OIZOM
REDEFINING RESOURCES

COMPLETE GUIDE TO ODOUR MONITORING

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INTRODUCTION

Odor is a highly unpleasant nuisance, characterized by certain substances stimulating chemical sense receptors (olfactory receptors) even in minute concentrations, affecting the surrounding air. Numerous activities such as manufacturing processes (e.g., pharmaceuticals, distilleries, meat processing) and urban waste-related activities (e.g., sewage, drains, municipal solid waste) emit unpleasant odors, significantly impacting the quality of life, especially in residential areas. Residents frequently report complaints about such odors, necessitating measures to mitigate and control them.

Sampling and monitoring techniques play a crucial role in regulatory frameworks, aiding in the assessment, evaluation, and implementation of economically sustainable measures for odor reduction. A well-designed sampling and monitoring plan is essential to gather pertinent information from each analysis.

This paper discusses the perception of odors, associated health concerns, real-time odor monitoring, and the use of odor units to effectively quantify odors.

WHAT IS ODOR?

Odor is the perception of smell; it may range from being unpleasant (like the rotten smell of garbage) to pleasant (fragrance). Odors, pleasant or unpleasant, are produced by inhaling airborne volatile organic and inorganic compounds. People do not generally perceive other common air pollutants, even if the exposure limit concentrations are exceeded. On the contrary, odors can be perceived even at below-normal exposure limit concentrations. Also, due to its subjective nature, the level of odor sensitivity can vary from person to person within the same community. It is, therefore, very important to measure odor in quantifiable units to be able to control it

United States Environmental Protection Agency (USEPA) Defines odor as

“A response of the olfactory receptor in the nose to certain types of volatile chemicals present in the atmosphere”, and
“The characteristic property of a substance which makes it perceptible to the sense of smell” [1]

ODOR AND HUMAN HEALTH

Although odor sensitivity differs from person to person, at sufficiently high concentrations, odorous compounds can have impacts on human health and well-being.[2] If the offensive odor persists, it generally leads to headaches, nausea, stress, anxiety, vomiting, sleep disorders, and behavioral changes.[3] Moreover, the odor-generating pollutants also cause irritation to the eyes, respiratory tract, skin, bronchi, and lungs furthermore prolonged exposure can cause serious health issues. People are increasingly complaining about their inability to enjoy their own property and outdoor activities such as gardening, playing outside, etc. due to odor nuisance in their neighborhood.

BASIC CONCEPTS OF ODOR

- **Odor nuisance**

  The development of odor nuisance is directly influenced by the characteristics of odorous compounds released from the source, the effect of atmospheric dispersion and dilution, the threshold value of the odorant, and the concentration of the released compound. To be able to manage odor complaints effectively it is imperative to understand the basics of odor, its properties, effects, and various methods of its measurement.

  Odor is the perception of the brain's response to the chemicals present in the air that we breathe.[4] Various odor properties that govern the perception of odor, serve as the basis for odor measurement.

- **Character of odorous compounds**

  Odor character or quality is the property to identify an odor and to differentiate it from other odors of equal intensity. Odor character is what the substance or compound smells like.

  Odor character, also known as odor quality refers to the specific and distinctive qualities or attributes that make up the overall smell or scent of a substance or object [5]. It describes the subjective perception of the odor and is often used to describe and differentiate various smells. Odor character can be influenced by a combination of chemical compounds and sensory receptors in our olfactory system.

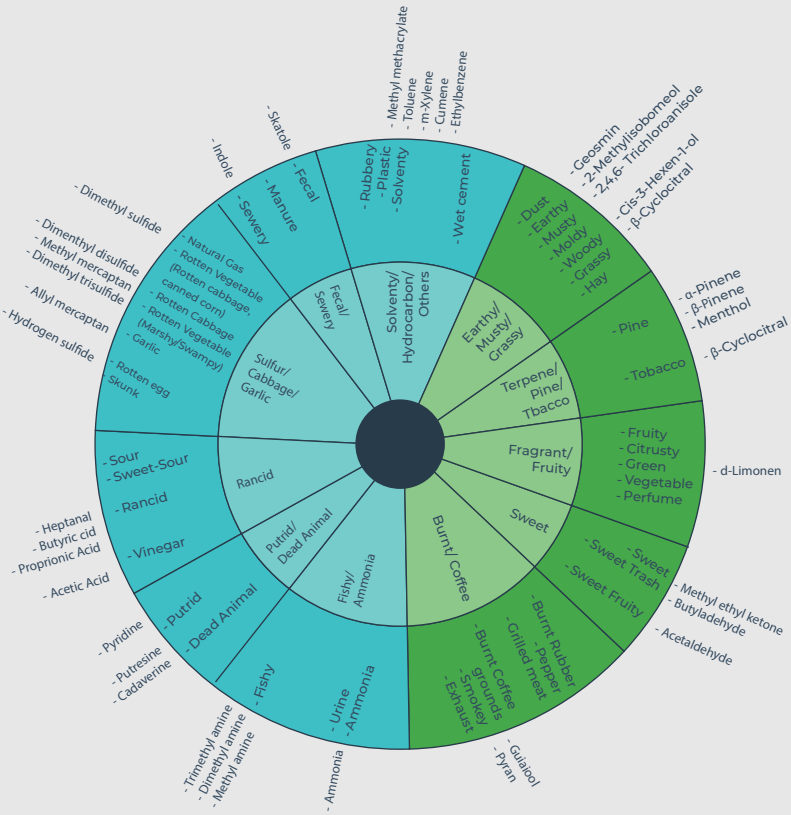


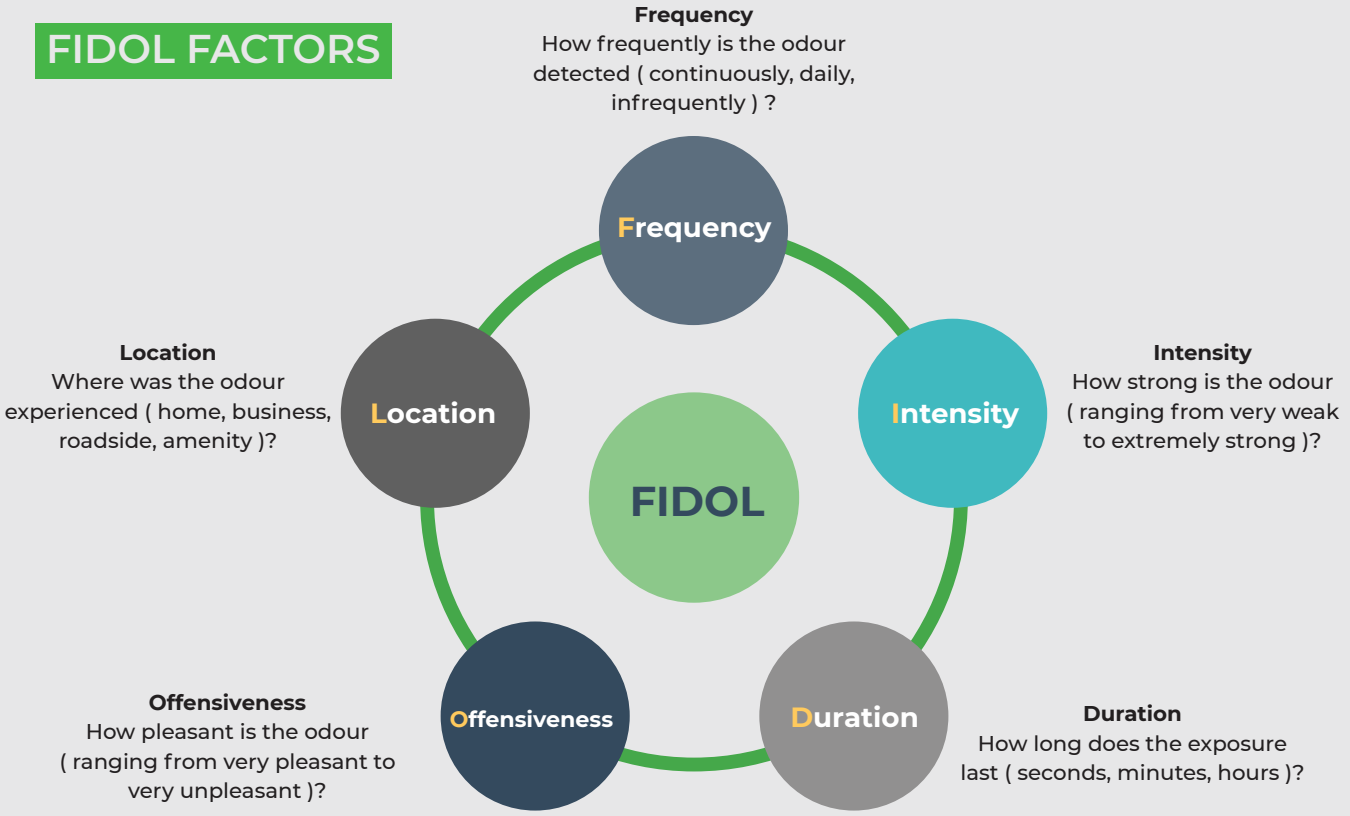
Fig 1 Descriptor wheel for a few odorous compounds

- **Odor persistence**

  Odor persistence is a measure of the relative change in odor intensity to the number of odor dilutions. The odor intensity of a non-diluted source is measured by comparing an n-butanol concentration to the odor source using a recognized Odor Intensity Referencing Scale (OIRS) [6]. For example, hydrogen sulfide odor is more persistent than ammonia.

DEVELOPMENT OF ODOR - FIDOL

There are five factors that determine the development of odor nuisance. Together they are known as FIDOL factors [7].



Different combinations of these factors can result in adverse effects. For example, odors may occur frequently in short bursts, or for longer, less frequent periods, and may be defined as having 'chronic' or 'acute' effects.

- **Frequency (F)**

  The frequency of the odor occurrence is how often an individual is exposed to odor in the ambient environment. Frequency is influenced by the odor emission source and its characteristics, the prevailing wind conditions, the location of the source in relation to the individual affected, and the topography of the area [8]. The frequency of odor exposure is generally greatest in areas that are most often downwind of an odor source, especially under stable conditions with low wind speeds (provided that the odor is not emitted at a significant height above the ground).

- **Intensity (I)**

  Odor intensity is the perceived strength of an odor at a given concentration. The perception of the intensity of an odor is in direct logarithmic relation with the concentration of the odorant [9].

ODOR	INTENSITY LEVEL
Extremely Strong	6
Very Strong	5
Strong	4
Distinct	3
Weak	2
Very weak	1
Not perceptible	0

- **Duration (D)**

  Like the frequency of exposure, the duration of exposure to the odor is related to the type of odor source, the local meteorology, and the location of the odor source.

- **Offensiveness (O)**

  Odor unpleasantness describes the character of an odor as it relates to the 'hedonic tone' (which may be pleasant, neutral, or unpleasant) at a given odor concentration/intensity [10].
  The hedonic tone (pleasantness-unpleasantness) of an air pollution odor depends on its character and influences how annoying the odor may be. In the context of air pollution, both unpleasant and pleasant odors may become objectionable, while this is less likely for hedonically neutral odors.
  The hedonic tone is independent of odor character and is often ranked on a nine-point scale ranging from extremely unpleasant (-4) to extremely pleasant (+4) and zero (0) being a neutral odor.

- **Location (L)**

  The type of land use and nature of human activities in the vicinity of an odor source affect the tolerance and expectation of the receptor. The 'Location' factor can be considered to encompass the receptor characteristics, receptor sensitivity, and socio-economic factors.

HOW IS ODOR MEASURED?

The odor measurement methods can be classified as olfactory, chemical analysis, and the introduction of new sensing technology that can measure the real-time concentration of odorous compounds.

- **Olfactory Analysis**

  As the traditional method of measuring odor, Olfactory analysis is conducted by human assessors who smell and judge the gas sample, and this method is applied to measure odor perception across the world[11]. The indicators of olfactory analysis include odor concentration (odor threshold), odor intensity, and hedonic tone, among which odor concentration is the most common indicator when assessing odor pollution [12]. There are several standard methods of measuring odor concentrations, e.g., the dynamic olfactometry method[13], the triangle odor bag method[14], and the use of sensor technology to measure the concentration of odorous compounds.

- **Chemical Analysis**

  Chemical analysis uses instruments to measure the composition of odor, which is more objective and convenient than olfactory analysis. Chemical analysis methods are being developed continuously, and various methods are applicable for different odorants[15].

- **Sensor Technology**

  Sensor-based air quality monitoring systems for all kinds of applications provide real-time air quality monitoring data along with meteorological parameters. Deep machine learning algorithms ensure high data quality which gives more than 90% accurate data when calibrated against the standard reference system. Sensors such as Electrochemical and PID sensors are used for odor monitoring.

WHAT ARE ODOR THRESHOLDS?

An odor threshold (OT), generally speaking, is the lowest concentration of an odorant in the air that can be detected by a human being[16]. In the scientific determination of odor thresholds, the terms and definitions are more specific:

Odor detection threshold (ODT): the concentration in air at which 50% of a population detects an odor but does not recognize the odor as a specific compound[17]. [For an individual, the ODT represents the concentration where that person can detect the odor 50% of the time[18].

Odor recognition threshold (ORT): the minimum concentration that is recognized as having a characteristic odor quality by a specific percentage (usually 50%) of the population[19].

The terms “odor threshold” and “ODT” are often used interchangeably in the literature. For the current report, odor threshold is used when discussing thresholds as a concept and when referring to all types of odor thresholds. At the same time, ODT is used when referring to ODT values determined in a laboratory.

An odor threshold can be useful in emergency planning and response as a rough estimate of the phone call zone. A chemical's odor threshold is the lowest concentration of that chemical in the air that people can smell. Ethyl mercaptan has a very low odor threshold, so most people will smell it even at very low concentrations [20].

Substances with odorous properties have a unique threshold value. The detection threshold value is the concentration of an odorous compound when it is detectable by a human olfactory system.

WHAT ARE ODOR UNITS?

The odor threshold per definition has an odor concentration of 1 odor unit/ m^3.

- **American and Australian Odor Unit (OU)**

  One odor unit is a number where a panel presents odors in decreasing dilution (increasing concentration) until detection. This is termed the detection threshold (DT) and is 1 Odor Unit[21]. Above all, if a sample were diluted 500 times, the odor concentration is 500 dilutions / 1 OU of the sample. This would result in 500 OU. This can be expressed as 'dilutions to threshold'. However, the panel can only detect at 1OU (the detection threshold) and not 2OU for example.

- **European Calculation (OUE/m^3)**

  One European Odor Unit, [OUE/m^3], is the amount of odorant(s) evaporated into one cubic meter of neutral gas. At standard conditions, it elicits a physiological response from a panel (detection threshold). Above all, This is equivalent to that produced by one European Reference Odor Mass (EROM), evaporated in 1 m^3 of neutral gas. One EROM is equivalent to 123 microg n-butanol. Subjects are standardized to n-butanol which is the reference material. When odors are detected at the threshold, it is expressed as a multiple of the reference material[22].

- **Oizom's Odor Unit (OU)**

  The concentration of a particular gas in air at which 50% of a population detects an odor but does not recognize the odor as a specific compound is defined as one ODOR UNIT. In general, one odor unit is equal to the odor detection threshold concentration of that particular gas.

  In practice, these odor detection thresholds are determined using olfactometry which is conducted by human assessors who smell and judge the gas sample. As for real-time monitoring, olfactometry is not suitable, the detection thresholds are predefined based on literature and used to determine the odor unit.

  Based on various literature, Oizom uses the following odor threshold limit to convert the readings from ppb to OU.

SR. NO.	POLLUTANT	DETECTION THRESHOLD (PPM)	CONVERSION FACTOR (1 PPB TO OU)
1	Sulfur Dioxide (SO_2)	1 OU = 0.547 ppm	0.00813
2	Hydrogen Sulfide (H_2S)	1 OU = 0.013 ppm	0.07692
3	Ammonia (NH_3)	1 OU = 2.58 ppm	0.00039
4	Methyl Mercaptan (CH_3SH)	1 OU = 0.005 ppm	1.96078
5	Formaldehyde (CH_2O)	1 OU = 0.49 ppm	0.00204
6	Nitrogen Dioxide (NO_2)	1 OU = 0.12 ppm	0.00833
7	Chlorine (Cl_2)	1 OU = 0.048 ppm	0.02083
8	Hydrogen Chloride (HCl)	1 OU = 10 ppm	0.1000

The literature used is as follows:

- American Industrial Hygiene Association. Odor thresholds for chemicals with established occupational health standards. Aiha, 1989.
- Leonardos, Gregory, David Kendall, and Nancy Barnard. "Odor threshold determination of 53 odorant chemicals." Journal of Environmental Conservation Engineering 3.8 (1974): 579-585.
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- Guidelines on Odor Measurement Techniques, Central Pollution Control Board (CPCB)

However, Odor Thresholds vary due to several factors such as:

- The way the stimulus is presented to the observer,
- The influence of extraneous odorants in the presentation system,
- The type of observer used,
- The definition of the odor response,
- The treatment of the data obtained,
- The chemical purity,
- Genetics, gender, age, environment, and health,
- The number and functionality of odorant receptors in the observer's nose,
- Small variations in chemical nature and structure

Hence, Oizom’s OU can be used as an indicative value for odor. Various certification agencies approve olfactometry analysis and can be used to get more information on the odor intensity and characteristics.

CONCLUSION

Odor monitoring systems play a critical role in improving air quality, ensuring adherence to recommended standards, and enhancing community relations. As technological advancements continue to break down the barriers associated with odor monitoring, these systems will become even more integral to industries around the world.

With Oizom's advanced odor monitoring solutions, businesses can stay ahead of regulatory requirements, manage odor emissions more effectively, and contribute to healthier, more liveable environments.

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MEET THE AUTHORS

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With experience in environmental engineering and research, Kruti Davda currently leads environmental analysis at OIZOM, where she puts her mind to gross air pollution data and extrude insights through environmental research and analysis.

HI,
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Vrushank has 11 Years of experience in helping different industries in designing products with great usability and experience. He is leading a great team of Designers, Engineers, and Environment scientists at Oizom. He is always up for meaningful discussions in Air Quality.

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