Emission estimates for diffuse sources
Netherlands Emission Inventory

Corrosion of water conduits in office buildings

Version dated June 2008

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

Corrosion from water conduits in office buildings

1 Description of emission source

Emissions described in this factsheet are copper emissions due to the corrosion of drinking water conduits in commercial buildings (offices). The copper content of drinking water pipes is higher than the original level in the water supply by three causes: the flow of water through the pipes, water standing in the pipes, and heating in boilers and geysers. This fact sheet deals with all these causes together. The corrosion of drinking water pipes in residential dwellings is part of the domestic waste water system (see the fact sheet on Domestic Waste Water [13]), and is not covered here.
This emission source is attributed to the governmental target sector "Trade and services".

2 Explanation of calculation method

Emissions are calculated by a simple method which involves multiplying an activity rate (AR), in this case the area of office space in the Netherlands, by an emission factor (EF) per substance, expressed in emission per AR unit. This method of calculation is explained in detail in the Guide to the Regional approach to diffuse sources [2].
The calculation method for emissions from this emission source is described in further detail in the water system survey of construction materials [15] and is largely based on Van Oppen's work [14]. The emission calculated in this way is referred to as the total emission.

3 Activity rates

Information on the area of build-up area with offices in the Netherlands is taken from statistics produced by Statistics Netherlands. The figures are based on the total area of all types of offices: socio-cultural facilities, other public facilities and the service sector (categories 16, 17 and 20 respectively). The total area in 1989 was 3.397 x 10^8 m^2. This figure was subsequently converted in the light of the increase in area used for the second environmental report [12] to give a figure for 1990 of 3.41 x 10^8 m^2. In the absence of any later data from Statistics Netherlands, figures for subsequent years are based on the growth trends in industrial premises areas shown in the European Renaissance scenario in the second environmental survey, which pointed to growth of 1.2% a year between 1990 and 2006 [12].

Table 1: Trend in the AR, the area of office buildings in the Netherlands

Year	Building-up area with offices (m^2)	Reference
1985	316,300,000	[11], page 34
1990	341,000,000	[12], page 28 and [13]
1993	353,280,000	[12], page 28 and [13]
1995	361,460,000	[12], page 28 and [13]
2000	381,920,000	Estimate, + 1.2%/year
2005	402,380,000	Estimate, + 1.2%/year
2006	406,472,000	Estimate, + 1.2%/year

4 Emission factors

The emission factor for copper is derived from [15], taking account of softening of drinking water, i.e. the percentage of drinking water deliberately softened by water supply companies. This is because the rate of corrosion of water pipes is significantly affected by the proportion of drinking water that is softened; the more water is softened, the slower the rate of corrosion and the less copper is dissolved in the drinking water. A softening factor has been worked out to take account of partial softening (see section 5 below).

An emission factor for 1993 has been calculated on the basis of [15]: the combined contact surface area of copper water pipes for residential and commercial/industrial buildings is 10.6 million m^2. The figure for residential dwellings alone is 9.2 million m^2, leaving 1.4 million m^2 for commercial/industrial buildings. Combined copper emissions for residential dwellings and commercial/industrial buildings is 101,000 kg of copper, which means that the emission figure for commercial/industrial buildings can be calculated as 13,300 kg of copper (= 1,400,000/1,0600,000 ×101,000). The emission factor for commercial/industrial buildings in 1993 is then worked out by dividing 13,300 kg of copper by 353,280,000 m^2 of commercial office space, giving a result of 37.6 mg Cu/m^2 of office space per year. The softening factor is applied to correct the emission factor.
The emission factors are expressed as mg/m^2 office buildings/year.

Table 2: Emission factor trends: mg copper/m^2 office buildings/year

Year	Emission factor
1985	39.8
1990	39.6
1993	37.6
1995	36.6
2000	35.6
2005	34.6
2006	34.4

As water hardness affects the emission of copper from pipes (the lower the hardness, the less copper is emitted), this aspect is taken into account by means of a softening factor. The softening factor is calculated in [15] as:

$1 - 0.5 \times (y - x)$

Where: x = the fraction of softened water in 1985 and y = the fraction of softened water in year y. The table below shows the fractions of softened water reported for individual years (figures obtained from the Dutch association of drinking water companies, VEWIN [17]). The calculated softening factors are also given for the years in question. The softening factors have been used to work out the emission factors for 1985, 1990, 1993, 1995, 2000, 2005 and 2006 (see section 4).

Table 3: Summary of percentages of softened water in individual years

Year	Percentage of softened water (%)	Softening factor
1985	19	1.000
1990	20	0.995
1993	30	0.930
1995	35	0.920
2000	40	0.895
2005	45	0.870
2006	46	0.865

From 2000 onwards no data is available on the percentage of drinking water actively softened by water supply companies. It is assumed that this figure has been rising by 1% a year since 1995 (similar to the trend in previous years), meaning that in 2006 46% of drinking water was softened.

5 Effects of policy measures

Water supply companies have been increasing the extent of drinking water softened. This was taken into account in the calculation of the emission factor.

6 Emissions calculated

The table below shows copper emissions caused by the corrosion of water pipes in office buildings. The emissions are calculated by multiplying the activity rate (the area of office space in the Netherlands in the year in question) by the emission factor (the corrosion of copper water pipes in office buildings ea ch year).

Table 4: Emission of copper (tonnes/year) as a result of corrosion of water pipes in office buildings

Year	Copper emission (tonnes/year)
1985	12.589
1990	13.504
1993	13.076
1995	13.235
2000	13.596
2005	13.922
2006	13.994

7 'Release into environmental compartments

All emissions caused by the corrosion of water pipes in office buildings enter the sewers (indirect emissions).

8 Description of emission pathways to water

Emissions into water arise indirectly as a result of emissions from the sewer system, combined sewer overflows, and effluents from urban waste water treatment plants. The fact sheet "Effluents from waste water treatment plants and sewer systems" [8] describes this in further detail.

9 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 [16] for a list of available locators), as not every conceivable parameter can be used as a locator. In practice the locator judged to be the best proxy of the activity rate of 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
Corrosion of water pipes in industrial/commercial buildings	Number of inhabitants per grid cell measuring 500x500 metres

The method used to determine the locators is described in [16]:

Number of inhabitants
The number of inhabitants per grid cell measuring 500x500 metres is derived from the MNP's map of grid cell distribution based on the number of inhabitants, residential dwelling units and inhabitants per sewage 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

comprehensive database of address coordinates in the Netherlands (which contains addresses and types of dwelling unit) and the 2003 sewage unit database.

10 Comments and changes in regard to previous version

There have been no changes in the calculation methodology compared to previous publications, such as [15], [2] and [9].

11 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 [9]. 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 emission factors are classified as D; the major point of uncertainty is in determining the percentage of drinking water that is deliberately softened. The activity rate is also based on records and assumptions, and comes into class C. Distribution of emissions among the various components can easily be identified and is logical, and therefore comes into class A. Emission pathways into water are not discussed in this fact sheet, but are classed as C in reference [8]. The spatial allocation of emissions is fairly reliable and classed as C.

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

The main areas where improvements could be made are:
- Improving the quality of information about the activity rate
- Improving information about the effects of the influence of water softening on copper corrosion.
- Improving data on the percentage of water actively softened by water supply companies.
- Investigation into corrosion of substances other than copper from water pipes.

12 Request for reactions

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13 References

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