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Odour Impact Criteria in South American Regulations

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Environmental odour exposure that results from anthropic activities may cause an adverse effect on human health. The exposure is frequently classified as airborne pollutant and therefore mainly regulated by federal or state jurisdictions. The goal of the regulations is the limitation of odour exposure to avoid nuisance. For this purpose, odour impact criteria (OIC) are formed by an odour concentration threshold and an accepted probability of exceedance of this concentration (i.e., percentile) to define compliance. Dispersion models generally calculate time series of hourly-mean concentration values at receptors surrounding odour sources. To mimic odour perception of the human nose, short-time peak concentrations derived from one-hour mean values may also be considered in OIC by using the peak-to-mean concept. In this paper, a review of OIC applied in jurisdictions throughout South America is provided according to the desired level of protection. The focus is on OIC which are used predominantly for the evaluation of the time series of ambient odour concentration, calculated by dispersion models. Particularly, the odour framework in countries such as Brazil, Chile and Colombia is presented. Sampling and analysis methods of odours and technical guidance associated with odour modelling will also be presented when mentioned in the regulations or technical guides. Furthermore, the importance of establishing exposure limits is discussed, to provide regulatory agencies and industry an effective and objective tool for the realization of odour impact assessment studies. Undeniably, olfactometric methodologies combined with criteria for impact assessment are essential instruments for managing conflicts arising from odour episodes and to achieve compliance for new, existing or expansion of facilities.

1. Introduction

The rising global development, due to rapid population and industrial growth of the last decades, is increasing the complexity and the amount of pollutants emitted into the environment. Regarding air quality, complaints related to nuisances caused by environmental odours, usually emitted from industrial and agricultural activities, are a very common form of populations express discontentment to the competent authorities.
One of the impact assessment methods most commonly used is based on the determination or estimation of odour emission rates, given by multiplying the odour concentration by the flow rate of the source, and simulation of topographic and meteorological data of the site to estimate the odour dilution in the surrounding environment by using dispersion modelling. This approach allows to predict the distance reached by the plume from the emitting source and the ambient odour concentrations. Once the concentrations in ambient air are calculated, the values are compared against a jurisdictional standard, called odour impact criteria (OIC) to assess if the impact level simulated can be tolerated (Needham and Freeman, 2009). OIC are generally formed by a combination of two components: odour concentration threshold and a probability of exceedance of this concentration, also called percentile (Sommer-Quabach et al., 2014). To mimic the odour sensation of the human nose, short-time peak concentrations, which are derived from 1 h mean values simulated by dispersion models, can also be included in the criteria (Schauberger and Piringer, 2012, Schauberger et al., 2012). The FIDOL factors frequently provide the basis for the development of jurisdictional criteria of

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environmental odours (Griffiths, 2014). This acronym responds for frequency (F), intensity (I), duration (D), offensiveness (O), and location (L) (Watts and Sweeten, 1995, Freeman and Cudmore, 2002).

Dispersion models calculate odour concentrations in each receptor point in the modelling domain. In the case of a 12-month hourly meteorological data, the model simulates 8,760 concentrations in ambient air for each receptor. For instance, if the compliance frequency of 99.5% is required, the 44 highest 1 h concentrations simulated are eliminated. Therefore, 99.5th percentile establishes that in 44 h over a year the odour impacts are accepted.

The need to adopt objective and quantitative air quality standards, scientifically supported, which would adequately protect communities from odour impacts is widely acknowledged. These criteria, established by regulations, would provide to the public an understanding of the degree of protection against odours. Furthermore, numerical guidelines with which success in preventing or mitigating odour episodes could be effectively measured by those responsible for the odour sources, and to evaluate abatement technologies. And, specially, the adoption of objective limits shifts the focus from pollution removal to pollution prevention (Nicell, 2009).

The aim of this work is to review odour regulations throughout South America and provide, when existing, the OIC according to the desired level of protection. The focus is on OIC which are used predominantly for the evaluation of the time series of ambient odour concentration, calculated by dispersion models. Particularly, the odour policy in Brazil, Chile and Colombia is presented.

2. Odour regulations in South American countries

2.1 Brazil

Federal regulations

The Brazilian National Environmental Policy – federal Law No. 6,938:1981 (Brasil, 1981) – launched the concept of environment, environmental quality degradation and pollution. Article 3 defines pollution as the environmental quality degradation resulting from activities that directly or indirectly harm the health, safety and well-being of the population; create adverse conditions for social and economic activities; adversely affect the biota; affect the aesthetic or sanitary conditions of the environment; release materials or energy in disagreement with established environmental standards. Accordingly, odour can be interpreted as a form of pollution for the provisions of the Law. Other legal documents address the issue of pollution similarly, as, for instance, Decree No. 76,389:1975, which presents concepts about the prevention and control of industrial pollution (Brasil, 1975) and Article 225, from the Constitution of the Federative Republic of Brazil.

The National Environment Council released the Resolution No. 003:1990 (CONAMA, 1990) that deals with air quality standards and, consequently, sets concentrations in ambient air for certain atmospheric pollutants. However, odours are not included. Article 7 mentions that other air quality standards, in addition to the pollutants considered in the Resolution, may be established by CONAMA, if necessary. Resolution CONAMA 436:2011 (Complements Resolutions No. 05:1989 and No. 382:2006) provides emission limits for air pollutants. The values are established by pollutant and industrial activity. The annoyance caused by odours beyond the boundaries of the site is only mentioned to cellulose manufacturing activities. Resolution 436:2011 delegates to the licensing environmental agency the power to set more stringent emission limits depending on local features of the area where the pollution source is located (CONAMA, 2011).

State regulations

In Brazil, the states have the autonomy to develop their own regulatory framework with regard to air quality, as occurs, for example, in the United States and Australia. In the state of Paraná, Resolution SEMA 016:2014, developed by the Secretariat of the Environment and Water Resources, can be considered the Brazilian regulation of reference in odour control and management. This Resolution refers, in Article 12, that odour-generating facilities must be implemented to a distance considered sufficient to avoid olfactory nuisance in population centers (Paraná, 2014). Resolution SEMA 016:2014 was issued from the experience acquired in Resolution SEMA 054:2006, in which was set a maximum odour emission rate of 5×10^6 ou h^{-1} for odour-emitting activities or a minimum abatement efficiency of 85%, determined by olfactometry, for control systems. Therefore, Resolution SEMA 016:2014, currently in force, regulates the impact on receptors (i.e., immission protection) and no longer fix emissions at source. Nonetheless, criteria to provide an effective and concrete basis to conduct odour impact studies using dispersion models or field evaluations are not established.

The Decree No. 59,113:2013 (São Paulo, 2013), from state of São Paulo, sets air quality standards and gives related provisions for conventional airborne pollutants. However, there is no mention when the context is odour pollution. The Decree No. 8468:1976 (amended by Decree No. 54,487:2009), which deals with the prevention and control of environmental pollution, provides in Article 33 the prohibition of the odoriferous substances emission in the atmosphere in amounts that may be perceptible outside the boundaries of the site. The verification of the perception that this article refers is performed by qualified technicians in the field (São

Paulo, 1976). Nonetheless, no other guidance is established for the definition of any method to conduct this confirmation. The first version of this Decree regulated on 55 chemical compounds, and compared the ambient air concentration in the fence line of a facility against the odour perception threshold. Nevertheless, this approach was revoked.

The state of Santa Catarina, through the Law No. 14,675:2009 – Article 290, assigned to the Environment State Council (CONSEMA) the goal to regulate odour criteria and methodologies in a period of (1) one year from the date of publication of this Law. Article 179 states that the definition of air quality standards should be provided in federal regulations, with responsibility given to CONSEMA to establish additional standards by those existing at the federal level (Santa Catarina, 2009). However, to date, no issue related to methods and criteria for odours was regulated. Therefore, to date, specific regulatory instruments, at federal or state basis, that fix criteria to define legal limits or target values for acceptability of odour impacts on receptors are not set in Brazil. In addition, no specific national standards for sampling and analysis of odours, guidance or technical standards to conduct field impact studies and atmospheric dispersion modelling of odours are existent.

2.2 Chile

The existing Chilean air pollution legislation, regarding environmental odour exposure, includes emission standards for total reduced sulphur compounds (TRS) associated with the manufacture of sulphated pulp industry. Complaints to the Health Authority are handled with jurisdictional intervention through a protection resource, and subsequent interventions are counted among the actions taken against specific odour episodes. A large number of landmark complaints related to odour conflicts occurred in Chile in recent years. Particularly, during 2012, a swine production facility, located in the commune of Freirina (Atacama), caused serious socio-environmental issues in the community due to odour episodes. This event associated with the fact that legal limits or target values for odours or chemical compounds, except for TRS, are not regulated in Chile mobilized the Ministry of Environment to develop a document called “Strategy for Odors Management in Chile (2014 – 2017)” (Ministry of the Environment, 2013). The introduction contemplates sources potentially emitting odours in Chile, current regulatory instruments to odour control and a brief review of international criteria and health implications by environmental odour exposure. The objective is to enforce the regulatory framework with short, medium and long term measures. This will enable to address the odour management with a comprehensive approach to quantify, control and prevent the formation of the pollutant. Two pillars with specific actions to manage odours in Chile were established to be followed in parallel (Figure 1).

Figure 1 – Outline of the strategy for odour management in Chile (adapted from Ministry of the Environment, 2013).

Pillar 1 aims to strengthen the existing regulatory framework with directives that will leverage odour issues in priority sectors of the economy. Concurrently, generate knowledge to develop a standard on environmental odours in the near future. Pillar 2 objectives to increase expertise and local capacities to insert odour control in environmental management in the country. Develop directly a standard with odour limits was not considered in Chile due to the lack of records available. Therefore, prior to the preparation of an odour regulation, actions were proposed. To strengthen the regulatory framework, one of the first actions of the Ministry of the

Environment is to develop a regulation on the prevention and control of environmental odours. Thus, sectors with odour-emitting sources can adopt improvements in technologies and best practices. Consequently, the basis for the development of future environmental standards on odours will be established. The regulation will be complemented by actions related to the homologation of technical standards for standardization of odour measurement; consideration of odours in the territorial location; potential existing environmental instruments for the control and prevention of odours; evaluation of projects in the framework of the environmental impact assessment system; set protocols for control of odours and add a chapter dedicated to odour control and prevention in the Referential Guide of Municipal Environmental Ordinance (Ministry of the Environment, 2013). To date, the standards homologated in Chile by the National Institute of Normalization (INN) are: NCh3387:2015: Air Quality – Assessment of odour annoyance – Survey (INN, 2015b). Reference to German standard VDI 3883 Part 1:2015 (VDI, 2015); NCh3386:2015: Air Quality – Static sampling for olfactometry (INN, 2015a). Reference to German standard VDI 3880:2011 (VDI, 2011); NCh3190:2010: Air Quality – Determination of odour concentration by dynamic olfactometry (INN, 2010). Reference to European standard EN 13725:2003 (CEN, 2003). With respect to second pillar, the actions considered are: to increase ongoing training both in the public and private sectors, strengthening communication channels from odour-emitting sources to citizenship and the inclusion of the topic in the curriculum of academic and technical programs (Ministry of the Environment, 2013). The strategy of action included the realization of the "International Seminar on Odours Management in the Environment" that was held in Chile in march of 2014. This seminar provided exchange of experiences on odours regulation, dissemination new tools for managing odour emissions, besides presenting the odour issues in Chile. The implementation of the strategy is expected to improve the quality of life of individuals affected by olfactory nuisances, in addition to inserting odours in the regulatory framework and environmental management in Chile.

2.3 Colombia

In Colombia, the Resolution 1541:2013 (MINAMBIENTE, 2013) establishes directives for processing complaints, ambient air quality standards and source emission assessment of offensive odours. The application of this Resolution is performed as follows: (i) presentation of the complaint as an indicator of the existence of an alleged odour issue; (ii) evaluation of the complaint using standardized surveys; (iii) requirement of the plan to reduce the impact of offensive odours (PRIO) by the competent authority to the generating activity; (iv) plan implementation, assessment and monitoring by the competent authority; (v) measurement in case of noncompliance of the PRIO.

Complaints and plan to reduce the impact of offensive odours (PRIO)

The competent authority will have thirty (30) working days to evaluate the odour complaint, after the presentation of the alleged nuisance. Within this period, a visit to the activity can be conducted. Upon expiration of this period, the competent authority will have thirty (30) calendar days to issue the administrative act. Then, the feasibility to require to the facility the presentation of a PRIO will be decided. The activity must present a PRIO within the next three (3) months to the regulator, in accordance with Chapter V of the Resolution 1541:2013 (MINAMBIENTE, 2013). Evaluation of complaints are performed according to Resolution 2087:2014 (MINAMBIENTE, 2014) using the Colombian Technical Standard NTC 6012-1:2013 (ICONTEC, 2013). Basically, the PRIO must contain the following information: location and description of the activity; description, design and technical justification for the effectiveness of good practice or best available techniques to be implemented in the generating process of the offensive odour; specific goals; contingency plan; chronogram of implementation. As impact indicator of the PRIO, the number of hours in which offensive odours are perceived is performed using the Colombian Technical Standards NTC 6049-1:2014 (ICONTEC, 2014a) and NTC 6049-2:2014 (ICONTEC, 2014b).

Assessing ambient air quality standards of individual chemical or mixtures of chemicals

Table 1 shows the OIC applied in Colombia for mixtures of chemicals (i.e., odours) according to Resolution 1541:2013. In accordance with Table 1, OIC in Colombia are regulated considering the frequency, intensity (or concentration), duration and offensiveness, characterizing, therefore, the FIDO factors. Only the location factor is not specified. As compliance with the 98^{th} percentile is required, in approximately 175 h (~ 7.3 days) during a typical year the impact should be accepted at each receptor point in the modelling domain. Furthermore, the more offensive the odour is, lower the tolerable level of odour concentration. Dispersion modelling covered by Resolution 1541:2013 should be performed according to the guide adopted by the Ministry of Environment, Housing and Territorial Development. While the Guide to Air Quality Modelling is issued, the simulations should be carried out using atmospheric dispersion models recommended by the Environmental Protection Agency of the United States (USEPA): CALPUFF and AERMOD. As there is no mention to peak-to-mean factor, it can be assumed that this value is 1 (one). Therefore, odour concentrations calculated using dispersion models are on hourly basis.

Table 1: Odour impact criteria in Colombia according to Resolution 1541:2013 (MINAMBIENTE, 2013).

Activity	Permitted level *
Processing and preservation of meat, fish, crustaceans and mollusks Production of oil refining products Manufacture of cellulose pulp, paper and cardboard Tanning and leather retanning; retanning and dyeing of fur Treatment and disposal of non-hazardous waste and transfer plants Wastewater treatment plants Water catchment in water bodies receiving dumps Manufacture of chemicals and basic chemicals products Heat treatment of animal by-products	3 ou_E m^{-3}
Livestock production unit; preparation of vegetable oils and greases	5 ou_E m^{-3}
Decaffeination, toast and coffee grinding; other activities	7 ou_E m^{-3}

* The permitted level gives the ambient air odour concentration in European odour units (ou_E) which should not be exceeded by the 98th percentile (1 h mean value, calculated by a dispersion model) on an annual basis.

The method used to measure odours is detailed in the Colombian standard NTC 5880:2011 (ICONTEC, 2011), adopted identically from European standard EN 13725:2003 (CEN, 2003). Briefly, the objective determination of odour concentration of a gas sample using dynamic olfactometry with human assessors and the emission velocity from point sources and surface sources are addressed. Moreover, Resolution 1541:2013 establishes ambient air quality standards for chemical compounds that may cause odour episodes. The levels are set at reference conditions (i.e., 25 °C and 1013 hPa) and apply to the activities described in Table 1. Regulated chemicals are H_2S, TRS and NH_3 with daily limits of 7, 7 and 91 µg m^{-3}. The hourly limits for H_2S, TRS and NH_3 are 30, 40 and 1,400 µg m^{-3}, respectively.

3. Conclusions

The odour policy in Brazil, Chile and Colombia was presented to summarize environmental odour regulations throughout South America according to the desired level of protection. In Brazil, at the federal or state level, objective criteria and specific methodologies for evaluation of odours were not regulated so far. Chile is in progress to implement limits for odours until 2017, with standards published and a well-delineated work schedule. To date, Colombia is the only country in South America with a regulatory approach on maximum impact criteria (immission protection) defined by time series of ambient air odour concentrations calculated by dispersion models, besides having odour standards homologated. Consolidated practical and scientific experiences support odour impact criteria as a basic and essential tool for air quality management and control that aim at recovering, preservation or improvement of the quality of life through the protection of human health, safety and well-being of the population.

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