

APPENDIX PART C: PRESENT AND FUTURE QUALITY OF SEDIMENTS IN THE RHINE CATCHMENT AREA - PAHs, PCBs

Chapter 1: Introduction

1.1 Individual PAHs and sum parameters

<i>individual PAHs</i>		<i>sum 6</i>	<i>sum 10</i>	<i>sum 16</i>
naphtalene			X	X
acenaphtalene				X
acenaphtene				X
fluorene				X
phenanthrene			X	X
anthracene			X	X
fluoranthene	Fl	X	X	X
pyrene				X
benz(a)anthracene			X	X
chrysene			X	X
benzo(b)fluoranthene	BbFl	X		X
benzo(k)fluoranthene	BkFl	X	X	X
benzo(a)pyrene	BaP	X	X	X
dibenz(ah)anthracene				X
benzo(ghi)perylene	BghiPe	X	X	X
indeno(1,2,3-cd)pyrene	Ind	X	X	X

sum 6 PAHs: also referred to as Borneff PAHs, most often used in German monitoring programmes and regulations

sum 10 PAHs: also referred to as VROM PAHs in Dutch regulations

sum 12 PAHs: also referred to as US-EPA PAHs

Chapter 3: Modelling of point and diffuse sources in the Rhine catchment area

3.1.2a PAH concentrations in influents and effluents of municipal wastewater treatment plants (LAU Hessen, 1989)

<i>n</i> =12		FI		BbFI		BkFI		BaP		BghiPe		Ind	
		1985 ng/L	1988 ng/L	1985 ng/L	1988 ng/L	1985 ng/L	1988 ng/L	1985 ng/L	1988 ng/L	1985 ng/L	1988 ng/L	1985 ng/L	1988 ng/L
influent	min	18	31	2	14	< 2	4	< 2	7	3	< 2	< 2	< 2
	25-percentile	52	97	18	28	2	14	2.8	27	5.5	< 2	4.8	< 2
	median	105	115	24	51	8.5	21	12	43	32	< 2	15	< 2
	75-percentile	180	188	51	76	23	34	21	69	82	2.8	29	< 2
	max	610	410	140	200	60	61	86	130	230	19.0	61	< 2
effluent	min	3	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
	25-percentile	6.5	9	2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
	median	11	15	3.5	< 2	1.5	< 2	< 2	< 2	2	< 2	< 2	< 2
	75-percentile	16	22	10	< 2	3	< 2	6.3	< 2	4.3	< 2	2	< 2
	max	88	190	31	< 2	5	3	8	3	13	< 2	8	< 2

FI - fluoranthene, BbFI- benzo(b)fluoranthene, BkFI - benzo(k)fluoranthene,
BaP - benzo(a)pyrene, BghiPe - benzo(ghi)perylene, Ind - indeno(1,2,3-cd)pyrene

3.1.2b PCB concentrations in influents and effluents of municipal wastewater treatment plants (LAU Hessen, 1989)

<i>n</i> =12		PCB 28 ng/L	PCB 52 ng/L	PCB 101 ng/L	PCB 138 ng/L	PCB 153 ng/L	PCB 180 ng/L
influent	min	< 5-50	< 10-50	< 10	< 10	< 10	< 10
	25-percentile	< 5-50	< 10-50	< 10	10	8	< 10
	median	< 5-50	< 10-50	< 10	14	20	< 10
	75-percentile	< 5-50	< 10-50	11	18	27	3
	max	< 5-50	16	20	60	80	30
effluent	min	< 5-50	< 2	< 1	< 1	< 1	< 1
	25-percentile	< 5-50	< 2	< 1	< 1	< 1	< 1
	median	< 5-50	< 2	< 1	< 1	< 1	< 1
	75-percentile	< 5-50	< 2	< 1	0.3	< 1	< 1
	max	< 5-50	< 2	< 1	1	< 1	< 1

3.1.2c PAH concentrations in sewage sludge of 53 WWTPs in Germany, 1994-1995
(UBA , 1998b)

<i>n</i> = 53	FI mg/kg dw	BbFI + BkFI mg/kg dw	BaP mg/kg dw	sum 6 PAHs mg/kg dw	sum 16 PAHs mg/kg dw
min	0.12	0.08	0.09	0.6	1.0
median	1.0	0.37	0.35	2.5	6.1
max	4.3	2.1	3.4	12.5	25.6

3.1.2d PAH concentrations in sewage sludge of 29 WWTPs located at the Rhine, 1994-1995 (Vedewa, 2000)

<i>n</i> = 29	FI mg/kg dw	BbFI + BkFI mg/kg dw	BaP mg/kg dw
min	0.12	0.1	0.09
25-percentile	0.74	0.24	0.18
median	0.98	0.37	0.35
75-percentile	1.3	0.51	0.6
max	4.3	2.1	3.4

3.1.2e PCB concentrations in sewage sludge from 11 WWTPs in Hessen, Germany, 1988
(LAU Hessen, 1989)

<i>n</i> =11	PCB 28 µg/kg dw	PCB 52 µg/kg dw	PCB 101 µg/kg dw	PCB 138 µg/kg dw	PCB 153 µg/kg dw	PCB 180 µg/kg dw
min	<3-5	<3-5	9	20	14	11
25-percentile	16	16	17	48	28	22
median	20	17	30	60	45	30
75-percentile	25	20	43	78	60	43
max	55	30	50	110	85	60

3.1.3a Atmospheric deposition of benzo(b)fluoranthene in Germany (Pacyna, 1999)

	NILU-EMEP Zingst Jan-Dec 95 <i>n</i> =10 ng/(m ² *day)	McLachlan Zingst Oct 95 - Mar 96 <i>n</i> =6 ng/(m ² *day)	McLachlan Berlin Oct 95 - Mar 96 <i>n</i> =6 ng/(m ² *day)	McLachlan Bayreuth Oct 94 - Apr 96 <i>n</i> =13 ng/(m ² *day)
min	0.7	28	152	22.7
mean	9.0	64	370	52.7
max	50.9	130	663	103.3

3.1.3b Atmospheric deposition of benzo(a)pyrene in Germany (Pacyna, 1999)

	NILU-EMEP Zingst Jan-Dec 95 <i>n</i> =8 ng/(m ² *day)	McLachlan Zingst Oct 95 - Mar 96 <i>n</i> =6 ng/(m ² *day)	McLachlan Berlin Oct 95 - Mar 96 <i>n</i> =4 ng/(m ² *day)	McLachlan Bayreuth Oct 94 - Apr 96 <i>n</i> =13 ng/(m ² *day)
min	0.8	13.5	152	8.3
mean	6.8	23.9	315	21.1
max	35.6	40.0	663	40.0

3.1.3c PCB pattern in atmospheric deposition, re-calculated from data for Sweden and Finland (Pacyna, 1999)

PCB	28	52	101	138	153	180
% of Σ 6	15	14	13	23	20	15

3.1.4a Benzo(a)pyrene concentrations in top soils in Germany

<i>Land use: agriculture (crops etc.), density of population: rural regions or not specified</i>							
	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw
<i>land use</i>	C	C	C+P	C	C	C	C
<i>populat. density</i>	III	III	III		III		III
<i>State</i>	Nordrhein- Westfalen	Nieder- sachsen	Bayern	Branden- burg	Sachsen	Thüringen	Saarland
<i>reference</i>	NRW 1993	NS 1996	GLA 1994	Brand 1995	Sachs 1997	Thür 1996	Saar 1999
<i>no. of samples</i>	<i>n</i> =94	<i>n</i> =84	<i>n</i> =53	<i>n</i> =162	<i>n</i> =306	<i>n</i> =63	
<i>50 percentile</i>	25	7	8	10	<10	18	14
<i>90 percentile</i>	70	20	49	36	28	91	29
<i>Land use: agriculture (crops etc. or not specified), density of population: medium to high</i>							
	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw	BaP µg/kg dw
<i>land use</i>	C	C	C			A	C
<i>populat. density</i>	II	I	I-II	I	II		I
<i>State</i>	Nordrhein- Westfalen	Nieder- sachsen	Bayern	Hamburg	Hamburg	Hamburg	Sachsen
<i>reference</i>	NRW 1993	NS 1996	GLA 1994	HH 1996	HH 1996	HH 1996	Sachs 1997
<i>no. of samples</i>	<i>n</i> =238	<i>n</i> =20	<i>n</i> =44	<i>n</i> =90	<i>n</i> =18	<i>n</i> =21	<i>n</i> =68
<i>50 percentile</i>	60	27	23	360	30	90	19
<i>90 percentile</i>	260	57	142	1260	160	310	80
<i>Land use: A - agriculture (not specified), C - crops etc., P - pasture</i>							
<i>Population density: I - high density, II - medium density, III - rural</i>							

3.1.4b PCB concentrations in top soils in Germany

<i>Land use: agriculture (crops etc.), density of population: rural regions or not specified</i>								
	PCBs sum 6 µg/kg dw	PCBs sum 6 µg/kg dw	PCBs sum 6 µg/kg dw	PCBs sum 6 ? µg/kg dw	PCBs sum 6 µg/kg dw	PCBs sum 6 µg/kg dw	PCBs sum 6 µg/kg dw	PCBs sum 7 µg/kg dw
<i>land use</i>	C	C (vineyards)	C	C	C	C	C	C
<i>poluat. density</i>			III	III	III	III		III
<i>State</i>	Rheinland-Pfalz	Rheinland-Pfalz	Baden-Württemberg	Nordrhein-Westfalen	Saarland	Niedersachsen	Brandenburg	Thüringen
<i>reference</i>	RLP 1996	RLP 1996	BW 1997	NRW 1993	Saar 1999	NS 1996	Brand 1995	Thür 1996
<i>no. of samples</i>	n=102	n=26	n=58	n=41		n=88	n=188	n=63
<i>50 percentile</i>	<1	4	-	4.5	-	<2	<1	-
<i>90 percentile</i>	12	23	7	10.1	11	2	<1	3

<i>Land use: agriculture (crops etc. or pasture), density of population: medium to high</i>						
	PCBs sum 6 ? µg/kg dw	PCBs sum 6 ? µg/kg dw	PCBs sum 6 µg/kg dw	PCBs sum 6 µg/kg dw	PCBs sum 6 µg/kg dw	PCBs sum 6 µg/kg dw
<i>land use</i>	C	P	C	C	P	C
<i>poluat. density</i>	I	I	I-II	I-III	I-III	I
<i>State</i>	Nordrhein-Westfalen	Nordrhein-Westfalen	Saarland	Bayern	Bayern	Niedersachsen
<i>reference</i>	NRW 1993	NRW 1993	Saar 1999	GLA 1994	GLA 1994	NS 1996
<i>no. of samples</i>	n=61	n=28		n = 76	n = 60	n = 16
<i>50 percentile</i>	6.5	4.3	1	20	-	<2
<i>90 percentile</i>	43.8	12.6	20	154	50	16

Land use: A - agriculture (not specified), C - crops etc., P - pasture
Population density: I - high density, II - medium density, III - rural

3.1.4c PCB pattern in agricultural top soils in the Netherlands, re-calculated from data from RIVM (1995)

PCB	28	52	101	138	153	180
% of Σ 6	10	8	18	24	24	14

3.2a Results of emission analysis for fluoranthene (present state, *BAU* and *Green* scenarios).
 Loads according to pathways/processes at selected stations along the Rhine and its
 tributaries

Fluoranthene loads / kg·yr ⁻¹	pathway/ process	Rhine	Neckar	Main	Rhine	Rhine	Mosel	Rhine	Rhine
		Lauter- bourg	Mann- heim	Bischofs- heim	Mainz	Koblenz	Koblenz	Bad Honnet	Bimmen/ Lobith
<i>Present</i>	urban area	548	169	233	1060	1159	277	1458	2025
<i>BAU</i>	urban area	493	152	210	954	1043	249	1313	1822
<i>GREEN</i>	urban area	400	143	192	829	909	201	1129	1565
<i>Present</i>	erosion	120	28	77	235	252	31	285	300
<i>BAU</i>	erosion	120	28	77	235	252	31	285	300
<i>GREEN</i>	erosion	102	21	57	189	201	23	226	237
<i>Present</i>	atm. dep.	92	3	9	108	113	15	130	141
<i>BAU</i>	atm. dep.	83	3	8	98	102	13	117	127
<i>GREEN</i>	atm. dep.	74	3	7	87	91	12	104	113
<i>Present</i>	WWTPs	23	25	31	96	109	12	123	169
<i>BAU</i>	WWTPs	21	22	28	87	98	11	111	152
<i>GREEN</i>	WWTPs	13	14	18	55	62	7	70	96
<i>Present</i>	shipping	129	75	88	340	374	41	423	600
<i>BAU</i>	shipping	97	56	66	255	281	31	317	450
<i>GREEN</i>	shipping	65	37	44	170	187	20	211	300
<i>Present</i>	total	913	299	438	1840	2007	375	2419	3235
<i>BAU</i>	total	814	261	389	1629	1775	334	2142	2851
<i>GREEN</i>	total	654	217	319	1329	1450	263	1740	2312

Present: present state (1994-1996)

BAU: 'business as usual' scenario until 2015

GREEN: 'green environment' scenario until 2015

urban area: paved urban areas

erosion: erosion from top soils

atm. dep.: direct atmospheric deposition to surface waters

WWTPs: wastewater treatment plants

shipping: shipping related activities

3.2b Results of emission analysis for benzo(b)fluoranthene (present state, *BAU* and *Green* scenarios). Loads according to pathways/processes at selected stations along the Rhine and its tributaries

Benzo(b)fluoranthene loads / kg·yr ⁻¹	pathway/ process	Rhine	Neckar	Main	Rhine	Rhine	Mosel	Rhine	Rhine	Rhine
		Lauterbourg	Mannheim	Bischofsheim	Mainz	Koblenz	Koblenz	Koblenz	Bad Honner	Bimmen/Lobith
Present	urban area	202	62	86	391	428	102	538	747	
BAU	urban area	182	56	77	352	385	92	484	672	
GREEN	urban area	148	53	71	306	336	74	417	578	
Present	erosion	133	31	85	261	280	34	317	333	
BAU	erosion	133	31	85	261	280	34	317	333	
GREEN	erosion	114	23	64	210	223	26	251	264	
Present	atm. dep.	35	1	3	41	43	6	49	54	
BAU	atm. dep.	32	1	3	37	39	5	44	48	
GREEN	atm. dep.	28	1	3	33	34	4	39	43	
Present	WWTPs	9	9	12	36	40	4	46	62	
BAU	WWTPs	8	8	10	32	36	4	41	56	
GREEN	WWTPs	5	5	7	20	23	2	26	36	
Present	shipping	129	75	88	340	374	41	423	600	
BAU	shipping	97	56	66	255	281	31	317	450	
GREEN	shipping	65	37	44	170	187	20	211	300	
Present	total	509	178	274	1069	1165	187	1372	1796	
BAU	total	452	152	242	937	1020	166	1203	1560	
GREEN	total	359	119	188	739	803	127	944	1220	

Present: present state (1994-1996)

BAU: 'business as usual' scenario until 2015

GREEN: 'green environment' scenario until 2015

urban area: paved urban areas

erosion: erosion from top soils

atm. dep.: direct atmospheric deposition to surface waters

WWTPs: wastewater treatment plants

shipping: shipping related activities

3.2c Results of emission analysis for benzo(a)pyrene (present state, *BAU* and *Green* scenarios). Loads according to pathways/processes at selected stations along the Rhine and its tributaries

Benzo(a)pyrene loads / kg·yr⁻¹	pathway/process	Rhine Lauterbourg	Neckar Mannheim	Main Bischofsheim	Rhine Mainz	Rhine Koblenz	Mosel Koblenz	Rhine Bad Honnet	Rhine Bimmen/Lobith
<i>Present</i>	urban area	196	60	83	379	414	99	521	723
<i>BAU</i>	urban area	176	54	75	341	373	89	469	651
<i>GREEN</i>	urban area	141	50	62	283	309	64	379	527
<i>Present</i>	erosion	67	15	43	131	140	17	158	167
<i>BAU</i>	erosion	67	15	43	131	140	17	158	167
<i>GREEN</i>	erosion	57	12	32	105	112	13	126	132
<i>Present</i>	atm. dep.	33	1	3	39	41	5	47	51
<i>BAU</i>	atm. dep.	30	1	3	35	37	5	42	46
<i>GREEN</i>	atm. dep.	27	1	2	31	33	4	38	41
<i>Present</i>	WWTPs	8	9	11	34	39	4	44	60
<i>BAU</i>	WWTPs	7	8	10	31	35	4	40	54
<i>GREEN</i>	WWTPs	5	5	7	21	23	3	27	37
<i>Present</i>	shipping	86	50	59	227	249	27	282	400
<i>BAU</i>	shipping	65	37	44	170	187	20	211	300
<i>GREEN</i>	shipping	43	25	29	113	125	14	141	200
<i>Present</i>	total	390	135	199	810	883	153	1052	1401
<i>BAU</i>	total	345	116	175	708	771	135	920	1218
<i>GREEN</i>	total	273	92	132	554	601	98	710	937

Present: present state (1994-1996)

BAU: 'business as usual' scenario until 2015

GREEN: 'green environment' scenario until 2015

urban area: paved urban areas

erosion: erosion from top soils

atm. dep.: direct atmospheric deposition to surface waters

WWTPs: wastewater treatment plants

shipping: shipping related activities

3.2d Results of emission analysis for PCB 52 (present state, *BAU* and *Green* scenarios). Loads according to pathways/processes at selected stations along the Rhine and its tributaries

PCB 52 loads / kg·yr ⁻¹	pathway/ process	Rhine		Neckar		Main		Rhine		Mosel		Rhine		Rhine	
		Lauter- bourg	Mann- heim	Bischofs- heim	Mainz	Koblenz	Koblenz	Koblenz	Bad Honner	Bimmen/ Lobith					
Present	urban area	1.45	0.46	0.59	2.79	3.04	0.70	3.80	5.29						
BAU	urban area	0.97	0.31	0.39	1.86	2.03	0.47	2.54	3.54						
GREEN	urban area	0.45	0.16	0.18	0.88	0.95	0.19	1.15	1.61						
Present	erosion	0.53	0.12	0.34	1.05	1.12	0.14	1.27	1.33						
BAU	erosion	0.53	0.12	0.34	1.05	1.12	0.14	1.27	1.33						
GREEN	erosion	0.45	0.09	0.26	0.84	0.89	0.10	1.00	1.05						
Present	atm. dep.	3.68	0.13	0.34	4.33	4.52	0.58	5.17	5.64						
BAU	atm. dep.	2.43	0.09	0.23	2.86	2.98	0.39	3.41	3.72						
GREEN	atm. dep.	1.21	0.04	0.11	1.43	1.49	0.19	1.71	1.86						
Present	WWTPs	0.54	0.35	0.43	1.55	1.72	0.18	1.94	2.74						
BAU	WWTPs	0.40	0.26	0.31	1.14	1.26	0.14	1.43	2.02						
GREEN	WWTPs	0.26	0.16	0.20	0.72	0.79	0.09	0.90	1.27						
Present	total	6.20	1.07	1.70	9.71	10.39	1.61	12.17	15.00						
BAU	total	4.33	0.78	1.28	6.91	7.40	1.13	8.64	10.60						
GREEN	total	2.37	0.46	0.74	3.86	4.13	0.57	4.76	5.79						

Present: present state (1994-1996)

BAU: 'business as usual' scenario until 2015

GREEN: 'green environment' scenario until 2015

urban area: paved urban areas

erosion: erosion from top soils

atm. dep.: direct atmospheric deposition to surface waters

WWTPs: wastewater treatment plants

shipping: shipping related activities

3.2e Results of emission analysis for PCB 138 (present state, *BAU* and *Green* scenarios). Loads according to pathways/processes at selected stations along the Rhine and its tributaries

PCB 138 loads / kg·yr ⁻¹	pathway/ process	Rhine	Neckar	Main	Rhine	Rhine	Mosel	Rhine	Rhine
		Lauter- bourg	Mann- heim	Bischofs- heim	Mainz	Koblenz	Koblenz	Koblenz	Bad Honner
<i>Present</i>	urban area	2.78	0.91	1.09	5.29	5.76	1.29	7.15	10.00
<i>BAU</i>	urban area	1.88	0.62	0.73	3.58	3.90	0.86	4.83	6.76
<i>GREEN</i>	urban area	0.88	0.32	0.33	1.69	1.83	0.34	2.20	3.08
<i>Present</i>	erosion	1.60	0.37	1.02	3.14	3.35	0.41	3.80	4.00
<i>BAU</i>	erosion	1.60	0.37	1.02	3.14	3.35	0.41	3.80	4.00
<i>GREEN</i>	erosion	1.36	0.28	0.77	2.51	2.68	0.31	3.01	3.16
<i>Present</i>	atm. dep.	6.26	0.22	0.59	7.37	7.70	0.99	8.81	9.60
<i>BAU</i>	atm. dep.	4.13	0.15	0.39	4.87	5.08	0.66	5.81	6.34
<i>GREEN</i>	atm. dep.	2.07	0.07	0.19	2.43	2.54	0.33	2.91	3.17
<i>Present</i>	WWTPs	0.96	0.60	0.72	2.67	2.95	0.32	3.33	4.72
<i>BAU</i>	WWTPs	0.71	0.45	0.54	1.99	2.20	0.24	2.48	3.51
<i>GREEN</i>	WWTPs	0.47	0.29	0.35	1.29	1.42	0.16	1.61	2.28
<i>Present</i>	total	11.60	2.10	3.42	18.48	19.77	3.01	23.09	28.32
<i>BAU</i>	total	8.33	1.58	2.68	13.57	14.53	2.17	16.92	20.61
<i>GREEN</i>	total	4.78	0.96	1.63	7.93	8.47	1.13	9.73	11.69

Present: present state (1994-1996)

BAU: 'business as usual' scenario until 2015

GREEN: 'green environment' scenario until 2015

urban area: paved urban areas

erosion: erosion from top soils

atm. dep.: direct atmospheric deposition to surface waters

WWTPs: wastewater treatment plants

shipping: shipping related activities

3.2f Results of emission analysis for PCB 180 (present state, *BAU* and *Green* scenarios). Loads according to pathways/processes at selected stations along the Rhine and its tributaries

PCB 180 loads / kg·yr ⁻¹	Rhine		Neckar		Main		Rhine		Mosel		Rhine	
	Lauter- bourg	Mann- heim	Bischofs- heim	Mainz	Koblenz	Koblenz	Koblenz	Bad Honnet	Bimmen/ Lobith			
pathway/ process												
Present	urban area	1.73	0.56	0.69	3.30	3.59	0.81	4.47	6.25			
BAU	urban area	1.16	0.38	0.46	2.22	2.42	0.54	3.01	4.21			
GREEN	urban area	0.54	0.20	0.21	1.05	1.13	0.22	1.37	1.92			
Present	erosion	0.93	0.22	0.60	1.83	1.96	0.24	2.22	2.33			
BAU	erosion	0.93	0.22	0.60	1.83	1.96	0.24	2.22	2.33			
GREEN	erosion	0.80	0.16	0.45	1.47	1.56	0.18	1.76	1.84			
Present	atm. dep.	4.09	0.14	0.38	4.81	5.02	0.65	5.74	6.26			
BAU	atm. dep.	2.70	0.10	0.25	3.17	3.32	0.43	3.79	4.13			
GREEN	atm. dep.	1.35	0.05	0.13	1.59	1.66	0.21	1.90	2.07			
Present	WWTPs	0.49	0.31	0.37	1.37	1.51	0.16	1.70	2.41			
BAU	WWTPs	0.36	0.23	0.28	1.01	1.12	0.12	1.26	1.79			
GREEN	WWTPs	0.23	0.15	0.18	0.65	0.72	0.08	0.81	1.15			
Present	total	7.23	1.23	2.04	11.30	12.08	1.86	14.14	17.25			
BAU	total	5.16	0.92	1.58	8.24	8.81	1.33	10.28	12.46			
GREEN	total	2.92	0.55	0.96	4.75	5.07	0.69	5.84	6.98			

Present: present state (1994-1996)

BAU: 'business as usual' scenario until 2015

GREEN: 'green environment' scenario until 2015

urban area: paved urban areas

erosion: erosion from top soils

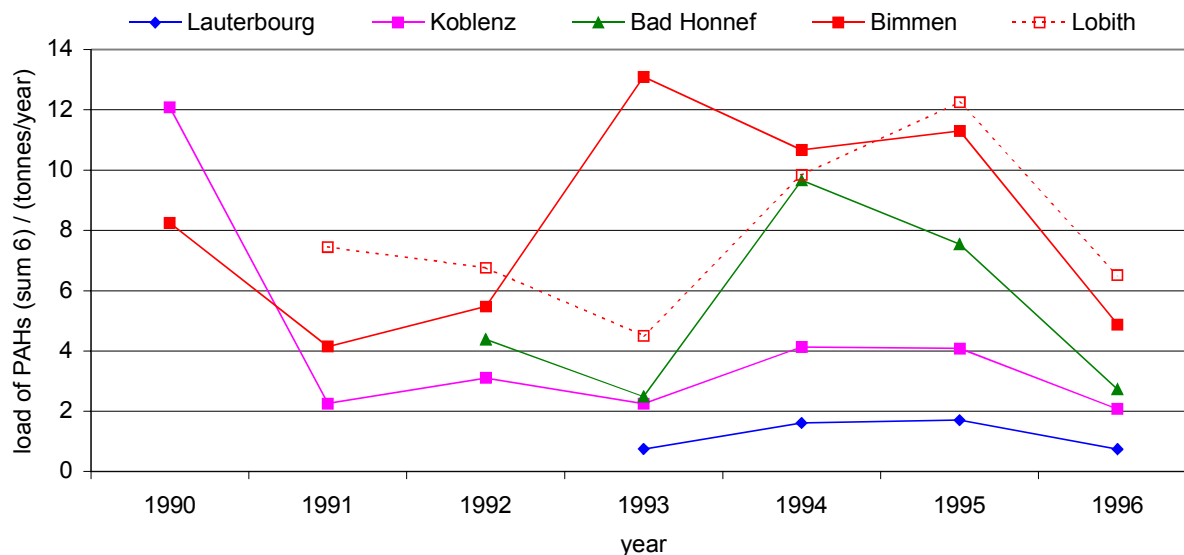
atm. dep.: direct atmospheric deposition to surface waters

WWTPs: wastewater treatment plants

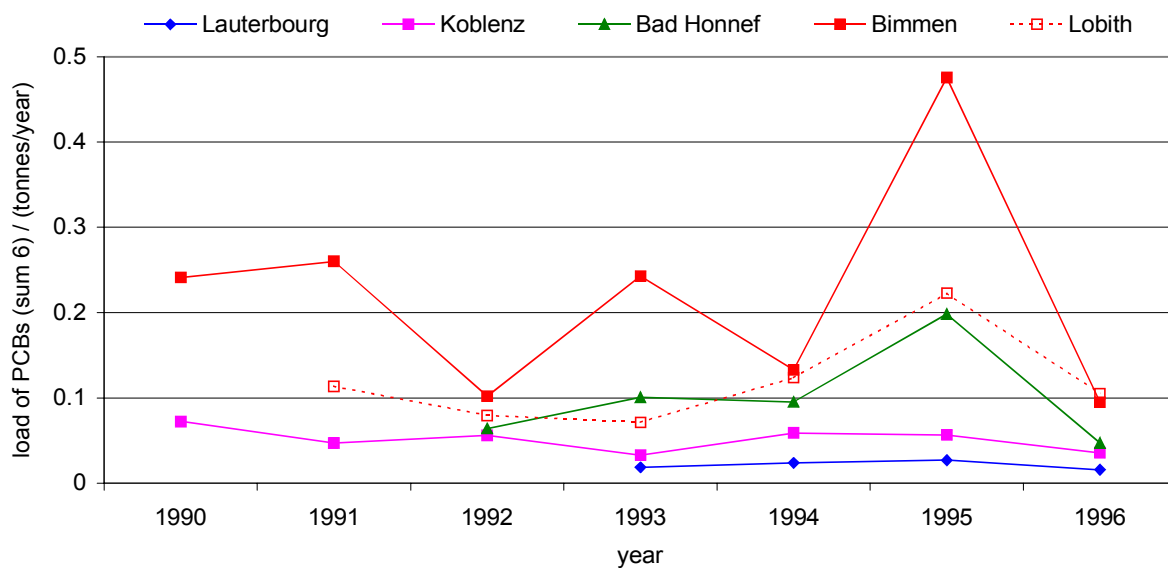
shipping: shipping related activities

Chapter 4: Trends in the quality of suspended particulate matter in the Rhine and link to the quality of dredged material in Rotterdam

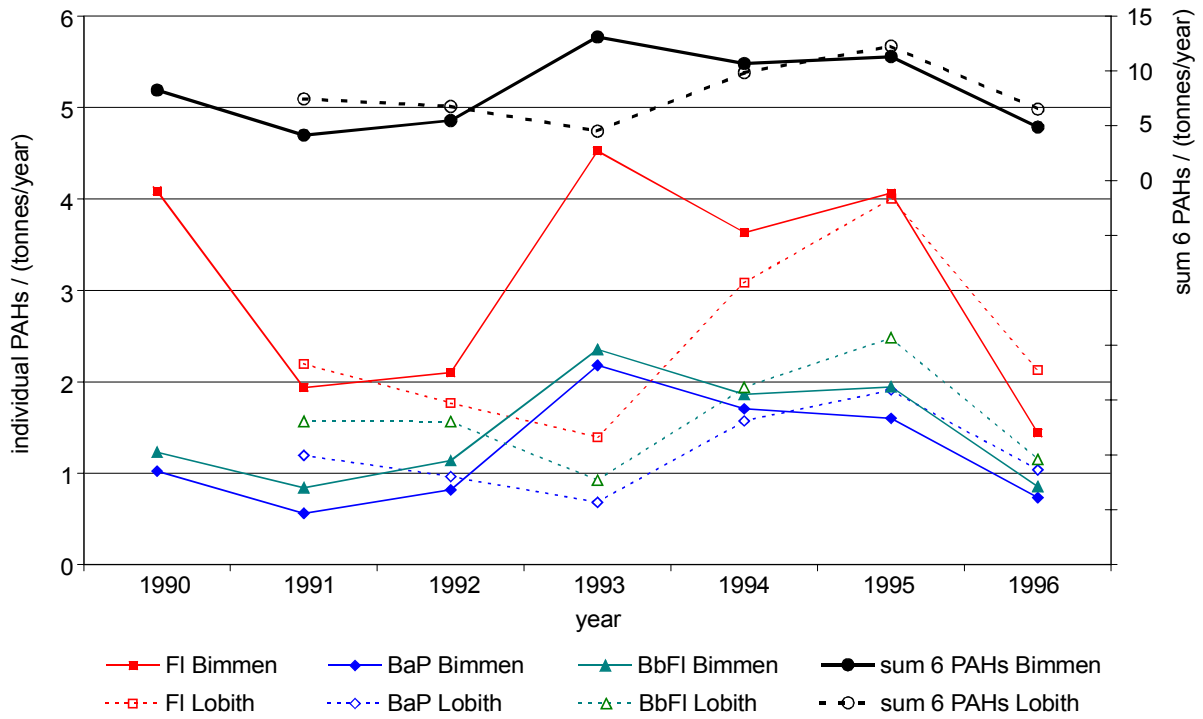
4.1a Annual loads of sum 6 PAHs along the Rhine river



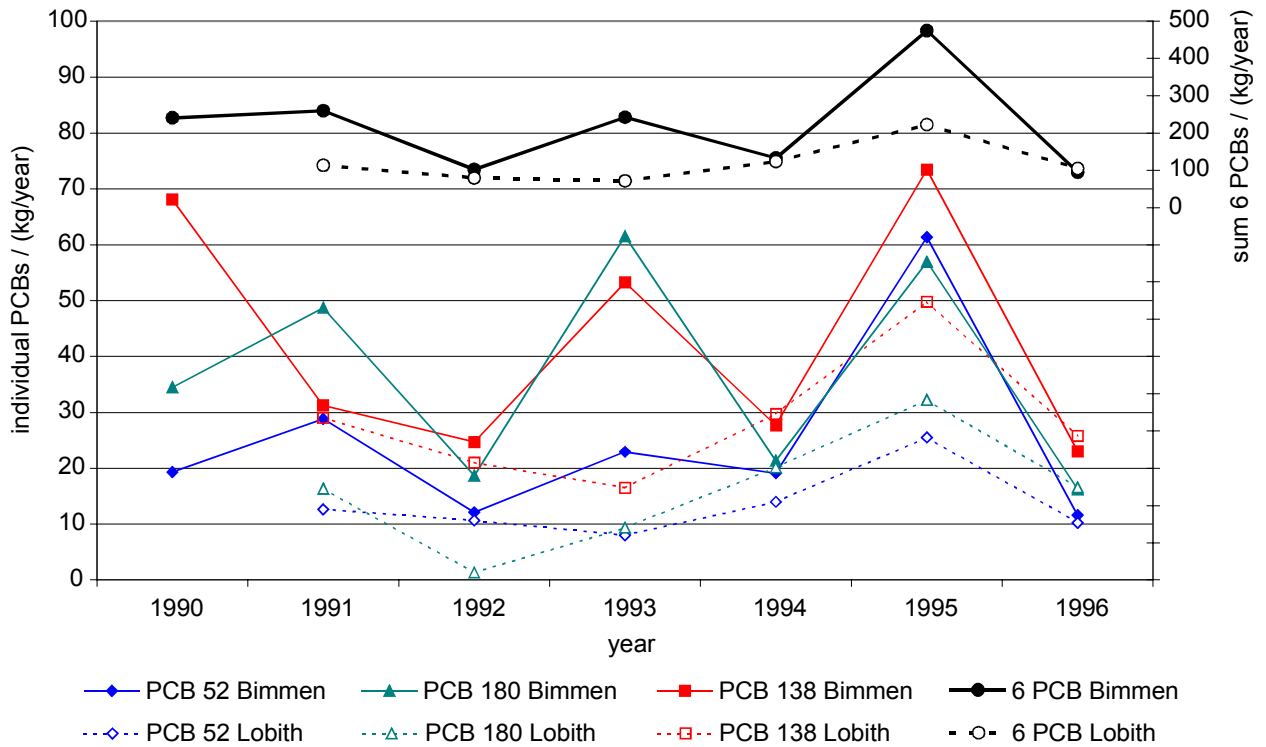
4.1b Annual loads of sum 6 PCBs along the Rhine river



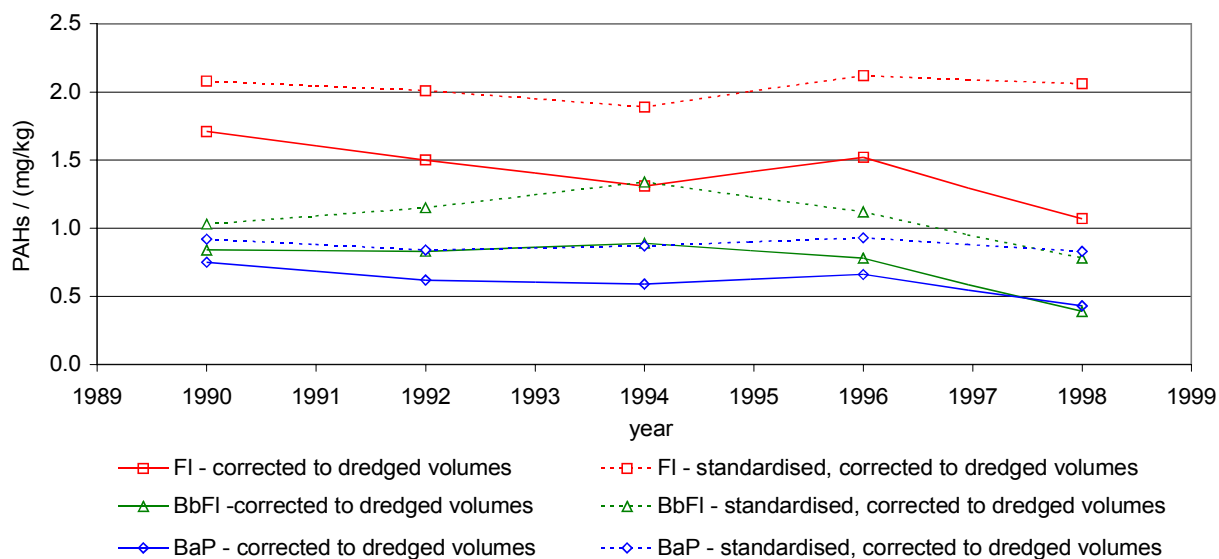
4.1c Annual loads of individual PAHs in comparison to sum 6 PAHs at Bimmen and Lobith



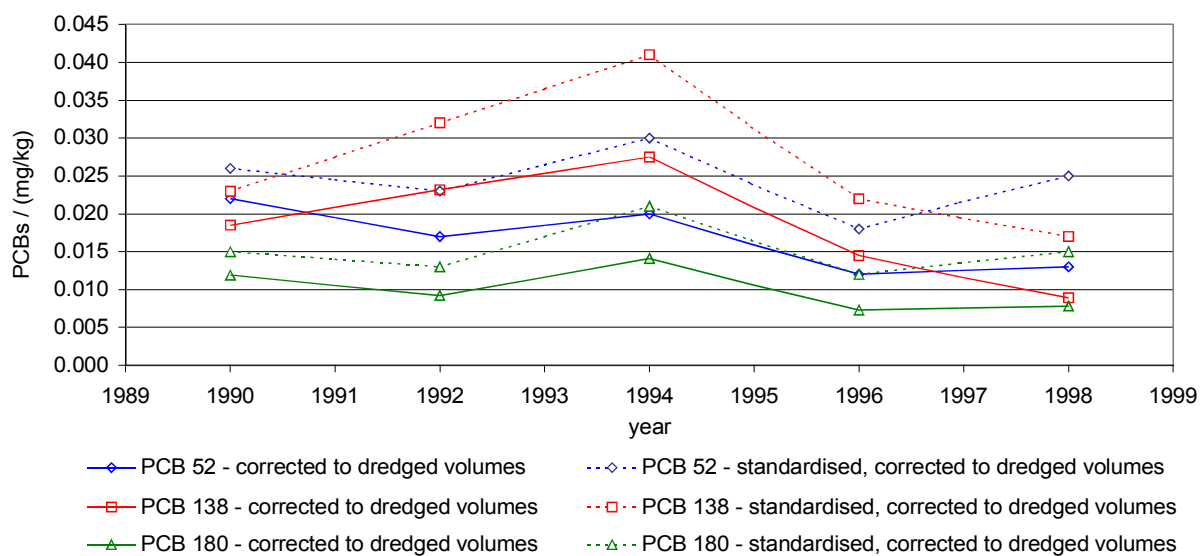
4.1d Annual loads of individual PCBs in comparison to sum 6 PCBs at Bimmen and Lobith



4.2a Averaged annual PAH concentrations in eastern parts of the port of Rotterdam



4.2b Averaged annual PCB concentrations in eastern parts of the port of Rotterdam



Chapter 5: Scenarios of future development in the Rhine catchment area and impact on dredged material quality in Rotterdam

5.1.a Estimated benzo(a)pyrene emissions to air for Germany 1994 and reduction potentials (adapted from UBA 1998a)

	1994		est. reduced emissions BaP t/yr	absolute reduct.pot. BaP %	relative reduct. pot. BaP %
	estimated emissions BaP t/yr	estimated emissions BaP %			
Total	14	100	10	28	100
Stationary combustion	9.3	68	7.8	16	41
Publ. power, cogen. & district heating	0.0056	0.04	0.0056	0	0
Public power etc. brown coal	0.0003		0.0003		
Public power etc. hard coal	0.00026		0.00026		
Public power etc. fuel oils	0.0050	0.04	0.0050		
Public power etc. other fuels	0.000075		0.000075		
Comm. instit. & resid. combustion	9.3	68	7.8	17	41
Commercial etc. brown coal	3.3	24	2.9	12	
Commercial etc. hard coal	0.69	5.0	0.61	12	
Commercial etc. fuel oils	3.4	25	2.8	16	
Commercial etc. other fuels	1.9	14	1.4	26	
Industrial combustion	0.028	0.2	0.028	0	0
Industrial combustion brown coal	0.0022		0.0022		
Industrial combustion hard coal	0.0057		0.0057		
Industrial combustion fuel oils	0.017	0.13	0.017		
Industrial combustion other fuels	0.0026		0.0026		
Production processes	3.98	29	1.99	50	52
Petroleum industries	n.q.				
Iron & steel industry					
Coke production	1.1	7.9	0.15	87	25
Electric arc furnace					
Production process	0.031		0.031		
Electrode production	0.23		0.23		
Sinter plants	0.053		0.0018	97	1.3
Non-ferrous metal industry					
Al industry					
Anode production	2.0	15	1.00	50	26
Primary Al production	0.58	4.2	0.58		
Organic chemical industry	n.q.				
Paper and pulp industry	n.q.				
Road paving with asphalt	n.q.				
Extraction & distribution of fossil fuels	n.q. 1)				
Solvent use	0.16	1.1	0.016	90	3.7
Wood preservation					
Production process	0.1		0.006	94	
Use	0.057		0.01	82	
Road transport	0.27	1.9	0.13	50	3.5
Other mobile sources & machinery	1)				
Waste treatment & disposal	0.0078	0.06	0.0078	0	0
Waste incineration	n.q.				
Landfill	0.0078		0.0078		

n.q.: not quantified, 1) low relative emissions estimated

5.1.b Comparison of estimated benzo(a)pyrene emissions to air – Germany, the Netherlands, Europe

<i>Estimated emissions for: country / countries</i>	GER		NL		EUR (25)	
<i>Estimated emissions for: year</i>	1994		1990		1990	
<i>Reference</i>	UBA 1998a		TNO 1995		TNO 1995	
	BaP		BaP ¹⁾		BaP ¹⁾	
	t/yr	%	t/yr	%	t/yr	%
Total	14	100	14.1	100	1138	100
Stationary combustion	9.3	68	3.3	23	425	37
Publ. power, cogen. & district heating	0.0056	0.04	0.065	0.46	1.0	0.09
Public power etc. brown coal	0.0003					
Public power etc. hard coal	0.00026					
Public power etc. fuel oils	0.0050	0.04				
Public power etc. other fuels	0.000075					
Comm. instit. & resid. Combustion	9.3	68	3.2	23	424	37
Commercial etc. brown coal	3.3	24				
Commercial etc. hard coal	0.69	5.0				
Commercial etc. fuel oils	3.4	25				
Commercial etc. other fuels	1.9	14				
Industrial combustion	0.028	0.2				
Industrial combustion brown coal	0.0022					
Industrial combustion hard coal	0.0057					
Industrial combustion fuel oils	0.017	0.13				
Industrial combustion other fuels	0.0026					
Production processes	3.98	29	2.4	17	235	21
Petroleum industries						
Iron & steel industry	1.4	10	2.1	15	117	10
Coke production	1.1	7.9				
Electric arc furnace						
Production process	0.031					
Electrode production	0.23					
Sinter plants	0.053					
Non-ferrous metal industry	2.6	19	0.33	2.3	118	10
Al industry						
Anode production	2.0	15				
Primary Al production	0.58	4.2				
Organic chemical industry						
Paper and pulp industry						
Road paving with asphalt						
Extraction & distribution of fossil fuels						
Solvent use	0.16	1.1	8	57	426	37
Wood preservation			8		426	
Production process	0.1					
Use	0.057					
Road transport	0.27	1.9	0.42	3.0	52	4.6
Other mobile sources & machinery						
Waste treatment & disposal	0.0078	0.06				
Waste incineration						
Landfill	0.0078					

GER: Germany, NL: The Netherlands, EUR (25): 25 European countries

1) The estimated emissions from publ. power, cogen. & district heating include industrial combustion.

5.1.c Estimated PCB emissions to air in Germany

<i>Estimated emissions for: year</i>	1990	1980	1990	2000
<i>Reference</i>	UBA 1997	RIVM 1995	RIVM 1995	RIVM 1995
	PCBs ¹⁾	PCBs ²⁾	PCBs ²⁾	PCBs ²⁾
	t/yr	t/yr	t/yr	t/yr
Total	43	170	44	19
Stationary combustion	1.6	1.5	1.5	1.5
Publ. power, cogen. & district heating	0.94	1.2	1.2	1.2
Public power etc. brown coal	0.78			
Public power etc. hard coal	0.15			
Public power etc. fuel oils	0			
Public power etc. other fuels	0.009			
Comm. instit. & resid. combustion	0.14	0.26	0.26	0.26
Commercial etc. brown coal	0.13			
Commercial etc. hard coal	0.010			
Commercial etc. fuel oils	0			
Commercial etc. other fuels	0			
Industrial combustion	0.50			
Industrial combustion brown coal	0.31			
Industrial combustion hard coal	0.18			
Industrial combustion fuel oils	0			
Industrial combustion other fuels	0.0010			
Production processes	0.29	0.29	0.29	0.29
Iron & steel industry				
Coke production		0.15	0.15	0.15
Open hearth furnace	0.015			
Basic oxygen furnace	0.13			
Sinter plants	0.15	0.14	0.14	0.14
Road transport				
Waste treatment & disposal		0.033	0.033	0.033
Waste incineration		0.032	0.032	0.032
Landfill		0.0008	0.0008	0.0008
Open uses		116		
Electrical equipment	41	52	41	17
Transformers		1.9	1.9	0.90
Large capacitors		33	33	16
Small capacitors		16	6.2	
Re-emission from soil		0.062	0.062	0.062
Re-emission from water		0.57	0.57	0.57

1) Data included as submitted by Germany for 1985-90, but most data incl. electrical equipm. estimated by TNO.

2) The estimated emissions from publ. power, cogen. & district heating include industrial combustion.

5.1.d Comparison of estimated PCB emissions to air - Germany, the Netherlands, Europe

<i>Estimated emissions for: country / countries</i>	GER	NL	EUR (25)	EUR (38)	GER	NL	EUR (25)
<i>Estimated emissions for: year</i>	1990	1990	1990	1990	2000	2000	2000
<i>Reference</i>	RIVM 1995	RIVM 1995	RIVM 1995	UBA 1997	RIVM 1995	RIVM 1995	RIVM 1995
	PCBs ²⁾	PCBs ²⁾	PCBs ²⁾	PCBs ¹⁾	PCBs ²⁾	PCBs ²⁾	PCBs ²⁾
	t/yr	t/yr	t/yr	t/yr	t/yr	t/yr	t/yr
Total	44	0.50	144	119	19	0.38	70
Stationary combustion	1.5	0.030	5.0	5.7	1.5	0.030	5.0
Publ. power, cogen. & district heating	1.2	0.030	3.8	3.8	1.2	0.030	3.8
Public power etc. brown coal				2.6			
Public power etc. hard coal				1.2			
Public power etc. fuel oils				0.001			
Public power etc. other fuels				0.009			
Comm. instit. & resid. combustion	0.259	0	1.2	0.80	0.26	0	1.2
Commercial etc. brown coal				0.24			
Commercial etc. hard coal				0.55			
Commercial etc. fuel oils				0			
Commercial etc. other fuels				0			
Industrial combustion				1.1			
Industrial combustion brown coal				0.37			
Industrial combustion hard coal				0.67			
Industrial combustion fuel oils				0			
Industrial combustion other fuels				0.0010			
Production processes	0.29	0.042	1.3	1.8	0.29	0.042	1.3
Iron & steel industry							
Coke production	0.15	0.019	0.65		0.15	0.019	0.65
Pig iron				0.030			
Open hearth furnace				0.25			
Basic oxygen furnace				0.50			
Electric arc furnace				0.006			
Rolling				0.025			
Sinter plants	0.14	0.023	0.65	0.65	0.14	0.023	0.65
Road transport				0.08			
Waste treatment & disposal	0.033	0.0099	0.1360	0.060	0.033	0.0099	0.14
Waste incineration	0.032	0.0097	0.13	0.045	0.032	0.0097	0.13
Landfill	0.0008	0.0002	0.006		0.0008	0.0002	0.006
Open uses							
Electrical equipment	41	0	116	111	17	0	42
Transformers	1.9	0.0	8.3		0.90	0.0	3.6
Large capacitors	33	0	87		16	0	39
Small capacitors	6.2	0.1	21				
Re-emission from soil	0.062	0.006	3.8		0.062	0.006	3.8
Re-emission from water	0.57	0.26	17		0.57	0.26	17

GER: Germany, NL: The Netherlands, EUR (25): 25 European countries, EUR (38): 38 European countries

1) Data included as submitted by Germany for 1985-90, but most data incl. electrical equipment estimated by TNO.

2) The estimated emissions from publ. power, cogen. & district heating include industrial combustion.

