What Is Bioremediation?

Bioremediation works with living organisms – plants, fungi, and microbes – to clean up pollution in soil or water. This method can be used to remove and reduce contaminants in soil after fires.

This can be a lower-cost, in-place option, but it is not suitable for every site and still requires testing and professional oversight.

Bioremediation Approaches

Phytoremediation

Plants extract or stabilize contaminants in soil.



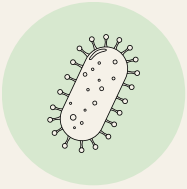
Mycoremediation

Fungi break down organic contaminants and support plant survival in poor soils.



Microbial Remediation

Soil microbes transform or degrade certain contaminants.



Common Cleanup Approaches After Fires

Faster Options

Excavation & Disposal

- Removes contaminated soil completely
- Fastest and most certain option
- May be expensive

Soft Capping & Stabilization

- Covers contaminated soil with mulch, gravel, or clean soil
- Reduces immediate exposure risk
- Useful when full excavation is not possible

Long-Term Options

Bioremediation

- Works with plants, fungi, compost, or microbes to support soil recovery
- Best for moderate contamination levels

Combined Approaches

- Some properties may require multiple cleanup methods
- Cleanup decisions depend on contaminant type, budget, and timeline

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How Can Bioremediation Help After Fires?

Changes to Soil After a Fire

- Low nutrient content
- Low organic matter
- Reduced soil structure
- Low water and nutrient retention
- Reduced plant and microbial diversity – dominated by early successional fungi and plants

- Increased soil erosion and dust
- Elevated heavy metals and other contaminants
- Increased hydrophobicity and water runoff
- Increased soil exposures and temperatures

Instead of excavating contaminated soil, **bioremediation** works with plants, fungi, and natural ecosystem processes to restore damaged environments.

Why Plants & Fungi?



Southern California Native Plants

- Adapted to local drought conditions
- Deep roots stabilize soil
- Absorb or immobilize contaminants
- Improve vegetation recovery

Arbuscular Mycorrhizal Fungi (AMF)



- Attach to plant roots
- Help plants survive drought and contamination stress
- Increase metal uptake from soil
- Improve plant growth and biomass

Fungi Can Reduce Hydrocarbons by 99.75%

Decomposer fungi such as oyster mushrooms (*Pleurotus ostreatus*) have been highly effective at breaking down petroleum-based contaminants.

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Common Contaminants
After Fires

After a fire, harmful chemicals and toxic materials can settle into the soil from burned homes, buildings, vehicles, plastics, electronics, smoke, and ash. These contaminants may remain in the environment long after the fire is extinguished.

Impacts of Contaminants

Inhalation

Breathing in contaminated ash, smoke, or toxic dust can irritate the lungs and increase long-term health risks.



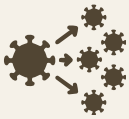
Soil Contact

Touching polluted soil or debris may expose people to harmful chemicals and toxic metals.



Wider Spread

Contaminated particles can spread into homes and public spaces, increasing everyday exposure risks.



Common Post-Fire Contaminants

- Heavy metals
- Volatile organic compounds (VOCs)
- Semi-volatile organic compounds (SVOCs)
- Dioxins and furans
- Petroleum hydrocarbons
- Per- and polyfluoroalkyl substances (PFAS)
- Asbestos



Different Contaminants Need Different Approaches!

Heavy Metals
(lead, arsenic, etc.)

- They do not biodegrade, so they stay in soil forever.
- Remediate by removing the soil with the metals and disposing of it OR by removing metals from the soil using special plants and fungi, then disposing of the plants and fungi.
- You can also prevent or reduce exposure by covering the soil or by adding soil to dilute the metals.

Organic Contaminants
(diesel oil, dioxins, etc.)

- They can be broken down by fungi and microbes.
- Fungi can typically handle the most complex organic contaminants.

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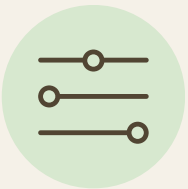
Soil Testing 101

What Are Soil Screening Limits?

Soil screening limits are health-based guidelines used to identify potentially unsafe levels of contaminants in soil. After fires, these limits help environmental agencies assess whether residential areas may require further testing, cleanup, or remediation.







Why Soil Testing Matters

Soil testing helps identify contaminants that may remain in residential areas long after a fire and can assist in determining potential environmental and health risks.

Common Residential Soil Screening Limits

Contaminant	Limit		Contaminant	Limit
Lead (Pb)	80 ppm CalEPA	200 ppm EPA	Formaldehyde	4.3 ppm
Arsenic (As)	0.67 ppm		PCBs	0.23 ppm
Mercury (Hg)	13 ppm		Benzo[*a*]pyrene	0.11 ppm
Cadmium (Cd)	7.1 ppm		PFOS	0.0063 ppm
Chromium(VI) (Cr(VI))	0.3 ppm		PFOA	0.000019 ppm
Nickel (Ni)	140.88 ppm		TCE	0.94 ppm
Benzene	1.2 ppm		DRO	500 ppm

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Bioremediation Lifecycle

Start With Soil Testing

Cleanup decisions should be based on soil testing, contamination level, health risks, and long-term property goals.

Important Questions to Consider

Was your property directly affected?



- Burned homes and fire debris increase contamination risk.
- Nearby smoke and ash can also affect surrounding soil.

Who uses the property?



- Children, pets, and pregnant people may face higher exposure risks.
- Outdoor activities that stir up dust may increase exposure.

Bioremediation Process Overview

1. **Site Assessment**
   Identify contaminant types and concentrations.
2. **Site Design**
   Create a treatment plan based on risks and land use.
3. **Installation**
   Add plants, fungi, compost, mulch, or clean soil.
4. **Monitoring & Maintenance**
   Retest soil over time and ensure organisms grow.
5. **Disposal**
   Remove contaminated plant material safely.
6. **Final Testing**
   Test plant material to confirm success at metal removal. Confirm remediation goals are met.

Timelines Vary Depending on Contaminant Type and Concentration

- **Organic contaminants** may only take months under optimal conditions.
- **Metal extractions** may require one year or longer.
- **Highly contaminated sites** may require combined approaches.

Effective bioremediation takes time

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Health Effects & Exposure Reduction

During Treatment

- Keep soil covered.
- Avoid disturbing bare soil.
- Wet mop indoors and remove shoes.
- Prevent children and pets from contacting soil.

Food Safety

- Do not grow food in contaminated soil.
- Use raised beds with clean soil until testing confirms safety.



Potential Health Effects of Contaminant Exposure





- Immediate exposure to ash and airborne particles may cause coughing, throat irritation, and breathing difficulties.
- Long-term exposure to heavy metals such as lead and mercury may impact brain and nervous system function.
- Contaminants can spread into soil, water systems, homes, and surrounding ecosystems after fires, harming people and wildlife.

Ways to Reduce Exposure

- Minimize disturbance of ash and contaminated soil.
- Practice proper hand hygiene after outdoor exposure.
- Remove shoes before entering indoor spaces and limit children's and pets' access to contaminated areas.
- Cover soil with 4–8 inches of clean material while planning remediation.
- Use indoor air filtration to reduce airborne contaminants.
- Consider professional soil testing to identify toxic metals and fire-related contaminants.

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Benefits of Ecological Remediation

What Is Ecological Remediation?

A model, system, and set of methods for cleaning up polluted sites that truly mimics nature by drawing on principles of ecology

Excavating and disposing contaminated soil releases a ton of greenhouse gas emissions, and the disposal process often involves transporting unwanted material into other communities.

A more cost-effective and environmentally sound soil remediation strategy is bioremediation, which works with living organisms to clean up environmental pollution.

Principles of Ecological Remediation

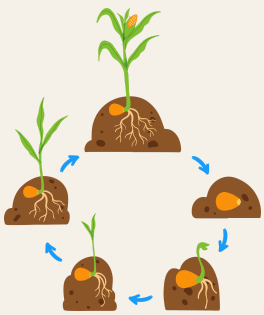
Mimic Succession
Starting the process enables natural regeneration

Diversity = Resilience
Address multiple contaminants while restoring ecosystem function and stability

Bioregional Approaches
Prioritize native species and avoid working with invasive ones

Waste as Resource
Divert material from landfills and support circular systems

Keystone Remediation Species
Ensure the species needed are present to fulfill remediation goals



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Field Studies in Los Angeles County

- Researchers in Southern California are exploring ecological remediation as a sustainable alternative to traditional soil cleanup methods.
- Studies conducted across contaminated Los Angeles sites demonstrated that native plants and beneficial fungi can significantly improve soil recovery while reducing pollution.

Sites Tested

- LA Eco-Village
- Taylor Yard
- Slauson & Wall



Common Contaminants

- Lead
- Arsenic
- Chromium(VI)
- Diesel & PAHs



Results of Ecological Remediation

- Increases available nutrients
- Increases organic matter
- Increases microbial biomass
- Improves soil structure
- Improves water retention
- Restores plant and microbial diversity

- Reduces soil erosion and dust formation
- Reduces heavy metal contamination
- Reduces water runoff
- Reduces soil exposure to high temperatures
- Reduces pollutant impacts on ecosystems

Field Study Findings

- 10× lower CO_2 emissions per acre
- ~50% cost savings
- 40× increase in biodiversity
- 60% vegetation recovery within 12 months
- Produces less waste than conventional remediation, with the potential to reuse the byproducts

Helping Fire-Impacted Sites

Ecological remediation methods can help restore fire-damaged landscapes by rebuilding soil health, reducing contaminant exposure, preventing erosion, and supporting long-term ecosystem recovery.

These approaches are already being applied across fire-impacted parks and residential sites in Los Angeles County.

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Keep in Mind

When Is Bioremediation Appropriate?

- Soil testing confirms contamination
- Moderate contamination
- 12+ months available for treatment
- Excavation is not feasible
- Combined with exposure reduction methods

- Very high contamination levels
  For example, lead levels above 500 ppm
- Immediate move-in or rebuild timelines require fast clearance
- Insurance requirements demand rapid removal
- High exposure risk for children or pets

Testing and Professional Oversight Are Essential

Bioremediation requires

- Follow-up soil testing
- EPA-based sampling methods
- Proper disposal of contaminated material
- Monitoring to prevent contaminant spread



Without monitoring, remediation is not verified.

Choosing a remediation approach should balance

- Contamination level
- Urgency
- Household risk
- Budget
- Long-term property plans

No single method is right for every property!

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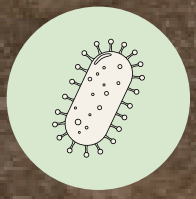
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The Centre for Applied Ecological Remediation (CAER)
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