Emission estimates for diffuse sources
Netherlands Emission Inventory

Oil spills by inland navigation

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

Oil spills by inland navigation

1 Description of emission source

The emissions described in this factsheet are the result of accidental and intentional discharges of liquid waste, not including discharge of bilge water for which a separate methodology has been established. Spills are caused by a series of incidents and events, in some cases intentionally. The nature of the spilled material varies from mineral oils such as fuels and greases to watery oil emulsions. This document is limited to emissions of mineral oil and PAH.
This emission source is allocated to the governmental target sector "Transport" within the national emissions inventory.

2 Explanation of calculation method

The emissions are calculated based on the recorded quantity of spills annually. An assumed composition of this spilled quantity is derived from the composition of the spills in the 1990-2000 time period. In this derivation, the activity rate (AR) is the annually registered spill quantity. The PAH profile of the average spill in the 1990-2000 period provides the emission factors (EF) for specific PAHs, expressed in emission per unit of the AR.
The emission calculated in this way is referred to as the total emission. Because this form of emission involves direct discharge into surface waters, the total emission is the same as the emission directly to water.

3 Activity rates

Until 2002, the quantity of spills was obtained from the registrations of the 'Werkgroep olie- en chemicaliënbestrijding binnenwateren' (WOCB), a working group of Directorate-General of Public Works & Water Management. The Netherlands Centre for Water Management (RIZA), an agency of the Ministry of Public Works & Water Management, took over the WOCB registration for 2003 and 2004. For 2005 and 2006, only the spills in the port areas of Amsterdam [5] and Rotterdam [6] were available; for inland waters, the data from 2004 was used.
The activity rate for spills is calculated as the total spills of mineral oils (excluding spills of bilge water) from which the removed quantities are withdrawn. The table below shows the quantity of spilled oil over the years.

Table 1: Activity rate (AR)

Year	Registered spills of mineral oil (kg)
1985	1,189,000
1990	803,000
1995	458,000
2000	41,000
2005	66,728
2006	59,180

4 Emission factors for the period 1990-2000

The emission factors for PAH from spills are determined in three steps:

- in the Netherlands, data on spills was registered in the period from 1990-2000 [1]. This data reports both the number of spills and the total spilled and removed quantities for all relevant types of contamination (diesel oil, lubricating oil, fuel oil, gas oil, etc.). Based on this data, a profile of the average composition of spills is produced, using both the available information on spills within national inland waters, spills on other inland waters and spills in the Rotterdam and Amsterdam port areas. This last category is interesting in relation to the high concentration of specific industrial, bunker and storage/transfer activities in the two port areas. In consideration of the intended result, this study examined only the group of mineral oils;
- for each spilled type (diesel oil, lubricating oil, etc.) one standard PAH profile [2,3] for mineral oils was applied. This assumes that the PAH-profile is comparable to that of either diesel oil, gas oil or fuel oil, or that a specific component contains no PAH. Based on this figure and the total quantity of spilled material, the total PAH emission is calculated;
- the average PAH concentration and the PAH profile is obtained by dividing the total PAH emission (in kg) by the spills total (in kg).

The PAH profiles for the diesel oil, lubricating oil and fuel oil are shown in table 2. For the components in italics, no profile was available and the concentration of these components is an estimate. This estimate is based on the fact that as a rule, PAH contents in mineral oils decrease when arranged in this sequence (by molecular weight).

Table 2: PAH profiles for petrol, diesel and fuel oil (in g/kg)

	Petrol	**Diesel**	**Fuel oil**
Naphthalene	*0.075*	1.08	3.24
Phenanthrene	0.056	0.75	2.25
Anthracene	0.0037	0.15	0.45
Fluoranthene	0.0041	0.10	0.30
Chrysene	0.0018	0.010	0.030
Benzo[a]anthracene	0.0020	0.020	0.062
Benzo[b]fluoranthene	0.0017	*0.015*	*0.025*
Benzo[k]fluoranthene	0.0017	*0.015*	*0.025*
Indeno[1,2,3-cd]pyrene	0.0005	*0.015*	*0.025*
Benzo[g,h,i]perylene	0.0022	0.00035	0.001
Benzo[a]pyrene	0.0017	0.010	0.030

The PAH profile of the spills is shown in the table below.

Table 3: PAH profile for spills (g/kg mineral oil)

	VROM-10	**Borneff-6**
Naphthalene	1.15	
Phenanthrene	0.81	
Anthracene	0.16	
Fluoranthene	0.11	0.11
Chrysene	0.011	
Benzo[a]anthracene	0.022	
Benzo[b]fluoranthene		0.0002
Benzo[k]fluoranthene	0.0002	0.0002
Indeno[1,2,3-cd]pyrene	0.00005	0.00005
Benzo[g,h,i]perylene	0.0004	0.0004
Benzo[a]pyrene	0.011	0.011
Total	**2.28**	**0.12**

5 Effects of policy measures

Measures against spills consist primarily of handling oil residues more carefully on board and acting against spills through enforcement. The effectiveness of such measures is difficult to document.

6 Time series of emission factors

Because there are no known steps that have an impact on the emission factors identified in section 4, the emission factors remain constant over time. From 1985 on, there is a falling trend in the registered spills.

7 Emissions calculated

The table below shows the calculated emissions, expressed in kg/year. The emission factors were calculated by multiplying the emission factors from section 6 by the activity rate shown in section 3.

Table 4: Emissions of mineral oil and PAH resulting from spills (kg/year)

	Mineral oil	Naphthalene	Phenanthrene	Anthracene	Fluoranthene	Chrysene	Benzo[a]anthracene
1985	1.189.000	1373	962	192	128	12.9	26.3
1990	803.000	927	650	130	87	8.7	17.8
1995	458.000	529	371	74	49	5.0	10.1
2000	41.000	47	33	6.6	4.4	0.4	0.9
2005	66.728	77	54	11	7.2	1.5	1.0
2006	59.180	68	48	9.6	6.4	0.6	1.3

Table 4, continued: Emissions of PAH and PAH-total resulting from spills (kg/year)

	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Indeno[1,2,3-cd]pyrene	Benzo[g,h,i]perylene	Benzo[a]pyrene	VROM-10	Borneff-6
1985	0.2	0.2	0.06	0.5	13	2708	142
1990	0.1	0.1	0.04	0.3	8.8	1829	96
1995	0.07	0.07	0.02	0.2	5	1043	55
2000	0.01	0.01	0.002	0.02	0.5	93	4.9
2005	0.01	0.01	0.003	0.03	0.7	152	8.0
2006	0.01	0.01	0.003	0.02	0.6	135	7.1

8 Release into environmental compartments

The full amount of the emissions is discharged to the surface water. Emissions to the soil and atmosphere can be assumed to be negligible.

9 Description of emission pathways to water

The full amount of the emissions is discharged directly to the surface water. There are no emissions of this type to the sewer system.

10 Spatial allocation

The spatial distribution of emissions is assigned on the basis of a set of digital maps held by the Netherlands Environmental Assessment Agency (PBL) drawn up using emission records. 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 [15] 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 emissions in the Amsterdam and Rotterdam port areas are quantified separately based on the spill reports [1]. The emissions of the other inland waters are spatially allocated using data on the amount of cargo capacity per shipping section transported by inland waterway shipping, expressed in the number of tonne-kilometres (the number of tonnes of capacity times the number of km over which that capacity is transported), as recorded in the emission inventory.

11 Comments and changes in regard to previous version

There have been no changes made in the methodology for making estimates as compared to previous years.

12 Accuracy and indicated subjects for improvement

The method used in the Emission Inventory publications has been followed as far as possible in classifying the quality of information [4]. It is based on the CORINAIR (CORe emission INventories AIR) methodology, which applies the following quality classifications: CORINAIR uses 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 activity rate is assigned the classification D. The reporting of spills was discontinued after 2001. The amount spilled in the period up to 2001 is uncertain, however, because the amount of the spill is an estimate based on the oil slick left behind. In many cases, an estimate was impossible, and additionally some of the spills may not have been noticed.
The emission factors are based on a limited number of spills of several years ago, which have been extrapolated to the present based on certain assumptions. Additionally, the effects of potentially currently applied measures to limit spills are not taken into account. This means that we can classify the emission factors in category D.
As far as the distribution of emissions among individual compartments and emission pathways is concerned, it is clear that all the emissions directly enter the surface water, so category A applies here. Finally, the spatial allocation of emissions is ultimately fairly reliable, so the reliability classification is B.

Element of emission calculation	Reliability class
Activity rates	D
Emission factors	D
Distribution among compartments	A
Emission pathways to water	A
Spatial allocation	B

The most important points for (possible) improvements are:
- Improvement of the registration of spills in the years after 2002
- Resumption of the registration of spills on inland waters
- Improvement of the transparency of spatial allocation

13 Request for reactions

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14 References

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