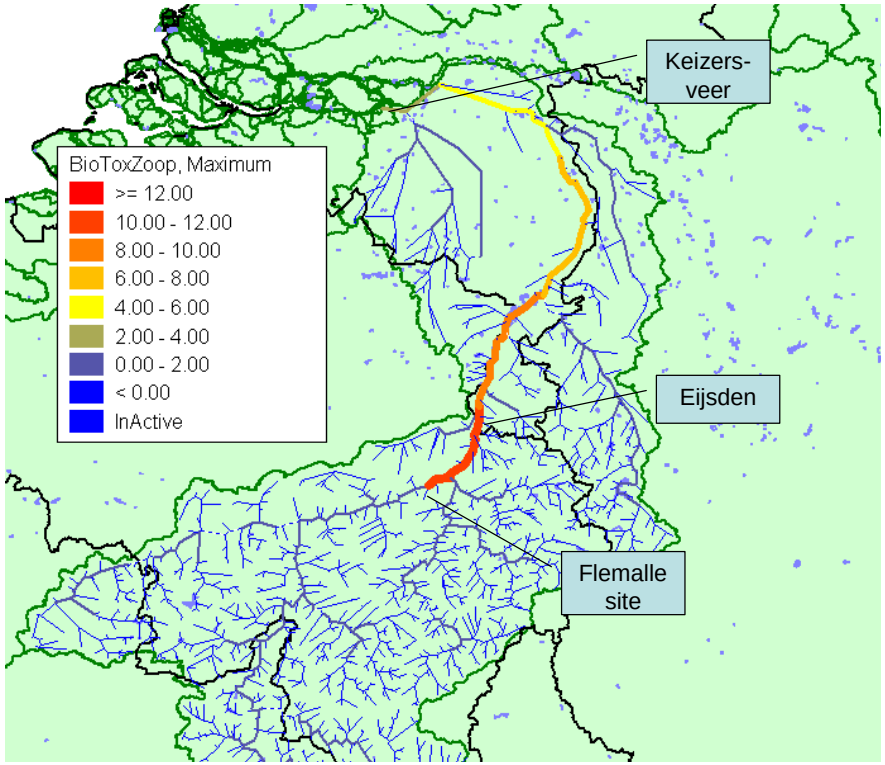
Results: Effects of water quality

	Toxic units for Invertebrates	Toxic units for Fish	Toxic units for Algae
Benzene	**0.01**	**0.19**	**0.10**
Fluoranthene	**9.94**	**33.9**	**1.56**



Maximum Toxic units for *Daphnia* and fluoranthene

- Toxic units based on dissolved concentrations and LC_{50} values for:
  - *Daphnia* (Water flea);
  - *Pimephales (*Carp like fish*);*
  - *Selenastrum* (Algae species).

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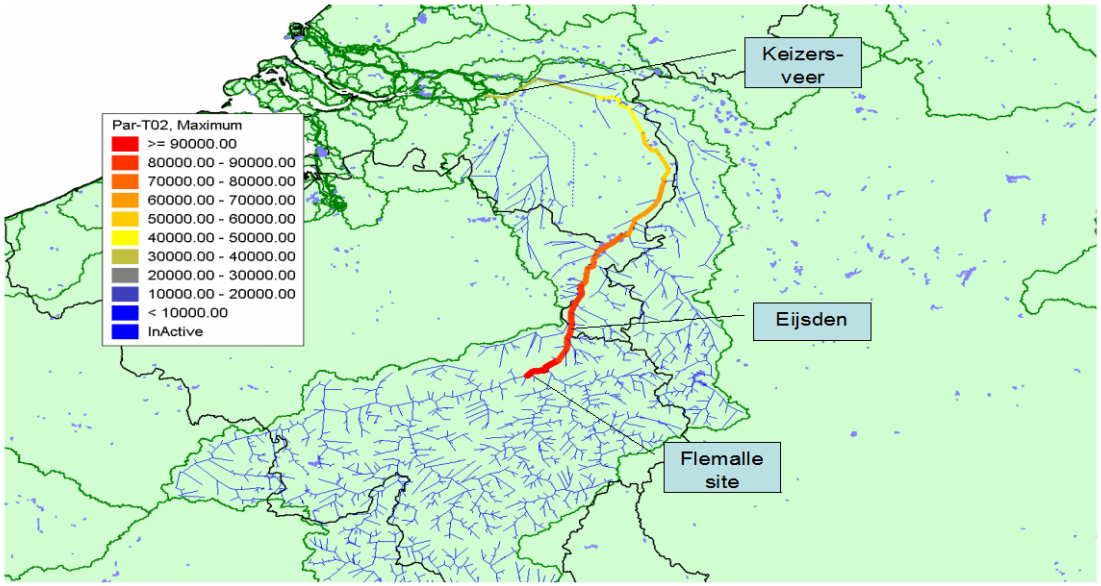
Results: Quality of deposited sediment

	Eroded mass (kg)	Mass passing Eijsden (kg)	Mass passing Keizersveer (kg)	Retention up to Eijsden	Retention up to Keizersveer
Benzene	**874**	**873**	**856**	**0.1%**	**2%**
Fluoranthene	**5023**	**4915**	**1714**	**2%**	**66%**
Cadmium	**29.2**	**29**	**10**	**2%**	**67%**



Fluoranthene in deposited sediment (µg/kg dw)

- Retention mainly determined by sorption (partition coefficient).
- Benzene concentrations mainly determined by dilution,dispersion and volatilization.

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Results: Effects of sediment quality

Fluoranthene concentration	PAF (chronic EC50)	EQS (CIS-WFD) (1.1 mg/kg)	LC50 (3.4 – 5.1 mg/kg)
Eijsden 90 mg/kg	48%	82x	18-26x
Keizersveer 30 mg/kg	33%	27x	6-9x

- If the contaminated suspended matter settles in floodplains, not only effects on the ecosystem occur, but also economic damage:
  - Reduced possibilities for grazing cattle;
  - Reduced possibilities for recreation;
  - Higher costs for dredging and soil excavation.

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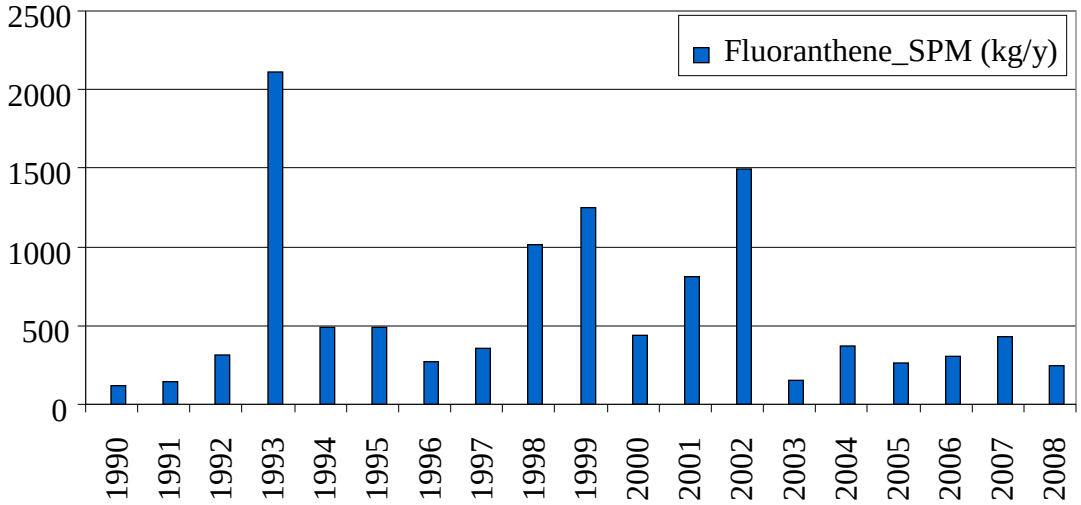
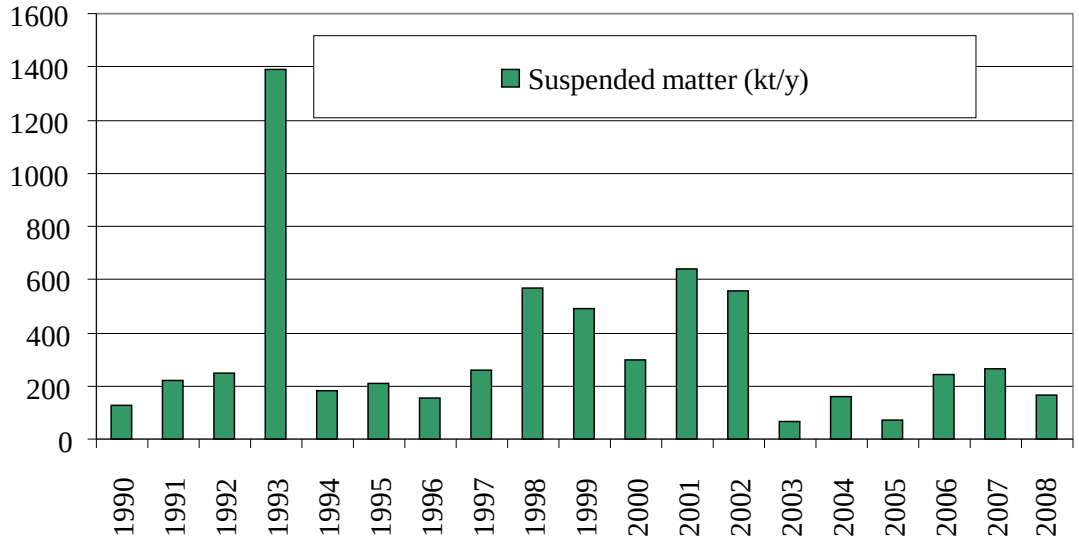
Fluoranthene loads in perspective



- This case study:

  Estimated eroded total fluoranthene mass: 5023 kg, which • 2.4x the 1993 annual load (• 2100 kg).



- This case study:

  Estimated total eroded soil mass: 11 kton, which is 0,8% of the 1993 SPM annual load (1400 kt).

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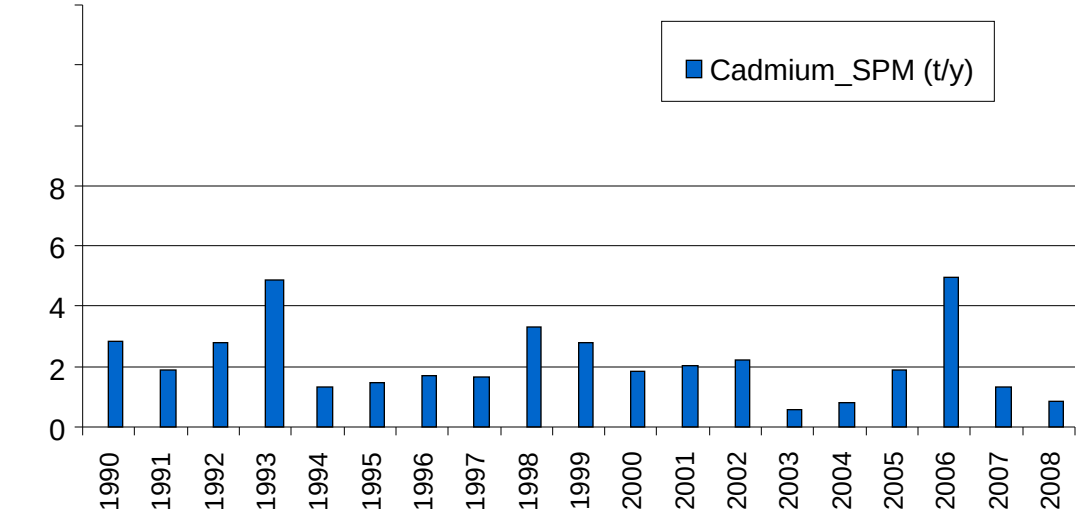
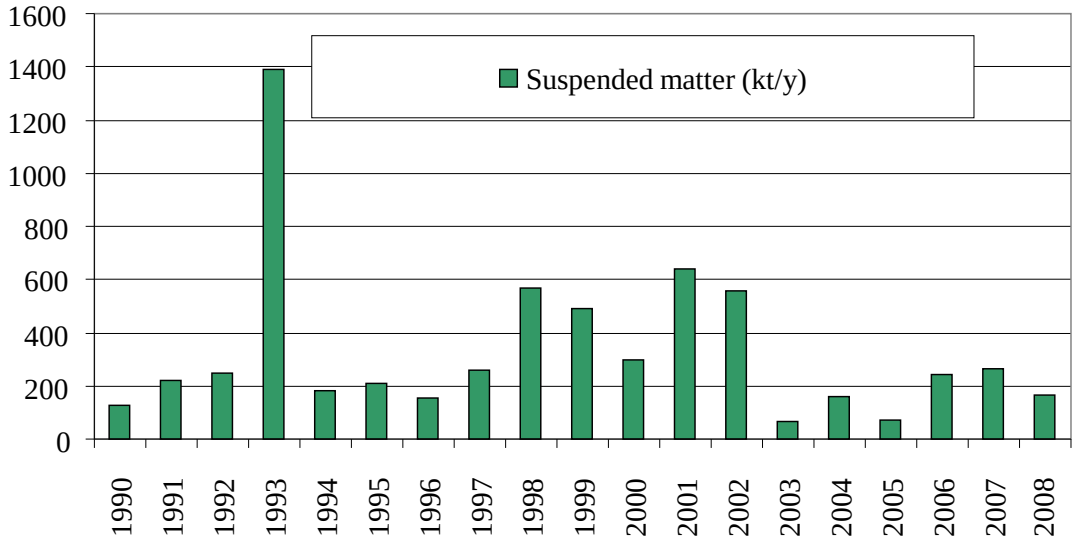
Cadmium loads in perspective



- This case study:

  Estimated eroded total cadmium mass: 29.2 kg, which is 0.58% of the 1993 annual load (• 5.000 kg).



- This case study:

  Estimated total eroded soil mass: 11 kton, which is 0,8% of the 1993 SPM annual load (1.400 kt).

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Conclusions

- The performed tentative model calculations indicate that the contaminated sites along the upper Meuse present a potential hazard to the aquatic and benthic ecology in downstream areas;

- œ1% Erosion of just one contaminated site can already lead to considerable mortality amongst fish, invertebrates and algae;

- There are dozens of contaminated sites along the upper Meuse and floods like the 1993 flood (or even more extreme) are likely to occur in the future;

  It seems therefore sensible to anticipate measures to prevent future erosion of contaminated Meuse river banks.

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Recommendations

- We recommend to take a closer look at the issue of downstream risk from remobilized contaminants from Meuse river banks:
  1. Gather all available information on contaminated sites;
  2. Screen and prioritise these sites and contaminants, e.g. in the way as done in this case study;
  3. Define ‘hot spot’ sites and assess the risks posed by these sites in more detail.

- Extend this risk assessment with an economical impact analysis;

- Define possible cost effective measures to prevent future erosion of contaminated Meuse river banks.

Thank you for your attention!

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