A report by Industrious Labs

THE HIDDEN COST OF LANDFILLS

How flawed landfill regulations perpetuate a methane crisis

May 2024

Industrious Labs

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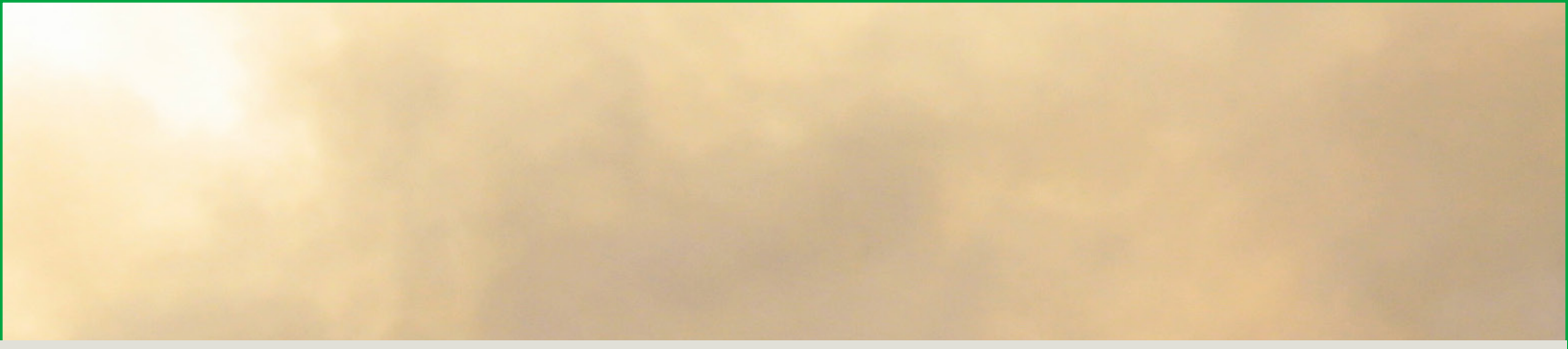


EXECUTIVE SUMMARY

The way the United States manages its trash is creating a growing threat to both local communities and our climate. Piled high in landfills across the country, the waste we throw away sits rotting in the ground for decades, creating air and water pollution for millions of Americans and emitting unchecked methane, a potent greenhouse gas, into our atmosphere. In 2022 alone, estimated methane emissions from landfills reached the same climate-warming impact of running 74 coal-fired power plants for a year[1] — and scientific research reveals that those estimates are far too low. These impacts aren't felt proportionally; of the 3.2 million people who live within one mile of a landfill, 46% are Black, Indigenous, or people of color.[2]

But much like the landfills themselves, these harms have remained out of sight and out of mind for policymakers for decades, and are perpetuated by ineffective EPA regulations, with flawed methane capture and monitoring practices, all relying largely on an honor system. After a review of a number of EPA's inspection reports of landfills across the country, it's clear the agency's current standards are failing.

Industrious Labs was able to request inspection reports from the EPA Office of Enforcement and Compliance Assurance. A review of EPA's inspection reports of 29 municipal solid waste landfill facilities across eight different states revealed that:

- **There are hundreds of methane exceedances.** Across the 22 landfills where EPA inspectors conducted emissions monitoring, they recorded a total of 711 methane exceedances over 500 parts per million (ppm), the methane concentration limit set by the EPA.
- **The inspection reports reveal disturbing discrepancies.** A number of landfill operators reported that they found few or no methane exceedances at their facilities, while EPA inspectors found many, sometimes explosive, methane exceedances.

We're seeing these disturbing issues happen for several reasons:

1. Perpetuated by flawed regulations, landfill operators do not use the full suite of practices, tools, and technologies they have available to track and find methane exceedances.

2. Current EPA regulations around gas collection and control allow for many landfills to avoid or delay installation of these systems, and do not require methane leak detection at all components of the gas collection and control systems, even though these systems are prone to failure and leaks. Water and leachate from landfills clog landfill pipes, preventing effective gas collection and flow, but federal regulations do not require landfills to monitor for water build-up.
3. Landfills with exceedances had poor "cover integrity" in places, meaning there are cracks, erosion, or other cover issues that allow methane to escape. There are no federal air requirements for cover materials or timing, despite the key role cover plays in limiting methane emissions.

Fortunately, there are proven and cost-effective tools to curb these unchecked emissions. In fact, a number of states have already updated their landfill regulations to go beyond the EPA's standards to better control harmful emissions. The following are some[3] of the key improvements the EPA can make to its landfill air emissions rules to equip landfill operators with what they need to accurately manage, find, and reduce emissions:

- **Require more effective, comprehensive monitoring for methane leaks using up-to-date technologies that make finding and fixing methane leaks exponentially easier and limit error.** Ensure that methane emissions data is publicly available and accessible.
- **Require landfills to use cover that minimizes air pollution.** The type of cover landfills use, and when it is installed, significantly affects surface methane emissions, yet current federal regulations don't require that landfill operators use the most effective cover practices.
- **Require earlier installation of gas capture systems and leak detection.** According to EPA's own research, 50% of the carbon in food waste degrades into methane within 3.6 years. Yet current EPA federal rules allow five years to pass before landfill operators are required to expand gas collection systems. As a result, an estimated 61% of methane generated by landfilled food waste is released into the atmosphere.[4]
- **Institute lower thresholds for installing gas collection and control systems.** Only landfills of a certain size that meet certain additional criteria are required to install a gas collection and control system. Because the threshold is set too high, many landfills don't have gas collection and control systems.

- **Establish a super emitter response and detection program.** No matter how large the plume found at a landfill site by an airborne remote sensing device like an air flight or a satellite, landfills aren't required to take action to fix the super emitter event— it's voluntary. As it has for certain large emissions identified for oil and gas sources, the EPA should require landfill owners and operators to investigate and mitigate exceptionally large emissions sources once they're notified about them.

The EPA has an opportunity to press the "emergency brake" on climate change by taking common sense steps to reduce methane emissions from landfills. **By August 2024, the EPA is statutorily required to review whether to update its New Source Performance Standards and Emissions Guidelines under section 111 of the Clean Air Act. By requiring landfill operators to start using available best practices and technologies to identify and fix major methane leaks,** the Biden administration can make an immediate impact on our climate-warming emissions, while delivering cleaner air and water for local communities. In the absence of federal action, the problem will only spread.

COMMON LANDFILL MANAGEMENT TERMS:

- **Surface emissions monitoring:** Federal regulations require that some landfills perform quarterly surface emissions monitoring[5] as defined by their Method 21 guidance, to detect and mitigate emissions greater than 500 parts per million.
- **Landfill cover:** There are multiple types of landfill covers: daily, interim/intermediate, and final. Cover placed on top of waste on a landfill site is very important — they help control smell, blowing trash, fires, and invisible methane emissions. The type, material, and depth of cover varies.
- **Gas collection and control system:** The method some landfills use to capture and dispose of or treat landfill gas through a series of pipes that draw the gas in and route it to a control device (flare, etc).
- **Working face:** The active area of the landfill where new waste is being added.

DEFINING THE PROBLEM

Methane is a super-polluting, but short-lived greenhouse gas that has around 80 times the planet-warming potential of carbon dioxide in the first 20 years it's released into the atmosphere.

Scattered across the United States in both rural and urban areas, there are over 2,600 active and closed municipal solid waste landfills leaking methane into the air. Landfills are a major and often overlooked culprit of skyrocketing methane emissions, contributing to an estimated 287 million metric tons of methane emissions per year, which is the equivalent of 74 coal-fired power plants or more than 68 million cars on the road for a year.[6]

In 2022, municipal solid waste landfills were the largest industrial source of methane emissions in 38 states. Worse, these emissions are underestimated. EPA Senior Chemical Engineer Susan Thorneloe has stated publicly that the EPA has been understating methane emissions from landfills by a factor of two,[7] and independent research, satellite, and flyover measurements show that landfill methane emissions are higher than EPA's figures suggest.[8]

According to EPA's top emissions scientist, the U.S. understates methane emissions from landfills by a factor of two.

Landfills also leak leachate and toxic air pollutants that harm the health of nearby communities, including carcinogens like benzene and toluene. Methane plumes can signal that there are other pollutants harmful to the health of nearby communities, emitting invisible pollutants[9] like volatile organic compounds (VOCs) that react in the sunlight to form smog, triggering asthma attacks and making it harder for nearby communities to breathe. Residents who live near landfills report burning eyes, nose and throat, headaches, that their drinking water is contaminated, and that they're unable to perform outdoor activities when the air quality plummets or the foul smells become too overwhelming.

Families living near the notoriously harmful Chiquita Canyon Landfill in Southern California have reported long-lasting health harms including cancer, headaches, congestion, cough, body aches, burning eyes, and ear pain.[10] And unfortunately, these residents have experienced these health impacts for years, with little action from policymakers to hold the landfill site accountable and bring relief to the community.

Community members attend a February 2024 rally to protest health and quality of life harms caused by the Chiquita Canyon Landfill
Image Credit: Industrious Labs

These grave health impacts aren't felt proportionally; of the 3.2 million people who live within one mile of a municipal solid waste landfill in the U.S., 46% are Black, Indigenous, or people of color.

- In Texas, people of color are two times more likely than white people to live within one mile of a landfill
- In California, Hispanic people are 3.4 times more likely than white people to live within one mile of a landfill
- In North Carolina, Black people are 2.6 times more likely than white people to live within one mile of a landfill
- In New Mexico, Indigenous people are 3.5 times more likely than white people to live within one mile of a landfill[11]

PUTTING THESE SUPER EMITTERS ON THE MAP

While the standard practice to monitor for methane leaks is severely limited, akin to operating on Windows 2000, advancements in technology are a game changer in quickly finding and fixing super-emitting methane sources from landfills. Carbon Mapper and other scientific monitoring efforts such as Tropospheric Monitoring Instrument (TROPOMI) and GHGSat, are using direct monitoring to pinpoint, quantify, and track methane emissions around the globe. These technologies are uncovering the lurking climate dangers of landfill methane plumes, which are discrete sources of emissions that emit large amounts of concentrated methane.

Landfills leak an array of toxic pollutants[12] harmful to human health, the air and water, such as:

LEACHATE

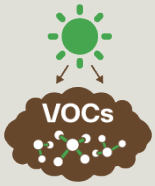
A liquid pollutant containing harmful chemicals that can seep through landfills and impact drinking water for nearby communities.

BENZENE

A carcinogen that can impact blood cell count and cause drowsiness, dizziness, headaches, tremors, confusion, and/or unconsciousness in the short term.

TOLUENE

A colorless liquid that can impact the nervous system, cause headaches, dizziness, confusion, and nausea, and birth defects.



VOLATILE ORGANIC COMPOUNDS

A variety of chemicals that react in the sunlight with nitrogen oxides (NO_x) to form ozone pollution, also known as smog.

HYDROGEN SULFIDE

Known for its "rotten egg" odor, can cause irritation to the eyes and respiratory system, upset stomach, dizziness, apnea, coma, and more.

Addressing methane exceedances can simultaneously limit the release of hazardous air pollutants.

EPA's approach to methane leak detection isn't working.

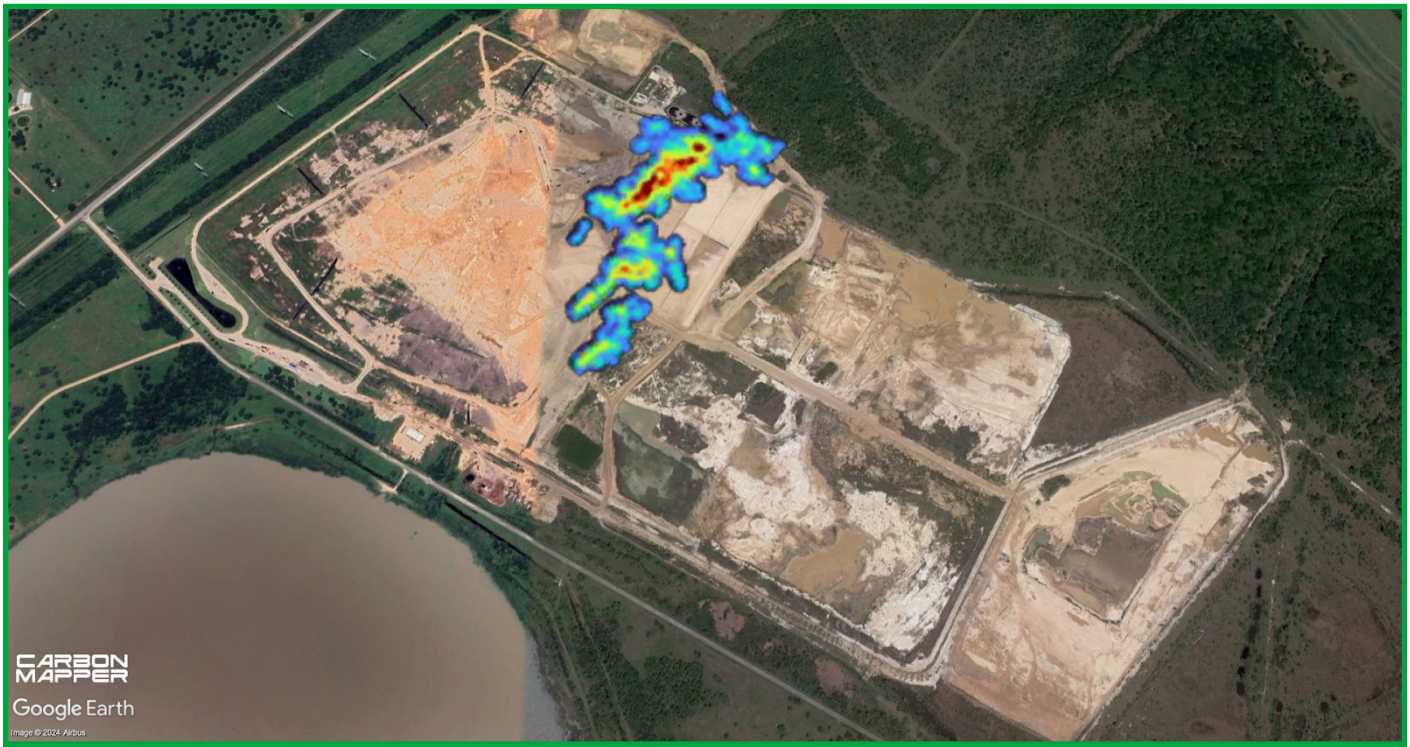
Per federal regulation, someone from a landfill, in reality often a contracted consultant, will walk around a waste facility just four times a year with a detection device, stopping to monitor for leaks every 100 feet (30 meters)—the length of a full basketball court—and skipping the active working face of the landfill and areas where it is deemed too dangerous to monitor. If the methane concentration detected is above 500 ppm, the location must be noted and reported as an exceedance, and the landfill operator has 10 days to take corrective action and re-monitor.[13]

These methods are by definition spotty, vulnerable to human error, and pose safety threats to landfill inspectors, causing leaks to go undetected.

The White House itself, in its national monitoring strategy, acknowledges that human-based surface emissions measurements alone are insufficient.[14]

In March 2024, scientists from Carbon Mapper, EPA, and others published a study providing the largest comprehensive assessment of hundreds of U.S. landfills using aerial surveys. The researchers found significant gaps in the emissions that landfill operators are reporting, and what the aerial surveys revealed.

Super-emitters — or very large releases of methane — were identified at 52% of landfills surveyed. On average, aerial emission rates were 40% higher than the EPA's Greenhouse Gas Reporting Program (GHGRP), confirming a significant discrepancy between reported and actual methane emissions.[15]



Methane plume observed by Carbon Mapper during aerial monitoring at a landfill in Texas
Image Credit: Carbon Mapper

LARGE METHANE LEAKS ARE FALLING THROUGH THE CRACKS

Only certain municipal solid waste landfills are required to follow EPA emissions regulations under the Clean Air Act, which includes conducting surface emissions monitoring in parts of the landfill four times a year and installing and maintaining gas collection and control systems to certain performance parameters. These regulations only apply to landfills above a certain size and that meet other criteria, making landfills that are below the threshold effectively unregulated by federal air emissions regulations.[16]

Landfill operators that meet the threshold are required to follow recordkeeping requirements and submit periodic compliance reports to state regulators. Not least because of resource constraints, only a fraction of landfills in the U.S. are ever actually inspected by the EPA's Office of Enforcement and Compliance Assurance. This office is using the resources they have available to spotlight and address methane emissions, but because the regulations are flawed, it's a game of whack-a-mole.

Some states throughout the country, like California, Maryland, and Oregon, have issued landfill regulations that are stronger than EPA's. These state rules require pollution controls at more landfills and stronger performance standards like requiring monitoring gas collection and capture system components for leaks, and practices to ensure that methane generated from the landfill is flared or destroyed before being released into the atmosphere.

Public access to the inspection reports landfills are required to file is very limited, and typically requires a public records request, adding an unnecessary barrier to public transparency. Industrious Labs filed public records requests for inspection reports in 13 states and reviewed a total of 29 reports for landfills across eight states: Louisiana, California, Delaware, Illinois, Michigan, Washington, Texas, and Oregon.

The information we reviewed was alarming.

In our analysis of these inspection reports, we discovered that EPA found many, sometimes explosive levels of methane emissions at landfill sites - and when landfill operators had self-reported zero or few methane exceedances. At least one methane concentration above 500 ppm was found at 96% of landfill sites where EPA tested for methane exceedances, indicating that methane is leaking out of landfills at a dramatic rate and that other harmful pollutants are being released into the air. These exceedance citations were often close together and were sometimes in places where landfills already said they had fixed the problem.

The inspections, which represent a mere fraction of landfills throughout the country, showed:

- **96% or 21** of the 22 landfill sites where EPA conducted surface emissions monitoring had significant documented methane exceedances, above the 500 ppm regulatory limit.
- **48% or 10** of the 22 landfill sites where EPA conducted surface emissions monitoring previously reported few or no exceedances despite the fact that the EPA inspectors found numerous exceedances,

indicating possible concerns with the quality of the landfill operator's surface emissions monitoring surveys.

- **86% or 19** of the 22 landfill sites where EPA conducted surface emissions monitoring had issues with cover integrity, meaning inspectors found erosion, inadequate vegetation or exposed waste.
- **80% or 20** of the 25 landfill sites where EPA monitored gas collection wells had methane exceedances above the 500 ppm regulatory limit at a gas collection wellhead or well.
- There were **711** total methane emissions exceedances over 500 ppm detected by the EPA, across the 22 inspection reports.

Something is clearly wrong with the status quo. Emissions from landfills across the U.S. are out of control, harming our climate and neighboring communities, yet EPA has still failed to update its landfill rules.

THE CONSEQUENCES OF INEFFECTIVE REGULATION

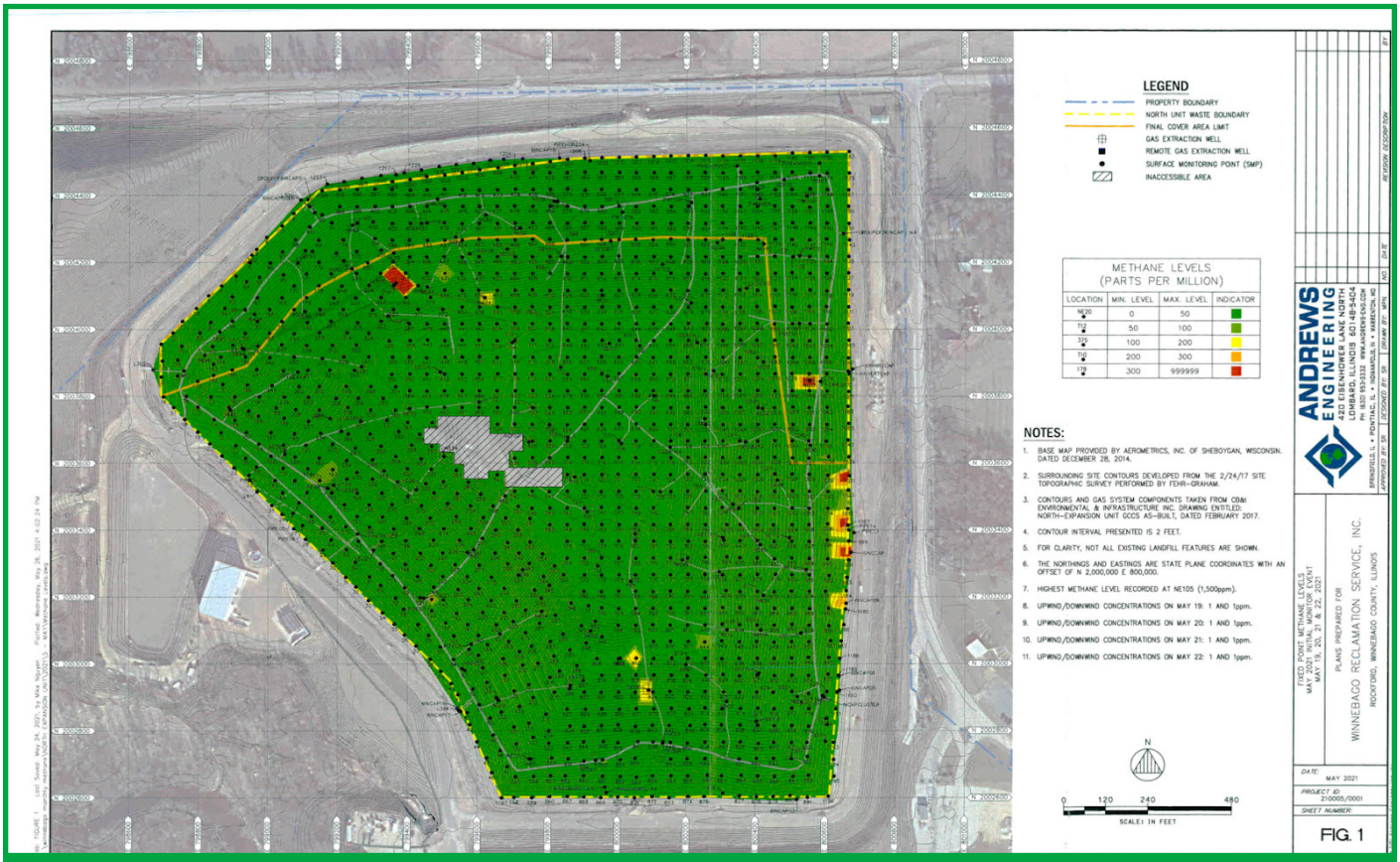
In our review, we saw a common thread in the challenges facilities are facing to document and curb these harmful emissions.

Existing monitoring practices rely on ineffective technology, and loopholes in EPA rules allow methane exceedances to go undetected for years at a time. For example, during an EPA inspection of the SeaBreeze Landfill in Angleton, Texas, Waste Connections, the company responsible for monitoring emissions at the site, reported that they couldn't monitor emissions in certain areas because the grass was too high and inspectors were afraid of encountering snakes. During the inspection, EPA staff confirmed that the landfill operators did indeed have lawn mowing equipment on site, so could have easily reduced the risk to inspectors by simply cutting the grass around the landfill or using remote sensing technologies like drones. At the Prairie Hill Landfill in Illinois, inspectors flagged that the landfill operator appeared to only monitor a very limited area of the landfill, exclusively covering specific points at closed parts of the landfill. It's clear that relying on landfill operators to perform self-monitoring of only a small portion of a landfill area has significant limitations.[17]

At a number of landfills, operators previously reported few exceedances, yet when the EPA inspectors conducted the same surface emissions monitoring, they found many. EPA inspectors at the LRI 304th Street Landfill near Tacoma, Washington detected explosive concentrations of methane, despite the landfill's failure to detect the same. To quote the inspector, "The tarped area... around the meeting of Cells 2B, 3A, 5, and 6 appeared to be visibly inflated with landfill gas, with explosive levels of gas being measured coming out of it, indicating both an environmental concern and a safety hazard."[18] At the Roxana Landfill in Edwardsville, Illinois, the landfill's contractor reported zero exceedances in their last four quarterly inspections, while EPA identified 42.[19] At the Brent Run Landfill in Michigan, inspectors found concentrations of methane above 500 ppm in 38 different places, while landfill operators had reported far fewer exceedances.[20]

The EPA inspection report for the large Winnebago Landfill in Rockford, Illinois noted that there were emissions distinctly above historic rates, some even at locations that were supposed to have been recently corrected.[21]

The May 2021 status report filed by the Winnebago landfill with the Illinois EPA found five surface emissions exceedances over 300 ppm in the northern expansion unit:



May 2021 status report filed by Waste Connections Winnebago Landfill operator in Rockford, Illinois reported 5 exceedences over 300 ppm in the Northern Expansion Unit.
Image Credit: EPA Inspection Report

A June 2021 EPA inspection found 32 SEM hits above 300 ppm, of which 24 were above 500 ppm, on the Northern Expansion Unit. (points on the map are the well number or map label). Image Credit: EPA Inspection Report

The EPA inspection of the same section of the Winnebago Landfill a month later found 59 methane exceedances. At the Pine Trees Acre Landfill just outside of Detroit, Michigan, EPA, as well as state regulators, found 74 total methane exceedances. Inspectors noted a disparity between the number of exceedances they had found compared with historic rates reported by the landfill operator.[22] At the Waste Management Atascocita Landfill in Humble, Texas, EPA's report indicated a significant disparity between the number of exceedances the agency detected compared with what the landfill had reported.[23]

In report after report, EPA is finding most of the landfills inspected have poor cover integrity. Clean Air Act regulations have minimal requirements about landfill cover, with a vague directive for landfills to operate a gas control system, perform cover maintenance, monitor cover integrity, and implement cover repairs "as necessary on a monthly basis."[24]

The inspection reports indicate that this directive is not accomplishing what it should. For example, at the McCommas Bluff Landfill in Dallas, Texas, EPA inspectors issued an official notice of violation which found the facility is not maintaining proper cover, and inspectors documented that the landfill failed to implement necessary repairs when they found large racks and erosion.[25] At the Prairie Hill Landfill in Morrison, Illinois, inspectors found audible bubbling and gas escaping from holes in the ground.[26] The EPA inspectors at the McCarty Road Landfill in Houston, Texas noted that erosion and exposed waste were seen across the site and that methane exceedances were largely found in areas where there was erosion and exposed waste.[27]

Loopholes in EPA regulations are creating chronic issues with the gas collection and control system. EPA's current regulations do not require landfill operators to conduct equipment leak detection and repair of gas collection and control systems, leaving valves, pumps, and other components emitting methane and other air toxics. Moreover, water and leachate from landfills clog landfill pipes, preventing effective collection and flow, yet EPA regulations do not require any monitoring for water build up. At the Coffin Butte Landfill in Corvallis, Oregon, EPA inspectors found that the landfill collects around 30 million gallons of leachate every year. But during the inspection, EPA staff found eight different methane exceedances over 500 ppm at leachate cleanout locations.[28] At the Quad Cities Landfill in Princeton, Illinois, EPA inspectors found methane exceeded 500 ppm at half of the site's gas wells.[29] At the Countryside Landfill in Grayslake, Illinois, most of the observed exceedances were at gas wells.[30]

Evidence from the examined U.S. EPA inspection reports demonstrates that MSW landfills with biomethane infrastructure have significant methane emissions.

Turning waste into energy is a growing trend as utilities continue to propose ways to prolong the use of methane for energy. The continued investment in landfill-to-gas projects only makes it more essential for the EPA to strengthen standards to ensure all landfills, especially those that monetize landfill gas, are not emitting methane. Of the nine facilities that had landfill-gas-to-energy systems identified in the Inspection Reports, **73%** of those landfills experienced methane exceedances.

For example, the Roosevelt Landfill in Washington, operated by Republic, collects LNG and routes landfill gas to an RNG plant. A 2022 EPA inspection found 16 exceedances above 500 ppm. Five of those exceedances were above 10,000 ppm, yet Republic's monitoring found no surface emissions exceedances in the past five years of quarterly monitoring.[31]

Landfill gas-to-energy projects create misaligned incentives to continue dumping organic waste in landfills and lead to practices that maximize revenue generation, rather than emissions reductions. **For example, landfills with gas-to-energy projects want to maximize the amount of high-quality methane they collect, which can result in drawing less gas where the methane quality might be lower, causing methane emissions to escape.[32]**

IMAGES OF COMMON ISSUES

Photo of a SEM exceedance with audible bubbling liquid, Prairie Hill Landfill, Morrison, Illinois
Image credit: EPA Inspection Report

Photo of gas buildup on tarp, Coffin Butte Landfill, Corvallis, Oregon
Image credit: EPA Inspection Report

Photo of exposed waste, Southeast Berrien County Landfill, Niles, Michigan
Image credit: EPA Inspection Report

SOLUTIONS

There are proven and cost-effective practices and technologies that would improve monitoring and significantly reduce the chronic issues found in these inspection reports. These solutions, however, are missing from the current federal air emissions requirements, known as the New Source Performance Standards and Emissions Guidelines for municipal solid waste landfills. EPA should implement rules that:

- **Require more effective, comprehensive monitoring for methane leaks using up-to-date technologies that make finding and fixing large methane leaks exponentially easier.** Strengthening surface emissions monitoring through improved walking patterns, integrated monitoring, and leveraging technologies like drones or other remote sensing techniques can improve coverage and frequency of leak detection and ensure greater objectivity and transparency.
- **Institute lower thresholds for installing gas collection and control systems.** Current rules require landfills to install gas collection and control systems for sites that meet certain size or emissions thresholds, but the threshold is set too high, meaning most landfills aren't regulated.
- **Require earlier installation of gas capture systems and leak detection.** According to EPA's own research, 50% of the carbon in food waste degrades into methane within 3.6 years. Yet current EPA federal rules allow five years to pass before landfill operators are required to expand gas collection systems. As a result, 61% of methane generated by landfilled food waste is released into the atmosphere.
- **Require landfill cover design that minimizes air pollution.** The type of cover on a landfill is a factor that significantly affects surface methane emissions, and current regulations don't require that landfill operators use the most effective cover materials and minimize active cover.
- **Monitor and respond to super-emitters.** No matter how large the methane emission found at a landfill site by a remote sensing device, landfills aren't required to take action to fix the super emitter— it's voluntary. EPA's new oil and gas rules incorporate advanced methane monitoring technologies, including a program to identify large emissions[33] recognizing that periodic or continuous monitoring provides more representative data than landfills' quarterly sampling. EPA should take a page from these rigorous emissions detection and correction programs and require landfill owners and operators to investigate and mitigate exceptionally large emissions events from certified third parties once they're notified about the emissions.

EPA already recognizes the importance of using available technologies to monitor emissions. EPA is requiring drone monitoring for methane emission leaks as part of a suite of corrective actions that the owner of a landfill in Lawrence, Kansas, is required to undertake due to alleged violations of the Clean Air Act found in a 2022 inspection.

CONCLUSION

It's clear that EPA's existing landfill air emissions regulations are failing both local communities and our climate. Even in states with relatively strong landfill methane rules, we're seeing enormous methane plumes – there were 124 identified above California landfills alone in 2023 according to public data from Carbon Mapper.[34] Technology that could dramatically mitigate methane emissions is here today and should be part of EPA's regulations.

Likewise, millions of Americans, a disproportionate percentage of which are low-income or communities of color, are left with health-harming air and water pollution.

As the agency responsible for protecting people and places from environmental health harms, EPA has both the authority and the responsibility to take immediate action on landfill emissions.

Acting quickly to reduce methane emissions from landfills is the single best strategy we have to slow climate change and to deliver cleaner air and water to communities. This August, EPA is required to review whether to update its New Source Performance Standards and Emissions Guidelines under section 111 of the Clean Air Act. They must use this opportunity to tackle this growing problem.

Active working face of Coffin Butte Landfill in Oregon
Image Credit: EPA Inspection Report

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12 Environmental Protection Agency, https://www.epa.gov/landfills/municipal-solid-waste-landfills.

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14 The Greenhouse Gas Monitoring and Measuring Interagency Working Group. (2023). (rep.). National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System, p. 46. Available at: https://www.whitehouse.gov/wp-content/uploads/2023/11/NationalGHGMMISStrategy-2023.pdf

15 Cusworth, D.H., et. al. (2024) Quantifying methane emissions from United States landfills, Science. Available at: https://www.science.org/doi/10.1126/science.adi7735

16 The 2016 New Source Performance Standards and Emission Guidelines revisions state that landfills must install a collection system if their design capacity is greater than or equal to 2.5 million Mg and 2.5 m3 and their calculated non methane organic compound (NMOC) emission rate of 34 Mg/year or more. This threshold applies under Subparts XXX and Cf. See 40 C.F.R. §60.33f(a)(3); 40 C.F.R. §60.762(b)(1).

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18 U.S. Environmental Protection Agency, CLEAN AIR ACT INSPECTION REPORT, Waste Connections LRI-304th St Landfill, Graham, WA, May 2, 2022, page 3.

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21 U.S. Environmental Protection Agency, CLEAN AIR ACT INSPECTION REPORT, Waste Connections Winnebago Landfill, Rockford, IL, June 1, 2021, page 7.

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32 Incentivizing landfill energy production is dangerous without robust standards in place to efficiently capture methane emissions and co-pollutants from the landfill. As discussed above, landfill gas collection efficiency can vary widely, including at landfills with energy projects. At biomethane-producing landfills, operators may optimize wellfield tuning for landfill gas quality rather than maximizing gas collection, which can lead to more fugitive emissions. Landfills may engage in other potentially harmful management practices, such as leachate recirculation, that accelerate methane production in the present.

33 U.S. Environmental Protection Agency, CLEAN AIR ACT INSPECTION REPORT, Roosevelt Regional Landfill, Roosevelt, Washington, June 28, 2022, page 6.

34 Carbon Mapper Data Portal, https://carbonmapper.org/data/

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