Overview of Odors

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Introduction

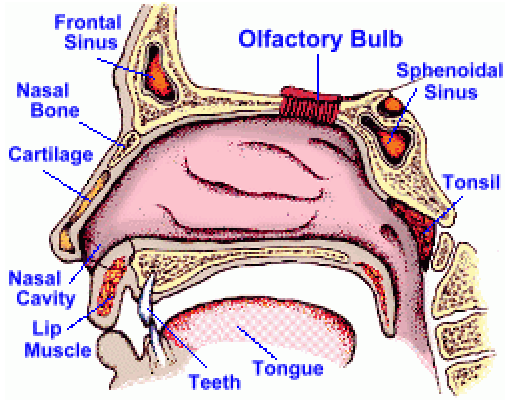
One of the most challenging environmental problems that an engineer may face is that of odors, or specifically, malodorous compounds. Odor problems are often in contrast to typical problems faced by the environmental engineer because, as you will see, odors often trigger emotional responses from those exposed to it. Most people believe that if a compound has a strong, annoying odor, it must be toxic or otherwise unhealthy. Many people also believe that breathing in odorous compounds from outside sources is an infringement of their freedom to enjoy their property.

This reasoning is not always correct. There are many compounds that are lethal at certain concentrations, yet are odorless. For example, it was reported that in the late 1990's about 40,000 Americans per year required emergency room treatment from odorless carbon monoxide poisoning. And there are many compounds that have been determined to be neither toxic nor a public health threat at concentrations that are detectible and/or bothersome.

The solution to odor problems is to reduce the ground-level concentration of the odorous compounds to below their detection thresholds, even if the effort results in little environmental or health benefits. Another challenge facing the environmental engineer addressing an odor issue is that the very nature of an odorous compound has a detectible low ambient concentration. So the challenge is to determine and implement strategies to reduce emissions or ambient concentrations of such compounds to a very low concentration. Finally, odors often result in emotional outbursts by those exposed, leading to a unique burden of dealing with the public.

Nature of Odors

The study of odors is a complex one. Technology has not yet caught up to the human olfactory system (our nose), which is believed to be able to detect over 10,000 different compounds based on exposure to minute concentrations found in the ambient air. (Refer to the diagram of the human nose below.) Odor characterization is further complicated due to the complex chemistry taking place at the moment of sensation. Differences between people certainly exist too. What is odorous to one person may be undetectable to another (even healthy) person. What is annoying or downright disgusting to one person may be neutral or even pleasant to another. For example, the familiar scent of "coffee" is really the interaction of at least six compounds emanating from the drink and stimulating our olfactory senses.



The chemistry of what causes certain compounds to stimulate olfactory nerves to cause the sensation of odor is incomplete. It is known that olfactory nerve endings in the nose do set out signals to a center in the brain, causing the different characteristics of odor that we are familiar with to be sensed. Complicating matters is that the odor center is located in the limbic portion of our brain next to an area specialized for emotion and next to one specialized for memory. This probably explains why stimulation of the odor center also causes stimulation of our emotions and strong memory retention of an odor episode. In addition, signals from the odor center of the brain are known to go to the frontal lobe which controls logical thought and contributes to our logical assessment of an odor and strategizing on how to react.

Further complicating matters is the phenomenon known as olfactory fatigue; the inability to distinguish odors after a prolonged exposure to those compounds. After a period of exposure, people can become desensitized to certain odor stimuli. This is particularly important to workers who may be exposed to the same odorous compounds on regular basis, but after time, do not realize it and do not protect themselves against it.

An odor detected by a person results from:

- the volatilization of a compound from the solid or liquid state into the gaseous state, followed by;
- the transportation of the gas away from the source and in the atmosphere (i.e., out through a stack or window and transportation by winds), and finally;
- detection by a person who has a specific sensory response when olfactory cells in the nose are stimulated by the particular gaseous compounds.

Odors can be generated from a variety of natural and human-caused processes and activities, from the scent of wild flowers in nature and foods in the kitchen to the smell of manure in agriculture and chemicals being used. Such compounds are found in the gaseous state, transported in the ambient air, and detected by our noses.

Many people associate odors with manmade industrial or wastewater processes. However, it cannot be emphasized enough that odor is very much a natural phenomenon. Nature uses pleasant odors for attraction (i.e., insects pollinate flowers) and malodorous odors for protection (i.e., skunks). The scientific community does agree that for humans there is no exact correlation between human odor interpretation and toxicity. In other words, some odorless gaseous compounds have a significant potential public health risk, while many odorous compounds are not toxic. Therefore, scientists know that odor in and of itself is rarely critical in determining whether a compound poses a human health risk. Of course, the public often thinks differently. Please note the table below demonstrating this. A compound may not be detectible until its concentration is already considered toxic, while others are detectible well below the levels that are considered toxic. This table is presented for illustration purposes only.

Compound	Workplace (Toxic) Threshold* (mg/m^3)	Odor Threshold** (mg/m^3)
Benzene	0.3	5
Toluene	377	10
Xylene	434	8
Naphthalene	52	0.5
Formaldehyde	1.2	0.1

* Workplace air standards as presented by either ACGIH (TLVs) or NIOSH (TWAs). Values are not equivalent to residential exposure.

**Odor Threshold is a rough estimate of the lowest concentration in air noticeable by smell.

For example, note that the common odor detection threshold for benzene is 5 mg/m^3 above its threshold for being toxic. One can be exposed to a level of benzene with adverse health risks without knowing it. The odor detection limit of naphthalene is over 100 times lower than the ambient concentration when it begins to show toxic effects.

Addressing odors is an important issue for residents in terms of quality of life. In general, the public becomes irate when it senses odors (even if pleasant, but particularly malodorous) inside one's home or on their property emanating from an external source. Interestingly, people will accept an odor wafting through their home if they generate it (for example, from a spice or sauce that they use while cooking), but not if it comes from somebody else. I was involved in a project involving a warehouse storing, blending, and packaging food additives and spices. Neighbors complained strongly of odors within their homes. When asked to describe them, they often described them as “vanilla”, “strawberry”, or “fruity”. They admitted that the odors were pleasant or, at least, not annoying, but they did not want them in their homes.

Here is another example illustrating the “human” factor involved in addressing odor detection issues. A different flavoring facility had been in existence for over a century in an area that was hardly developed. They did little to control their odors because the few people who lived near enough to be able to detect them were plant workers who had gotten used to the odors or were not about to “make waves.” A developer bought some land upwind of the prevailing wind and built condos and homes and sold these new “luxury” units. The new residents quickly began complaining about odors even though they rarely experienced them. After spending half a million to a million dollars (their life savings) on their new homes, they were not going to tolerate anything that would affect their lifestyle (or their investment). Of course, this leads to the debate of buyer beware; the buyers of the new homes should have done their “homework” and knew before buying the nature of the area. Also, came the argument of who was there first. Well, it was the industrial facility, of course, being a source of employment and taxes for decades and now these new people wanted to force their way. But fair or unfair to the facility, this is a different kind of argument, and ultimately, the plant, for the first time, had to seriously address odor control. (They had wished they had bought that land instead of the developer and let it stay fallow!)

Air Pollution Regulations

Because of the emotions involved with odors, odor control were among the first air pollution laws in states to please the public beginning in the 1950’s and 1960’s. But also because of the lack of precise science defining them, most of these laws are written as nuisance laws. Nobody is permitted to be responsible for a discharge, emission, etc. that would cause a nuisance or negatively affect the quality of life of another person. Typical of these rules is New York State’s regulation 6 NYCRR Part 211.2, Air Pollution Prohibited, as follows:

> No person shall cause or allow emissions of air contaminants to the outdoor atmosphere of such quantity, characteristic or duration which are injurious to human, plant or animal life or to property, or which unreasonably interfere with the comfortable enjoyment of life or property. Notwithstanding the existence of specific air quality standards or emission limits, this prohibition applies, but is not limited to, any particulate, fume, gas, mist, odor, smoke, vapor, pollen, toxic or deleterious emission, either alone or in combination with others.

Given the lack of precise science, this is a difficult rule to enforce. The New York State Department of Environmental Conservation (NYSDEC) has historically enforced this rule to address odor complaints. But how can it be proven that a facility’s emissions actually caused the nuisance to someone else? The NYSDEC (and other agencies) normally proceed by sending an Inspector to the site after receipt of an odor complaint. The Inspector must detect the odor past the property line during the visit and be able to track and prove its specific origin. It is quite common that by the time the Inspector arrives at the site the odor episode has ended and he or she cannot detect an odor. Even if an odor is detected, the Inspector may have difficulty proving its origin to a specific property or activity. For example, an odor may be so common that it may originate in several places. Finally, because of all of this uncertainty, many agencies do not aggressively look for these types of violations nor fines the guilty party a huge amount. (A company that receives a citation has many avenues to contest it.)

Yet, the odor problem may remain and as it lengthens in time, the surrounding neighborhood can get quite emotional. Companies realize that good will is of growing importance to their well-being, and being accused of causing a malodorous situation (rightly or wrongly) can negate years of efforts. Therefore, it is in a facility's best interests to address odor complaints and not dismiss them as meaningless.

Odor Characteristics

To begin to address an odor concern, it is important to understand the characteristics that odor.

As mentioned above, an odor is detected when enough olfactory nerves are stimulated to create a nervous signal to the brain which recognizes it as an odor. Therefore, odor detection depends on the concentration of a compound in the ambient air exceeding an "odor detection threshold" to stimulate the olfactory nerves. This threshold can vary from person to person. It is common for firms studying odors to convene groups of people (odor control "panels") to determine the average or typical detection threshold.

It is possible to have an ambient concentration of an odorous compound, yet it not be detectible by anyone if that concentration is low and below its odor detection threshold. That is the goal of the environmental professional is to reduce emissions into the atmosphere or dilute the compounds sufficiently so that it is not detected.

What follows are the main properties of an odor, and what is generally studied to develop a better understanding of the compounds that may be causing people in a community to detect an unpleasant odor.

Character. The character of an odor is the actual description of what it smells like to people, so that such odors can be determined and individualized in the future. There are nearly 150 common characteristic descriptors. Examples of an odor's character (sometimes also called quality) include "rotting berries", "skunk-like", "oily", and "vanilla".

Strength. The strength of an odor refers to its overall intensity or concentration. The stronger the odor, the more likely a resident will find it objectionable. Even pleasant odors, such as perfumes, can be annoying at high odor strength.

Strength is sometimes measured based on a dilution to threshold or D/T scale. A sample of ambient air is diluted by a known amount of fresh air and a panel determines how much it is diluted before it becomes barely detectible.

Note the difference between strength and character. It is possible to have an odor that has such a low strength that it is detectible, yet cannot be characterized. People in an odor control panel may state that something is there (it is detectible) but cannot describe it. While some may think this is impossible or is counterintuitive, this is a real phenomenon.

Strength is also measured on an eight-point scale, ranging from 1 which represents a very faint, barely detectible odor with no ability for characterization, to 8 which represents an overwhelming, intolerable odor that prevents the person from focusing on anything but the odor ("stops people in their tracks"). The odor intensity scale is as follows:

- 1 is an odor that is barely perceptible and may not be detected unless the person is specifically trying to detect odors;
- 2 is an odor that is very light, able to activate the sense of smell, but may not be distinguishable in characterization;
- 3 is an odor that is detectible, distinguishable, but not necessarily objectionable;
- 4 is an odor that is light to moderate, is distinguishable, and may be at times objectionable;
- 5 is an odor that is moderate, is distinguishable, and may be objectionable and/or irritating;
- 6 is an odor that is moderate to strong, very distinguishable, at most times objectionable, and may cause people to avoid the area;
- 7 is an odor that is strong, objectionable, and would cause most people to avoid the area completely; and
- 8 is an odor that is very strong, overwhelming, and intolerable for any length of time.

Duration. The duration is the elapsed time of each odor episode. Longer duration odor episodes can lead to more quality of life complaints than episodes of short durations which may "pass by" and be forgotten.

Frequency. The frequency refers to how often the person experiences odor episodes. The more frequent the intrusion into the community's life, the more objectionable each experience becomes; as such repetition breeds greater annoyance or emotion.

The cumulative effect of these four parameters: character, strength, duration, and frequency, is important to understand the odor and to develop strategies to reduce emissions of the offending compounds. When cataloging odors, the environmental engineer should collect data from people who complain about the odor to compile details of these 4 parameters when possible.

Odor Sources

To investigate an odor complaint it is important to identify the source of the odor. It is important to reliably trace it back to a presumed source. Correlating an odor to its direct source is the key to devising strategies to reduce emissions below its detection threshold and, therefore, its nuisance effect.

Therefore, an important parameter to record when gathering information from people complaining about odors is the direction of the wind when the odor is sensed. This will point you in the right direction of where the odor originates.

Once some potential sources are identified (based on wind direction or based on the odor's character correlating to what they may use or emit), it is important to correlate the timing of odor detection to activities at the potential sources. However, be careful before determining that an odor could not have come from a certain plant because it was "closed" at the time of detection. There may be a time lag between operation and emission of the odorous compounds. I was involved in one project where the community believed that an odor emanated from a certain industrial facility based on the compounds it uses and their odor characteristics. The facility denied that it was the source because the neighbors stated that odors were worse in the late afternoon and early evening, but this was not when they performed the activities that may have caused emissions. In addition, they operated control equipment to capture the odorous compounds, such as carbon canisters attached to the underside of the roof. The problem was that as time went by in a given day, the roof became hotter and hotter as it absorbed more of the sun's radiation, heating the canisters, causing the compounds to (all at once) desorb from the canisters, exceeding odor thresholds, culminating in the late afternoon. This is what caused odor emissions from morning activities to be detected in the late afternoon.

Perhaps the most common source and operation that causes odor complaints is wastewater and its treatment. Municipal and industrial wastewater contain about 30 to 40 compounds that have low odor thresholds. The most common ones are sulfur-containing compounds, such as hydrogen sulfide (H_2S), dimethyl sulfide, carbon disulfide, and mercaptans, which have been chemically reduced by bacteria. Some nitrogen-based compounds, such as ammonia and amines, are found in wastewater as well. These compounds are prevalent in wastewater (byproduct of bacterial degradation), have very low detection thresholds, and are quite volatile into the air. H_2S is the main compound representative of wastewater odor because it is prevalent, toxic (at high enough concentrations), and easy to measure. H_2S has an odor detection threshold in humans as low as 1 part per billion (more commonly at 10 ppb) that can be measured by readily available hand-held monitors. Its character (along with that of other sulfur compounds) is easy to describe ("rotten eggs"). Its Immediately Dangerous to Life or Health (IDLH) standard is 100 ppm. Identification of "rotten eggs" odor is a sign that there is a wastewater treatment process nearby with odors not captured or that there is an uncovered wastewater stream nearby.

Potential odor sources can be assessed by a combination of odor monitoring and modeling. Monitors exist to record real-time concentrations of many common odorous compounds. Typically, several units are placed on property lines and the concentration of the compounds in question in the ambient air are measured and recorded over a time frame (commonly 24 hours, but sometimes less). A disadvantage of this approach is the expense, not only of renting the equipment, but the labor to service and/or take samples for analysis and servicing them. This can limit the length and breadth of many studies. Most studies also include a meteorological station to record wind speed and direction while the sample is taken. Such real-time data can be valuable. However, it may not necessarily indicate the exact point of origin.

Dispersion modeling can be performed for H_2S or any gaseous molecule from a stack or exit location to estimate concentrations at exact points where people may be exposed to it (receptors) given the understanding of the area topography and climate. Such models can estimate the cumulative concentration from many sources. However, these are computer models, may not represent perfectly real conditions, and are based on the information inputted. Therefore it must be realized that such computer-based estimates are indeed just that: estimates.

Odor Control

The goal of odor control is not necessarily to eliminate the odorous compound, but to reduce its concentration in the ambient air outside the source's property line (receptor) so that it is below the compound's detection limit. Still, this is a challenge given that many nuisance compounds have very low detection thresholds. While some general approaches are discussed here, they will emphasize application to wastewater odor control since this is the most prevalent source of odor problems.

The first priority for the environmental engineer in designing the best odor control strategy is to have a full understanding of what the odorous compounds in question are and their potential concentrations, not only at the receptor end but at the source as well. The engineers also needs to have an understanding of how much the compound needs to be diluted and the inlet characteristics into a potential control device. Therefore, it is important to perform a complete emissions inventory at the source(s) of odorous compounds and answer the following questions:

- How many such odorous compounds are there and what are the maximum concentrations that may be found in the exhaust or air leaving the process or building?
- What is the timing of such emissions?

- Could two or more odorous compounds be released simultaneously or may concentrations vary throughout the day? Or is there no reliable pattern?

By understanding the nature and pattern of odorous emissions the environmental engineer can develop the most reliable options for their elimination.

Process Modification.

There are several approaches to odor control. The first approach that the environmental engineer should examine is whether the odor problem is caused by a simple, unintentional release of the compound in question. Can a simple process modification or repair successfully solve the problem? Simply repairing a leak or covering an opening may be sufficient to eliminate the odor problem. Similarly, the environmental engineer should research reasonable steps to modify the process to reduce the volatilization of the compound in question. One common example is reducing the turbulence of the liquid phase compounds, thereby reducing volatilization into the air. Can a reduction in turbulence be achieved without affecting the process? If so, this could contribute to solving the problem. Understanding the process may identify other means to modify it without affecting the product, yet reducing volatilization or concentration of the compounds in question.

Chemical Addition.

Another approach to controlling odors is chemical addition to alter the odorous compound or to minimize its volatilization into the air. Some examples of chemical additives and their effects include:

- Binders: addition of iron salts to convert the odorous compound in the liquid phase into a solid which will fall out of the solution and be captured;
- Oxidants: addition of oxidants, such as chlorine and hydrogen peroxide, to reduced compounds, such as H_2S and ammonia, will convert the odorous compounds to other, non-odorous compounds;
- Caustic: addition of caustics, such as sodium or potassium hydroxide, can raise the pH, causing the odorous compound to stay polarized and remain in the solution (a lower percentage volatilizes into the atmosphere);
- Nitrates: addition of calcium or sodium nitrate reduces the degree of reduced sulfur-containing compounds from forming;
- Enzymes: addition of enzymes could permanently modify the odorous compound.

Odor Control.

If modifying or repairing the process and chemical addition do not succeed in reducing the concentration of an odorous compound below its detection threshold, then a more active approach is necessary. The following steps need to be taken:

Isolate. First, the source(s) of odors must be isolated, such that the air containing the volatilized odorous compounds is separated from the main sources of exhaust air. This allows the proper design of the control equipment or strategy and more cost effectively addresses the main source of odors.

Again, given the low detection threshold of these compounds in question, this is not an easy task. The best approach is to put a cover over the area to keep the odorous air in place and convey it elsewhere for treatment. The cover must be properly extensive (exact fit) and not cause any leaks. It must be made of material that is not damageable by the liquid or gas (for example, non-corrosive), and be durable for many years. For open wastewater treatment areas, fiberglass-reinforced plastic, aluminum, concrete, and stainless steel are commonly used as covers. The shape of the cover is important, too, as H_2S and other odorous compounds are combustible if they build up excessively. Covers are commonly flat, arched, or geodesic dome-like. Maintain negative pressure.

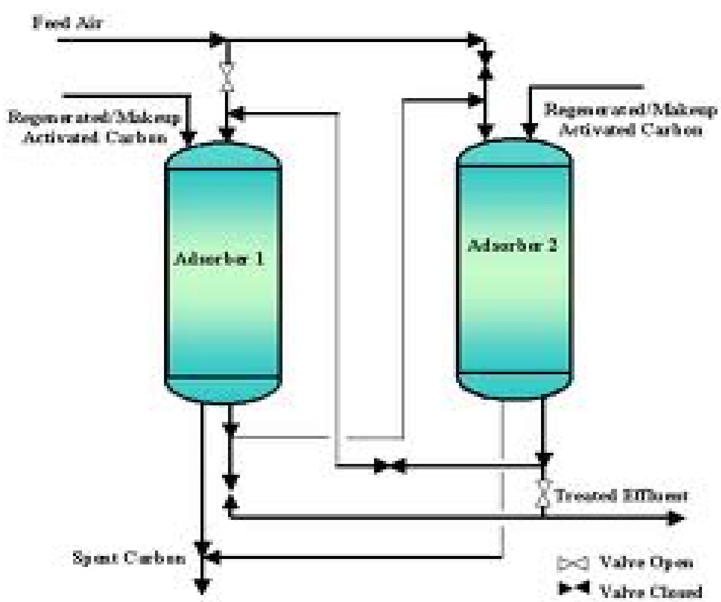
Conveyance. Now that the source is isolated, its odorous exhaust must be conveyed to a control device. It is important to maintain negative pressure to prevent leaks or backflow and to ensure that the air does flow downstream to the control device. Conveyance parameters are particularly important should workers need to be present for any repairs or other work.

Control Devices. There are many control devices that treat and remove odorous compounds from the exhaust air. The most common one in wastewater treatment plants is carbon adsorption. Adsorption is a physical process where the gas stream flows through a solid bed of particles, and certain gas molecules physically attach and adhere to the outside of a solid molecule. This is a physical attachment and is not to be confused with absorption, which is dissolving of a compound in a liquid. The attachment is caused by polar forces that are weaker than chemical bonds, called chemisorption.

In practical terms, the most common adsorbant used in pollution control is activated carbon because of its affinity for many compounds, its inexpensive cost, its history of success, and its huge external surface area. A given carbon molecule has a considerable external area for gas compounds to “find” and adhere to.

Certain gas compounds have a strong affinity to adhere to carbon while others have a weak or no affinity. Therefore, the affinity of the odorous compounds, you wish to remove from an air stream, to carbon must be fully understood before selecting this technology. Nearly all of the common odorous compounds from wastewater treatment (ammonia and the reduced sulfur compounds) have a high affinity to carbon. So carbon adsorption is an excellent choice for most wastewater control applications. However, if the compound that needs to be removed has a low affinity to carbon, then this technology should not be used. Another consideration in designing the carbon adsorption system is that the inlet stream cannot be too concentrated for the size of the carbon bed. Otherwise, some odorous compounds may breakthrough the device and be emitted without binding to the carbon.

Typically, carbon adsorbers contain two beds of solid. Exhaust (odorous) air is conveyed to one bed which is removing compounds, while the other bed is desorbing compounds that have already adsorbed earlier. Most compounds are easy to desorb with heat, steam, or vacuum. Then they can be captured and treated for permanent disposal.



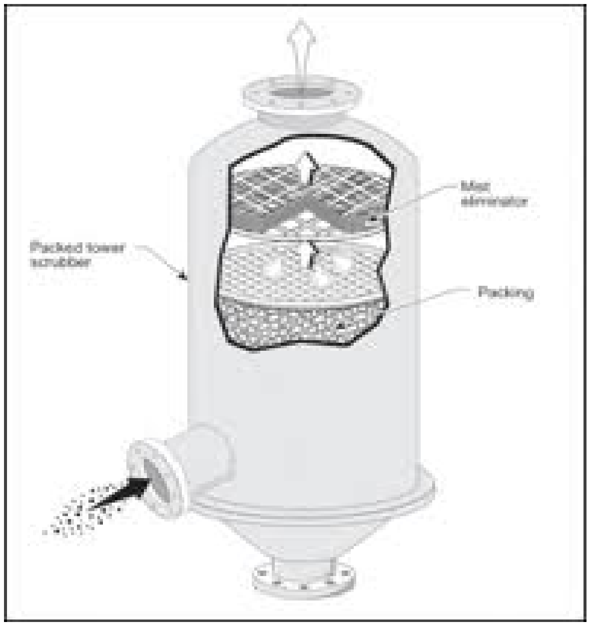
In summary, carbon adsorption is an effective way to control many odorous compounds. It works effectively on low to high concentration streams, as long as the size is proper for a high concentration stream (so there is no breakthrough). As long as the unit is managed properly (bed is monitored and taken offline when it is "full" and desorbed for reuse), then it can control over 99% of the inlet compound (such as H_2S). The key factor is the degree of affinity of the compound for carbon.

It is critical to monitor the use and effectiveness of any control option, particularly carbon. As discussed earlier, I worked on an industrial project involving a facility whose neighbors complained of odors from compounds with odor characteristics unique to the activities of that facility. The neighbors said that most of the odors were detected in the mid to late afternoon and early evening, with little or no odor at night, in the morning, or at noon time. The facility denied that there was a problem because odor detection did not correlate with activities that might volatilize odorous compounds (in the morning) and because of the use of carbon canisters throughout the facility under the tall ceiling below the roof. The problem then became apparent. Because the canisters were 40 or more feet above the floor level, workers were not regularly servicing them. Because they were located right under the uninsulated roof, the immediate ceiling area would get warm due to the sun's rays (even in the winter), causing desorbtion of the adsorbed compounds all at once. As the roof is absorbing different radiation from the sun (UV, visible, IR, etc.), the energy was building up and dissipating as heat. That explained why the carbon canisters, which were absorbing pollutants throughout the morning and early afternoon, would release these compounds all at once in the afternoon or early evening. Release of all the compounds at once would lead to high concentrations emitted from the facility and exceeding their detection thresholds. While carbon adsorption is generally a good solution to odor control, it was not for this facility due to its installation design. Carbon, perhaps made the problem worse.

The other common odor control technology is absorption or wet scrubbing. Certain compounds are soluble in water, the most common scrubbant. Therefore, a well-designed scrubber can absorb odorous compounds and take them out of the exhaust air stream. It is critical to design the scrubber to enable the maximum contact between dirty gas and scrubbant. Most scrubbers designed for wastewater odor control contain inert packing to hold up both the gas and water flows allowing more contact. Typically, a liquid film forms over the packing through which the gas must flow, thereby enabling the necessary compund to dissolve in the water.

The first concern when it comes to selecting scrubbing is whether the target odor compounds are soluble in water and just how soluble. A compound that is insoluble or weakly soluble in water, such as certain volatile organic compounds (VOCs), render scrubbing as a useless control strategy. Toluene is an example of an odorous organic compound that has a very weak solubility in water. So if toluene is the target compound, scrubbing should not be used. In the wastewater area, nearly all of the major odorous compounds are strongly water-soluble.

While water is the most common scrubbant, many odor control scrubbers mix other chemicals with the water to more effectively control the target odor compounds. For example, caustic (high pH) water not only absorbs H_2S effectively, but also reduces its level by reacting with the sodium or potassium of the hydroxide compound of the caustic solution, and drives the H_2S to its polar form causing more of it to stay in the liquid wastewater solution. At a pH of about 8, about 90% of the H_2S in the solution is converted to HS^- and remains in the solution. Some scrubbers are designed to use hypochlorite or other oxidizing agent to chemically modify the reduced sulfur odorous compounds to other, less or non-odorous compounds.



Control Strategy and Management. One cannot write about odor control options without a discussion about strategy implementation and management. In most <u>other</u> air pollution control situations, the environmental engineer needs to know to what regulatory or other emission standard the facility or process must meet, as well as the nature of the exhaust stream to be controlled, then design and test the selected strategy to meet the goals. For example, a rule states that a facility must reduce emissions of a compound to a maximum of, say, 3 lb/hr. Based on this, determine the worst-case inlet, select the proper control device, design for lower than 3 lb/hr, install, and test. If the standard is not met, great; modify the design or installation accordingly until it is met.

Things are not so simple when it comes to odor control as many odorous compounds have no regulatory limits (New York is an exception, having a state ambient air quality standard for H_2S). First of all, as discussed earlier, for many odorous compounds the emission rate must be brought down to a very low rate, well below most common regulatory limits to ensure the odor is not detected or is quite weak in strength. Second, you have to doubly ensure that the chosen equipment is designed to meet the stringent goal, because if there is any excursion from the standard (even briefly), the public will be able to detect it and will get emotional, complain, and not trust that you know what you are doing. For that reason, many facilities controlling emissions implement redundancy by installing multiple controls for further reduction of emissions and as a backup in case one unit fails. Third, you must institute stringent management control of the odor control equipment, such as frequent or continual monitoring of key parameters (i.e., water flow rate, pH, odorous compounds coming off a carbon unit), and servicing because even one failure will be detected, thereby making you the subject of the complaints.

The environmental engineer must initiate standards more stringent than usual for issues involving odors because of their easy detection (carbon monoxide, which can be deadly, is odorless) and the emotion tied to them. The environmental engineer must be technically astute, but be able to deal with the public as well. To illustrate, I worked with a municipal wastewater treatment plant which had been under constant odor complaints for years by nearby residents. The plant manager decided to install an expensive, state-of-the-art, redundant system to address the residents' concerns. Construction and testing went so smoothly that the system was installed and in operation a few days earlier than the originally proposed (publicly announced) date. Well, literally on the hour that the system was supposed to go on line on the originally announced date, the facility switchboard "lit up" with odor complaints and insults regarding the plant manager's competency. It was then when the facility revealed to the nearby residents that the system was already in place, so it was unlikely to have been a rise in odorous emissions at that moment. In fact, the new system monitors demonstrated that the system was properly working by bringing H_2S concentrations down to ppb levels in the surrounding neighborhood.

As a side point being made here is that public sensitivity is part of what an environmental engineer (working on the design, construction and operation of odor control systems) must deal with.