TECHNICAL NOTE

Metrology of odors – Olfactometry vs chemical analysis

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Written by : Adeline Narjoux M.Sc.A.
Verified by : Thierry Pagé ing. M.Sc.A.

Intended Audience

Professionals dealing with odor measurements and assessment of nuisance odors.

Objective

This Technical Note briefly outlines the scientific aspects, methods and instruments of the two available approaches to measuring odors: the analytical approach, and the olfactometric approach.

Summary

Characterization via chemical analysis, and sensory or olfactometric characterization have advantages and drawbacks. Despite the known benefits of the conventional chemical analysis characterization (accuracy, reproducibility, etc.), olfactometric measures are generally preferred due to the characteristics of the measured parameters (Gostelow et al., 2003):

- Complex blend, in the environmental samples, of numerous odors with low concentrations,
- Interaction between mixed odors, without a simple predictive model of the effects of the perceived odor,
- Low odor perception thresholds comparatively with the detection limits of the analytical methods.

The main advantages of olfactometry derive from the direct correlation between the odor and the sensitivity of the detector being used, i.e. the human nose.

Chemical Analysis and mixed odor characteristics

In general, it is difficult to use the chemical analysis method for mixtures of odorous compounds due to the phenomena of synergy, inhibition and masking between different compounds (Gostelow et al., 2003).

Complex mixtures, such as environmental air samples, contain many odorous compounds, generally at very low concentrations (Gostelow et al., 2001) (Schiffman et al., 2001) (Parker et al., 2002) (Filipy et al., 2006). To analyze all the odorous compounds that are present, the composition of the sample must be known in advance, and the detection limits of the chemical analysis devices are often too high to identify and quantify all these odorous compounds (Gostelow et al., 2003). Finally, the olfactory perception threshold values are not always available in the existing literature, the values reported vary by several orders of magnitude (AIHA, 1989) (US EPA, 1992) (Harreveld et al., 1999), and the available references are not recent.

The effects of synergy and masking between different odorous compounds can be observed in samples. For example, in a sample of food odor, the volatile compounds were identified and regrouped in five key odorous families. This was done to study the effect on odor resulting from different combinations of the five groups of compounds (Hallier et al., 2004). Synergy and masking effects were thus observed.

Numerous researchers have studied odorous mixtures and have created models to predict the effect that the mixtures' composition has on the perceived odor (composition and concentration) (Gostelow et al., 2003). In general, the use of these models is limited and applies only to the experimental conditions of the study. As well, the mixtures of compounds are mostly studied in the laboratory because of the complexity of mixed odors.

Studies have identified dominant odorous compounds in environmental samples. For example, a positive relation can be established between the odor concentration determined by olfactometry and the odor principle identified in the odor samples of liquid hog manure (Hobbs et al, 2000) and odor samples of composting mushrooms (Noble et al., 2001). However, these studies also show that a relation between the mixture composition and the odor concentration is still misunderstood and difficult to predict. For waste water treatment procedures where H_2S is the predominant odor, Gostelow and Parsons (2000, from Stuetz and Frechen 2001) show the values of r^2 between the H_2S and the odor concentrations to be as low as 7 to 69%.

Odor Perception Threshold Values

The *American Industrial Hygiene Association* (AIHA, 1989) compiled numerous studies and established a critical analysis of odor threshold values. The AIHA document is a recognized reference today and is often used as a source for odor threshold values.

The scale of acceptable odor threshold values was established for H_2S from 0,001 ppmv to 0,130 ppmv (1 µg/m^3 to 181 µg/m^3). The recommended value held by the AIHA (1989) is 0,0094 ppmv (13 µg/m^3). H_2S is a well-studied odorous compound and yet the AIHA proposes a scale of values for the threshold of two orders of magnitude, after their critical review. The example of H_2S illustrates why it is often inappropriate to work with odor threshold values because reliable values are not always readily available.

Olfactometry Analysis

Olfactometry generates standard sensory analyses, and the principal tool to measure odor characteristics is a trained jury of “noses” or a group of selected experts chosen according to rigorous and precise criteria (Harreveld, 1999) (Gostelow et al., 2003). An olfactometer is a device designed to dilute the odorous gas samples and to present these dilutions to the jury. After obtaining the responses of the jury, a statistical treatment of the data permits the olfactometric result to be calculated.

Olfactometric analyses are tested in the laboratory (EN 13725 and ASTM E679) or in the field during which the odor samples are gathered and then exposed to the target population in the study area. Olfactometric analyses of ambient air in the field are not recommended because of frequent variations of odor concentrations in ambient air and the low resolution of these methods. The Odotech #ODO 2007-25 (2007) Technical Note reveals the phenomena responsible for the temporal fluctuations of the odor concentrations in ambient air and presents observations of tests of these concentrations in a wind tunnel.

Applications

In England, the Environmental Agency published a guide on the measure of H_2S and the reduced sulphur totals at the source of ambient air (Environment Agency, 2001). This guide recommends that the measuring strategy be directly related to the objective of the measurement study. Thus, if the objective establishes the required abatement to eliminate the nuisance odor, it is specified in the guide that the odor concentration measurements expressed in odor units per cubic meter (o.u./m^3) are more appropriate than the kind obtained through chemical measurement.

Conclusion

The main advantage of olfactometry is the direct correlation between the odor and the sensitivity of the detector used, i.e. the human nose (Gostelow et al., 2003).

Despite the advantages of the classic analytical methods (accuracy, reproducibility, etc.), olfactometry remains the best available approach to measure odors directly, in order to objectively quantify the perception of odors.

References

AIHA (1989). Odor Thresholds for Chemicals with Established Occupational Health Standards. American Industrial Hygiene Association.

ASTM (1997). E679-91 (reapproved 1997) - Standard Practice for Determination of Odor and Taste Thresholds By a Forced-Choice Ascending Concentration Series Method of Limits. American Society for Testing and Materials: p. 34-38.

CEN (2003). EN 13725 - Air quality - Determination of odour concentration by dynamic olfactometry. European Committee for Standardization: p. 71.

Environment Agency (2001). Technical Guidance Note M13: Monitoring hydrogen sulphide and total reduced sulphur in atmospheric releases and ambient air. ISBN 1 857 05696 5. Environment Agency's National Compliance Assessment Service, England and Wales.
www.environment-agency.gov.uk/business/techguide/monitoring/m13.html

Filipy, J., B. Rumburg, et al. (2006). "Identification and quantification of volatile organic compounds from a dairy." Atmospheric Environment 40: 1480-1494.

Gostelow, P., SA Parsons (2000). "Sewage treatment works odour measurements." Wat. Sci.Technol. 41(6), 33-40.

Gostelow, P., SA Parsons, RM Stuetz (2001). "Odour Measurements for Sewage Treatment Works." Water Research 35(3): 579-597.

Stuetz R. and Frechen FB (2001). " Odours in Wastewater Treatment. Measurement, Modelling and Control ".

Gostelow, P., P.J. Longhurst, SA Parsons, RM Stuetz (2003). Sampling for Measurement of Odours. London UK, IWA, 80 pages.

Hallier, A., P. Courcoux, et al. (2004). "New gas chromatography–olfactometric investigative method, and its application to cooked Silurus glanis (European catfish) odor characterization." Journal of Chromatography A 1056: 201-208.

Harreveld, A. P. v., P. Heeres and H. Harssema (1999). "A Review of 20 Years of Standardization of Odor Concentration Measurement by Dynamic Olfactometry in Europe." Journal of the Air and Waste Management Association Vol. 49: pp. 705-715.

Hobbs, P. J., T. H. Misselbrook, T. Dhanoa and K. Persaud (2000). "Development of a relationship between olfactory response and major odorants from organic wastes." Journal of the science of food and agriculture Vol. 81: pp. 188-193.

Noble, R., P. J. Hobbs, A. Dobrovin-Pennington, T. H. Misselbrook and A. Mead (2001). "Olfactory Response to Mushroom Composting Emissions as a Function of Chemical Concentration." Journal of environmental quality Vol. 30: pp. 760–767.

Note technique Odotech #ODO 2007-25 (2007). "Non-validité de l'échantillonnage discontinu d'odeur en air ambiant afin de caractériser l'impact odeur." Barnéoud P., Leduc R., 3 pages, 12 mars 2007.

Parker, T., J. Dottridge and S. Kelly (2002). R&D Technical Report P1-438/TR: Investigation of the Composition and Emissions of Trace Components in Landfill Gas, Environment Agency, England and Wales.

Schiffman, S. S., J. L. Bennett, et al. (2001). "Quantification of odors and odorants from swine operations in North Carolina." Agricultural and Forest Meteorology 108: 213-240.

US EPA (1992). "Reference Guide to Odor Thresholds for Hazardous Air Pollutants Listed in the Clean Air Act Amendments of 1990" (#EPA600/R-92/047). TRC Environmental Consultants Inc., S. S. Cha, J. R. Mellberg, G. L. Ginsberg, K. E. Brown, K. Raab and J. C. Coco. US EPA, pp. 93.