



National Pollutant Inventory

Emission Estimation Technique Manual

for

Potable Water Treatment

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**EMISSION ESTIMATION TECHNIQUES
FOR
POTABLE WATER TREATMENT**

TABLE OF CONTENTS

1.0	INTRODUCTION	1
2.0	PROCESSES AND EMISSIONS	2
	2.1 Process Description	2
	2.2 Emission Sources and Control Technologies.....	3
	2.2.1 Emissions to Air	3
	2.2.2 Emissions to Water	3
	2.2.3 Emissions to Land.....	4
3.0	EMISSION ESTIMATION TECHNIQUES	5
	3.1 Direct Measurement.....	6
	3.1.1 Sampling Data	6
	3.1.2 Continuous Emission Monitoring System (CEMS) Data	7
	3.2 Mass Balance	7
	3.3 Engineering Calculations.....	8
	3.4 Emission Factors	8
	3.4.1 Predictive Emission Monitoring (PEM).....	8
4.0	EMISSION ESTIMATION TECHNIQUES: ACCEPTABLE RELIABILITY AND UNCERTAINTY.....	9
	4.1 Direct Measurement.....	9
	4.2 Mass Balance	9
	4.3 Engineering Calculations.....	9
	4.4 Emission Factors	10
5.0	REFERENCES.....	11

POTABLE WATER TREATMENT

LIST OF FIGURES AND EXAMPLES

Figure 1 - Basic Process Steps for Potable Water Treatment 2

Example 1 - Emission of Fluoride Compounds to Waters 6

2 - Fugitive Losses of Chlorine..... 7

1.0 Introduction

The purpose of all Emission Estimation Technique (EET) Manuals in this series is to assist Australian manufacturing, industrial and service facilities to report emissions of listed substances to the National Pollutant Inventory (NPI). This Manual describes the procedures and recommended approaches for estimating emissions from facilities engaged in the treatment of water for drinking purposes.

EET MANUAL: Potable Water Treatment

HANDBOOK: Water Supply

ANZSIC CODES : 3701 and all codes in within the 370 ANZSIC code group.

This Manual was drafted by the NPI Unit of the Queensland Department of Environment and Heritage on behalf of the Commonwealth Government. It has been developed through a process of national consultation involving State and Territory environmental authorities and key industry stakeholders.

2.0 Processes and Emissions

The following section presents a brief description of the potable water treatment process and identifies likely sources of emissions.

2.1 Process Description

Potable water treatment is the treatment of water to ensure that it is suitable for human consumption and use. The degree and components of the treatment process depends largely on the quality of the raw water. However, a typical water treatment plant includes the following processes:

- Coagulation/flocculation;
- Sedimentation;
- Filtration;
- Disinfection; and
- Water correction.

A number of different methods can be implemented within each of these processes. However, their main purpose is to clarify the water by removing suspended particles (coagulation, flocculation, sedimentation and filtration), to remove any potentially harmful pathogens by disinfection of the water, and to correct the water chemically (eg. water softening and pH correction).

Figure 1 gives a general overview of the conventional water treatment process, this, however, can vary from site to site depending on the local situation and raw water supply.

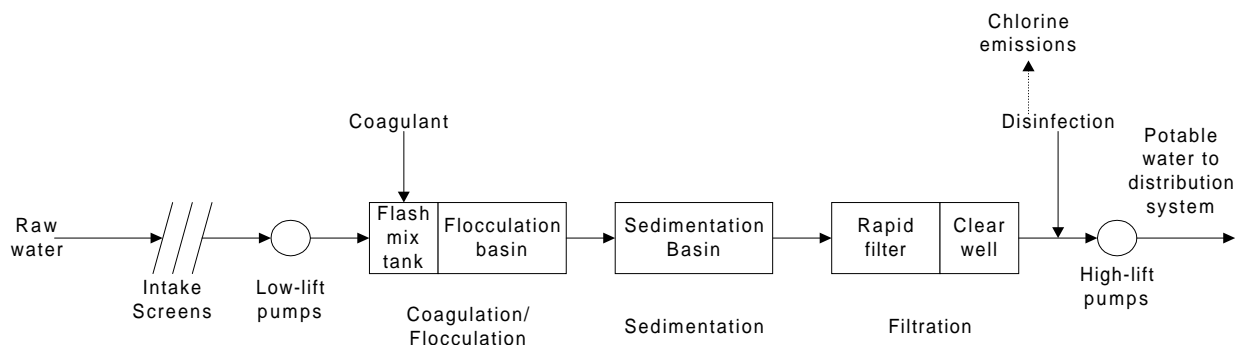


Figure 1 - Basic Process Steps for Potable Water Treatment

Source: Nathanson, 1997

2.2 Emission Sources and Control Technologies

2.2.1 Emissions to Air

Air emissions may be categorised as:

Fugitive Emissions

These are emissions that are not released through a vent or stack. Examples of fugitive emissions include volatilisation of vapour from storage vessels, or spills and materials handling. Emissions emanating from ridgeline roof-vents, louvres, and open doors of a building as well as equipment leaks, and leaks from valves and flanges are also examples of fugitive emissions. Emission factor and mass balance EETs are the usual methods for determining losses through fugitive emissions.

Chlorine and ammonia are the most likely substances to be lost fugitively to air from a water treatment facility. Other substances, such as fluoride, chlorine dioxide and hydrochloric acid, may also be emitted in smaller volumes. Water treatment processes vary from one facility to the next and each reporting facility may handle a different range of substances on the reporting list.

Point Source Emissions

These emissions are exhausted into a vent (excluding roof vents) or stack and emitted through a single point source into the atmosphere. It is unlikely that any water treatment facilities in Australia will emit any NPI-listed substances from a point source.

2.2.2 Emissions to Water

Emissions of substances to water can be categorised as discharges to:

- Surface waters (eg. lakes, rivers, dams, and estuaries);
- Coastal or marine waters; and
- Stormwater.

Substances contained within an end product, such as water treated and distributed to the consumer for domestic and commercial use, are not considered as emissions to water.

Because of the significant environmental hazards posed by emitting toxic substances to water, most facilities emitting NPI-listed substances to waterways are required by their relevant State or Territory environment agency to closely monitor and measure these emissions. This existing sampling data can be used to calculate annual emissions.

If no water monitoring data exists, emissions to process water can be calculated based on a mass balance, engineering calculation or using emission factors. The substances most likely to be emitted to water from a water treatment facility are chlorine dioxide, fluoride compounds, hydrochloric acid and sulfuric acid. Other substances, such as ammonia, may be emitted in smaller volumes.

Note that chlorine is only a reportable substance as elemental chlorine. Therefore, it may not be necessary to report chlorine emissions to water, as chlorine tends to dissociate into a mixture of hypochlorous and hydrochloric acid when added to water. This dissociation may however constitute coincidental production of hydrochloric acid, which is an NPI-listed substance, and determination of whether coincidental production of hydrochloric acid exceeds 10 tonnes would subsequently be required. Other listed substances such as fluoride and ammonia require total compounds to be reported. Consult the list of reportable substances in Appendix A of The NPI Guide to determine which require total compounds to be reported, and which require only the specific listed substance to be reported.

The discharge of listed substances to a sewer or tailings dam does not require you to report to the NPI. However leakage and other emissions (including dust) from a tailings storage facility are reportable. (See also Section Three of The NPI Guide).

2.2.3 Emissions to Land

Emissions of substances to land on-site include solid wastes, slurries, sediments, spills and leaks, storage and distribution of liquids and may contain listed substances. These emission sources can be broadly categorised as:

- surface impoundments of liquids and slurries; and
- unintentional leaks and spills.

3.0 Emission Estimation Techniques

Estimates of emissions of NPI-listed substances to air, water and land should be reported for each substance that triggers a threshold. The reporting list and detailed information on thresholds are contained in *The NPI Guide* at the front of this Handbook.

In general, there are four types of emission estimation techniques (EETs) that may be used to estimate emissions from your facility.

The four types described in *The NPI Guide* are:

- sampling or direct measurement;
- mass balance;
- fuel analysis or other engineering calculations; and
- emission factors

Select the EET, (or mix of EETs), that is most appropriate for your purposes. For example, you might choose to use a mass balance to best estimate fugitive losses from pumps and vents, direct measurement for stack and pipe emissions, and emission factors when estimating losses from storage tanks and stockpiles.

If you estimate your emission by using any of these EETs, your data will be displayed on the NPI database as being of 'acceptable reliability'. Similarly, if your relevant environmental authority has approved the use of EETs that are not outlined in this handbook, your data will also be displayed as being of 'acceptable reliability'.

This Manual seeks to provide the most effective emission estimation techniques for the NPI substances relevant to this industry. However, the absence of an EET for a substance in this handbook does not necessarily imply that an emission should not be reported to the NPI. The obligation to report on all relevant emissions remains if reporting thresholds have been exceeded.

You are able to use emission estimation techniques that are not outlined in this document. You must, however, seek the consent of your relevant environmental authority. For example, if your company has developed site-specific emission factors, you may use these if approved by your relevant environmental authority.

You should note that the EETs presented in this manual relate principally to average process emissions. Emissions resulting from non-routine events are rarely discussed in the literature, and there is a general lack of EETs for such events. However, it is important to recognise that emissions resulting from significant operating excursions and/or accidental situations (eg. spills) will also need to be estimated. Emissions to land, air and water from spills must be estimated and added to process emissions when calculating total emissions for reporting purposes. The emission resulting from a spill is the net emission, ie., the quantity of the NPI reportable substance spilled, less the quantity recovered or consumed during clean up operations.

The **usage*** of each of the substances listed as Category 1 and 1a under the NPI must be estimated to determine whether the 10 tonnes (or 25 tonnes for VOCs) reporting threshold is exceeded. If the threshold is exceeded, **emissions** of these Category 1 and 1a substances must be reported for all operations/processes relating to the facility, even if the actual emissions of the substances are very low or zero.

* Usage is defined as meaning the handling, manufacture, import, processing, coincidental production or other uses of the substances.

3.1 Direct Measurement

You may wish to undertake direct measurement in order to report to the NPI, particularly if you already do so in order to meet other regulatory requirements. However, the NPI does not require you to undertake additional sampling and measurement. For the sampling data to be adequate and able to be used for NPI reporting purposes, it would need to be collected over a period of time, and to be representative of operations for the whole year.

3.1.1 Sampling Data

Water sampling tests often provide emissions data in terms of milligrams per litre. Annual emissions for NPI reporting can be calculated from this data. Water sampling tests for NPI reporting should be performed under representative (ie. normal) operating conditions. You should be aware that some tests undertaken for a State or Territory licence condition may require the test be taken under maximum emissions rating, where emissions are likely to be higher than when operating under normal operating conditions.

Example 1 demonstrates how sampling data can be used to estimate emissions of listed substances.

Example 1 - Emission of Fluoride Compounds to Waters

A potable water treatment facility adds fluorine to the water supply. During an emergency situation, 20 000 m³ of treated water from a water storage tank was drained into a local creek. Frequent sampling of the water supply indicated that the water contained a concentration of 0.4 mg/L of fluorine. From this information, fluoride compounds emitted to waters could be calculated:

$$E_F = (V * C_F) / 10^6$$

where

$$\begin{aligned} E_F &= \text{emissions of fluoride compounds (kg)} \\ V &= \text{volume of water emitted (L)} \\ C_F &= \text{concentration of fluoride compounds in water (mg/L)} \\ 10^6 &= \text{conversion of mg to kg} \end{aligned}$$

If volume is given in m³, then conversion of m³ to L is 1000 L/m³

$$\begin{aligned} E_F &= (20\,000\text{ m}^3 * 1000\text{ L/m}^3 * 0.4\text{ mg/L}) / 10^6\text{ mg/kg} \\ &= 8\text{ kilograms of fluoride emitted to water} \end{aligned}$$

3.1.2 Continuous Emission Monitoring System (CEMS) Data

A continuous emission monitoring system provides a continuous record of emissions over time, usually by reporting pollutant concentration.

Once the pollutant concentration is known, emission rates are obtained by multiplying the pollutant concentration by the volumetric gas or liquid flow rate of that pollutant.

It is important to note that prior to using CEMS to estimate emissions, you should develop a protocol for collecting and averaging the data in order that the estimate satisfies your relevant environmental authority's requirement for NPI emission estimations.

3.2 Mass Balance

A mass balance identifies the quantity of substance going in and out of an entire facility, process, or piece of equipment. Emissions can be calculated as the difference between input and output of each listed substance. Accumulation or depletion of the substance within the equipment should be accounted for in your calculation.

A mass balance may be used to estimate fugitive emissions of substances, such as losses through pipes and valves from equipment. Example 2 demonstrates how fugitive emissions of chlorine gas can be estimated using a mass balance.

Example 2 - Fugitive Losses of Chlorine

A water treatment facility utilises chlorine gas as a disinfectant. A total chlorine concentration (chlorine dosage) of 11 mg/L is applied to the water. The treatment plant has a daily water throughput of 112 megalitres. From purchasing data, it was determined that 34.5 tonnes of chlorine are used every 4 weeks. Water sampling of the source water indicates that no chlorine is present in the water before entering the treatment plant. From this, fugitive emissions of chlorine can be determined:

$$E_{Cl} = P_{Cl} - (((Cl_{treated} - Cl_{initial}) * V) / 10^6)$$

where:

E_{Cl}	=	emissions of chlorine (kg/d)
P_{Cl}	=	weight of chlorine purchased (kg/d)
$Cl_{treated}$	=	total chlorine concentration in treated water (mg/L)
$Cl_{initial}$	=	concentration of chlorine in water supply initially (mg/L)
V	=	volume of water treated per day (L/d)
10^6	=	conversion from milligrams to kilograms
$E_{kpy,Cl}$	=	$(34\ 500\ \text{kg Cl}/28\ \text{d}) - (((11 - 0)\ \text{mg Cl/L} * 112 * 10^6\ \text{L}) / 10^6\ \text{mg/kg})$
	=	$(1232.14 - 1232)\ \text{kg Cl/d}$
	=	0.14 kg/day or 140 g/day of chlorine emitted
	=	51 kg/yr

3.3 Engineering Calculations

An engineering calculation is an estimation method based on physical/chemical properties (eg. vapour pressure) of the substance and mathematical relationships (eg. ideal gas law).

3.4 Emission Factors

An emission factor is a tool that is used to estimate emissions to the environment. Emission factors are usually expressed as the weight of a substance emitted divided by the unit weight, volume, distance, or duration of the activity emitting the substance.

Emission factors developed from measurements for a specific process may sometimes be used to estimate emissions at other sites. Should a company have several processes of similar operation and size, and emissions are measured from one process source, an emission factor can be developed and applied to similar sources. You are required to have the emission factor reviewed and approved by State or Territory environment agencies prior to its use for NPI estimations. No emission factors are available for potable water treatment calculations.

3.4.1 Predictive Emission Monitoring (PEM)

Predictive emission monitoring is based on developing a correlation between pollutant emission rates and process parameters. A PEM allows facilities to develop site-specific emission factors, or emission factors more relevant to their particular process.

Based on test data, a mathematical correlation can be developed which predicts emissions using various parameters.

4.0 Emission Estimation Techniques: Acceptable Reliability and Uncertainty

This section is intended to give a general overview of some of the inaccuracies associated with each of the techniques. Although the National Pollutant Inventory does not favour one emission estimation technique over another, this section does attempt to evaluate the available emission estimation techniques with regards to accuracy.

Several techniques are available for calculating emissions from potable water treatment facilities. The technique chosen is dependent on available data, available resources, and the degree of accuracy sought by the facility in undertaking the estimate. In general, site-specific data that is representative of normal operations is more accurate than industry-averaged data.

4.1 Direct Measurement

Use of licensing and/or workplace health and safety sampling data is likely to be a relatively accurate method of estimating emissions from potable water treatment facilities. However, collection and analysis of samples from facilities can be very expensive and especially complicated where a variety of NPI-listed substances are emitted and where most of these emissions are fugitive in nature. Sampling data from a specific process may not be representative of the entire manufacturing operation and may provide only one example of the facility's emissions.

To be representative, sampling data used for NPI reporting purposes needs to be collected over a period of time, and to cover all aspects of water treatment.

In the case of CEMS, instrument calibration drift can be problematic and uncaptured data can create long-term incomplete data sets. However, it may be misleading to assert that a snapshot (single sample) can better predict long-term emission characteristics. It is the responsibility of the facility operator to properly calibrate and maintain monitoring equipment and the corresponding emissions data.

4.2 Mass Balance

Calculating emissions from a potable water treatment facility using mass balance appears to be a straightforward approach to emission estimations. However, inaccuracies associated with individual material tracking or other activities inherent in each material handling stage can often result in large deviations of total facility emissions. Because emissions from specific materials are typically below 2 percent of gross consumption, an error of only ± 5 percent in any one step of the operation can significantly skew emission estimations.

4.3 Engineering Calculations

Theoretical and complex equations or *models* can be used for estimating emissions from water treatment processes.

Use of emission equations to estimate emissions from potable water treatment facilities is a more complex and time-consuming process than the use of emission factors. Emission equations require more detailed inputs than the use of emission factors but they do provide an emission estimate that is based on facility-specific conditions.

4.4 Emission Factors

Every emission factor has an associated emission factor rating (EFR) code. This rating system is common to EETs for all industries and sectors and therefore, to all Industry Handbooks. They are based on rating systems developed by the United States Environmental Protection Agency (USEPA), and by the European Environment Agency (EEA). Consequently, the ratings may not be directly relevant to Australian industry. Sources for all emission factors cited can be found in Section 5.0 of this Manual. The emission factor ratings will not form part of the public NPI database.

When using emission factors, you should be aware of the associated EFR code and what that rating implies. An A or B rating indicates a greater degree of certainty than a D or E rating. The less certainty, the more likely that a given emission factor for a specific source or category is not representative of the source type. These ratings notwithstanding, the main criterion affecting the uncertainty of an emission factor remains the degree of similarity between the equipment/process selected in applying the factor, and the target equipment/process from which the factor was derived.

The EFR system is as follows:

A	-	Excellent
B	-	Above Average
C	-	Average
D	-	Below Average
E	-	Poor
U	-	Unrated

5.0 References

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