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Odour - A Vision On The Existing Regulation

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The legislation on odours is being discussed and gradually implemented throughout the world. Some countries and regions have specific and detailed legislation on the subject, while in others countries legislation is not so detailed or even inexistent. The purpose of this article is presenting the definitions, procedures and legislations already implemented in some countries and in Brazil, by discussing their philosophies on regulation and coercion. It seems that a great deal of scientific work is still necessary to create the means which will allow legislators to regulate on odours and/or odours compounds in a way that is compatible with the current stage of social and industrial development. A worldwide standardization may not be possible due to cultural, educational and other factors that interfere in the perception of risk of a given population, but at least some equivalent procedures must be used in order to achieve some degree of similarity among the various national and international laws.

1. Introduction

Many factors have been contributing to an increased need of odour regulation: urban expansion, closing the distance between factories and residential areas; agriculture industry growth; acculturation of society, which makes it more demanding regarding its quality of life; and new kinds of relationship between humans and the environment. These factors are fostering legislators and academics to discuss the subject.

The term odour refers to the perception experienced when one or more chemicals come in contact with the receptors in the olfactory nerve and stimulates it. As the concentration of an odorant increases, a person can: detect, then recognize, and finally feel uncomfortable.

According to Schiffmann and Williams (2005), the odorant gases emitted by large installations of intensive animal farming and sewage treatment plants, for example, can cause irritation of eyes, nose and throat, headache, nausea, diarrhea, hoarseness, sore throat, cough, chest tightness, nasal congestion, palpitations, hotness of breath, stress, drowsiness and mood changes.

In this context, in several countries, laws and standards have been created so that odorant emissions do not affect the surrounding area, causing discomfort or harmful effects to the population.

In 2004, the state of Minnesota in the USA hired a consulting group to produce a review of national and international odour policy, odour measurement technology and public administration (SRF Consulting Group Inc.. 2004), which analyzed the various approaches on existing laws and trends in the USA and abroad. Also, The Greater Vancouver Regional District in Canada contracted the services of another consulting group to produce a report of successful experiences in other jurisdictions and suggestions for legislation on odours (RWDI Engineers & Scientists, 2005b). These reports showed differences of approach on odour legislation. It can be seen a convergence on ways to measure odour, but some divergence in the definitions of their characteristics, units and thresholds to be considered. Some

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regions or countries have legislated based on the principle of nuisance caused by odour, while others correlate it with measurable quantities such as concentration, intensity, duration and frequency. The purpose of this article is to present an overview of legislation on odours adopted in some countries of the world and also in Brazil. This study confirms that the laws vary between regions and countries, but there are scientific work being carried out to standardize immission and emission measurements and thresholds as well as operational procedures and control depending on the type of source. Scientists, legislators and stakeholders should converge to a further approximation of legislation between countries in order to safeguard the welfare of the population, and it is essential that plants that potentially emit odours are required to comply with appropriate regulations.

2. Odour dimensions and units

2.1 Dimensions

There are different classifications of odour dimensions. The book entitled Odour Thresholds for Chemical Established with Occupational Health (1997) produced by the American Industrial Hygiene Association (AIHA) cites four dimensions of odour: detection, intensity, character and hedonism. McGinley et al. (2006) classified the dimensions of the odour as: intensity, nuisance, perception and pleasantness. The report commanded by The Greater Vancouver Regional District in Canada in 2005, describes five dimensions of odour and symbolized them by the mnemonic acronym FIDOL (frequency, intensity, duration, offensiveness, location). According to Nicell (2009), the intensity, frequency and duration are inextricably linked, so the choice of only one of these factors to determine the odour threshold is questionable, and this is one of the causes of the mismatch between the needs of the population and industrial emission which is considered acceptable, since the odour threshold may be chosen taking into account various factors. For example, it might require a low concentration, allowing a low frequency and/or restrict an episode of long duration. Alternatively, you can allow a high concentration in the environment, but restricting the frequency and duration of the odour.

One of the main concepts associated with odour is the question of the reasonable time that an individual may be exposed to it without complaining. So, one might think either to limit the level of concentration of odour that is not detectable at all times or to enable occasionally noticeable reasonable levels over short periods and intermittent to protect the public against odours impact. Niccell (2009) affirms that a conservative criterion commonly used is to limit the level of exposure to a maximum concentration of 1 OU (odour unit) based on an average of 10 min, which cannot be exceeded in 99.5 % of the time.

2.2 Units

Another noteworthy finding is the diversity of units of measurement of odours in the literature: OU, OU/m^3, OU_E/m^3, OC, DT and D/T.

The OU (Odour Unit) is the minimum amount at which a substance dissolved in 1 m^3 of air at standard temperature and pressure (1013 mb and 288.15 K), reaches the limit of detection (VDI3882, Part 1-1992)

An alternative odour unit OU_E/m^3 is defined by the European Community for Standardizations (CEN TC264/WG2 Odours, 1999) is the mass of pollutant that, when evaporated (diluted) within a 1 m^3 of gas in the standard conditions without odour causes the same discomfort as 1 OU of the reference odorant (123 g of n-butane).

The OC (odour concentration) is defined by ASTM E544: 1999 as the volume of neutral gas (m^3) required to dilute a sample gas odorant to reach the limit of detection. This measure appears referenced to the unit volume, i.e. OU/m^3.

The DT and D/T are given by the number of concentration/dilution that the odorant requires to reach the threshold of perception or the DT unit, used in the USA and European Union, the concentration of odorant is increased to a value in which 50 % of the panelists perceive the odour, using dynamic olfactometry. For the unit D/T, used in Japan, the dilution is made to decrease the odorant concentration, using the triangular method. Ueno et al. (2008) compared these two methods and concluded that the results are similar, despite the substantial differences in the choice of panelists, which could insert some bias in the results.

According to Higushi (2003), in Japan, the Ministry of the Environment adopted in 1995, a parameter called Odour Index to measure the emission intensity from a source.
ASTM E679: 2004 (USA) and CEN EN13.725: 2003 (EU) offer guides as how to measure the value of odour concentration in these units with the aid of equipment, panelists and statistical methods. McGuinley et al. (2006) point the ASTM E679: 2004 and EN13.725: 2003 as a trend to standardize the concept of odour concentration, facilitating the management of odours by the decision makers.

3. Odour Management

One of the main difficulties of legislating on odour is that society perception of odour is qualitative, and it is difficult to quantify. Thus, in various countries or regions, several criteria are adopted to manage the nuisance caused by odours, ranging from the principle of collective administration where the society is responsible for determining whether there is or not the nuisance, to the management by the concentrations of substances that cause nuisance, such as:
• Criterion of odour concentration: Consists in adopting a concentration threshold for odour perception. Typically, this criterion is used for design, not coercion.
• Criterion of individual substances concentration: Uses quantitative values of ambient concentration for individual substances, in areas near plant sites.
• Criterion of minimum separation distances: Uses minimum distances, fixed or variable, or buffer zones. There are countries or regions that determine minimum separation distances for a large number of industries and other types of establishments. However, in most countries, the use of separation distances is limited to agricultural sources, sewage treatment plants and composting.
• Criterion of duration and frequency of the odour: This criterion assess whether the discomfort is significant. Not only considers the intensity of an odour, but also its duration and frequency.
• Criterion of odour intensity scale: Adopts a semi-quantitative scale of odour intensity to assist and beacon staff when they are investigating a complaint of odours on field.
• Criterion of odour index: Adopted in Japan, is a mathematical formula based on the outcome of the triangular method. It differs from an odour intensity scale because it is a calculated numerical value.
• Criterion of nuisance prevention: This criterion is based on narrative patterns of "nuisance" or "quality of life." The exact wording varies by region, but essentially requires that the odour of a plant does not result in a nuisance.
• Criterion of quantitative emission: Specifies quantitative values of emission of any odour or specific chemicals. This criterion seems to be different for each country or region.
• Criterion of claims: This criterion consists in a system based on answering the complaints of odour. The ways to address the complaints have much variation.
• Criterion of the best available technology: Tends to require the use of best practices and technologies, to new plants or expansion of existing ones, regarding emissions and odour control.

4. Odour estimates

Since the nuisance management caused by odours depends on measurements in both the source and the environment, various methods have been developed. Some are based on human sensitivity, known as sensory methods, and other are based on physicochemical properties of odoriferous substances quantifiable by instruments, known as analytical methods. Such procedures, defined and standardized in different regions and times, may vary significantly in their methodologies.
Sensory methods depend on the sensitivity of a group of people (panelists) to perceive the odour. Despite the similarity, panelist perceptions exhibit considerable variation which may provide different results.
In Japan, the measurement of odour is made using the triangle method, consisting of three bags: one with an odour sample and two others with neutral gas. This forces the panelist to identify which bag has the odorant. There are variations within the method for measuring odour in the environment or measuring the emission source, Higuchi (2003).
In the USA, ASTM E679 (1991) describes the dynamic olfactometry methodology with neutral gas flow of 8 liters/minute (minimum of 3 liters/min). The standardization subcommittee EE-6 A & WMA (Air and

Waste Management Association) suggested to the ASTM to alter the measuring methodology from a single sample to three samples (one with an odorant and the others with neutral gas). This amendment was incorporated into the revision made in 1997 and retained in 2004.
In Europe, EN13.725 CEN(2003) is similar to ASTM E679 (2004), but with neutral gas flow of 20 liters per minute. Harreveld, et al. (2008) found that 2/3 of European laboratories that were accredited to work in accordance within EN 13.725 fail for not having precision and accuracy. In a study on standardization of olfactometry methods, Schulz and Harreveld (1996) argued that the worldwide trend is to use the dynamic olfactometry of forced choice method.
The analytical methods are based on the results found by devices which measure directly or indirectly the concentration of odour. The methods commonly used are: gas chromatography, mass spectrometry, concentration monitoring equipments and odour sensors such as the electronic nose.

5. Laws on Odour

A study by Mahin (2001) showed that in the USA, where each state is free to legislate, there are very different standards concerning ambient concentration of H_2S, which is a very common odorant gas.
Germany adopts the factors that compose the FIDOL. It uses the emission threshold, which varies with distance between the emitter and the rceptor position. VDI-3940 (1993) is applied to licensing, using the initial value of odour impact, the hedonic tone of offensiveness, besides considering minimum separation distances.
In German agriculture there are several documents with practical standards that are applied to limit the environmental impact, including odour emission. Some refer to the creation of pigs, imposing a minimum distance between the facilities and residential areas. VDI-3471. 1986 takes into account the size and layout of the facilities. However, if such a plant site does not meet the specifications of the standard, it is possible to request a technical evaluation based on dispersion models.
Austria has a specific legislation for pigs, similar to Germany, in which it considers the number of animals, conditions of release, waste stock, atmospheric conditions, among other parameters to determine the so-called "odour number" (Schauberger et al., 2000).
In England, the Environmental Protection Act, Part 1, provides two schemes to control emissions: one known as Integrated Pollution Control (IPC), which covers integrated control for more complex processes that pollute the air, water and soil; and the LAAPC (Local Authority Air Pollution Control), delegating to local authorities control over processes causing minor aggression to the environment. Hobson and Vincent (1998) apud Jehlickova et al. (2008) report that in the United Kingdom (1990), the emission of odour at its source due to new industrial buildings must, for significant receivers, not exceed 5 OU_E/m^3 during more than 175.5 hours per year.
In New Zealand, the "Common Law" contains recommendations that fall within the concepts of frequency, intensity, duration and hedonic tone. It also considers cultural issues and the best technology available to prevent odour emission, and recommend validation of complaints by a council of managers. It suggests not trying to justify odour complaints made by the community by the use of odour dispersion models and also suggests community meetings to discuss odour issues.
The Brazilian federal law does not directly address odour impact. The National Environment Policy (Law 6938/81) refers to activities that affect the welfare of the population, which indirectly include the nuisance caused by odours. The National Council for the Environment (CONAMA) has stated emission threshold for reduced sulphur compounds (TR) from pulp manufacturing processes (CONAMA Resolution No. 382/2006) due to odour complaints associated to this type of industry. Some Brazilian states have specific laws on odours originating from some industrial and tertiary sector activities.
The management criterion to prevent the nuisance caused by odour is one of the fundamentals points for legislation creation. One can note that existing standards have varying criteria even within a country. Germany adopts the five criteria of the acronym FIDOL, but uses distance as a constraint in intensive rearing of animals. In the U.S. there are diverse criteria such as FIDOL (Connecticut), FID and impact on population (Oregon), discomfort (Rhode Island), maximum intensity (North Carolina) and others. Several criteria are also adopted in New Zealand, but the final decision is strongly influenced by the affected community. Japan has a standard limiting odour defined by numerical formula. It is quite common to use models to approve new projects or expansions of existing plants. Thus, a complete law

should include the olfactometry model to be used, make use of dispersion models in the approval of new projects or expansions, adopt FIDOL constraints, and take into account the neighbourhood disturbance criterion. The use of the best available technology to prevent odour should also be required. Table 1 shows a sample of the existing variation on management policies adopted in some countries and regions to prevent odour nuisance.

Table 1. Criteria management examples.

Criteria	Countries/Regions
Odour concentration	Japan, Australia, CEN, California, Washington.
Substance concentration	Minnesota, California, Australia, Brazil.
Minimum distance	Germany, Australia, Ontario, New Zealand.
Duration and Frequency	Germany, New Zealand.
Odour Intensity	Germany, Netherlands, New Zealand.
Odour index	Japan.
Nuisance prevention	Germany, Holland, USA 42 states, Brazil.
Quantitative emission	Germany, France, Denmark, Holland, Switzerland, California, Holland, Japan, Brazil.
Complaints	Switzerland, New Zealand, California, Australia.
Best technology	Germany, Australia, Washington, Scotland.

7. Conclusion

In conclusion, some points should be highlighted as ongoing activities that need further work by the scientific community and others as inexistent but worthwhile investigating:

- Greater clarity and uniformity in the definitions of the measurement units, averaging times and their uses, and wider dissemination of this information to the decisions makers concerning odour regulation;
- Intense involvement of laboratories militating in odour measurements, in order to elaborate reliable measurement procedures whose results are both accurate and repeatable;
- Given the complexity of this issue, projects involving working groups from different worldwide nations with specific focus on certain peculiarities of odour-people relationship should be created;
- Future research may yet be developed, for instance, the perception of risk by the communities affected by odour nuisance which may explain the discrepancies between ambient odour concentration and complaints. Another interesting field is related to indoor nuisance which is the case of enclosed public buildings, public offices and manufacturing facilities, where individuals may be subjected to the annoyances of odours with concentrations, frequencies and intensities that can not only cause discomfort, but also acute or chronic health problems. Odours in public offices and manufacturing facilities are usually considered as healthy and safety at the workplace and not addressed by Environmental Agencies.

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