Emission estimates for diffuse sources
Netherlands Emission Inventory

Effluents from wastewater treatment plants and sewer systems

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NETHERLANDS NATIONAL WATER BOARD - WATER UNIT
In cooperation with DELTARES and TNO

Effluents from wastewater treatment plants and sewer systems

1 Description of emission source

The sewer system and urban waste water treatment plants in the Netherlands collect and treat polluted water, meeting requirements prior to discharge into surface water. Not all the pollution is removed (varying according to the substance in question), meaning that discharges from the system contribute to surface water pollution. This fact sheet presents a calculation method for emissions caused by effluents from urban waste water treatment plants, rainwater sewers, unconnected sewer systems, discharges (due to overflow and other causes) and small wastewater treatment systems (SWWTSs). This fact sheet describes how a large number of substances in effluent from urban waste water treatment plants are quantified, excluding total nitrogen, total phosphorous, arsenic, cadmium, chromium, copper, mercury, lead, nickel and zinc. The quantification of the latter is based on actual measurements and is described in another fact sheet [1].

Rainwater and waste water from dwellings, shops and companies is collected by the local sewer system, and most of it is transported to urban water treatment plants (UWWTP) for further treatment. The effluent is discharged to surface water. Heavy rainfall can overload the system for a time, and as a result polluted water is discharged into surface water via combined sewer overflows. The diagram below gives a general picture of a sewer system and the steps that take place during quantification of emissions.

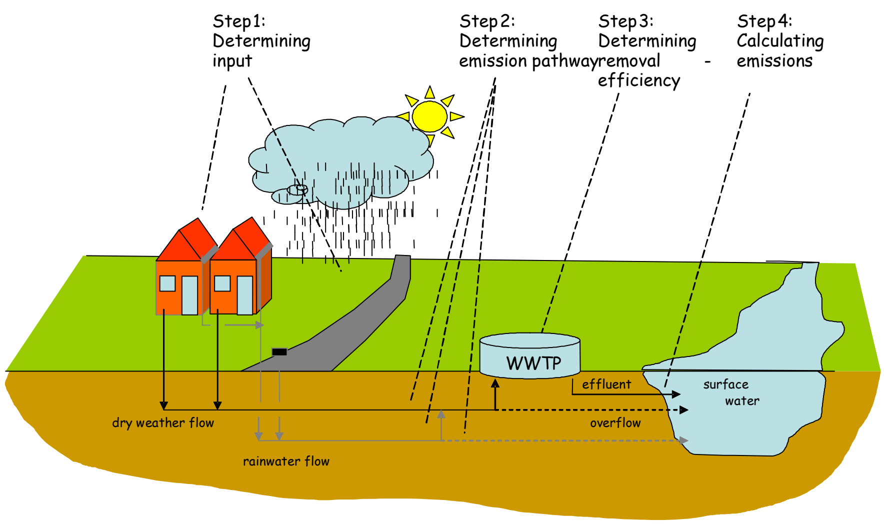

Figure 1: emissions from a sewer system and the calculation thereof

In practice, various alternatives are applied to the situation as described in figure 1. Rainwater flow and dry weather flow can be considered in separate systems or in a single system, and overflows may or may not be relevant. Sewer systems can be described as combined, improved combined, separate, or improved separate systems with the following characteristics:

Combined:
- dry weather and rainwater flow in a single system
- discharge via overflows in the event of calamities

Improved combined:
- dry weather and rainwater flow in a single system
- discharge via overflows, but with additional facilities (settlement tanks) to limit pollution

Separate:
- dry weather flow and rainwater flow in separate systems
- no overflow of dry weather flow
- rainwater is lead directly into surface water

Improved separated:
- dry weather flow and rainwater flow in separate systems

- no overflow of dry weather flow
- rainwater will flow directly to surface water. In the event of relatively heavy polluted rainwater (first flush: start of a shower), rainwater flow can be transported to the UWWTP.

More information about sewer systems is given in [2].

Emissions from these sources are allocated to the governmental target sector 'Sewage and Waste water treatment' in the national emission inventory.

2 Explanation of calculation method

Emissions from this source are quantified in a different way than emissions from most other sources in the emission inventory (the actual emission is usually the product of an activity rate and an emission factor). In this case, the calculation follows a number of steps (see also figure 1):

1. Firstly, the pollution load to the sewer system is determined. This information is taken from emission inventory sources both for diffuse sources and individual sources. A distinction is made between the pollution load caused by rainwater flow (rwf), dry weather flow from dwellings (dwf-hh) and other dry weather flow (dwf).
2. The next aspect to be considered is how the pollution subsequently is processed by the sewer system and which part of the pollution load is relevant at which point.
3. Then, a removal efficiency is applied for the part of the pollution load that is processed in an urban waste water treatment plant (UWWTP) or an SWWTS.
4. Finally, the definitive emission calculated for substance i at point j is calculated as

$$E_{i,j,s} = \Sigma_s\, I_{i,s} \times R_{j,s} \times (1 - Eff_{i,j})$$

Where:

$E_{i,j}$ = the emission of substance i via emission pathway j (in kg/year)
Σ_s = the sum of the three flow types (rwf, dwf-hh, dwf)
$I_{i,s}$ = the input of substance i into the sewer system for flow type s (in kg/year)
$R_{j,s}$ = the part of the pollution that reaches location j for flow type s (in %)
$Eff_{i,j}$ = the removal of substance i via emission pathway j (in %)

The chapter structure of this fact sheet has been selected according to this alternative approach to quantification, therefore chapters 3, 4 and 5 are different from most other fact sheets for diffuse sources as regards.

3 Input of pollution into the sewer system ($I_{i,s}$)

The activity rate is constituted by the input of pollution into the sewer system from dwellings, as a result of industrial activities and other diffuse sources discharging through the sewer system. All these sources have been determined in accordance with methods described in the Netherlands National Water Board Water Unit fact sheets on emission estimates for diffuse sources [3].

For the purpose of the calculation method described in this fact sheet, a distinction is drawn between two methods of processing waste water: rainwater flow and dry weather flow. Rainwater flow (rwf) mainly contains pollutants that are released by precipitation; dry weather flow (dwf) comprises pollution mainly produced by processes that are not dependent on precipitation. Waste water from dwellings (dwf-hh) is an important form of dry weather flow and is considered separately.

Table 1 contains a summary of relevant sources, the flow circumstances (rwf, dwf-hh or dwf) and indicates whether the method used to determine the pollution load imposed on the sewer system by this source has been established in the Netherlands National Water Board Water Unit fact sheets on emission estimates for diffuse sources [3].

Table 1: Summary of sources discharging into the sewer system

Source	type of flow	fact sheet available
Chemical weed control on pavements	rwf	yes
Road traffic tyre wear	rwf	yes
Road traffic engine oil leaks	rwf	yes
Road traffic brake wear	rwf	yes
Road surface wear	rwf	yes
Letting off fireworks	rwf	yes
Lead sheet used on buildings for flashings and weatherproofings	rwf	yes
Atmospheric corrosion of stainless steel in industry	rwf	yes
Atmospheric corrosion of galvanised steel and sheet zinc	rwf	yes
Atmospheric deposition run-off to sewer system	rwf	yes
Domesticwaste water	dwf-hh	yes
Indirect discharges from individually registered companies	dwf	yes
Statistical estimates for indirect discharges from companies	dwf	yes
Dental practices	dwf	yes
Emissions from waste landfill sites	dwf	no
Emissions from tram/metro overhead wires	rwf	yes
Greenhouse cultivation	dwf	**yes**

4 Method of processing ($B_{i,j}$)

The way pollution is processed by the sewer system and which part of the pollution load reaches which location, is determined by which part of the water flow is connected to which type of sewer system. De Heer [2] has classified sewer systems into various types, each designated below by a letter:

A: combined sewer systems
B: improved combined sewer systems
C: dwellings with a unconnected rwf system (dwf normally is not unconnected)
D: separate sewer systems
E: improved separate sewer systems
F: unconnected dwellings, apart from SWWTS
G: connected to a pressurised sewer system
H: dwf discharged through SWWTS
K: discharges through sewer systems not connected to an UWWTP

Three additional destinations for polluted water have also been defined:

L: evaporation
M: direct discharge to surface water
N: direct discharge to the soil.

The processing of waste water has been quantified using De Heer's model [2]. This model calculates the method of processing ($B_{i,j}$) for individual years and for the various flow systems (rwf, dwf-hh and dwf). Basically, this consists of determining what part of the pollution load is eventually processed through which pathway (for example which part is processed in an UWWTP, which part is left behind in sewer sediments, which part is emitted through the UWWTP effluent, etc).

The distribution of waste water among the various types of systems is an important element of De Heer's model [2]. Improvements in waste water infrastructure mean that this distribution does not remain constant over time.

Table 2 shows the national average distribution of the number of dwellings discharging into various types of sewer systems [2, 5]. Regarding rainwater, it is assumed that the distribution among the different types of sewer systems is the same as for dwellings (as described in table 2), but the volume of rainwater in areas supplied with SWWTSs or pressurised sewer systems does not physically pass through the pressurised sewer system or SWWTSs, but instead the rainwater is either discharged directly to surface water or infiltrated into the soil (see figure 2). The system for other dry weather flow is similar to the system for dwelling waste water flow, but SWWTSs and pressurised sewer systems are not relevant here, and there are no companies that are not connected to a sewer system (see figure 4).

Table 2: National average distribution of dwellings connected to various sewer systems (in %)

		1985	1990	1995	2000	2005	2006
A	combined sewer systems	72	82	79	49	22	16
B	improved combined sewer systems	0	0	0	25	47	52
C	dwellings with unconnected rwf	0	0	0	1.8	3.6	4.1
D	separate sewer systems	10	10	13	16	16	16
E	improved separate sewer systems	0	2	4	5	6.8	7.2
F	unconnected dwellings, apart from IWWTS	8	4	2.8	1.9	0.7	0.5
G	connected to pressurised sewer system	0	0	0.7	1.3	3.2	3.5
S	dwf-hh discharged through SWWTS	0	0	0	0	0.6	0.7
K	untreated sewer discharged to water	10	2	0.55	0	0	0
	Total	**100**	**100**	**100**	**100**	**100**	**100**

a) Rainwater flow

Figure 2 shows the flowchart for the rainwater flow related pollution load.

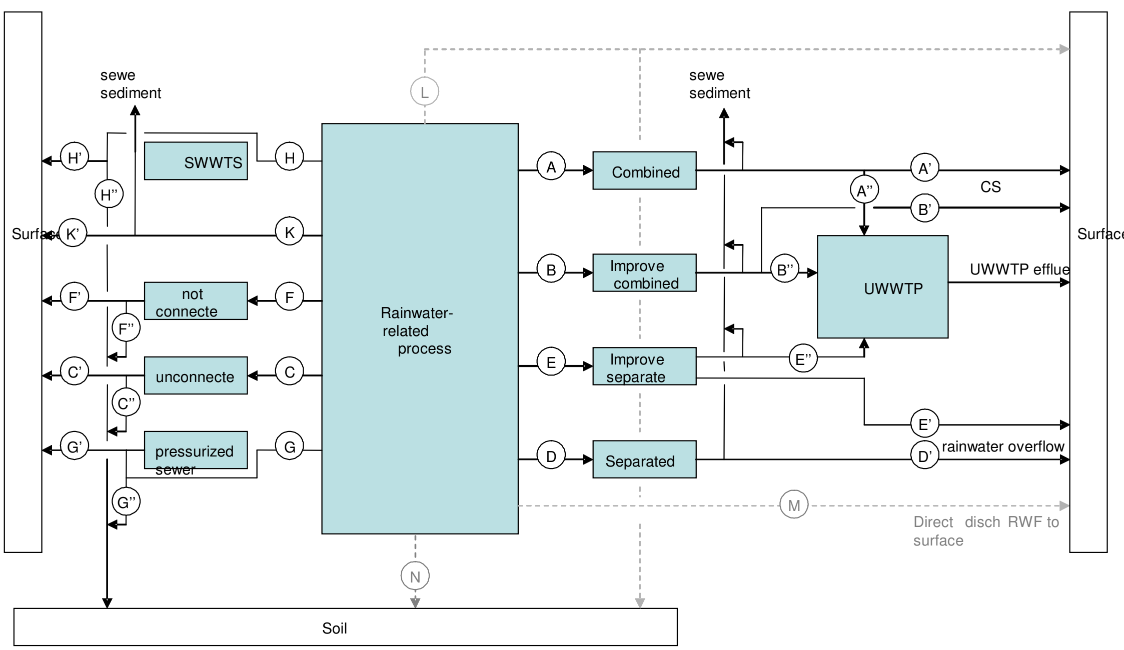

Figure 2: the processing of rainwater flow by the sewer systems

The destination of the pollution load is calculated as follows in de Heer's model [2]. See [2] for an explanation of various assumptions.

Table 3: Calculation of the destination of rwf

	calculation	Explanation and assumptions
A'	0.75x(1-0.09)x0.085xAxcorr	0.75 is the fraction of the rwf that ends up in the sewer system 0.09 is the fraction of pollution removed with sewer sediments 0.085 is the volume fraction present in combined sewer overflow corr is a correction factor, see footnote
B'	0.75x(1-0.09)x0.062x0.6xBxcorr	0.75 is the fraction of the rwf that ends up in the sewer system 0.09 is the fraction of pollution removed with sewer sediments 0.062 is the volume fraction present in overflow 0.6 is the effective reduction of discharge from overflow as a result of additional facilities corr is a correction factor, see footnote
C'	0.75x1/3xC	0.75 is the fraction of the rwf that ends up in the sewer system 1/3 is the proportion of pollution load discharged into surface water
D'	0.75x(1-0.09)xcorrxD	0.75 is the fraction of the rwf that ends up in the sewer system
E'	0.75x0.25x(1-0.09)x Excorr-0.1xE/6.2	0.75 is the fraction of the rwf that ends up in the sewer system 0.25 is the proportion of the water that is not transported to a UWWTP 0.09 is the fraction of pollution removed with sewer sediments corr is a correction factor, see footnote 0.1xE/6.2 is the first flush effect, estimated at 0.1 for 2004 and scaled up on a pro-rata basis for other years (for 2004 E=6.2%)
F'	0.75x2/3xF	0.75 is the fraction of the rwf that ends up in the sewer system 2/3 is the proportion of pollution load discharged into surface water
G'	0.75x0.5xG	0.75 is the fraction of the rwf that ends up in the sewer system 0.5 is the proportion of pollution load discharged into surface water
H'	0.75x2/3xH	0.75 is the fraction of the rwf that ends up in the sewer system 2/3 is the proportion of pollution load discharged into surface water
K'	0.75x(1-0.09)xKxcorr	0.75 is the fraction of the rwf that ends up in the sewer system

Footnote: corr is a correction for the pollution load of water that evaporates and some of which re-enters the sewer system via precipitation. It is assumed that half the pollution load of the evaporated water ends up in precipitation and is divided among streams A, B, D, E and K on a pro-rata basis. This increases the pollution load of each stream by about 4 to 4.5% depending on the year. For each year corr can be calculated as (1+0.5xL/(0.75x(A+B+D+E+K)), where L is the amount of water that evaporates (in the current calculation this is assumed to be 6.25%). For 2005, corr=1.045.

Applying the calculation methods in table 3 to the distributions in table 2 produces the following distribution of destinations of pollution load.

Table 4: Destination of the pollution load ($D_{i,j}$) for rainwater flow

Pathway no.	**Emission pathway**	**1985[1]**	**1990**	**1995**	**2000**	**2005**	**2006**
A'+B'	Combined sewer overflow		4.96%	4.78%	3.63%	2.57%	2.35%
D'+E'	separate stormwater sewers		7.39%	9.87%	12.20%	12.76%	12.62%
C'+F'+G'+H'	not connected to water[2)]		2.00%	1.66%	1.89%	2.75%	2.94%
C''+F''+G''+H''	not connected to soil[2)]		1.00%	0.96%	1.87%	3.33%	3.67%
A''+B''+E''	UWWTP influents (calculated)[3)]		73.65%	72.65%	70.85%	69.25%	69.15%
K	untreated sewer discharged into water		1.43%	0.39%	0.00%	0.00%	0.00%

[1)] destinations were not estimated for 1985.
[2)] these direct emissions to soil and surface water are also counted for separate stormwater sewers. The heading 'not connected to water' is also counted under the heading 'separate stormwater sewers' under compartment D (direct) and the heading 'not connected to soil' is also counted under the heading 'rainwater sewer systems soil' under compartment S (soil)
[3)] this is part of the UWWTP effluents emission pathway. The amount of pollution reaching UWWTPs is calculated as 1- (other pathways, including seepage into the soil and drainage with sludge).
N.B. The values in this table do not add up to 100%. Some of the pollution load is left behind in sewer sediments.

b) Dry weather flow-dwellings

The diagram for dry weather flow from dwellings is similar to that for rainwater flow. The only difference is that flow of dwf physically passes through SWWTSs and pressurised sewer systems in areas that have these facilities.

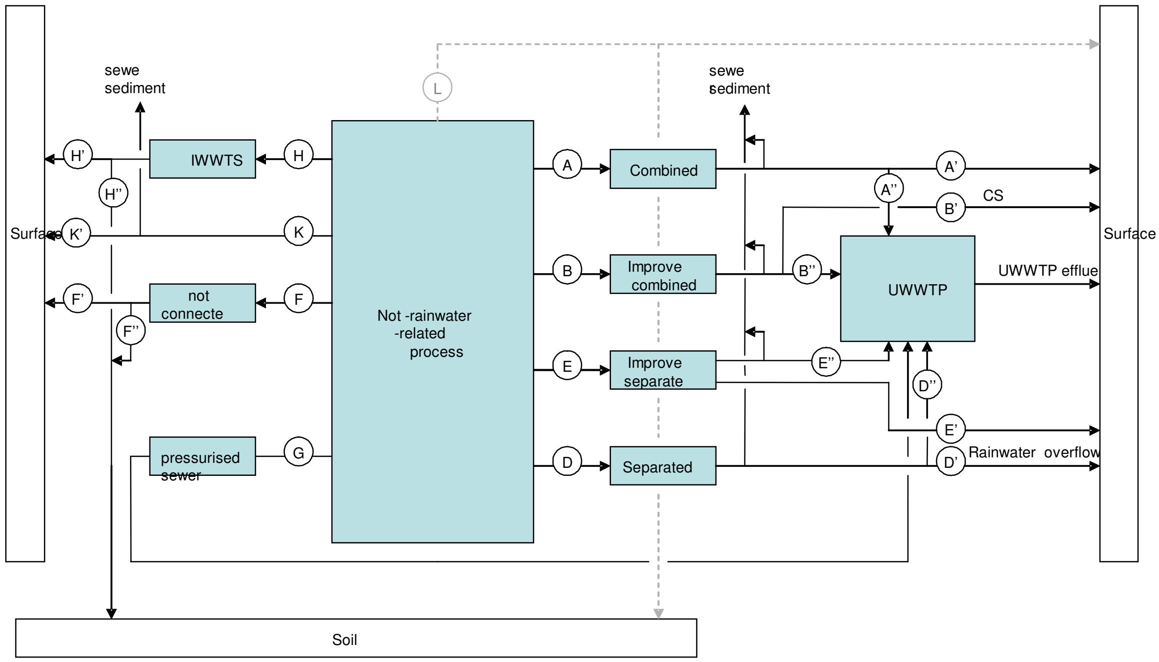

Figure 3: processing of dwelling dry weather flow

In De Heer's model [2], the destination of the pollution load is calculated as follows (see [2] for an explanation of the various assumptions):

Table 5: Calculation of the destination of dwf-hh

	calculation	Explanation and assumptions
A'	(1-0.09)x 0.0018xAxcorr	0.09 is the fraction of pollution drained together with sewer sediments 0.0018 is the volume fraction present in overflow corr is a correction factor for non-disconnection of dwf, see footnote
B'	(1-0.09)x0.0013x0.6xBxcorr	0.09 is the fraction of pollution drained together with sewer sediments 0.0013 is the volume fraction present in overflow 0.6 is the effective reduction of discharge from overflow as a result of additional facilities (such as settlement tanks) corr is a correction factor for non-disconnection of dwf, see footnote
C'	0	Balanced by A'and B'
D'	0.02x(1-0.09)xD	0.02 is the proportion incorrectly connected 0.09 is the fraction of pollution drained with sewer sediments
E'	0.02x(1-0.09)x 0.25xE	0.02 is the proportion incorrectly connected 0.09 is the fraction of pollution drained with sewer sediments 0.25 is the fraction of this that is eventually discharged into surface water
F'	2/3xF	2/3 is the proportion that is discharged to surface water
H'	2/3 x0.34xH	2/3 is the proportion of the volume that is discharged to surface water 0.34 is the proportion of the untreated pollution load that ends up in surface water (0.17 directly and 0.17 indirectly with suspended solids)
K'	(1-0.09)xK	0.09 is the fraction of pollution drained with sewer sediments

The correction factor corr is calculated as (1+C/(A+B))

Applying the calculation methods in table 5 to the distributions in table 2 produces the following distribution of destinations of pollution load.

Table 6: Destination of the pollution load ($D_{i,j}$) for dwelling dry weather flow

Pathway no.	Emission pathway	1990	1995	2000	2005	2006
A′+B′	combined sewer overflow	1,06%	0,74%	0,38%	0,11%	0,07%
D′+E′	separate stormwater sewers	0,19%	0,26%	0,31%	0,33%	0,32%
F′	not connected to water[1)]	2,68%	1,88%	1,27%	0,47%	0,34%
F′′	not connected to soil[1)]	1,32%	0,92%	0,63%	0,23%	0,17%
A′′+B′′+E′′ + G″	UWWTP influents (calculated) [2)]	85,20%	87,60%	89,00%	89,70%	89,90%
H′	dwf-hh discharged to water via a IAS	0,00%	0,00%	0,00%	0,14%	0,47%
H′′	dwf-hh discharged to soil via a IAS	0,00%	0,00%	0,00%	0,46%	0,23%
K	untreated sewer discharged into water	1,82%	0,50%	0,00%	0,00%	0,00%

[1)] these direct emissions into soil and surface water are described in greater detail in the dwelling waste water fact sheet [6]
[2)] this is part of the UWWTP effluents emission pathway. The amount of pollution reaching UWWTPs is calculated as 1- (other pathways, including seepage into the soil and drainage with sludge).
N.B. The values in this table do not add up to 100%. Some of the pollution load is left behind in sewer sediments.

c) Dry weather flow-other

The diagram for other dry weather flow is the same as for dwf-hh except that streams C, F, G and H are not featured in this flow. These streams are distributed to the other streams on a pro-rata basis.

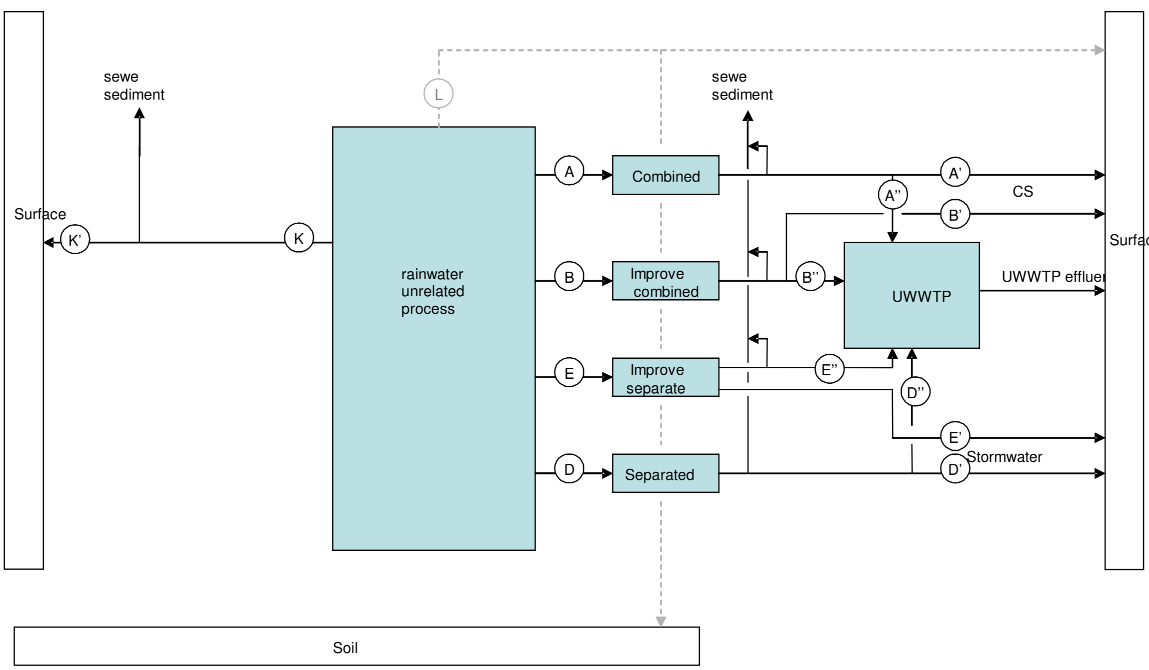

Figure 4: processing of dry weather flow for other sources

The calculation method is the same as for dwf-hh in table 5. The results are given in the table below.

Table 7: Destination of the pollution load ($D_{i,j}$) for other dry weather flow

Pathway no.	Emission pathway	1990	1995	2000	2005	2006
A'+B'	combined sewer overflows	1.06%	0.74%	0.38%	0.11%	0.07%
D'+E'	separate rainwater sewers	0.19%	0.26%	0.31%	0.33%	0.32%
A''+B''+E''	UWWTP influents (calculated) [1)]	89.20%	90.40%	90.90%	91.00%	91.01%
K'	untreated sewer discharged into water	1.82%	0.50%	0.00%	0.00%	0.00%

[1)] this is part of the UWWTP effluents emission pathway. The amount of pollution reaching UWWTPs is calculated as 1- [other pathway, including seepage into the soil and drainage with sludge].
N.B. The values in this table do not add up to 100%. Some of the pollution load is left behind in sewer sediments.

5 Removal efficiencies ($Eff_{i,j}$)

The table below shows the removal efficiencies in UWWTPs and SWWTSs The removal efficiencies for UWWTPs are taken from a bibliographical review conducted by Witteveen and Bos [7], and those for SWWTSs are taken from a study carried out by DHV [8]. Note: this means that table 8 is based on two separate studies that were conducted using different information sources which are not equally accurate. One of the consequences of this, is that there are considerable discrepancies between the removal efficiencies of UWWTPs and SWWTSs for particular components. The impact of no removal efficiency being available is also different in respect of UWWTPs and SWWTSs. Where no removal efficiency is available for UWWTPs or SWWTSs, effluents from these facilities are calculated on the basis of estimates taking account of substance properties and known removal efficiencies of comparable substances.

Table 8: Removal efficiencies for UWWTPs and SWWTSs (%).

	UWWTP	SWWTS
Nitrogen compounds	[1)]	70
Phosphorous compounds	[1)]	80
Carbendazim	0	*0* [3)]
Chlorobenzenes,	84	*65*
- Dichlorobenzene,1,2-	76	65
- Dichlorobenzene,1,3-	85	45
- Dichlorobenzene,1,4-	87	45
- Hexachlorobenzene	88	80
Trichlorobenzene,	86	65
Chloronitrobenzenes,	8	*4*
- Chloronitrobenzene,1,2-	*8*	*4*
- Chloronitrobenzene,1,3-	*8*	*4*
- Chloronitrobenzene,1,4-	*8*	*4*
Dichloropropane,1,2-	84	5
Tetrachloroethene (per)	93	*5*
Tetrachloromethane (tetra)	94	5
Chlorophenolene,	27	*65*
- Pentachlorophenol	55	65
- Tetrachlorophenol,2,3,4,5-	24	65
- Tetrachlorophenol,2,3,4,6-	24	65
- Trichlorophenol,2,3,6-	16	65
- Trichlorophenol,2,4,5-	16	65
Phenol/phenolates	12	15
Nonylphenol	61	15
Diuron	2	[2)]
Isoproturon	2	[2)]
Phthalates,	32	[2)]
- Diethylphthalate	1	75
- Diisobutylphthalate	49	75
- Dimethylphthalate	1	75
- Di(2-ethylhexyl)phthalate	95	75
- Dibutylphthalate	14	75
Benzene	89	90

	UWWTP	SWWTS
Ethylbenzene	91	90
Isopropylbenzene (cumene)	92	*90*
Methyl-t-butylether	54	*90*
Propylbenzene,n-	90	65
Styrene	83	2)
Trimethylbenzene,1,3,5-	91	45
Toluene	90	90
Aluminium	*80*	*40*
Antimony	93	*45*
Arsenic	54	80
Barium	25	
Cadmium	66	55
Chromium	*83*	80
Cobalt	*40*	*20*
Copper	*80*	70
Mercury	97	70
Lead	*90*	80
Molybdenum	20	*10*
Nickel	*90*	80
Strontium	0	*0*
Tin	10	*5*
Silver	65	*30*
Zinc	*80*	70
Chlorpropham	12	2)
Cyanides as CN	70	2)
Extractable organic chlorine (EOCl)	NQ	2)
Mineral oil excluding benzene and toluene	NQ	80
Nonylphenolethoxylate	NQ	15
Organotin compounds	5	2)
Phentinacetate	5	2)
Triphenyltin salts (TBT)	NQ	2)
Chlorothalonil	3	*3*
Chloroform (trichloromethane)	86	5
Dichloroethane,1,1-	89	*45*
Dichloroethane,1,2-	70	*35*
Dichloroethene,1,2-	90	*45*
Endosulfan	10	*5*
Hexachlorocyclohexane,alpha-	11	*5*
Hexachlorocyclohexane,beta-	9	*5*
Hexachlorocyclohexane,gamma-	9	*5*
Methylene chloride (dicl-meth.)	86	5
Trichloroethane,1,1,1-	93	*45*
Trichloroethane,1,1,2-	64	*30*
Trichloroethene (tri)	91	*45*
Chlorobenzenes	*50*	*25*
Chlorophenolene	*30*	*15*
Vinylchloride (chloroethene)	94	*45*
Dichlorvos	46	*25*
Polycyclic aromatic hydrocarbons (6 Borneff)	84	*80*
- Benzo(a)pyrene	88	80
- Benzo(ghi)perylene	93	80
- Benzo(k)fluoranthene	88	80
- Fluoranthene	59	80
- Indeno(1,2,3-cd)pyrene	93	80
Anthracene/anthracene oil	68	65
Benzo(a)anthracene	81	80
Chrysene	82	80
Phenanthrene	31	65

	UWWTP	SWWTS
Naphthalene	55	80
Pyrene	46	80
PCB	95	*80*
TEQ of PCDD – PCDF	*90*	80
Simazine	1	*1*
Xylene	92	90
Anorganic chlorine compounds as Cl	0	[2)]
Anorganic fluorine compounds as F	0	[2)]
Sulphates as SO_4	0	[2)]

1) Emissions of these substances with effluent from a UWWTP are calculated differently, see [1] for details. This is why no removal efficiency for UWWTPs is given for these substances.
2) When calculating effluents from a UWWTP, a 0% conversion is assumed if the removal efficiency is unknown. When calculating emissions from an SWWTS, the component in question is not reported if the removal efficiency is unknown.
3) Values in italics are estimates.

6 Emissions calculated

Emissions of the various substances can be calculated from the aforementioned information as described in section 3. The results for 2006 are summarised below.

Table 9: Results of the calculations for 2006 (in kg/year).

	Combined sewer overflows	Separate stormwater sewers	Separate stormwater sewers discharging to soil	Not connected to UWWTP	UWWTP effluent calculated	SWWTS discharging to water	SWWTS discharging to soil
N - total	172,479.55	1,015,051.78	179,706.13	0.00	elsewhere [1)]	97,987.67	48,993.83
P - total	10,028.08	45,842.65		0.00	elsewhere [1)]	12,063.73	6,031.86
Chlorobenzenes	0.03	0.23	0.05	0.00	0.16		
Dichlorobenzene, 1,4-	4.13	18.87		0.00	688.37	15.13	7.57
Hexachlorobenzene	0.05	0.28	0.05	0.00	1.88	0.02	0.01
Trichlorobenzenes	2.24	10.24		0.00	402.49	5.23	2.61
Tetrachloroethene	0.08	0.38		0.00	7.63		
Tetrachloromethane	0.34	1.57		0.00	26.43	2.17	1.09
Phenol and phenolates	3.63	16.60		0.00	4,154.47		
Diuron	0.00	0.00	0.00	0.00	0.00		
Phthalates	0.00	0.00		0.00	0.03		
Glyphosate	1,193.80	7,807.96	1,864.36	0.00	14,402.56		
Di(2-ethylhexyl)phthalate	12.58	57.50		0.00	806.74	20.96	10.48
Dibutylphthalate	2.06	9.41		0.00	2,270.60	3.43	1.72
Benzene	2.28	10.45		0.00	326.57	0.08	0.04
Ethylbenzene	2.45	11.18		0.00	285.95	0.08	0.04
Isopropylbenzene	0.05	0.21		0.00	4.72		
Styrene	1.52	6.95		0.00	336.18		
Toluene	3.56	16.27		0.00	458.31	1.75	0.88
Aluminium compounds (as Al)	94.61	432.49		0.00	24,600.55		
Antimony compounds (as Sb)	144.48	944.35	225.15	0.00	325.17		
Arsenic compounds (as As)	17.80	111.10	23.57	0.00	elsewhere [1)]	3.05	1.52
Barium compounds (as Ba)	3,361.44	21,984.86	5,249.27	0.00	74,368.43		
Cadmium compounds (as Cd)	7.77	49.51	11.11	0.00	elsewhere [1)]	1.72	0.86
Chromium compounds (as Cr)	389.60	2,537.25	599.81	0.00	elsewhere [1)]	3.05	1.52
Copper compounds (as Cu)	1,775.58	11,455.62	2,648.03	0.00	elsewhere [1)]	149.55	74.78
Mercury compounds (as Hg)	4.79	30.87	7.11	0.00	elsewhere [1)]	0.41	0.21

Lead compounds (as Pb)	777.18	5,062.74	1,197.58	0.00	elsewhere [1)]	12.04	6.02
Molybdenum compounds (as Mo)	0.55	2.52		0.00	573.65		
Nickel compounds (as Ni)	232.92	1,501.91	346.71	0.00	elsewhere [1)]	7.62	3.81
Strontium compounds(as Sr)	816.97	5,343.33	1,275.86	0.00	24,039.76		
Tin compounds (as Sn)	0.08	0.38		0.00	96.10		
Silver compounds (as Ag)	0.14	0.64		0.00	63.84		
Zinc compounds (as Zn)	3,720.56	24,068.30	5,599.63	0.00	elsewhere [1)]	235.31	117.65
Cyanides	0.13	0.60		0.00	51.31		
Nonylphenol/Ethoxylates(Np/Npe)	20.76	94.92		0.00	10,388.42	117.66	58.83
Organotin compounds	0.00	0.00		0.00			
Dichloromethane	4.26	19.50		0.00	765.96	27.01	13.51
Trichloromethane	1.80	8.23		0.00	323.22	11.37	5.68
Dichloroethane, 1,2-	0.12	0.55		0.00	46.68		
Dichloroethene, 1,2-	0.00	0.00		0.00	0.05		
Endosulfan	0.00	0.00		0.00	0.00		
Hexachlorocyclohexane	0.00	0.00		0.00	0.00	0.00	0.00
Trichloroethane, 1,1,1-	0.00	0.00		0.00	0.03		
Trichloroethene	0.22	1.02		0.00	25.98		
Chlorophenolene	2.91	13.31		0.00	2,762.88		
Pentachlorophenol	0.07	0.31		0.00	38.55	0.16	0.08
Vinyl chloride	0.01	0.04		0.00	0.77		
PAH (Borneff 6)	109.23	714.35	170.53	0.00	521.90	0.00	0.00
Benzo[a]pyrene	6.78	44.22	10.51	0.00	30.98	0.06	0.03
Benzo(ghi)perylene	10.72	70.10	16.73	0.00	23.04	0.01	0.01
Benzo[k]fluoranthene	7.98	52.15	12.43	0.00	30.98	0.02	0.01
Fluoranthene	78.66	513.89	122.39	0.00	1,096.64	0.38	0.19
Indeno[1,2,3-cd]pyrene	3.40	22.20	5.29	0.00	7.84	0.01	0.01
Anthracene	11.28	73.76	17.60	0.00	109.47	0.02	0.01
Benzo(a)anthracene	4.81	31.39	7.46	0.00	34.06	0.04	0.02
Chyrsene	6.24	40.71	9.67	0.00	44.09	0.07	0.03
Phenanthrene	25.52	166.61	39.60	0.00	662.81	0.39	0.19
Naphthalene	156.67	1,024.30	244.37	0.00	2,185.06	0.26	0.13
PCBs	0.43	2.79	0.67	0.00	0.63	0.00	0.00
Simazine	0.00	0.00	0.00	0.00	0.00		
Xylenes (total)	2.25	10.29		0.00	233.89	0.13	0.06
Chlorides	72,910.38	333,304.61		0.00	94,793,915.03		
Anorganic fluorine compounds (as F)	28.94	132.31		0.00	37,629.26		
Sulphates (as SO4)	16,998.89	77,709.20		0.00	22,100,982.09		

[1)] quantified elsewhere, see [1]

7 Release into environmental compartments

Indirect discharge from the sewer system mainly takes place to surface water. In addition, minor direct emissions to surface water have also been calculated and are reported elsewhere. Direct emissions into soil are also calculated for SWWTSs. The fraction of the pollution load emitted directly to surface water and soil varies from year to year and is described in tables 4, 6 and 7.

8 Description of emission pathways to water

The emissions to water described in this fact sheet are direct emissions into surface water. This means that emissions to water (including those in table 9) reach the surface water in their entirety and with no significant delay.

9 Spatial allocation

The spatial distribution of emissions is worked out on the basis of a set of digital maps held by the Netherlands Environmental Assessment Agency (PBL). These maps present the spatial distribution of all kinds of parameters throughout the Netherlands, such as population density, traffic intensity, area of agricultural crops, etc. For the purposes of emission registration these maps are used as 'locators' to determine the spatial distribution of emissions. The range of possible locators is limited (see [9] for a list of available locators), as not every conceivable parameter can be used as a locator. That is why the locator judged to be the best proxy of the activity rate of the emission in question is used.
It is assumed that the distribution of emissions throughout the country is proportional to the national distribution of the locator.

The table below shows the locator used for the spatial allocation of the various emission sources.

Table 10: Summary of spatial allocation method

Element	Locators
Combined sewer overflows	Overflow locations (historic)
Separate stormwater sewers	Locations of stormwater sewer outlets (historic)
Inhabitants, not treated in UWWTP	Number of inhabitants per grid cell measuring 500x500 metres, not connected
Inhabitants, SWWTSs	Number of inhabitants per grid cell measuring 500x500 metres, not connected
UWWTP effluents, calculated	Location of individual UWWTPs, pro-rata based on N in influent

The method used to determine the locators is described in [9]:

Locations of overflows and stormwater sewer outlets
The distribution is applied to emissions from combined sewer overflows and separate stormwater sewers into surface water as calculated by the Netherlands Centre for Water Management (Riza). The emissions records show locations of combined sewer overflows and rainwater sewer discharge points. The emissions are distributed among the number of 'upstream' inhabitants in the area served by sewers in which a particular discharge point is located. This is done for areas of 500 x 500 metres. Information on the type of sewer system is taken from the sewer units map (from PBL/ERC geodata). Information on overflows and discharge points dates back to the late 1990s. Data on inhabitants covers the year 2005. Information from the sewer units map dates back to approximately 2003.

Number of inhabitants
The number of inhabitants per grid cell measuring 500x500 metres is derived from the PBL's map of grid cell distribution based on the number of inhabitants, residential dwelling units and inhabitants per sewer unit. This map is based on figures produced by Statistics Netherlands (CBS) on numbers of inhabitants and numbers of residential dwelling units in each local authority (for 2005). The distribution of inhabitants among grid cells in a local authority was calculated using the extensive database of address coordinates in the Netherlands (which contains addresses and types of dwelling unit) and the 2003 sewer unit database.

Location of individual UWWTPs
Statistics Netherlands provides information on the location of UWWTPs (address details and coordinates) and figures on quantities of treatment sludge produced and its metal and nutrient content. Most of the sludge is incinerated, while a much smaller proportion is landfilled. Rules on heavy metal content have led to a significant decline on its use in agriculture since 1995. The distribution is linked to the location of the waste water processing plant, based on the sludge's heavy metal content.

Effluents (the discharges left behind after waste water treatment) from UWWTPs are regarded as part of individually registered industrial emissions and as such are directly linked to the location.

10 Comments and changes in regard to previous version

The method has been drastically changed from that used in previous years as a result of
a) in 2007: publication of De Heer's model;
b) in 2008: improvement in information on removal efficiencies for UWWTPs and SWWTSs.

11 Accuracy and indicated subjects for improvement

In classifying the quality of information the method used in Emission Inventory publications has been followed as far as possible [10]. It is based on the CORINAIR (CORe emission INventories AIR) methodology, which applies the following quality classifications:

A: a value based on a large number of measurements from representative sources;
B: a value based on a number of measurements from some of the sources that are representative of the sector;
C: a value based on a limited number of measurements, together with estimates based on technical knowledge of the process;
D: a value based on a small number of measurements, together with estimates based on assumptions;
E: a value based on a technical calculation on the basis of a number of assumptions.

The accuracy of input data depends on how this data is quantified. In some cases this is based on a reasonably accurate model, topped up with measurements. In other cases it is not much more than an estimate. The accuracy classification ranges from B to E depending on the source. See the relevant fact sheets for more information.
Destination data is based on De Heer's detailed model, which takes account of a large body of practical experience, and is classified in accuracy class C.
Data on UWWTP and SWWTS removal efficiencies is based on interpretations of records that have been collected. These are most accurate for UWWTP nutrient content and least accurate for the 'other substances' content of SWWTSs. Information on nutrients and heavy metals in UWWTP effluents is reported elsewhere and is not taken into account in this study.

Element of emission calculation	**Reliability class**
Input	B-E
Destination	C
Removal efficiencies	
- other substances, UWWTPs	C
- nutrients, SWWTSs	C
- heavy metals, SWWTSs	D
- other substances, SWWTSs	D
Compartment distribution	B
Emission pathways to water	C
Spatial allocation	
- UWWTPs	A
- Other	D

The most significant areas for improvement are:
- When quantifying the various sources, also an estimate of the distribution of emissions to atmosphere, soil, and directly into surface water is produced. But De Heer's model again determines emissions into atmosphere and surface water. The current calculation does correct for this, but not completely. This means that in the way the model is currently applied, emissions to surface water are in some cases lower because pollution enters the soil while these emissions into soil are not

taken into account in other calculations. We recommend consulting Mr. de Heer and revising the model to make it more suitable for this application.

- Stronger arguments for the reduction in water pollution as a consequence of removing sewage sediments. It may be necessary to adjust this value, showing values for each substance separately.
- A closer assessment of assumed UWWTP and SWWTSs removal efficiencies, taking account of the connections between the two types of facility.
- Spatial distribution of emissions could be made more accurate by also allocating emissions to separate sewer systems.
- Improving spatial allocation of emissions from SWWTSs by application of information on the areas in which SWWTSs are used.
- Improving spatial allocation for various systems, especially combined sewer overflows.

12 Request for reactions

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13 References

[1] Rijkswaterstaat waterdienst, 2008. Effluenten RWZI's (gemeten), factsheets industriële en communale bronnen. RWS-WD, Lelystad, juni 2008.

[2] Heer, H. de, 2007, Aanpassing procesmodellen ten behoeve van hoeveelheidschattingen lozing microverontreinigingen met communaal afvalwater, afkomstig van huishoudens, RIZA, Lelystad.

[3] http://www.rijkswaterstaat.nl/rws/riza/wateremissies/Bibliotheek/ under 'diffuse bronnen'.

[4] Leidraad Riolering, maart 2006, concept module C 2200

[5] Stichting RIONED, 2005. Riool in cijfers 2005-2006. Stichting RIONED, Ede.

[6] Rijkswaterstaat waterdienst, 2008. Huishoudelijk afvalwater, factsheet diffuse bronnen. RWS-WD, Lelystad, juni 2008.

[7] Witteveen en Bos, 2006, Zuiveringsrendementen RWZI voor gebruik in de landelijke Emissieregistratie, Witteveen en Bos, Proj. Nr. RW 1628-1, Deventer.

[8] DHV, 2006, Witte vlekken riolering en afvalwaterzuivering, schatting landelijke emissies met SESRIO, DHV, Amersfoort.

[9] Molder, R. te, 2007. Notitie ruimtelijke verdeling binnen de emissieregistratie. Een overzicht.

[10] Most, P.F.J. van der, van Loon, M.M.J., Aulbers, J.A.W. en van Daelen, H.J.A.M., juli 1998. Methoden voor de bepaling van emissies naar lucht en water. Publicatiereeks Emissieregistratie, nr. 44.

Appendix 1
Calculated emissions 1990-2006

Table B1.1: Emissions from overflows into surface water (kg)

Component	1990	1995	2000	2005	2006
N - total	1,153,523.04	887,741.82	500,438.66	220,486.29	172,479.55
P - total	118,115.80	91,710.34	50,628.09	15,948.57	10,028.08
Chlorobenzenes	0.05	0.11	0.08	0.04	0.03
Dichlorobenzene, 1,4-	56.99	41.20	21.76	6.48	4.13
Hexachlorobenzene	0.21	0.19	0.14	0.06	0.05
Trichlorobenzenes	30.94	22.40	11.82	3.52	2.24
Tetrachloroethene	1.76	1.18	0.49	0.13	0.08
Tetrachloromethane	6.32	3.88	1.81	0.54	0.34
Phenol and phenolates	0.00	3.93	6.36	7.48	3.63
Diuron	62.00	10.23	0.00	0.00	0.00
Phthalates	0.00	0.00	5.31	0.01	0.00
Glyphosate	22.32	75.05	762.30	1,305.56	1,193.80
Di(2-ethylhexyl)phthalate	173.65	125.55	66.31	19.73	12.58
Dibutylphthalate	28.42	20.54	10.85	3.23	2.06
Benzene	210.92	32.27	7.02	1.57	2.28
Ethylbenzene	9.20	45.53	13.88	2.87	2.45
Isopropylbenzene	0.03	0.09	0.01	0.05	0.05
Styrene		0.06	7.29	1.60	1.52
Toluene	462.23	53.76	24.71	5.02	3.56
Aluminium compounds (as Al)	0.00	0.00	0.00	109.51	94.61
Antimony compounds (as Sb)	159.99	227.97	199.80	157.97	144.48
Arsenic compounds (as As)	179.70	114.04	44.42	20.94	17.80
Barium compounds (as Ba)	3,212.79	5,181.40	4,654.61	3,676.08	3,361.44
Cadmium compounds (as Cd)	50.05	46.50	24.70	8.76	7.77
Chromium compounds (as Cr)	896.35	861.33	602.06	425.70	389.60
Copper compounds (as Cu)	4,190.11	3,964.49	3,115.55	1,980.03	1,775.58
Mercury compounds (as Hg)	140.02	53.03	14.04	5.73	4.79
Lead compounds (as Pb)	2,458.60	2,048.49	1,574.11	850.96	777.18
Molybdenum compounds (as Mo)	0.00	0.00	0.84	1.30	0.55
Nickel compounds (as Ni)	784.14	694.99	400.50	257.76	232.92
Strontium compounds(as Sr)	780.89	1,259.37	1,131.33	893.45	816.97
Tin compounds (as Sn)	0.00	0.21	0.00	0.16	0.08
Silver compounds (as Ag)	2.90	25.98	2.26	0.57	0.14
Zinc compounds (as Zn)	14,375.14	11,400.89	6,935.67	4,191.31	3,720.56
Cyanides	10.04	3.80	4.87	0.07	0.13
Nonylphenol/Ethoxylates(Np/Npe)	286.68	207.27	109.47	32.57	20.76
Organotin compounds	0.00	0.71	0.00	0.00	0.00
Dichloromethane	58.88	42.57	22.49	6.69	4.26
Trichloromethane	24.82	18.25	9.63	2.83	1.80
Dichloroethane, 1,2-	37.12	1.14	0.39	0.43	0.12
Dichloroethene, 1,2-	0.00	0.33	0.12	0.00	0.00
Endosulfan	0.00	0.00	0.00	0.00	0.00
Hexachlorocyclohexane	1.90	0.68	0.00	0.00	0.00
Trichloroethane, 1,1,1-	0.02	0.18	0.00	0.00	0.00

Trichloroethene	703.45	4.09	4.24	0.38	0.22
Chlorophenolene	0.00	0.13	0.00	4.03	2.91
Pentachlorophenol	3.95	0.80	0.36	0.10	0.07
Vinyl chloride	0.00	0.00	0.00	0.04	0.01
PAH (Borneff 6)	797.28	488.75	194.32	119.26	109.23
Benzo[a]pyrene	22.46	16.60	10.03	7.38	6.78
Benzo(ghi)perylene	42.78	29.59	15.86	11.67	10.72
Benzo[k]fluoranthene	41.28	26.62	12.17	8.73	7.98
Fluoranthene	660.90	397.96	149.46	86.09	78.66
Indeno[1,2,3-cd]pyrene	15.19	10.20	5.13	3.71	3.40
Anthracene	76.53	47.76	20.05	12.30	11.28
Benzo(a)anthracene	8.17	8.03	6.86	5.21	4.81
Chyrsene	11.36	10.80	8.90	6.77	6.24
Phenanthrene	42.45	42.24	36.51	27.68	25.52
Naphthalene	321.52	289.29	227.64	169.63	156.67
PCBs	1.88	1.60	1.27	0.54	0.43
Simazine	0.00	0.38	0.00	0.00	0.00
Xylenes (total)	70.03	61.41	18.94	6.40	2.25
Chlorides	1,153,090.16	815,992.43	577,214.39	164,799.46	72,910.38
Anorganic fluorine compounds (as F)	2,721.05	187.37	255.66	42.06	28.94
Sulphates (as SO4)	227,918.17	132,854.31	94,788.91	38,616.09	16,998.89

Table B1.2: Emissions from separate stormwater sewers into surface water (kg)

Component	1990	1995	2000	2005	2006
N - total	822,992.28	916,656.12	1,006,802.27	1,055,809.67	1,015,051.78
P - total	21,171.70	32,222.55	41,301.86	47,845.70	45,842.65
Chlorobenzenes	0.09	0.20	0.32	0.25	0.23
Dichlorobenzene, 1,4-	10.22	14.48	17.75	19.43	18.87
Hexachlorobenzene	0.12	0.23	0.36	0.30	0.28
Trichlorobenzenes	5.55	7.87	9.64	10.55	10.24
Tetrachloroethene	0.32	0.41	0.40	0.40	0.38
Tetrachloromethane	1.13	1.36	1.48	1.62	1.57
Phenol and phenolates	0.00	1.38	5.19	22.44	16.60
Diuron	117.38	24.67	0.00	0.00	0.00
Phthalates	0.00	0.00	4.33	0.03	0.00
Glyphosate	42.26	181.02	2,958.90	7,879.08	7,807.96
Di(2-ethylhexyl)phthalate	31.13	44.11	54.10	59.19	57.50
Dibutylphthalate	5.09	7.22	8.85	9.69	9.41
Benzene	37.81	11.34	5.72	4.70	10.45
Ethylbenzene	1.65	16.00	11.32	8.62	11.18
Isopropylbenzene	0.00	0.03	0.01	0.16	0.21
Styrene		0.02	5.95	4.81	6.95
Toluene	82.85	18.89	20.16	15.06	16.27
Aluminium compounds (as Al)	0.00	0.00	0.00	328.52	432.49
Antimony compounds (as Sb)	296.64	547.72	774.65	951.87	944.35
Arsenic compounds (as As)	259.19	218.60	128.03	112.86	111.10
Barium compounds (as Ba)	6,082.29	12,498.22	18,067.08	22,184.73	21,984.86
Cadmium compounds (as Cd)	75.34	96.80	85.03	49.89	49.51
Chromium compounds (as Cr)	1,362.80	1,749.89	2,215.53	2,539.52	2,537.25
Copper compounds (as Cu)	5,559.24	7,611.68	10,719.86	11,557.53	11,455.62
Mercury compounds (as	254.56	122.80	49.36	33.37	30.87

Hg)					
Lead compounds (as Pb)	4,248.50	4,632.36	5,906.48	5,084.88	5,062.74
Molybdenum compounds (as Mo)	0.00	0.00	0.69	3.89	2.52
Nickel compounds (as Ni)	942.96	1,252.81	1,369.22	1,504.46	1,501.91
Strontium compounds(as Sr)	1,478.33	3,037.76	4,391.30	5,392.00	5,343.33
Tin compounds (as Sn)	0.00	0.07	0.00	0.47	0.38
Silver compounds (as Ag)	0.52	9.13	1.85	1.72	0.64
Zinc compounds (as Zn)	23,632.92	23,147.40	24,772.88	24,637.15	24,068.30
Cyanides	1.80	1.33	3.97	0.20	0.60
Nonylphenol/Ethoxylates(Np/Npe)	51.39	72.83	89.31	97.72	94.92
Organotin compounds	0.00	0.25	0.00		0.00
Dichloromethane	10.55	14.96	18.34	20.07	19.50
Trichloromethane	4.45	6.41	7.85	8.49	8.23
Dichloroethane, 1,2-	6.65	0.40	0.32	1.29	0.55
Dichloroethene, 1,2-	0.00	0.11	0.10	0.00	0.00
Endosulfan	0.00	0.00	0.00	0.00	0.00
Hexachlorocyclohexane	0.34	0.24	0.00	0.00	0.00
Trichloroethane, 1,1,1-	0.00	0.06	0.00	0.00	0.00
Trichloroethene	126.09	1.44	3.46	1.14	1.02
Chlorophenolene	0.00	0.05	0.00	12.08	13.31
Pentachlorophenol	0.71	0.28	0.29	0.31	0.31
Vinyl chloride	0.00	0.00	0.00	0.12	0.04
PAH (Borneff 6)	1,508.45	1,177.94	753.91	719.65	714.35
Benzo[a]pyrene	41.41	39.08	38.18	44.33	44.22
Benzo(ghi)perylene	80.73	71.16	61.38	70.40	70.10
Benzo[k]fluoranthene	77.72	63.83	46.94	52.57	52.15
Fluoranthene	1,244.42	954.06	575.53	518.17	513.89
Indeno[1,2,3-cd]pyrene	28.52	24.39	19.76	22.34	22.20
Anthracene	144.68	115.04	77.68	74.18	73.76
Benzo(a)anthracene	14.75	18.75	26.15	31.33	31.39
Chyrsene	20.35	25.05	33.77	40.65	40.71
Phenanthrene	76.41	98.46	139.01	166.26	166.61
Naphthalene	604.08	693.81	880.44	1,022.80	1,024.30
PCBs	3.07	3.86	4.92	3.25	2.79
Simazine	0.00	0.92	0.00	0.00	0.00
Xylenes (total)	12.55	21.58	15.45	19.20	10.29
Chlorides	206,685.97	286,700.04	470,885.42	494,398.38	333,304.61
Anorganic fluorine compounds (as F)	487.73	65.83	208.57	126.18	132.31
Sulphates (as SO4)	40,853.26	46,678.54	77,327.80	115,848.28	77,709.20

Table B1.3: Emissions from rainwater sewer systems into soil (kg)

Component	1990	1995	2000	2005	2006
N - total	72,489.45	58,936.56	100,576.84	168,357.46	179,706.13
P - total					
Chlorobenzenes	0.01	0.02	0.04	0.05	0.05
Dichlorobenzene, 1,4-					
Hexachlorobenzene	0.01	0.02	0.04	0.05	0.05
Trichlorobenzenes					
Tetrachloroethene					
Tetrachloromethane					
Phenol and phenolates					

Diuron	12.50	2.05	0.00	0.00	0.00
Phthalates					
Glyphosate	4.50	15.07	392.70	1,691.64	1,864.36
Di(2-ethylhexyl)phthalate					
Dibutylphthalate					
Benzene					
Ethylbenzene					
Isopropylbenzene					
Styrene					
Toluene					
Aluminium compounds (as Al)					
Antimony compounds (as Sb)	31.52	45.57	102.78	204.05	225.15
Arsenic compounds (as As)	26.70	17.40	15.43	21.37	23.57
Barium compounds (as Ba)	647.74	1,040.62	2,397.83	4,762.96	5,249.27
Cadmium compounds (as Cd)	7.81	7.84	10.90	10.07	11.11
Chromium compounds (as Cr)	141.41	141.05	289.75	538.96	599.81
Copper compounds (as Cu)	565.61	606.06	1,374.22	2,398.22	2,648.03
Mercury compounds (as Hg)	26.99	10.15	6.37	6.91	7.11
Lead compounds (as Pb)	447.93	381.31	776.71	1,080.97	1,197.58
Molybdenum compounds (as Mo)					
Nickel compounds (as Ni)	94.39	98.30	175.17	312.15	346.71
Strontium compounds(as Sr)	157.44	252.93	582.81	1,157.66	1,275.86
Tin compounds (as Sn)					
Silver compounds (as Ag)					
Zinc compounds (as Zn)	2,476.93	1,865.48	3,211.95	5,150.07	5,599.63
Cyanides					
Nonylphenol/Ethoxylates(Np/Npe)					
Organotin compounds					
Dichloromethane					
Trichloromethane					
Dichloroethane, 1,2-					
Dichloroethene, 1,2-					
Endosulfan					
Hexachlorocyclohexane					
Trichloroethane, 1,1,1-					
Trichloroethene					
Chlorophenolene					
Pentachlorophenol					
Vinyl chloride					
PAH (Borneff 6)	160.63	98.06	100.05	154.49	170.53
Benzo[a]pyrene	4.40	3.24	5.04	9.47	10.51
Benzo(ghi)perylene	8.60	5.92	8.14	15.10	16.73
Benzo[k]fluoranthene	8.27	5.31	6.22	11.27	12.43
Fluoranthene	132.45	79.35	76.22	110.96	122.39
Indeno[1,2,3-cd]pyrene	3.03	2.03	2.62	4.79	5.29
Anthracene	15.41	9.58	10.30	15.92	17.60
Benzo(a)anthracene	1.56	1.55	3.45	6.70	7.46
Chyrsene	2.15	2.07	4.45	8.68	9.67
Phenanthrene	8.09	8.15	18.35	35.53	39.60

Naphthalene	64.28	57.71	116.74	219.40	244.37
PCBs	0.32	0.32	0.65	0.70	0.67
Simazine	0.00	0.08	0.00	0.00	0.00
Xylenes (total)					
Chlorides					
Anorganic fluorine compounds (as F)					
Sulphates (as SO4)					

Table B1.4: Emissions from untreated sewer (kg)

Component	1990	1995	2000	2005	2006
N - total	1,466,900.64	425,488.16	0.00	0.00	0.00
P - total	202,802.59	61,966.45	0.00	0.00	0.00
Chlorobenzenes	0.02	0.03	0.00	0.00	0.00
Dichlorobenzene, 1,4-	97.85	27.84	0.00	0.00	0.00
Hexachlorobenzene	0.29	0.08	0.00	0.00	0.00
Trichlorobenzenes	53.13	15.14	0.00	0.00	0.00
Tetrachloroethene	3.02	0.80	0.00	0.00	0.00
Tetrachloromethane	10.85	2.62	0.00	0.00	0.00
Phenol and phenolates	0.00	2.65	0.00	0.00	0.00
Diuron	17.88	0.83	0.00	0.00	0.00
Phthalates	0.00	0.00	0.00	0.00	0.00
Glyphosate	6.44	6.12	0.00	0.00	0.00
Di(2-ethylhexyl)phthalate	298.16	84.83	0.00	0.00	0.00
Dibutylphthalate	48.79	13.88	0.00	0.00	0.00
Benzene	362.14	21.80	0.00	0.00	0.00
Ethylbenzene	15.79	30.76	0.00	0.00	0.00
Isopropylbenzene	0.05	0.06	0.00	0.00	0.00
Styrene		0.04	0.00	0.00	0.00
Toluene	793.65	36.32	0.00	0.00	0.00
Aluminium compounds (as Al)	0.00	0.00	0.00	0.00	0.00
Antimony compounds (as Sb)	51.33	19.22	0.00	0.00	0.00
Arsenic compounds (as As)	119.33	25.58	0.00	0.00	0.00
Barium compounds (as Ba)	926.27	422.75	0.00	0.00	0.00
Cadmium compounds (as Cd)	30.61	8.22	0.00	0.00	0.00
Chromium compounds (as Cr)	536.94	164.76	0.00	0.00	0.00
Copper compounds (as Cu)	3,186.33	885.96	0.00	0.00	0.00
Mercury compounds (as Hg)	49.14	5.80	0.00	0.00	0.00
Lead compounds (as Pb)	1,047.24	256.18	0.00	0.00	0.00
Molybdenum compounds (as Mo)			0.00	0.00	0.00
Nickel compounds (as Ni)	677.48	178.82	0.00	0.00	0.00
Strontium compounds(as Sr)	225.13	102.75	0.00	0.00	0.00
Tin compounds (as Sn)				0.00	0.00
Silver compounds (as Ag)	4.97	17.55	0.00	0.00	0.00
Zinc compounds (as Zn)	7,129.76	2,185.11	0.00	0.00	0.00
Cyanides	17.24	2.57	0.00	0.00	0.00
Nonylphenol/Ethoxylates(Np/Npe)	492.23	140.05	0.00	0.00	0.00
Organotin compounds	0.00	0.48		0.00	0.00
Dichloromethane	101.10	28.77	0.00	0.00	0.00
Trichloromethane	42.61	12.33	0.00	0.00	0.00

Dichloroethane, 1,2-	63.73	0.77	0.00	0.00	0.00
Dichloroethene, 1,2-	0.00	0.22	0.00	0.00	0.00
Endosulfan	0.00	0.00	0.00	0.00	0.00
Hexachlorocyclohexane	3.25	0.46	0.00	0.00	0.00
Trichloroethane, 1,1,1-	0.03	0.12	0.00	0.00	0.00
Trichloroethene	1,207.81	2.76	0.00	0.00	0.00
Chlorophenolene	0.00	0.09	0.00	0.00	0.00
Pentachlorophenol	6.78	0.54	0.00	0.00	0.00
Vinyl chloride				0.00	0.00
PAH (Borneff 6)	230.64	40.16	0.00	0.00	0.00
Benzo[a]pyrene	7.40	1.63	0.00	0.00	0.00
Benzo(ghi)perylene	12.55	2.48	0.00	0.00	0.00
Benzo[k]fluoranthene	12.27	2.28	0.00	0.00	0.00
Fluoranthene	196.18	34.17	0.00	0.00	0.00
Indeno[1,2,3-cd]pyrene	4.57	0.89	0.00	0.00	0.00
Anthracene	22.22	3.94	0.00	0.00	0.00
Benzo(a)anthracene	2.95	0.83	0.00	0.00	0.00
Chyrsene	4.24	1.17	0.00	0.00	0.00
Phenanthrene	15.53	4.44	0.00	0.00	0.00
Naphthalene	96.53	24.76	0.00	0.00	0.00
PCBs	0.95	0.13	0.00	0.00	0.00
Simazine	0.00	0.03	0.00	0.00	0.00
Xylenes (total)	120.25	41.50	0.00	0.00	0.00
Chlorides	1,979,834.05	551,346.23	0.00	0.00	0.00
Anorganic fluorine compounds (as F)	4,671.98	126.60	0.00	0.00	0.00
Sulphates (as SO4)	391,331.20	89,766.43	0.00	0.00	0.00

Table B1.5: Emission of effluents from UWWTPs (kg)

Component	1990	1995	2000	2005	2006
N - total	elsewhere [1)]				
P - total	elsewhere [1)]				
Chlorobenzenes	0.12	0.19	0.25	0.36	0.16
Dichlorobenzene, 1,4-	589.20	629.75	660.37	686.42	688.37
Hexachlorobenzene	1.61	1.75	1.88	1.89	1.88
Trichlorobenzenes	344.50	368.73	386.18	401.35	402.49
Tetrachloroethene	10.25	10.02	8.24	7.64	7.63
Tetrachloromethane	30.15	27.40	25.33	26.35	26.43
Phenol and phenolates		419.37	1,333.86	5,446.58	4,154.47
Diuron	902.21	152.36	0.00	0.00	0.00
Phthalates			861.20	5.60	0.03
Glyphosate	135.88	467.65	6,100.19	14,423.39	14,402.56
Di(2-ethylhexyl)phthalate	690.51	738.04	773.93	804.46	806.74
Dibutylphthalate	1,943.48	2,077.24	2,178.25	2,264.18	2,270.60
Benzene	1,932.03	430.26	183.66	142.31	326.57
Ethylbenzene	68.41	496.85	297.51	213.79	285.95
Isopropylbenzene	0.18	0.88	0.18	3.47	4.72
Styrene		1.34	295.63	225.27	336.18
Toluene	3,836.79	642.42	582.20	410.30	458.31
Aluminium compounds (as Al)	0.00	0.00	0.00	18,118.54	24,600.55
Antimony compounds (as Sb)	183.76	250.34	277.39	325.14	325.17
Arsenic compounds (as As)	elsewhere [1)]				

Barium compounds (as Ba)	35,779.58	59,063.06	68,136.22	74,391.66	74,368.43
Cadmium compounds (as Cd)	elsewhere [1)]				
Chromium compounds (as Cr)	elsewhere [1)]				
Copper compounds (as Cu)	elsewhere [1)]				
Mercury compounds (as Hg)	elsewhere [1)]				
Lead compounds (as Pb)	elsewhere [1)]				
Molybdenum compounds (as Mo)			160.18	857.23	573.65
Nickel compounds (as Ni)	elsewhere [1)]				
Strontium compounds(as Sr)	11,595.24	19,140.80	22,081.18	24,074.53	24,039.76
Tin compounds (as Sn)				115.42	96.10
Silver compounds (as Ag)	84.47	1,103.25	188.83	166.24	63.84
Zinc compounds (as Zn)	elsewhere [1)]				
Cyanides	250.97	138.28	348.08	16.38	51.31
Nonylphenol/Ethoxylates(Np/Npe)	8,891.81	9,503.79	9,965.91	10,359.06	10,388.42
Organotin compounds	0.00	81.86			
Dichloromethane	655.61	700.73	734.81	763.79	765.96
Trichloromethane	276.32	300.63	314.75	323.09	323.22
Dichloroethane, 1,2-	927.64	41.45	28.04	106.82	46.68
Dichloroethene, 1,2-	0.00	3.95	2.81	0.05	0.05
Endosulfan				0.00	0.00
Hexachlorocyclohexane	137.17	73.27	0.00	0.00	0.00
Trichloroethane, 1,1,1-	0.11	1.50	0.01	0.03	0.03
Trichloroethene	5,273.88	44.62	91.02	28.17	25.98
Chlorophenolene				2,432.08	2,762.88
Pentachlorophenol	141.24	42.44	37.47	38.44	38.55
Vinyl chloride				1.91	0.77
PAH (Borneff 6)	1,900.13	1,196.68	610.95	517.59	521.90
Benzo[a]pyrene	45.04	36.03	29.84	30.83	30.98
Benzo(ghi)perylene	45.15	32.27	22.53	22.96	23.04
Benzo[k]fluoranthene	75.56	50.84	31.02	30.98	30.98
Fluoranthene	4,128.22	2,599.67	1,328.23	1,098.36	1,096.64
Indeno[1,2,3-cd]pyrene	16.38	11.53	7.77	7.83	7.84
Anthracene	365.92	234.93	128.11	109.28	109.47
Benzo(a)anthracene	28.14	29.04	31.90	33.79	34.06
Chyrsene	38.23	38.56	41.22	43.77	44.09
Phenanthrene	537.76	560.71	621.59	657.44	662.81
Naphthalene	2,226.49	2,067.96	2,098.00	2,166.20	2,185.06
PCBs	2.31	1.22	1.24	0.73	0.63
Simazine	0.00	5.75	0.00	0.00	0.00
Xylenes (total)	465.92	595.64	360.90	423.26	233.89
Chlorides	96,054,585.99	99,021,783.71	137,620,061.40	136,334,097.50	94,793,915.03
Anorganic fluorine compounds (as F)	226,668.23	22,737.46	60,955.49	34,795.55	37,629.26
Sulphates (as SO4)	18,986,013.72	16,122,050.02	22,599,672.19	31,946,041.04	22,100,982.09

[1)] quantified elsewhere, see [1]

Table B1.6: Emissions from SWWTSs into water (kg)

Component	1990	1995	2000	2005	2006
N - total	0.00	0.00	0.00	83,845.45	97,987.67
P - total	0.00	0.00	0.00	10,322.61	12,063.73

Chlorobenzenes					
Dichlorobenzene, 1,4-	0.00	0.00	0.00	12.95	15.13
Hexachlorobenzene	0.00	0.00	0.00	0.01	0.02
Trichlorobenzenes	0.00	0.00	0.00	4.47	5.23
Tetrachloroethene					
Tetrachloromethane	0.00	0.00	0.00	1.86	2.17
Phenol and phenolates					
Diuron					
Phthalates					
Glyphosate					
Di(2-ethylhexyl)phthalate	0.00	0.00	0.00	17.94	20.96
Dibutylphthalate	0.00	0.00	0.00	2.94	3.43
Benzene	0.00	0.00	0.00	0.07	0.08
Ethylbenzene	0.00	0.00	0.00	0.07	0.08
Isopropylbenzene					
Styrene					
Toluene	0.00	0.00	0.00	1.50	1.75
Aluminium compounds (as Al)					
Antimony compounds (as Sb)					
Arsenic compounds (as As)	0.00	0.00	0.00	2.61	3.05
Barium compounds (as Ba)					
Cadmium compounds (as Cd)	0.00	0.00	0.00	1.47	1.72
Chromium compounds (as Cr)	0.00	0.00	0.00	2.61	3.05
Copper compounds (as Cu)	0.00	0.00	0.00	127.97	149.55
Mercury compounds (as Hg)	0.00	0.00	0.00	0.35	0.41
Lead compounds (as Pb)	0.00	0.00	0.00	10.31	12.04
Molybdenum compounds (as Mo)					
Nickel compounds (as Ni)	0.00	0.00	0.00	14.68	7.62
Strontium compounds(as Sr)					
Tin compounds (as Sn)					
Silver compounds (as Ag)					
Zinc compounds (as Zn)	0.00	0.00	0.00	201.35	235.31
Cyanides					
Nonylphenol/Ethoxylates(Np/Npe)	0.00	0.00	0.00	100.68	117.66
Organotin compounds					
Dichloromethane	0.00	0.00	0.00	23.11	27.01
Trichloromethane	0.00	0.00	0.00	9.73	11.37
Dichloroethane, 1,2-					
Dichloroethene, 1,2-					
Endosulfan					
Hexachlorocyclohexane	0.00	0.00	0.00	0.00	0.00
Trichloroethane, 1,1,1-					
Trichloroethene					
Chlorophenolene					
Pentachlorophenol	0.00	0.00	0.00	0.13	0.16
Vinyl chloride					
PAH (Borneff 6)	0.00	0.00	0.00	0.00	0.00
Benzo[a]pyrene	0.00	0.00	0.00	0.05	0.06
Benzo(ghi)perylene	0.00	0.00	0.00	0.01	0.01

Benzo[k]fluoranthene	0.00	0.00	0.00	0.02	0.02
Fluoranthene	0.00	0.00	0.00	0.33	0.38
Indeno[1,2,3-cd]pyrene	0.00	0.00	0.00	0.01	0.01
Anthracene	0.00	0.00	0.00	0.02	0.02
Benzo(a)anthracene	0.00	0.00	0.00	0.03	0.04
Chyrsene	0.00	0.00	0.00	0.06	0.07
Phenanthrene	0.00	0.00	0.00	0.33	0.39
Naphthalene	0.00	0.00	0.00	0.22	0.26
PCBs	0.00	0.00	0.00	0.00	0.00
Simazine					
Xylenes (total)	0.00	0.00	0.00	0.11	0.13
Chlorides					
Anorganic fluorine compounds (as F)					
Sulphates (as SO4)					

Table B1.7: Emissions from SWWTSs into soil (kg)

Component	1990	1995	2000	2005	2006
N - total	0.00	0.00	0.00	41,922.73	48,993.83
P - total	0.00	0.00	0.00	5,161.31	6,031.86
Chlorobenzenes					
Dichlorobenzene, 1,4-	0.00	0.00	0.00	6.48	7.57
Hexachlorobenzene	0.00	0.00	0.00	0.01	0.01
Trichlorobenzenes	0.00	0.00	0.00	2.24	2.61
Tetrachloroethene					
Tetrachloromethane	0.00	0.00	0.00	0.93	1.09
Phenol and phenolates					
Diuron					
Phthalates					
Glyphosate					
Di(2-ethylhexyl)phthalate	0.00	0.00	0.00	8.97	10.48
Dibutylphthalate	0.00	0.00	0.00	1.47	1.72
Benzene	0.00	0.00	0.00	0.03	0.04
Ethylbenzene	0.00	0.00	0.00	0.03	0.04
Isopropylbenzene					
Styrene					
Toluene	0.00	0.00	0.00	0.75	0.88
Aluminium compounds (as Al)					
Antimony compounds (as Sb)					
Arsenic compounds (as As)	0.00	0.00	0.00	1.30	1.52
Barium compounds (as Ba)					
Cadmium compounds (as Cd)	0.00	0.00	0.00	0.73	0.86
Chromium compounds (as Cr)	0.00	0.00	0.00	1.30	1.52
Copper compounds (as Cu)	0.00	0.00	0.00	63.98	74.78
Mercury compounds (as Hg)	0.00	0.00	0.00	0.18	0.21
Lead compounds (as Pb)	0.00	0.00	0.00	5.15	6.02
Molybdenum compounds (as Mo)					
Nickel compounds (as Ni)	0.00	0.00	0.00	7.34	3.81
Strontium compounds(as Sr)					

Tin compounds (as Sn)					
Silver compounds (as Ag)					
Zinc compounds (as Zn)	0.00	0.00	0.00	100.67	117.65
Cyanides					
Nonylphenol/Ethoxylates(Np/Npe)	0.00	0.00	0.00	50.34	58.83
Organotin compounds					
Dichloromethane	0.00	0.00	0.00	11.56	13.51
Trichloromethane	0.00	0.00	0.00	4.86	5.68
Dichloroethane, 1,2-					
Dichloroethene, 1,2-					
Endosulfan					
Hexachlorocyclohexane	0.00	0.00	0.00	0.00	0.00
Trichloroethane, 1,1,1-					
Trichloroethene					
Chlorophenolene					
Pentachlorophenol	0.00	0.00	0.00	0.07	0.08
Vinyl chloride					
PAH (Borneff 6)	0.00	0.00	0.00	0.00	0.00
Benzo[a]pyrene	0.00	0.00	0.00	0.03	0.03
Benzo(ghi)perylene	0.00	0.00	0.00	0.01	0.01
Benzo[k]fluoranthene	0.00	0.00	0.00	0.01	0.01
Fluoranthene	0.00	0.00	0.00	0.16	0.19
Indeno[1,2,3-cd]pyrene	0.00	0.00	0.00	0.01	0.01
Anthracene	0.00	0.00	0.00	0.01	0.01
Benzo(a)anthracene	0.00	0.00	0.00	0.02	0.02
Chyrsene	0.00	0.00	0.00	0.03	0.03
Phenanthrene	0.00	0.00	0.00	0.17	0.19
Naphthalene	0.00	0.00	0.00	0.11	0.13
PCBs	0.00	0.00	0.00	0.00	0.00
Simazine					
Xylenes (total)	0.00	0.00	0.00	0.05	0.06
Chlorides					
Anorganic fluorine compounds (as F)					
Sulphates (as SO4)					