Part 1

Introduction

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1.1 Origin and Definition

Odour is the property of a substance, or better; a mixture of substances that depending on their concentration, are capable of stimulating the olfaction sense sufficiently to trigger a sensation of odour (Brennan, 1993; Devos *et al*., 1990; Bertoni *et al*., 1993). Even better, odour is a sensory response to the inhalation of air containing chemicals substances. When the sensory receptors in the nose come into contact with odorous chemicals, they send a signal to the brain, which interprets the signal as an odour. The olfactory nerve cells in humans are highly sensitive instruments, capable of detecting extremely low concentrations of a wide range of odorous chemicals. The type and amount (or intensity) of odour are both important in processing the signal sent to the brain. Most odours are a complex mixture of many odorous compounds.

Fresh or clean air is usually perceived as not containing any contaminants that could cause harm and it smells clean. Clean air may contain some chemical substances with an associated odour, but these odours will usually be perceived as pleasant, such as the smell of grass or flowers. However, not everyone likes the smell of wet grass or hay. Due to our sense of odour and our emotional response to it being synthesized by our brain, different life experiences and natural variation in the population can result in people having different sensations and emotional responses to the same odorous compounds (See Section 2.5).

Odour is a parameter that cannot be physically measured, unlike wavelength for sight or pressure oscillation frequency for hearing, nor can it be chemically determined as it is not an intrinsic characteristic of the molecule. It represents, in fact, the sensation that the substance

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provokes after it has been interpreted by the human olfactic system. The impossibility of physically and chemically measuring odour, the complexity of the odorants, the vast range of potentially odorous substances, the physical and psychic subjectivity of odour perception and environmental factors, together with the complexity of the olfactic system, represent a series of obstacles that render the characterization of odours and the control of olfactive pollution particularly complex (Zarra *et al*., 2007a; Dalton, 2002).

Public opinion plays a decisive role in evaluating the extent of annoyance caused by bad odours, often leading to associating unpleasant or malodorous emissions with any industrial or sanitary installation (Bertoni *et al*., 1993; Stuetz *et al*., 2001). In fact, even though nuisance odours are not generally associable to harmful effects on human health, they do represent a cause of undoubted and persistent annoyance for the resident population, thus becoming an element of contention both in the case of existing plants as well as in the selection of new sites (Shusterman *et al*., 1991; Zarra, 2007b). In this light, the impacts caused by the aesthetics of the plants and their inclusion in the landscape, the noise produced, the traffic generated and, above all, the emissions of unpleasant odours are becoming increasingly important (Zarra *et al*., 2008b).

Over the last few years, there has been more and more technical and scientific interest in these matters thanks to the greater attention being paid to protecting the environment and human health and, above all, due to the growing number of plants located in urbanized zones (Zarra, 2007b). As a result, for some time now, attention has been drawn to the need to monitor air quality in relation to environmental odour levels. However, the particular and complex nature of the substances responsible for odour impact, their variability both over time and with respect to meteoclimatic conditions and the subjective nature of olfactic perception are factors delaying any such regulation (Park and Shin, 2001; Zarra, 2007b).

As described in the following chapters, the components that can be evaluated in order to identify an olfactic type annoyance are concentration, intensity, hedonic tone (i.e. the pleasant or unpleasant sensation obtained from an odour) and quality (association of an odour with a known natural compound). As detailed later, of these components, only the first can be determined in an objective manner, while the others are highly subjective (see Part 3).

1.2 Quantifying Odour

Dynamic olfactometry, electronic noses (e-nose) and specific chemicals can be used (with varying success) to indicate the relative amount of odorous chemicals present in the air. This and other techniques for odour sampling and measurement are described in detail in Part 3.8.

Briefly, we could distinguish between sensorial, analytical and mixed methods. Sensory analysis, carried out prevalently using dynamic olfactometry, provides precise data on odour concentration, but it does not allow to evaluate the magnitude of the disturbance to which a population is exposed, nor can it determine the effective contribution of different sources to the level of environmental odour (Jiang, 1996; Sneath, 2001). The principal causes of the uncertainty of the olfactometric method are the significant biological variability in olfactic sensitivity and its inability to detect low odour concentration. Even though the introduction of criteria for the selection and behaviour coding of the panel has notably increased the repeatability and reproducibility of the measurements, the variability associated with the use of human subjects as detectors constitutes one of the principal limitations (Koster, 1985; Zarra *et al*., 2008b).

Analytical methods (GC-MS, colorimetric methods) allow the substances present to be screened and their concentrations identified, but they do not provide information on the odorous sensation produced by the mixture as a whole (Davoli, 2004; Zarra *et al*., 2007b; Zarra *et al*. 2008c). The analysis methods are also heavily influenced by the sampling techniques (Gostelow *et al*., 2001) which differ according to the type of source (areal or point, active or passive type) and the actual sampling methods (see Part 5). In order to reduce problems linked to sampling, a number of recent literary works propose the use of portable GC-MS analysers (Zarra *et al*., 2008b; Zarra *et al*., 2008c).

1.3 Effects of Odour

Odour exposure could cause annoyance and nuisance. A more serious effect, it may lead to feelings of nausea and headache, and other symptoms that appear to be related to stress. It has been postulated that the mechanism of 'environmental worry' helps to explain the occurrence of physiological effects in people exposed to odorous substances at concentrations much lower than might be expected to lead to actual toxic effects (see Section 2.5).

Many odorous compounds are indeed toxic at high concentrations, and in extreme cases of acute exposure toxic effects such as skin, eye or nose irritation can occur. However, such effects are most likely to occur as the result of industrial accidents, such as the rupture of tanks containing toxic compounds or severe upset conditions in chemical or combustion processes.

Repeated exposure to odour can lead to a high level of annoyance, with the receiver becoming particularly sensitive to the odour. Complaints are most likely to come from individuals who are either physiologically or psychologically sensitive to the odour, and certainly a combination of both types of sensitivity will increase the likelihood of complaint. The individual components of an odour necessary to cause an adverse reaction from people are usually present in very low concentrations; far less than will cause adverse effects on physical health or impacts on any other part of the environment.

The odour threshold values for many chemicals are several orders of magnitude less than the relative threshold limit values (TLV). This means that the chemicals can be smelled at much lower concentrations than those causing adverse effects on health. Therefore, if present in sufficient quantities, these compounds would create an odour problem at much lower concentrations than would be needed to create a public health problem.

Despite these examples, it should not be assumed that odour thresholds will always be much lower than toxicological thresholds. The potential for significant adverse effects on public health from chemicals in odorous discharges should be considered on a case-by-case basis.

There is very little information available about the physiological effects of odour nuisance on humans. However, it is known that prolonged exposure to environmental odours can generate undesirable reactions in people such as unease, irritation, discomfort, anger, depression, nausea, headaches or vomiting. In our experience, other effects reported by people subjected to environmental odours can include:

- difficulty breathing;
- frustration, stress and tearfulness;
- being woken during the night by the odour;

- odour invading the house and washing;
- reduced appetite and pleasure in eating, and difficulty preparing food;
- reduced comfort at night (the need to close bedroom windows on hot nights);
- reduced amenity due to the need;
- embarrassment when visitors experience the odours;
- reduced business due to prospective customers being affected by the odour.

All these aspects are related to odour attribute and the relative response of people, discussed in Part 2.

1.4 Odour Impact Assessment Approaches

Odour impact is defined as the alteration of air quality in terms of odours that cause nuisances. An assessment of odour impacts in the environment may need to be carried out for a variety of reasons, including:

- preparing or evaluating resource consent applications, or impact assessments, for three separate categories:
  1. renewing an existing activity,
  2. proposed modifications to an existing activity (mitigation or process change),
  3. proposed new activity.
- monitoring compliance with resource consent conditions;
- investigating odour complaints to determine if an offensive or objectionable odour is present.

The methods used to assess the odours will depend on the type of situation. A number of different techniques for odour assessment are available and discussed in Part 7. The choices of the best tools to use for an odour assessment partly depend on whether the assessment is an evaluation or a compliance issue.

Evaluation involves assessing the actual and potential effects of an activity to determine whether significant adverse environmental effects will occur. If the consent is granted, the consent holder is then required to comply with (and be able to demonstrate compliance with) any conditions imposed as part of that consent.

These two processes for evaluation and compliance are quite separate, and often the evaluation criteria are different to the criteria imposed as conditions of consent.

Assessment tools can also be classified in two categories, methods with direct measurement of odour exposures or their assessment by dispersion modelling, and respectively:

1. Odour impact assessment from exposures measurement
2. Odour impact assessment from sources

All these tools with their strengths and weaknesses are discussed in Part 7, where the criteria for choosing the best one according to the specific situation are also presented.

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