Abstract

The air in houses can be affected by bad stuff, called contaminants. Sometimes harmful chemicals enter the air in buildings from nearby contaminated soil and groundwater through cracks or gaps in the foundation – a process known as vapor intrusion. This poses some risk to our health because we spend so much of our time indoors. Currently it’s difficult and expensive to figure out if vapor intrusion is happening. That’s why we wanted to see if trees can serve as indicators for vapor intrusion. We collected samples from 109 trees in a contaminated area in a Nebraska town and analyzed them for tetrachloroethene (PCE), a chemical used mostly as a cleaner and to make other chemicals. When comparing our results with the data the U.S. Environmental Protection Agency (EPA) had collected, we found that trees are good indicators of vapor intrusion.

Introduction

When we talk about air pollution, we usually imagine big factories that produce a lot of chemicals, or traffic jams in big cities. These are serious issues that can cause many health problems, but they usually affect the air outside. Most of us spend much more of our lives indoors – at home, school, or work – where we breathe “indoor air,” or air inside buildings. Sometimes the indoor air can be contaminated: some building materials emit harmful vapors, paints can emit volatile organic compounds (VOCs), wood-burning stoves produce a lot of smoke particles, etc. There is another pathway for harmful chemicals to enter our homes. Sometimes harmful chemicals are spilled on the ground surface, polluting the soil and groundwater underneath. These pollutants can then enter the buildings from underneath our feet – usually through cracks in the foundations (Figure 1). This process is called vapor intrusion.

It’s not very easy to measure and assess vapor intrusion because it takes a lot of time and expensive equipment, as well as access to private homes (and many people don’t want any strangers there). That’s why we wanted to see if analyzing nearby trees could give us the same information. After all, through photosynthesis, trees absorb water and various nutrients from surrounding soil and groundwater. Trees can also absorb harmful chemicals if they are present. We thought maybe we could use tree samples to measure concentrations of these harmful chemicals in soil vapor and groundwater near homes. If it worked, it would be cheaper and faster than the traditional methods.
Methods

Tree-core samples have been used for years by foresters to count tree rings and determine the age of trees. We decided to adapt this method to look for contamination. In November 2016 we collected a total of 121 samples from a site in Nebraska contaminated with tetrachloroethene (PCE) (Figure 2). The samples consisted of:

- 109 tree-core samples
- 10 replicate samples (samples of the same trees to see how well the values can be repeated)
- 2 control samples (samples that show if there is contamination getting into the tree-core samples from other sources).

About half of the samples originated from a residential area and the other half came from the downtown business area. Next we analyzed these samples for PCE using gas chromatography (separation of chemical compounds).

Between November 2014 and September 2016, the U.S. Environmental Protection Agency (EPA) tested this region. They collected and analyzed groundwater, soil, and soil-gas samples as well as indoor air and air below the foundations of buildings, also called sub-slab samples (Figure 3).

We compared the data the EPA had collected with our results to see if trees would be good indicators for vapor intrusion.
What Can Trees Tell Us About the Air We Breathe at Home?

Results

The concentrations of PCE were high (greater than 4.7 nanograms per liter) in 14 of the trees we sampled. However, we also detected PCE in 23 more trees at lower concentrations (see the triangles in Figure 2). Most of the trees with high concentrations of the harmful compound were near the downtown business area. The control samples were clean (meaning no chemicals got into the tree-core samples from outside sources) and the replicate samples had only small variations.

Figure 4 shows the correlation between our tree sample results regarding PCE concentrations and the results from the EPA’s traditional methods.

Discussion

We did not see any correlation between PCE concentrations in the tree-core samples we collected to PCE in groundwater or soil samples. The reason for this may be that the locations of trees we sampled were not spread evenly across the area where the EPA samples were collected, and where there were high groundwater and soil PCE concentrations there were not many trees to sample. Comparing the results for soil gas and sub-slab to tree-core samples, however, showed more promising results. This is good news, because other scientists and the EPA have shown that both soil gas and sub-slab samples seem to be good indicators for vapor intrusion.

Other good news is that the tree samples we collected are good indicators of chemicals in indoor air as well. There was a high correlation between PCE concentrations in tree-core samples and PCE concentrations in indoor air samples the EPA had collected over long periods of time (months to years). This is another advantage of tree-core sampling over traditional methods: trees give information about contamination over longer periods of time while traditional samples give information about contamination over shorter periods of time.

Trees make an excellent initial indicator for vapor intrusion because tree core sampling doesn’t require much equipment, takes less time, and is a lot cheaper than traditional sampling methods.

Conclusion

In the unlikely event you find out there is contamination near your home or school, it’s not a bad idea to check for vapor intrusion. Even if there is no contamination nearby, we can all do a lot of things to improve the quality of our indoor air: open windows regularly, completely close the caps on all chemicals at home, and not buy more chemicals than we need.

Do tree-core PCE concentrations correlate well with indoor air PCE concentrations?

![Figure 4: Correlation between tree-core PCE concentrations and recent (within 6 months) or older (more than 6 months to 2 years) average groundwater, soil, soil gas, sub-slab, and indoor air tetrachloroethylene (PCE) concentrations.](image)
WHAT CAN TREES TELL US ABOUT THE AIR WE BREATHE AT HOME?

Glossary of Key Terms

**Control sample** – sample collected to determine if anything is getting into samples that should not be attributed to the main sample. In our case, we wanted to be sure no contaminants from somewhere else were getting into the tree-core sample.

**Correlation** – in our case, agreement between two measurements. If our tree-core concentrations were exactly the same as the EPA concentrations, that would be a correlation of 1. If our concentrations didn’t agree at all, that would be a correlation of 0.

**Emit** – to release something, especially a gas or radiation.

**Gas chromatography** – a laboratory technique for the separation and identification of individual chemicals in complex mixtures.

**Photosynthesis** – the process by which plants turn sunlight into food for themselves. They consume water and nutrients from the subsurface as well as carbon dioxide from the air, and release oxygen in the process.

**Replicate sample** – sample collected to measure the reproducibility of results because there can be variability in nature.

**Sub-slab** – area below the foundations of buildings.

**Tetrachloroethene (PCE)** – chemical used in dry cleaning and as an industrial degreaser. It’s a volatile organic compound, meaning it evaporates quickly and likes to be a vapor rather than a liquid. It can cause damage to the kidneys, liver, and central nervous system. It may also increase the risk of cancer.

**Vapor intrusion** – when chemicals in soil or groundwater (especially volatile organic compounds) enter buildings through cracks or gaps in the foundations.

**Volatile organic compounds (VOCs)** – organic chemical compounds that evaporate under normal indoor air conditions (because they have a low boiling point). Some VOCs have harmful health effects. For example, toluene, a component in many paints, is a VOC and can cause brain damage.

Check your understanding

1. If there is no contamination near your home, should you be worried about vapor intrusion?
2. What are the advantages of tree sampling over the traditional methods for assessing vapor intrusion?
3. What makes trees potential indicators for soil contamination in general?
4. Can you think of any other indicators (plants or animals) for air pollution?

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