PVC and Infrastructure: An Update on the Emerging Threat to Ecological and Human Health

CEH
CENTER for ENVIRONMENTAL HEALTH

About CEH

The Center for Environmental Health (CEH) is a nonprofit organization committed to protecting people from toxic chemicals by working with communities, consumers, workers, government, and the private sector to demand and support business practices that are safe for public health and the environment. CEH assists large purchasers from government, education, healthcare, and private businesses to prefer healthier products and leverages their buying power to move the market towards safer products.

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Executive Summary

In the three years since the Center for Environmental Health (CEH) published our landmark report on the adverse health and safety impacts of plastic PVC pipes, "Our Health, PVC, and Critical Infrastructure" there have been significant developments to address and better understand the deleterious role of plastics in infrastructure and its associated ecological and human health harms.

The first meeting of the Intergovernmental Negotiating Committee (INC) to develop an international legally binding multilateral agreement on plastic pollution, including in the marine environment (Plastic Pollution INC-1), took place from 28 November to 2 December 2022 in Punta del Este, Uruguay. INC-1 is one of the most comprehensive and overarching attempts to address the 6.3 billion tons of planetary plastic waste, including the 8-12 million tons of plastic leaking into the marine environment each year. If the INC process succeeds it potentially will play a critical role in abating plastic pollution –which is expected to more than triple by 2050.

The road to INC-1 saw non-governmental organization (NGO) advocacy against plastic pollution accelerate. In 2021 the US based Center for Biological Diversity sued the U.S. Environmental Protection Agency (EPA) to force federal regulation of PVC as a hazardous material. While the outcome of this issue will be resolved by the federal court system, there is ample evidence to support many of the concerns raised by the Center's case, including much of the information included in our original report as well as the information exposed and highlighted herein.

Scholars have also weighed in against plastic pollution. New research has emerged from Purdue University's Prof. Andrew J. Whelton showing a definitive link between the thermal degradation of plastic pipes and components (during wildfires in particular) and the volatile organic chemicals later found to have contaminated drinking water.

2023 may be a breakthrough year in assembling previously disparate efforts to stave off the unfolding planetary plastics crisis. At a minimum there are clear pathways to begin curtailing plastic use in many sectors—from piping to critical infrastructure; and advance a robust national effort to ultimately end our use and dependence on plastics.

The Emerging Threat of Wildfires and PVC to Drinking Water Systems

Considerable resources in California are focused on making sure buildings – residential, commercial, educational, community, etc. – are either built or retrofitted to standards that will aid them in surviving an earthquake. For generations, fears of the so-called "Big One" have defined and shaped construction and building codes. While we are wise to continue our vigilance against earthquakes, we need to pay as much attention to an emerging, perennial threat of "The Hot One" – the rise of massive climate change induced wildfires that are destroying millions of acres and threating communities across California and the west which pose real and long term threats to drinking water systems.

Melting plastic pipes in water systems threaten health and safety both during and after the wildfire event.

Six of the California's most destructive wildfires – five of the deadliest and four of the largest in terms of land mass – took place in just the past five years (2017 and 2018).

We urgently need to better understand and study the aftermath of these infernos and the specific ways in which thermal degradation and destruction of PVC and plastic materials threaten human health across the state and region.

Melting plastic pipes in water systems threaten health and safety both during and after the wildfire event. Access to clean water is necessary for human health and for combatting diseases, including COVID. When plastic water pipes melt in a fire, firefighters do not have access to water to fight the fire. Megafires – a fire that burns more than 100,000 acres –are rare events. As a result of our changing climate, they are becoming all too common. In addition to these impacts while the fire is raging, the public is just now learning more about what happens *after* the flames are extinguished.

Melting Plastic Pipes: The Danger Lurking in the San Lorenzo Valley Water District

In August 2020, a powerful thunderstorm produced nearly 11,000 lightning strikes that started hundreds of fires of varying size and intensity across Northern California. In the San Lorenzo Valley of the Santa Cruz Mountains, a particularly dangerous wildfire melted more than 5 miles of plastic pipe that conveyed water to residences and businesses in the Boulder Creek area. That fire became known as the "CZU Lightning Complex Fire," and it eventually burned more than 86,000 acres and destroyed more than 7,000 buildings and much of the existing infrastructure across the area.

> "The 7.5 miles of pipe melted in Boulder Creek was made of polyethylene — a plastic that can release toxic compounds."

Water utilities in California and the other Western states that must contend with wildfires face a choice when they decide what kind of pipes to use throughout their systems. The San Lorenzo Valley Water District learned first-hand the perils of plastic pipes and the impact the fire had on their water system. The *Santa Cruz Local* described the situation[1] accordingly:

> "Many homes and businesses around Boulder Creek remained without running water Wednesday as the San Lorenzo Valley Water District replaces 7.5 miles of water intake pipeline melted or otherwise damaged by the CZU Lightning Complex Fire.
>
> "Beyond the immediate destruction, melted pipelines may contaminate the water supply with dangerous chemicals, officials said.
>
> "The 7.5 miles of pipe melted in Boulder Creek was made of polyethylene — a plastic that can release toxic compounds.
>
> "Even if the melted pipes have not immediately contaminated the water supply, the ash and debris left by the fires may impact the health of the watershed for months to come. Long after the fires are put out, rains can wash ash and toxic debris into local rivers and streams.

A plastic water pipe (left) and meter box (right) recovered from homes in Paradise, Calif., after the Camp Fire scorched the community in 2018 reveal the degree to which plastics can melt when exposed to high temperatures

Required attribution: Andrew Whelton/Purdue University, CC BY-ND.

Source: [33] **Pulled from:** [34]

> ” The damaged surface piping was made of flammable plastic. To prevent damage in future fires, [Rick Rogers, San Lorenzo Valley Water District's district manager,] said the new pipelines will either be buried underground or made of a fireproof material such as steel. “When you look at how [the pipes] melted, it's a catastrophic failure,” said Rogers. “We can't put them back that way.”

The result of the fire and the damage to their water supply system was “an estimated $11 million in damage to pipes, meters, mains, tanks and other San Lorenzo Valley Water District infrastructure and equipment,” according to the *Santa Cruz Sentinel*[2]. Melting plastic pipes have cost communities millions of dollars to rebuild their water systems, and the residents eventually have to shoulder that burden.

San Lorenzo isn't the only water system that's facing this challenge. The town of Grizzly Flats, CA, was “nearly decimated”[3] by the Caldor Fire, which ultimately burned over 200,000 acres in August through October of 2021.[4] The destroyed structures are far from the only problem Grizzly Flats faces following the fire. While the water treatment plant “miraculously ... escaped the flames,” underground plastic pipes weren't so lucky. “PVC line that was two feet deep was burned because of tree roots on fire,” said Jodi Lauther, general manager of the Grizzly Flats Community Services District, which treats and provides water for the town.[5]

New Research into the Hazards Presented by Melting Plastic Pipes After Wildfires

In addition to the monetary costs of repairing or replacing water system components due to damage cause by melted plastic pipes, the damaged plastic pipes present many other problems. Melting plastic emits dangerous toxins into the air, and degradation of plastic pipes will release dangerous toxins into the water system. As detailed below, studies of the California wildfires and other research shows the following: buried plastic pipe has melted

during wildfires; plastic pipes can absorb benzene and other dangerous chemicals more than other pipe materials and are more difficult to flush than other materials; and a pattern has emerged of benzene contamination following wildfires in communities that have plastic pipes.

In 2018, the Camp Fire tore through Butte County, CA, and surrounding areas. Tragically, 85 people lost their lives. It took less than 24 hours to completely destroy the town of Paradise. As residents slowly made their way back home, they had no idea that another danger was lurking. The town used plastic pipes in its drinking water system, all too common in California and other communities across the country. Yet the plastic pipes were insufficiently resilient and did not stand up to the wildfire and led to broader health, safety, and contamination issues for their community.[6]

"Paradise Irrigation District officials say they have taken about 500 water samples around town, and they have found benzene 30 percent of the time."

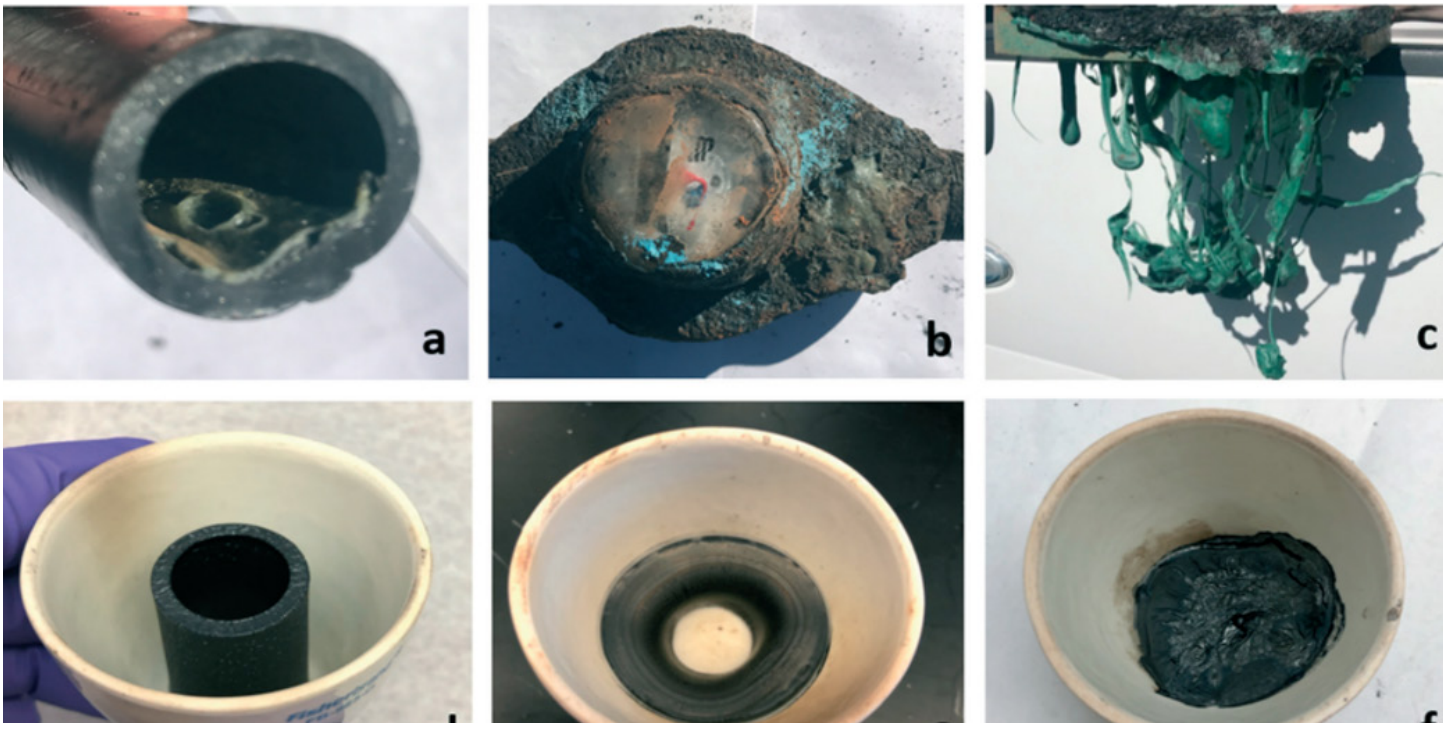
After reports of bad odors coming from faucets and other places, officials investigated and eventually found that benzene had seeped into the drinking water system. An *NBC News* report[7] described the situation:

> "Officials said they believe the contamination occurred when the November firestorm created a 'toxic cocktail' of gases in burning homes that got sucked into the water pipes as residents and firefighters drew water heavily, causing a vacuum in the system that sucked in the toxic fumes, the *Sacramento Bee* reported Thursday.
>
> "Officials say that may explain why benzene, which has been linked to anemia and leukemia, has been found in tests at various spots rather than from one source in Paradise, where 90 percent of the buildings were destroyed.
>
> "Paradise Irrigation District officials say they have taken about 500 water samples around town, and they have found benzene 30 percent of the time."

Researchers also found evidence of benzene contamination in some areas following the Tubbs Fire in 2017. Both the Tubbs and

the Camp Fire were the first known instances of such poisoning after a wildfire, and the state embarked on extensive testing following each.[8] Data are sparse to give us a full picture of how many other communities impacted over the years by destructive wildfires have had similar contaminated water flowing into their homes following the fires. A common denominator with these two communities is that all the areas where benzene was detected had some presence of plastic pipes in their water distribution systems.[9]

Thermally degraded plastic can release a dangerous chemical cocktail. Researchers at MIT have found burning plastic releases a mixture of dangerous chemicals including: hydrochloric acid, sulfur dioxide, dioxins, furans heavy metals, as well as particulates.[10] These emissions are known to cause respiratory ailments and stress human immune systems, and they're potentially carcinogenic.[11] That's what we *know* happens when plastic is burned. However, since widespread testing of water systems following damaging fires is only recently beginning to become a standard practice, the body of academic research on how a wildfire can affect pipes that melt down to ash when burned is also just beginning.



Images of fire-damaged water system components including (a) a HDPE plastic pipe, (b) a water meter, and (c) a water meter cover following the Camp Fire. Thermally degraded pipe samples in laboratory experiments include the (d) PEX-c pipe degraded at 300 °C, (e) HDPE pipe degraded at 300 °C, and (f) HDPE pipe degraded at 400 °C.

Source:[35]

Other pipe materials made out of metal or even concrete are on their face much more resilient to fire, if only because we know they are subject to considerably less wildfire degradation, in comparison to the PVC plastic based counterparts.

In a 2021 paper, titled: "Drinking water contamination from the thermal degradation of plastics: implications for wildfire and structure fire response" researchers from Purdue University found, "A variety of plastic materials were present in all water distribution networks affected by the fires, including polyvinyl chloride (PVC), high-density polyethylene (HDPE), and polybutylene (PB) pipes, along with ethylene propylene diene monomer gaskets and polypropylene and nylon water meter components." The Purdue researchers added, "certain plastics in the network may serve as a primary [volatile organic compound] source through *in situ* plastic pyrolysis."[12]

Whelton and a team of researchers received funding[13] from the Paradise Irrigation District and Paradise Rotary Foundation to investigate dangerous levels of benzene and other chemicals detected in the town's drinking water after the Camp Fire. They conducted an extensive investigation and found that local officials had underestimated the danger presented by the off-putting odor of drinking water. To be fair, prior to Whelton's team efforts, few suspected the extent of dangerous contamination belabouring the water system.

There has been no official determination of the specific cause of the benzene poisoning, and despite the strong correlation, Whelton's initial research has yet to make a direct link between the melted plastic pipes in Paradise and subsequent benzene contamination. Nevertheless, the research is clear that VOCs like benzene are generated when plastic pipes are thermally damaged by fire, and those contaminants can then leach from damaged plastic into drinking water.[14] Plastic pipes can melt, but metallic pipe materials do not melt in wildfire situations. With those facts, one has to ask why the plastic pipe industry rushed out a report[15] denying any connection between the melted plastic pipes – the same types of pipes that we extensively detailed in our original

report are manufactured from a potent chemical concoction – and the benzene poisoning or other contamination.

Researchers reveal that degraded PVC plastics are a major part of the post-wildfire drinking water problems.

Importantly, further analysis and additional research from Whelton and colleagues shows there *is* a connection between melted plastic and contaminated water. In his September 2021 Royal Society of Chemistry paper Whelton, et. al., note:

> "Widespread volatile organic compound (VOC) contamination was found in water distribution systems following three wildfires in California. A potential source of this contamination was thought to be due to the degradation of plastic components in drinking water distribution systems. Eleven plastic drinking water pipes, across eight brands, were exposed to elevated temperatures (200 °C to 400 °C), and subsequently submerged in water or in n-hexane to observe the extent of VOC leaching. Results indicated that thermally damaged drinking water pipes can be sources of VOC leaching, with ten of the eleven materials leaching benzene, a carcinogen, into water."[16]

What's more, the plastics industry clearly has a vested interest in issuing reports that confirm its innocence. However, the initial studies from independent researchers who have examined this issue lead to more questions than the plastic industry can seemingly answer. Conducting further independent research or government funded studies into this important issue will hopefully bring about a conclusion to this issue and we expect those studies to show that the plastic industry's attempt at public relations spin is not rooted in empirical facts.

Whelton and Proctor argue, "Evidence suggests that the toxic chemicals originated from a combination of burning vegetation, structures and plastic materials."[17] They further add that while "some plastic pipes needed more than 280 days of flushing to make them safe again. ... Some plastics may be practically impossible to make safe again, since all types are susceptible to fire and heat."

Whelton and Proctor also make a strong case for PVC plastic pipes being linked to the benzene contamination. While they may not

be the sole cause, as indeed there could be several reasons, it appears that the melted plastic played some role in contaminating Paradise's drinking water system. The damage was so extensive that the town spent[18] $53 million over two years to rebuild. Unfortunately, officials in Paradise don't seem to have learned the lesson that, when it subject to the intense heat from wildfire, plastic pipes will burn, melt, and release volatile chemicals as they are rebuilding their drinking water system with HDPE piping. It will be even more costly if those pipes are again destroyed by a wildfire.[19] Given the questions about benzene, plastic and wildfires, certainly the residents of Paradise would benefit from further research and answers from their elected officials.

In a second 2021 study[20] and accompanying article[21] Whelton, et. al., consider the after-effects of contamination to drinking water from wildfires. Researchers reveal that degraded PVC plastics are a major part of the post-wildfire drinking water problems. They argue: "The problem starts when wildfire smoke gets into the system or plastic in water systems heats up. Heating can cause plastics to release harmful chemicals, like benzene, which can contaminate drinking water and permeate the system."[22] In that same post and accompanying article, Whelton and his colleagues indicated that they have found at least seven water systems contaminated after a fire, "suggesting drinking water contamination may be a more widespread problem than people realize."

Eliminating Plastics: Towards A National Strategy

The Biden Administration has made clear that it is taking the threat of plastic to our environment very seriously both now and in the future as a major contributor to climate change[23]. The images of plastic-covered beaches, plastic rings strangling ocean life and sea birds, and enormous rash piles in undeveloped countries that seem like easy dumping grounds for the world's pollution –are sadly much too familiar.

The Center for Environmental Health is proud to be among the more than 550 organizations that signed[24] a Presidential Plastics

Action Plan that provides eight executive actions President Biden could take to start solving the plastic pollutions crisis. The list of actions includes:

- Use the purchasing power of the federal government to eliminate single-use plastic items and replace them with reusable products;
- Suspend and deny permits for new or expanded plastic production facilities, associated infrastructure projects, and exports;
- And stop subsidizing plastic producers.[25]

PVC plastic pipes require more energy to pump water than other pipe materials, many of which have been proven to be more resilient and longer lasting than plastic.

The United States could also do well by following the lead of the Canadian government, which is considering adding PVC plastic manufactured items to its national Toxic Substances List. These efforts began in 2019 when the Canadian government announced it was taking steps to reduce plastic waste, including banning certain single-use products[26]. The Vinyl Institute and fellow plastic industry allies have sent letters to the Canadian Minister of Environment and Climate Change asking that it not proceed accordingly.

The Canadian Minister of Environment and Climate Change's terse reply is telling: "In your Notice of Objection, you state that the Science Assessment of Plastic Pollution was published without a complete view of the best available science. I can assure you that in preparing the Science Assessment, the current state of science regarding plastic pollution was reviewed and the assessment presented a thorough summary of the science available in the peer-reviewing literature at the time it was written."[27]

It's not just the production process that creates emissions. PVC plastic pipes require more energy to pump water than other pipe materials, many of which have been proven to be more resilient and longer lasting than plastic. Plastic pipes are themselves generally not sustainable because they are typically made of virgin material, requiring more waste and a more intensive manufacturing process.

The Center for Environmental Health calls on the federal and state governments to take swift and immediate action to curtail the use and manufacturing of more plastic.

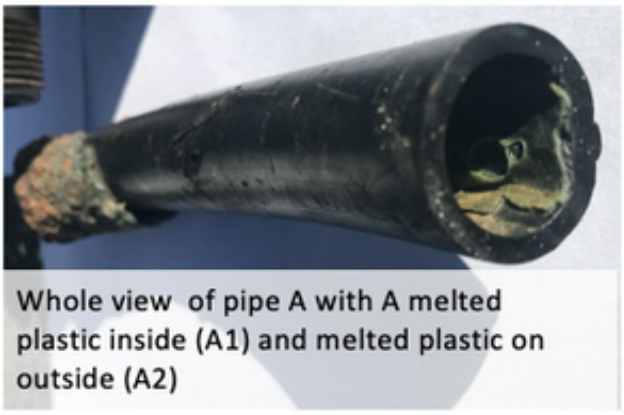
Alongside possible federal action, as of February 2021, eight states have enacted bans[28] on single-use plastic bags: California, Connecticut, Delaware, Hawaii, Maine, New York, Oregon, and Vermont. Washington, D.C., is among jurisdiction that created a fee for each single-use plastic bag customers use. California, Vermont, and several municipalities have banned plastic straws with some exceptions.

Those bans came about, in part, because consumers demanded them. The plastics industry and its allies strongly pushback against all instances to curb usage of their products, but the writing on the wall is clear: people are looking for an alternative to plastics—one that is environmentally safe and meets the requirements for materials to do not contribute to worsening climate change.

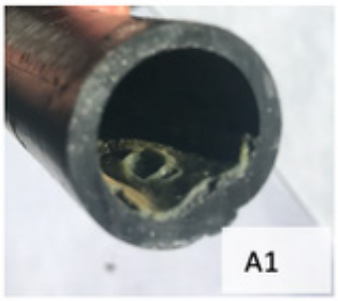
As for the plastics industry's efforts to rebrand itself as an environmental champion have proven wanting at best and a demonstrable failure in the worst cases. *PBS'* "Frontline" teamed up with National Public Radio to produce a scathing look[29] at the plastics industry's decades-long deception over recycling. Industry

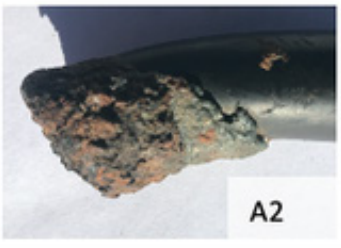
Melted and re-hardened plastic inside pipe w/ different color

Pipes — melted plastic found within pipes



Whole view of pipe A with A melted plastic inside (A1) and melted plastic on outside (A2)





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Source: [36] **Pulled from:** [37]

insiders and former plastics executives talked about the recycling initiatives that companies promoted. However, at their heart those efforts were a shady effort to make people feel better about using products in which no more than 10 percent ever get recycled[30]. The industry's dirty secret, which it started to make people feel better about buying more plastic, is out. "There was never an enthusiastic belief that recycling was ultimately going to work in a significant way," Lew Freeman, former vice president of Government Affairs for the Society of the Plastics Industry, told "Frontline."[31]

Governments should protect the health and safety of its residents by prohibiting the use of plastic water pipes in general and especially in areas prone to wildfires given the known and unknown risks of plastic water pipes.

The Center for Environmental Health calls on the federal and state governments to take swift and immediate action to curtail the use and manufacturing of more plastic. Governments should protect the health and safety of its residents by prohibiting the use of plastic water pipes in general and especially in areas prone to wildfires given the known and unknown risks of plastic water pipes. At the federal level, the Biden Administration can at a minimum follow through on statements to end subsidies to the plastics industry; and order the EPA to investigate the link between melted plastic pipes and benzene poisoning. [32] States should prohibit single-use plastics in public buildings and require state-level environmental protection agencies to look at listing plastic as a toxic substance to their registries. States prone to wildfires should require utilities that are in areas likely to suffer catastrophic blazes to analyze the lines used in drinking water systems for the prevalence of plastic pipes; and require them to conduct feasibility studies of replacing plastic pipes with more resilient materials that will not melt when burned.

Plastic products are so ubiquitous that even those deeply committed to the eradication of single-use items struggle to eliminate them from our daily lives. We understand the need for using plastic materials in health care and certain other industries. But the prevalence of plastic in our drinking water systems is something that can and should be avoided. The plastics industry is in a fight for survival, and that kind of fight makes people do desperate things. It's time we call them out on their hubris, which matches that of tobacco executives. May their fall be just as magnificent.

Endnotes

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