UNITED NATIONS
NATIONS

EP

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

UNEP

Regional Meeting on Reporting of Releases to Marine and Coastal Environment from Land Based Sources Activities and related Indicators

Tirana, Albania,19-20 March 2019

Agenda item 4: Methodology for Developing and Applying National Emission Factors

Methodology for Developing and Applying National Emission Factors

UNEP/MAP
Athens, 2019

Table of Contents

List of Abbreviations / Acronyms

EF	Emission Factors
EIPPCB	European Integrated Pollution and Control Bureau
BAT	Best Available Techniques
BAT-AEL	BAT Associated Emission Levels
BATC	BAT Conclusions
BOD$_5$	Biochemical Oxygen Demand
BREF	BAT Reference Document
EIA	Environmental Impact Assessment
ELV	Emission Limit Values
EQS	Environmental Quality Standards
UNIDO	United Nations Industrial Development Organization
UO	Unit Operation
WHO	World Health Organization

1   Introduction

1.   The application of emission factors (EF) for the estimation of the release of industrial pollutants into the environment is a widespread method for an approximate assessment of the relevant loads which is usually applied when/if real-time measurement values cannot be obtained. These Emission Factors are based on a statistical analysis of values of pollutants released by representative facilities of the respective industrial sectors in the world and they are reflected as range and/or averages.

2.   As a general rule, EF are values of inputs (e.g. water consumption) and/or outputs (e.g. pollutants such as Biochemical Oxygen Demand – BOD5) referring to quantities (in tons) of raw material or product.

3.   The World Health Organisation (WHO)[1] developed EF for the main industrial sectors in the past which still are applicable in most cases. The European Integrated Pollution, Prevention and Control Bureau (EIPPCB) also developed similar EF which are reflected in the Best Available Techniques (BAT) Reference Documents (BREFs)[2] which can be used as guidance for industrial operators and authorities to assess the relevant pollutants releases. The European Union, after having approved the relevant BREF (lengthy, complex documents), adopted the so-called BAT Conclusions (BATC) where associated emission levels (BAT-AEL) are defined, and referred to the relevant production processes. BATC can be seen as the BREF summary and are easier to be read/used.

4.   UN Environment/MAP in cooperation with UNIDO published a document containing internationally applicable EF which can be used as a reference for a first approximation of the pollution loads emitted from industrial operations[3]. Its aim is to provide to the Mediterranean countries a tool for the estimation of pollutants' releases which will not be far from the reality (since these international EFs are derived from typical industrial processes and the relevant releases) and can form a first estimation of the pollution loads.

5.   Furthermore, UN Environment/MAP [MEDPOL] presented the international emission factors during the Regional meeting on PRTR and Pollution Indicators in Ankara (16-17 June 2014) where the necessity for developing national EF has been pointed out; during the 2nd ENI SEIS II South Support Mechanism Regional Workshop on Indicators (17-18 April 2017, Athens) the Southern Mediterranean countries stressed the need to develop EF on the basis of the nationally prevailing conditions in order to assess the pollution loads more accurately, whereas the EU member states apply the factors developed by the EIPPCB if no real data information is available.

6.   Following this request, a methodological approach has been prepared and is proposed in this document which can be used as a reference for interested operators and authorities to obtain "tailor-made" data which can act as "substitute" for cases where measurements cannot be performed.

7.   It must be pointed out that the purpose for EF application serves two major issues: 1) the facilitation of reporting obligations (e.g. NBB update), and 2) the elaboration of national inventories (in case of absence of real-time measurements) in order to set policy priorities (i.e. to assess the environment's carrying capacity to accept pollution releases from important industrial sectors). the application of the EF allows a quick estimation of pollution loads and taking decisions where to place industrial facilities in an area.

---

[1] https://apps.who.int/iris/bitstream/handle/10665/58750/WHO_PEP_GETNET_93.1-A.pdf?sequence=1&isAllowed=y
[2] http://eippcb.jrc.ec.europa.eu/reference/
[3] UNEP(DEPI)/MED WG. 399/Inf.3 (16 May 2014)

8.   This document also aims to support Contracting Parties to comply with their legal obligation under Art.13 of the Land Based Sources (LBS) Protocol regarding reporting on NAP implementation throughout preparation and submission of the 4th Cycle of NBB update (2018).

2   What is an emission factor?

9.   The simplest form of an emission factor is a ratio of the mass of pollutant emitted per unit of activity generating the emissions (e.g. kg of particulate matter emitted per ton of coal burned).

10.   Typically, emissions factors are used to estimate process emissions as follows:
$$E = A \times EF \times [1 - (ER/100)]$$
   Where:
E = emissions quantity
A = activity rate (quantity of raw material)
EF = emission factor
ER = overall emissions reduction achieved by controls - treatment (%).

11.   EF are typically developed to represent long-term (e.g. annual) average emissions and, accordingly, data used for developing them is usually based on emissions testing collected during normal process operating conditions. Short-term emissions from a particular process will vary significantly over time because of fluctuations in normal process operating conditions, control device operating conditions, raw materials, ambient conditions and other factors.

3   Purpose for setting national emission factors

12.   Some national authorities prefer, instead of adopting internationally applicable EF, to develop their own ones hoping that they will better fit into the nationally prevailing operational conditions. This approach, although wishful, bears various risks due to the fact that reliable EF, if different from international ones, should be based on a detailed knowledge of the operational conditions of the industrial facilities and on reliable actual data (measurements).

13.   As a helpful way out, some methodologies are described below which can be taken into consideration for developing national EF.

4   Methodology for the definition of national emission factors

14.   To set national, "tailor-made" EF, there are various possibilities available which can be explored by authorities and operators in order to adjust international experience to actual national needs. It must be pointed out that usually these national EF factors do not significantly differ from the international ones which are derived from long lasting experience of evaluation of operational patterns of industries worldwide. Below, the major methods are presented which should be taken into consideration as basis for setting the nationally applicable EF.

4.1   *Use of BREF*

15.   The easiest way to develop national EF would be to search in the relevant BREFs (e.g. cement production, iron and steel, food industry etc.); find the relevant emission limit values (which are associated with the respective BAT); and adopt either these EF as is, or "play" with the specified numbers. The following Example 1 illustrates the calculation method.

Example 1: Cement industry - BREF[4] - BATC[5]

Calculation of EF for NOx emissions:
In the BATC go to page L100/18 and see table 2.

Kiln type	BAT-AEL (mg/Nm^3) as daily average value
Preheater kilns	< 200 - 450
Lepol and long rotary kilns	400 - 800

If preheater kilns are used, then choose the range < 200 – 450.

So for example, if 1,000 tons/day is the cement production and 500 Nm3 are emitted daily then 200 – 450 mg x 500 = 100 - 225 g NOx/1,000 tons of cement is emitted daily (i.e. 0,1 – 0.225 g/tons of cement for preheater kilns).

16.   The authorities/operators can then adopt either the lower or the higher value or the average of the given range according to their knowledge of the sector.

17.   The EF presented in the BREF documents/BATC are based on the newest stand of experience about industrial processes and expected emissions releases which are applicable worldwide.

18.   Therefore, national EF can be set by "playing" with the relevant figures for each industrial sector (minimum/ maximum/average values).

4.2   Permits

19.   All industrial operations are subject to a permitting procedure in order to commence their activities. The relevant permits (e.g. Environmental Impact Assessment Permits) prescribe the level of emissions of each pollutant (Emission Limit Values – ELV) and can be taken as reference to define the EF according to the calculation provided in Example 1. The relevant EF would be specific to each installation and according to the prevailing national/local conditions.

20.   Exceeding these ELVs is, however, a usual case in many countries due to the fact that either the ELV are too strict or the facilities do not operate properly. In that case, the records of the inspection authorities can be taken as reference showing the actual emission levels.

21.   A statistical analysis of these records can be taken into consideration, i.e. all values found for similar installations of the same sector (e.g. cement production, tanning etc.) can be interpreted and adjusted accordingly. However, if the ELV values are set arbitrarily in the permits, or with limited knowledge of the actual situation, they can be totally misleading. This is the case when the authorities simply adopt the emission factors proposed by the industrial operators who usually try to underestimate the pollution loads emitted. In that case, as stated earlier, the actual measurements are more reliable. The following Example 2 illustrates the calculation method.

---

[4] http://eippcb.jrc.ec.europa.eu/reference/cl.html
[5] http://eippcb.jrc.ec.europa.eu/reference/BREF/CLM_BATC_Published.pdf

> **Example 2: Tanning industry**
>
> In a permit for a tanning industry the relevant ELV is that it should discharge < 2 mg/l of chromium in the receiving river. That means that, by a given production capacity of 100 tons/day of skins processed and 20 m^3 wastewater/day, < 40 g of chromium are allowed to be discharged/day.
>
> Referring to the production capacity, the relevant EF is 40/100 = 0.4 g of chromium/ton of skin.

4.3   Environmental Quality Standards (EQS)

22.   In several countries there are the so called Environmental Quality Standards (EQS) in place which prescribe the quality of the environmental recipients (water, air, soil) to be maintained. In doing so, the emissions from facilities located in a definitive area have to be limited to such acceptable level so that the EOS are not exceeded.

23.   Setting EQS and the permissible ELV for facilities is a complex task requiring modelling of emissions and taking into consideration factors such as wind directions/frequency, river flows, dilution patterns etc. However, if defined, the relevant ELV should be reflected in the EIA permits and can then be taken from there.

24.   This method prescribes locally prevailing ELV. In developing national EF, a statistical evaluation of all set EQS has to be performed aiming to define the allowable ELV in the country. The locally defined ELV for all respective industrial sectors will be collected, interpreted/evaluated and either a statistical analysis will be elaborated (to define the average values) or the maximum permissible ELV will be considered.

25.   Usually such time/resource consuming modelling procedures are not properly applied in some countries so that reliable ELV cannot always be derived. The following Example 3 illustrates the calculation method.

> **Example 3: ELV for BOD**
>
> The modelling for setting EQS for a river showed that, in order to maintain the river's quality at acceptable levels, the ELV for BOD$_5$ for all industrial facilities discharging their effluents into this river should not exceed 50 mg/l (reflected in the permit).
>
> The calculation goes the same way as defined in section 4.2.

4.4   Direct measurements

26.   Direct measurements of facility or process emissions are conducted for a variety of reasons such as:

- Characterize process emissions and/or control device performance;
- Assess changes in process or control device operation on emissions and;
- Demonstrate compliance with national/local regulations.

27.   This is the most reliable method for EF identification: all large industrial facilities perform real-time measurements of their emissions and record them daily. These records reflect the actual situation in the facilities and are subject to inspections by the controlling authorities.

28.   In cases of absence of these measurements, the inspecting institutions perform periodically their own tests and collect the relevant data which can be then act as basis for the identification of the EF.

29.   The measurements of the ELV can then be transformed into the relevant EF by applying the calculation presented in Example 4.

Example 4: Cement industry

If 1,000 tons/day is the cement production, 200 mg/Nm^3 is the measured concentration (daily average) and 500 Nm^3 are emitted daily then
200 mg x 500 = 100 g NO$_x$/1,000 tons of cement are generated/day i.e. 0,1 g/ton of cement for preheater kilns (EF).

4.5   *Mass balance*

30.   The mass balance method is a reliable tool for the detailed calculation of all inputs and outputs in a unit operation (UO) of an industrial process. The process consists of a sequence of UO starting from the raw materials feeding and ending in the production of the final product.

31.   An industrial production process is schematically presented in Figure 1.
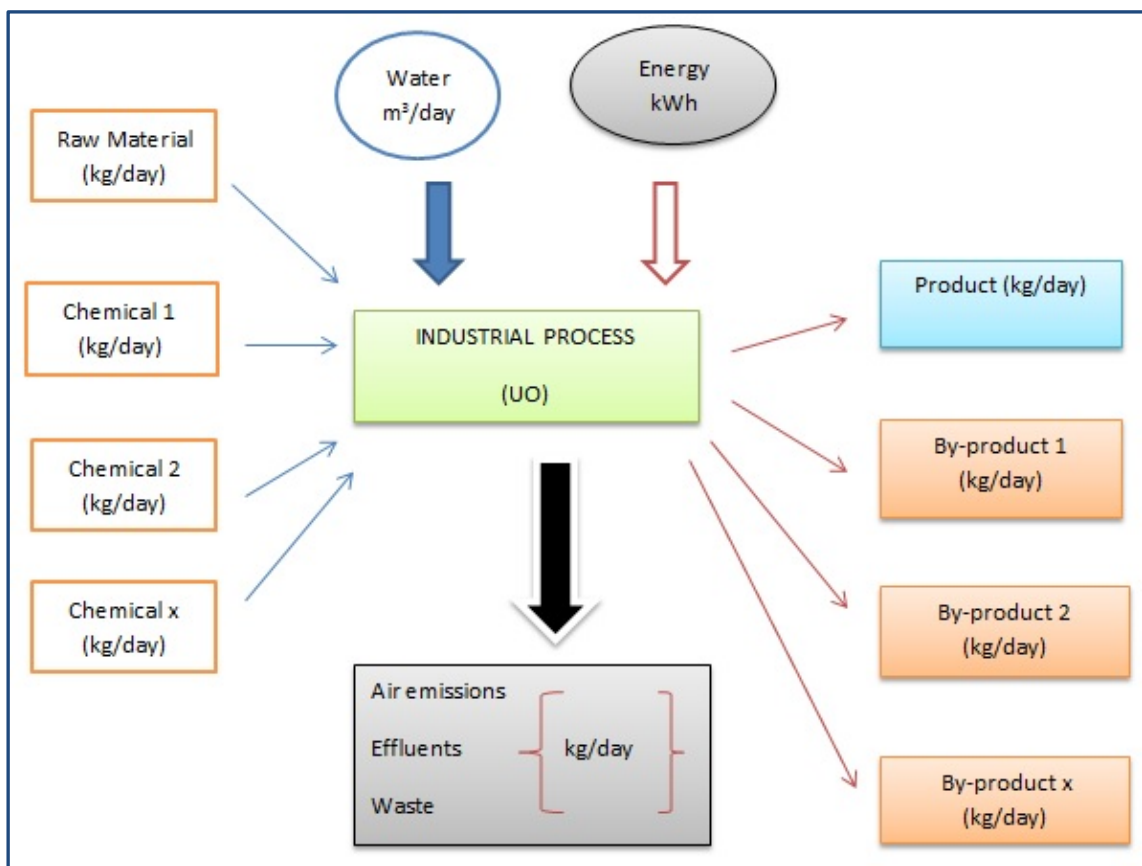

Figure 1: Mass balance in a UO

32.   The industrial operator knows exactly the quantities of raw materials, chemicals, water/energy usage (inputs) as well as of the final products and by-products (outputs), in addition to the chemistry and the physical operations which transform the raw materials to the products. Having this information in mind, he can then calculate the loads of emissions into the air and water and refer them to the raw materials quantities.

33.   The mass balance method can become very accurate if real-time measurements of the emissions exist, so that a clearer correlation between raw materials and emissions can be made. The following Example 5 illustrates the calculation method.

Example 5: Tanning industry

Raw material (skins) = 20,000 kg/day
Chemical 1 (chromium) = 100 kg/day
Water used: 10 m3/day
Product (leather products) = 15,000 kg/day
Wastewater = 7 m3/day
Chromium absorption by the production process = 80% (80 kg/day)

Then 20 kg of chromium/day are discharged with the effluents. The EF for chromium is 20kg/20 tons = 1kg/tons of raw material.

---

5   Selection of options

34.   Each one of the five options presented above has its own advantages/disadvantages. This depends totally on the authorities to choose the most appropriate option (or combination) according to their knowledge/experience, and to derive the relevant EF. The ranking of these options is presented in table 3.

Table 1: Ranking of methods for setting national EF

Ranking	Method	Advantages	Disadvantages	Data needed
1	Direct measurements	1. Reflects the actual situation of emissions; 2. Usually available (large installations); 3. Adaptable to changes of industrial processes	1. Small/medium enterprises are not always capable to have emissions recording devices; 2. If the facility is not operated properly data is not representative; 3. Inspection data is sometimes needed if the facility does not provide its own records. It is a resource consuming task	Emission records for air/water releases and production capacities
2	Mass balance	1. Simple and reliable; 2. Based on figures which usually exist (inputs/ outputs of industrial processes)	Authorities depend totally on the information provided by the industry (cross-check difficult)	Quantities of all inputs and outputs
3	Permits	Simple (application of set ELV)	Sometimes the set ELV do not correlate with the actual situation	ELV and production capacities prescribed in the permit
4	BREF	Confidence that the national EF do not deviate from international practice	Actually, they are not national EF	BREF EF

Ranking	Method	Advantages	Disadvantages	Data needed
5	Environmental Quality Standards (EQS)	Scientifically the most accurate method	Very complex, needs considerable resources and knowledge	ELV and production capacities prescribed in the permit

35. From the presented ranking it is obvious that, if real-time measurements of the emissions occur, it is the most favorable option to be adopted. The combination of this option with the mass balance method will give the best possible results whereas the mass balance method can be a "stand alone" option.

36. The simplest alternative is to adopt the ELV stated in the environmental permits; however, it is advisable to use it as a starting basis and oblige the industries to perform real-time measurements in order to obtain more accurate data.