**5E LESSON PLAN**



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| **COSMOS Experiment: Air Quality** |
| **Grade/ Grade Band: 11-12** | **Topic: Weather and Climate Earth and Human Activity**  | **Lesson # 3 in a series of 5 lessons** | **Teacher Notes**  |
| **Brief Lesson Description**: In this lesson, SWBAT measure air quality using a[Gravity Laser PM2.5 Air Quality Sensor for Arduino](https://www.dfrobot.com/product-1272.html) to determine if particulate matter plays a role in the formation of a heat island. Urban heat islands raise demand for electrical energy in summer. Companies that supply electricity typically rely on fossil fuel power plants to meet much of this demand, which in turn leads to an increase in air pollutant and greenhouse gas emissions. The primary pollutants from power plants include:* [sulfur dioxide](https://www.epa.gov/so2-pollution) (SO2)
* [nitrogen oxides](https://www.epa.gov/no2-pollution) (NOx)
* [particulate matter](https://www.epa.gov/pm-pollution) (PM)
* [carbon monoxide](https://www.epa.gov/co-pollution) (CO) and
* [mercury](https://www.epa.gov/mercury) (Hg)

These pollutants are harmful to human health and also contribute to complex air quality problems such as the formation of [ground-level ozone](https://www.epa.gov/ozone-pollution) (smog), [fine particulate matter](https://www.epa.gov/pm-pollution), and [acid rain](https://www.epa.gov/acidrain). Increased use of fossil-fuel-powered plants also increases emissions of greenhouse gases, such as [carbon dioxide](https://www.epa.gov/climatechange/emissions/co2.html) (CO2), which contribute to [global climate change](https://www.epa.gov/climatechange/index.html).  |  |
| **Performance Expectation(s):** Heat islands can contribute to poor air quality, magnify the impacts of extreme heat events, and put people’s health at higher risk. Identifying hot spots within a city can help focus interventions where they are most needed during heat waves. I CAN … design, conduct, and evaluate an [experiment](https://www.epa.gov/heat-islands/measuring-heat-islands) on the relationship between air quality (as measured by PM concentration in the air) and the formation of heat islands.  |  |
| **Specific Learning Outcomes:** SWBAT collect air quality data to determine if there is a relationship between PM and heat islands; or, in conjunction, or alternatively, groups can use . * Students will design an experiment that does the following:
	+ Collects PM and air temperature data in selected area within .25 miles of our school building
	+ Compare PM data to temperature to establish if there is an direct or inverse relationship to air temperature
	+ Determine if the PM data meets or exceeds [National Ambient Air Quality Standards](https://www.epa.gov/criteria-air-pollutants/naaqs-table) (NAAQS) to gauge the impact air quality measurements are having on public health

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| **Narrative / Background Information**  | **Teacher Notes** |
| **Background for teachers:*** Review [heat island phenomena](https://www.epa.gov/heat-islands) and impact specifically as it relates air quality
* Will need to familiarize themselves with one or both Arduino air and air quality sensors Examine existing data to determine whether there are documented heat islands in the area around or near our school; or, whether conditions exist for heat islands to form

**Teacher preparation**: * Test Arduino and/or Vernier sensors - in particular, the sensors ability to collect data wirelessly and organize into an Excel or CSV table that can be analyzed statistically and graphed
* Set-up experimental kits for student groups
* Review content to teach students in advance of lab

**Prior Student Knowledge and Preparation:** * Understanding of applying the scientific method and all of its steps (emphasis on making a scientifically-sound hypothesis, identifying constants and variables in the first part; making conclusions and analyzing data after the experiment)
* Understanding of [historical and current temperature data](https://www.epa.gov/heat-islands/measuring-heat-islands)
* Understanding of PM and its relationship to temperature
* Understanding of PM data collected by the EPA’s [AirNow](https://airnow.gov/) and [New York City Community Air Survey](https://www1.nyc.gov/site/doh/data/data-publications/air-quality-nyc-community-air-survey.page) (NYCCAS) - students can view data in our Bronx Community
* Understanding of PM’s relationship to ground level ozone
* Understanding the heat island phenomena in terms of its environmental, public health, and justice impact
 | This lesson could come during unit 6, Pollution, which would necessitate a review since we may have introduced heat islands in unit 1, Earth Systems.A concern is the ability to collect data wirelessly in the field and export in a usable format. May need to establish a hotspot for connectivity purposes. Students will need to spend a good part of a period reviewing recent historical and current data trends as well as reviewing publicly available NYCCAS PM data - Morrisania/Crotona, our school community, has a PM2.5 value of 9.5, which is below EPA and WHO standards, but may be attributable to Crotona Park  |
| **Science & Engineering Practices:** [Analyzing and Interpreting Data](http://www.nap.edu/openbook.php?record_id=13165&page=61)Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.* Analyze data using computational models in order to make valid and reliable scientific claims.
 | **Disciplinary Core Ideas:** ESS3.D: Global Climate Change* Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
 | **Crosscutting Concepts:** Stability and Change* Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
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| **Possible Preconceptions/Misconceptions:** * PM is something that we see - than anything physical is visible
* Increases in temperature are due solely to the sun
* Ozone is not emitted but formed as a secondary pollutant in the troposphere
* The difference between “good” and “bad” ozone
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| **LESSON PLAN – 5-E Model**  |  |
| **ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:** 1. Warm-up: ask students to describe what gets emitted from cars/trucks and from factory smoke stacks? Ask students if air pollution is always a gas?
2. Ask students to describe the relationship between PM pollution and temperature, PM pollution and smog, and PM pollution and health.
3. Ask students how we can determine if PM plays a role in the formation of heat islands in the Bronx.
4. Review the experiment protocols and purpose -- review data portals from the NWS and [NYC Environment and Health](http://a816-dohbesp.nyc.gov/IndicatorPublic/VisualizationData.aspx?id=2027,719b87,122,Summarize) (for PM 2.5 and ozone)
5. Examine how to set-up the Arduino (or Vernier) sensors to collect data over the course of the academic year
 | Point out or show the [PM and Ozone study](https://blog.ldeo.columbia.edu/atmoschem/files/2015/09/JeanG-Thesis-Presentation-v3.pdf) conducted by LamontThere is a searchable database for the [environment and health](http://a816-dohbesp.nyc.gov/IndicatorPublic/VisualizationData.aspx?id=2027,719b87,122,Summarize) that students can access.  |
| **EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:** Materials needed for each group: * Rasberry Pi and Arduino sensor kit (air and surface temperature)
* Laptop to review National Weather Service data and NYCCAS PM data
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| **EXPLAIN: Concepts Explained and Vocabulary Defined:** Teacher: * Ask students to visualize PM
* Discuss PM and its relationship to ground ozone (define what ground ozone is)
* Discuss environmental justice and ask if high levels of PM and the correlatively high rates of [asthma related emergency visits](https://blogs.ei.columbia.edu/2016/06/06/air-quality-pollution-new-york-city/) is a matter of environmental justice

Students: * Explain research and experimental findings using evidence from text or experiments
* Listen critically to teacher and student explanations
* Pose questions if they do not understand important concepts
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| **ELABORATE: Applications and Extensions:** **Teacher** * Ask students to evaluate data collected during the experiment for the following:
	+ PM 2.5 concentration compared to temperature
	+ Seasonal variation (compare means in the winter to the spring)
	+ Other factors influencing temperature and PM concentration
* Based on an evaluation of data reviewed during research and experimentation, ask students what they know about the proof of the connection between PM concentration and heat islands and what they don’t know, and why

**Student** * Students will investigate the environmental justice and public health component of PM 2.5 concentrations
* Students will look at concentrations of PM 2.5, ozone, and temperature data to see if there is a relationship
* Students will see if there are any mitigation or reduction strategies for PM and ozone
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| **EVALUATE:** **Formative Monitoring (Questioning / Discussion):** * Asks open ended questions such as:
	+ What evidence do you have that best supports or refutes your hypothesis?
	+ Why do you think a heat island does or does not exist in your experimental area?
	+ How does your data compare to the control data (NWS daily temps/Crotona Park)?
	+ How would you explain your results to a friend, a parent, politician?

**Summative Assessment (Quiz / Project / Report):** * Formal lab report
* Powerpoint presentation of findings
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| **Elaborate Further / Reflect: Enrichment:** * Students consider ways of sharing their data with the school and local community -
	+ Presentation to school parent association
	+ Presentation to Bronx Community Board 3, which focuses on parks, to make a case for more green space
* Students develop PM 2.5 and ozone reduction strategies for the Morrisania/Crotona section of the Bronx (ideas that can be scalable citywide)
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| **Materials Required for This Lesson/Activity** |
| **Quantity** | **Description** | **Potential Supplier (item #)** | **Estimated Price** |
| 6 | Raspberry Pi computers  | COSMOS RET or grant request | $210 (35 each from [Adafruit](https://www.adafruit.com/product/3775?src=raspberrypi))  |
| 6 | Gravity surface temperature sensor  | COSMOS RET or grant request | [$96](https://www.dfrobot.com/product-1495.html) |
| 6 | Gravity air temperature sensor | COSMOS RET or grant request | [$27](https://www.dfrobot.com/product-76.html) |
| 6 | Gravity air quality sensor for Arduino | COSMOS RET or grant request | [$281.40](https://www.dfrobot.com/product-1272.html) |
| 6 | Sainsmart MQ-131 Gas Sensor Ozone Module | COSMOS RET or grant request | [$161.40](https://www.sainsmart.com/products/mq-131-gas-sensor-ozone-module)  |