

Developing EU environmental standards for the food, drink and milk industries: key environmental issues and data collection

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Abstract

Background The European Commission organised the review of the best available techniques reference document for the food, drink and milk industries according to the provisions of the Industrial Emissions Directive (Directive 2010/75/EU). Under this policy, an exchange of information between Member States, industrial organisations, non-governmental organisations promoting the protection of the environment and the European Commission took place. **Results** A crucial part for developing these EU environmental standards was a systematic determination of the key environmental issues of the food, drink and milk sector. Key environmental issues were defined for emissions to air and water, and for energy and water consumption. The key environmental issues were systematically determined by using four criteria proposed by the European Commission. Moreover, a data collection procedure was designed and real-plant emissions and consumption data were obtained for the first time from a representative variety of food, drink and milk installations across the European Union. **Conclusions** The development of the EU environmental standards for the food, drink and milk sector are based on a systematic determination of the key environmental issues and on a representative data collection for this sector. This paper also highlights the main normative, organisational and procedural factors addressed during the environmental policy integration carried out to develop these standards.

Background

The European food, drink and milk (FDM) sector produces both finished products destined for consumption and intermediate products destined for further processing. Europe's food and drink industry is the largest manufacturing industry in the EU-28 with an annual turnover of EUR 1 039 billion and 4.42 million jobs in 2016. This represented 14.6 % of the total manufacturing sector turnover and 14.5 % of the total manufacturing sector employment in the EU-28. This industry sector is highly fragmented with almost 290 000 companies, with the majority being small and medium-sized enterprises (Giner Santonja et al., 2019a).

Moreover, the EU-28 FDM sector is characterised by its diversity compared to many other industrial sectors. This diversity can be seen in many aspects, e.g. in the configuration and size of companies, the wide range of raw materials and products, and the numerous processes and the combinations of each (Giner Santonja et al., 2019a).

The original best available techniques reference document (BREF) on Food, Drink and Milk Industries was formally adopted by the European Commission in 2006 (European Commission, 2006) under the IPPC Directive (Council EU, 1996). This report described the key environmental issues of the FDM sector, although they were not determined systematically. Moreover, a plant-specific data collection from real FDM industries was not carried out at that time.

Data from the European Pollutant Release and Transfer Register (E-PRTR) show that FDM industries represent a small share of the total industrial emissions for most of the pollutants reported (E-PRTR, 2020). However, the number of installations and substances identified by this approach needs to be treated with caution because it is strongly influenced by the E-PRTR reporting thresholds. For example, there may be substances which are emitted by a large number of FDM installations but at levels just below the E-PRTR reporting threshold so those installations will not appear in the E-PRTR.

Another report (ICF, 2018) attempted to assess the significance of pollution caused by the FDM industries, in particular by allowing the comparison and/or aggregation of different pollutants. The report described different methods such as weighting the pollutants according to their human health toxicity and ecotoxicity. This report also indicated a low significance of the pollution caused by the FDM industries, compared to other industrial sectors. This report needs to be analysed carefully, considering the uncertainties inherent to the USEtox model used to characterise the toxicity and ecotoxicity of various substances.

The adoption of the Industrial Emissions Directive (2010/75/EU) (European Parliament and Council, 2010) reinforced the legal nature of the best available techniques (BAT). Due to the legal nature of this type of environmental standard, the development of BAT for the FDM industries needs to be based on sound scientific evidence.

Standards play a key role in defining acceptable levels of environmental protection and as an effective tool to regulate environmental issues including in countries outside the EU (Goulden et al., 2019). Moreover, the participation of non-governmental stakeholders, including industry and environmental organisations, in determining the benchmarks upon which policies are enacted is deemed extremely important. In this sense, the reference documents on best available techniques (BREFs) are considered a vital basis for the development of environmental standards worldwide. Furthermore, the necessity for environmental policy integration has become a key endeavour, as governments prepare to implement the 2030 Agenda and the 17 Sustainable Development Goals adopted by the UN General Assembly in 2015 (Nilsson and Persson, 2017).

Three types of factors can be addressed in an environmental policy integration: normative factors, organisational factors and procedural factors (Lenschow et al., 1998). Normative factors refer to the legal framework of the policy-making, organisational factors include the interaction of stakeholders, and

procedural factors refer to the procedure carried out for the environmental policy integration (Persson, 2004). This paper describes a case of policy implementation, which is a critical step for environmental policy integration (Person and Runhaar, 2018).

A study was carried out with the following key concepts: (1) determine the key environmental issues for the FDM industries; (2) analyse the environmental performance of FDM installations and techniques in terms of emissions, consumption and nature of raw materials, water and energy consumption, through a data collection from FDM industries.

As explained in Section 2 of this paper, the key environmental issues and the environmental performance of the FDM industries are essential to develop the environmental standards known as best available techniques. Section 2 also describes the main factors of the environmental policy integration used to develop these EU environmental standards. Section 3 describes the outcome of the determination of the key environmental issues and of the data collection performed to analyse the environmental performance of the FDM industries in the EU.

Methodology

2.1 Legal framework: the Industrial Emissions Directive

The Industrial Emissions Directive (2010/75/EU) (European Parliament and Council, 2010) is the primary EU legal instrument to regulate industrial emissions and aims to achieve significant benefits for the environment and human health, in particular through the application of Best Available Techniques (BAT) whereas ensuring a level playing field for industry.

The scope of the Industrial Emissions Directive (IED) covers a large spread of industrial sectors and activities (e.g. combustion plants, production of cement, lime and magnesium oxide, intensive rearing of poultry and pigs, waste management), usually over a certain capacity threshold, specified for individual sectors and activities. All these industrial sectors and activities as well as their respective capacity threshold (if relevant) are defined in Annex I to the IED.

The IED regulates pollutant emissions to air, water and soil, and aims to prevent the generation of waste and promote the efficient use of resources from about 50 000 industrial installations across the European Union (EU). These industrial installations generate almost a quarter of the total EU emissions to air and water. It is estimated that they account for around 23 % by mass of emissions to air. For emissions to

water, the situation is less clear, but it is estimated to represent 20 % to 40 % of emissions of heavy metals and 30 % to 60 % of pollutants other than nutrients and organic carbon (European Commission, 2017).

The installations covered by the IED must be operated in accordance with a permit granted by the relevant competent authority in the Member States. The technical basis for national competent authorities in EU countries to set permit conditions for industrial installations is the BAT conclusions. BAT conclusions cover a variety of environmental issues such as emissions to air and to water, waste generation, energy efficiency and water consumption (European Commission, 2012).

Permit conditions must be based on the use of BAT, with the BAT conclusions adopted by the European Commission serving as the reference for setting these conditions. BAT are defined as established techniques which are the most effective at achieving a high level of protection of the environment as a whole and which are developed on a scale that allows implementation in the relevant sector under economically and technically viable conditions taking into account the costs and advantages (European Parliament and Council, 2010).

The techniques listed and described in the BAT conclusions are neither prescriptive nor exhaustive. Other techniques that ensure at least an equivalent level of environmental protection may be used. The selection of (a) technique(s) to prevent or reduce a specific pollutant at installation level is a decision that depends on various factors, such as the technical configuration of the installation, the raw materials used, economics, sector legislation or safety issues (European Commission, 2012).

An individual BAT conclusion with BAT-associated emission levels (BAT-AELs) will contain a numerical range of emission levels. The units, the reference conditions (e.g. flue-gas oxygen level, temperature, pressure) and the averaging period (e.g. hourly/daily/weekly/monthly/yearly average) for a given BAT-AEL must be unambiguously defined. If considered necessary, and if the data available allow for doing so, BAT-AELs may be expressed as short-term and long-term averages (Giner-Santonja et al., 2019b). The Member States' competent authorities shall set emission limit values that ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques (European Parliament and Council, 2010).

Environmental performance levels (BAT-AEPLs) other than emission levels can be associated with certain BAT. Examples include consumption of material, water or energy, the generation of waste, abatement efficiency on pollutants and duration of visible emissions.

According to the IED, the Commission should organise an exchange of information with Member States, the industries concerned and non-governmental organisations promoting environmental protection in order to draw up, review and, where necessary, update BAT reference documents (hereafter BREFs). That exchange of information shall, in particular, address the following (European Parliament and Council, 2010):

- the performance of installations and techniques in terms of emissions, consumption and nature of raw materials, water and energy consumption, and generation of waste;
- the techniques used, economic and technical viability and developments therein;
- best available techniques.

A best available techniques (BAT) reference document (BREF), resulting from this exchange of information, is a document drawn up for defined activities describing, in particular, applied techniques, present emission and consumption levels, techniques considered for the determination of BAT as well as BAT conclusions and emerging techniques (European Commission, 2012).

In more detail, 'BAT conclusions' are defined as the parts of a BREF laying down the conclusions on BAT, their description, information to assess their applicability, the emission levels associated with the BAT, associated monitoring, associated consumption levels and, where appropriate, relevant site remediation measures. The BAT conclusions are adopted through the procedure referred to in Article 75(2) of the IED. They shall be the reference for setting permit conditions for the installations covered by the IED (European Parliament and Council, 2010).

Best available techniques (BAT) are defined as the most effective and advanced stage in the development of activities and their methods of operation, to reduce emissions and the impact on the environment as a whole (European Parliament and Council, 2010):

(a) *'techniques'* includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned;

(b) *'available techniques'* means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator;

(c) *'best'* means most effective in achieving a high general level of protection of the environment as a whole.

The BAT conclusions document for a specific industrial sector contains several individual conclusions, each of them addressing an environmental objective related to the prevention or reduction of one or more pollutants. The IED permits should make reference to one or a combination of the techniques listed in the corresponding BAT conclusion(s). The IED sets the objective to review each BREF every 8 years in order to reflect technical progress.

The reviews of BREFs are coordinated by the European Integrated Pollution Prevention and Control Bureau (EIPPCB), part of the Joint Research Centre that belongs to the European Commission. Evidence-based decisions on BAT and BAT-AEPLs are taken with the consensus of the Technical Working Group members (see Section 2.1). The information collected during a BREF review is shared among the TWG members through an online platform called BATIS (BAT Information System). Whilst an evaluation based on quantitative data is preferable, qualitative information, such as stakeholder opinions and criteria, is an important complement to quantitative data.

Food, drink and milk industries are covered by points 6.4 (b) and 6.4 (c) of Annex I to the IED. Specifically, these points state the following (European Parliament and Council, 2010):

"6.4 (b) Treatment and processing, other than exclusively packaging, of the following raw materials, whether previously processed or unprocessed, intended for the production of food or feed from:

(i) only animal raw materials (other than exclusively milk) with a finished product production capacity greater than 75 tonnes per day;

(ii) only vegetable raw materials with a finished product production capacity greater than 300 tonnes per day or 600 tonnes per day where the installation operates for a period of no more than 90 consecutive days in any year;

(iii) animal and vegetable raw materials, both in combined and separate products, with a finished product production capacity in tonnes per day greater than:

– 75 if A is equal to 10 or more; or,

– $[300 - (22.5 \times A)]$ in any other case,

where 'A' is the portion of animal material (in percent of weight) of the finished product production capacity.

Packaging shall not be included in the final weight of the product.

This subsection shall not apply where the raw material is milk only.

6.4 (c) Treatment and processing of milk only, the quantity of milk received being greater than 200 tonnes per day (average value on an annual basis)."

2.2 The procedure for KEI and data collection

A technical working group (TWG) was created to discuss the key environmental issues and the data collection process from FDM industries. The Technical Working Group (TWG) is the main source of information for the drawing up and reviewing of a BREF. It is comprised of relevant technical experts from Member States, industrial organisations and non-governmental organisations for the protection of the environment (European Commission, 2012).

The reactivation of the TWG for the review of the FDM BREF took place in early 2014, and it consisted of around 180 technical and regulatory experts. The TWG for the review of the FDM BREF held its Kick-off Meeting (KoM) in Seville, Spain on 27 to 30 October 2014.

Around 80 experts representing national competent authorities, industrial organisations and non-governmental organisations attended the KoM. Experts covering a large diversity of the food sector (e.g. dairies, breweries, sugar manufacturing, starch production, animal feed, oilseed processing and refining, meat production) were present at the KoM. This representativeness was extremely important, taking into account the diversity of the sector and the numerous different applied processes and techniques.

The meeting focused on the key environmental issues (KEIs) of the FDM sector, on the most effective arrangements for exchanging and gathering information on best available techniques (addressing the basic features required by Article 13 of the IED), on the definition of the scope of the FDM BREF and on issues related to the data and information collection.

KEIs are a tool to focus the TWG resources on a manageable number of issues. It is important for KEIs to be identified at the beginning of a BREF review process with the intention of deriving BAT-AELs or other BAT-AEPLs for these KEIs.

The following criteria have been proposed by the European Commission for the identification of KEIs (European Commission, 2015):

- the environmental relevance of the (air, water, or soil) pollution caused by the activity or process concerned, i.e. whether it may cause an environmental problem;
- the significance of the activity in terms of number of installations, their geographical spread and their contribution to the total (industrial) emissions in the EU;
- the potential of the BREF review for identifying new or additional techniques that would further significantly reduce pollution;
- the potential of the BREF review for defining BAT-AELs that would significantly improve the level of protection of the environment as a whole in comparison with the current emission levels.

In order to assist the discussions during the KoM, a background paper detailing the main items to be discussed was prepared by the European Integrated Pollution Prevention and Control Bureau (EIPPCB) and sent to the TWG members in advance of the meeting. The items had been derived from about 1 000 initial positions sent by the TWG in advance of the KoM. Initial positions are preliminary suggestions and comments provided by the members of the TWG.

Around 2 800 European FDM installations are covered by the IED (Giner Santonja et al., 2019a). The TWG applied several criteria for selecting plants for the plant-specific data collection via questionnaires, in order to ensure a balanced representation of the FDM sector:

- the environmental performance;
- the use of BAT and innovative techniques;
- the production capacity – both small and large;

- the age of the plant – both newer and older;
- the processes – single and multi-product processes;
- the FDM subsector;
- geographical distribution;
- products/processes that required a dedicated approach due to their environmental relevance;
- availability of data.

The data collection took place by using a tailor-made questionnaire (see Section 3.2). The questionnaire is an important tool for every BREF review process, since it should enable the efficient and comprehensive collection of representative data and contextual information for the derivation of technically sound BAT conclusions.

A first draft questionnaire template (in Excel form) was prepared by the EIPPCB and distributed to the TWG for their comments. Based on these comments, the EIPPCB updated the first draft questionnaire and a TWG meeting took place in Brussels to finalise it. The final draft questionnaire was tested by a limited number of FDM installations. Once the questionnaire was finished, it was distributed by EU Member States' representatives to the selected plants. The EU Member States' representatives were also responsible for collecting the filled-in questionnaires, checking the quality of the data and submitting the quality-checked questionnaires to the EIPPCB.

The questionnaire was designed in such a way that avoided requesting confidential data as much as possible. The only information considered confidential was the amount of energy consumed and raw materials used as well as the amount of products.

In parallel to the FDM data collection, the TWG collected information on the applied processes and techniques in the different FDM subsectors, on the techniques to be considered for the determination of BAT and on the emerging techniques. These techniques covered both pollution prevention and control measures, and the information included the following elements: technical description, achieved environmental benefits, environmental performance and operational data, cross-media effects, technical considerations relevant to applicability, economics, driving force for implementation, example plants and related reference literature. Around 100 contributions/sources of qualitative information were used to update the FDM BREF.

Based on the new information/data, a draft of the revised FDM BREF was produced and made available to the whole TWG for their comments. A major update was the inclusion of real-plant consumption and emission data for the identified key environmental issues (see Section 3).

The TWG members submitted 1 963 comments in relation to the draft FDM BREF. The majority of them (around 60 %) were on the BAT conclusions chapter of the FDM BREF. The EIPPCB assessed all the comments and made proposals which were then incorporated in the final draft of the FDM BREF.

An intense 5-day final meeting took place in Seville (Spain) between 14 and 18 May 2018, involving around 80 TWG members. The purpose of the final meeting is for the TWG to conclude the technical discussions and decide on BAT for the sector. The basis of the meeting was a background paper produced by the EIPPCB taking into account the TWG comments on the BAT conclusions section of the draft FDM BREF.

A consensus was achieved on the BAT for the FDM sector, consisting of 37 individual BAT conclusions. Of these, 4 covered general aspects including environmental management and monitoring practices, 8 related to energy efficiency, 3 to resource efficiency, 2 to harmful substances, 2 to water consumption and waste water discharge, 3 to waste, 10 to emissions to air, 2 to emissions to water, 1 to odour and 2 to noise.

Based on the outcome of the final meeting and the TWG comments on the draft FDM BREF, a pre-final draft was produced for the TWG to verify the decisions taken in the final meeting were brought on board of the BREF. The TWG comments on the pre-final draft were used to produce the final draft of the FDM BREF.

Further steps outside the remit of the TWG were followed, in relation to the opinion of the formal IED Forum (November 2018) on the final draft of the revised FDM BREF, the positive vote by EU Member States (decide by a qualified majority in June 2019) on the BAT conclusions, required to proceed with the legal adoption of the BAT conclusions by the Commission (European Commission, 2019). The revised FDM BREF is publicly available on the EIPPCB website (Giner Santonja et al., 2019a).

Results

3.1 Key environmental issues

3.1.1 Emissions to water

In general terms, waste water originating from the FDM industry is, in most cases, biodegradable. Taking this into account, along with the information in the FDM BREF adopted in 2006 and in the initial TWG positions, the EIPPCB considered that there was a basis for a horizontal proposal across the FDM sector in relation to the KEIs for emissions to water. Therefore, the EIPPCB initially proposed chemical oxygen demand (COD), total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) as KEIs.

The EIPPCB also proposed total organic carbon (TOC) as a KEI as an alternative to COD. The basis of this proposal is that the analytical method for COD includes the use of the toxic dichromate compound.

Furthermore, it was proposed to collect data for the parameters biochemical oxygen demand (BOD) and ammonium nitrogen, but only as contextual information to assess the performance of the waste water treatment plant. Biodegradable compounds covered by BOD are a subset of all organic matter present in the waste water. BOD is therefore included in the parameter COD/TOC. Moreover, the measurement uncertainty for BOD is higher than for COD/TOC and the monitoring result is only available several days after sampling (Brinkmann et al., 2018).

The discussion at the KoM showed that the EIPPCB proposals were largely acceptable. There was general concern about the availability of data in relation to TOC. The merit of promoting the measurement of TOC was explained by the EIPPCB. It was also clarified that

the intention was to collect all the available TOC data and that the TWG assessment would show the suitability of establishing a related BAT-AEL.

It was also agreed during the KoM to collect data for Cl⁻ emissions to water for dairies and fish and shellfish processing, since brine is generated from various processes within these sectors (e.g. production of cheese, demineralised powder, fish processing and preservation).

Table 1 presents a general overview of the key environmental issues for emissions to water agreed on at the KoM for the review of the FDM BREF across the 13 FDM sectors for which data were collected.

Table 1: Key environmental issues for emissions to water from the FDM sector (adapted from Giner Santonja et al., 2019a)

| FDM subsector | Common parameters | Additional parameters |
|---|-----------------------|-----------------------------|
| Dairies | TOC, COD, TSS, TN, TP | Chloride (Cl ⁻) |
| Sugar manufacturing | | — |
| Fruit and vegetables | | — |
| Meat processing | | — |
| Animal feed | | — |
| Oilseed processing and vegetable oil refining | | — |
| Starch production | | — |
| Brewing | | — |
| Fish and shellfish processing | | Chloride (Cl ⁻) |
| Olive oil processing and refining | | — |
| Soft drinks and juice made from concentrate | | — |
| Ethanol production | | — |
| Grain milling | — | — |

3.1.2 Emissions to air

A different pattern was followed to decide on the KEIs for emissions to air. The diversity of the applied processes in the FDM sector made it necessary to discuss the KEIs using a sector-by-sector approach, identifying the different air pollutants and the relevant emission sources. Overall, it was concluded that dust was the predominant KEI in relation to emissions to air.

The emission source is important contextual information in relation to emissions to air. For some FDM subsectors, the TWG decided at the KoM on the KEIs without any indication of the emission source. At a later stage of the FDM BREF review process, the TWG identified the major emission sources for emissions to air.

Table 2 presents an overview of the key environmental issues for channelled emissions to air with an indication of the emission sources.

On-site combustion plants to produce electricity or heat are excluded from the scope of the FDM BREF, as they are covered by the scope of the Large Combustions Plants BREF (Lecomte et al., 2017) or by the scope of the Directive EU/2015/2193 (European Parliament and Council, 2015).

Table 2: Key environmental issues for channelled emissions to air from the FDM sector (adapted from Giner Santonja et al., 2019a)

| Substance/Parameter | FDM subsector | Emission source |
|-------------------------------|---|---|
| Dust | Animal feed | Drying of green fodder |
| | | Compound feed manufacturing |
| | Brewing | Handling and processing of malt and adjuncts |
| | Dairies | Drying processes |
| | Grain milling | Grain cleaning and milling |
| | Oilseed processing and vegetable oil refining | Handling and preparation of seeds, drying and cooling of meal |
| | Starch production | Drying of starch, protein and fibre |
| | Sugar manufacturing | Drying of beet pulp |
| Total volatile organic carbon | Fish and shellfish processing | Smoke chambers |
| | Meat processing | Smoke chambers |
| | Oilseed processing and vegetable oil refining | — |
| | Sugar manufacturing | High-temperature drying of beet pulp |
| NO _x | Meat processing | Smoke chambers |
| | Sugar manufacturing | High-temperature drying of beet pulp |
| Carbon monoxide | Meat processing | Smoke chambers |
| | Sugar manufacturing | High-temperature drying of beet pulp |
| SO _x | Sugar manufacturing | Drying of beet pulp when natural gas is not used |

3.1.3 Energy consumption

FDM manufacturing generally requires significant amounts of energy. Electrical and thermal energy are commonly used in every process step. Electricity is normally needed for process control of the installation, for heating, for refrigeration and as the driving power for machinery. Thermal energy is normally needed for heating processing lines.

Energy consumption was largely recognised as a KEI for the FDM sector by the TWG members. The TWG conclusion of the KoM was to collect data and contextual information on the consumption of energy for relevant FDM subsectors (Giner Santonja et al., 2019a).

3.1.4 Water consumption

A large part of the FDM sector cannot operate without a substantial amount of usually good quality water. Water is generally used in the FDM sector for:

- food processing, where the water either comes into contact with or is added to the product;
- cleaning of equipment and the installation;
- washing of raw and packaging materials;
- auxiliary processes, e.g. boilers, cooling circuits, refrigeration.

Hygiene and food safety standards have to be maintained and this issue affects the proportion of water that can be recycled and reused.

As for energy consumption, water consumption was largely recognised as a KEI for the FDM sector by the TWG members. The TWG conclusion at the KoM was to collect data and contextual information on the consumption of water for relevant FDM subsectors (Giner Santonja et al., 2019a).

3.2 Data collection

The diversity of the FDM sector required that the data collection be focused on a defined group of FDM subsectors. Factors, such as the information included in the FDM BREF adopted in 2006 and the number of FDM installations across Europe, were taken into account. The TWG decided that the FDM subsectors for which emission data would be collected via questionnaires were the following:

- animal feed;
- brewing;
- dairy sector;
- ethanol production, taking place in a FDM installation or as a directly associated activity;
- fish and shellfish processing;
- fruit and vegetables;
- grain milling;
- meat processing;
- oilseed processing and vegetable oil refining;
- olive oil processing and refining;
- soft drinks and nectar/juice;
- starch production;
- sugar manufacturing.

The data and information requested by the final questionnaire regarding emissions to water consisted mainly of the following:

- Type of waste water discharge: direct, indirect or landspreading.

- Volume of waste water discharged (in m³/year).
- Volume of waste water reused/recycled (in m³/year).
- Share of waste water treated in the waste water treatment plant (WWTP) from sources other than from the FDM activity (e.g. municipal waste water, industrial waste water other than originating from the FDM activity).
- Waste water treatment techniques.
- Emission levels for each KEI, expressed in concentrations and specific loads for the influent and effluent of the WWTP. Statistical values were requested for each year: minimum, average, 95th percentile, maximum.
- For each KEI: number of measurements taken during 1 year, measurement method, emission limit values prescribed by the competent authority in the permit.
- In the case of a FDM installation with a seasonal activity: duration of the campaign period (in months).

The data and information requested by the final questionnaire regarding emissions to air for the major emission sources consisted mainly of:

- type of emission source and processes connected to it;
- waste gas flow (Nm³/h) and oxygen level (% by volume);
- abatement techniques implemented for the emission source;
- for each KEI: number of measurements taken during 1 year, measurement method, average abatement efficiency, emission limit values prescribed by the competent authority in the permit;
- in the case of a dryer: type of dryer, type of dried product, characterisation of dust fraction;
- in the case of a FDM installation with seasonal activity: duration of the campaign period (months).

The data and information requested by the final questionnaire regarding energy consumption consisted mainly of:

- total amount of energy consumed by the FDM installation (MWh/year);
- energy consumption (MWh/year) by use, e.g. in the FDM process, for cooling, for cleaning;
- techniques implemented for the reduction of energy consumption.

The data and information requested by the final questionnaire regarding water consumption consisted mainly of:

- total amount of water consumed by the FDM installation (m³/year);
- source(s) of the inlet raw water (e.g. water supply network, seawater, underground water);
- water consumption (m³/year) by use, e.g. in the FDM process, for cleaning, for cooling;
- total amount of water recycled/reused (m³/year);
- techniques implemented for the reduction of water consumption and water reuse or recycling.

Additionally, the following data were requested for all FDM installations:

- total amount and share of raw materials and/or products;
- type and frequency of cleaning procedures;
- chemicals and other substance used for cleaning;
- characteristics of the main residues, wastes and by-products generated by the FDM installation.

Data from 353 European FDM installations, gathered for the years 2012 to 2014, were collected using the final questionnaire. These questionnaires were validated and submitted by 16 EU Member States, ensuring a satisfactory representation at EU level. This was an important step in comparison to the FDM BREF adopted in 2006.

The distribution of the submitted questionnaires in relation to the FDM subsectors is depicted in Figure 2.

Overall, the agreed FDM subsectors were well represented, except for olive oil processing and refining along with fish and shellfish processing and ethanol production. The majority of the submitted questionnaires referred to dairies, followed by the brewing subsector.

Validated data were subsequently assessed and discussed within the TWG (e.g. through the comments provided on the first draft of the revised FDM BREF and during two dedicated data assessment workshops). This assessment was essential to draw up BAT conclusions and set BAT-AELs.

Due to the large amount of data collected, this paper is presenting a few examples, e.g. Table 3, Table 4, Table 5 and Table 6 present a summary of data regarding TSS, COD, TN and TP emissions to water across the FDM subsectors.

Table 3: Ranges of yearly average concentrations of TSS in the effluent of the WWTP (Giner Santonja et al., 2019a)

| FDM subsector | Yearly average TSS concentration (mg/l) | | |
|---|---|--------------------|---------------|
| | Direct discharge | Indirect discharge | Landspreading |
| Animal feed | 4.6-97 | 91-303 | NI |
| Brewing | 2.5-21 | 1.58-1 095 | NI |
| Dairies | 0.6-41.4 | 18-1 095 | NI |
| Ethanol production | NI | NI | NI |
| Fish and shellfish processing | NI | 1 570 | NI |
| Fruit and vegetables | 3-65.3 | 84 | 301-1 132 |
| Grain milling | NI | NI | NI |
| Meat processing | 0.02-51.2 | 135-1 440 | 481.25 |
| Oilseed processing and vegetable oil refining | 0.02-166 | 0.15-153 | NI |
| Olive oil processing and refining | NI | 130-300 | NI |
| Soft drinks and nectar/juice | 0.05-34.4 | 29 | 88 |
| Starch production | 5-42.8 | 29 | 130-5 107 |
| Sugar manufacturing | 0.04-128 | 980 | 4 021 |
| All FDM subsectors | 0.02-166 | 0.15-1 440 | 88-5 107 |

B: NI = no information provided.

Table 4: Ranges of yearly average concentrations of COD in the effluent of the WWTP (Giner Santonja et al., 2019a)

| FDM subsector | Yearly average COD concentration (mg/l) | | |
|---|---|--------------------|----------------|
| | Direct discharge | Indirect discharge | Landspreading |
| Animal feed | 19-155 | 778-8 890 | NI |
| Brewing | 16-85 | 111-5 779 | NI |
| Dairies | 8-147 | 40-4 475 | 20.1 and 1 001 |
| Ethanol production | 41-65 | NI | NI |
| Fish and shellfish processing | NI | 5 741 | NI |
| Fruit and vegetables | 13-187 | 2 319 | 2 205-5 402 |
| Grain milling | NI | NI | NI |
| Meat processing | 22-259 | 406-3 800 | 1 692 |
| Oilseed processing and vegetable oil refining | 15-363 | 53-5 561 | NI |
| Olive oil processing and refining | NI | 53-645 | NI |
| Soft drinks and nectar/juice | 6-78 | 1 537-3 253 | 3 322 |
| Starch production | 31-284 | 76.25 | 513-11 333 |
| Sugar manufacturing | 22-132 | 4 675 | 5 556 |
| All FDM subsectors | 6-363 | 40-8 890 | 20.1-11 333 |

B: NI = no information provided.

Table 5: Ranges of yearly average concentrations of TN in the effluent of the WWTP (Giner Santonja et al., 2019a)

| FDM subsector | Yearly average TN concentration (mg/l) | | |
|---|--|--------------------|---------------|
| | Direct discharge | Indirect discharge | Landspreading |
| Animal feed | 2.4-12 | 89-231 | NI |
| Brewing | 4.8-25 | 26.5-81.5 | NI |
| Dairies | 1.1-23.4 | 38-214 | 4.2-111 |
| Ethanol production | NI | NI | NI |
| Fish and shellfish processing | NI | NI | NI |
| Fruit and vegetables | 0.4-22.8 | 10.2 | 9-105 |
| Grain milling | NI | NI | NI |
| Meat processing | 2.4-17.9 | 33-358 | 53 |
| Oilseed processing and vegetable oil refining | 0.9-15.3 | 2.5-110 | NI |
| Olive oil processing and refining | NI | 4 | NI |
| Soft drinks and nectar/juice | 1.3-4.1 | 10 | 11.7 |
| Starch production | 3-13.4 | 4.3 | 55-2 150 |
| Sugar manufacturing | 1.7-26.3 | 265 | 86 |
| All FDM subsectors | 0.4-26.3 | 4-358 | 4.2-2 150 |

B: NI = no information provided.

Table 6: Ranges of yearly average concentrations of TP in the effluent of the WWTP (Giner Santonja et al., 2019a)

| FDM subsector | Yearly average TP concentration (mg/l) | | |
|---|--|--------------------|----------------|
| | Direct discharge | Indirect discharge | Landspreading |
| Animal feed | 19-155 | 778-8 890 | NI |
| Brewing | 16-72 | 111-5 779 | NI |
| Dairies | 9-68 | 40-4 475 | 20.1 and 1 001 |
| Ethanol production | 65 | NI | NI |
| Fish and shellfish processing | NI | 5 741 | NI |
| Fruit and vegetables | 18-114 | 2 319 | 2 205-5 402 |
| Grain milling | NI | NI | NI |
| Meat processing | 26-260 | 406-3 800 | 1 692 |
| Oilseed processing and vegetable oil refining | 14-308 | 53-5 561 | NI |
| Olive oil processing and refining | NI | 53-645 | NI |
| Soft drinks and nectar/juice | 6-65 | 1 537-3 253 | 3 322 |
| Starch production | 42-284 | 76.25 | 513-11 333 |
| Sugar manufacturing | 26-493 | 4 675 | 5 556 |
| All FDM subsectors | 6-493 | 40-8 890 | 20.1-11 333 |

B: NI = no information provided.

Table 7 presents a summary of data received in relation to channelled dust emissions to air across some FDM subsectors.

Table 7: Ranges of channelled dust emissions to air (adapted from Giner Santonja et al., 2019a)

| FDM subsector | Emission source | Average dust concentration over the sampling period (mg/Nm ³) |
|---|---|---|
| Animal feed | Drying of green fodder | 116.2-184.2 |
| | Compound feed manufacturing | 0.01-59.7 |
| Brewing | Handling and processing of malt and adjuncts | 0.02-138.1 |
| Dairies | Drying processes | 0.1-198.0 |
| Grain milling | Grain cleaning and milling | 0.1-84.0 |
| Oilseed processing and vegetable oil refining | Handling and preparation of seeds, drying and cooling of meal | 0.01-48.1 |
| Starch production | Drying of starch, protein and fibre | 0.16-78.72 |
| Sugar manufacturing | Drying of beet pulp | 1.1-1 955.9 ⁽¹⁾ |
| ⁽¹⁾ Concentration normalised at 16% O ₂ . | | |

Discussion

The data collection and the discussions within the TWG revealed a number of issues that may need to be addressed during the next (second) review of the FDM BREF. These issues include the following:

- The first review of the FDM BREF collected data related to emissions to water (TSS, COD, TOC, TN and TP) expressed in specific loads. However, it was not possible to derive a BAT-AEL expressed as specific loads due to: 1) BAT-AELs expressed as concentrations and BAT-AEPLs for waste water discharge were sufficient from an environmental point of view; 2) the confidentiality of the data necessary to calculate the specific loads, as the yearly production and the waste water flow were considered confidential by the TWG; 3) the difficulties to associate the specific loads with the performance of process-integrated techniques; 4) the lack of data for some FDM sectors and/or products.
- Collection of information on on-site combustion plants with a rated thermal input of less than 50 MWth and which generate hot gases that are not used for direct contact heating, drying or any other treatment of objects or materials should be considered during the next review of the FDM BREF, while taking into account the information exchange foreseen under Directive (EU) 2015/2193.
- Clarify the boundaries of the installation related to energy consumption (e.g. for sugar manufacturing, brewing or for oilseed processing and vegetable oil refining).
- Collect information on conversion factors between different forms of energy.

- Collect information on PM₅/PM₁₀ emissions from FDM subsectors.
- Collect information on emissions from oilseed processing and vegetable oil refining installations performing soap-stock splitting.
- Collect information on the impact of the abatement of SO_x emissions to air on the waste water generation.
- Collect information on dust emissions from pet food manufacturing.
- Collect information on emissions from fish smoke kilns.
- Collect information on emissions of total volatile organic carbon and other compounds (e.g. PAHs) from meat smoke kilns as well as on the use of purified smoke.
- Collect information on techniques to reduce channelled total volatile organic carbon emissions from oilseed processing and vegetable oil refining.
- Collect information on the influence of the physical state of the starch on the energy consumption.
- Collect information on the effect of hot gas recirculation on the SO_x emission levels from high-temperature beet pulp drying.

Conclusions

A thorough exchange of information took place over 5 years in the context of the review of the FDM BREF undertaken pursuant the Directive 2010/75/EU, involving technical experts representing a variety of stakeholders (EU Member States, industrial organisations, non-governmental organisations for the protection of the environment and the European Commission).

KEIs were defined for emissions to air and water, and for energy and water consumption. Afterwards, a data collection process for a variety of FDM installations across Europe was designed and carried out. Real plant-specific data were collected for the first time under the IED framework for the FDM sector, giving a reliable depiction of the key environmental issues, mainly for emissions to water, emissions to air, energy and water consumption. Information on the techniques used in industry to tackle those emissions and to reduce those consumptions was also collected. The analysis of the data provided the basis for the derivation of BAT conclusions for the food, drink and milk industries. The BAT derivation was a collective, participative, iterative, evidence-based exercise of the TWG set up for the purpose.

The development of these EU environmental standards for the FDM sector will be the reference for the operation of around 2 800 installations in Europe until the FDM BREF is reviewed again. This paper highlights the main normative, organisational and procedural factors addressed during the environmental policy integration carried out to develop these case of policy implementation. The IED creates a level

playing field for industry, aligning environmental performance requirements for industrial installations, and will likely foster enhanced resource efficiency in the FDM industries.

Abbreviations

BAT: Best available technique(s), as defined in Article 3(10) of the IED

BAT-AEL: Best Available Techniques - associated emission level, as defined in Article 3(13) of the IED

BAT-AEPL: Best Available Techniques - associated performance emission level, as described in Section 3.3.2 of Commission Implementing Decision 2012/119/EU

BREF: Best available techniques (BAT) reference document

COD: chemical oxygen demand

EIPPCB: European Integrated Pollution Prevention and Control Bureau

EU: European Union

FDM BREF: BAT Reference Document for the Food, Drink and Milk Industries

IED: Industrial Emissions Directive

KEI: Key environmental issue

KoM: Kick-off meeting

TN: Total nitrogen

TP: Total phosphorus

TSS: Total suspended solids

TWG: Technical working group

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and material

All data analysed during this study are included in:

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Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Germán Giner Santonja and Panagiotis Karlis conceptualized and wrote the manuscript. All authors read and approved the final manuscript.

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Figures

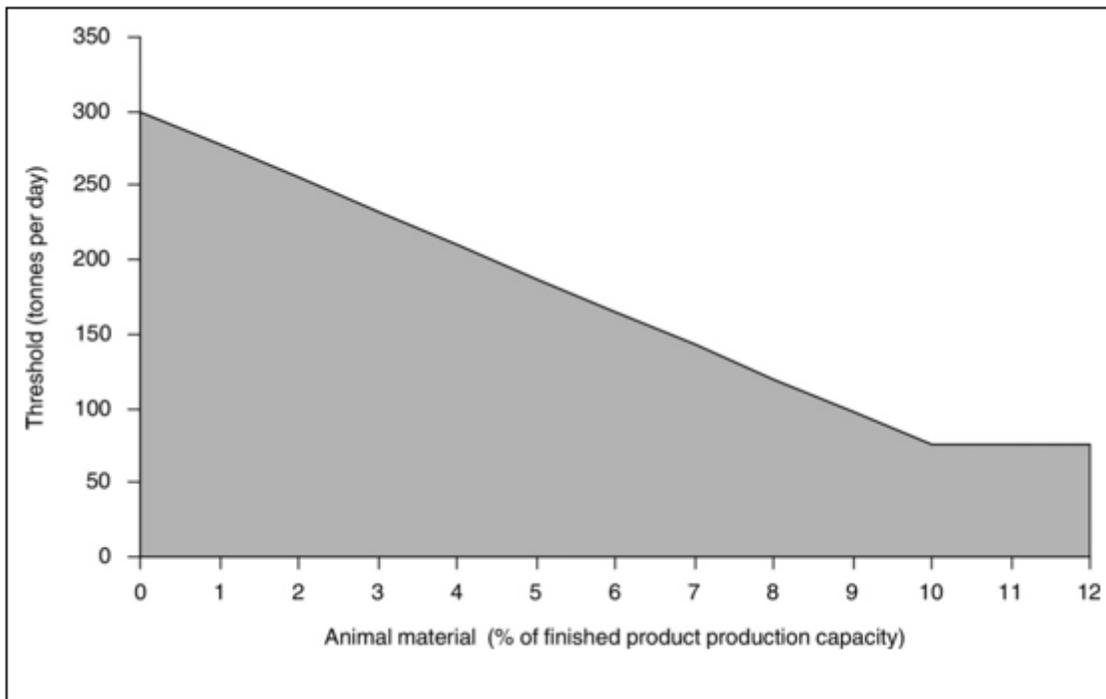


Figure 1

IED threshold for activity 6.4 (b) iii (European Parliament and Council, 2010)

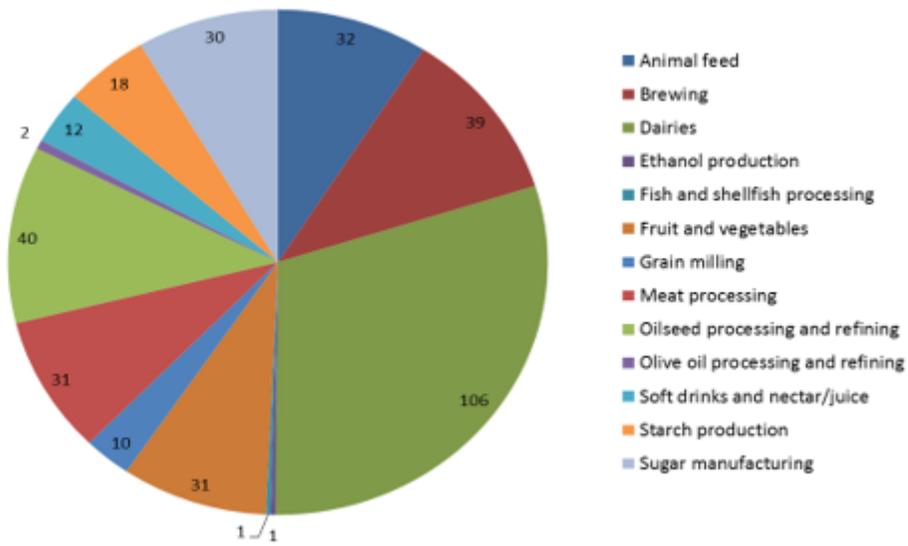


Figure 2

Distribution of submitted questionnaires in relation to the FDM subsectors (adapted from Giner Santonja et al., 2019a)