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The significance of sediment contamination in the Elbe River Floodplain (Czech Republic)

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- part of ELSA project - Schadstoffsanierung Elbsedimente

http://www.elsa-elbe.de/

= restoration of polluted Elbe sediments

Source: HPA - METHA

- *Main partner:*

Freie und Hansestadt Hamburg
- Behörde für Stadtentwing und Umwelt
Amt für Umweltschutz,
Wasserwirtschaft

Hamburg Port Authority - Hafeninfrastruktur,
Infrastruktur Wasser

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- *Co-researchers:*

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Geomin, s.r.o., Jihlava - *RNDr. Michal Černý, Ing. Miroslav Žáček, Ph.D.*
DHI, a.s., Praha - *Ing. Petr Jiřinec, RNDr. Jana Kaiglová*

Phases, goals and methods

- identification of the most contaminated localities in the middle course of the Elbe River - project focused on side river structures

- monitoring plan

Phase 1 - mixed samples of subaquatic sediments from fluvial lakes (oxbow/cut lakes)

Phase 2 – subaquatic cores from fluvial lakes (oxbow/cut lakes) + floodplain cores

- evaluation of sediment contamination

grain structure analyses, chemical analyses
evaluation according to the methodology
of the FGG Elbe and ICPER

- estimation of sediment volume

maps, measurements, field survey

- risk assessment of the flood remobilisation of sediments

mathematical modelling

- complex risk assessment of selected localities

evaluation according to the methodology of the FGG Elbe and ICPER

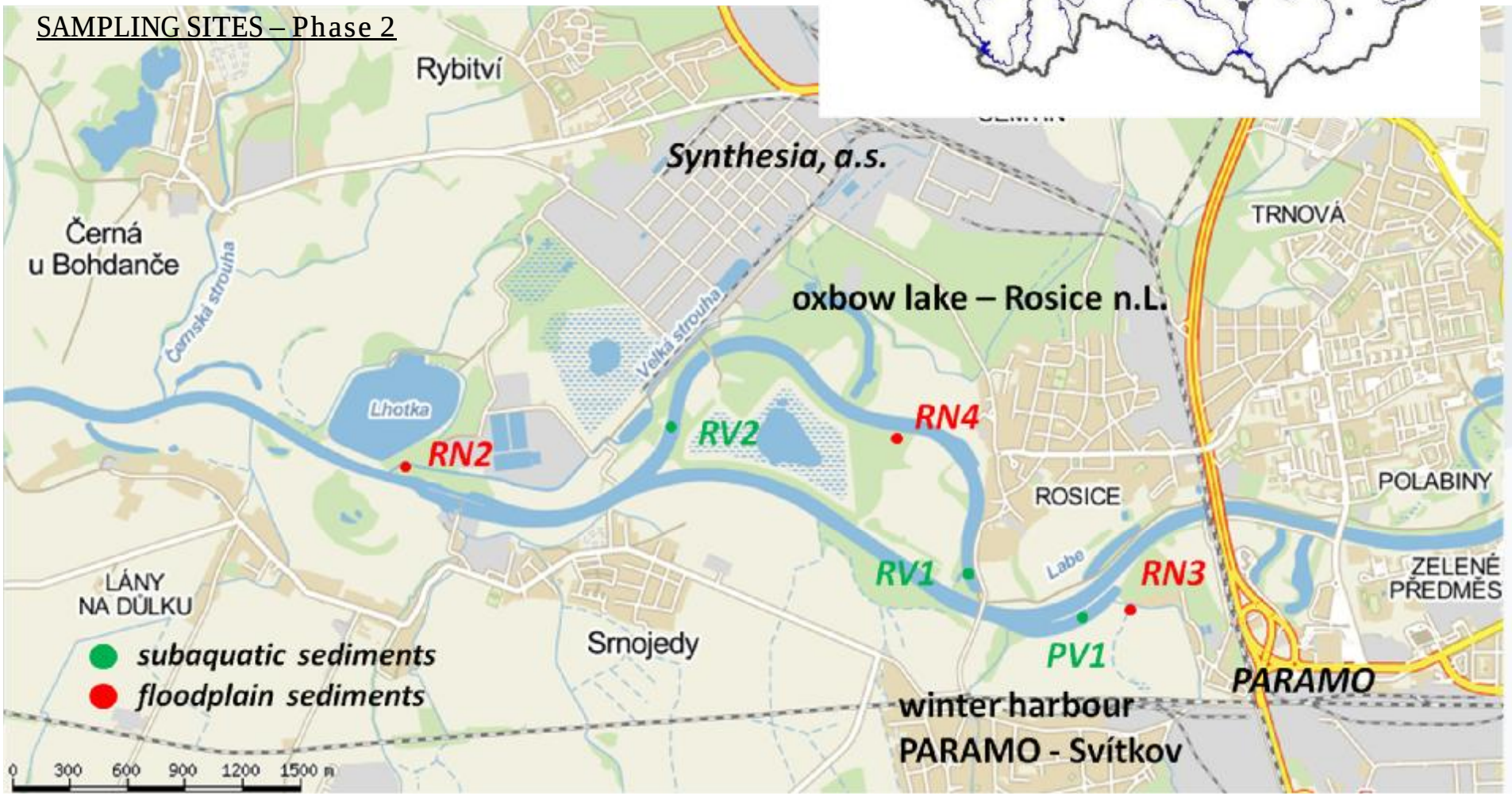
Localities and sources of pollution:

- Pardubice region:

Synthesia, a.s. - chemical factory - originally Explosia, later VCHZ Synthesia
- production of explosives, substances for production of explosives, pigments, dyes , AOX, other chemicals...

PARAMO, a.s. - refinery
- lubrication oils, plastic lubricants, asphalt products

SAMPLING SITES – Phase 2

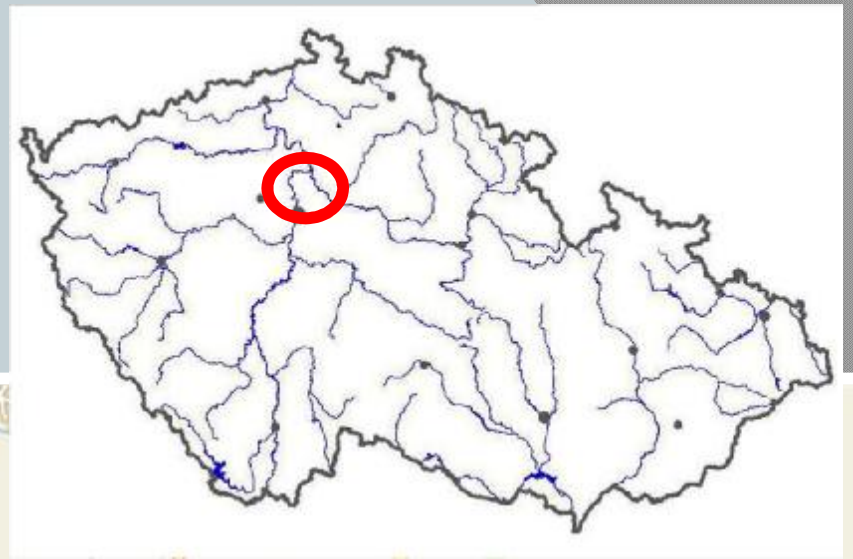


Localities and sources of pollution:

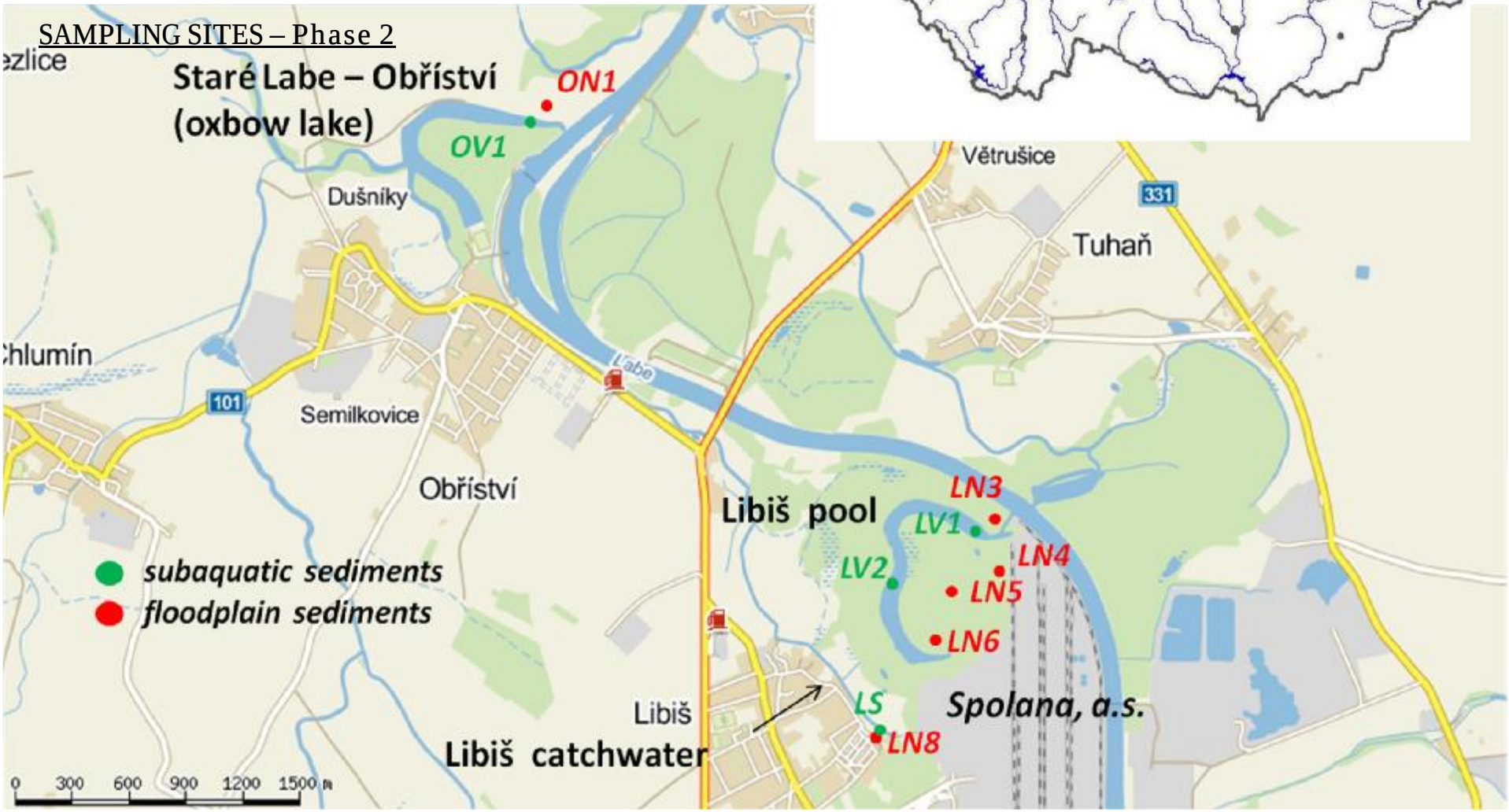
- Neratovice and Obříství:

Spolana, a.s., - chemical factory,

- linear alpha olefins, Hg from chlorine production by the use of outdated amalgam electrolysis, DDT, lindan and dioxins from herbicide and Agent Orange production)



SAMPLING SITES – Phase 2



Pollution assessment – Phase 2 Pardubice region

- concentration < Lower Limit Value green; concentration > Lower Limit Value and < Upper Limit Value yellow; concentration > Upper Limit Value red; concentration without possibility of classification blue

R = Rosice
P = harbour PARAMO
N = floodplain core
V = lake core
1=20cm 2=30cm
3=30cm 4=70cm

Parameter	Zn	Ni	Pb	As	Cu	Hg	Cd	Cr	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180
Upper Limit	800	3	53	40	160	O,47	2,3	640	20	20	20	20	20	20	20
Sample	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
RN2/1	387	39	37	37	29	0,4	1,0	100	<1	1	6	2	16	19	18
RN2/2	229	39	62	40	27	0,6	0,7	93	<1	<1	<1	<1	2	2	2
RN2/3	189	54	37	30	13	0,2	0,2	60	<1	<1	<1	<1	<1	<1	<1
RN2/4	165	47	52	41	14	1,5	0,2	64	<1	<1	<1	<1	<1	1	1
RN3/1	329	40	101	38	39	0,5	0,5	85	5	<1	<1	<1	3	3	3
RN3/2	304	42	94	43	39	0,5	0,5	88	<1	<1	<1	<1	3	2	5
RN3/3	142	37	42	37	13	0,1	0,2	66	<1	<1	<1	<1	<1	1	1
RN3/4	107	37	39	35	4	0,1	0,1	60	3	<1	<1	<1	<1	<1	<1
RN4/1	231	37	62	31	25	0,2	0,4	64	<1	<1	<1	<1	<1	<1	<1
RN4/2	98	26	29	40	2	0,2	0,2	43	1	<1	<1	<1	2	2	2
RN4/3	146	42	49	48	11	0,2	0,3	72	<1	<1	<1	<1	<1	<1	<1
RN4/4	117	38	36	42	3	0,2	0,2	59	<1	<1	<1	<1	<1	<1	<1
RV1/1	249	33	55	16	41	0,4	0,7	63	2	2	3	2	7	10	9
RV1/2	427	42	74	7	77	0,5	1,8	150	5	13	6	4	15	21	17
RV1/3	422	42	83	17	74	0,5	3,4	229	6	11	9	4	19	25	21
RV1/4	591	39	77	15	66	0,5	2,3	201	11	19	13	6	25	34	30
RV2/1	1050	47	144	5	140	1,2	3,2	342	2	4	11	6	17	20	16
RV2/2	577	39	121	10	82	0,9	0,6	178	2	3	5	5	10	10	6
RV2/3	522	42	115	9	73	0,8	1,2	167	2	2	5	4	8	8	5
RV2/3	444	41	111	14	65	0,7	1,2	158	16	14	27	23	28	32	9
PV/1	1780	45	181	23	238	4,4	2,7	71	25	13	34	13	69	88	74
PV/2	1290	58	142	18	211	2,0	2,7	83	69	47	32	15	92	102	103
PV/3	1430	61	385	15	240	2,2	3,0	116	51	64	51	25	114	130	126
PV/4	1610	55	381	22	170	2,0	3,0	115	18	16	30	14	58	73	63

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Parameter	alfa-HCH	HCB	pentaCB	beta-HCH	gama-HCH	p,p-DDE	p,p-DDD	p,p-DDT	PAU-5	anthracene	fluoranthene	b(a)pyrene	C10-C40	NES	TBT
Upper Limit	1,5	17	400	>5	1,5	6,8	3,2	3	>2,5	0,31	>0,18	0,6			>0,02
Sample	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	mg/kg	mg/kg	µg/kg
RN2/1	<3	<3	<3,0	<3	<3	4	<3	17	774	63	419	211	<100	263	
RN2/2	<3	<3	<3,0	<3	<3	<3	<3	<3	192	24	116	47	<100	61	
RN2/3	<3	<3	<3,0	<3	<3	<3	<3	<3	<29	5	9	5	<100	167	
RN2/4	<3	<3	<3,0	<3	<3	<3	<3	<3	<28	10	17	7	<100	34	
RN3/1	<3	6	<3,0	<3	<3	<3	4	9	3327	813	2060	992	390	443	
RN3/2	<3	4	<3,0	<3	<3	<3	6	49	707	37	264	138	250	270	
RN3/3	<3	<3	<3,0	<3	<3	<3	<3	<3	144	21	74	36	<100	115	
RN3/4	<3	<3	<3,0	<3	<3	<3	<3	<3	92	19	63	24	<100	21	
RN4/1	<3	<3	<3,0	<3	<3	<3	<3	<3	<24	13	40	7	<100	60	
RN4/2	<3	<3	<3,0	<3	<3	<3	<3	<3	147	20	80	36	<100	195	
RN4/3	<3	<3	<3,0	<3	<3	<3	<3	<3	205	27	126	57	<100	130	
RN4/4	<3	<3	<3,0	<3	<3	<3	<3	<3	98	20	76	24	<100	17	
RV1/1	<3	<3	<3,0	<3	<3	8	7	7	2361	185	1420	681	270	1878	12,0
RV1/2	<3	<3	<3,0	<3	<3	12	6	<3	2534	214	1750	469	710	2666	86,0
RV1/3	<3	<3	<3,0	<3	<3	18	8	7	3423	250	1880	915	1300	3193	180,0
RV1/4	<3	<3	<3,0	<3	<3	39	22	<3	4794	347	2620	1230	2100	3612	56,0
RV2/1	<3	<3	<3,0	<3	<3	86	56	<3	7622	824	4480	1840	10600	13211	<2,0
RV2/2	<3	<3	<3,0	<3	<3	36	26	<3	6783	607	4170	1830	2600	4475	3,7
RV2/3	<3	<3	<3,0	<3	<3	16	12	<3	6296	636	3590	1590	1300	3027	2,6
RV2/3	<3	<3	<3,0	<3	<3	<3	<3	<3	4791	619	2800	1120	1300	3043	<2,0
PV/1	<3	21	<3,0	<3	<3	38	54	5	5470	590	2080	1650	30000	39125	440,0
PV/2	<3	46	<3,0	<3	<3	62	90	25	8590	4820	7620	4220	190000	273693	
PV/3	<3	134	<3,0	<3	<3	150	980	41	8540	3040	2820	3730	220000	331531	
PV/4	<3	136	<3,0	<3	<3	48	100	6	4050	580	1590	1480	40000	33819	

Pollution assessment – Phase 2 Neratovice and Obříství

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O = Obříství, L = Libiš
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Parameter	Zn	Ni	Pb	As	Cu	Hg	Cd	Cr	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180
Upper Limit	800	3	53	40	160	O,47	2,3	640		20	20	20	20	20	20
Sample	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
ON1/1	313	39	86	31	68	1,1	1,00	83	3	10	5	1	4	11	9
ON1/2	623	48	162	50	106	3,5	2,5	154	<1	<1	<1	<1	3	4	5
ON1/3	364	47	111	40	61	1,6	1,1	101	4	<1	<1	<1	<1	1	1
ON1/4	291	44	106	68	49	1,3	0,8	95	4	<1	<1	<1	<1	1	1
LN3/1	411	47	75	32	64	0,6	0,9	82	6	6	3	1	4	6	5
LN3/2	213	37	66	58	41	0,9	0,6	71	2	2	2	<1	4	7	5
LN3/3	235	44	74	27	32	0,5	0,5	79	1	<1	<1	<1	<1	1	<1
LN3/4	125	38	49	21	13	0,2	0,1	59	<1	<1	<1	<1	<1	<1	<1
LN4/1	207	38	72	33	27	1,0	0,3	78	3	1	<1	<1	2	3	2
LN4/2	175	44	69	57	23	0,6	0,2	75	<1	<1	<1	<1	<1	2	2
LN4/3	165	41	51	23	13	0,2	0,1	70	<1	<1	<1	<1	<1	<1	<1
LN4/4	169	40	44	21	11	0,1	0,2	63	3	1	<1	<1	<1	1	2
LN4/5	177	40	38	18	8	0,2	0,4	53	<1	<1	<1	<1	<1	<1	<1
LN6/1	154	33	56	26	24	1,5	0,1	61	<1	<1	4	1	5	15	9
LN6/2	172	38	56	22	12	0,5	0,2	67	<1	<1	<1	<1	<1	2	<1
LN6/3	184	40	37	39	10	0,1	0,3	62	6	1	1	<1	<1	<1	<1
LN6/4	178	41	34	14	7	0,1	0,4	57	16	3	<1	<1	<1	<1	<1
LN8/1	222	39	105	28	62	1,1	0,4	67	<1	<1	3	<1	5	11	8
LN8/2	171	38	57	20	31	0,4	0,3	63	<1	<1	1	<1	2	4	3
LN8/3	190	38	65	19	35	0,6	0,3	64	<1	<1	2	<1	3	6	5
LN8/4	144	38	61	19	17	0,4	0,2	63	<1	<1	<1	<1	<1	<1	<1
LN8/5	151	53	43	17	30	0,3	0,2	71	5	<1	<1	<1	<1	<1	<1
LN8/6	100	51	24	26	22	0,2	0,1	54	<1	<1	<1	<1	<1	<1	<1
LN8/7	40	18	18	5	<2	0,2	<0,1	39	6	1	<1	<1	<1	<1	<1
LS/1	938	61	179	83	288	14,0	2,2	84	26	17	150	31	360	540	450
LS/2	226	40	54	47	69	3,2	0,7	65	7	5	12	3	49	50	46
OV1/1	391	33	97	9	130	1,7	2,0	103	13	61	20	3	14	21	18
OV1/2	399	31	107	9	134	2,4	2,3	115	32	46	16	5	19	29	26
OV1/3	335	29	77	9	104	2,2	2,9	91	200	84	31	19	26	37	25
OV1/4	584	50	146	11	178	7,3	4,1	173	45	34	26	16	29	39	31
LV1/1	865	57	131	15	153	5,7	4,0	124	51	39	31	13	44	62	48
LV1/2	2330	50	223	20	203	14,0	5,0	236	12	10	9	5	11	13	9
LV1/3	787	33	164	29	83	4,0	2,2	96	<1	<1	1	<1	2	2	1
LV1/4	167	37	64	6	31	0,5	0,5	62	<1	<1	<1	<1	<1	<1	<1
LV2/1	480	37	96	20	66	2,0	0,9	68	3	3	2	1	4	5	3
LV2/2	141	29	56	8	28	0,5	0,5	49	<1	<1	<1	<1	<1	<1	<1
LV2/3	152	40	65	5	23	0,3	0,5	61	4	<1	<1	<1	<1	<1	<1

Pollution assessment – Phase 2 Neratovice and Obříství

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4=50/70cm 5,6,7=50cm

Parameter	alfa-HCH	HCB	pentaCB	beta-HCH	gama-HCH	p,p-DDE	p,p-DDD	p,p-DDT	PAHs 5	anthracene	fluoranthene	b(a)pyrene
Upper Limit	1,5	17	400	>5	1,5	6,8	3,2	3	>2,5	0,31	>0,18	0,6
Sample	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
ON1/1	<3	7	<3,0	<3	<3	14	12	50	1273	103	626	359
ON1/2	<3	4	<3,0	8	<3	15	7	19	757	59	437	170
ON1/3	<3	<3	<3,0	<3	<3	5	<3	5	293	25	99	82
ON1/4	<3	<3	<3,0	<3	<3	10	<3	7	875	62	485	228
LN3/1	<3	4	<3,0	<3	<3	12	8	5	2399	212	1380	666
LN3/2	<3	7	<3,0	3	<3	33	7	12	2139	267	1230	627
LN3/3	<3	<3	<3,0	<3	<3	6	<3	<3	417	46	203	106
LN3/4	<3	<3	<3,0	<3	<3	<3	<3	<3	2356	329	1410	749
LN4/1	<3	3	<3,0	<3	<3	25	<3	8	322	33	175	84
LN4/2	<3	<3	<3,0	<3	<3	15	<3	4	122	11	62	35
LN4/3	<3	<3	<3,0	<3	<3	<3	<3	5	<17	8	7	<5
LN4/4	<3	<3	<3,0	<3	<3	<3	<3	<3	71	9	13	5
LN4/5	<3	<3	<3,0	<3	<3	<3	<3	3	<24	13	11	6
LN6/1	<3	25	<3,0	<3	<3	330	9	410	191	20	192	46
LN6/2	<3	5	<3,0	<3	<3	62	<3	47	32	27	15	7
LN6/3	<3	<3	<3,0	<3	<3	51	<3	7	<17	16	11	<5
LN6/4	<3	<3	<3,0	<3	<3	9	<3	7	48	14	31	14
LN8/1	<3	52	<3,0	<3	<3	980	15	420	379	33	204	104
LN8/2	<3	26	<3,0	<3	<3	540	9	215	340	24	176	93
LN8/3	<3	18	<3,0	<3	<3	324	6	130	168	19	103	43
LN8/4	<3	<3	<3,0	<3	<3	9	<3	4	<17	10	7	<5
LN8/5	<3	<3	<3,0	<3	<3	47	<3	19	37	18	24	10
LN8/6	<3	<3	<3,0	<3	<3	15	<3	6	37	17	14	9
LN8/7	<3	<3	<3,0	<3	<3	<3	<3	<3	<30	8	24	<5
LS/1	34	110	18,0	63	16	260	1380	890	10220	1150	9050	2740
LS/2	14	19	5,0	13	6	60	345	79	148	34	156	36
OV1/1	<3	<3	<3,0	<3	<3	8	4	<3	1962	488	1320	490
OV1/2	<3	<3	<3,0	<3	<3	10	6	<3	2034	2080	1310	467
OV1/3	<3	8	<3,0	<3	<3	21	9	4	1823	1740	991	432
OV1/4	<3	5	<3,0	<3	<3	30	26	<3	2522	1030	1320	662
LV1/1	4	7	<3,0	4	<3	91	135	4	2600	734	1580	568
LV1/2	10	8	4,1	<3	<3	220	113	5	4189	466	2270	898
LV1/3	<3	<3	<3,0	<3	<3	<3	<3	<3	3016	259	1670	704
LV1/4	<3	<3	<3,0	<3	<3	<3	<3	<3	143	41	93	29
LV2/1	4	7	<3,0	<3	<3	82	66	3	1629	165	857	308
LV2/2	<3	<3	<3,0	<3	<3	<3	<3	<3	959	120	436	229
LV2/3	<3	<3	<3,0	<3	<3	<3	<3	<3	237	34	18	15

Modelling of sediment remobilisation

→ the main aim was to find when the sediment remobilisation starts

input data:

- extend of polluted sediments in the researched lakes
- results from grain structure analyses (upper layer of subaq. sediments – grain size 0,007-0,039 mm)
- concentrations of suspended load during floods March/April 2006 and June 2013 from Valy and Obříství station and hydrological data from limnigraphic stations Němčice, Přelouč, Kostelec n.L., Vraňany (the Moldau River) – floods 2002, 2006, 2013

application of 2D hydrodynamic model of the Elbe River
application of MIKE 21 C software for simulation of sediment transport
sediment remobilisation criteria:

- sediment erosion in the zones of polluted sediments at least 1mm/hour repeatedly
- suspended load conc. (from the zones of polluted sediments) exceeded 0,5 $g.m^{-3}$ in the Elbe River

Pardubice

- flood from the Elbe River
- flood from the Jesenčanský brook

Neratovice – Libiš pool

- flood from the Elbe River
- flood from Libiš catchwater

Obříství

- flood from the Elbe River
- flood from the Moldau River
- flood from the Černavka brook

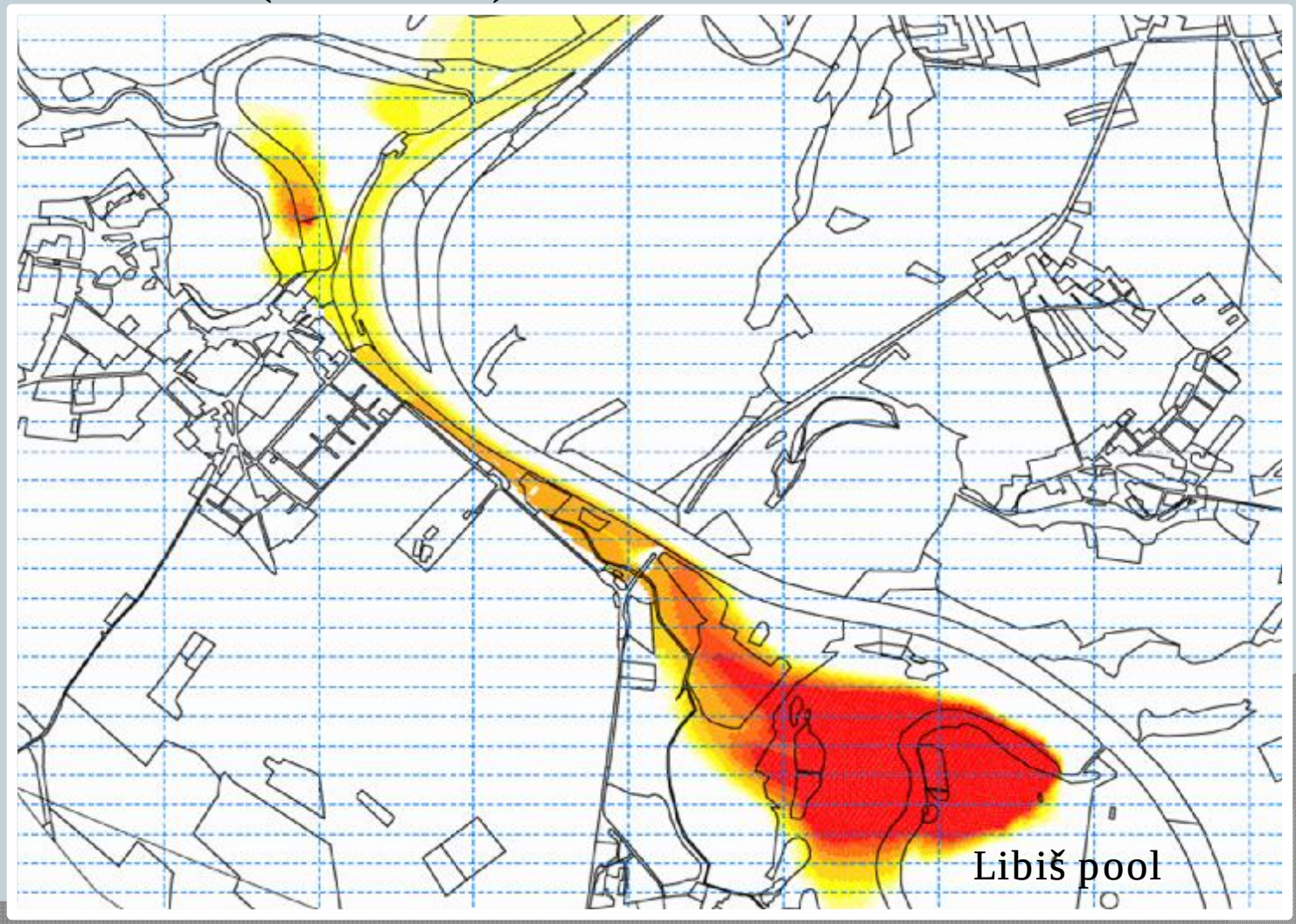
grade of sediment removal risk	interval characteristics
1	less than $Q_{80\text{-day}}$
2	middle characteristics of the interval $Q_{30\text{-day}}$
3	upper limit on Q_1
4	characteristics of the interval (in 2/3) Q_2; lower limit Q_1
5	middle characteristics of the interval Q_5
6	middle characteristics of the interval Q_{20}; upper limit Q_{50}
7	more than Q_{50}

- the method of rainfall-runoff modelling applied on small streams (10-year rainfall with the duration of 1 hour on a saturated catchment); application of MIKE 11R RR software

Modelling of sediment remobilisation

- example of MIKE 21 C simulations - concentrations of suspended matter flushed out from Libiš pool and Staré Labe at Obříství - the Elbe River flood Q = 1210 m^3s^{-1}

Staré Labe – Obříství (oxbow lake)



Complex risk assessment of selected localities

- evaluation according to the Sedimentmanagementkonzept FGG Elbe and ICPER (4 grades) based on: sediment contamination/volume of polluted sediments/grade of sediment remobilisation risk

Locality	grade of risk	grade of sediment remobilisation risk	Volume	Sediment quality														
				DDX	HCB	HCH	PCB	PAHs 5	b(a)pyrene	anthracene	fluoranthene	TBT	Hg	Cd	Pb	Cu	other metals	NES C10-C40
oxbow lake Rosice - Phase 1 (R 1-3)		7									X							X
oxbow lake Rosice - Phase 2 (RV1-2)								X	X		X	X						XX
winter harbour PARAMO - Phase 1 (B)		7 - Elbe		XX	X		X	X	XX	X	XX			X	XX			XX
winter harbour PARAMO - Phase 2 (PV1)		6 - Jesenčan.b.		X			X	X	X	X	XX	XX			X			XX
floodplain at Velká strouha (RN2)																		
floodplain at the Jesenčanský brook (RN3)											X							
floodplain at oxbow lake by Rosice (RN4)																		
Libiš pool - Phase 1 (L 1-3)		6		X							X		XX	X				
Libiš pool - Phase 2 (LV1-2)																		
Libiš catchwater - Phase 1				XX	X	X							XX	X				
Libiš catchwater - Phase 2 (LS)				XX			XX	X	X		XX		XX					
oxbow lake Staré Labe by Obříství - Phase 1 (O1-2)		5 - Moldau										X						
oxbow lake Staré Labe by Obříství - Phase 2 (OV1)		7 - Elbe								X		X	X					
floodplain at Libiš pool (LN3)																		
floodplain at Libiš pool and Spolana (LN4)																		
floodplain at Libiš pool (end) (LN6)				X														
floodplain at Libiš catchwater (LN8)				XX														
floodplain at oxbow lake Starého Labe by Obříství (ON1)																		

Contamination		low		middle		high	X	significant	XX	extreme	Grade of remobilisation risk	1	2	3	4	5	6	7
Volume (m^3)	<10 000	small	10000 - 50000	middle	>50 000	large	Complex risk of locality significance				insignificant		low		middle	X	high	

Highest complex risk of locality significance:

- winter harbour PARAMO: extreme contamination, risk of remobilisation, middle volume
- oxbow lake Staré Labe by Obříství: high-significant contamination, risk of remobilisation, large volume

Lowest complex risk of locality significance:

- floodplain sediments (low contamination, remobilisation restricted with vegetation)
- Libiš catchwater (significant-extreme pollution, remobilised sediment does not reach the Elbe River

Thank you for your attention!

Vielen Dank für Ihre Aufmerksamkeit!