Transcript

Environmental Impacts of Fires at the Wildland-Urban Interface

January 31, 2025

Jessica Neu:

Good afternoon everyone, and thank you for joining us today. My name is Jessica Neu. I'm a scientist who studies air quality and climate at the Jet Propulsion Laboratory and I'll be your host today. I'm also a resident of Altadena, and so I share many of the concerns that you have about air quality and other environmental hazards resulting from the fires. But as scientists, we believe that knowledge is power, and so today we're hoping to provide you with some data from during and after the fires and some ways to think about that data that can help you as you make personal decisions as we move forward as a community. So we'll start with some short presentations from the panelists and then transition to audience questions. You're welcome to submit questions via the Q&A function. If you submitted a question during the registration, we have those on hand already, so there's no need to resubmit.

Before we start, I need to define a couple of key terms that we'll be using throughout the seminar. So the first term that you'll see is VOCs. The V stands for volatile, and so that just means that they evaporate at or near room temperature. The O stands for organic, which simply means that they contain carbon atoms, and the C stands for compounds, which means that they contain a mix of different types of atoms. So some examples of VOCs are things like benzene, which is found in gasoline, toluene that's found in paint and paint thinners. And then another example would be limonene, which is found in household cleaners that smell like lemon. The second set of definitions I was going to provide you with are PM 10 or PM 2.5. So PM stands for particulate matter, and that just means solid and or liquid particles that are suspended in the air. If we're talking about PM 10, it's less than 10 microns PM 2.5 is less than 2.5 microns.

And just for reference, dust that's visible to the human eye is about 25 microns in size. So some examples of particulate matter are things that are produced by fires or things like black carbon, nitrate. For normal wildfires, we wouldn't see trace metals, but in urban fires like we had in this situation, you'll see trace metals like lead, arsenic, cadmium. And then finally we have a class of compounds called polycyclic aromatic hydrocarbons that are just compounds that are produced anytime you burn something that's organic or contains carbon including your dinner on the grill. So those are what those are. I want to now take a moment to introduce our panelists.

So our first panelist is Lauriane Quenee. She's the senior director of environmental health and safety at Caltech, where she develops and implements safety strategies on campus. Our second speaker is Sina Hasheminassab. He's an air quality scientist at JPL L who studies air pollution sources trends and their societal impacts, and he'll be joined by Caltech graduate student in environmental science Haroula Baliaka to present some of her data. Our next speaker is Francois Tissot, who is a Caltech professor of geochemistry whose research ranges from the formation of our solar system and history of earth's chemical processes to studying human health. And finally, we'll hear from Joost de Gouw who is a professor of chemistry from the University of Colorado Boulder who did extensive sampling of homes following the 2021 Marshall Fire in Colorado. So we're going to kick things off with Lauriane Quenee, Lauriane take it away.

Lauriane Quenee:

Good afternoon everyone, and thank you for joining us. I am absolutely honored to be here and to get us started. So the Eaton fire started on January 7th. It raged for several days through the Los Angeles National Forest and through the city of Altadena, it resulted to more than 14,000 acres of burning and damaged or destroyed more than 10,000 structures. So what I'm going to focus on today is how risk assessment are usually conducted in those type of events and our approach to risk mitigation when we face those events. So what is risk assessment? Risk assessment is a process that identifies potential hazards and that analyzes the likelihood of those hazards to cause harm. And so the very first step of risk assessment is hazard identification. In the situation of the Eaton fire, Caltech and Pasadena were experiencing wildfire, smoke, ash and dust, but also urban fire, smoke and dust, and those are known to more likely contain toxic material.

The second aspect of risk assessment is understanding and evaluating the potential for harm. And usually this is depending on likelihood of exposure and the consequence of exposure. In the case of the fire exposure dose and exposure time, the length of time that someone can be exposed to the material is also factors that contributes to the risk assessment. So in the acute phase of the fire, the short term that can last between one or four days, depending on the containment of the fire, we can assume that we have very highest dose of smoke and air contaminants and the route of exposure that we have to really consider is direct inhalation of the smokes and those contaminants, direct contact when you are outside can also be a route of exposure. On the longer term, we can expect the dose to be lower, but the source of contaminants have settled in the impacted area.

So wherever the plume of smoke was, there is a likelihood of those contaminants to now be on surfaces. And here again, the route of exposure that we need to be mindful of our inhalation, especially when the ash and the dust is disturbed by human activity, eye contact, skin contact with the source material of the hazards is also of concern and to a lesser degree, but also a route of exposure ingestion. And that's especially true for young children at that stage. It's important to note that individual circumstances will also impact the individual risk assessment. And so that's how we frame risk. Now when we go to risk mitigation, safety professional rely on what we call the hierarchy of controls.

So you can see the different type of controls that can be applied, and we usually have them as an inverted pyramid. And the controls on the top of the pyramid are the ones that are considered the most effective. The controls at the bottom of the inverted pyramid are considered to be less effective, mostly because they can depend on human factors. So in the case of the fire and in facing any type of risk, elimination is your first and most effective control. So in the case of the fire can't really eliminate it right away. So leaving the area at the acute phase is a very good control and a lot of people evacuated and did that.

Once we settled in the more long-term phase, it is absolutely critical to stick with elimination. And here elimination will rely on removing the source of the hazards, cleaning up the dust, cleaning up the ash, and remembering that because the main route of exposure is inhalation, that cleaning needs to be done, it is recommended to do those cleaning using wet methods. This is how we can prevent the dust and ash to be resuspended in the air and prevent inhalation. The second layer of hierarchy of control for risk mitigation is substitution, in the case of the fire, there was nothing that we could substitute, so we go directly to the next layer, which is engineering control. Engineering controls are the controls that rely on mechanical means to block, capture or trap the hazards. So in the case of the fire and the days after filtration became a very important engineering control and that can be applied at multiple level.

You can apply filtration to HVAC system to buildings that are equipped with HVAC system, but you can also apply filtration at the individual level at individual room with air purifier. The next level of control is administrative control. And so here it's those tiny actions that the small things that you can do, but that will still give you the ability to reduce the risk. And one of the key element when you consider wildfire and wildfire smoke is controlling entry points. And so we've been talking a lot about windows and doors opening, and so the situation will vary depending on your particular situation. For example, in commercial buildings where a lot of people come and go, the recommendation is to keep the doors and the window closed because you have the HVAC system that is the main control point for air quality inside the building. So what you want is rely on your building engineers or building administrator to really make sure that the HVAC system does the mitigation and the control.

In individual home it's a little bit different because you don't necessarily have a full HVAC system. And so what you want to do is open the doors and the windows to remove the contaminants if they're present inside the house or keep the windows and door closed when contaminants are outside and to prevent intrusion of those outside contaminants indoor. And so to effectively put those control in place, the next important step is to be able to monitor the hazards. And so that's what can be done with monitoring air quality levels, either indoor or outdoor to apply the best administrative control. The last layer of controls that could be applied to mitigate risk are PPE, personal protective equipment. And so PPE is the last line of defense. This is the prevention of exposure at the individual level. So in case of the wildfire wearing high quality masks such as N-95 were the PPE of choice, and then you can think about additional protective gear when you are engaging in cleanup activity with a lot of the source material for the hazards.

So you will likely see a lot of folks with gloves and Tyvek suits cleaning up the burn site. And so following the principle of the hierarchy of control, those are a couple of example of containment measures that we've been applying at Caltech, the idea was to prevent outdoor contaminants to reach people inside the laboratories inside the offices, and a lot of those measures can be applied to protect homes as well. So following the principle of elimination, we engage in a very active cleaning of the campus, making sure that we would wet, clean the dust, the ash, and remove as much as possible of the source of the hazards. What can be done inside for things that cannot be wiped is use HEPA vacuum and for carpets and other types of porous material. In terms of engineering control, the facilities department and the H&S department worked relentlessly to deploy MERV and charcoal filter filtration for our HVAC system, worked on recirculating the air as much as possible in our building to prevent infiltration of the outside air.

We've also distributed throughout campus to student housing and most of the campus building over 2000 air purifiers to provide filtration at the individual level, other type of administrative control that could be put in place, and we've done that in our high traffic area, adding sticky mats that prevents people to drag contaminants through their shoes inside the building. We're looking also at assessing our windows and our doors for seal quality. You can put a lot of controls in place if you have a gap underneath your door. This is something that will be an entry point for the contaminants. And so things as simple as removing shoes before entering into an indoor space when you do that in your home can be an effective containment measure for preventing contaminants. And so what we did too was measure air quality, both indoor and outdoor. We focused on the outdoor PM 2.5 with one of the reader that we have on the top of the Caltech Library.

QR code is here and I'm pretty sure people will put the link in the chat. Airnow.gov is also a good source for air quality outdoor quality information, but we also looked at how our building behave with poor air quality outside by measuring indoor air quality. So we have a handheld monitor that we could use to do spot checks through campus. And we also deployed continuous monitoring with 10 monitors that you can see here looking at little suitcase on the stand. We deployed 10 around campus through the two weeks. And really the idea is to understand how our building behave when the air quality outside is poor and whether or not the mitigation practices that we've put in place are efficient.

We even had a little experiment with a room that had an air purifier turned on in the middle of the measurement to see if we could measure the impact of a single air purifier in a room. And so we don't have the data yet. We're going to look at that. And so as those results come in, as more information become available, risk assessment can always be refined and then we can modify our mitigation practices. But the overarching principle of risk mitigation is elimination first, engineering control, administrative control, and then PPE. And that's where I leave you. Thank you.

Jessica Neu:

Thank you, Lauriane. Our next speakers are Sina Hasheminassab and Haroula Baliaka.

Sina Hasheminassab:

Thanks, Jessica. And hi, everyone. So my colleague Haroula and I are going to give a brief presentation about the air quality pre, during and post fires. All right, so this slide shows the satellite imagery of Southern California taken on January 9th, which clearly shows the spread of wildfire smoke as seen from the space. The Palisades fire, since it was closer to the ocean, it generally had a smaller impact on the air quality in the downwind regions as opposed to the Eaton fire, which was situated in the northern part of the Los Angeles basin. And given the strong offshore winds that we had during that period, it's facilitated this spread of smoke to a larger areas and impacted larger communities downwind. This slide shows hourly, outdoor PM 2.5 levels measured across the Los Angeles basin pre, during and post fires. Note that different line colors represent different air monitoring sites, which are shown on the right-hand side while the background color shows different air quality index categories.

And also keep in mind that there is no connection or association between these colors. They're just meant to show different sites and different air quality index categories. The time series chart starts from the end of December of last year, which also captures the impact of New Year's Eve fireworks on the local air quality in the region. This is also a good reference point for us to compare the magnitude of the PM pollution that we experience during the fires with. Now focusing on the fire period starting the late evening of January 7th, we see that a number of monitoring sites recorded highly elevated PM 2.5 levels well into the hazardous region. The maximum PM 2.5 level was measured at Caltech's campus with the peak of PM 2.5 exceeding 650 microgram per cubic meter. Around the same time the two other monitoring sites, one in downtown LA in North Main streets, and the other one in Huntington Park also recorded elevated PM 2.5 levels.

Moving forward, we see that the two nearest monitoring sites to the Eton fire, specifically Caltech and JPL, continued to record highly elevated PM 2.5 levels, but then after that, especially after January 9th, we see a gradual decline in PM 2.5 levels across all of the monitoring sites such that by midday on January the 12th, we see that the PM 2.5 concentrations we return back to pre-fire levels. And since then, the concentrations of PM 2.5 remained within the typical ranges. And in fact, the rain events that we had over the past weekend also further helped with using the PM 2.5 levels. This slide compares the PM 2.5 pollution levels during the recent fires with two other fires that we experienced over the past few years. One is the line fire and the other one is the Bobcat fire. There are several factors that determine the impact of wildfires on air quality.

Some of the most important ones include size and location of the fire, materials burned, and of course the meteorology specifically wind speed and wind direction. Looking at the line fire, we see that the maximum PM 2.5 measured at the big burn monitoring sites around 900 microgram per cubic meter. This site was the closest monitoring station to the line fire. Now looking at the Bobcat fire, the peak of PM 2.5 is not as high as the other two fires, but what's notable during that fire is that the air quality was degraded for an extended period of time, much longer than the other fires that is shown on this light.

We can also see how PM 2.5 pollution levels varied by location, especially relative to the path of wildfire smoke. On this map, the markers indicates the location of PM 2.5 monitoring sites color coded by the maximum hourly air quality index that they recorded between January 7th and 12th. On top of that is the map of smoke plumes again during the same time period where darker brown colors indicate thicker and heavier smoke.

There are two things that are quite obvious from this map. Areas downwind of the Eaton fire, especially within the densest part of this smoke experienced higher PM 2.5 levels. Another thing that's evident from this map is that PM 2.5 levels clearly decreased with distance from the fire, such that as you can see, the monitoring site in Long Beach recorded a maximum air quality index of unhealthy. Now I want to share a couple words about air quality index, what it measures and what does not. Air quality index is a simple and easy to understand metric to communicate how clean or polluted the air is and its potential health impacts. AQI is calculated based on near real-time concentration of a certain regional pollutants, specifically ozone, carbon monoxide, nitrogen dioxide, as well as PM 2.5 and PM 10. However, AQI does not account for several chemicals such as air toxics that may be of concern during extreme events like wildfires.

In general, measuring air toxics especially continuously and near and near real time is quite complex and very expensive and requires quite advanced monitoring technology. Currently, there are very few resources available in our region that can continuously and in near real time measure the levels of such chemicals. One such resource is a research monitoring network called Ascent, which has a site in Pico Rivera, which is shown with an X marker on the map that is equipped with a number of advanced monitors that is capable of measuring several chemicals in ambient particulate matter. This monitoring site was operational during the fire and my colleague Haroula has looked at the data from that site and is going to share some of the results with you.

Haroula Baliaka:

Thank you, Sina. So yes, I'll be talking about the data collected in Pico Rivera, as Sina said, marked with an X on this map here. And ASCENT is a nationwide collaborative effort to provide continuous and high resolution measurements of PM 2.5 specifically focusing on the species that comprise this particulate matter. If we can go on to the next slide, please, Sina. So we've been measuring since 2023 at the 12 sites across the U.S. and we are still in the process of building an open and free database for everyone to access the data. But in light of the current devastating fires in LA, we have some preliminary real-time data that you can access using this QR code or as I noted, there is a link in the chat as well. So what does the data tell us? And what I'm showing here is three plots, one for lead, chlorine and black carbon.

If we could go to the next slide please, Sina. The Y-axis is the concentration in micrograms per cubic meter, and the X-axis is local time starting from January 6th, so a day before the fires up until January 16. So 10 days later, the two vertical lines just indicate the start of the Palisades and Eaton Canyon fire. And just for reference, I'll mention a few of the sources that are related to these species. So lead is typically found in older batteries, older paints, pipes and soil, which we'll hear in the next presentation as well. Chlorine is found in plastics, household chemicals and even pools. And black carbon is a product of incomplete combustion of fuels, and Los Angeles is notoriously known for its bad air quality. So even day-to-day we can find black carbon attributed to cars, fireplaces or wood stove cooking. Next slide please. So conventional wildfires that primarily burn grass and trees, the Eaton Canyon and Palisades fires were structural urban fires that burned significant portions of the built environment where painted surfaces, pipes, plastics, and even the structures themselves became the fuel.

So preliminary results here show that PM 2.5 lead actually peaked at 0.5 micrograms per cubic meter on the 9th of January of 2025 at the ASCENT site. This is on average was around a hundred times higher than the typical range. For each of these pieces, you'll notice that there are two columns, one for the enhanced period between January 8th till January 11th. And the next column is just the typical range calculated from 2023 to 2024 at the site. For chlorine, we have a peak at about 13 micrograms per cubic meter, a value 40 times higher than the typical levels and black carbon was about eight times the average concentration. Next slide. Now notice that the green column here is showing the average concentrations from January 12 to January 30th. So this is the most recent data up until yesterday. And we can see that all three species on average have reached typical levels.

And for lead specifically, if you see in the figure in the previous slide, you'll see that we've returned to levels similar to those before the fire, even from January 11th. Now the presence of lead or heavy metals in general is not unusual in urban fires, urban fire emissions specifically in California and especially considering that a large number of the structures that were affected by the fire were built, for example, when leaded paint were still common, the Camp Fire in 2018 also recorded elevated airborne lead concentrations. But just to put these values in context, I'll end with this figure in the next slide. While lead is a toxic air contaminant due to regulations and especially the US Clean Air Act of 1970, airborne lead levels have dramatically improved since the 1980s. And the dotted orange line here is the lead-containing PM 2.5 that we measured at the ASCENT site. And this is just to say that measures including eliminated lead from consumer products or gasoline have helped improve lead concentrations in the atmosphere. And with that, I'll pass along to Sina.

Sina Hasheminassab:

Thanks Haroula. In the interest of time, I'm going to skip the first couple of bullet points, which are essentially a summary of what we just presented and just focus on the last bullet, which is about the next steps. So there are many research institutions including JPL and several universities that plan to assess air quality impacts, study ash composition and analyze longer term air pollution trends in the fire impacted communities. We are aware of several efforts that are currently underway to secure funding and resources to initiate monitoring and support several public agencies once these projects initiate and as they progress, findings will be shared with the communities and of course with the local officials to support their decision making.

Jessica Neu:

Great, thank you Sina and Haroula. Our next speaker is Francois Tissot.

Francois Tissot:

Hi, everyone. My name is Francois Tissot. I'm a professor of geochemistry at Caltech. I'll be following in the same vein as what Sina was talking about, looking at the composition of the dust and the fine particles that were released by the fire. In particular, the heavy metals that are concerned for health. So starting with an image of the fire, we can see here on the right, the two smoke and dust plumes from the Palisades fire and the Eaton fire. LA, Malibu and Pasadena are also shown on the map. And as Sina has said, urban fires can release heavy metals such as cadmium and lead either as vapors or fine particles. And these will be transported by the winds and then deposited depending on the trajectory of the fire plume. And so a question that is on everybody's mind is how much, were heavy metals released by the Eaton fire?

The answer is definitely, yes. How much of these metals were deposited downstream of the fire, especially in indoor spaces a few miles south of the fire. We will look at this in detail, we'll look at how these values compare to the EPA clearance levels and also we will look at the effectiveness of basic surface cleaning, wet wiping essentially. So to get us started, here's a map of Altadena, Pasadena.

Caltech is shown at the very bottom. The region has been overlaid with a map from the BBC showing in red damaged slash destroyed structures, which represent more than 7,000 houses in Altadena alone. And the thing with Altadena, which is also where my house was, 90% of the houses were built before the 1970s before the lead paint was banned, which means that there is a very high chance for lead to be released during the fires.

So my group and I, with help from colleagues have done some preliminary work. We've gone and sampled about 10 ash samples throughout Pasadena, and then we've looked at Caltech, which is about three to four miles south of the fire region. And we've taken a hundred dust samples inside four different buildings to look at the concentration of heavy metals on desk and windowsills, trying to assess how much of a danger that is. So here we will focus on lead, cadmium, arsenic, and chromium as four important heavy metals that people might be familiar with. And the findings we have with those elements applied to other heavy metals. Our sampling technique was extremely simple. We have a stencil of a given surface area. We use the wet wipe to simply gently wipe the surface with some water, some clean water, of course. We did the sampling about one week after the fire started and then we went into the lab, released the metals from the wipe and measured them on a mass spectrometer.

So I will be showing three or four of those graphs. Let me guide you through it. On the Y-axis, on the vertical axis, you see an enrichment. This is a multiplicative factor a number of times that the concentration is higher than what you would find in a typical soil or ground. The chromium, arsenic, cadmium, and lead are represented. And the two colors red is for the ashes and the pale colors for the dust or the finer particles that you might not be able to see at the naked eye. So what we see immediately is that for lead and cadmium in ashes we have about 10 times more lead than in typical soil while the dust, fine dust and the particulates show enrichment going from a hundred to a thousand times more lead than you would find in the dust coming from your garden in a normal day before the fire.

So the enrichments are tens to a thousand times more abundant in the dust than in the soil. And there is a greater risk coming from the finer dust, which is the one that you might not be able to see, than coming from the ashes, which you will be able to very clearly see. Now, if we look at actual quantity of elements in those samples, this is in microgram per square meter, although the cadmium and the arsenic were elevated compared to the soil, the levels remain very low. This is only one microgram per square meter. This is a very low value. Chromium is at about five to 10 micrograms. The one element that really stands out is lead, which is clearly enriched at hundreds to thousands of micrograms per square meter. So the one we have to worry about is definitely lead, cadmium and arsenic, at least as far as the region that Caltech is compared to the fire.

So a few miles south of the fire are not as much of a concern. Now those lead levels are elevated, but how does it compare with the EPA dust lead clearance levels that have been recommended for health reasons? On the floors, the EPA recommends that there should be less than a hundred microgram per square meter for it to be safe. On window sills, they recommend less than a thousand micrograms per square meter. So although we can clearly see that the fire has released lead and we can see an enrichment in the samples we have taken in the Caltech buildings, a lot of the values are still below the EPA window seal clearance threshold. Half of them are above the floor requirement, and we will look at that in more detail.

If we look at the data as a function of the distance to the window, the left for each of the elements, the left box shows the concentration when you are within one meter of a window, so right next to a window. If you are more than a meter away from a window, this is going to be the right box and you can see that very clearly close to the window. We have a lot more lead being deposited compared to further away from the window. This is completely natural. The window is the place where the lead will be able to enter as it is carried by the air as fine dust. So it is important to clearly to very well clean the window seals also inside your house, but the window seal is going to be the dirtiest place of any house. Now how much of a cleaning do you need to do and how effective is that going to be?

Again, we're looking at the four elements here this time. The left box is showing the levels of the heavy metals after cleaning, while the right box is showing the levels before cleaning. And again, the two blue lines are the floor and the window seal, EPA clearance thresholds. What we can see is that the cleaning, which by the way is just a very simple cleaning with a wet wipe, a wet cloth, the cleaning removes about 90% of those heavy metals because they tend to be highly soluble. So although there is lead that has been deposited in indoor surfaces, a simple clean will already remove most of it. After one cleaning. We are well below the EPA dust clearance level in the Caltech buildings that we have tried. And the cleaning was done like anyone would clean their own house. So if I have to summarize what our preliminary findings have revealed, although a lot of people are worried about the ashes, the ashes actually do not contain the highest amount of lead.

It is only a factor of five to a factor of 10 more than a typical soil. The lead is going to be mostly confined to very small particles and dust, and those will make their way inside indoor spaces. We see a very high deposition close to the window compared to furthest from the window. And wet cleaning is therefore necessary. But the good news is that it is efficient. So we recommend of course, that you wear protective equipment when you do the cleaning, put on gloves, put on goggles, put on an N 95 mask, and then wet wipe all the surfaces that you want to restore to a usable state. And of course, for the bigger particle, everything that is ash, a HEPA vacuum will be needed to minimize exposure to the dust. And with this, I'll give it to the next speaker.

Jessica Neu:

Thank you, François. Our final speaker is Joost de Gouw, who will be talking about lessons learned from the Marshall Fire in Colorado.

Joost de Gouw:

Yeah, hello everyone. My name is Joost de Gouw. I'm a professor with the University of Colorado. And three years ago my community was in a very similar place as where you all are now. And I want to tell a brief story of the work that my colleagues and I did following this fire and what we found. So the Marshall Fire was really very similar to the Eaton fire. It started in the winter, December 30th, 2021. The winds were very high, a hundred mile per hour and a small grass fire got completely out of control and burned a swath of land to the east of Boulder.

As a result of this fire, over a thousand buildings were burned, around 149 were damaged and two lives were lost. And this picture is taken the day after the fire. So ambient air quality was only briefly impacted. Ironically, it snowed the day after the fire and it put all of the fire out. And so on the day of the fire, we saw very high PM 2.5 loadings as this plot shows. But then soon after that, things returned really to normal conditions. One caveat here is that the purple air monitors that we use to construct is graph. Many of them were destroyed or went offline during power outages during the fire.

But post-fire impacts were very significant. Here are some photographs that I took of a house that was right downwind from a block of homes in Superior that burned completely to the ground. This was a modern home, so good seals, and nevertheless, due to these strong winds, a lot of ash and soot got blown inside. The picture on the right, for instance, is a window sill on the second floor of the home and that window doesn't even open. And still there is a very thick covering of soot on the window sill. Also, people reported strong burn smell indoors.

So in response to the community concerns, what did we do? The first thing we did was start looking at the scientific literature to see what was actually known at the time. So we summarized this on this website, it's still up, and even we updated it after the LA fires. The QR code on the right leads you straight to this website. But over the course of putting together this website, what we discovered is there's not much known about the environmental impacts of these urban fires. So that prompted us to do some research. So one thing we did was we instrumented one home very heavily. This was a very strongly impacted home. And what we put in there is a device that measures the airborne PM 2.5. We put in a mass spectrometer that measures volatile organic compounds that Jessica introduced. We had a smaller cousin of the same instrument that we later took outside, and then we had a bunch of low-cost sensors that we brought to other homes after this day.

We also made measurements outside to see what kind of VOCs were released from burn vehicles, for instance. And we also took a mass spectrometer to people's homes in a survey that included homes both inside and outside of the burnt area. And then finally, some colleagues of mine collected soil samples and also have been collecting water samples since the fire. So what did we find? Let's start with the chemical composition of indoor ash and soot. So this is a little bit similar to what Francois just showed. We focused on the indoor ash and the picture on the left shows you the metal concentration of those samples. So the bar on the left is the typical concentration of metals in Colorado soils.

There's a lot of mining in our area, so our soils do contain a lot of, and then the next group of points come from a smoke-impacted homes and then the last come from control homes that were not impacted by smoke. So at first glance, you don't see a big difference between the different categories. If anything, the soil, the regular soil sample on the left has the highest concentrations. If we zoom in, we get to these trace metals like lead. And now you do see that there's a little bit of enhancement indoors in smoke-impacted homes relative to the control homes. So like Francois, we recommend that you remove this and that you protect yourself when doing that. But the enhancements are not super high.

This is a measurement of airborne PM 2.5 inside a smoke-impacted home. And there was a lot of good news here. Indoor PM 2.5 Was generally very low after the fire and we stayed in this home for a month. The only exception was that when the home was being cleaned and this was done professionally, in this case, the indoor PM 10 went up to very high values. And the explanation is simple. All of the cleaning activities resuspends a lot of this dust through the air that is a risk. And to protect yourself from that risk, you really should wear a mask while cleaning.

A lot of people reported indoor burn smells. We had a lot of surveys done after the fire. And so the majority of people who responded to the survey said, yes, my home smelled differently after the fire. And of those people, most of them said their home smelled like a campfire. Some of them said it smelled like a chemical fire. We also asked people about health effects and the people who reported burn smells in their homes were more likely to report symptoms like headaches and a strange taste in their mouth. What people's noses were implying, what we saw with our mass spectrometers was that VOCs indoors were enhanced. So here is one example, it's benzene. We measured hundreds of compounds more. We picked benzene because it is an air toxic, it is a carcinogenic. And what we saw over the course of the month that we were in this home was a gradual decline in the indoor concentration of benzene.

So what happened during the fire is that benzene got absorbed into materials and then after the fire it gets returned to indoor air. And this removal took much longer than we had expected around four or five weeks. During this time, you can protect yourself by using air cleaners. So we tested this, do-it-yourself, air cleaner, put together with a box fan and four carbon filters. And the picture on the right shows that as you turn the air cleaner on the indoor concentration of benzene really goes down to levels that are comparable to outsides. Unfortunately, after you turn the cleaner off, the levels return to where they were before. We also analyzed soil samples. So these were samples of soil both inside the burnt area as well, outside of it. And the good news is that if you compare the samples from burnt and unburnt area, we don't see very large enhancements. The data on lead, for instance, show hardly any enhancement for soils.

Now, there's one caveat to make here. The homes that burnt in Colorado were largely built in the nineties. Some were newer. And so you do expect them to contain lower levels of lead, lead based paint, for instance. So this means that these findings cannot immediately be translated to the California situation. There is an ongoing project to analyze surface water. If you look at the map on the right, the Coal Creek runs straight through the burnt area. And my colleagues in engineering have been collecting samples along the Coal Creek for two years now, and they're still analyzing the data. Publications from this will be forthcoming. So with that, I'd like to stop. We found that indoor airborne dust was low in smoke-impacted homes except during cleaning. We found that VOCs can linger for weeks inside smoke-impacted homes. Air cleaners are very useful to temporarily reduce indoor VOCs, indoor dust soils and water showed only weak enhancements in the concentrations of metals and air toxics. And I'll stop there and return to Jessica.

Jessica Neu:

Okay, I want to say thank you to Joost and all of our speakers. If we could have all of our speakers turn their cameras on, we'll answer as many questions as we have time for. So the first question that we're going to talk about is how concerned should residents be about debris removal? What are the dangers of recontamination of cleaned homes once the debris removal is underway? And Lauriane, if you could kick us off on that, please.

Lauriane Quenee:

Absolutely. So I really strongly recommend that people worried about debris removal go to the city of Pasadena website. They have a very nice infograph that shows there are debris removal process, and they described two phases. The first phase will be focusing on the removal of hazardous material, so lithium battery, propane tank, but also asbestos abatement. And so the way this is usually done, you wet the area to compact and prevent aerosolization of the hazards. You wrap it in a heavy plastic bag and you seal it. So you make a burrito. It's called the burrito wrapping method.

And so that is what's usually done to remove hazardous debris. And then once that's done, they do, they have a couple of verification step and then they move to the removal of non-hazardous debris. So this is really well spelled out on the Pasadena City website. And my understanding is this will be monitored by the EPA to make sure that this is done appropriately. So because the area is massive as people just regular human activity, this is going to take time and regular human activity has a risk of resuspending some of those contaminants in the air, but the removal process should be under very heavy oversight.

Jessica Neu:

Joost, do you have anything to add to that from the Marshall Fire?

Joost de Gouw:

Yeah, what we saw after the Marshall fire is the debris removal takes a long time, and during that time, there's of course concern about resuspension of ash. And now for the period that we measured inside these homes, there were windy days when you worried that ash is going to get resuspended. Inside these homes we did not see an effect necessarily of that. So the home seems to protect you from this at that point. It's important to keep windows closed on high wind days, but we think in combination with everything that Lauriane described, this can be mitigated to some extent.

Jessica Neu:

Great, thanks. So the next question that we're going to take is how far is far enough away not to worry? When is it safe for kids to play outside? And how do you think about that question? Sina, could you start us off with that?

Sina Hasheminassab:

Sure. So there is not a magic distance or that after which we can say it's safe and it's not really a black and white situation. There are a number of factors that really play together to determine the amount of exposure. A couple of things that come to mind is that the source itself is quite important, whether it's a minor source or a short-term emission, such as a passing vehicle that may resuspend dust, versus let's say leaf blowers that are constantly resuspending the deposited ash and dust for an extended period of time. So it's really important to keep in mind that what is the source of emission that we are talking about.

In addition to that, the meteorology specifically wind speed and direction is another factor. If wind is generally calm, we don't expect these resuspended ash on particles to travel longer distance. But of course, when we have a much stronger wind, we expect these particles to travel longer distances. At some point they will deposit, but again, it really depends on how much of them are in the atmosphere and how strong the wind is to carry them around. So those are some thoughts that I usually think about whenever it comes to the localized sources in this particular case deposited ash and dust.

Jessica Neu:

Thanks. Lauriane, is there anything you can add about how your risk pyramid kind of relates to making these types of decisions?

Lauriane Quenee:

Yeah, I mean, looking back at the inverted pyramid, elimination is always the first to go. So it might not be very actionable. Aside from leaving the area, there is no elimination aside from elimination of the source as well. So if you have visible source, you have also likely that fine dust. And so removal is really the critical piece to get us I would say on the other side of that event, engineering control would be keeping air purifiers indoors, making them run, making sure they're in the rooms where people sleep, and then PPE. So I know a lot of question about children and it's always hard to have them wear a mask. It's not always possible. So if you cannot apply the controls, you can only apply certain controls in certain situation and everybody's situation is very different. So there is a lot of factors, but really staying away from the source of the hazard, staying away from the hazard is the most efficient thing that you can do. So think about what is actionable at your level in each of those categories to make the best choice that's going to work for you.

Jessica Neu:

And then, Joost, could you speak for just a minute about how you might use the air quality index to help you make decisions about when to mask, when not to mask, when you're close and when you're not close?

Joost de Gouw:

Yeah, I think outside the air quality index remains a really good indicator of the risk you have with the caveat that the AQI was built for urban pollution and the pollution we're talking about here is a little bit different, but it's a good indicator nonetheless. If it's elevated, you run more risk. And I think another thing to add is that in Colorado the amount of metals in soils was limited, so that's heartening. But we need to be careful to translate this directly to Altadena given the age of the homes that was burned. So hopefully the measurements that Francois is still making, we'll shed some light on that.

Jessica Neu:

Okay. Francois, I'm going to ask you our last question. So lead doesn't just disappear. What happens when the ash mixes with soil and ordinary dirt post-fire? And should folks take precautions, for example, with their edible gardens or with grass where children and pets play?

Francois Tissot:

Yeah, absolutely. So yeah, lead doesn't disappear, absolutely. If you have a garden that you're growing things into, the general recommendation is if you have the option to remove the first six inches and replace it with fresh soil, do that. There are articles that we will post on the chat or in a follow-up link that show that it's mostly the grass-root vegetables that will uptake lead and other heavy metals. So things that grow outside the ground like tomatoes, if you rinse them, they should not have elevated lead inside of them. That has been found to be relatively safe as far as kids playing and the lead making it into the ground.

Most of the ashes we've tested so far is just like Joost has measured in his study, don't show extremely elevated lead, just a factor of a few compared to a regular soil. So once the lead will make it into the soil, it will at most double the amount of lead that is present, which means that you don't run a much higher risk. Of course, don't eat the ground and try to minimize how much you put the soil in your mouth, but it is not like because of the fire now everything is a hundred times more dangerous. So that would be the main recommendation.

Jessica Neu:

Great. Thanks. Sina, we've gotten quite a few questions about monitoring equipment and the availability of that kind of equipment. I'm going to say that maybe if you can give just a very brief response and then we'll put resources for people on the website for some of the things that you might talk about.

Sina Hasheminassab:

Sure. So I would start by saying that AQI is still a great resource here. That is sort of the official air quality information that's put out by regulatory agencies. Despite its caveats, we can still use that to get a good sense of air quality at the regional level. I also want to take this opportunity and recommend people to check out air quality forecasts that South Coast AQMB puts out on a daily basis. They also put out hourly forecasts, which is really useful for planning your daily activities. Another thing that I encourage people to keep an eye on is the air quality advisories that AQMB puts out. I mean, these are the notifications that they send out ahead of some events that are going to significantly impact air quality. The windblown dust advisories is quite relevant to this topic. So you can download their apps, set the settings to receive notifications and so on and so forth.

At the more local level, there are some other resources that I would like to encourage people to consider. One is the EPA's Fire AirNow, which aggregates data from regulatory monitors and a number of low-cost sensor networks. They calibrate the data from low-cost sensor networks and bring all of the data into the same scale. That is really useful for understanding the PM 2.5 levels at a more low level. Of course, people can also check out the Purple Air website or some other low-cost sensor dashboards or platforms to understand the levels of air pollution. But always keep in mind that these low-cost sensors readings may not be very accurate. Now going back to your question, Jessica, there are a number of commercial sensors out there that are now very popular. Some of the well-known ones include Purple Air and Clarity, that also, EPA Fire AirNow website aggregates those data into their map.

Generally speaking, the technology is quite mature for these low-cost sensors for particulate matter measurements. When it comes to VOCs, we do not recommend people to trust the readings of these sensors because again, the technology for VOC measurements at these consumer level products are not really there yet to provide accurate information about the levels of VOCs. Finally, at the very personal level, I want to encourage people to trust their common senses. That's very important. If you smell smoke, if you see plume of dust or ash, or even if you hear activities that may lead to resuspension of ash and dust, such as construction, such as leaf blower, those are the moments that you should trust your common sense and take actions regardless of what the AQI says or any of the other websites that I just mentioned. So I believe with the combination of these tools and resources, everyone can be very well aware of the environment and the air quality that they're being exposed to.

Jessica Neu:

Okay. Thanks, Sina. We want to thank everyone for attending and just to say that our hearts go out to everyone who has been affected by these fires and especially those who lost loved ones. A recording of the webinar and a recap of the discussion will be posted on Caltech's YouTube channel and on the Caltech Science Exchange. Researchers are contacting everyone in this group about various studies that are going to go on in the area. Right now there's a request for access to properties in the vicinity of the fire for ash testing. If you're interested in allowing access to your property, we've put a link for the Google form in the chat. For more information on this topic, the LA County Department of Public Health is hosting a town hall today at 6:00 PM. For residents to learn about air quality, safe cleanup, procedures, and soil and water safety. So go to their YouTube channel to watch, and again, the link is in the chat. Thank you everyone, and have a good rest of your day.