Facts About Landfill Gas

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What is landfill gas?

Landfill Gas (LFG) is the product of micro-biological decomposition of land-filled garbage. The bugs turn complex organic compounds in garbage into methane, carbon dioxide, and trace amounts of other compounds. LFG is about 50-55% methane and about 40-45% carbon dioxide. The balance is made up of hundreds of other compounds, including nitrogen and oxygen. About 0.2 to 0.5% of LFG is composed of complex organic compounds that were never degraded by the bugs. A small % of LFG is composed of hydrogen sulfide and other sulfur compounds.

The remaining compounds in the gas could be just about anything, depending on the climate and the garbage profile. The exact composition of landfill gas is unique to each location. Monitoring is important if specific trace compounds are to be identified.

What compounds are commonly found in landfill gas?

Landfill gas is made up of a combination of different compounds including:

- **Methane** is odorless. Methane is non-reactive and not harmful to human health, except that if there is so much methane in a room that it displaces the oxygen, one could die from suffocation. Methane is a flammable gas. When present in very high concentrations it can be potentially explosive.

- **Carbon Dioxide** is everywhere. The human lung transforms the oxygen inhaled in each breath into carbon dioxide (CO2) which is exhaled. Plants “inhale” CO2 and “exhale” oxygen.

If methane and CO2 are odorless, then which compounds contribute to odor?

- Since the odorless gases carbon dioxide and methane are produced in large quantities, these gases carry the other landfill gases in low concentrations. These other gases are what give the LFG its unpleasant odor and may include:

- **Hydrogen Sulfide and other Sulfur Compounds**: Hydrogen sulfide (H_2S) has an odor normally associated with rotten eggs / rotten garbage. H_2S has a very low odor threshold, which means that the human nose can detect it at very small concentrations. The Occupational Safety and Health Administration (OSHA) imposes an 8 hour exposure limit of 20 ppm (0.002%). That means that OSHA has determined that workers will be safe if the concentration of H_2S remains below 0.002% for an 8 hour work day, 40 hour work week, etc. The National Institute for Occupational Safety and Health has determined that there is immediate danger to life and health if H_2S concentrations reach 100 ppm (0.01%).

- **Non-Methane Organic Compounds (NMOC)**, or complex organic compounds are compounds with more than one carbon atom. These compounds also have hydrogen atoms and could

have oxygen, sulfur, chlorine, nitrogen, atoms as well. Generally, NMOCs are volatile and can have a cleaning solvent-type of odor. NMOCs are found in several everyday items such as gasoline. Organic compounds are sources of energy for people, animals, microorganisms, and industry.

How long does it take before appreciable amounts of LFG begin to generate in a landfill?

Approximately one to three years, depending on type of garbage, amount of moisture or other factors. Peak production of LFG is 5 to 7 years after the garbage was dumped.

Where does LFG come from?

Garbage contains many organic (carbon-based) compounds. Micro-organisms (bugs), which are found everywhere (air, water, soil, etc.), feed on organic compounds. Using water from rain or other sources, and nutrients found in the soil or garbage (oxygen, nitrogen, sulfur, phosphorus, etc.), the bugs degrade complex organic compounds to form methane (the simplest of all organic compounds), and carbon dioxide.

How does landfill gas migrate?

When landfill gas (LFG) is formed in a landfill, the vapors do not just say where they were formed. Instead, they move around, taking the path of least resistance. This means that the vapor particles move most easily when there are large open spaces for them to move through. However, because the LFG molecules are
microscopic, an open space as big as a few grains of sand would be relatively large.
LFG molecules can move laterally through the landfill, or they can move up and down in the landfill, depending on where they easiest path is. LFG can also escape through the top of the landfill into ambient air.

How do weather events affect LFG release and odor problems?

Vapor particles constantly move around randomly in the outside air, inside air, back and forth, everywhere.

Low pressure days: When the vapor pressure of the ambient air and the atmosphere is lower than the pressure of the gases inside the landfill, more landfill gas will seep out of the landfill into the air, because the vapors are trying to equilibrate the pressures, moving from areas of high pressure to areas of low pressure.

Atmospheric Stability (wind and sun): The atmosphere is considered stable when the number and speed of moving vapor particles is very low. Obviously, wind makes the atmosphere unstable. Sunlight also makes the atmosphere unstable, because when sunlight hits one packet of air molecules, the air packet heats up. Since hot air rises, that packet moves upward and then a cooler air packet moves down to take it place. Sooner or later that cool packet will be heated and rise, and another packet will move to take its place repeating the process.

Inversion Layer: At some height in the atmosphere, there is a line (parallel to the ground) above which there is all cold air and below which there is only warm air. The warm air is trying to rise, and the cold air is trying to drop, but these levels of air just keep bumping into each other. This imaginary line parallel to the ground is called the inversion layer. Vapor particles and air packets that are above the inversion layer cannot easily get below it, and vice versa. Usually the inversion layer is higher during the day and lower at night. Depending on other weather conditions it can move around.

Any landfill gas or vapor odors that escape the landfill on a sunny and windy day (atmosphere unstable) won't hang around too long. However, when there is no sun and no wind, the vapors and odors linger around the landfill. If the inversion layer is low, then the vapors and odors being emitted from the landfill are trapped between the inversion layer and the ground. Therefore, suppose the same amount of gas is emitted from the landfill on Monday and on Tuesday. If it is sunny and windy on Monday, and cloudy with a low inversion layer on Tuesday, Tuesday will smell much worse.

How does cover control landfill gas?

On a daily basis (or more frequently if warranted) the garbage and solid waste that is disposed at a landfill must be covered with material to control garbage odors, disease, fires, blowing litter, and scavenging animals such as rats and seagulls.

The less porous the daily cover material, the less likely it is that odors from recently deposited garbage will be detectable. As a broad generalization, a good cover requires a mixture of different sized particles to make the cover less porous and better at trapping the odors inside the landfill.

When a section of a landfill is closed permanently, it is normally covered with a series of materials: dirt, gravel, clay, synthetic materials, durable plastic liners, etc. Finally, vegetation is planted on the top of the landfill. The vegetation serves two purposes: 1) esthetics; 2) it helps to hold the cover materials in place and prevent serious erosion during rain events.

Cover will be discussed further during the landfill tour.

If nothing further were done, then gaseous molecules of LFG created by the microorganisms would slowly seep out of the landfill into the ambient air, taking the path of least resistance by making their way in between the soil, clay, and gravel particles to the surface.

How is LFG collected?

Usually LFG is collected using a system of wells or trenches. These wells or trenches are connected, through piping, to a large industrial fan or other vapor moving unit which maintains a negative pressure on the whole gas collection system. Negative pressure means that the fan is always pulling gases out of the system, never pushing gases into the system. In this way, LFG is vacuumed out of the landfill.

To install a well, one must drill deep into the landfill trash mound and insert a long section of vertical pipe. Each well has its own pressure regulator on it, so that the force of the vacuum can be controlled at each individual well. This is important, because if the vacuum pressure were too great, then not only LFG would be collected, air would be sucked into the landfill from the ambient air above the landfill. If the pressure at a certain well was too low, then it would not collect all of the LFG and some of the LFG would seep out of the landfill cover surface. Therefore, the pressure at each well must be different based on the depth of the trash, the density of the trash, the age of the trash, and other factors.

Trenches are sections of pipe that are laid horizontally in the landfill. They function in a manner similar to wells.

Questions?

For more information on landfill gas (LFG), call Rebecca Fishman at EPA New England toll free at:

What happens to LFG after it is collected?

- Once the LFG is collected using the wells, trenches, and fans, it is usually channeled to some sort of control device, typically a combustion device.

- Methane, although the simplest organic compound, is still a source of energy. One molecule of methane does not release as much heat and energy as one molecule of an NMOC, but it is still useful. Therefore, LFG (usually 50-55% methane) is often channeled to a turbine or other unit for the production of electricity or heat or power. The Internal Revenue Service offers tax credits to companies that burn LFG for energy.

- The combustion of Methane (or other organic compounds) results in carbon dioxide, carbon monoxide, and water as the primary products. Many other compounds in LFG (complex sulfur compounds and NMOCs) are also destroyed in the combustion process – eliminating many of the odors associated with LFG.

- If the use of the methane energy in LFG is not feasible for whatever reasons, the LFG is often combusted in an open flare. Flare combustion of LFG has the same resulting products, however, the energy resulting from the combustion is not recovered for use.

Diagram of Landfill Gas Collection System