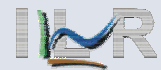


Monitoring of Pesticides from Sewage Treatment Plants in Germany

Bach, M., Blarr, A., Hügelschäffer (née Eyring), J., Frede, H.G.

Contact: martin.bach@umwelt.uni-giessen.de

Motivation



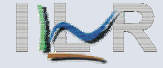
□ Background

EU Thematic Strategy on Sustainable Use of Pesticides
(*Reduktionsprogramm chemischer Pflanzenschutz*)

□ Objectives

- Quantification of emissions from sewage treatment plants (STP)
- Identification of main factors for STP entries – „hot spots“?
- Estimation of risk of activities corresponding to handling of pesticides on farmyards
- Conception of mitigation measures

Monitoring strategy



7 sewage treatment plants (STPs)

Continuous sampling

All STPs: 16 Aug - 31 Oct 2006

05 Mar - 04 Jun 2007

STP A,D,E: 16 Aug - 03 Dec 2007

03 Mar - 09 Jun 2008

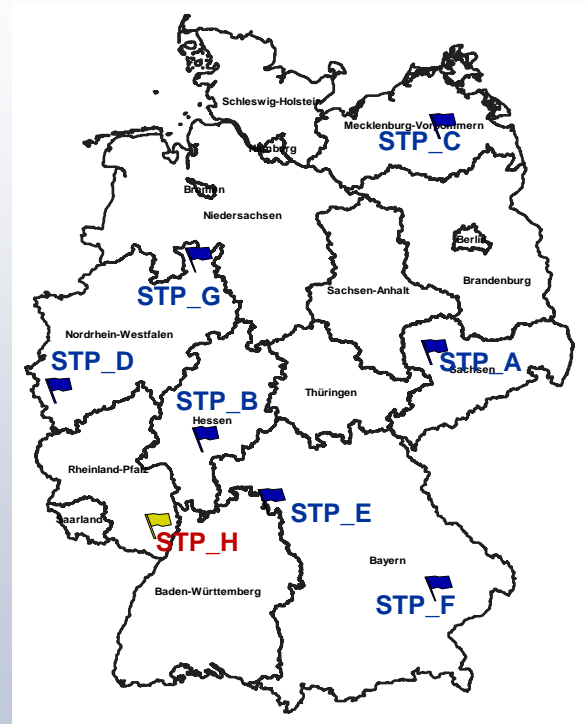
Analysis*:

- 3-d/4-d composite samples
- 28 (37) substances + 2 metabolites
- HPLC + LCMS/MS
- Limit of detection: 50 ng/L

Load Calculation

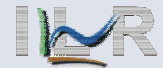
Concentration x STP discharge

Detections < DL: not considered



*) Institut für Umweltforschung (InfU), University Dortmund [Institute of Landscape Ecology and Resources Management](#)

Characteristics of the sewage treatment plants (STPs)



STP:	A	B	C	D	E	F	G
STP capacity [PE]	50 000	25 000	5 000	23 000	34 000	16 000	20 500
Number of farms connected to STP	8	191	7	97	637	315	161
Mean farm size	164 ha	54 ha	1133 ha	48 ha	30 ha	45 ha	68 ha
Number of sprayers „connected“ to STP	5	111	9	64	482	284	72
Sprayer per 1000 hectare arable land	4.3	12.4	1.4	17.0	26.0	21.8	8.1

Frequency of detections

7 STP

Sampling period:
Autumn 2006 and
spring 2007

28 substances

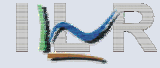
Rank	Substance	Detections total	Detections >DL	Percentage >DL
1	Diuron	267	212	63.7%
2	Isoproturon	275	195	58.6%
3	MCPPP	218	153	45.9%
4	MCPA	190	151	45.3%
5	Tebuconazol	196	140	42.0%
6	Ethofumesat	133	132	39.6%
7	Desamino-Metamitron	139	120	36.0%
8	Metamitron	156	113	33.9%
9	2,4 DP	102	63	18.9%
10	Bentazon	98	60	18.0%
11	Propiconazol	163	58	17.4%
12	Epoxiconazol	107	57	17.1%
13	Atrazin	116	56	16.8%
14	Terbutylazin	122	44	13.2%
15	Metribuzin	49	42	12.6%
16	2,4 D	67	34	10.2%
17	Metazachlor	141	31	9.3%
18	Desethyl-Atrazin	44	27	8.1%
19	Spiroxamine	65	26	7.8%
20	Azoxystrobin	81	20	6.0%
21	S-Metolachlor	60	18	5.4%
22	Diffufenican	32	17	5.1%
23	Amidosulfuron	12	11	3.3%
24	Dimethoat	18	7	2.1%
25	Flufenacet	24	7	2.1%
26	Fenpropidin	24	3	0.9%
27	Fenpropimorph	7	0	0%
28	Bromacil	0	0	0%
	SUM	2906	1797	19.3%

Total pesticide load in the effluent of STPs in 2006/07



STP	A	B	C	D	E	F	G
2006/07	Total load, 27 substances (without diuron) [g]						
Autumn 2006	127	731	12	641	1 644	89	68
Spring 2007	485	1 427	123	5 306	13 149	407	79
Sum 2006/07	612	2 158	135	5 947	14 793	496	147

Total pesticide loads in the effluent of STPs in 2006/07 and 2007/08



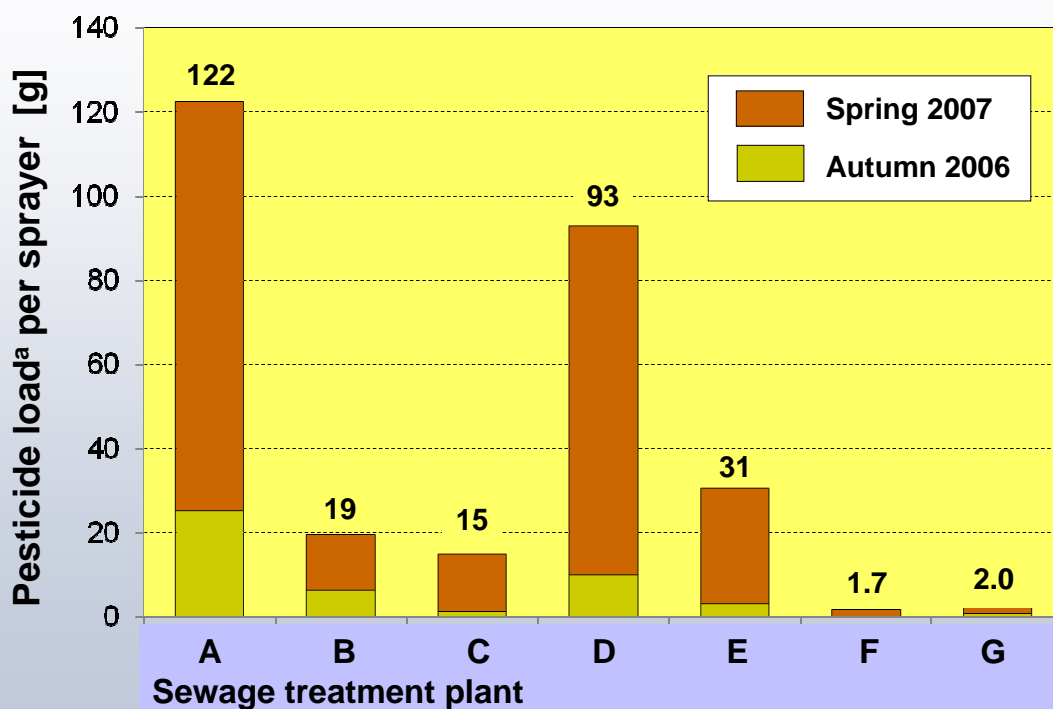
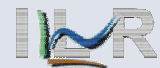
STP	A	B	C	D	E	F	G
2006/07 Total load, 27 substances (without diuron) [g]							
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Spring 2007	485	1 427	123	5 306	13 149	407	79
Sum 2006/07	612	2 158	135	5 947	14 793	496	147
2007/08 Total load, 36 ^a substances (without diuron) [g]							
Autumn 2007	402			1 543	23 951 ^b		
Spring 2008	1 824			6 501	11 109		
Sum 2007/08	2 226			8 044	35 060		

a) Sampling period 2007/08: 9 substances have been analysed additionally

b) thereof: 17700 g 2,4-DP and 3550 g isoproturon

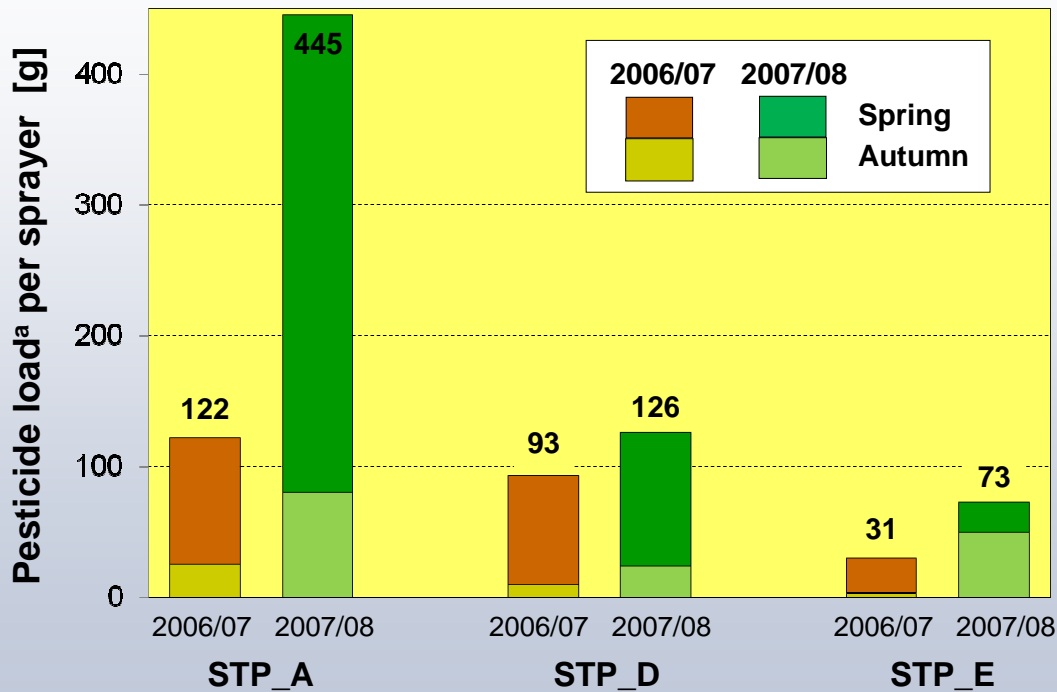
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Pesticide entries per sprayer, sampling period 2006/07 (7 STPs)



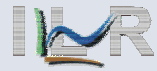
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Pesticide entries per sprayer, sampling periods 2006/07 vs. 2007/08 (3 STPs)

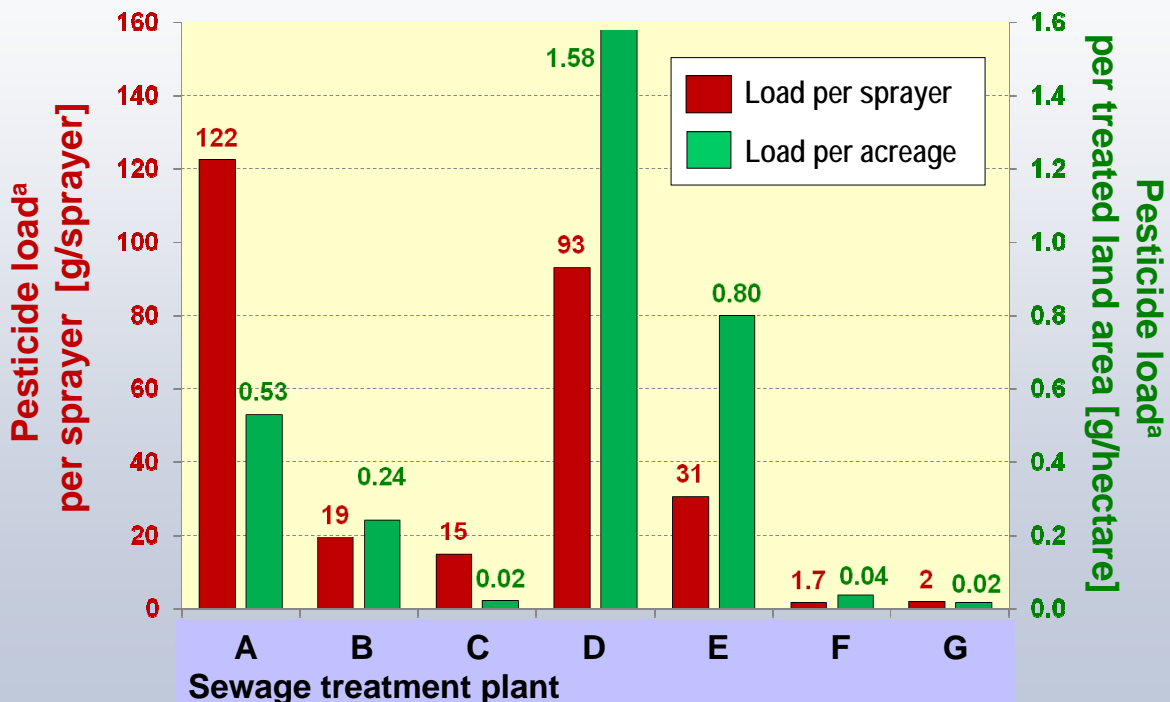


a) 2006/07: 27 substances analysed; 2007/08: 36 substances (both without diuron)

Pesticide entries, related to number of sprayers vs. potentially treated acreage



7 STP, sampling period autumn 2006/spring 2007



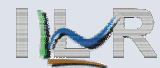
Conclusions (I)



- Average of pesticide loads in the effluent of STP, related to:
 - the number of sprayers: ca 40 g per sprayer (7 STP, period 2006/07)
 - cropping acreage: ca 0.5 g per hectare arable land
- Very high variability; max loss per sprayer 445 g (STP A, period 2007/2008)
- Seasonal peak in spring (two- to ten-fold higher than autumn)
- Real loads higher:
 - glyphosate not analyzed
 - effluent of CSO not sampled
- Reasons for "hot spots" not identifiable; erratic events (not predictable)
- Crucial factor: operator's awareness (mitigation strategies: TOPPS recommendations etc, e.g. poster B41)
 - ➔ Loss potential of individual activities?

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Tank mixture volume equivalent to monitored substance losses per sprayer

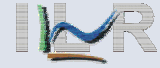


Substance	Monitored STP substance load per sprayer [g/sprayer]	Concentration in tank mixture ^a	Volume of tank mixture, equivalent to monitored load per sprayer
Bentazon	0.77	12 g/L	0.06 L
Ethofumesat	2.47	5 g/L	0.5 L
Epoxiconazol	1.02	0.5 g/L	2.0 L
Isoproturon	6.32	7.5 g/L	0.8 L
MCPA	3.69	4 g/L	0.9 L
MCPP	1.69	6 g/L	0.3 L
Metamitron and desamino-Metamitron	9.87	7 g/L	1.4 L
Metazachlor	1.08	4 g/L	0.3 L
Tebuconazol	1.75	2 g/L	0.9 L

➤ See also Beltman et al., poster A37

a) Assumption: recommended compound dosage, 200 L spray liquid per hectare

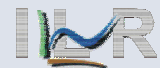
Pesticide entries from STPs – impact on river quality?



- Pesticide concentration data in rivers affected by STP dumping not available → Estimation approach
- Extrapolation, based on the specific substance entry into river system per (potentially) treated land area (sampling period 2006/2007)
- Rivers: Main (13 397 km²), Rur (1 730 km²), Parthe (232 km²)
- Reference for water quality standards: WFD (EQS and MAC-EQS)

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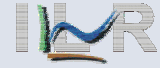
Calculated substance concentrations in rivers, extrapolated from studied STP



Substance	WFD reference	River Parthe STP_A	River Rur STP_D	River Main STP_E
	EQS (µg/L)	Annual average conc. (µg/L)		
Atrazine	0.6	0.010	0.005	0.000
Bentazon	0.1	0.014	0.000	0.003
Isoproturon	0.3	0.074	0.031	0.021
MCPA	0.1	0.037	0.024	0.011
MCPP	0.1	0.016	0.003	0.004
Metazachlor	0.4	0.003	0.000	0.000
S-Metolachlor	0.5	0.000	0.000	0.001
Terbutylazine	1.0	0.009	0.002	0.003

EQS: Environmental Quality Standard; MAC-EQS: Max Annual Conc.-EQS

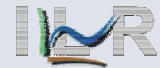
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Metazachlor	0.4	0.003	0.000	0.000
S-Metolachlor	0.5	0.000	0.000	0.001
Terbutylazine	1.0	0.009	0.002	0.003
	MAC-EQS	Maximum conc. (µg/L)		
Atrazine	2.0	0.726	0.292	0.000
Isoproturon	1.0	6.102	0.662	0.424
Terbutylazine	4.0	0.391	0.126	0.111

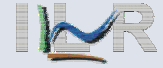
EQS: Environmental Quality Standard; MAC-EQS: Max Annual Conc.-EQS

Conclusions (II)



- WFD water quality standards scarcely exceeded in the three rivers (based on extrapolation approach)
- STP effluents can be a relevant source of surface water contamination, but pesticide concentrations and loads in river basins in Germany decline generally
- Situation in other EU countries?

Many thanks ...



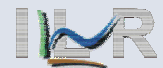
... to the German Federal Ministry for Food, Agriculture and Consumer Protection (BMELV) for generous funding

... to the STP staff for assistance and sampling

... for your patience!

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Mitigation measures



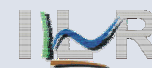
- Enhanced efforts on advisory and training of operators

Focus on: Keep away with all pesticide and sprayer handling operations from paved ground (connected to surface water network)

- Purchase new equipment, upgrading of existing sprayers
- Modifications of pesticide handling on farmyards (compounds, packaging)
- Establishment of washdown facilities (biobeds)
- STP: advanced wastewater treatment techniques

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Substance entires related to the potentially treated area under specific crops^a

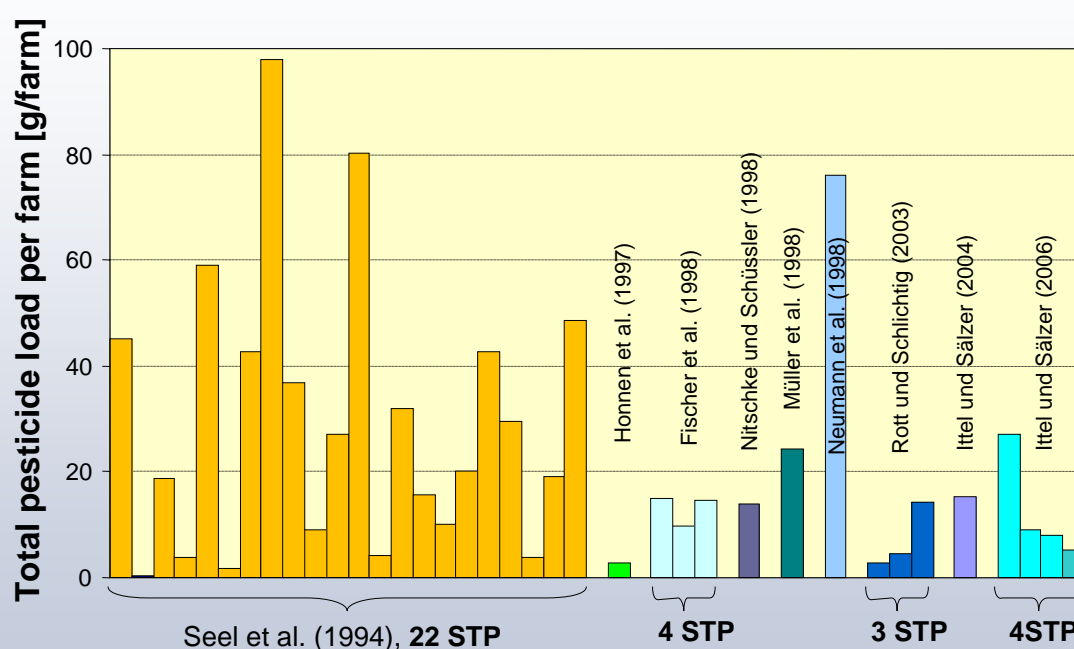


STP	A	B	C	D	E	F	G
Load ^b related to the total arable land area^b (AA) [g/ha]							
2006/07	0.52	0.24	0.02	1.57	0.80	0.04	0.02
2007/08	1.91			2.13	1.89		
2006/07 Load related to the acreage of specific crops [g/ha]							
Grain ^c	0.44	0.15	0.01	1.59	0.48	0.03	0.01
Maize ^d	0.23	0.44	--	0.75	0.23	0.02	0.01
Sugar beet ^e	1.56	0.65	0.53	2.03	1.89	0.17	--
Rape seed ^f	0.27	0.24	0.01	--	2.25	0.13	0.05

- a) potentially treated area = acreage of the respective crops of the farms which are connected to the STP
- b) Sum of all 27 substances (without Diuron)
- c) Sum of substances 2,4-D, 2,4-DP, Isoproturon, MCPA and MCPP
- d) Sum of substances Bentazon, S-Metolachlor and Terbutylazin
- e) Sum of substances Ethofumesat and Metamitron (incl. desamino-Metamitron)
- f) Sum of substances Metazachlor and Tebuconazol

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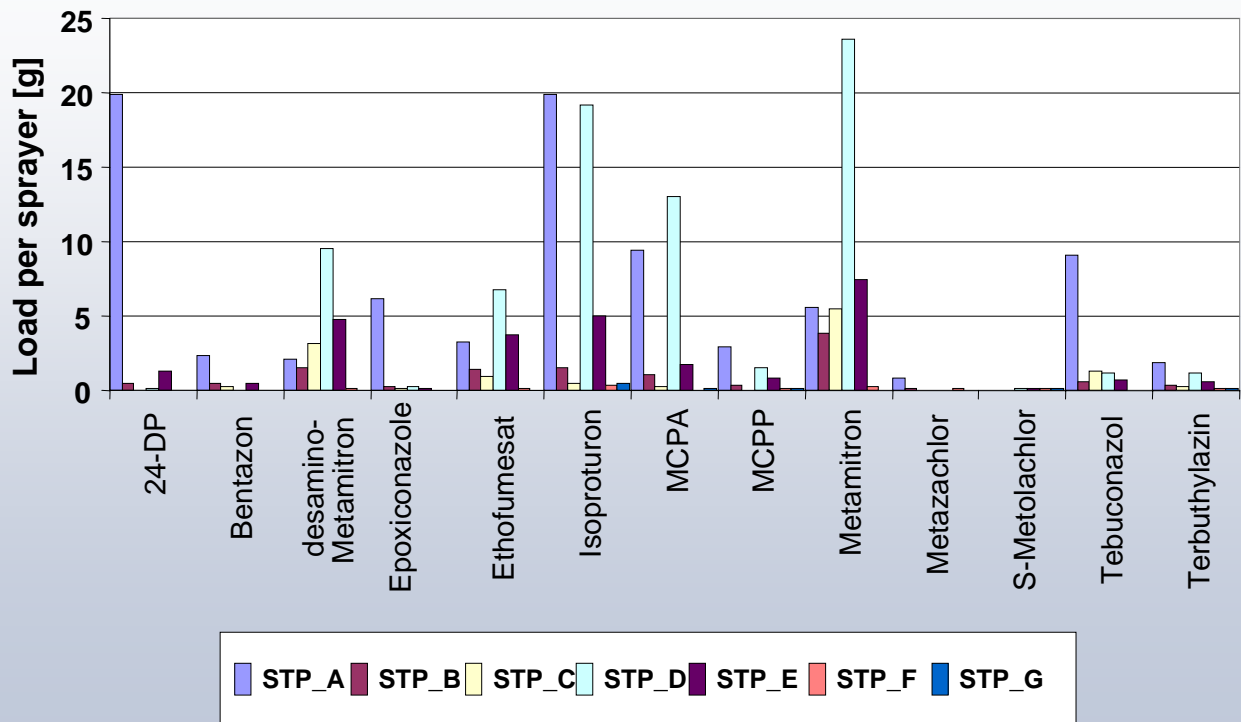
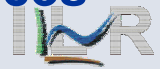
Pesticide loads of STPs^a in Germany related to the number of connected farms



- a) Literature review; different sources, various number of substances analysed, different periods and strategies of sampling etc.

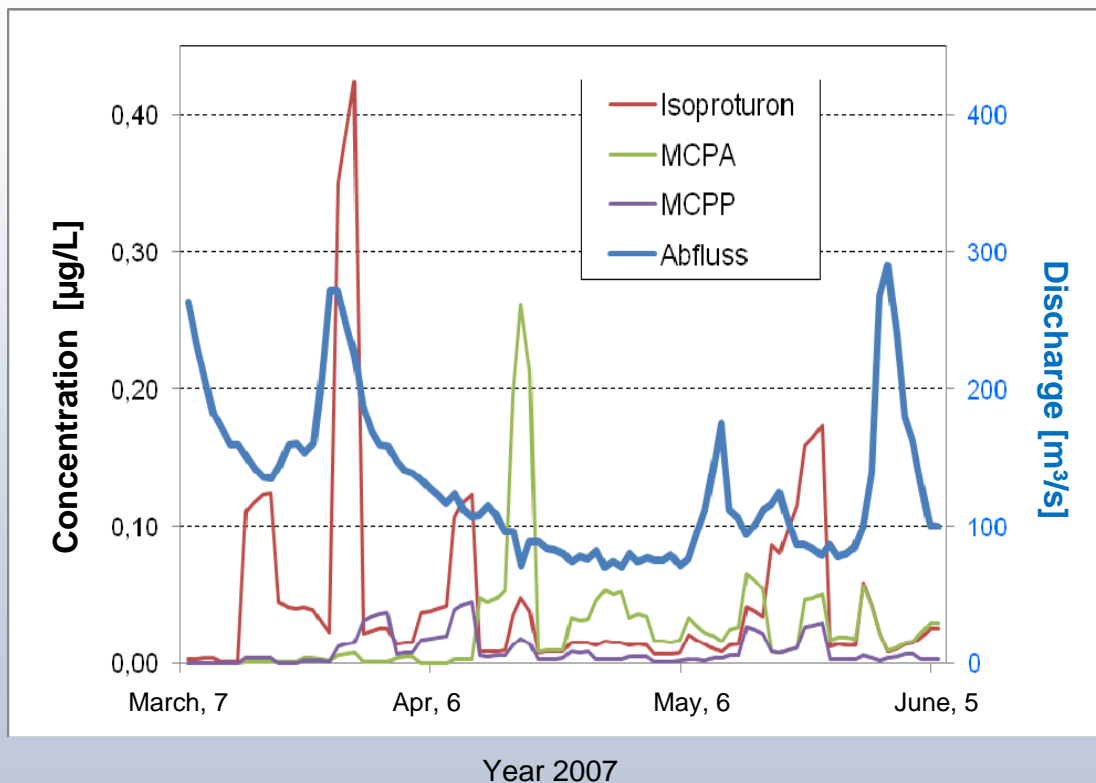
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Load per sprayer – Most detected substances 7 STPs, autumn 2007



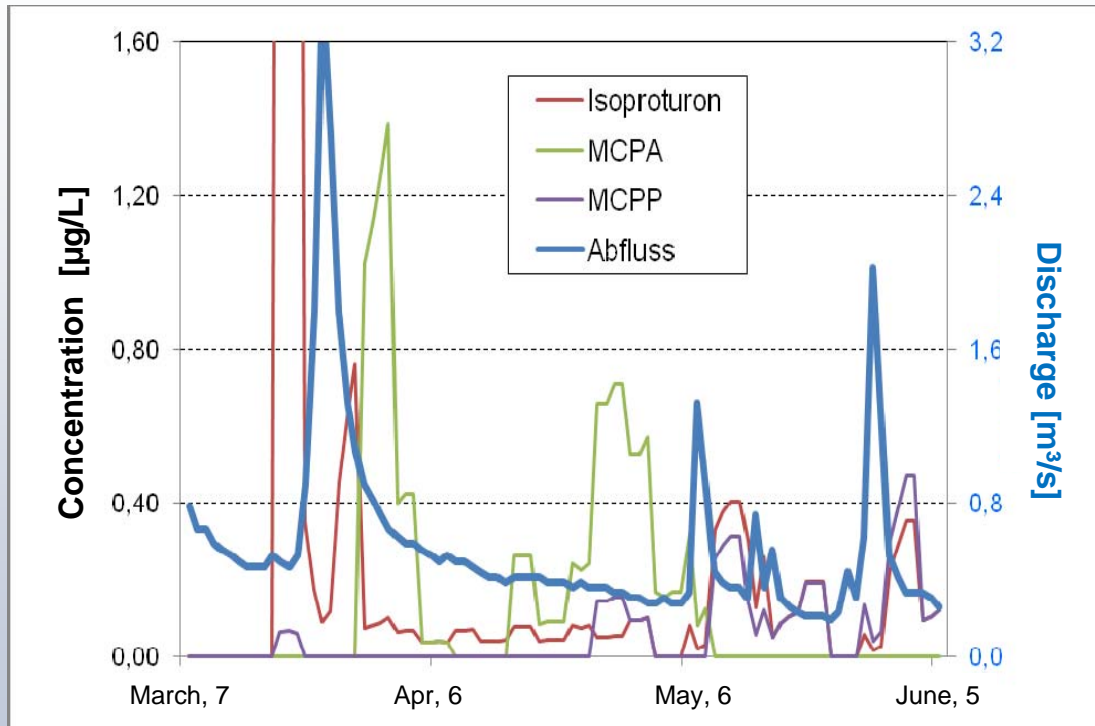
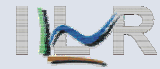
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Calculated substance concentrations - River Main, STP E extrapolated



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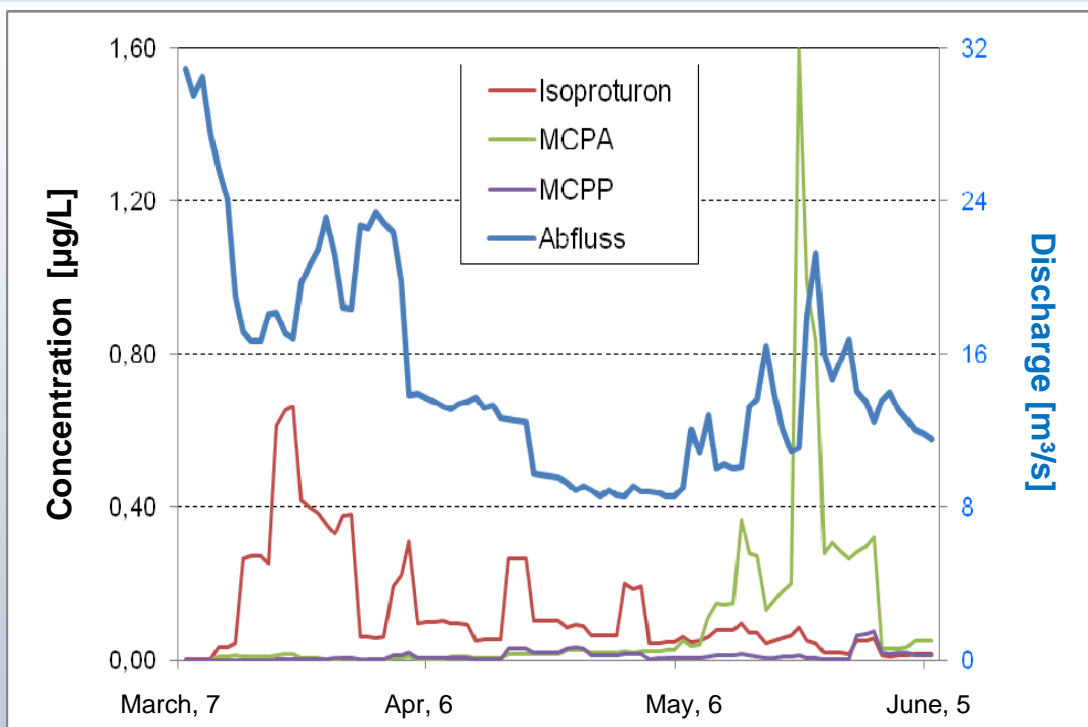
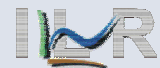
Calculated substance concentrations - River Parthe, STP A extrapolated



Year 2007

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Calculated substance concentrations - River Rur, STP D extrapolated



Year 2007

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