Emission estimates for diffuse sources
Netherlands Emission Inventory

Discharges of bilge water by inland navigation

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

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Netherlands Emission Inventory

1 Description of emission source

The emissions described in this factsheet result from the discharge of oil-contaminated water generated in the bilge area (bottom of engine room) of inland vessels. Boatmasters of inland vessels must deliver their bilge water to an authorised collector. This is being done more and more, particularly in recent years, but it is still assumed that some bilge water is being illegally discharged. In addition to oil, bilge water can also contain other contaminants, such as cleaning agents and solvents, coolants and greases. The scope of this document is limited to the mineral oil in bilge water and the amount of Polycyclic Aromatic Hydrocarbons (PAH) in the mineral oil, these being the most relevant components from an environmental perspective.
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 by multiplying the quantity of bilge water produced (minus the collected amount of bilge water) by the average content of mineral oil in the bilge water:

mineral oil emission = (bilge water produced – collected bilge water) * oil content in bilge water

The difference between the produced and collected amount of bilge water is the discharged quantity, and this can be qualified as the activity rate (AR). The average oil content in the bilge water is the emission factor (EF), expressed in emission per unit of AR.

The PAH emission is then derived from the mineral oil emission by assuming a PAH content for this oil:

PAH emission = mineral oil emission * PAH content of mineral oil

Because this form of emission involves direct discharge into surface waters, the total emission is the same as the net impact to the water.

3 Activity rates

The produced quantity of bilge water (m^3/year) is calculated from the number of tonne-kilometres traversed. This calculation relies on an annual series of tonne-kilometres traversed, a set of values developed based for the period after 1996 on data from the Statistics Netherlands [2], and for the period before 1996, calculated retroactively based on developments in transport capacity of inland navigation [3]. Using a value of over 33 billion tonne-kilometres traversed in 1985, the production of bilge water per tonne-kilometre traversed in 1985 is estimated at 2.15 litres per million tonne-kilometres. This figure comes from the WSV task group study Binnenvaart [4], and is based on a study by the Gemeentelijk Havenbedrijf Rotterdam in which the waste generated by 820 ships was screened over the course of a year.

Technological developments (such as better seals) and increasing scale caused a decrease in the amount of bilge water produced. For propellor shaft lubricant, it is estimated that this has lead to a 48% reduction in emissions per tonne-kilometre in the period of 1985-2006 (a decrease in the loss of propeller shaft lubricant from 60 to 35%) [5]. The measures against emission of propeller shaft lubricant partially overlap with those for the reduction of bilge water generation, and consequently, for lack of better information, an equivalent effect is assumed for bilge water. The change in bilge water production calculated in this manner is shown in the table below.

With the exception of the year 1994, the collected amount of bilge water has been administered by SAB (the Stichting Scheepsafvalstoffen Binnenvaart) and reported annually [6]. For the year 1985, a percentage of discharged bilge water of 30% is used (in accordance with the WSV target group study). For later years, the assumption is that the amount of bilge water collected from foreign ships in the Netherlands and the amount of bilge water delivered in for collection by Dutch boats abroad is in balance, including for the years after 2002 when collection of bilge water was subject to a fee in the Netherlands while this was not yet so in other countries. An analysis of the quantities of bilge water collected abroad shows that those quantities increased slightly (by 2,500 tonnes in Germany and 1,000 tonnes in Belgium in 2003) [7]. Research by IVW [12] showed that in 2003, Dutch ships delivered in 4,940 m3 of bilge water, and 8,309 m3 in 2004. SAB sees a more stable picture of bilge water collection in the Netherlands from 2005 on, and expects that less will be delivered in abroad, so a figure of 8,300 m3 is assumed for 2005.
In 2003, the amount of bilge water collected dropped sharply (almost 50% from 2000 level). Querying a major bilge water collection station [8] revealed that the drop in collection in 2003 occurred immediately. Employees of the collection station also had the impression that the oil content of the bilge water had slightly increased since 2002 (up to approximately 20 percent). It may be that bilge water is being pre-concentrated before delivery.

The emission of the discharged bilge water is calculated from the difference between bilge water production and collection.

Table 1: **Calculation of activity rate, discharged bilge water (m^3)**

year	sailing intensity (mil. tonne-km)	relative technology development	bilge water produced (m^3)	bilge water collected (m^3)	bilge water collected abroad (m^3)	activity rate, discharged bilge water (m^3)
1985	38,115*	1	81,886	57,320	-	24,566
1990	39,591*	0.9	76,551	56,520	-	20,031
1995	40,253*	0.9	77,831	70,310	-	7,521
2000	41,297	0.65	57,669	47,635	-	10,034
2005	43,066	0.54	49,963	18,765	8,300	22,898
2006	43,577	0.52	48,683	17,494	8,300	22,889

* Sailing intensity for these years is calculated from the sailing intensity registered for 1997, corrected for the transport capacity available in the Netherlands (number of ships * average tonnage)

4 Emission factors for 1985

The WSV target group study [4] derives an emission factor of 144 kg of oil per m^3 of bilge water. This factor is based on an average oil content of bilge water of 16 percent by volume and an average oil density of 0.9 kg/l. This applies to the total oil component. For this reason, the adjusted mathematical model is further calculated with the oil content in the *water component*, instead of the total oil component [12]. The result of a previous study by the Netherlands Centre for Water Management (RIZA) [14] was used for this calculation. In that study, the average oil content was calculated at 275 mg/l.

The PAH profile of bilge water is derived from the sulphur content as measured at final processing. This sulphur content varies between 0.5 and 1%, according to AVR [9]. Diesel oil actually has a sulphur content of 0.2%, while lubricating oil (grease) has a sulphur content of 1.5%. This would appear to indicate that the organic contamination of bilge water consists of approximately half diesel oil and half grease-like components. For this reason, this study proposes using the average of the PAH profiles of diesel oil and lubricating oil as the PAH profile for bilge water [10]. This average is shown in the table below.

Table 2: PAH profile of bilge water (in mg per kg mineral oil in bilge water)

Component	VROM-10*	Borneff-6
Naphthalene	2160	
Phenanthrene	1500	
Anthracene	300	
Fluoranthene	200	200
Chrysene	20	
Benzo[a]anthracene	40	
Benzo[b]fluoranthene		*20*
Benzo[k]fluoranthene	*20*	*20*
Indeno[1,2,3-cd]pyrene	*20*	*20*
Benzo[g,h,i]perylene	0.7	0.7
Benzo[a]pyrene	20	20
total	**4.240**	**220**

*** 10 PAH substances designated by the Ministry of Housing, Spatial Planning & the Environment**

5 Effects of policy measures

A variety of measures can have a potential impact on the amount of the activity rate. Care and proper maintenance can substantially reduce the amount of bilge water produced. Installation of a leak-free propeller shaft seal can even effectively eliminate the production of bilge water. This effect is taken into account in the development of the activity rate in section 3 (relative technology development). There is, however, no reliable information available in reference to the impact of these measures on the emission factor (the oil content and PAH profile of the bilge water).

6 Time series of emission factors

Because there are no known measures that have an impact on the emission factors identified in section 4, the emission factors are kept constant over time.

7 Emissions calculated

The table below shows the emissions, expressed in kg/year. The emission factors were calculated by multiplying the emission factors from section 6 by the activity rate (amount of bilge water discharged) shown in section 3.

Table 3: Mineral oil and PAH emissions (kg/year)

	Mineral oil	Naphthalene	Phenanthrene	Anthracene	Fluoranthene	Chrysene	Benzo[a]anthracene
1985	6.756	14.6	10.1	2.027	1.351	0.135	0.270
1990	5.509	11.9	8.3	1.653	1.102	0.110	0.220
1995	2.068	4.5	3.1	0.621	0.414	0.041	0.083
2000	3.247	7.0	4.9	0.974	0.649	0.065	0.130
2005	6.297	13.6	9.4	1.889	1.259	0.126	0.252
2006	6.295	13.6	9.4	1.888	1.259	0.126	0.252

Table 4: Emissions of PAH, total VROM-10 and Borneff-6 (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	0.135	0.135	0.135	0.0047	0.135	28	1.9
1990	0.110	0.110	0.110	0.0039	0.110	22	1.5
1995	0.041	0.041	0.041	0.0014	0.041	8	0.6
2000	0.065	0.065	0.065	0.0023	0.065	13	0.9
2005	0.126	0.126	0.126	0.0044	0.126	26	1.8
2006	0.126	0.126	0.126	0.0044	0.126	27	1.8

8 Release into environmental compartments

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

9 Description of emission pathways to water

The emissions calculated here are direct emissions into water.

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). 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 inventory these maps are used as 'locators' to determine the spatial distribution of emissions. The range of possible locators is limited (see [13] for a list of available locators), as not every conceivable parameter can be used as a locator. In practice the locator judged to correlate most closely with the emission in question is applied for the distribution of emissions.
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 5: Summary of spatial allocation method

Element	**Locators**
Bilge water	Professional inland navigation

The method used to determine the locators is described in [13]:

Professional inland navigation
The allocation is determined by multiplying the number of vessels per shipping lane segment by the length of that segment (in kilometres). A distinction is made between push-towing and other inland navigation.
The latter category is in turn subdivided into two classes based on cargo capacity.
Data on numbers of inland vessels originate from Statistics Netherlands; location and length of shipping lanes originate from the database Nationaal Wegenbestand.

11 Comments and changes in regard to previous version

In 2007, the recommendations from the previous publication to assume tonne-km of transported cargo for the activity rate have been adopted. The recommendation to account for both the bilge water produced (and collected or discharged) by Dutch ships abroad and the bilge water collected in the Netherlands from foreign ships in the activity rate is not adopted, because this effect appeared to be negligible (see above). Additionally, in the previous method the emission of benzene and toluene are strongly overestimated, due to an erroneous substance profile being assigned to the discharges. A further inventory shows that the emissions of benzene and toluene are zero. Consequently, these emissions are no longer assessed in this document.

No changes were made in 2008.

12 Accuracy and indicated subjects for improvement

The method used in National Emission Inventory publications has been followed as far as possible in classifying the quality of information [11]. 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 activity rate can be assigned with classification D. The activity rate is based on a somewhat outdated inventory of bilge water production extrapolated to the current situation. This extrapolation does take improvement of the technology into account, but the quantification of the technological improvement is weak. The emission factors are based on a large-scale survey of the composition of the bilge water. Although that survey is arguably somewhat dated, the emission factors still hold the classification 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 Emission calculation	**Reliability Classification**
Activity Rates	D
Emission factors	D
Distribution among compartments	A
Emission pathways to water	A
Spatial allocation	B

The main areas for improvement and potential improvement are:

- Improvement or updating of measurement data in relation to the average concentration of oil in bilge water produced and collected, and average amount of bilge water produced per ship
- If the reduction of the amount of bilge water collected proves to be structural, further investigation of the cause and potential adjustment of the methodology (for example, correction for the possibly increased oil content in the collected bilge water).
- Better substantiation of the effect of technological improvements and other measures on the amount of bilge water produced and on the emission factors

13 Request for reactions

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