INTRODUCTION

Volatile organic compounds (VOCs) are emitted into the atmosphere, either by natural or anthropogenic processes, as a gas that derives from certain solids or liquids. Common VOCs include carbon dioxide and monoxide, methane, propane, butane, etc.

DANGERS OF VOC

Minor symptoms of VOC exposure are irritation to the eyes and throat as well as headaches. Significant or prolonged exposure has been shown to increase risks of cancer, along with potential damage to the central nervous system, liver, and kidney ([Minnesota Department of Health](https://www.health.state.mn.us/communities/environment/air/toxins/voc.htm#:~:text=Common%20examples%20of%20VOCs%20that,and%201%2C3%2Dbutadiene.)).

VOC SPECIFIC TO STUDY

Roughly a dozen common VOCs can be found indoors at 2-5 times the level that they would be found at in outdoor environments ([EPA](https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality)). Studies have found that certain household products can elevate and maintain higher concentrations of VOCs for an extended period. One of these appliances is the stove. In this analysis, we investigate the VOC levels in 3 areas differing in either setting or appliance use.

METHODS & MATERIALS

To examine the effects of stoves on household VOC levels, we used pre-deployed and programmed [Particle.io Air Quality Senor Kits](https://docs.particle.io/air-quality-monitoring-kit/) at three locations. Code used to program and run these devices can be found [here](https://jakehosen.github.io/Ecological_Sensors/sensorsetup.html). An outdoor sensor collected data that was used in a setting comparison (outdoor versus indoor) as well as being a control for the natural VOC levels outside when comparing electric and gas stove use indoors. GPS coordinates were used to identify sensor location via [Google Maps](https://www.google.com/maps). The outside sensor was located near a bus stop in Gainesville, Florida. Both indoor readings came from Indiana, with the gas-stove home being in Lafayette and the electrical stove home in West Lafayette.

All data analyses were completed using Microsoft Excel (Microsoft Corporation, Redmond, Washington). Each site was graphed on a scatterplot with millivolts at a range of 0-800, obtained from Air Quality kit raw data. The greater the millivolts, the higher the VOC levels. This was used for comparison over the VOC level as the raw data provides a more in-depth quantitative analysis. In each graph the first 5000 plots for each data set were used, with the millivolts plotted y-axis and successive data plot count on the x-axis. An MS Excel generated linear trendline with an R2 value was applied to each scatterplot to determine coarse trends in the data and to compare how well the linear function matches to the data (Figure 1). Site-based statistics were created to make comparisons between the data (Table 1).

RESULTS & DISCUSSION

Site-Statistics

The site-statistic results can be accessed in Table 1. The outdoor location experienced an average millivolt reading of 120, with a maximum recorded value of 174 and a minimum of 90. A range of 84 was found within the first 5000 data plots, the lowest range at any site. The indoor location with an electric stove experienced the highest average millivolt reading of 423, with a maximum recorded value of 774 and a minimum of 251.The electric stove site also had the largest range of 523. Regarding the indoor location using a gas stove, the mean millivolt reading was 164, with a maximum value of 470 and a minimum of 100.

Scatterplots over time

Visual comparisons of the scatterplot graphical comparisons can be accessed in Figure 1. The outdoor site recorded consistent and low millivolt readings. However, this site had the lowest R2 value, indicating that even thought the data was consistent, most linear interpretations did not accurately reflect the data. The slope of this line was also roughly zero (m=-0.0003) indicating similar fluctuations around the trendline occur throughout time. The indoor electric stove site contains the highest millivolt readings, with six to eight dramatic spikes in millivolt values that sharply declined and one spike at the 3250 data plot that declines gradually through the remainder of the analysis. The indoor gas stove had less spikes both in quantity and value over the analysis, yet almost all rises in millivolts ended with a gradual reduction in value.

Outdoor vs indoor stove

In the comparisons between indoor versus outdoor location in terms of VOC exposure, all site statistic values found in Table 1 are smaller at the outdoor site than either of the indoor sites. Outdoor mean exposure levels are roughly 3.5 times less than in the electric stove location, while the gas stove location is roughly 1.4 times the exposure compared to the outdoor. No major fluctuations in the data occurred at the outside location. The high amount of similarly valued fluctuations in the outdoor sensor is assumed to be due to wind, as this natural phenomenon stirs up air and can control or alter the path of VOCs in the atmosphere.

Gas vs electric

When comparing the two indoor locations between each other, electric stove levels millivolt readings were on aveage over 2.5 times the readings of the indoor location using a gas stove. The minimum value of the electric location is also higher than average value of the gas location. This is unexpected, as gas stoves typically emit higher levels of VOCs than electric ones. Thus, we conclude that there is most likely an additional souce of VOC emmisions in the electric stove envrionment.

Graphical user interface, application, table, Excel

Description automatically generated

Graphical user interface, application

Description automatically generated

CITATIONS

*Air Quality Monitoring Kit: quick start*. Particle. (n.d.). <https://docs.particle.io/air-quality-monitoring-kit/>.

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Volatile Organic Compounds (VOCs) in Your Home - EH: Minnesota Department of Health. (n.d.). <https://www.health.state.mn.us/communities/environment/air/toxins/voc.htm#:~:text=Comm on%20examples%20of%20VOCs%20that,and%201%2C3%2Dbutadiene>.

Code for Air Quality Sensor Setup

<https://jakehosen.github.io/Ecological_Sensors/sensorsetup.html>

GPS Locations – Google Maps

<https://www.google.com/maps/place/29%C2%B039'20.6%22N+82%C2%B018'52.9%22W/@29.65571,-82.3168887,17z/data=!3m1!4b1!4m5!3m4!1s0x0:0x0!8m2!3d29.65571!4d-82.3147>

<https://www.google.com/maps/place/40%C2%B024'53.6%22N+86%C2%B052'02.3%22W/@40.41488,-86.8673,17z/data=!3m1!4b1!4m5!3m4!1s0x0:0x0!8m2!3d40.41488!4d-86.8673>

<https://www.google.com/maps/place/40%C2%B028'17.3%22N+86%C2%B056'36.6%22W/@40.47146,-86.9435,17z/data=!3m1!4b1!4m5!3m4!1s0x0:0x0!8m2!3d40.47146!4d-86.9435>