



Case Study

Lake Rummelsburg / Berlin

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&

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Lake Rummelsburg: a partly separated expansion of the river Spree in the urban area of Berlin

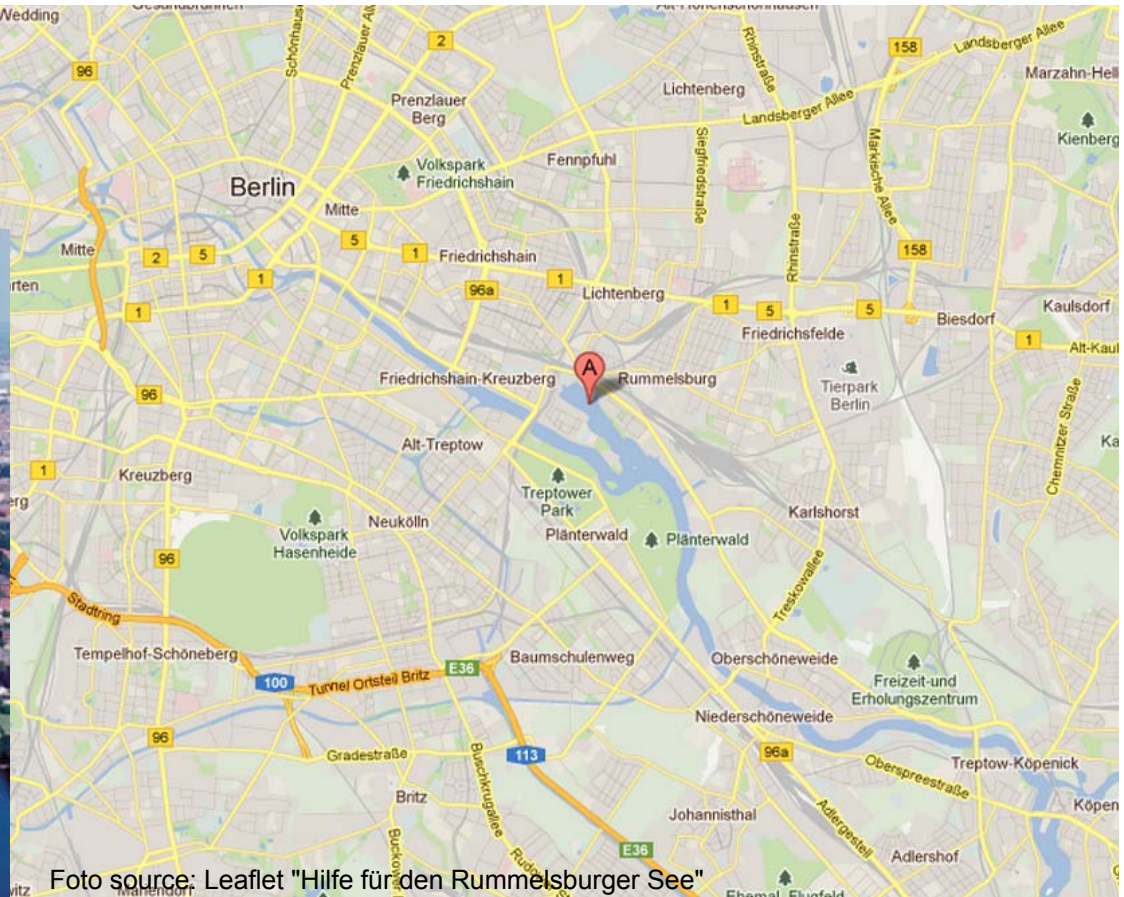
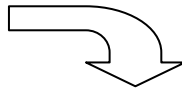


Foto source: Leaflet "Hilfe für den Rummelsburger See"
Senate Department for Urban Development and the Environment, Berlin



Hydrographical data

Lake surface

45 hectare

Largest extension

ca. 1,6 km

Width

ca. 0,3 km

Maximum water depth

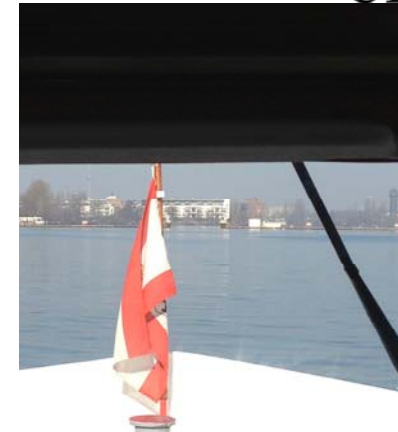
ca. 4,8 m

Average water depth

ca. 2,5 m

Lake surface separated by a sheet pile

34 hectare



Changed claims of utilization

Since the 19th century mainly industrial use of the area around the lake
- asphalt-production, glass factory, galvanisation plant, old ships graveyard,
effluents from waste water treatment plant, rain water drainage channel

City-centre brownfield land since the 1990s

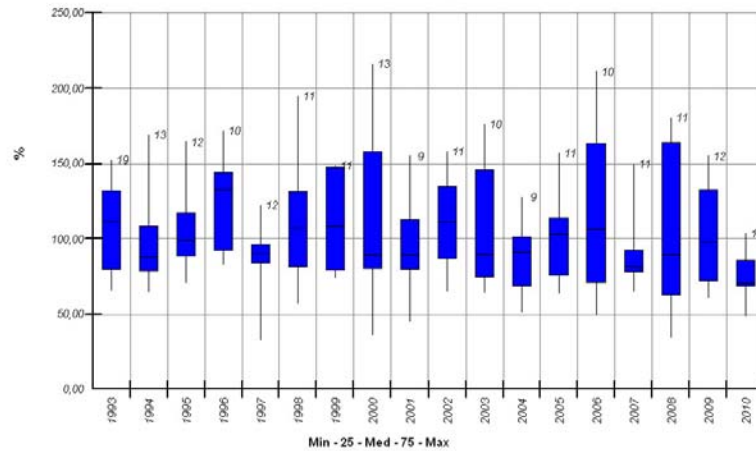
Reclassification as attractive services and residential area
with water connection

Changed claims: residential area, „floating lofts“, watersports, recreation area

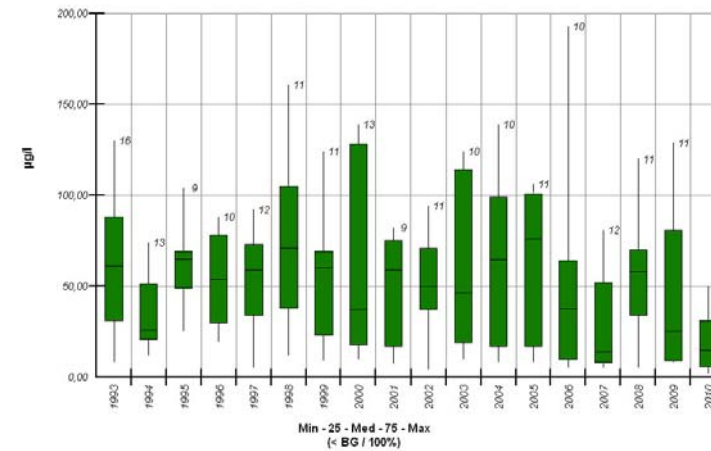


Some water quality parameters

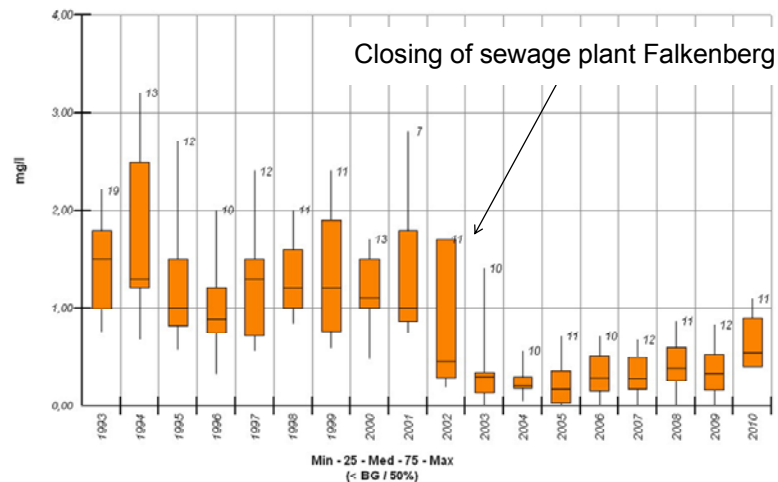
Oxygen saturation Index



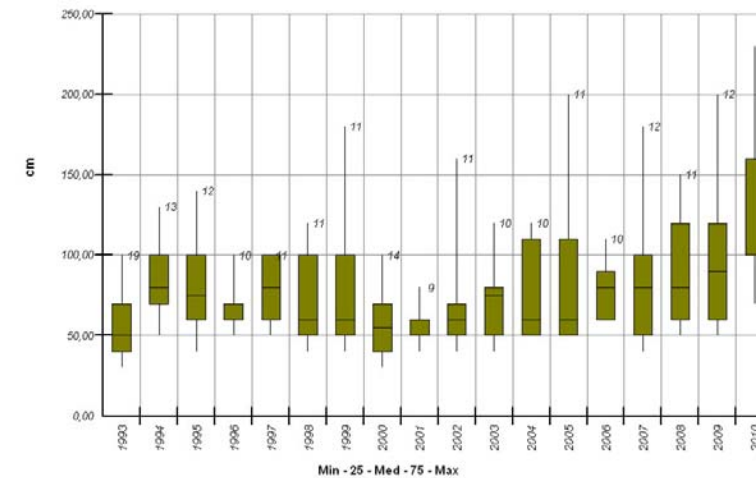
Chl a



Nitrate



Visibility depth



The lake has a problem

Sediments of the lake have been contaminated with heavy metals, mineral oil hydrocarbons and other organic contaminants due to the discharge of mainly industrial waste water in the course of about one century.

Furthermore, nutrients and easily biodegradable substances were carried into the lake



Algal blooms, oxygen deficiency, odour constraints, accelerated formation of digested sludge, substantial ecological instability



First Measures 1999 – 2001
(Sediment conditioning)



First Measures

- 1) Installation of a bulkhead with drive-through access





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- 2) Detection and clearing munitions
phosphor bombs, grenades, weapons



Fotos: Leaflet "Hilfe für den Rummelsburger See"
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First Measures

- 1) Installation of a bulkhead with drive-through access
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phosphor bombs, grenades, weapons
- 3) Partial sludge removal
expensive environmental disposal procedures





First Measures

- 1) Installation of a bulkhead with drive-through access
- 2) Detection and clearing munitions
phosphor bombs, grenades, weapons
- 3) Partial sludge removal
expensive environmental disposal procedures
- 4) Sediment conditioning with $\text{FeO}(\text{OH})$ and CaNO_3
- 5) Pneumatic destratification plant



Perforierte Rohre vor dem Verschweißen



Kompressoren

The questions

- What are the reasons for the biological deficiencies of the lake?
- What measures can be taken in order to improve the situation significantly?



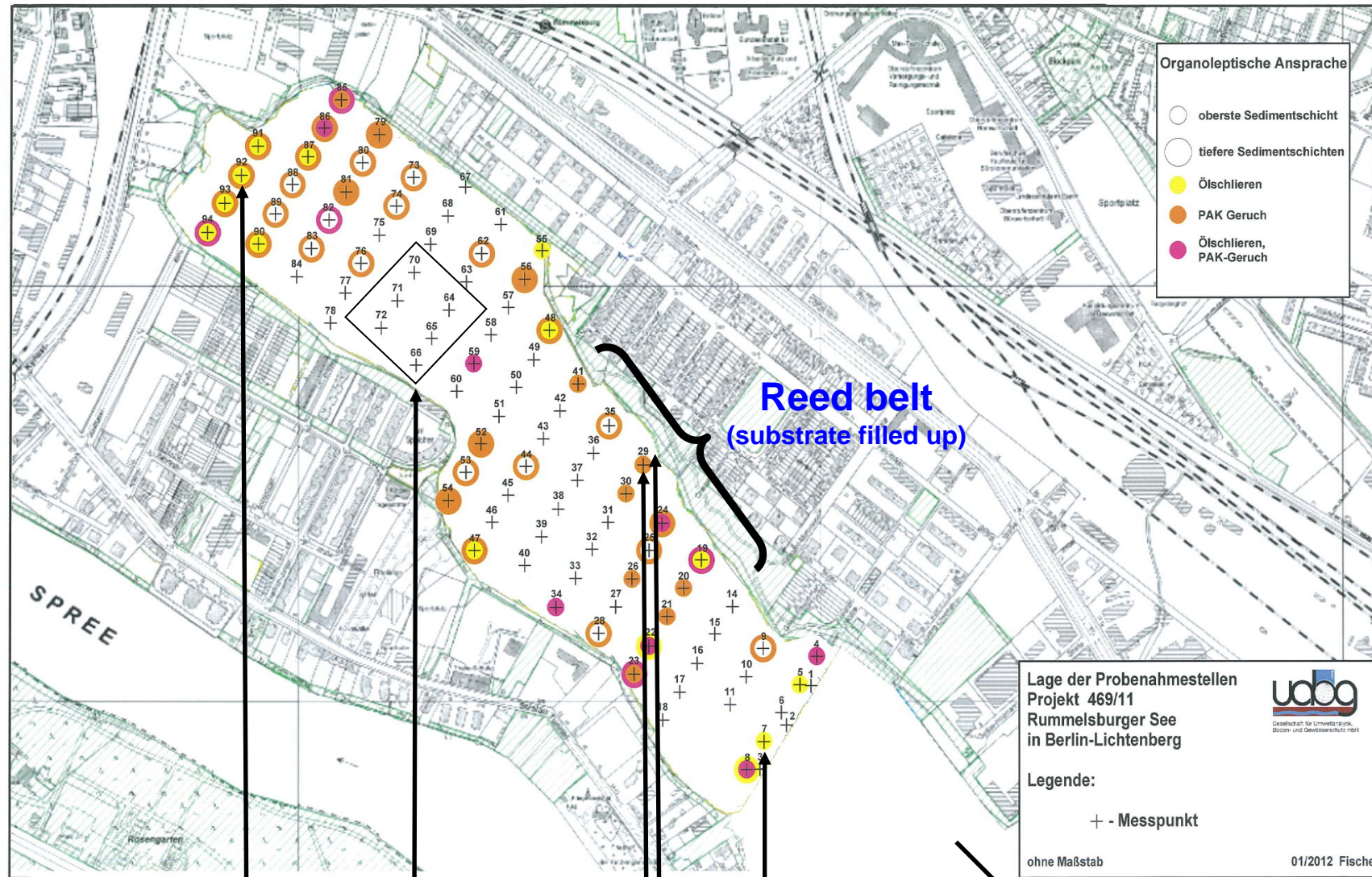
Attempt to answer the questions by a **sediment triad approach**:

- chemical analyses
- toxicological tests
- ecological analyses (macro zoobenthos)

plus

- sediment guideline approach

Sampling sites



120271

120265
sediment core
(only chem. anal.)

120263
120264

120262

120261
Spree „reference site“

Concentrations of organic contaminants
normalized to the <63 µm fraction of freshly deposited sediments:

400 – 1400	µg/kg (sum of 7 PCB),
90-700	µg/kg p,p'-DDD,
2500-6500	µg/kg mineral oil hydrocarbons,
55-370	mg/kg (sum of 16 EPA-PAHs),
1100-2400	µg/kg tributyltin and
9,7-76	ng I-TE/kg dioxin like activity.

GC/MS screening showed also:

- Long-chained hydrocarbons
- Alkylbenzenes
- Dichloro naphthalenes, Phenyl naphthalenes
- Mono- to tetra-alkylated PAHs
- Heterocyclic compounds (Furans, Thiophenes Quinolines)
- Phenoles
- Plasticisers
- Flame retardants
- Steroids



Metals, measured in the fine grained fraction < 63 μ m:

80-440 mg/kg Cr

9-46 mg/kg Cd

2,2-4,1 mg/kg Hg

1000-6400 mg/kg Cu

64-98 mg/kg Ni

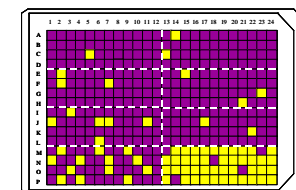
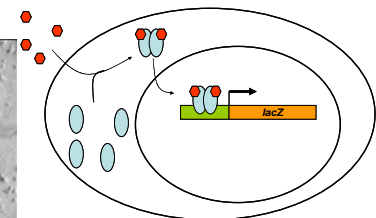
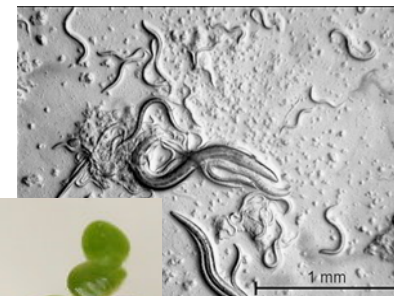
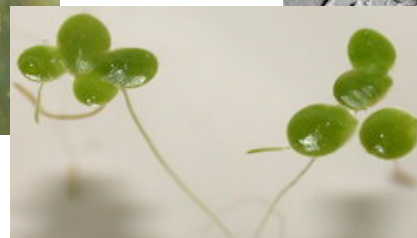
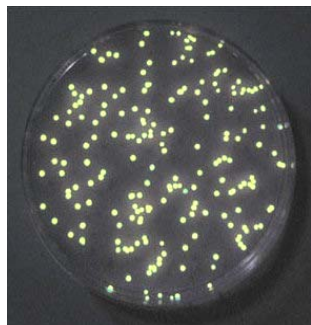
1600-2700 mg/kg Zn

340-830 mg/kg Pb

20-51 mg/kg As

Biotest battery

Biotest	Organism	Toxicity endpoint	Acute / chronic exposure	Samples	Standard
Luminescent bacteria test	<i>Aliivibrio fischeri</i>	Inhibition of Bioluminescence	Acute (30 min)	Pore water Elutriate	DIN EN ISO 11348-2
Green algae test	<i>Desmodesmus subspicatus</i>	Growth inhibition	Chronic (72 hrs)	Pore water Elutriate	DIN 38412-33
Daphnia test	<i>Daphnia magna</i>	Immobilisation	Acute (24 hrs)	Pore water Elutriate	DIN 38412-30
Lemna test	<i>Lemna minor</i>	Growth inhibition	Acute (7 d)	Pore water Elutriate	DIN EN ISO 20079
Myriophyllum test	<i>Myriophyllum aquaticum</i>	Growth inhibition	Acute (10 d)	Sediment	ISO 16191
Nematode test	<i>Caenorhabditis elegans</i>	Growth inhibition, fertility, reproduction	Chronic (96 hrs)	Pore water Elutriate Sediment	DIN ISO 10872
YES	<i>Saccharomyces cerevisiae</i>	ER activation	28 hrs	Pore water, elutriates, extracts	ISO NWIP in preparation
Ames test	<i>Salmonella typhimurium</i>	Mutagenicity	48 hrs	Pore water, elutriates, extracts	ISO 11350



Ecotoxicological sediment classification (BfG-Guidelines)

highest dilution without effect	dilution factor as exponential fraction	pT-value	toxicity classes		management categories	
			index	designation	toxicity class	designation
original sample	2^0	0	0	non-detectable toxicity	0	not contaminated
1:2	2^{-1}	1	I	very slightly toxic	I	non-hazardously contaminated
1:4	2^{-2}	2	II	slightly toxic	II	
1:8	2^{-3}	3	III	moderately toxic	III	critically contaminated
1:16	2^{-4}	4	IV	distinctly toxic	IV	
1:32	2^{-5}	5	V	highly toxic	V	hazardously contaminated
$\leq (1:64)$	$\leq 2^{-6}$	≥ 6	VI	extremely toxic	VI	

Classification of the ecotoxicological potential for dredged material and sediments with the pT-value system (Krebs 1988 & 2005)

Results

Algae, Luminescent bacteria, Daphnia

Sample No.	Algae				Luminescent bacteria				Daphnia				pT-max	Toxicity-class
	Pore water		Elutriate		Pore water		Elutriate		Pore water		Elutriate			
	A %	pT	A %	pT	L %	pT	L %	pT	D %	pT	D %	pT		
120261	-12	0	-28	0	32	1	37	2	0	0	30	1	2	II
120262	-5	0	-52	0	5	0	28	2	0	0	0	0	2	II
120263	-1	0	-14	0	32	2	4	0	0	0	0	0	2	II
120264	-21	0	-18	0	18	0	-7	0	0	0	0	0	0	0
120265	-9	0	-30	0	-18	0	33	1	0	0	0	0	1	I
120271	3	0	8	0	30	1	45	3	0	0	0	0	3	III

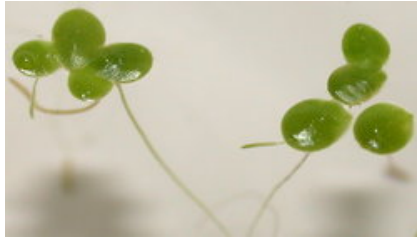


Algae, Luminescent bacteria, Daphnia toxicity

Sample No.	Sample	Physico-chemical parameters				Green Algae DIN 38412-33		Luminesc. bact. DIN EN ISO 11348-2		Daphnia DIN 38412-30		Toxicity class
		pH	NH ₄ ⁺ -N [mg/l]	O ₂ [mg/l]	Cond. [mS/cm]	Inhib. in G1 [%]	pT- Value	Inhib. in G1 [%]	pT- Value	Inhib. in G1 [%]	pT- Value	
120261	PW	7,4	1,7	7,2	0,79	-11,5	0	32	1	0	0	II
120261	E					-28	0	37	2	30	1	
120262	PW	7,7	10,7	7,2	0,83	-4,8	0	5	0	0	0	II
120262	E					-52	0	28	2	0	0	
120263	PW	7,3	23,7	6,0	0,88	-1,3	0	32	2	0	0	II
120263	E					-14	0	4	0	0	0	
120264	PW	7,5	5,7	6,1	0,75	-20,7	0	18	0	0	0	0
120264	E					-18	0	-7	0	0	0	
120265	PW	7,3	9,0	6,3	0,84	-8,8	0	-18	0	0	0	I
120265	E					-30	0	33	1	0	0	
120271	PW	7,3	19,8	6,4	1,11	2,8	0	30	1	0	0	III
120271	E					8	0	45	3	0	0	



Lemna toxicity



Sample No.	Lemna (area)				Lemna (number)				pT-max	Toxicity-class
	Pore water		Elutriate		Pore water		Elutriate			
	I %	pT	I %	pT	I %	pT	I %	pT		
120261	18	3	19	2	10	0	21	2	3	III
120262	13	4	35	2	6	4	37	2	4	IV
120263	37	2	n.t.		19	2	n.t.		2	II
120264	5	2	14	1	-3	0	15	1	2	II
120265	21	4	34	1	15	2	17	0	4	IV
120271	40	4	16	4	24	5	9	0	5	V



Toxicity on Nematodes (*C. elegans*)

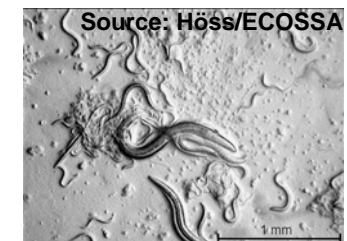
Sample No.	Nematodes								Toxicity-class
	Pore water 100%				Elutriate 100%				
	Growth I %	Tox. Cat.	Reprod. I %	Tox. cat.	Growth I %	Tox. cat.	Reprod. I %	Tox. cat.	
120261	81	3	100	3	35	2	91	3	3
120262	41	2	98	3	82	3	100	3	3
120263	n.d.*		n.d.*		68	3	100	3	3
120264	50	2	99	3	10	1	79	2	3
120265	41	2	95	3	65	3	99	3	3
120271	70	3	100	3	65	3	100	3	3

* Not measured

100 %-approach (not according to ISO)

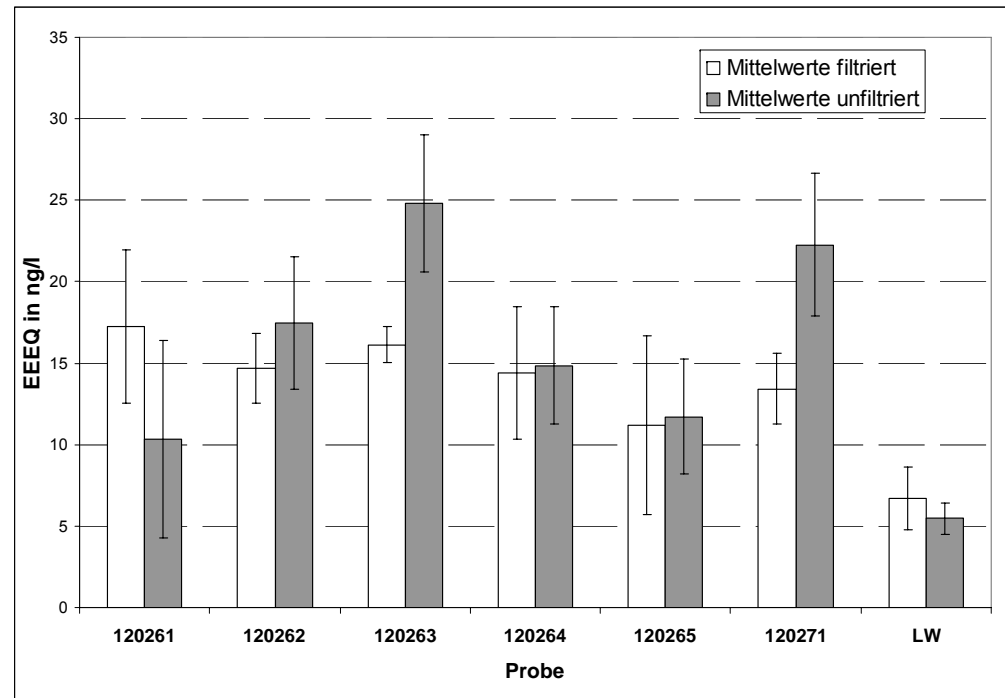
Sample No.	Nematodes								Toxicity-class
	Pore water 50%				Elutriate 50%				
	Growth I %	Tox. Cat.	Reprod. I %	Tox. cat.	Growth I %	Tox. cat.	Reprod. I %	Tox. cat.	
120261	30	2	65	2	7	1	38	1	2
120262	40	2	94	3	50	2	92	3	3
120263	43	2	97	3	8	1	28	1	3
120264	29	2	85	3	1	1	23	1	3
120265	24	1	78	2	26	2	80	2	2
120271	89	3	100	3	32	2	97	3	3

Category (cat)	Description	Plants	Nematode Growth	Nematode Reproduction
1	no significant effect	< 20	< 25	< 50
2	medium effect	20-40	25-50	50-80
3	strong effect	> 40	> 50	> 80





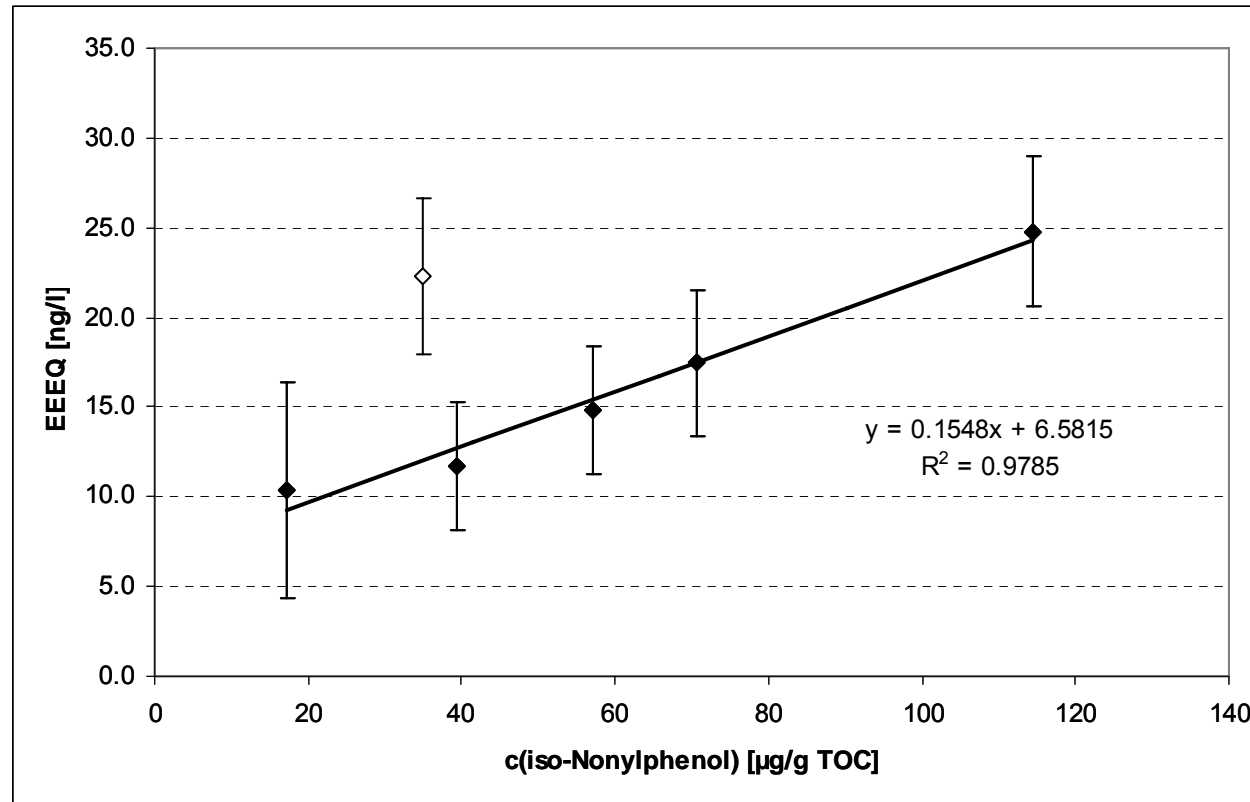
Estrogenicity *in vitro* (YES)



Estrogenic potentials of filtrated and non-filtrated pore water samples



Correlation estrogenic effects in pore water with iso-Nonylphenol



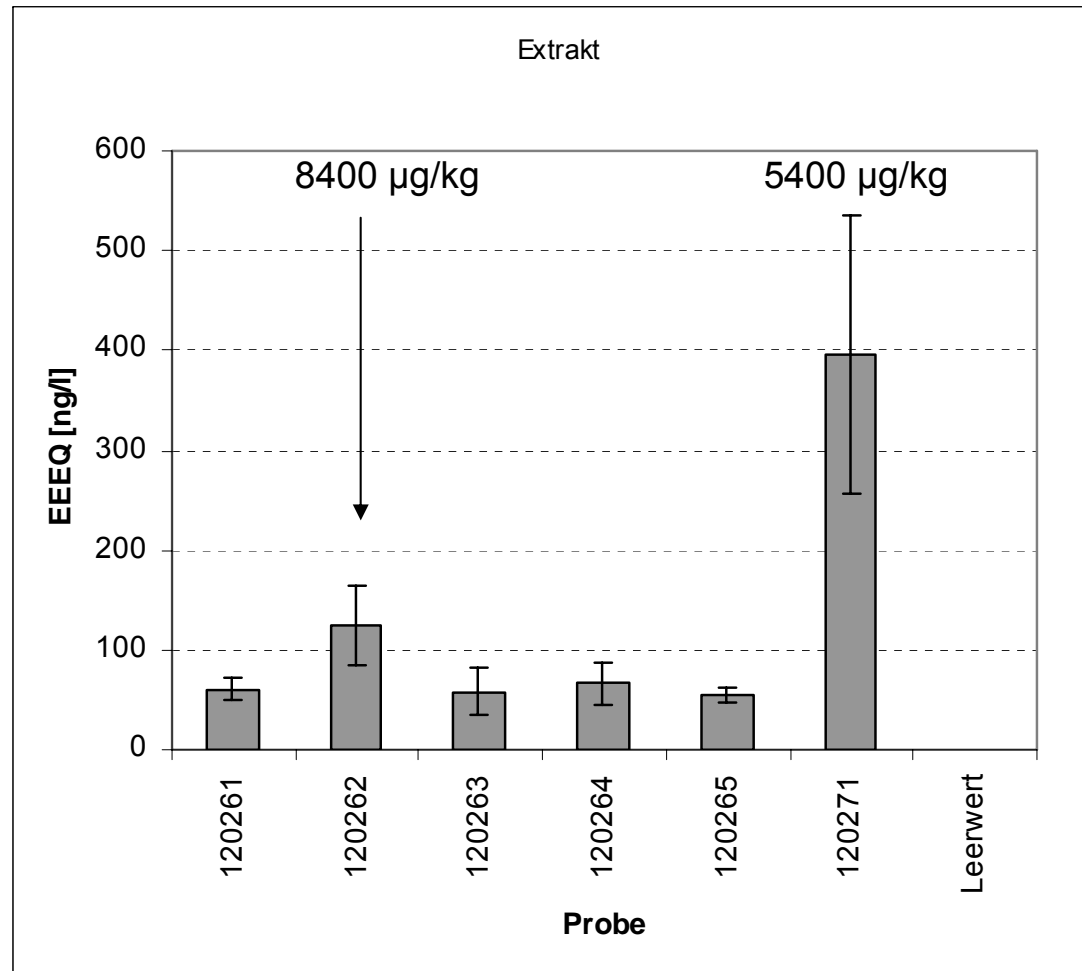
- c(iso-Nonylphenol) normalised to total organic carbon (TOC), to take availability for the water phase into account
- high correlation of chemical data and effect data
- sample 271 does not correlate → indication of other endocrine active compound(s)



Estrogenic effects extract

c(iso-Nonylphenol)

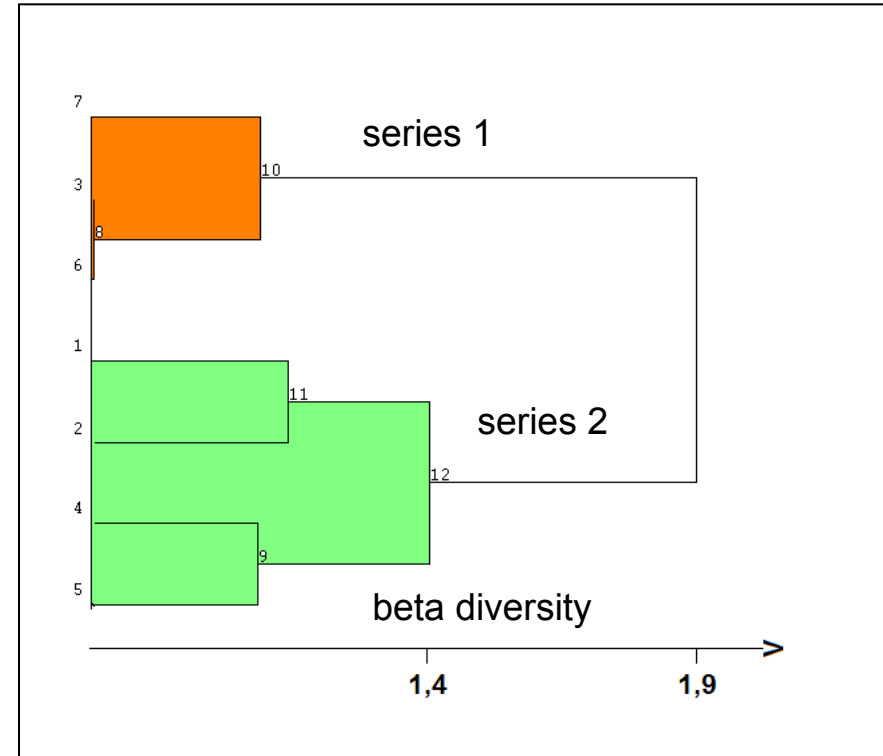
- Estrogenicity mainly
particle bound



- the two most contaminated samples (iso-Nonylphenol) show the highest effects
 - but: no correlation between concentrations of iso-Nonylphenol and effect
 - effect $P_{271} > \text{effect } P_{262}$ even though $c(\text{iNP})_{P_{271}} < c(\text{iNP})_{P_{262}}$
- in line with the observation with pore water (other estrogen active compound(s) in sample 271)

Characteristical taxa depend on sediment structural parameters

Taxa	Series 1	Series 2
No of samples	3	4
Abu[Ind/m ²]	619	25384
No of Taxa	2	22
Max Dom[%]	86,21	37,06
Sc	1.7±0.6	12.8±5.4
Beta-Diversity	=100/86,7=1,2	=100/73,0=1,4
characteristic Taxa	Presence [%]	
Oligochaeta	100,00	100,00
Chironomidae	66,67	100,00
Valvata piscinalis	0,00	100,00
Unio pictorum	0,00	100,00
Dreissena polymorpha	0,00	100,00
Pisidium sp.	0,00	75,00
Unio tumidus	0,00	75,00
Potamopyrgus antipodarum	0,00	50,00
Anodonta anatina	0,00	50,00
Gammarus fossarum	0,00	50,00
Unio sp.	0,00	50,00
Gammarus sp.	0,00	50,00



	MZB	rare	rare	rare	Shore area	"Reference"
		120271	120262	120265	120264	120261
		S3b	S1 (a)	S2c	S2b	S0b
	Series	1	1	1	2	2
F1 >2000	Gravel	0,6	8,6	5,3	5,9	2,7
F2 630-2000	Sand coarse	2,0	3,9	9,6	7,2	1,7
F3 200-630	Sand medium	1,8	2,1	5,1	33,7	3,7
F4 63-200	Sand fine	6,9	22,7	6,0	35,4	65,5
F5 63-20	Silt coarse	21,0	23,3	21,8	2,0	10,6
F6 <20	Silt fine /medium	62,0	32,3	43,9	12,1	11,0

Occurrence of SPEAR

Species/Taxon	SPEAR_pest*	Sensitivity*	120271 S3b	120262 S1 a	120265 S2c	120264 S2b	120261 S0b
<i>Bithynia tentaculata</i>	0	-1,82				24	
Oligochaeta	0	-1,10	24	48	128	2672	728
<i>Helobdella stagnalis</i>	0	-0,60					16
<i>Valvata piscinalis</i>	0	1,82				8	8
<i>Unio tumidus</i>	0	-2,09				64	
<i>Unio pictorum</i>	0	-2,09				1	8
<i>Dikerogammarus haemobaphes</i>	0	0,16				216	
<i>Potamopyrgus antipodarum</i>	0	-1,82				24	
<i>Gammarus</i> sp.	0	0,17				104	
<i>Unio</i> sp.	0	-2,09					8
<i>Dreissena polymorpha</i>	0	-2,09				216	8
Chironomidae	0	-0,39		8	24	232	384
<i>Gammarus fossarum</i>	0	0,16					8
<i>Pisidium</i> sp.	0	-2,09				8	16
<i>Anodonta anatina</i>	0	-2,09					1
<i>Chelicorophium curvispinum</i>	0	0,16					8

Amphipoda

Threshold: > -0,36

* Source: <http://www.systemecology.eu/spear/>



Meiobenthos

Taxon	120261	120271	n = 3
	S0b	S3b	
Nematoda	116533	728	
<i>No. Species</i>	15	3	
<i>No. NemaSPEAR</i>	5	0	
Ostracoda	46905	291	
Rotifera	18063	9031	
Oligochaeta	17189	1894	
Gastrotricha	1748	146	
Phylopoda	1748	874	
Harpacticoida	1602	0	
Copepoda	1165	2476	
Nauplius larvae	1165	146	
Chironomidae	1020	0	
Acari	583	437	
Plathelminthes	583	0	
Tardigrada	291	0	
Ciliata	146	0	
Daphnia eggs	18354	51712	

Sediment Quality Guidelines (SQGs)

derivation of numerical SQGs by empirical and theoretical approaches for the assessment of sediments

- Screening Level Concentration Approach (SLCA)
- Effects Range Approach (ERA)
- Effects Level Approach (ELA)
- Apparent Effects Threshold Approach (AETA)
- Equilibrium Partitioning Approach (EqPA)
- Logistic Regression Modelling Approach (LRMA)
- Consensus Approach (CA)

Sediment Quality Guidelines SQGs

Meaning of

TEC: Threshold Effect Concentrations ...if [] <: low toxicological risk

PEC: Probable Effect Concentrations ...if [] >: high toxicological risk

- TECs are concentrations below which adverse effects on benthic invertebrates are unlikely to be observed
- PECs are concentrations above which harmful effects on benthic invertebrates are likely to be observed
- PEC-quotients may be used to assess sediments with a complex mixture of contaminants

MacDonald, 2000: “TECs, PECs and PEC-quotients offer a reliable basis to classify non-toxic and toxic sediments”



Toxic potential (mean PEC-Q) of the lake sediments

Sample No.	120261	120262	120263	120264	120265	120271
Sampling location	S0b	S1	S2a	S2b	S2c	S3b
Number of substances	39	39	39	39	39	39
Substances >PEC	32	34	32	32	33	35
Mean PEC-Q	7,33	7,80	4,21	3,70	5,71	11,69
Max. PEC-Q	103,14	47,90	32,13	20,17	32,45	60,94

Max	Cu	PCB 28	Cu	Cu	PCB 28	<i>p,p</i> -DDD
2.	<i>p,p</i> -DDD	PCB 31	PCB 28	PCB 28	PCB 31	PCB 28
3.	PCB 170	<i>p,p</i> -DDD	PCB 31	PCB 31	<i>p,p</i> -DDD	PCB 31
						+ PAHs, MKWs, Cu

basis for evaluation: SQGs from de Deckere et al. (2011)

Sample No.	120261	120262	120263	120264	120265	120271
Sampling location	S0b	S1	S2a	S2b	S2c	S3b
Number of substances	21	21	21	21	21	21
Substances >PEC	18	18	17	16	18	18
Mean PEC-Q	4,72	3,07	3,14	2,64	2,30	5,51
Max. PEC-Q	41,53	8,48	12,94	8,12	5,46	12,04

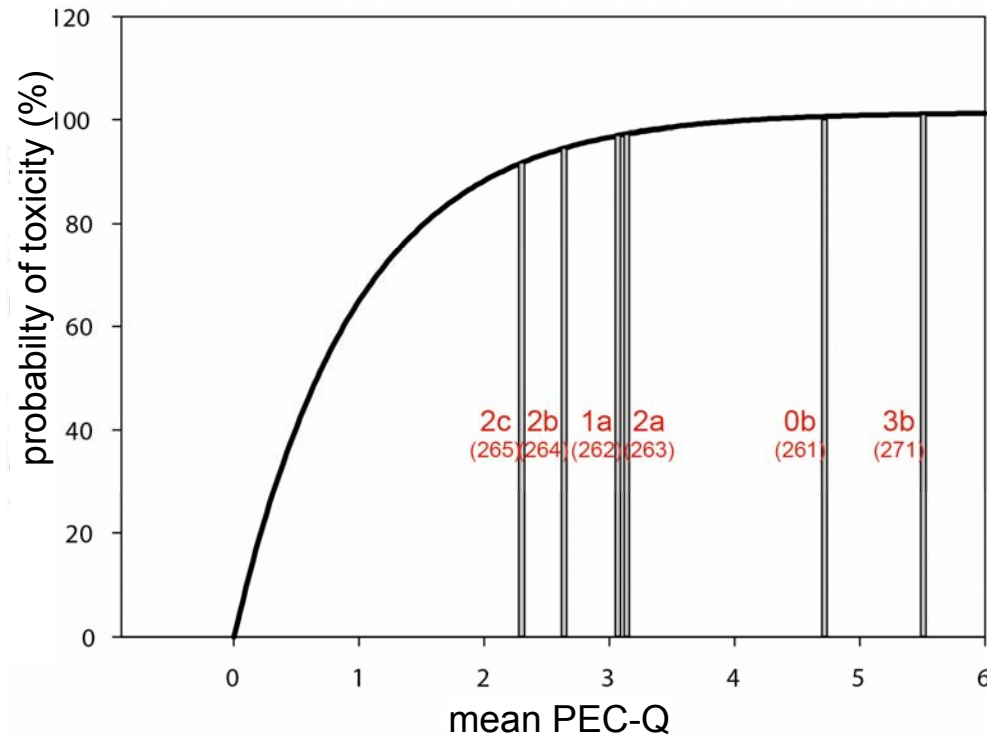
Max	Cu	Cu	Cu	Cu	Cu	Pyrene
2.	Pb	Cd	Cd	Zn	Cd	Fluoranthene
3.	SumDDD	Zn	Zn	Cd	Zn	Benzo[a]anthracene

basis for evaluation: SQGs from McDonald et al. (2000)



Probability of toxicity

for benthic organisms in Lake Rummelsburg



Curve adopted from MacDonald et al. (2000)

Summary

- Lake Rummelsburg is area-wide contaminated, mainly due to past industrial production.
- From the river Spree further pollutants enter the lake.
- The „reference“ Spree is also contaminated, mainly by Cu and Pb, PCB and PAH (a new reference should be found and tested).
- Green algae, daphnia, and luminescent bacteria tests show no to low toxicity.
- *Lemna* test shows low to high toxicity.
- *C. elegans* shows moderate to very high toxicity.
- Estrogenicity: 10 to 25 ng /L EEQ [correlates with c(iso-Nonylphenol) normalised to TOC] and is mainly particle bound.
- Mutagenicity: not detectable in pore water. Detectable in extracts. Increasing with the metabolic competence of the test strains (data not shown).
- Characteristical MZB taxa depend on sediment structural parameters.
- SPEAR organisms are rare and depend on the sediment structure.
- Mean PEC-Q values predict high toxicity at all sites.



Main conclusions

The combination of

high chemical contamination with persistent organic and inorganic chemicals,

toxicity and

specific substrate composition

makes a natural repopulation scenario for the improvement of the biological diversity extremely improbable.

The study suggests that a significant improvement of the habitat could only be achieved by either a very cost-intensive removing of the sludges or by covering the sediments with uncontaminated substrate of appropriate structure or a combination of both.

→ the study will be completed by the assessment of a „true“ reference site with comparable sediment structure and low chemical contamination



Bundesministerium
für Verkehr, Bau
und Stadtentwicklung



Thank you for your attention !

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