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After a Wildfire: Considerations for Building Environmental Testing

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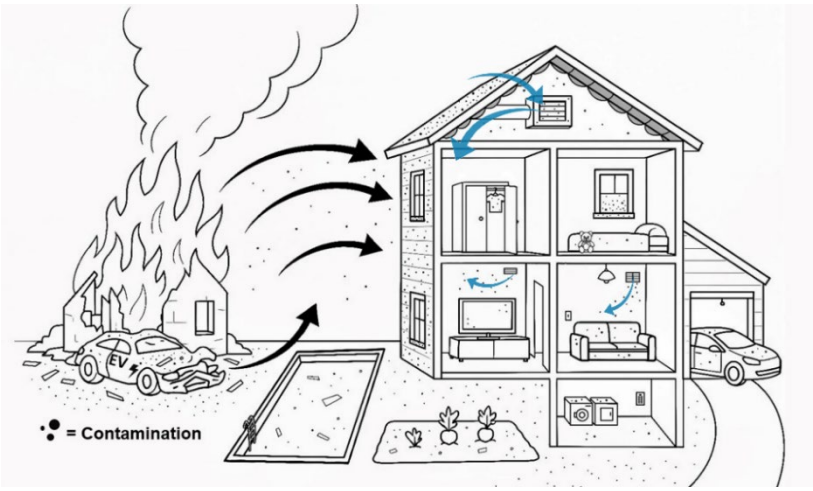

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1. Damage and Building Contamination

Wildfires can directly and indirectly make buildings unsafe by introducing physical, chemical, and microbiological pollutants. These pollutants can pose an immediate and long-term health and safety risks to building users. Particles, gases, and vapors are often released and created from burning structures, vehicles, and other items. Microorganisms can grow due to the presence of water due to pipe breaks and leaks, fire-fighting activities, local climate, and other conditions. Before entering a fire-impacted building, proper inspection and testing are highly recommended.

Signs of contamination being present can include broken and melted building components and systems, dust, debris, ash, and soot deposits on floors, walls, ceilings, personal items, inside HVAC components, corroded metals, electrical system malfunctions, and discolored interior and exterior walls. Indirect damage indicators can be odors and illness symptoms. Not all damage may be visible (i.e., in wall cavities, attics, drywall, personal items).

Persons impacted by wildfire should seek advice from their health department and competent professionals. The property should not be entered without proper safety equipment and protocols to protect against hazards and spreading contamination to their vehicles, other residences, and other people.

Following A Structural Assessment, A Building Inspection Should Be Conducted and Include:

- The building exterior
- Natural gas system
- The garage, attic, crawlspace
- The heating ventilation and air conditioning (HVAC) units and associated components
- All ceilings, walls, floors, shelves in every room, including hallways and closets
- Electrical system including the breaker box, wiring, and electrical components (i.e., switches, outlets).
- Personal electronic items (i.e., TV, personal devices, stereo, DVD, VCR, etc.)
- Personal items
- Plumbing fixtures
- Other fixtures (i.e., cabinets, lights, etc.)
- Furniture (i.e., couches, mattresses, etc.)
- Appliances such as microwave, oven, dishwasher, washing machine, dryer, humidifier, etc.
- Pools and spas
- Fire sprinkler system

At a minimum, persons conducting the assessment should wear proper safety equipment including a properly fitted respirator (P100+OV/AG elastomeric air purifying respirator with organic vapor and acid gas cartridges), safety goggles (ANSI Z87.1 D5), chemical-resistant gloves, long sleeves, long pants, sturdy shoes, disposable Tyvek suit, and shoe covers to limit exposure and contamination spread. Inspections should be carried out with more than one individual. Conditions may be present where greater levels of protection are necessary.

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2. What and Where are the Contaminants?

Contamination can be in solid form or present as vapors and aerosols. Sometimes particles are visible, but sometimes particles will be too small to be seen with the naked eye. Contamination may be on the surface of objects, and it may have also penetrated inside of objects.

3. Role of Sampling and Testing in Restoration, Damage Identification, and Remediation

Restoration is a general industry term that is defined as returning a property to a "*pre-loss condition by the removal of damaging residues or odor to remedy damage or distress*." To restore something, the damage must first be identified. Here, damage refers to reduced or loss of the appearance, functionality, safety, or value of an asset. In this document, we focus on sampling and testing activities to identify environmental contaminants for a fire or smoke impacted building. Remediation is the act of removing *specific environmental contaminants* from a property to return it to safe use. Remediation can include source removal (i.e., particulates on hard surfaces, replacement soft HVAC ductwork, upholstery furniture, soft goods, etc.), extracting contamination from materials (i.e., VOCs in wood studs, walls, etc.), and other practices. The fire and smoke damage industry defines "cleaning" as removing residues or contaminants. The USEPA uses the terms "remediation" and "cleanup" interchangeably. To add context, fire and smoke damaged buildings can present life-threatening and life-altering contaminant hazards (i.e., asbestos, lead, benzene, etc.). As people often associate "cleaning" their homes as an activity without fear of major contaminant exposure-caused injuries (i.e., mesothelioma, metal poisoning, cancer), the word remediation is used here for fire and smoke damaged properties to reduce the potential for confusion.

4. Sampling and Testing is Conducted to Understand the Damage

A primary objective of sampling and testing is to identify the type, location, and magnitude of environmental hazards. This information is then used to determine which remediation activities are needed to return the property to pre-loss conditions. Here, sampling and testing are linked activities. Sampling involves the collection of evidence, and testing is the examination of environmental samples. Sampling and testing approaches should also consider determining if there is localized or widespread contamination damage for the building (i.e., at a single windowsill, skylight, or inside the HVAC system, interior rooms, attic, spread throughout the home, etc.). The type of contaminants that are screened for should be appropriate for the specific building space and materials and consider specific warnings by health officials. *After remediation, sampling and testing should also be conducted to confirm hazards were removed.*

5. Who Should Conduct Testing and What is Their Scope?

A competent professional should evaluate the potential property damage and then conduct sampling. Based on hundreds of residential property investigation reports we reviewed after wildfires, there is wide variability in knowledge and approaches across companies. Problems identified in the reports were that some companies that conducted testing generated uninterpretable information, failed to collect samples or controls correctly, used the wrong testing methods, compared their results to inappropriate exposure standards, and misreported test results to the property owner. Possible professionals that might have the necessary expertise to conduct a property investigation include licensed professional engineers, certified industrial hygienists, or other credentials following appropriate ASTM, NIOSH, USEPA, and/or equal practices.

Before a contract is initiated, property owners can request that companies declare the estimated type, number, and location of samples to be collected, testing methods that will be used by the lab, how results will be reported (i.e., ug/ft^2 vs. ug/ 100 cm^2, etc.), indoor environmental exposure standards they will use for comparison, and whether the final report will take a position about remediation recommendations. The identification of control samples and date of final report delivery should also be included in the scope of work contract. Visual observations including either images or video should be recorded and may help describe sampling site conditions. Samples should be analyzed and validated by skilled laboratories. All results should be quantitative, not presence/absence responses.

6. What Should Be Tested for and Where?

- **Data Collection and Reporting:** The number and location of samples collected per property will depend on property impacts, characteristics, and activities carried out on property since the fire. Contaminants identified by local and state officials should be included in property screening. At a minimum, garage, attic, and crawlspace samples should be collected, along with surface floor and windowsill samples of each bedroom and living area. Additional locations to consider should include the HVAC furnace and ducting, hallway floors, kitchen countertops, any areas frequented by children, elderly or other vulnerable populations, and any areas where there is a desire to retain valuable or irreplaceable objects. Samples

should be collected in interior parts of the building as well as the outer parts of the building (i.e., interior windowsills, floors). “Control” samples should not be collected from within a fire damaged property. These samples can often be unopened sampling containers (i.e., trip blanks) and field blanks. Chain-of-custody forms are needed for samples collected.

- **Surfaces.** At a minimum, surface dust in buildings should be screened for RCRA8 metals and asbestos, due to existing regulatory thresholds which indicate a health risk exists. The *Resources Conservation and Recovery Act (RCRA)* metals are designated by federal law as knowingly toxic (i.e., arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). Lead, for example, has explicit federal limits of 5 µg/ft^2 for floors, 40 µg/ft^2 for windowsills, and 100 µg/ft^2 for window troughs, and other metals may exist in surface dust at concentrations where manipulation is likely to cause conditions that exceed state or federal airborne permissible exposure limits (PELs). Contaminant loadings are comparable when reported in ft^2, 100 cm^2, or equivalent. Results reported as “ug/wipe” are uninterpretable unless the report explicitly defines what surface area each wipe represents in ft^2 and cm^2. Comparison of indoor metal concentrations as mg/kg or ppm to residential soil standards is inappropriate, and bulk samples of walls or other construction material are not sufficient to assess surface dust risk.

  USEPA Method 6020B (and USEPA Method 7174B for mercury) should be considered for sample analysis. Because other metals may also be present, testing for the CAM-17 metals (California Administrative Manual) may be more appropriate. In addition to the RCRA8 metals, CAM-17 also includes antimony, barium, beryllium, cobalt, copper, molybdenum, nickel, thallium, vanadium, and zinc. Screening for lithium and manganese may be advisable as they are released in large quantities from some batteries and consumer products. USEPA Method 6010D has been used by some for metals analysis, and while it generally has higher reporting levels, it may also be sufficient for evaluation. Asbestos should be screened for when structures, or those impacted nearby, are known or suspected to contain asbestos containing items.

  - Like metals, semi-volatile organic compounds (SVOC) are often found on surfaces. SVOCs include polycyclic aromatic hydrocarbons (PAH), perfluoroalkyl substances (PFAS/PFOS), polychlorinated biphenyls (PCB), dioxins, and furans. PFAS and PCBs, for example, often have clear points of origination, compared to dioxins and furans. PFAS is frequently present in non-PHOS CHEK fire retardant foam and artificial turf. PCBs are present in some older electrical and hydraulic equipment. PAHs have often been associated with incomplete combustion. PAHs can be screened using USEPA Method SW-846 8270D/E, and USEPA Method SW-846 8082A for PCBs.
  - Ash, soot, and char are often referred to as combustion byproducts (CBP) and are particulates. There are no health-based human exposure standards for these materials. Testing for these materials alone, in a wildfire impacted building, is like confirming the sky is blue. By not testing for metals and asbestos for example, which have health-based regulatory exposure limits, property inhabitants may be led to believe the property is safe, become exposed, and spread contamination when it poses a serious health risk.
  - For surface sampling, samples should be collected individually, not as composites. This is because (1) if one area of a home is contaminated the person conducting the sampling may transfer that contamination elsewhere in the home (i.e., wipe samples), and (2) composite samples prevent the property owner from finding the location with the highest contaminant levels in the home. For example, this can prompt the highest lead level detected to be lower than a regulatory threshold prompting the need for abatement.

- **Air.** Volatile organic compounds (VOC) are a class of chemicals released from and created during and after fires involving structures and personal items. VOCs can penetrate walls, floors, insulation, HVAC ducts, furniture, soft goods, including plastics, and other building contents. Some VOCs can transform into other chemicals during their time inside the building. Some, but not all VOCs that pose a health risk, can contribute to an odor. Odors can be caused by the human olfactory system being exposed to one or more chemicals at the same time. The presence or absence of an odor for a fire-impacted building does not mean the chemical exposures are safe. VOC testing can sometimes help identify causes of odors and illnesses before and after initial remediation activities have been conducted. Consider sampling with USEPA Method Toxic Organics (TO)-15 and include screening of all 100+ chemicals. USEPA Method TO-11A may also be used in addition to, but not in place of, the TO-15 method. Other air sampling methods may be needed upon investigation. While some fire-related chemicals may not be on the TO-15 list, currently, this list seems

to be the most inclusive and many have federal and state indoor air regulatory limits.

Before indoor air sampling, the air **MUST** stagnate and be still. This allows VOCs to release from surfaces and items into the air, where they will accumulate and be sampled. The HVAC system should be off, and all windows/doors closed for 72 hours. Air sampling time, or the duration by which air is drawn into the sampling container, should be 24 to 72 hours duration. If the sampling time is not long enough, the sample collected may not accurately represent the indoor exposure. Consumer-grade VOC sensors and handheld photoionization detectors (PID) have little to no value assessing whether indoor air poses an immediate or long-term health risk after a fire. Instead, the specific chemicals should be identified, quantified, so the health risk can be properly assessed.

- Other gases. A variety of gases are generated during fires and some can remain indoors at levels that pose health risks (i.e., hydrogen cyanide).

- **Other Factors and Other Samples.** If significant water impacts occurred (i.e., firefighting, plumbing leaks/breaks, etc.), a microbial growth survey that includes testing may be necessary. Destructive sampling is sometimes conducted whereby a specific piece of the building (i.e., wallboard) or personal items (i.e., clothing, etc.) are removed and analyzed for specific pollutants at a laboratory. Invasive video and imaging techniques can also be conducted (wall and ceiling cavities, etc.). The decision to conduct this testing should be on a case-by-case basis informed by other property damage factors. Other utilities (i.e., property domestic plumbing, sewer, electrical, natural gas, pools and spas) may also need to be evaluated for health and safety risks.

7. Frequently Asked Sampling and Testing Questions

- ***Should I enter or live in my home if I haven't had it tested yet?*** Generally, no, but this depends on the damage to the property. Advice is recommended from competent professionals first. A property three miles away from a fire may have smoke entry, whereas a partially burned structure or home adjacent to a fire-damaged property may have much higher amounts of chemicals and hazards. Contaminated standing homes have sometimes caused people to become ill, requiring emergency department visits. Beyond environmental hazards, other hazards may exist (i.e., leaking natural gas pipes, damaged electric vehicle batteries, broken glass, nails, structural failure, exposed electrical wires, mold), and homes adjacent to burned structures or partially burned homes may have structural, electrical, and environmental safety risks as well.

- ***Is the presence or absence of one metal contaminant an indicator for all other chemicals?*** No. We have found no evidence to support this claim.

- ***Is the presence or absence of one VOC in indoor air an indicator for all other chemicals?*** No. We have found no evidence to support this claim.

- ***Does combustion byproduct (CBP) testing alone determine if the property is safe?*** No. Testing should include chemical specific screening. We have found no relationships between CBP and health-based regulatory exposure standards. In the past, CBP results have been used to inform theories about whether fire-caused contamination penetrated the interior rooms rather than just reaching exterior windows and doors, but CBP has no health-based indoor exposure standards. In contrast, lead, asbestos, and some VOCs do have such standards.

- ***Which contaminants could most influence the remediation activities selected?*** Lead and asbestos have federal exposure limits and require specific worker safety actions. The health consequences of their exposure can also be significant. By federal law, the removal of lead and asbestos from contaminated buildings requires abatement, a specialized training, site safety, and worker safety requirements. Initially, these contaminants may drive the decision making, though the presence of other contaminants (i.e., VOCs, SVOCs) could also influence sampling, testing, and even building remediation decisions.

- ***Is smelling my contaminated clothing a good way to assess its safety?*** No. Odors are often detected inside fire-impacted buildings because of a chemical exposure. Some VOCs are harmful at levels you can detect by odor, but other VOCs are harmful when odor is not detected. If the home is contaminated with metals or asbestos, smelling the contaminated items can cause exposures.

- **If we ask someone to "remediate" without testing, what will the harm be?** First, if hazardous levels of chemicals exist (i.e., lead, asbestos, VOCs, etc), exposures could prompt acute and even long-term health impacts to the workers. Contamination may be spread and left behind which the building inhabitants then encounter. The approach may also violate state and federal worker safety laws. Workers are required to be protected from hazards. To protect them, the hazards must be known. If they do not have the right training for remediation (i.e., lead, asbestos, etc.), are not wearing the property personal protective equipment, or have the proper controls to prevent contamination spreading through the building, they may harm themselves and the building inhabitants. Sampling and testing is critical to not just the property owner, but the workers who are potentially exposed to those hazards.
- ***Should my fire-impacted clothes be chemically tested?*** This may depend on whether your insurance company requires such testing to determine the need for replacement, or if other testing already proposed or conducted will indicate whether the clothing is contaminated. Different materials (i.e., synthetics, cotton, silk, linen, leather, suede, wool, etc.) respond differently when contaminated by fire contaminants (i.e., lead vs. VOC vs. SVOCs). The type and amount of contamination for the exposure, and duration before remediation, can impact whether the items will be salvageable.
- ***Should I "clean" my home if I haven't had it tested yet?*** Because damaged buildings can have life-threatening or life-altering hazards, feedback from competent professionals before doing anything is recommended. If contamination is found, remediation professionals skilled at removing the specific contaminants, *without spreading them throughout the property or harming building inhabitants*, should be engaged.

8. Remediation and Post-Remediation Testing

Remediation actions needed will depend upon the property damage. If the fire directly damaged the structure, remediation actions may be more involved than in buildings farther away because the contaminant levels inside the structure were much greater. Wet wiping all surfaces, use of high-efficiency particulate air (HEPA) filters for vacuuming floors and indoor air, as well as activated carbon scrubbers for indoor air may be able to remove light levels of contamination. If contaminants penetrated drywall and personal items (i.e., mattresses, pillows, clothing, paintings, upholstery furniture, rugs, etc.) specialized decontamination methods (and subsequent contamination testing of the items) may be needed or the items should be discarded. Using a HEPA filter vacuum cleaner on carpets, rugs, and upholstery, for example, has shown less than adequate lead removal effectiveness with detectable lead remaining. In contrast, HEPA filter devices are generally considered effective for lead dust on hard surfaces. Testing to assess remediation effectiveness is recommended and should be conducted by a contractor that did *not* conduct the remediation. Containment methods should be used to avoid the cross-contamination of rooms, such as plastic sheeting, air pressure, clean room booties, etc. Improper remediation activities can introduce new VOCs that accumulate in indoor air and cause illness. VOC contamination can remain indoors for more than four months.

9. Acknowledgement and Additional Information

Information provided here is intended as a public resource that can facilitate discussion and understanding. As more information about wildfire caused contamination becomes available, this guidance may be revised. Special thanks are extended to property owners and companies after the 2023 chemical disaster in East Palestine, Ohio and 2025 Los Angeles area fires who shared their experiences with the authors. Thanks are also extended to K. Wayne at Purdue University for assistance on the visual representation.

Persons impacted by wildfire should seek additional advice from their local health department as they have direct experience about the local situation and post-fire health threats in their community. Hazard identification continues to be a challenge for emergencies and disasters that affect buildings. Future work may indicate building sampling and testing practices should be modified to account for new contaminants (i.e., chromium-6, other SVOCs). These conditions may require the use of different sample collection and laboratory analysis methods.

Additional emergency and disaster response and recovery information for other residential and commercial property and municipal issues can be obtained at the Center for Plumbing Safety. This includes information about environmental health risks posed by fires and recommendations for recovery. This work was partially supported by funding from U.S. National Science Foundation grant 2327139 and Purdue University. Links to sampling and testing literature were included in the document. Other types of fires or contamination incidents such as man-made chemical incidents (i.e., vehicle fires, train derailments, petroleum fires) that contaminate buildings would have additional considerations than described here.

Some additional resources are shown below.

- Institute of Inspection Cleaning and Restoration Certification (IICRC). *ANSI/IICRC S700 Standard for Professional Fire and Smoke Damage Restoration.* January 2025. Las Vegas, NV USA.
- U.S. National Academies of Sciences, Engineering, and Medicine. *The Chemistry of Urban Wildfires*. 2022. Washington, D.C. USA.
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