Odor Modeling: Can It Help Your Facility?

Odors

Odors are generally defined as a distinctive, and an often unpleasant smell. They are often caused by a single or combination of volatile compounds that, at low concentrations, humans can smell. Odors may be “pleasant” or “unpleasant” and while one person might find a specific odor pleasant, another might find that same odor unpleasant or objectionable.

Some examples of odor sources are wastewater treatment plants, food processing facilities, landfills, and facilities with odor-emitting industrial processes. While wastewater treatment facilities emit obviously unpleasant odors, food processing facilities may emit odors that are more individualistic meaning some may be fine with the odor while others will not like the odor.

If someone objects to an odor then often, action by the local board of health authorities or state environmental regulators is triggered by these complaints of abnormal odors by local residents in a particular area. The source of the odor is generally easy to trace, and the facility then receives a notification that they are violating some general state air quality regulation. It is then up to the facility to enlist an engineering, design, or construction team to obtain the best solution.

Metrics

Since there are no mass-based regulatory standards, the severity of odor impacts are evaluated using a number of different metrics. These metrics attempt to combine the various factors that would determine an odor is a nuisance by looking at how strong the odor is (intensity), how often it occurs at a location (frequency), how many people does the odor affect (extent), and how offensive is the odor (characterization).

Intensity

The first metric to gauge odor impacts is the intensity of the odor concentration. A strong odor is more objectionable than an odor that is barely detectable or recognizable. More dilutions are needed to make the source concentration no longer detectable. Thus, a higher concentration downwind indicates a greater odor impact at that downwind location.

Odor generally falls under the topic of air quality in states’ environmental regulations, however many states do not have specific regulatory air quality thresholds like the criteria or hazardous air pollutants. Some states have adopted as a matter of policy, odor thresholds to assist in providing discrete measures with which to assess odor impacts. Generally these thresholds are only applicable at sensitive locations such as residences or other areas of interest (i.e., parks) Regulators often deem odor concentrations over these thresholds to be “adverse” and will often require sources to mitigate odor emissions such that downwind odor concentrations meet these thresholds.

Frequency

The second metric to gauge impact is frequency at a specific location. If an exceedance of an odor threshold occurs rarely, it's likely not a "nuisance". However, if that exceedance occurs on a weekly, daily, or even more frequent rate, then the likelihood of it being considered a nuisance grows.

States generally have no formal policy on odor frequency. There is currently no frequency threshold to decide if an odor source is a nuisance. It is examined on a case by case basis.

Extent

The third metric to gauge impact is the extent of the impact near the source. Using the odor threshold, the spatial area where the highest odor concentrations exceed that threshold is examined. Smaller impact areas are obviously preferable to larger areas as the goal is to adversely affect as few as possible.

Characterization

Odors have distinct scents and can be characterized as generally pleasant or unpleasant, depending on the individual as well as the other three metrics described above. Odors described as floral, fruity, or earthy are generally considered pleasant. While odors described as offensive, fishy, medicinal, or chemical can be noted as unpleasant. Again, scents are subjective and highly dependent on the individual. However, even pleasant odors can become a nuisance if the intensity is overwhelming to the individual, or the odor becomes too frequently observed.

Sampling and Analysis

Chemical sampling is performed, which targets a specific compound, and test methods and equipment are specifically designed by the United States Environmental Protection Agency to test specific compounds. If an odor-generating process has a distinct chemical signature, then sampling for that specific chemical compound is reasonable and effective. However, since "odors" often encompass a number of chemical compounds mixed together in the emission stream, there is no specific chemical signature to detect. Thus, odor sampling and characterization has a unique process.

Sampling for odors can be done using air pumps and Tedlar bags. Sampling hoses are inserted directly into the exhaust stream of the stacks and vents. For surface area sources such as odorous fluids or piles, flux chambers can be used. A flux chamber is a vessel that is placed directly on the surface of the odorous media, while the sampling hose is attached. The volume of odorous air within the chamber is transferred to the Tedlar bag, and prepared for shipping to be analyzed.

Analyzing the intensity of odors is done through the use of an "odor panel" within 24-hours of the sample being taken. The panel is a group of trained individuals of diverse ages placed in a sensory controlled testing environment, as to not affect their results. This group of six to eight panel members is chosen from a pre-determined pool of individuals certified by the American Society for Testing and Materials (ASTM). The testing uses a device called an olfactometer, which

discharges amounts of the sampled odorous air at equal volumetric rates until the panel member cannot recognize it, and/or detect it. At this point, a set volume of odorous air has been diluted a set number of times with clean or odor-free air. The results across the panel are averaged, and then converted into a linear scale. The resulting ratio is the dilution ratio, D/T, or more commonly called “odor units”.

The dilution ratio is the estimate of the number of dilutions necessary to make the actual odor emissions no longer detectable. This is essentially the process that occurs in the atmosphere downwind of an odor source.

Modeling

Dispersion modeling is the technique of using computer programs to estimate downwind concentrations at specific locations of emission produced from a source. These computer programs use physical equations, source and stack parameters, terrain, and meteorological data to conservatively predict odors at hourly intervals at hundreds to thousands of locations for generally periods of five years.

This analysis provides a large sample of hourly odor concentrations. From this sample, maximum intensity, frequency above thresholds, and spatial extent can all be identified. This analysis becomes the baseline case from which the owner of the source of the odor can develop mitigation strategies.

Evaluating the intensity of the odor concentration, a higher value indicates that more dilutions are needed to make the source concentration no longer detectable. Thus, a higher concentration downwind indicates a greater odor impact at that downwind location. Typically, this threshold is on the order of 5 D/T over 5 minutes, or 1 D/T over 1 minute. Hourly predicted concentrations can be converted to shorter time periods using the “one-fifth power law”.

Modeling analyses can be done for mitigation designs before implementation. This allows for the designer to predict what the effectiveness of the measures will be on the three primary metrics stated above. For facilities with multiple sources of odor, such as wastewater treatment plants or complex industrial facilities, the modeling analysis can compare different mitigation combinations such that the facility can implement the most cost-effective measures given a fixed capital improvement budget. The best mitigation plan may not be to control the source with the greatest initial intensity, but to control the source producing the greatest frequency, or the source producing the greatest extent, or some combination, which results in the best of all three metrics.

Mitigation

Odor mitigation measures vary by source type, chemical composition of the odor, and expected results. For wastewater treatment facilities, odor mitigation may come in the form of covering tanks and exhausting the odorous air through carbon filtration systems. For industrial processes, specific active control measures should be designed to produce reductions in specific chemicals

causing the odor. Chemical scrubbing, ozone injection, or ultraviolet treatment may be options. Depending on the chemical makeup of the odors, biological treatment may also be an option. In some cases, physical modifications to the exhaust, such as increasing the stack height or exhaust velocity may produce better dispersion such that downwind concentration intensities and/or frequencies are reduced.

Summary

For a facility that is experiencing odor complaints, a comprehensive analysis of the source or sources should be done. Odor samples should be taken, dispersion modeling should be considered to evaluate the potential impacts, and possible mitigation measures should be evaluated. Using this information, the facility management, along with design engineers, can develop cost-effective solutions to mitigate the odors, return the facility to air quality compliance, and become better neighbors within their communities.

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