Impact of marine traffic and dredging activities on resuspension and release of contaminants from sediments in the port of Antwerp

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The problem with sediment resuspension





The port of Antwerp





- Located at the Scheldt estuary
- Area of 12.068 hectares
- Max. water depth of ~18m
- Highly industrialized area

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- Medium to bad water quality



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(historically) polluted sediments (e.g. TBT, metals, PAHs ...)

- Intensive marine traffic (2014/2015 ~ 23.000 records)

maintenance dredging (vision 2020: ca 12.000.000 m³)



- Evaluate the contribution of marine traffic and dredging activities on:

 resuspension and transport of sediments and related contaminants
- 2. Characterize its impact on:
 - water quality and pollutant distribution within the port of Antwerp



What did we do?



• Field campaign -> 9 days on the boat (February – April 2016)



- Measurements: during resuspension events
 - sediment concentrations, water velocity & salinity
 - -> acoustic backscatter system: ADCP
 - -> optical sensors: OBS-3A, SiltProfiler
 - water samples
- -> SPM concentrations
- -> Contaminants: TBT, PAH's, PCB's, Mineral Oil, Metals
- -> TOC, DOC
- Quantity, spatial and temporal distribution

What did we do?





Dredging and dumping Sebastiano Caboto Trailing suction hopper dredger, Kanaaldok B1, AMORAS

> Departure Bow Firda, 4e Havendok Tanker: length 183 m, width 32 m, draught 10.5m

> > Docking Marianne, 3e Havendok Tanker: length 97 m, width 16 m, draught 8.8 m

23 ship manoeuvres, 2 dredging campaigns

 \Rightarrow

Results – ADCP and Silt Profiler



Results – 1. SPM





X Other determining factors:

 \Rightarrow TSH dredging & dumping > BLT dredging activities & shipping manoeuvres (p< 0.005) => strengths / direction of wind

 \Rightarrow Docking & turnings \Rightarrow of equal turning turnings \Rightarrow of equal turning t

- => use of tug boats
- => activities of other vessels

- PCBs -> concentrations below "limit of quantification"
- PAHs -> 3% of samples (pyrene)
- Mineral oil -> 18% of the samples





During resuspension

Results – 2. Contaminants: risk indicators



• Correlations:

SPM	<->	Total & Dissolved
SPM	<->	$(\Rightarrow \frac{\text{Metals tot } (\mu g/L) - \text{Metals } dis (\mu g/L)}{\text{SPM } (mg/L)} * 1000)$
SPM	<->	$LogKd => \frac{part (\mu g/kg)}{dis (\mu g/L)}$
Particulate fractions	<->	Dissolved fractions
LogKd	<->	Dissolved fractions



	Cd				Fe			
	tot	dis	part	logKD	tot	dis	part	logKD
SPM	R(80)=0.6	R(80)=0.11	R(35)=-0.48	R(35)=-0.53	R(80)=0.88	R(80)=0.3	R(79)=-0.48	R(79)=-0.47
Part	-	R(35)=-0.2	-	-	-	R(79)=0.19	-	-
logKD	-	R(35)=-0.24	-	-	-	R(79)=-0.93	-	-
	Pb				Cu			
	tot	dis	part	logKD	tot	dis	part	logKD
SPM	R(80)=0.74	R(80)=0.02	R(60)=0.05	R(58)=-0.14	R(80)=0.63	R(80)=-0.65	R(66)=-0.33	R(65)=-0.1
Part	-	R(60)=0.38	-	-	-	R(66)=-0.18	-	-
logKD	-	R(58)=0.1	-	-	-	R(65)=-0.53	-	-
	Mn				ТВТ			
	tot	dis	part	logKD	tot	dis	part	logKD
SPM	R(80)=0.84	R(80)=0.32	R(73)=-0.36	R(72)=-0.5	R(17)=0.20	R(16)=0.06	R(12)=-0.95	R(11)=-0.8
Part	-	R(73)=-0.24	-	-	-	R(12)=-0.2	-	-
logKD	-	R(72)=-0.68	-	-	-	R(11)=-0.78	-	-

Metals: - total: SPM

- dissolved: –

TBT: - total: -

- dissolved: LogKD

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Results – 2. Contaminants correlations





Results – 2. Contaminants correlations

- High exceedances of the WFD and VLAREM standards (>50%) by:
 - cadmium ; cobalt ; zinc ; arsenic & **selenium** (>30x)
 - TBT



→ higher than WFD, VLAREM standards -> ecotoxicoligical risk

Results – 3. Contaminants: calculated <-> measured

SPM (av.) during resuspension events x contaminant conc. (av.) in the sediment (dock level)



 \rightarrow Measured < calculated

1. SPM:

- ⇒ TSH dredging highest effect on sediment resuspension followed by BLT dredging and shipping manoeuevres
- \Rightarrow Highly variable factors important for resuspension intensity -> difficult to predict

2. Contaminants:

- \Rightarrow Effects of sediment resuspension on contaminant concentrations in the water layer much smaller than expected
 - -> overall exceedances of WFD and VLAREM standards
 - └→ system already under pressure
 - -> surface water contamination not caused/worsened by sediment resuspension events -> even positive effects found

3. Calculated <-> measured:

 \Rightarrow Often no correlation between contaminant and SPM concentrations in the water \Rightarrow Measured concentrations mostly lower than calculated

 \rightarrow High variation in the dataset (e.g. SPM resuspension, KD values, calculated <-> measured etc.) \rightarrow predictions still highly complex and unsure

Thank you for your attention!







Theoretical background

1. Ship propeller – main and bow propeller

- Diameter propeller
- Capacity
- Distance to sediment

2. Return current

- Speed of ship
- Ratio cross section ship/ water body
- Distance to shore/quay wall

3. Waves

4. Ship Maneuvre

- Passage
- Docking
- Departure
- Turning

