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Distributed Network for Odour Sensing,
Empowerment and Sustainability

Analysis of existing regulations in odour pollution, odour impact criteria 2

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AUTHORS

Cyntia Izquierdo
Carlos Diaz
Ainhoa Antón
Rebecca Kavanagh
(AMIGO)

Laura Capelli
(POLIMI)

Rosa Arias
Nora Salas Seoane
(Ibercivis, Science for Change)

Johana Burbano
(Science for Change)

REVIEWERS

Rosa Arias
(Ibercivis, Science for Change)

Johana Burbano
(Science for Change)

CONTRIBUTORS

Louise Francis
(Mapping for Change)

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This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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Acronyms

- AUSTAL2000G: Lagrangian odour dispersion model used in Germany
- ACT: Australian Capital Territory
- EPEA: Alberta Environmental Protection and Enhancement Act
- BAT: Best Available Technology
- BREF: Best available techniques Reference document
- C_T : Threshold Concentration
- CEN: European Committee for Standardization (in French: Comité Européen de Normalisation)
- D/T: Detection-to-threshold
- DPE: Walloon Environmental Police Division
- D-NOSES: Distributed Network for Odour Sensing, Empowerment and Sustainability (H2020 European project)
- ELV : Emission limit values
- EN: European Standard
- EU: European Union
- GOAA: Guideline on Odour in Ambient Air (Germany)
- IED: Industrial Emission Directive
- OIC: Odour Impact Criteria
- ou: odour units
- ou/m^3: Odour units per cubic meter
- ou_E/m^3: European Odour units per cubic meter
- ou_E/Nm^3: European Odour units per cubic meter to normal conditions
- OOCL: Offensive Odour Control Law in China
- OMP: Odour Management Plan
- PRIO: Plan para la Reducción del Impacto por Olores Ofensivos (Plan for the reduction of the offensive odours)
- $\mathbf{p_T}$**:** Exceedance Probability
- TRS: Total Reduced Sulphur
- su/m^3: Sniffing units per cubic meter
- U.S. EPA: United States Environmental Protection Agency
- VDI: Verein Deutscher Ingenieure (VDI) (in English: Association of German Engineers)
- VOCS: Volatile Organic Compounds
- WT: Waste Treatment
- WWTP: WasteWater Treatment Plant

Summary

This document provides an overview of odour regulations in several countries around the world

In the previous Deliverable 2.2, Diaz C., Izquierdo C., Capelli L., Arias R., Salas Seoane N. (2019), Analysis of existing regulations in odour pollution, odour impact criteria 1, D-NOSES, H2020-SwafS-23-2017-789315, the document was structured in several chapters, explaining the difference among regulations/laws, standards and guidelines.

In this document, we have tried to focus on existing odour regulation around the world, including the new advances in some countries where there is not an official legislation yet, but they are working on it, like the case of Chile.

This document is structured as follows:

Chapter 1. Introduction: it presents the goal of the document and some extra information that can be consulted.

Chapter 2. Odour regulations by Countries: it presents an update on the different regulatory approaches to deal with odour impact in 22 countries around the world. This chapter expands the information of the similar chapter 2 of the previous deliverable 2.2.

Chapter 3. To sum up: it presents a table and several figures where the countries are classified depending on their odour legislation.

Chapter 4. Acknowledgments: thanks to all the contributors.

Chapter 5. References: it presents a list of regulations and scientific articles related to odours that have been used for this document.

Index

1. Introduction

Odour is regulated under different formats and at different levels, using different techniques and criterias

Although there is a large set of guidelines and standards dealing with odours around the world, there are only a few specific regulations for odours. The focus of this document will only be the regulations or ways of managing odours in several countries.

In order to have a better understanding of the way odours are regulated, it is recommended to have a previous reading of the Deliverable 2.2 that the D-NOSES consortium published in 2019: Diaz C., Izquierdo C., Capelli L., Arias R., Salas Seoane N. (2019) Analysis of existing regulations in odour pollution, odour impact criteria 1, D-NOSES, H2020-SwafS-23-2017-789315. In this previous edition of the "Analysis of existing regulations in odour pollution, odour impact criteria 1", it is pointed out the difference between guideline, standard and regulation (laws, decrees, ordinances and other regulations)

In this deliverable, the main focus is the regulations and the difference between the odour regulating criteria in the countries selected. This information is based on the last article published related to odours by an international group of experts "Summary and Overview of the Odour Regulations Worldwide" (Bokowa et al. 2021). This paper has been published on the well known media Atmosphere from MDPI on the 3rd February 2021, written by 18 authors from Canada, Spain, USA, Poland, New Zealand, Austria, France, UK, Italy, Chile, Belgium, Colombia, China, Germany, the Netherlands and Japan. This article is open access thanks to the support and funding of the Iowa Agriculture and Home Economics Experiment Station (for J.A.K.): project number IOW05556 (Future Challenges in Animal Production Systems: Seeking Solutions through Focused Facilitation, sponsored by Hatch Act and State of Iowa funds) and the International Environmental Association of Odour Managers (AMIGO) that alloted some resources under the project D-NOSES (Distributed Network for Odour Sensing Empowerment and Sustainability) funded by the European Union's HORIZON 2020 research and innovation programme under grant agreement No 789315.

In general, odour issues are treated in different ways by regulators in the countries studied in the present report. The situations found in the jurisdictions analysed can be completely different in the same country, depending on the industrial activity or the different municipalities.

2. Odour regulations by Countries

This section will focus on the existing regulation/laws about odours in several countries around the world. This text includes the national, regional and local regulations, published in official journals, and the ones that would be published soon.

There is a large set of environmental laws and regulations around the world, however, unfortunately there are only very few texts dealing with controlling and managing odours.

In this section, the odour related regulations will be discussed, including the following countries, organized by alphabetical order: Australia, Austria, Belgium, Bulgaria, Canada, Chile, China, Colombia, France, Germany, Greece, Hungary, Italy, Japan, New Zealand, Portugal, Slovakia, Spain, The Netherlands, Uganda, United Kingdom and USA.

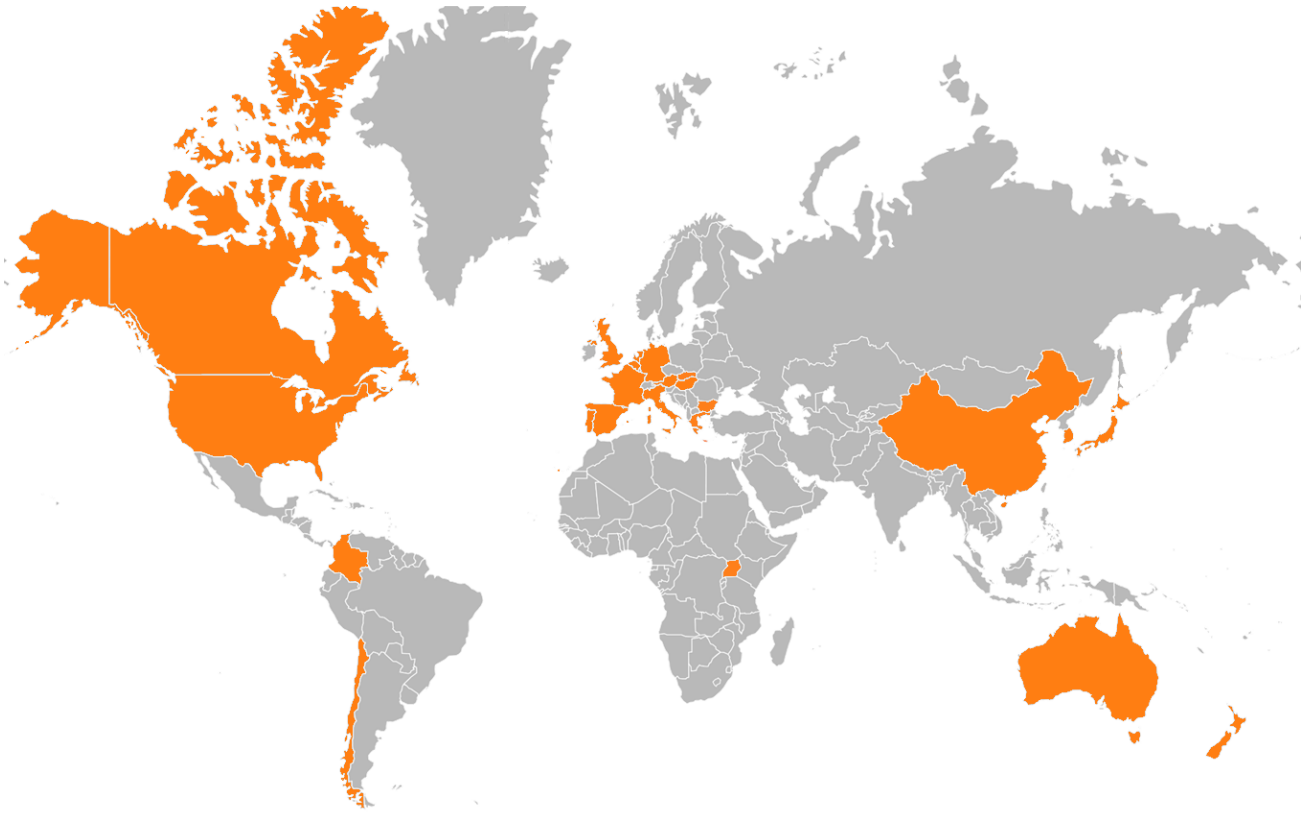

Figure 1. Map of all the countries taken into account on this document. Source: AMIGO

2.1 Australia

Odour is controlled under the Protection of the Environment Operations Act 1997

In Australia, odour is managed under the Protection of the Environment Operations Act 1997, where strict odour assessment criteria exist, and is legislated similarly to other noxious pollutants such as SO_2 and NO_x. Although there are no legal limits, the document aims to provide a framework for effective project planning with a regulatory regime for odour-emitting activities.

The main methodology for odour assessment criteria is primarily comparing odour concentrations from dispersion model outputs (in ambient air) in ou/m^3, and the use of odour guideline values to determine whether offensive effects are likely to occur. The Standard AS/NZS 4323.3 explains how to measure odours by dynamic olfactometry. For dispersion modelling, in some states a peak-to-mean ratio is used as a "corrective" way, trying to mimic the human sense of smell. For more information about peak-to-mean rate in Australia, we recommend to read the paper of Bokowa et al. (2021)

There are odour guideline documents for each Australian state. The main odour assessment criteria for each one is shown on the next table, that has been simplified for this document.

Table 1. Simplified odour assessment criteria for states of Australia.

	Impact assessment criteria	Percentile value	Averaging period
New South Wales	2.0 – 7.0 ou	99th or 100th	1 h but equivalent to 1 s
Western Australia	Risk-based approach	Dispersion modeling is no longer the first response	1 h
ACT* and South Australia	2.0 – 7.0 ou ACT 2.0 – 10.0 ou SA	99.9	3 min
Queensland	5 ou	99.5	1 h
Victoria	5.0 - 1.0 ou	99.9	3 min
Tasmania	2.0	99.5 or 99.9	1 h

*ACT: Australian Capital Territory

Although odour assessment criteria does not differ between industrial sectors in Australia, odour criteria can vary depending on the size of the potentially affected population. In several states such as New South Wales, South Australia, and Canberra (ACT), a range of odour assessment criteria is applicable depending on the sensitivity of the population as determined

by population numbers. Australia is one of the few countries that use this criteria based on sensitivities of the receptors.

Table 2. Odour assessment criteria range according to population in some states of Australia

South Australia (3-min Average 99.9 Percentile)		New South Wales (1-s Average 99.9 Percentile)		Australian Capital Territory (3-second average 99.9%)	
Number of People	**ou**	**Number of People**	**ou**	**Number of People**	**ou**
2000 or more	2	2000 or more	2	High Density	2
350 or more	4	Approx. 500	3	300 or more	3
60 or more	6	Approx. 125	4	50 or more	5
		Approx. 30	5	10 or more	6
12 or more	8	Approx. 10	6	Less than 10	7
Single Residence	10	Single Residence	7		

For example, in New South Wales, a single residence is assessed at 7 ou, whereas for larger populations, where there is a larger range of sensitivities to odour and a higher number of individuals, the agreed acceptable odour limit is defined as 2 ou. As an example, if an odour emitting activity has a rural residence to the north and a town of 500 people to the south, then the appropriate criteria would be 7 ou for the single rural residence and 3 ou for the town.

2.2 Austria

No odour regulations nor odour limits in the country.

As other similar European countries, Austria has no specific odour regulations but odour nuisance is "regulated" in qualitative terms (e.g. unacceptable odour is not permitted). The European *Industrial Emission Directive* is applied to several industrial activities and within this context, the facilities susceptible of producing an odour impact may have specific odour limits based on olfactometric studies and modelling.

The legal system in Austria makes a difference between legal values and target values. Although there are no legal values related to odours in Austria, there is a guideline setting target values for Spa areas, for the exceedance probability 3% for an odour concentration of 1 ou_E/m^3 (similar to Germany) is suggested.

Although there are no regulation nor legal values, it's worth mentioning that the Styria state government issued a guideline suggesting odour impact criteria depending on hedonic tone for four categories, characterised by typical odour sources: (1) small (e.g., biofilter, silage, horses, sheeps, goats), (2) medium (brewery oil mill, domestic fuel, pigs), (3) high (e.g., bitumen,

refinery, kitchen, poultry), and (4) very high (e.g., nauseating smell, tannery, composting facility, some parts of wastewater treatment plants). For continuous emitting sources, the exceedance probability (%) of the guideline is related to the German odour hour definition, which means the odour concentration threshold is 1 ou_E/m^3. For discontinuous emitting sources, the odour criteria are defined by a certain exceedance probability of 2% and an odour concentration.

Table 3. Odour impact criteria (OIC) based on the guideline of the local government of Styria, Austria.

Annoyance Potential	Non-Livestock Sources		Livestock Sources (Pure Residential Areas/Agricultural Dominated Villages/Other Utilization)	
	p_T (%) (1)	$C_T(ou_E/m^3)$ (2)	p_T (%) (1)	$C_T(ou_E/m^3)$ (2)
Small	*40*	*15*	*40/50/-*	*15/20/-*
Medium	*15*	*5*	*15/20/30*	*5/7/10*
High	*10*	*4*	*10/15/20*	*4/5/7*
Very high	*2*	*1*	*-/-/-*	*-/-/-*

(1) p_T Exceedance Probability
(2) C_T Threshold Concentration

It is also quite common in this country to have a look at what is being done in Germany, so in some cases the well known German guideline GOAA is also applied. See section 2.10 of this document for more information on the German GOAA.

Austria has also a guideline related to the livestock industry, setting a determined distance of separation of a plant from people affected by the odour impact, commonly known as setback distance. The *Preliminary Guideline to Assess Pollution Caused by Livestock Husbandry in Livestock Building*s estimates odour emissions from livestock facilities by using the following parameters: number and type of animals, ventilation system, manure removal and storage and animal feed type. From these parameters an odour number is calculated which is used in a dispersion model to calculate a setback distance for the facility.

2.3 Belgium

Belgium has both federal and regional legislation.

To cover environmental matters, the federal government and regional authorities share responsibility for the implementation of environmental policies. The Flemish and Wallonia regions have their own specificities.

Odour control is largely based on field inspections—the plume method, according to EN 16841-2. Global emission rate is determined using the odour concentration at the receptor

level and a reverse modelling approach. Most commonly used odour dispersion modelling varies from one region to the other: the ADMS model is used in Wallonia and the IMPACT model, in Flanders.

A big difference between Belgium and other European countries are the units of measuring odours. Meanwhile in Europe odour units are used determined by *detection*, in Belgium sniffing units are used, which are based on *recognition* of odour. This means that 1 sniffing unit per cubic metre is defined as the odour concentration at the border of the plume, that typically will correspond to a concentration of 1 to 5 ou_E/m^3 .

2.3.1 Walloon Region

No general legislation concerning odours exists for the Walloon region. Some *guidelines* for different activities have been laid out. For example, there is a specific regulation dealing with odour management for composting plants, but only a guideline for farms. For composting plants, the *Walloon Decree from 2009 (2009/204053)* states that odour concentration cannot be greater than 3 ou_E/m^3 at the 98th percentile to the closest neighbour. In the case of farms, the guideline is based on the calculation of a minimum separation distance to prevent odour annoyance. The requirements for farms depend on the sector's *area plan* where they are established and whether the farm is new or existing. However, these values for farms are not yet validated or compiled in a *Walloon decree*.

The Walloon Environmental Police Division (DPE) has competence in both environmental permitting and **complaint management**. A new trend is to promote the use of **resident diaries for monitoring odours**. This approach is considered relevant by the DPE and efficient in solving odour annoyance. The Walloon Agency for Air and Climate is actually working towards updating the Walloon odour regulation.

2.3.2 Flemish Region

Similar to the Walloon Region, no general legislation concerning odours exists for the Flemish Region. Flemish region follows these basic rules in their odours policy:

- When there is a nuisance, BAT measures must be taken to reduce it.
- When there is no nuisance, no measures need to be taken.
- Severe odour nuisance is never acceptable.
- Zero-emissions are not realistic.

One of the key concepts of odour assessment studies in Flemish region is the "acceptable nuisance level", which lies between the no-effect level or target value and the limit value, been the no-effect level a grade of nuisance above which no reduction in annoyance is observed; and the limit value is the level of annoyance at which severe complaints occurs. Both values are expressed as 98th percentile concentration values. So the acceptability level is determined, considering partial environmental, legal, social, economic, financial, technological, and contextual aspects.

The way these levels (target, limit and acceptable nuisance level) are derived is case-specific and must be determined by the odour consultant or odour laboratory that performs the odour study in each case. Some of the guidelines for this method include;

- Slaughterhouses and wastewater treatment plants (WWTPs), no effect value or and limit values were scientifically determined, but they are based on dose–response studies derived from previous elaborate studies at different companies. These values vary from 0.5 to 1.5 su/m^3 for Slaughterhouses an form 0.5 to 2.0 for WWTP, 98th percentile)
- Other odour-emitting sectors, only the no-effect levels were determined. Some of these levels are determined based on dose–response relationships; others are deduced based on the hedonic tone of the odour.

The target values and limit values used for odour impact assessment are depending on the sensitivity of the area. Less severe values are used on the odour evaluation in low sensitive areas (e.g., industrial areas), and higher values for sensitive areas (e.g., residential areas).

In 2015 and 2018, sectoral *Codes of Good Practice* for prevention, assessment, and control of odour nuisance caused by asphalt plants and WWTPs were developed, including an odour evaluation framework, depending also on the sensitivity of the are.

- For asphalt plants, the target and limit values (for highly sensitive areas) are fixed at 1 and 2.5 su/m^3 as the 98th percentile. These values and percentile vary if the asphalt plants are non-continuous odour sources.
- For WWTPs, a distinction is made between the sources that cause a very unpleasant odour (e.g., the primary treatment, sludge storage, and treatment) and sources that cause a neutral odour (such as the biological treatment).

An odour impact evaluation framework has been derived from livestock farming, and included on the environmental impact assessment guidebook for livestock farming, which distinguishes between isolated farms and livestock farms that belong to a cluster.

2.4 Bulgaria

No legislation for regulating odours.

There is no specific law regulation on odour pollution in general. However, the Ordinance related to air pollution published the 10th September 2012 included provisions for the imposition of a sanction for industries releasing odoriferous substances into the air (such as hydrogen sulphide, etc.), but this regulation has nothing specific about odours. The authority, which has the obligation and the legal right to impose such sanctions are the *Regional Inspectorates for Environment and Water* (RIEW) who are part of the control system of the *Ministry of Environment and Water* (MOEW).

As in other European countries, the *Industrial Emission Directive (IED)* is applied to the industrial activities, so the facilities susceptible of producing an odour impact may have specific odour limits based on olfactometric studies and modelling or other kind of studies.

2.5 Canada

Individual provinces and territories are responsible for odour regulations.

In general, Canadian federal legislation does not include odour regulations from industrial or agricultural facilities. In Canadian legislation, odour has many definitions in different ways, including odour as a pollutant, contaminant, type of substance, nuisance, or an odorous substance and odorous contaminant.

Although there is no standard method in Canada for odour assessments, the common approach is source odour measurements, dynamic olfactometry with dispersion modelling to predict off-site odour concentrations at any sensitive receptor. Odour assessments are performed for the following reasons:

- to verify and investigate odour complaints; to determine the off-site odour impact from existing, expanding, or new operations.
- to assess long-term odour levels in an area; to determine compliance with regional odour legislation, or to rank potential odour sources for mitigation purposes.

The dynamic olfactometry method is similar to the EN13725 with some exceptions, such as, odour analysis is only conducted once by eight panellists.

Also, ambient odour assessment can be performed through the use of a standard procedure and dynamic olfactometry evaluations using screened panellists. Additionally, ambient air odour assessments may include community/resident odour surveys, odour observations, and observation forms from citizens.

As an example, in Ontario, when citizens want to complain about odours, they can contact the Environmental Ministry, or directly complain to the facility. The environmental officer investigates the odour episode and very often conducts a site visit to the area. If the odour complaints are persistent in that area, the officer can ask the facility to perform an odour assessment, including odour testing, and, if the odour limit is exceeded, the facility is required to elaborate an odour controlling plan.

2.5.1 Alberta

The Alberta Environmental Protection and Enhancement Act (EPEA) has no specific mention of odours. However, odour may be a dispersed substance in the environment and, therefore, could be considered as a forbidden pollutant as it does mention adverse impacts on the physical and social environment.

2.5.2 British Columbia

In British Columbia, odour can be treated as an air pollutant interfering with the normal business operation or that causes physical discomfort to a person. Odours attributed to agricultural operations or farm activities in accordance with the Agricultural Waste Control Regulation, Code of Agricultural Practice for Waste Management are not forbidden.

2.5.3 Newfoundland and Labrador, Northwest Territories & Prince Edward Island

There are currently no regulations for odours in Newfoundland and Labrador, the Northwest Territories, and Prince Edward Island. However, odours are considered as a forbidden pollutant. In Newfoundland and Labrador, the Air Pollution Control Regulation 39/04 holds a prescribed air quality standard which are relevant to agricultural operations for odorants such as NH_3 , H_2S, and reduced sulfur compounds.

In Prince Edward Island, odour is considered a contaminant under the Environmental but without a regulation in place for odour.

2.5.4 Manitoba

Odour is a pollutant and is dealt with under the Environmental Act. There are some guidelines for odour concentration limits in the ambient air with a maximum of 2 odour units for a residential area, a maximum of 7 odour units for an industrial area, and 1 odour unit for all areas. Under the guideline, in order to determine these concentrations, duplicate odour measurements should be taken not less than 15 min apart and not more than 60 min apart. The measurements are based on ambient level.

2.5.5 Ontario

Odour is a pollutant under the Environmental Protection Act (EPA). Odour is considered a pollutant that may cause discomfort, loss of normal use of properties, or interfere with the normal business development.

The regulation includes dispersion models to calculate maximum impact point concentrations from emission rate data. Requirements for odour emission tests should be included as conditions for permitting of industrial sources, which are judged by the Ontario Ministry of the Environment.

If the Ministry of Environment receives an odour complaint, the role of the local district office is to follow up on the complaint, verify the information provided and assess whether further action is necessary.

2.5.6 Quebec

In Quebec odour is controlled under the Environmental Quality Act. There are odour specific standards for facilities, such as a fried food plant or coffee roasting plant. There is also an ambient air quality standard for H_2S, but nor for NH_3.

2.6 Chile

New odour regulation to be published this year in Chile.

There are no odour regulations for now in Chile, but there has been quite a lot of hard work from the Chilean Environmental Ministry on odours over the last two decades. The environmental Ministry has a specific department on odours, which happens only in 2 other countries in the world(Germany and The Netherlands).

In 2012, Chile started a large plan for the elaboration of a Strategy for Odour Management in Chile, whose objective was to strengthen the regulatory framework through measures in the short, medium and long term to quantify, control and prevent the generation of odours, approaching the management of the issue with an integrated approach.

In April 2019, the deputies of the Chamber of Chile approved the introduction of some amendments on the current text of the Chilean general Environmental regulation. The core of the amendment was focused on the introduction of "odour" as an environmental pollutant within this regulation.

On July 22, 2020, the Ministry of the Environment of Chile (MMA Chile) published in its Official Journal the "Extract of the draft standard for the emission of pollutants in pig farms that, due to their odors, generate discomfort and constitute a risk to the quality of life of the population". After a period of consultation, they received more than 300 observations. At this stage, the Ministry is elaborating the final document which will need to be approved by the Government.

The aim of this proposed draft standard is to protect the health of the population and to improve their quality of life, and it will be applicable to the entire Chilean territory, for the emitting sources defined as breeding, fattening and/or reproduction of pigs whose quantity is equal or higher than 750 animals and whose weight is above 25 kilograms.

Two types of odour limits are established depending on the emission abatement efficiencies or on the limit values in the receptors:

1. Odour Emission Limit by Reduction Efficiency for:
    a. existing emission sources that include slurry ponds as part of their production process, where Pond odour reduction of at least **70% or 75%** (depending on the number of pigs)
    b. new emission sources must have at least a 50% reduction for buildings, and 70% for ponds.
2. For pig units of more than 25,000 pigs, a Receptor Odour Emission Limit value is established for emitting sources so that the concentration in ambient air does not exceed an odour threshold in the receptors, depending on if they are new (3 ou/m^3 at P98) or existing pig units (5 ou/m^3 at P95).

This year, the Chilean Ministry of the Environment has begun the process of developing two odour emission standards for the following sectors:

- Swine's farms (swine sector) and
- sea products processing plants (fishing industry).

In addition, it has started the process of reviewing the emission standard for pulp mills, whose emissions of Total Reduced Sulphur (TRS) gases generate annoying odours. The preceding statements are framed in the deployment of the Strategy for the Management of Odours in Chile (Ministry of the Environment of Chile, 2017) and the Environmental Regulation Program 2020-2021.

2.7 China

China has regulations covering disorganised odour emissions and discharge limits from stacks.

In contrast to odour legislations in European countries, in East Asian countries such as China and Japan, the odour regulations are based on odour emissions and on discharge limits from stacks, instead of the limit at receptor levels.

In China, the emission standard for odour pollutants GB 14554-93 remains in place although it was legislated in 1994, whose revision is underway. This Standard specifies the maximum allowable limits for one-time emission of 8 odor pollutants concentration limit and odour concentrations from stacks. Depending on stack height, various levels of emission rates standards are given, with higher emission rates allowed for higher stack height. Nevertheless, the Shanghai area has a more restricted odour emission limit depending on the stack height, being the maximum allowed odour concentration 3000 for stacks higher than 50 m.

Table 4. The emission odour concentration limits from stacks

Stack Height (m)	***Standard for Odour Concentration (Dilutions)***
10	*2000*
20	*6000*
30	*15.000*
40	*20.000*
50	*40.000*
≥60	*60.000*

Industries such as livestock and poultry breeding have their own pollutant discharge standard with an odour concentration limit of 70.

The odour concentration detection follows the "triangle odour bag method" of dynamic olfactometry, also undergoing revision. The "triangle odour bag method" requires 6 panelists each for sniffing the 3 bags, where 2 bags are filled with clean air. If the sniffing panelist can recognise the bag with an odour sample, the odour sample bag will be diluted for the next level of sniffing until the panelists can not recognize among the three bags. The odour concentration can thus be estimated based on dilutions.

China also has other standards for the "Technical specification on environmental monitoring of odour" which specifies the layout of sampling locations, odour sampling frequency, sampling methods, pre-treatment of collected odour samples, odour analysis methods, data processing & reporting, quality control & assurance, and so on. The standard of the "Technical specifications for olfactory laboratory construction" also specifies the olfactory laboratory site selection and layout, interior design of the laboratory, etc.

2.7.1 Hong Kong

The Environmental Protection Department's website contains all information on Odour assessment criteria for Hong Kong. Odour is assessed at a 5-s averaging period. This is due to the nature of the shorter exposure period tolerable by human receptors. The computed hourly average under the conversion of the dispersion model is currently resulting in 5-s values. This is necessary for enabling comparison against the Hong Kong standard. Firstly, hourly concentration is converted to a 3-min average value according to the nature of atmospheric turbulence, and secondly, another conversion factor is applied to convert the 3-min average to a 5-s average, similarly to some States in Australia.

2.8 Colombia

Resolution 1541 establishes maximum acceptable limits for air quality in European odour units.

In 2011, the first step towards a statutory instrument was officially taken. T*he Colombian Technical Standard NTC 5880, "Air Quality. Determination of Odour Concentration by Dynamic Olfactometry".* The *EN 13725* was used as a reference document to guide on defining a method for objective determination of odour concentration of gas sampling through dynamic olfactometry.

Other documents related to odour measurement such as the Colombian Technical Standard NTC 6011 were published in 2013, *"Static Sampling for Dynamic Olfactometry"; the standard NTC 6012-1* about the "*Effects and Assessment of Odours. Psychometric Assessment of Odour Annoyance. Questionnaires"*; and the *NTC 6012-2 standard* about the "*Effects and Assessment of Odours. Determination of Annoyance Parameters by Questioning; Repeated Brief Questioning of Neighbour Panellists".*

In 2013, the Colombian Ministry of Environment and Sustainable Development approved the *Resolution 1541*. The main purpose of this offensive odour regulation was to encourage good environmental practices in activities or processes to promote appropriate management of environmental impacts. Besides, this set out acceptable levels for odours and odorants in ambient air, depending on the type of the emitting industries, that is, on the hedonic tone of the odour.

Table 5. Maximum acceptable odour limits in ambient air established on the Resolution 1541.

Activity	**Admissible Level**
Meat, fish, mollusc, and crustacean processing and preservation	3 ou_E/m^3
Oil refinery processes	
Paper pulp, paper, and cardboard manufacture	
Leathery and tanning of skins	
Non Hazardous waste collection, transport, transference, processing, or disposal	
WWTP	
Activities that collect water from water bodies receptors of wastewater discharges	
Manufacture of substances and basic chemical products	
Thermal destruction of animal by-products	
Farms	5 ou_E/m^3
Manufacture of vegetable oils and fats	
Decaffeination, roasting and grinding of coffee	7 ou_E/m^3
Other activities	

Resolution 1541 was supplemented by *Resolution 2087 "Protocol for Monitoring, Control, and Surveillance of Offensive Odours"*. This resolution defines methods, criteria, and suitable specifications for measurement of odorant substances or odours as well as the development of the Odour Impact Reduction Plan (PRIO in its acronym in Spanish)

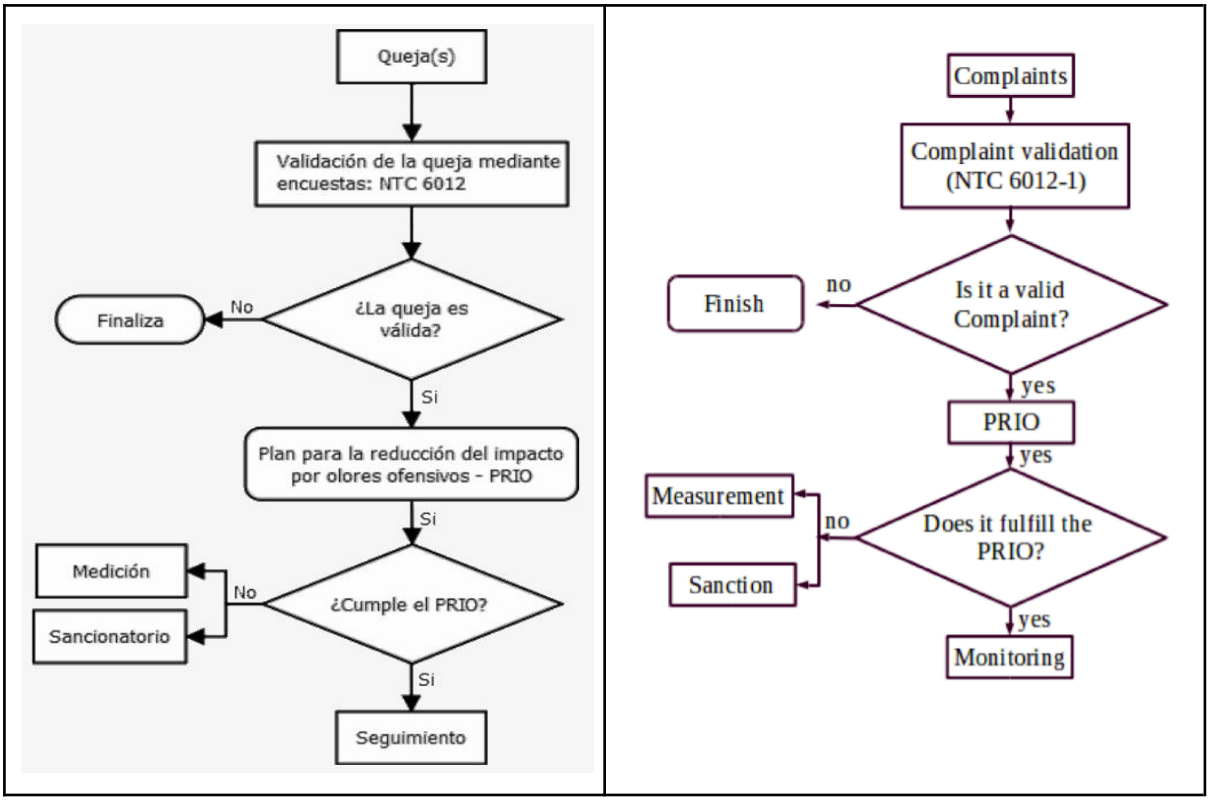

Figure 2. Steps for the implementation of Resolution 1541.

2.9 France

Specific odour regulation for Animal By-Product Processing Plants, Composting plants and Food & beverages industries

France has some specific regulations relating to odour control for specific activities: animal by-product processing plants and composting plants. As well as these, the food and beverage processing industry have some common emission limit values (ELV).

2.9.1 Animal By-Product Processing Plants

Arrêté du 12 février 2003 has undergone several revisions but still remains in force. Article 28 of this Order (Arrêté in French) lists an odour impact criteria depending on the status of a facility. The odour limit for a new plant is set to 5 ou_E/m^3, within a radius of 3km from the fence of installation for less than 44 hours per year (99.5th percentile). This calculation is required to be made from on-site odour measurements, followed by air dispersion modelling. If dispersion modelling is not performed, emitted odour concentration should not exceed 1 000 ou_E/m^3 for any source, regardless of stack height. But, if there are **any odour complaints**, an inspector may require an odour dispersion model or may ask for an increase in the frequency of odour measurements.

According to point 10 of this Order, if odour concentration at the stack for an Existing Plant exceeds the ELV of 100 000 ou_E/m^3, the olfactometric measurement according to the EN

13725 must be performed quarterly. The frequency of measurement of the odour concentration can be reduced to once per year if a continuous electronic sensing device is installed on the plant.

2.9.2 Composting Plants

Arrêté du 22 avril 2008 & Arrêté du 20 avril 2012 dealing with composting plants have undergone several revisions, but still remaining in force today. Article 26 states that there are different odour impact criteria to regulate composting plants, but all of them are based on measurement by dynamic olfactometry.

The Odour limit is set to 5 ou_E/m^3 in a radius of 3 km from the fence of the installation, less than 175h per year (98th percentile), in this case, for both new and existing plants. This calculation is derived from on-site odour measurements in the case of Existing Plants and based on estimations of New Plants.

For Existing Plants, if the sum of odour emissions from all the sources is less than 20 000 000 ou_E/h or if the plant is located within a low risk area of odour impact, no additional steps are required. If either two of the criteria are not met, an odour dispersion model should be performed in order to verify the Existing Plant complies with the OIC of 5 ou_E/m^3. If OIC is exceeded, the Existing Plant is required to send an Odour Management Plan stating the steps it will take to reduce their impact in order to meet previously outlined criteria.

2.9.3 Food and Beverage Industry

The Food & Beverage Industry follows Odour Emission Limit Values in ou_E/h depending on the height of the emission point. The minimum stack height is fixed and it is a function of the odour emission limits.

Table 6. Odour emission limit values (ELVs) for food and beverage industries.

Height of Point Source Emission (m)	Odour Emission Limit (ou_E/h)
0	1000×10^3
5	3600×10^3
10	$21{,}000 \times 10^3$
20	$180{,}000 \times 10^3$
30	$720{,}000 \times 10^3$
50	3600×10^6
80	$18{,}000 \times 10^6$
100	$36{,}000 \times 10^6$

2.10 Germany

The GOAA has become a new odour regulation during 2021

Germany published in 1964 an air pollution control regulation titled "Technical Instructions on Air Quality Control" (*Technische Anleitung zur Reinhaltung der Luft*) and commonly known as the ***TA Luft***, amended several times and being the last one in 2002 (TA-Luft, 2002).

The German Guideline on Odour in Ambient Air (GOAA), that has been a guideline for years, will be incorporated into the TA Luft, so the odour impact criteria set in the GOAA will be compulsory limits. Before this, there were no general odour limits in the German main legislation on ambient air (TA Luft). Once the process is finished, Germany will have a regulatory limit of 1 odour hour in ambient air that cannot be exceeded more than 876 hours a year in residential areas and 1 odour hour for more than 1314 hours for industrial areas.

This will be the **first general limit of odour in ambient air in Europe** as it applies to any facility that is a potential odour emitting activity in all sectors.

In Germany, livestock farms and industrial installations odour emission has been regulated since years ago. Several attempts to regulate odour exposure, e.g., by setback distances for livestock farms and industrial installations were established, until odour frequencies were detailed in the first GOAA (German Guideline on Odour in Ambient Air) in 1993, which was reviewed on 2008, introducing the concepts of odour intensity, hedonic tone, and annoyance potential of specific odours. The advantage of these new concepts is that the results of grid measurements and dispersion modelling can be directly compared.

Germany has a long history with the development of odour Standards, such as the VDI 3940-1 for the determination of odour in ambient air by using field inspections in a grid, allowing the measurement of recognisable odours. This Standard was superseded by the EN 16841 Part 1. This method is mainly applied in cases of complaints in the neighbourhood of odour sources or for determining the odour frequency, although the duration of the survey must be at least six months.

Odour emission measurement or estimation + Dispersion modelling is the most common method used in the country. The Lagrangian dispersion model AUSTAL2000G (G (Geruch) is the german word for odour) is the most used one.

There are many provisions in the TA Luft related to odour management, for example, for livestock activities there is a fixed setback distance (that is, the distance between a plant and a population) related to the number of animals that the plant has.

Besides, for Installations of Biological Treatment of Waste, odorous gases from the curing phase of ventilated windrows should be directed to a biofilter or an equivalent waste gas purification facility, having a fixed limit of 500 ou_E/m^3 in the emission from these odour control equipment, that need to be checked at least once a year. This exact same odour limit of 500 ou_E/m^3 is also set in some other industrial activities.

2.11 Greece

No specific odour legislation in Greece.

Currently there is neither national, nor regional, nor local odour legislation in Greece for any industrial sources. National legislation has remarks on odours for urban activities, but with no specific limits.

Nevertheless, as part of Europe, it has some tools (standards like EN 13725, EN 16841) for odour measurement. The *Industrial Emission Directive* (IED) can be applied to several industrial activities and within this context, the facilities susceptible of producing an odour impact may have specific odour limits based on olfactometric studies and modelling or other kind of odour studies, but it's a case by case basis.

2.12 Hungary

No legislation at national level in Hungary, but suggested limits.

At present, Hungary does not have a legal National Odour Impact Criteria in use. Although not mandatory, in order to avoid odour annoyance in Hungary, a suggested exceedance probability of 2% (98th Percentile) is used for an odour concentration threshold between 3 ou_E/m^3 and 5 ou_E/m^3 on the receptors.

2.13 Italy

Although there is not a national regulation, several regional laws have been published.

In Italy there is still not a national regulation, but some provinces and regions have been working on their own guidelines or regulations in order to define how odour emissions and odour pollution issues shall be managed.

The region of Lombardy was a pioneer in 2003, with a guideline for compost production facilities fixing limits, although this regulation is no longer valid. In 2012, a regional guideline specifically on odour emissions was published ("General determinations regarding the characterization of atmospheric emissions from activities with a high odour impact") This regional guideline was inspired by other regulations in Europe and it specifies that any plant with an odour impact shall evaluate the extent of this impact by drawing up impact maps indicating annual peak odour concentration values at the 98th percentile, thereby drawing the 98th percentile iso-concentration lines corresponding to the odour concentration values: 1, 3, and 5 ou_E/m^3, as resulting from atmospheric emission dispersion simulations.

Even though the Lombardy *guideline* mentioned above is a regional guideline, it is currently used as the regulatory reference for most other Italian regions. Indeed, the region of Piemonte and the autonomous province of Trento have recently issued their own odour guidelines, which are substantially transcriptions of the text of Lombardy.

The region of Puglia proposed a different kind of regulation, based on an analytical approach to measure the "limit concentration" of 40 different odorants (chemical compounds), each one with the use of a specific analytical technique. This complex approach was published on the D.g.r. 16 April 2015. It also fixed odour concentration limits in terms of 2 000 ou_E/m^3 for point sources and 300 ou_E/m^3 for diffuse emitting sources.

More information related to Italy can be found on the document *Analysis of existing regulations in odour pollution, odour impact criteria 1* (Diaz C., et al 2019) or on the Bokowa et al. 2021 paper.

2.14 Japan

Japan is one of the first countries regulating odours at national level.

Similarly to China, Japan regulates odour at emission sources. Odour legislation in Japan dates back to the 1960s when industries began to boom and in turn, environmental complaints arose. These complaints increasingly included odours and so with rapid industrial development and urbanisation, the need to address odour complaints was high on the agenda. As a result of this, t*he Offensive Odour Control Law (OOCL)* came into force in 1972. The purpose of this law is to regulate odours emitted from business activities and encourage preventive measures against odours. Protection of the environment and health of the people are at the heart of this law.

The three types of regulation standards on odours included in the OOCL are:

- at the property line of the site.
- discharged from stacks or other gas emission facilities.
- discharged from wastewaters.

Activities occurring in facilities or other businesses such as livestock farming within the regulated area (designated by local authorities) are controlled under odour legislation. Reports and conduct on-site inspections at odour-emitting facilities can be enforced by the Local Authority. However, local authorities should carry out odour measurements through chemical analysis or olfactometry. If an emitting odours installation in the regulated area does not comply with the standard, the local authority can advise it to improve operating conditions and take preventive measures. If the odour emission does not change, the facility can be ordered to improve the situation and penalties can be imposed on those in non-compliance.

The introduction of 22 substances that have been designated as "specified offensive odorants" followed the enactment of the OOCL, which local authorities have determined the regulation standard values at the property line for these 22 substances within a specified range established by the government and take into consideration land use, geographical conditions, odour characteristics, and people's sensitivity to odours. The OOCL was amended in 1995. This amendment was drawn up from an "odour index", a sensory index of odour determined by the triangular odour bag method (TOBM). In 1995, an "odour index" was introduced on the odour regulations based on a sensory index of odour determined by the triangular odour bag method.

In 2002, a quality control manual was published for laboratories on the triangular odour bag method use. At this stage, local authorities are entitled to choose between the two regulations: based on the concentrations of odorants, or on the odour index.

Nowadays, There are three types of odour regulation standards in Japan: for regulating odours at the property line of the site, for odours discharged from stacks or other gas emission facilities, and for the odours generated on wastewater.

Up to the present, more than thirty local authorities have published their own odour legislation ordinances or guidelines.

2.15 New Zealand

Odour is controlled under the 1991 Resources Management Act of New Zealand, where strict odour assessment criteria exists.

In New Zealand, odour is managed under the *1991 Resources Management Act of New Zealand*. Odour assessment criteria are primarily used to compare odour concentrations from dispersion model outputs, in ou/m^3, and the odour guideline values to determine whether offensive effects are likely to occur.

An odour guideline document was published in New Zealand. The document aims to provide a framework for effective project planning with a regulatory regime for odour-emitting activities.

In New Zealand, the peak-to-mean value is included within the odour assessment criteria. The peak-to-mean values can be applied to the emission rates or to the predicted odour concentrations. Besides, different percentile limits of 100%, 99.9%, and 99.5% are employed in New Zealand.

New Zealand does not provide different odour assessment criteria according to sectors. For example, a farm is assessed at the same odour rate as an industrial activity. However, odour assessment criteria ranges depending on the size of the nearby potentially affected population.

Table 7. New Zealand sensitivities of the receptors.

Sensitivity of the Receiving Environment	Concentration	Percentile
High[*1] (worst-case impacts during unstable to semi-unstable conditions)	1 ou/m^3	0.1 and 0.5
High[*1] (worst-case impacts during neutral to stable conditions)	2 ou/m^3	0.1 and 0.5
Moderate [*2] (all conditions)	5 ou/m^3	0.1 and 0.5
Low [*3]	5–10 ou/m^3	0.5

(all conditions)		

* 1 High sensitivity includes rural, rural residential, countryside living, commercial, and retail business.
* 2 Moderate sensitivity includes commercial, retail business, rural residential, countryside living, and light industry.
*3 Low sensitivity includes rural, heavy industry, and public roads.

2.16 Portugal

There are no odour regulations in Portugal for now.

In June 2021, the president of the Portuguese Environment Agency (APA) announced that The Portuguese Environment Agency is now undertaking the preparation of a Guidance toolkit for odour management and control in Portugal. This guideline will be based on activities risk assessment and corresponding management plans that identify odour mitigation measures adapting them to technical progress and also to citizen input.

For now, as other similar European countries, there are no specific regulations for managing odour pollution in the country. As it happens with their neighbours countries in Europe with no legislation about odour, the *Industrial Emission Directive* (IED) is applied to several industrial activities, so the industrial facilities susceptible of generating an odour impact may are forced to comply with specific odour limits based on previous olfactometric studies and modelling or other type of studies.

2.17 Slovakia

No odour regulations nor odour limits for now.

As other similar European countries, Slovakia has no specific odour regulations, for now. The Slovak Ministry of the Environment is currently finishing the preparation of a new air law, which could also answer odour questions. The forthcoming legislation will probably be available during October / November 2021.

Regarding odor monitoring in the Slovak Republic, the established method for the discontinuous measurement of odorous substances is olfactometry, as established on the Decree no. 60/2011 Coll. is in § 2 par. 11 letter (w). and as it happens in the other European countries with no odour legislation, the *Industrial Emission Directive* (IED) is applied to several industrial activities.

2.18 Spain

Not national nor regional law, but several municipal ordinances for odours.

There is not a national law regulating odour. As it happens in the rest of European countries, the *Industrial Emission Directive* (IED) is applied to several industrial activities and where olfactometric studies and modelling or other types of studies have been done to the facilities susceptible of producing an odour impact.

Some years ago, the Catalonia Government presented a draft "Against Odorous Pollution", inspired by the first H4 Horizontal Guideline of UK, although never ratified, the odour limits set in this regulation has been used as a reference on many studies/industrial permits. In addition, this draft was taken as a basis for ordinances in municipalities in Spain affected by odour impact. In the region of the Canary Island the environment authorities were setting limits of 3, 6 and 9 ou_E/m^3 for ambient air depending on the offensiveness, but once again, this is not going to be ratified.

Due to this lack of regulations at national and regional levels, some municipalities have taken the decision of developing their own ordinances for odour control. This is usually made in a very specific context during long term unresolved conflicts with an odour-emitting activity. That is why these ordinances are usually focused on some type of plant.

The list of municipalities with odour ordinances is the following:

- Castelldefels, Barcelona (1989)
- San Vicente del Raspeig, Alicante (1994)
- Las Palmas de Gran Canaria, Canary Islands (1999)
- Banyoles, Girona (2004)
- Lliça del Vall, Barcelona (2006)
- A Coruña, Galicia (2007)
- Riudellots de la Selva, Girona (2009)
- San Pedro del Pinatar, Murcia (2011)
- Alcantarilla, Murcia (2016)
- Sarria de Tèr, Girona (2018)

These ordinances are based on different methodologies: The first Spanish municipal ordinance was published in 1989, the Atmosphere Protection Ordinance of Castelldefels based on the IP index, which established a limit of 0,04 IP. On 26th January 1994, the city council of San Vicente del Raspeig approved its own Atmospheric Protection Ordinance, including odours, based also on an 'odour perception index' (IP), based on a mathematical formula that takes into account several factors. 5 years later, in June 1999, the municipality of Las Palmas de Gran Canaria developed a similar ordinance based on 'odour perception index' (IP). Similarly, the city council of A Coruña published an ordinance on odour in 2007, based on this index.

Ordinances like the ones of Banyoles, Girona, take into account the citizens complaints, or the one of Alcantarilla, Murcia, which according to the Ordinance, it is the duty of the municipality to create and maintain a standardized register of citizen complaints. The ordinance of Riudellots de la Selva, Girona, establishes an infrastructure for the recording of odour-related complaints and their notification to the responsible activities potentially associated with the complaint. Each complaint will be communicated to the management of the facilities most likely to have caused the incident, protecting the identity of the complainant. In Annex F of the ordinance, there is a "Sample form for odour episodes justification".

San Pedro del Pinatar, Murcia, establishes odour limits in ambient air (dynamic olfactometry+dispersion modelling or VDI 3490). The ordinance of Lliça del Vall, Barcelona, also sets odour limits depending on the odour threshold of the substances. Similar case in the

municipality of Sarria de Tèr, Girona, whose regulation sets odour limits in ambient air based on olfactometry measurements (3 ou_E/m^3 for paper mills) and also uses the field inspection method based on EN16841:2016.

2.19 The Netherlands

There is specific odour legislation only for livestock farming. For any other activity, the protection against odour is regulated in the Activities Decree.

There is an overarching odour regulation based on the Industrial Emission Directive (IED) for any activity included in this regulation in The Netherlands. Odour legislation for livestock farming has its own legislation. For all other activities, protection against odour nuisance is regulated in the Activities Decree (Besluit algemene regels voor inrichtingen milieubeheer. 2007). The Netherlands approach incorporates the use of BAT (Best Available Techniques) in order to reduce and where possible prevent odour and ensure that it does nor surpass the deemed appropriate level. As well as this, odour regulations may be introduced in decision making and permitting processes.

Local authorities have provision over the decision making process when it comes to determining the acceptable level. However, there are currently no clear national level odour evaluation frameworks in place to carry out this process. The local authority can set out a local odour policy to assist in identifying the acceptable nuisance level. Local odour policies are either based on the hedonic tone of an odour or on percentile values previously in use.

The development of an odour framework considered that at which scale value for hedonic tone is reached as a guide value. Differences in acceptable nuisance levels are made between existing and new developments and between residential areas and "rural or isolated" houses.

Several provinces have their own local odour evaluation frameworks: Flevoland, Gelderland, Groningen, North Brabant, Overijssel, South Holland, and Zeeland, whose frameworks are varied. It is under the jurisdiction of the province or municipalities to set local evaluation criteria, provinces or municipalities can base regulations on a number of documents for consideration. Odour evaluation criteria are used as guidelines when creating local odour evaluation frameworks. T*he letter from the Ministry of Housing, Spatial Planning and the Environment* states that in almost all cases, serious odour nuisance can be avoided when emission concentrations are below 5 ou_E/m^3 as 98th percentile (for continuous emission sources), but for discontinuous sources the 98th percentile concentrations do not reflect the expected odour nuisance. *The Law of October 5, 2006 on Livestock Odour Control of the Ministry of Housing, Spatial Planning and the Environment of the Netherlands* contains the determination of odour emission factors, minimum distances for fur-bearing animals, the method of calculating odour intensity and of the method of determining distance. Surprisingly, this regulation is reviewed annually to ensure the most up to date data and techniques are included.

2.20 Uganda

Uganda is developing a new Draft for Air Quality Regulations and Standards, including odours

The industrialisation of the country has led to environmental issues such as pollutants, including odours. Due to the progressive nature of odour issues and the fact that they are usually associated with other problems, Kampala was one of the ten cities in the world to develop and test a new approach to tackle odour pollution based on the engagement of communities and the collaboration of industries and the public administration (DNOSES pilot).

As with many other communities around the world, Kampala citizens also complain about odour nuisance. In an attempt to tackle this problem, the National Environmental Management Authority (NEMA), Kampala Capital City Authority (KCCA), in collaboration with other stakeholders are drafting the first ever Air Quality Regulations and Standards for Uganda. This has largely been facilitated by Uganda's move to revamp its 24-year old environmental law, the National Environment Act (Cap. 153) (the "NEA"), which has been replaced by The National Environment Act 2019. These regulations will establish health-based ambient air quality standards, set out guidelines for pollutants and odours in ambient air, against which plans will be developed and progress evaluated. The draft regulations include; emission limits for industrial sources, cars, trucks, motorcycles, and other mobile sources, a provision for odour standards and requirements for indoor air, and address worker's protection. They also establish a permit and compliance program for industrial sources and associated fees. The draft is in the final stage of review and due to be formalised later this year.

Despite the considerable progress made to introduce a new regulatory framework in Uganda, the World Health Organisation (WHO) has issued new Air Quality Guidelines (AQGs) for countries that are adjusted downwards and warns that exceeding them could lead to significant risks to health. The new WHO guidelines add to increasing pressure on Uganda to take measures to improve air quality; especially in cities and towns.

The guidelines include other major health and climate-damaging pollutants, both outdoor and indoor, such as particulate matter as well as ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.

2.21 United Kingdom

No official national regulation on odours.

There are no official national regulations about odours in the UK. However, each authority of England, Wales, Scotland and Northern Ireland uses similar published guidelines to issue permits for the industries.

All the activities under the IPPC directive are regulated by the environment agencies through Environmental Permitting Regulations (EPR), and smaller facilities are regulated by local authorities. Local authorities use three ways for controlling odours: (i) planning, (ii) permitting, and (iii) statutory nuisance.

When odour modelling is used, the local authority planning departments may ask for the predicted impact of the process and compare it against benchmark criteria that have been agreed. The most common potential criteria used in the UK is based on the Environment Agency (EA) H4 Horizontal Guidance, shown in the table below, classifying the activities depending on the offensiveness of their odours.

Table 8. Odour impact criteria based on Environment Agency (EA) H4 guidance

Offensiveness Scale	OIC	Example of Odour Sources
Most offensive odours	1.5 ou_E/m^3	Decaying animal or fish remains, septic effluent or sludge, biological landfill odours
Moderately offensive odours	3 ou_E/m^3	Intensive livestock rearing, fat frying (food processing), sugar beet processing, well-aerated green waste composting
Less offensive odours	6 ou_E/m^3	Brewery, confectionery, coffee roasting, bakery

The UK has other guidelines related to odours, such as guidance on the assessment of odour for planning and a guidance on interpreting dispersion modelling. The institutions for controlling and permitting the industrial and farming activities, not covered by the local authorities, are the Natural Resources Wales (NRW), the Scottish Environmental Protection Agency (SEPA) for Scotland, the Northern Ireland Environment Agency (NIEA) for Northern Ireland, and the Environment Agency (EA) for England.

These odour impact criteria may be used to support the planning or permit application. They are based on the annual 98th percentile of hourly average odour concentrations modelled over 3-5 years at sensitive receptor locations. Sometimes, city councils impose lower odour concentration values.

2.22 United States of America

Some local and regional legislations available in the country.

In the United States, states and local jurisdictions have begun to regulate odours as there is no common national framework. The statutes approved by the legislature of each state, provide the legal framework for addressing odour emissions. Corresponding state departments are responsible for the enforcement of each odour regulation. In some cases where odour regulations do not exist, the affected communities use “common law” nuisance lawsuits to deal with odour nuisance in their municipality.

In 1970 a “National Survey of the Odor Problem” was held, whose technical phase found the “dilution-to-threshold (D/T) ambient odour measurement method” to be a utilitarian and effective tool for investigation of odour and that odour judgment panels provided a definitive description of the odour emission. The D/T values are based on the dilution ratio of a

carbon-filtered air volume to the odorous air volume. The units of D/T are commonly used to specify the threshold value as being determined by field olfactometry.

The U.S. EPA commissioned another study in 1972 for the *"Development and Evaluation of a Model Odor Control Ordinance"*. This study resulted in recommendations for regulation and enforcement be relegated in states and local jurisdiction using scientific approaches with trained inspectors using the D/T method as well as source odour sampling.

At this stage, field olfactometry is still the most commonly utilised method for odour measurement and used in the development of regulation. Ten states currently use a D/T field olfactometry for their odour limits, most of these states have an odour limit of 7 D/T. If the measurements give twice the odour at 7 D/T or higher, with these measurements separated by at least 15 min, i.e., there is an odour above the limi.

Table 9. States of the U.S. with Odour Regulations.

Dilution-to-threshold (D/T)
Colorado
Connecticut
Delaware
Illinois
Kentucky
Missouri
Nevada
North Dakota
West Virginia
Wyoming

Besides, there are five states (Massachusetst, North Carolina, Oregon, Pennsylvania, Washington), which have odour nuisance regulations with specific reference to odour properties (concentration, intensity, offensiveness, etc), but with no criteria for odour measurement.

On the other hand, several municipalities have decided to regulate odours although their state does not hold any regulations. Louisiana is one of them and it's ordinance contains five stipulations:

- *illegal to cause emissions to air that can cause an odour nuisance,*
- *odour that is unreasonably unpleasant, distasteful, disturbing, nauseating, or harmful to a person of ordinary sensibilities and which is detectable after it is diluted with seven volumes of odour-free air by a field olfactometer, 7 D/T,*

- *any person may file a complaint,*
- *the city council will investigate the complaint,*
- *USD 500 penalty on conviction.*

Another example is the city of Des Moines, Iowa, which declares an *"Odor Alert" when they receive ten complaints within 24 hours*. An inspector would then respond, measure ambient odour, identify the sources, and serve a notice of violation. Facilities that receive three violation notices within a period of 90 days, are designated as "significant odor generators" and are then required to submit an "odour management plan".

2.22.1 Agriculture

As other countries, agriculture has specific laws and regulations relating to odour pollution and nuisances in the USA. The Council for Agricultural Science and Technology published a white paper, summarising the typical odour, other pollutants and particulate emissions from pig, poultry, beef, and dairy production. Odour is usually considered a locally specific issue, but hazardous gases (e.g., NH_3 and H_2S, some volatile organic compounds; VOCs) are a regional and national concern. A "common sense" approach to regulatie gas (including odour) emissions is being discussed on this Council.

The National Ambient Air Quality Standards regulate air pollutants associated with the processes of animal agriculture, where many odorous gases are classified as VOCs.

The emissions of odour and technologies to comprehensively mitigate them are becoming more and more important for the U.S. Environmental Protection Agency (EPA) and state regulatory agencies.

The *Redwine and Lacey* report is the most comprehensive resource in the U.S. on odour regulations and animal agriculture today, summarizing: 10 U.S. states regulations and 34 U.S. states have some rules or regulations designed to curtail odour emissions.

3. To sum up

Many countries do not have regulations to manage or prevent odour impact on their citizens, but there is a gradual change in the trend.

As seen on this document, there are a lot of countries with no odour regulation at national level, but there are some in which the regional or even local authorities are trying to provide a solution to this lack of regulation.

In the following table, we can have a quick look at a summary on how odour regulations are applied in the different countries discussed in this paper.

Table 10. Quick summary about odour regulation around the world.

Country	Odour legislation	Based on	Activities applied to
Australia	Regional	Dynamic olfactometry + modelling or Population sensitivities	All
Austria	No		--
Belgium	National & Regional	Dynamic olfactometry + modelling or Field inspections	Composting plants in Wallonia; Slaughterhouses and WWTP in Flemish region
Bulgaria	No		--
Canada	Regional	Dynamic olfactometry + modelling	All kinds of businesses. Fried food plant or coffee roasting plant for Quebec region
Chile	*Soon* (National)	Dynamic olfactometry + modelling	Pig farms
China	National	Dynamic olfactometry	All Specific standards for livestock and poultry breeding
Colombia	National	Dynamic olfactometry + modelling	All
France	National	Dynamic olfactometry + modelling or	Animal By-Product, Composting, Food &

		Dynamic olfactometry	Beverage
Germany	National	Dynamic olfactometry + modelling	All. Special focus on livestock activities and Biological Treatment of Waste
Greece	No		--
Hungary	No		--
Italy	Regional	Dynamic olfactometry + modelling	All
Japan	National	Dynamic olfactometry	All
New Zealand	National	Dynamic olfactometry + modelling or population sensitivities	All
Portugal	No		--
Slovakia	No		--
Spain	Locals	Dynamic olfactometry + modelling; others	Depends on the ordinances
The Netherlands	National & Regional	Dynamic olfactometry + modelling	Livestock farming
Uganda	No		--
United Kingdom	No		--
USA	Regional & local	Field olfactometry (D/T); Citizen complaints	All kind of activities. Specific one for Agriculture

*For more deep information on each country, we recommend to go the specific published regulation of the paper of Bokowa et al. 2021

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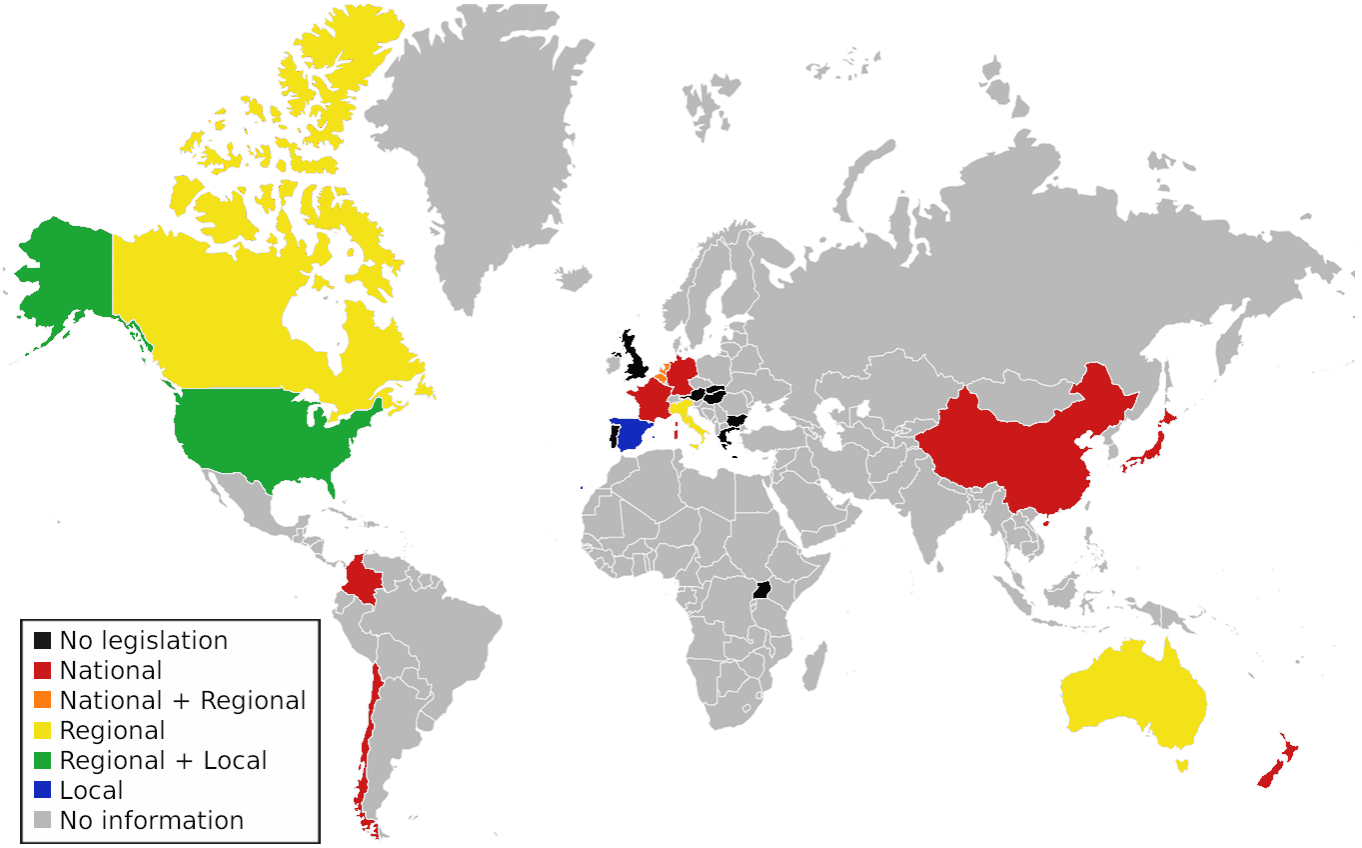

Figure 3. World map with the identification of countries where there is odour legislation. Source: AMIGO (Chile is represented in red, although the new legislation is not already published).

Just need to be clear, that although some countries have no specific odour regulation, they have other ways of controlling and regulating odour pollution, like standards, permits, etc.

Another way of analysing and summarising the odour regulations around the world is depending on the methodology applied for the odour controlling legislation. On the following figure, it can be appreciated that *dynamic olfactometry* (blues and red colours) is the predominant methodology in almost all countries, and a difference can be found between continents.

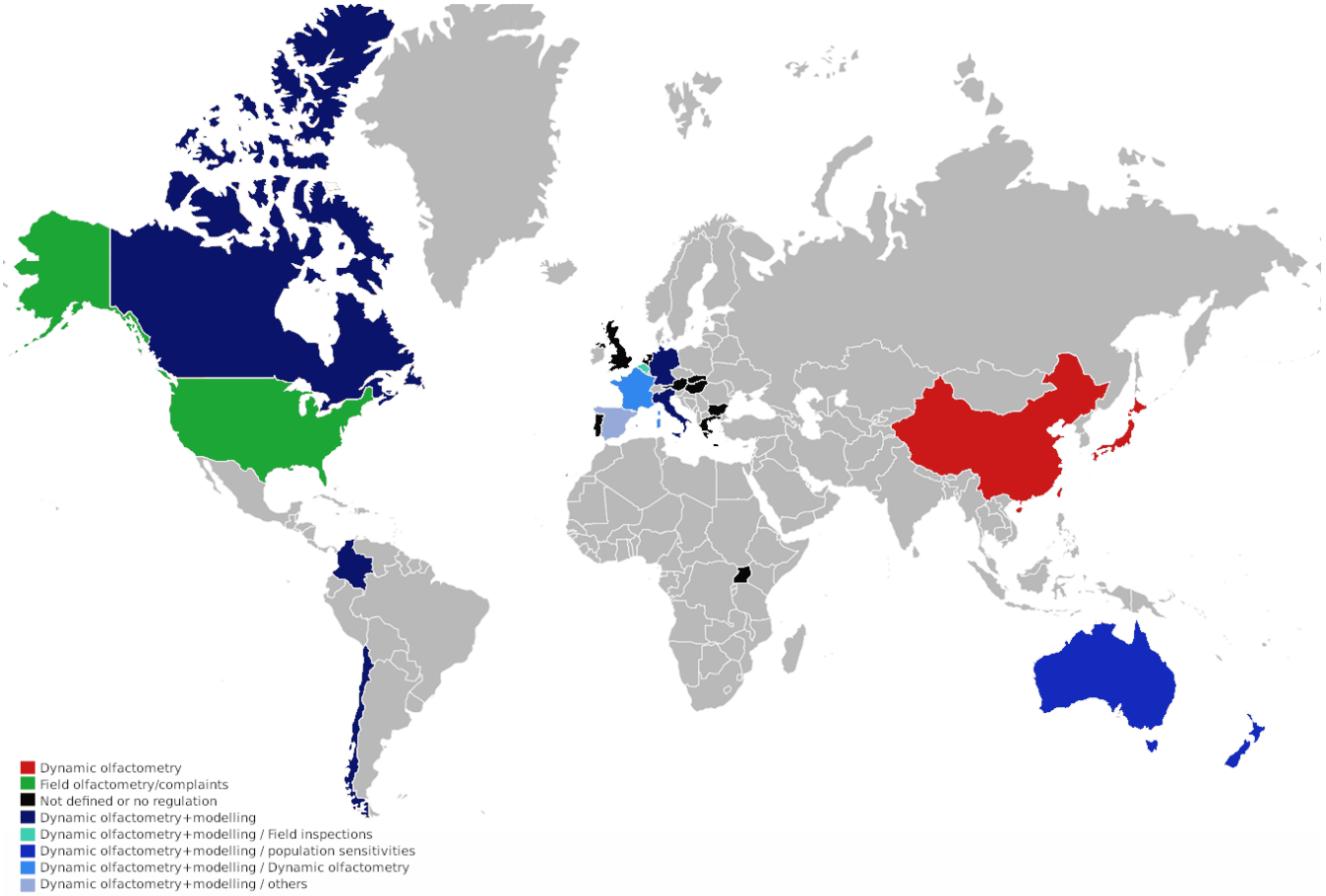

Figure 4. World map with the identification of the methodologies used for odour regulation in the different countries. Source: AMIGO

As a matter of fact, for **European countries and South America**, the most common way of regulation is establishing odour limits on ambient air, at receptors level, so the **dynamic olfactometry + dispersion modelling** is the most common methodology applied. On the other hand, **Asian countries** prefer to establish limits on the source, so **dynamic olfactometry** is the methodology used there. The **U.S.** has its own methodology through **field olfactometers**.

Finally, it's worth mentioning that, at present, the *European Union* (EU) and its **27 countries** have a common framework related to environmental permitting, known as the *Industrial Emission Directive* (IED). This European Directive rules that installations should operate only if they hold a written permit whose conditions are based on the use of the Reference documents for Best Available Technique (named as BREF). There are more than 30 BREFs in Europe, covering several industrial sectors, but only one, published in 2018, established the first European odour limit , the *(BAT) conclusions for* **Waste Treatment** (WT), so this implies that all the industries (of this sector) in Europe that use a biological treatment in waste sector have a range of **200 to 1000 ou_E/Nm^3 as the maximum allowed odour concentration**. And, it's a curious thing, this odour limit is established at the source, at emission level.

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Besides, the development of the D-NOSES project and its deliverables have helped to spread the word of odour pollution and, in this case, about odour regulation around the world. The team has been contacted by some entities interested in regulations or that need help with their own development of future legislation or standards thanks to this project and the publication of these deliverables. Isn’t it great?

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