State of Oregon Department of Environmental Quality

# Landfill Gas Primer - Meeting Materials 4

**Landfill Gas Emissions Rulemaking 2021**

Advisory committee meeting #1

## Landfill Gas Primer

### Source: Agency for Toxic Substance & Disease Registry (ATSDR) "Landfill Gas Primer": https://www.atsdr.cdc.gov/HAC/landfill/html/intro.html. Updates/modifications to the ATSDR document were made to focus on landfills in Oregon

### What types of landfills are found in Oregon?

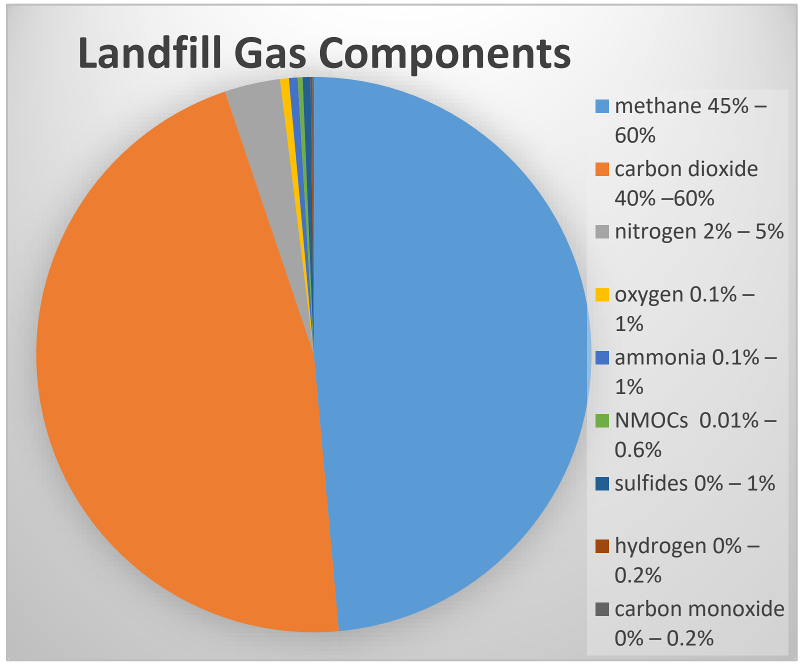
Your community may have different types of landfills within it or nearby:

- ***Municipal solid waste (MSW) landfills*** are used to dispose of household wastes and nonhazardous commercial and industrial wastes. Landfills constructed after 1979 are required, under Subtitle D of the Resource Conservation and Recovery Act (RCRA) and Oregon's regulations pertaining to municipal solid waste landfills (OAR 340-094), to be designed and operated to prevent contaminant migration to the environment. This design may include liners or collection systems. Landfills constructed before 1979 may not have such environmental safeguards.
- ***Open dumps*** are waste disposal areas that were used before 1979 and constructed without any engineering design and siting criteria, and few, if any, regulatory controls. Open dumps may have accepted household wastes, similar to MSW landfills, as well as commercial and industrial wastes. These dumps did not have liners and rarely used daily cover. No precautions were taken to prevent contaminant migration to the environment. Most open dumps were discontinued and covered in the 1960s. Unfortunately, the locations of many of these old dumps are not marked on local planning maps. Some of the current operating MSW landfills began in the 1960s as open dumps or are located adjacent to closed dumps.
- ***Hazardous waste landfills*** are used to dispose of wastes characterized under RCRA as "hazardous." These wastes include solvents, industrial wastes, and construction wastes such as asbestos. Operating or recently closed landfills containing hazardous materials are regulated under Subtitle C of RCRA. These regulations include strict requirements for treatment of the wastes prior to disposal in the landfill. These landfill are not included in the current rulemaking.
- ***Non-municipal solid waste landfills*** are landfills that do not meet the definition of MSW landfills and do not receive household wastes. Non- MSW landfills containing nonhazardous materials are regulated under Subtitle D of RCRA and Oregon's non-municipal solid waste rules. Non-MSW landfills in Oregon generally consist of the following types:
    - ***Construction and demolition (C&D) waste landfills*** are used for the disposal of construction and demolition waste such as wood, sheet rock, gypsum board, concrete, bricks, and paving materials. As with MSW landfills, C& D waste landfills containing nonhazardous materials are regulated under Subtitle D of RCRA and Oregon's non-municipal solid waste rules.
    - ***Industrial waste landfills*** are a type of non-municipal solid waste landfills. The waste types received will depend on the industry type. These landfills often only receive wastes from one particular company or industry. The wastes types are often inert and produce little to no gas.

- ***Wood waste landfills*** are a type of landfill for the wood and paper production industry. Wastes received in these landfills consist of chemically untreated wood pieces or particles generated by the timber products industry. Lignin in wood can significantly decrease landfill gas production.

## What is landfill gas composed of?

Landfill gas is composed of a mixture of hundreds of different gases. By volume, landfill gas typically contains 45% to 60% methane and 40% to 60% carbon dioxide. Landfill gas also includes small amounts of nitrogen, oxygen, ammonia, sulfides, hydrogen, carbon monoxide, and nonmethane organic compounds (NMOCs) such as trichloroethylene, benzene, and vinyl chloride.



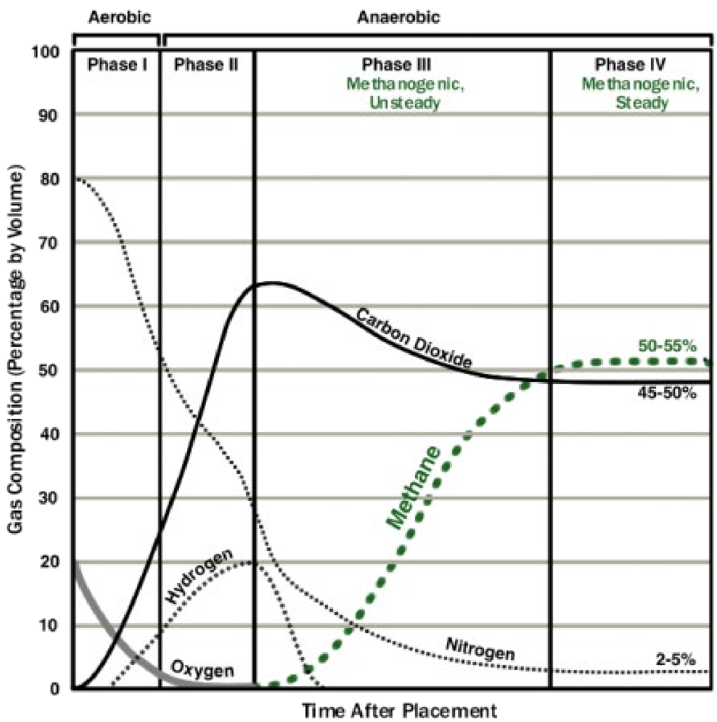

## How is landfill gas produced?

Three processes—bacterial decomposition, volatilization, and chemical reactions—form landfill gas.

1. ***Bacterial decomposition.*** Most landfill gas is produced by bacterial decomposition, which occurs when organic waste is broken down by bacteria naturally present in the waste and in the soil used to cover the landfill.
2. ***Volatilization.*** Landfill gases can be created when certain wastes, particularly organic compounds, change from a liquid or a solid into a vapor. This process is known as volatilization. NMOCs in landfill gas may be the result of volatilization of certain chemicals disposed of in the landfill.
3. ***Chemical reactions.*** Landfill gas, including NMOCs, can be created by the reactions of certain chemicals present in waste. For example, if chlorine bleach and ammonia come into contact with each other within the landfill, a harmful gas is produced.

## The Four Phases of Bacterial Decomposition of Landfill Waste

Bacteria decompose landfill waste in four phases. The composition of the gas produced changes with each of the four phases of decomposition. Landfills often accept waste over a 20- to 30-year period, so waste in a landfill may be undergoing several phases of decomposition at once. This means that older waste in one area might be in a different phase of decomposition than more recently buried waste in another area.




- **Phase I** – During Phase I decomposition, aerobic bacteria—bacteria that live only in the presence of oxygen—consume oxygen while breaking organic waste. The primary byproduct of this process is carbon dioxide. Nitrogen content is high at the beginning of this phase, but declines as the landfill ages. Phase I continues until available oxygen is depleted. Phase I decomposition can last for days or months, depending on how much oxygen is present when the waste is disposed of in the landfill.
- **Phase II** decomposition starts after the oxygen in the landfill has been used up. Using an anaerobic process (a process that does not require oxygen), bacteria convert compounds created by aerobic bacteria into acids and alcohols. As the acids mix with the moisture present in the landfill, they cause certain nutrients to dissolve, making nitrogen and phosphorus available to the increasingly diverse species of bacteria in the landfill. The gaseous byproducts of these processes are carbon dioxide and hydrogen. If the landfill is disturbed or if oxygen is somehow introduced into the landfill, microbial processes will return to Phase I.
- **Phase III** decomposition starts when certain kinds of anaerobic bacteria consume the organic acids produced in Phase II and form acetate, an organic acid. This process causes the landfill to become a more neutral environment in which methane-producing bacteria begin to establish themselves. Methane- and acid-producing bacteria have a symbiotic relationship. Acid-producing bacteria create compounds for the methanogenic bacteria to consume. Methanogenic bacteria consume the carbon dioxide and acetate, too much of which would be toxic to the acid-producing bacteria.
- **Phase IV** decomposition begins when both the composition and production rates of landfill gas remain relatively constant. Phase IV landfill gas usually contains approximately 45% to 60% methane by volume, 40% to 60% carbon dioxide, and 2% to 9% other gases, such as sulfides. Gas is produced at a stable rate in Phase IV, typically for about 20 years; however, gas can continue to be emitted for 50 or more years after the waste is placed in the landfill. Gas production might last longer, for example, if greater amounts of organics are present in the waste.

## What conditions affect landfill gas production?

The rate and volume of landfill gas produced at a specific site depend on the characteristics of the waste (e.g., composition and age of the refuse) and a number of environmental factors (e.g., the presence of oxygen in the landfill, moisture content, and temperature).

- ***Waste composition.*** The more organic waste present in a landfill, the more landfill gas (e.g., carbon dioxide, methane, nitrogen, and hydrogen sulfide) is produced by the bacteria during decomposition. The more chemicals disposed of in the landfill, the more likely NMOCs and other gases will be produced either through volatilization or chemical reactions.
- ***Age of refuse.*** Generally, more recently buried waste (i.e., waste buried less than 10 years) produces more landfill gas through bacterial decomposition, volatilization, and chemical reactions than does older waste (buried more than 10 years). Peak gas production usually occurs from 5 to 7 years after the waste is buried.
- ***Presence of oxygen in the landfill.*** Methane will be produced only when oxygen is no longer present in the landfill.
- ***Moisture content.*** The presence of moisture (unsaturated conditions) in a landfill increases gas production because it encourages bacterial decomposition. Moisture may also promote chemical reactions that produce gases.
- ***Temperature.*** As the landfill's temperature rises, bacterial activity increases, resulting in increased gas production. Increased temperature may also increase rates of volatilization and chemical reactions.

## What conditions affect landfill gas migration?

The direction, speed, and distance of landfill gas migration depend on a number of factors, described below.

- ***Landfill cover type.*** If the landfill cover consists of relatively permeable material, such as gravel or sand, then gas will likely migrate up through the landfill cover. If the landfill cover consists of silts and clays, it is not very permeable; gas will then tend to migrate horizontally underground. If one area of the landfill is more permeable than the rest, gas will migrate through that area.
- ***Natural and man-made pathways.*** Drains, trenches, and buried utility corridors (such as tunnels and pipelines) can act as conduits for gas movement. The natural geology often provides underground pathways, such as fractured rock, porous soil, and buried stream channels, where the gas can migrate.
- ***Wind speed and direction.*** Landfill gas naturally vented into the air at the landfill surface is carried by the wind. The wind dilutes the gas with fresh air as it moves it to areas beyond the landfill. Wind speed and direction determine the gas's concentration in the air, which can vary greatly from day to day, even hour by hour. In the early morning, for example, winds tend to be gentle and provide the least dilution and dispersion of the gas to other areas.
- ***Moisture.*** Wet surface soil conditions may prevent landfill gas from migrating through the top of the landfill into the air above. Rain and moisture may also seep into the pore spaces in the landfill and "push out" gases in these spaces.
- ***Groundwater levels.*** Gas movement is influenced by variations in the groundwater table. If the water table is rising into an area, it will force the landfill gas upward.
- ***Temperature.*** Increases in temperature stimulate gas particle movement, tending also to increase gas diffusion, so that landfill gas might spread more quickly in warmer conditions. Although the landfill itself generally maintains a stable temperature, freezing and thawing cycles can cause the soil's surface to crack, causing landfill gas to migrate upward or horizontally. Frozen soil over the landfill may provide a physical barrier to upward landfill gas migration, causing the gas to migrate further from the landfill horizontally through soil.

- ***Barometric and soil gas pressure.*** The difference between the soil gas pressure and barometric pressure allows gas to move either vertically or laterally, depending on whether the barometric pressure is higher or lower than the soil gas pressure. When barometric pressure is falling, landfill gas will tend to migrate out of the landfill into surrounding areas. As barometric pressure rises, gas may be retained in the landfill temporarily as new pressure balances are established.

## Alternative formats

DEQ can provide documents in an alternate format or in a language other than English upon request. Call DEQ at 800-452-4011 or email deqinfo@deq.state.or.us.