emep

European Environment Agency

| Category | | Title |
|---|---|---|
| **NFR** | 5.D | Wastewater handling |
| | 5.D.1 | Domestic wastewater handling |
| | 5.D.2 | Industrial wastewater handling |
| | 5.D.3 | Other wastewater handling |
| **SNAP** | 091001 | Wastewater treatment in industry |
| | 091002 | Wastewater treatment in residential/commercial sectors |
| | 091007 | Dry toilets (including latrines) |
| **ISIC** | | |
| **Version** | Guidebook 2023 | |


**Coordinator**

Céline Guéguen

**Contributing authors (including to earlier versions of this chapter)**

Carlo Trozzi, Jeroen Kuenen, Jan Berdowski, Pieter van der Most, Mike Woodfield, Magdalena Kachniarz and Céline Guéguen

# Contents

# 1 Overview

This chapter covers emissions from wastewater handling. Regarding wastewater treatment a distinction can be done between domestic (or residential), commercial and industrial wastewater. Usually, domestic and commercial wastewater are considered together because consistent in terms of composition, collection system and treatment. Domestic and commercial wastewater can be collected and treated in a centralised municipal wastewater treatment plant or un collected and treated using individual devices (septic tanks, dry toilets) or more rarely discharged in natural environment without treatment.

Industrial wastewater may be considered separately as more specific in terms of composition, collection system and treatment. Industrial wastewater can be treated in-situ, collected and treated in centralised industrial wastewater treatment plants or collected and treated together with domestic and commercial wastewater in municipal wastewater treatment plants (generally after a first in situ treatment).

The methodological descriptions considered within this sector relate to non-methane volatile organic compound (NMVOC) emissions from municipal, commercial and industrial wastewater treatment plants (Tier 1method if considered as a whole, Tier 2 method if domestic/commercial and industrial wastewater are considered separately) and ammonia ($NH_3$) emissions from dry toilets (Tier 2 method).

Emissions from domestic, commercial and industrial wastewater treated in municipal wastewater treatment plants and emissions from dry toilets may be reported in 5.D.1. Emissions from industrial wastewater treated in-situ or in centralized industrial wastewater treatment plants may be reported in 5.D.2.

In most cases, wastewater handling will be an insignificant source for air pollutants. NMVOC emissions from wastewater treatment plants may be of local importance, especially in urban areas (Atasoy et al., 2004). Dry toilets are generally only a minor source of $NH_3$ emissions except in countries where they are largely used.

# 2 Description of sources

## 2.1 Process description

This section describes the processes and emissions from treatment plants and dry toilets.

### *2.1.1 Wastewater treatment plants*

Wastewater from residential, commercial and industrial sectors may be collected by sewers connected to centralised wastewater treatment plants (WWTPs), where it is treated to reduce substance loads (organic matter, nutrient, hazardous substance) before being discharged in the aquatic environment.

Some industrial facilities have their own in-situ wastewater treatment plant before discharging in sewers or directly in aquatic environment, depending on substance loads in the effluent and national regulations.

Some households have autonomous wastewater treatment (e.g. septic tanks, dry toilets) and are not connected to the sewage system that transports the wastewater to treatment plants.

#### *2.1.2 Dry toilets*

Dry toilets are characterised by the fact that they do not require flushing with water and consequently do not need to be connected to a sewage system. Dry toilets must not be confused with septic tanks, which have a water flush.

The first generation of dry toilets were the latrines, also named or backhouses. A latrine is a simple dry toilet built outside the house, usually in a backyard. A storage tank under the latrine can be a hole dug in the ground, or a concrete reservoir. Capacity of the tank can vary between 1 $m^3$ and 2 $m^3$, depending on the family size. The time of storage can vary between a few months and 'forever'. Tanks are emptied by cesspool emptiers or contents are deposited on an animal manure heap.

The more recent generation of dry toilets, developed in the $20^{th}$ century to improve convenience, are mainly characterized by two types: source-separating toilets (urine is diverted from faeces and stored in a separate tank) and composting toilets (excreta is composted, with or without litter of plant matter, in a tank or pit under the toilet). Unlike latrines, they make the use of dry toilets possible within the home. The dried faeces and the diluted urine or the composted excreta are supposed to be suitable for being used in the garden and/or for agricultural use, depending on national regulation.

Ammonia, which is responsible for the majority of unpleasant odours, is formed during the rotting and decomposition processes of excreta. Ammonia emission from dry toilets depends mainly on quantity and form of nitrogen compounds in human excreta, as well as on temperature.

Nitrogen content in human excreta depends on the diet, health and physical activity of an individual. A moderately active person with a daily intake of about 300 g of carbohydrates, 100 g of fat and 100 g of proteins excretes about 16 g of nitrogen. Kidneys void 95 % of nitrogen and the residual 5 % is excreted mostly as N in faeces. A person on European diet voids 80 to 90 % of nitrogen as urea (Harper et al, 1983).

**Table 2-1 Daily excretion of nitrogen in normal urine (pH 6.0) (source: Harper et al., 1983)**

| **Compound** | **Quantity [g]** | **N equivalent [g]** |
|---|---|---|
| Nitrogen compounds (total) | 25–35 | 10–14 |
| Urea (50 % of solid compounds depends on diet) | 25–30 | 10–12 |
| Creatinine | 1.4 (1–1.8) | 0.5 |
| Ammonia | 0.7 (0.3–1) | 0.4 |
| Uric acid | 0.7 (0.5–0.8) | 0.2 |
| N in other compounds (e.g. amino acids) | | 0.5 |

## 2.2 Techniques

An overview is given in the process description. There are no specific techniques that are applicable here.

## 2.3 Emissions

**Wastewater treatment plants**

Emissions from wastewater treatment plants are mainly $NH_3$ and NMVOC and greenhouse gases ($CO_2$, $CH_4$ and $N_2O$ which are not treated in this chapter[1]. NMVOC emissions from WWTPs occur mainly through the volatilization of substances in influents (driven by the concentration differences between the air and the contacting aqueous phase), increased by agitation and forced-air flow, and evaporation (driven by the temperature difference between the air and the aqueous phase). The composition and magnitude of NMVOC emissions depend on the characteristics of the wastewater influents (flow rates, hydrocarbons concentrations) of environmental conditions (mainly the wind speed and the temperature). Therefore, NMVOC may vary substantially from a wastewater treatment plant to another (Atasoy et al., 2004).

NMVOC emissions to air from wastewater treatment plants may in some cases be significant in urban areas or in facilities handling wastewater with hight hydrocarbon loads and may even contribute significantly at a national level. More information is provided in Sree et al. (2000), Oskouie et al. (2008), Atasoy et al. (2004) and Escalasa et al. (2003).

**Dry toilets**

Atmospheric emissions from dry toilets are mainly $NH_3$. Ammonia emissions derive mainly from the decomposition of urea and uric acid. Excreted urea is hydrolysed to ammonium ($NH_4^+$) through the action of microbial urea and ammonium is volatilized ammonia. The rate of this hydrolysis depends on temperature, pH, amount of urea present and water content. The hydrolysis increases pH of collected urine and faeces to about 9. The decomposition of protein in faeces is a slow process, but during storage, 40 to 70 % of total N is converted to the $NH_4^+$ form (European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC), 1994).

## 2.4 Controls

The reduction of volatile organic compounds from wastewater in municipal or industrial wastewater treatment plants is possible if collected and degraded for instance by biofiltration and photocatalytic oxidation. However, these techniques are rarely used (e.g. in case of emissions of hazardous compounds and odours) because of the wastewater specific conditions such as diffuse emissions, high humidity, low concentration, large air flows. (emissions of hazardous compounds, odours).

Reduction of ammonia emissions from dry toilets is possible by the installation of water supply and sewage systems, which is particularly possible in urban areas.

# 3 Methods

This source is expected to be only of minor importance for emissions of air pollutants and little information is available on estimating emissions from wastewater handling.

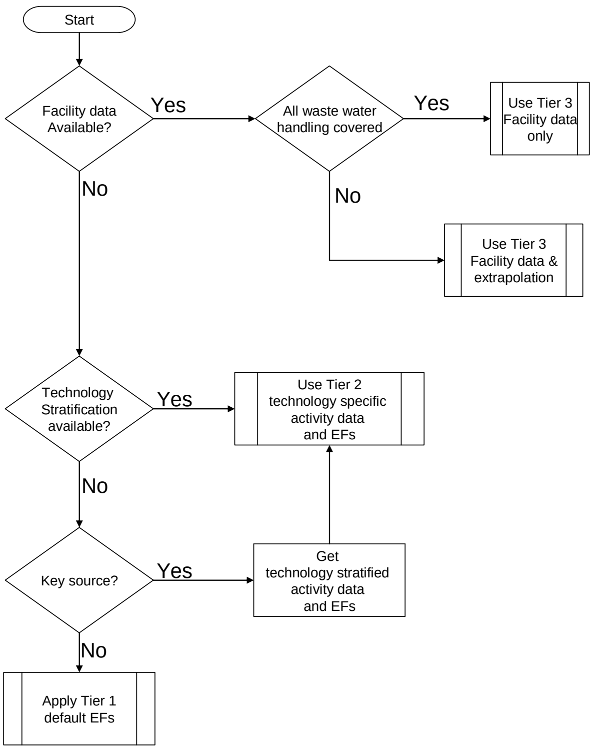
[1] Guidance on reporting greenhouse gas emissions is provided by the Intergovernmental Panel on Climate Change (IPCC) Guidelines.

## 3.1 Choice of method

Figure 3-1 presents the procedure to select the methods for estimating emissions from wastewater handling. The basic ideas behind this procedure are:

- if detailed information is available, use it;
- if the source category is a key category, a Tier 2 or better method must be applied and detailed input data must be collected. The decision tree directs the user in such cases to the Tier 2 method, since it is expected that it is easier to obtain the necessary input data for this approach than to collect facility-level data needed for a Tier 3 estimate;
- the alternative of applying a Tier 3 method, using detailed process modelling, is not explicitly included in this decision tree. However, detailed modelling will always be done at facility level and results of such modelling could be seen as 'facility data' in the decision tree.

**Figure 3-1 Decision tree for source category 5.D Wastewater handling**




## 3.2 Tier 1 default approach

### *3.2.1 Algorithm*

The Tier 1 approach for NMVOC emissions from wastewater treatment plants uses the general equation:

$$E_{pollutant} = AD \times EF_{pollutant} \quad (1)$$

This equation is applied at the national level. The Tier 1 emission factors assume an averaged or typical technology and abatement implementation in the country and integrate all different sub-processes in the handling of wastewater.

### *3.2.2 Default emission factors*

A default emission factor for NMVOC emissions from wastewater handling has been derived from a Turkish study (Atasoy et al., 2004). This emission factor should be handled with care, since it may not be applicable to all wastewater treatment plants. Furthermore, the emission factors reported in literature show a high variation. More specific information is available in the references indicated in subsection 2.3 of the present chapter. Emission factors for all other pollutants are not available and may be assumed negligible in most cases; therefore, this chapter does not report emission factors for these other pollutants.

For guidance on emissions from $CH_4$ and $N_2O$ emissions from this source, refer to the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006).

**Table 3-1 Tier 1 emission factors for source category 5.D Wastewater handling**

| Tier 1 default emission factors | | | | | |
|---|---|---|---|---|---|
| | Code | Name | | | |
| **NFR Source Category** | 5.D | Wastewater handling | | | |
| **Fuel** | NA | | | | |
| **SNAP (if applicable)** | 091001<br>091002 | Wastewater treatment in industry<br>Wastewater treatment in residential/commercial sectors | | | |
| **Not applicable** | NOx, CO, Sx, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP, SCCP | | | | |
| **Not estimated** | $NH_3$, TSP, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn | | | | |
| **Pollutant** | **Value** | **Unit** | **95% confidence interval** | | **Reference** |
| | | | **Lower** | **Upper** | |
| NMVOC | 15 | mg/m3 wastewater handled | 5 | 50 | Atasoy et al. (2004) |

### *3.2.3 Activity data*

The relevant activity statistic for the Tier 1 approach is the total amount of wastewater handled by all wastewater treatment plants in the country (municipal wastewater treatment plants and industrial wastewater treatment plants, centralized and in-situ).

## 3.3 Tier 2 technology-specific approach

### *3.3.1 Algorithm*

The Tier 2 approach is similar to the Tier 1 approach. To apply the Tier 2 approach, both the activity data and the emission factors need to be stratified according to the different techniques/processes that may occur in the country.

The approach followed to apply a Tier 2 stratifies the wastewater handling in the country by:

- defining the type of wastewater and/or process types (together called 'technologies' in the formulae below) separately; and
- applying technology specific emission factors for each of these 'technologies':

$$E_{pollutant} = \sum_{technologies} AR_{technology} \times EF_{technology,pollutant} \qquad (2)$$

where:

| | | |
|---|---|---|
| $AD_{,technology}$ | = | Activity data for the technology, |
| $EF_{technology,pollutant}$ | = | Emission factor for this technology and this pollutant. |

In the case of wastewater treatment, a distinction is done between domestic/commercial wastewater and industrial wastewater. In terms of process type, a distinction is done between municipal wastewater treatment plants, industrial wastewater treatment plants (in situ or centralised) and dry toilets.

### *3.3.2 Technology-specific emission factors*

This section presents emissions from wastewater handling in wastewater treatments plants, and also considers separately $NH_3$ emissions from dry toilets.

Regarding NMVOC emissions, the emission factor is identical to the emission factor used in the Tier 1 approach but a distinction is done in terms of activity data and reporting between domestic, commercial and industrial wastewater treated in municipal treatment plants (5.D.1) and industrial wastewater treated in situ or in centralised industrial treatment plants (5.D.2).

Regarding $NH_3$ emissions, an emission factor is proposed for dry toilets.

#### Dry toilets

The emission factor for dry toilets has been determined from the similarity between dry toilets and open storage of animal manure in lagoons or ponds (EMEP/EEA, 2006). Emission factors for $CO_2$, $N_2O$ and $CH_4$ are not provided in this chapter. Information about these greenhouse gas emissions can be found in the 2006 IPCC Guidelines (IPCC, 2006).

**Table 3-2 Tier 2 emission factors for source category 5.D Wastewater handling, latrines**

| **Tier 2 emission factors** | | | | | |
|---|---|---|---|---|---|
| | Code | Name | | | |
| **NFR Source Category** | 5.D.1 | Domestic wastewater handling | | | |
| **Fuel** | NA | | | | |
| **SNAP (if applicable)** | 091007 | Latrines<br>Other dry toilets | | | |
| **Technologies/Practices** | | | | | |
| **Region or regional conditions** | | | | | |
| **Abatement technologies** | | | | | |
| **Not applicable** | NOx, CO, SOx, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB | | | | |
| **Not estimated** | NMVOC, TSP, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn | | | | |
| **Pollutant** | **Value** | **Unit** | **95% confidence interval** | | **Reference** |
| | | | **Lower** | **Upper** | |
| NH3 | 1.6 | kg/person/year | 0.8 | 3.2 | EMEP/EEA (2006) |

**Wastewater handling in wastewater treatment plants**

The default Tier 2 emission factor for NMVOC emissions from wastewater handling is given in Table 3-3 below. The emission factor is equivalent to the emission factor used in the Tier 1 default approach.

**Table 3-3 Tier 2 emission factors for source category 5.D Wastewater treatment**

| Tier 2 emission factors | | | | | |
|---|---|---|---|---|---|
| | Code | Name | | | |
| **NFR Source Category** | 5.D.1<br>5.D.2 | Industrial wastewater handling | | | |
| **Fuel** | NA | | | | |
| **SNAP (if applicable)** | 091001<br>091002 | Wastewater treatment in industry<br>Wastewater treatment in residential/commercial sectors | | | |
| **Technologies/Practices** | Wastewater treatment plants | | | | |
| **Region or regional conditions** | | | | | |
| **Abatement technologies** | | | | | |
| **Not applicable** | NOx, CO, SOx, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB | | | | |
| **Not estimated** | NH3, TSP, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn | | | | |
| **Pollutant** | **Value** | **Unit** | **95% confidence interval** | | **Reference** |
| | | | **Lower** | **Upper** | |
| NMVOC | 15 | mg/m3 wastewater handled | 5 | 50 | Atasoy et al. (2004) |

### *3.3.3 Abatement*

Reduction efficiencies when abatement is in place are not available for this source category.

### *3.3.4 Activity data*

**Dry toilets**

Population with no connection to sewers are supposed to use autonomous treatment systems, such as septic tanks and dry toilets. Only population connected to dry toilets must be considered for the $NH_3$ estimate.

Dry toilets may also be used on a temporary basis (vacation home, local events, national parks) and very few statistics will be available.

Therefore, as a first approach activity data will be the population whose main house are using dry toilets.

In countries where dry toilets are largely used but on a temporary basis and expected to be a non-negligible source of $NH_3$, a more refined estimate of the population may be done (full time equivalent). This can for instance be based on the vacancy home occupancy rate.

**Wastewater handling in wastewater treatment plants**

Activity data must distinguish domestic, commercial and industrial wastewater treated in municipal treatment plants (5.D.1) and industrial wastewater treated in situ or in centralised industrial treatment plants (5.D.2).

## 3.4 Tier 3 emission modelling and use of facility data

Not available for this source.

# 4 Data quality

## 4.1 Completeness

No specific issues.

## 4.2 Avoiding double counting

As NMVOC emissions from wastewater treatment plants mainly occur through the volatilization of substances already present in influents, there is a risk of double accounting with NMVOC emissions from the solvent use sector, especially when a balance method is used to estimate emissions from solvent use.

Dry toilets must not be confused with septic tanks were there is water flush. Only population connected to dry toilets must be considered for the $NH_3$ estimate from wastewater handling.

Moreover, dry toilets may be used on a temporary basis (vacation home, local events, national parks) and there is a risk of over estimation when a full-time use is assumed.

## 4.3 Verification

### *4.3.1 Best Available Technique emission factors*

BAT emission factors are not available for this source. However, there is an extensive amount of information with regard to wastewater treatment available in the Reference Document on Best Available Techniques in Common Wastewater and Waste Gas Treatment / Management Systems (European Commission, 2003).

## 4.4 Developing a consistent time series and recalculation

No specific issues.

## 4.5 Uncertainty assessment

No specific issues.

### *4.5.1 Emission factor uncertainties*

No specific issues.

#### 4.5.2 *Activity data uncertainties*

No specific issues.

### 4.6 Inventory quality assurance/quality control QA/QC

No specific issues.

### 4.7 Gridding

For dry toilets, it is good practice to disaggregate national totals on the basis of population, taking urban and rural differences in the number of dry toilets (especially latrines) into account.

### 4.8 Reporting and documentation

No specific issues.

# 5 References

Atasoy et al. (2004). 'The estimation of NMVOC emissions from an urban-scale wastewater treatment plant', Water Research, Volume 38, pp. 3265–3274.

ECETOC (1994). 'Ammonia emissions to air in Western Europe'. Technical report No 62, ECETOC, Brussels.

Escalasa et al. (2003). 'Time and space patterns of volatile organic compounds in a sewage treatment plant', Water Research 37, pp. 3913–3920.

EMEP/EEA, 2006, *EMEP/CORINAIR Emission Inventory Guidebook, version 4 (2006 edition)*. European Environment Agency, Technical report No. 11/2006, (https://www.eea.europa.eu/publications/EMEPCORINAIR4), accessed 19 July 2019.

European Commission (2003). Integrated Pollution Prevention and Control (IPPC). Reference Document on Best Available Technologies in Common Wastewater and Waste Gas Treatment / Management Systems, February 2003, (https://eippcb.jrc.ec.europa.eu/reference/), accessed 23 July 2019.

Harper H.A., Rodwell V.W., Mayes P.A. (1983). Review of Physiological Chemistry, PZWL, Warszawa (Polish edition).

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

Oskouie A.K., Lordi D.T., Granato T.C. and Kollia L. (2008). 'Plant-specific correlations to predict the total VOC emissions from wastewater treatment plants', Atmospheric Environment, in press, corrected proof. Available online 13.2.2008.

Sree U., Bauer H., Ellinger R., Schmidt H. and Puxbaum H. (2000). 'Hydrocarbon emissions from a municipal wastewater treatment pilot plant in Vienna', Water, Air and Soil Pollution, 124, pp. 177–186.

# 6 Point of enquiry

Enquiries concerning this chapter should be directed to the relevant leader(s) of the Task Force on Emission Inventories and Projection's expert panel on combustion and industry. Please refer to the TFEIP website (www.tfeip-secretariat.org/) for the contact details of the current expert panel leaders.