Detecting Pesticides in UIUC Greenhouses

Save the Bees

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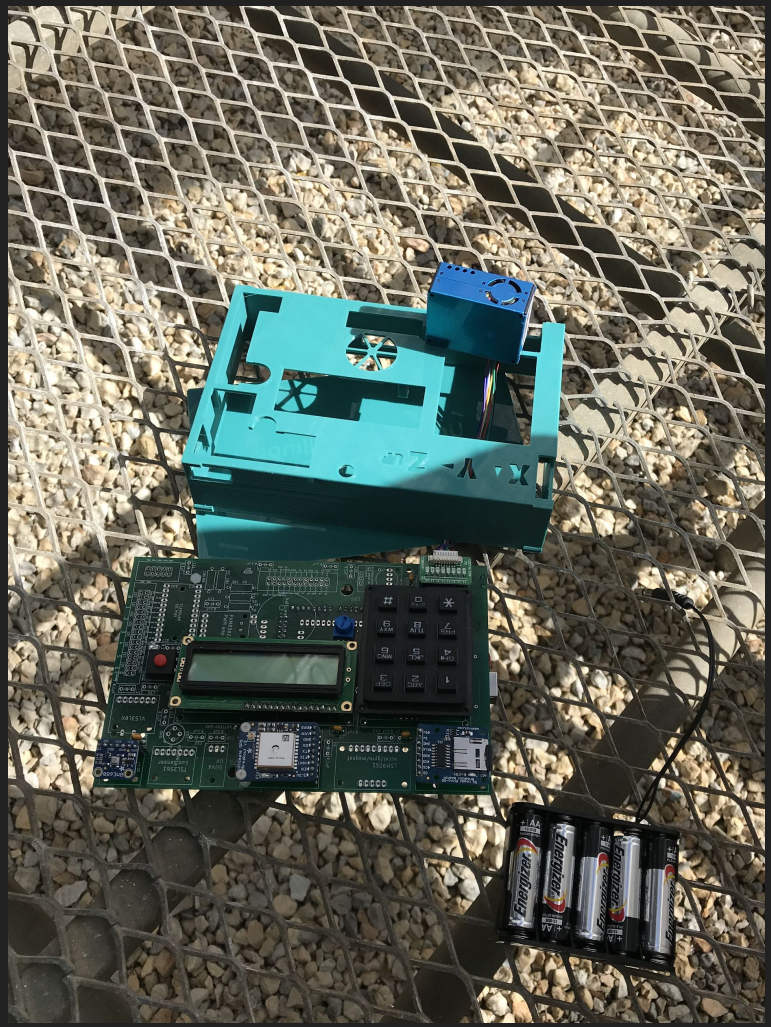
Introduction

- Purpose - acquire more data on pesticide use in order to learn more about their potential externalities
- Particulate Sensor measures how long aqueous pesticide particles persist in the air
- American study shows the rusty-patched bumble bee and monarch butterfly populations have decreased by ~90%

Hardware

- Arduino
- BME680 (temp., humidity, gas sensor, pressure)
- PM2.5 Air Quality Sensor
- Ultimate GPS Breakout
- Precision I2C Real Time Clock
- MicroSD Breakout
- INA219 DC Current Sensor
- Keypad
- Liquid Crystal Display screen

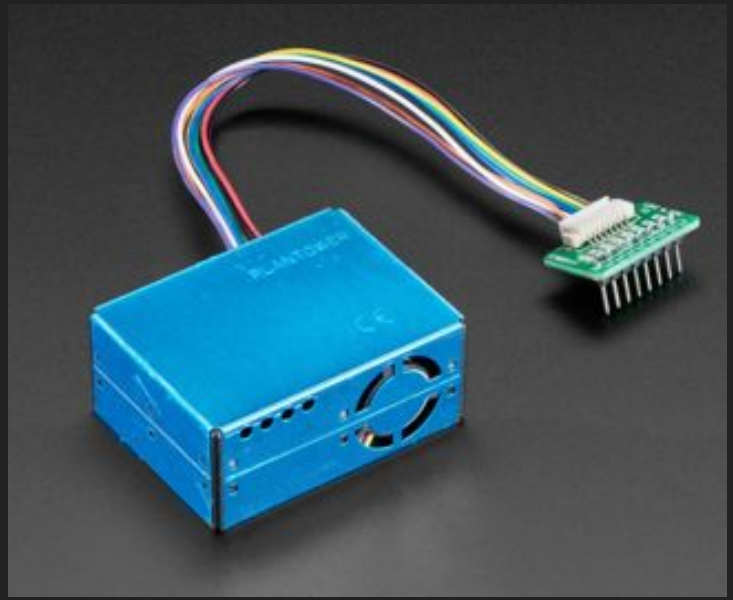

X- Y- Z+
Energizer


X- Y- Z+
Energizer

Hardware - PM2.5 Air Quality Sensor

PM2.5 Air Quality Sensor was the most important sensor used in our experiment since we were interested in determining the air quality, or persistence of pesticide particles in the air over a range of time.

- Uses light scattering to measure the amount of suspended particles in the air
- Collects data for 0.1L of air at a time with the fan inside the device
- Sensor specifications show that it data collection was very precise in the temperature of the greenhouses



Data Acquisition

- DAQ loop ran 20x per second
- Opened SD card on initial run
- SD file remained open until one of:
  - Batteries reaching critical level
  - Specified time limit reached
  - Manually turned off using keypad

Data Acquisition

- Data printed to SD card included:
  - BME680 Temperature, Pressure, Humidity, and Altitude
  - Particulate data of various sizes
  - Voltage, current, and power
  - GPS information when relevant
- Datum separated by commas
- Headers were printed at top

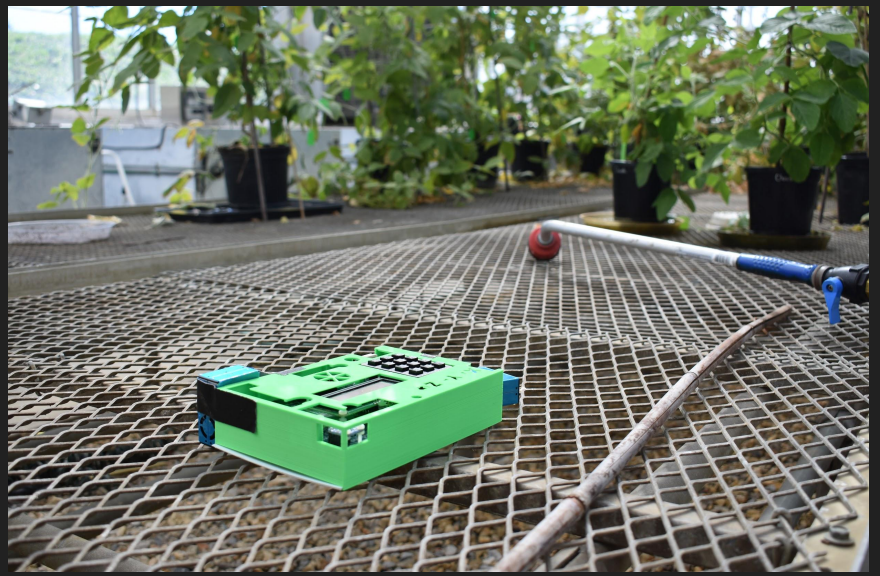
```
myFile.print(BME680_T); myFile.print(",");
myFile.print(BME680_P); myFile.print(",");
myFile.print(BME680_H); myFile.print(",");
myFile.print(BME680_A); myFile.print(",");
myFile.print(particles_03); myFile.print(",");
myFile.print(particles_05); myFile.print(",");
myFile.print(particles_10); myFile.print(",");
myFile.print(particles_25); myFile.print(",");
myFile.print(particles_50); myFile.print(",");
myFile.print(particles_100); myFile.print(",");
myFile.print(busVoltage); myFile.print(",");
myFile.print(current); myFile.print(",");
myFile.println(power);
```

Data Acquisition Testing

- Testing of device was done on various sources:
  - Soldering station
  - Grilled cheese sandwich
  - Flour in air
  - Sawing
  - Walking around Loomis

Experiment

- Experiments were originally planned to be done outside on fields. However, due to the fact that spraying happens in June and July, we had to conduct our experiments in green houses (30 ft by 15 ft, with a 12 ft ceiling)
- UIUC Green houses were sprayed by a licensed professional (S/O to Monty)



Experiment - Pesticides and Spraying details

- Various aqueous pesticide solutions were used in the spraying process
- Some were known to be more harmful to the environment and people's health than others

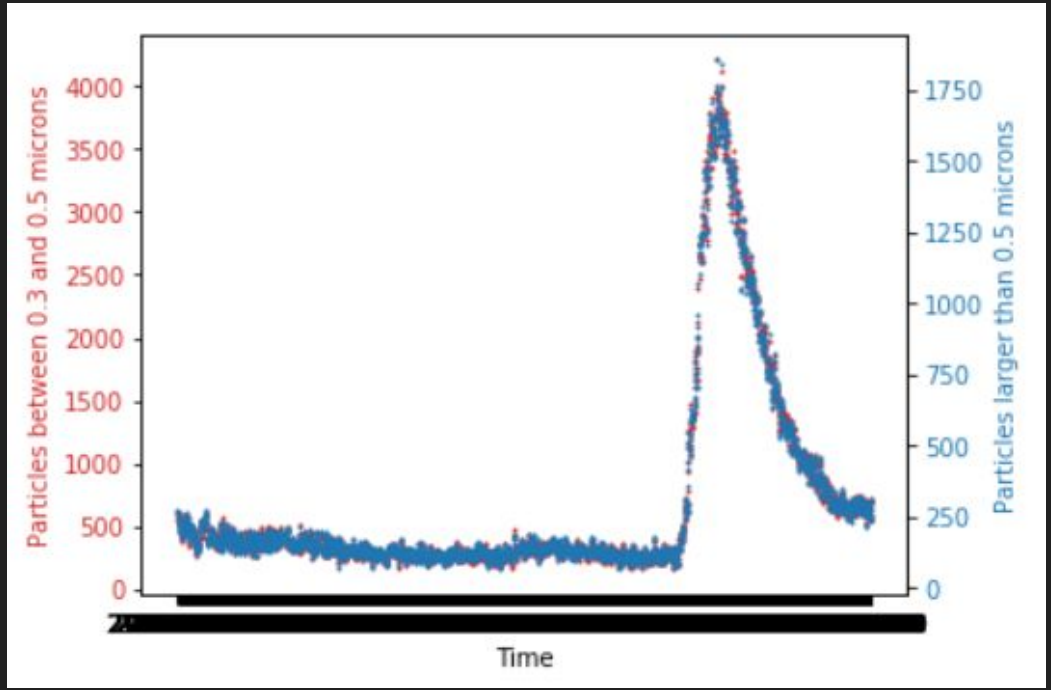
  Ex. Buprofezin is labeled as a health and and environmental hazard

- Spraying occured around 4pm
- Re-entry was not allowed until 7am the following day

Experiment - Results

- Spraying began at the start of the increased particle amounts.
- After the spraying, the particulate count falls exponentially

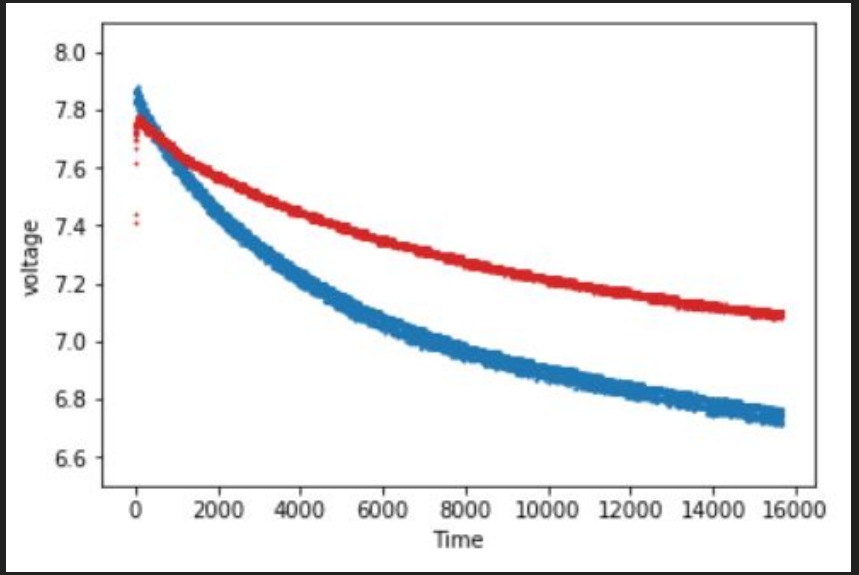
Data Analysis Details Explained in Next Slides



Experiment - Biggest Challenge to Overcome

Battery Life and Power

- 10 1.5 Volt batteries were used in our device after seeing that 5 batteries did not last long enough
- The device with 5 batteries only lasted approximitly 4 hours.
- Devices with 10 batteries were able to last more than double that time



*Blue: 5, Red 10 batteries

Experiment - Other Data Collection Challenges

- Files would get deleted when the battery pack died. In order to avoid this, code was added to have the device save the data once the total battery voltage reached 6.7V

  -If the device was still running when we got there, we close the file by pressing a button on the keypad (#) then powered off the device

- Files would not be created with a large amount of characters (This one took a while to figure out)

Data Analysis - Cleanup

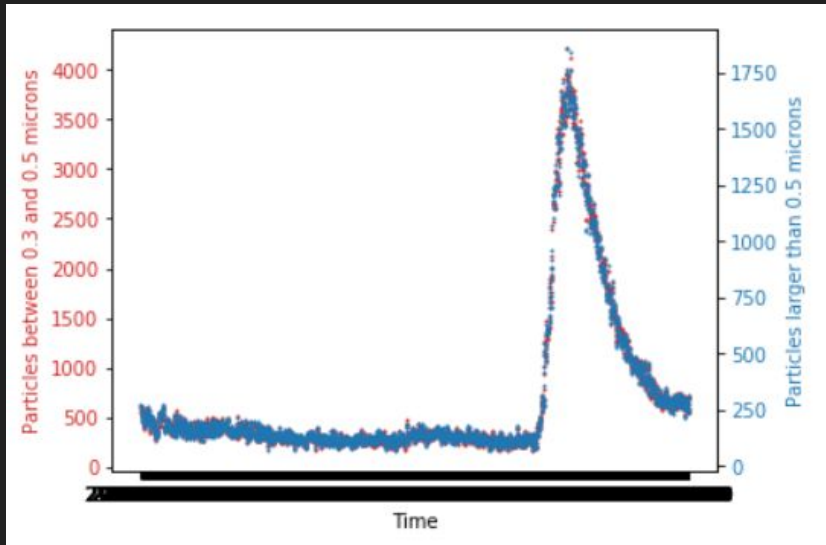
- Files directly from SD card needed clean up
  - Missing data from first few seconds
  - Shifted rows
  - Bad time values
- Files first opened using Excel
  - Data was manually searched for error
  - ~1% of lines needed removal
  - Saved as .csv file after cleanup

Data Analysis - Jupyter Notebook

- Python was used for analysis with Jupyter Notebook
- .csv files read into pandas dataframe
- Due to large quantity of data, it was simplified for speed
- Simplified dataset had every 100th value
- This corresponded to a data point every 5 seconds
- Simplified version was checked against full set
- Negligible difference in large-scale trends

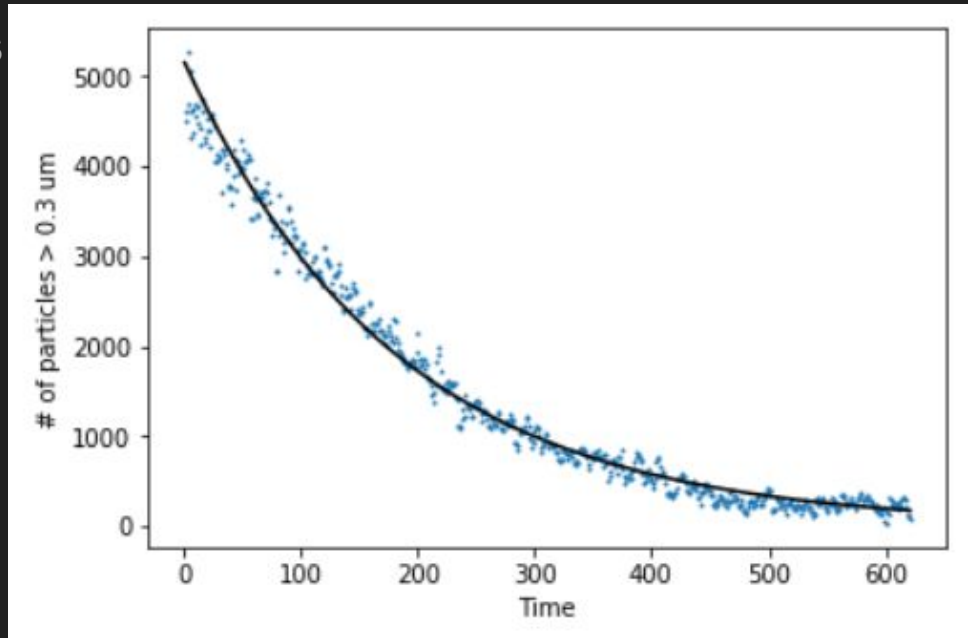
Data Analysis - Plotting

- Of the particulate options, the broadest was > 0.3 um
- This was used for the majority of plots
- All particle size bins agreed very well
- Data was scatter plotted
- Variation of +/- 100 particles was standard
- Significant peaks occurred due to spraying
- Other sources caused peaks as well
  - Ventilation system
  - Entrance into greenhouse room



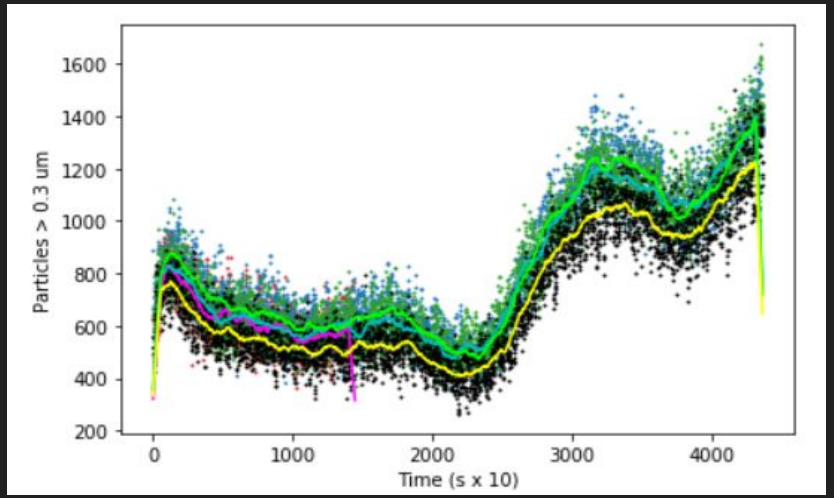
Data Analysis - Exponential Decay

- Particulate data followed exponential decay following spray event
- A curve was fit to determine the rate of this decay
- Found that half life was 21 minutes
- Note: only aqueous detection occurs
- Particles could still be in air as gas



Conclusions - Devices

- The devices worked to determine the number of particles in the air of the green house
- Each of the devices measured very similar values for particulate data. Differences in data are most likely due to the placement of each device. Although they were placed in the same greenhouse room, they were placed in slightly different areas of the room



Conclusions - Greenhouse Safety for Reentry

- The data of particulates in the air over time shows that greenhouse reentry is safe after the allotted time

- It was determined that reentry can actually be earlier than current guidelines permit

Conclusions - Greenhouse to Industrial Settings

- The results obtained for the particulates and their presence in the air are assumed to be quite different from industrial settings because of the area spraying in larger settings as well as the time it takes to spray a larger area
- Many pesticides are also actually used outside.
  - Greenhouses can’t take into account wind and the temperature and disbursement changes due to it
  - Wind could affect a larger area of air as well as the amount of particles present in one location over time

Questions?