Homework #4. Analyze real-world emissions data

Use the example data files provided in Learning Suite on the schedule for November 2

Feat.class.example.csv

1. Graph histograms of the fuel-based emission rates (g/kg-fuel) for HC, CO, and NOx for each date of measurements.
   1. How much does the maximum emission rate at each location compare to the median emission rate? (maximum divided by the median emission rate)
   2. Which pollutant has the most skewed distribution?
2. Do gasoline vehicles with high emissions of CO also tend to have high emissions of HC and NOx?
   1. Compare the data graphically
   2. What’s the R2 correlation between the different pollutants?
3. Vehicle emission Inspection and Maintenance (I/M) Programs are designed to prevent high emitting vehicles from operating on the road, either by requiring the owner to fix their vehicle, or to remove it from the vehicle fleet.

Researchers have not found meaningful impacts of I/M programs on reducing vehicle emissions and improving air quality[1], [2]. In addition, I/M programs are shown to impact lower income households more than higher income households[3].

* 1. How do you think we should address vehicle emissions from high-emitting vehicles?

1. Calculate the **90%** confidence intervals of the mean CO emission rate for gasoline vehicles for each day. Are the gasoline vehicle rates from each site significantly different from one another?

Note: You can edit my R code for this problem to re-sample the measurements.

If you do not have familiarity with R, you can approximate using the t-distribution.

3.1 What are advantages and disadvantages of using the re-sampling method?

1. Table MF-2 from Highway Statistics provides total sales of gasoline and special (diesel) fuel in 2020 by state in 1000’s of gallons[4].

We measured 50 diesel vehicles at 10 am across the four locations. The average diesel vehicle NO emission rate (g/kg) for the 10 am time period is:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pollutant | mean | median | sd | n | min | max | lower.95 | upper.95 |
| CO | 13.59425 | 6.759731 | 30.53268 | 50 | -18.2548 | 190.3729 | 4.828864 | 22.35964 |
| HC | 5.590014 | 4.538387 | 21.32577 | 50 | -31.9126 | 113.5856 | -0.53223 | 11.71226 |
| NH3 | 0.133595 | 0.070125 | 0.434446 | 46 | -0.41951 | 2.41061 | 0.003155 | 0.264035 |
| NO | 4.631564 | 0.164322 | 10.75692 | 50 | -1.56201 | 46.8546 | 1.543446 | 7.719683 |
| NO2 | 0.536723 | 0.423853 | 1.270595 | 29 | -2.16289 | 3.984007 | 0.04486 | 1.028586 |

* 1. Use the road-side emission factors (g/kg-fuel) to estimate the total amount of NOx (NO + NO2) emitted from gasoline and diesel in Utah.

You can use the energy density provided in the MOVES fuel report. The density of gasoline is 2.839 kg/gallon, and the density diesel is 3.167 kg/gallon [5]

* 1. Calculate the % contribution of vehicle NOx from gasoline and diesel vehicles.
  2. How does the % contribution from gasoline and diesel vehicles compare to the NOx emission distribution estimated for Salt Lake City using MOVES in Homework #3?
  3. Do you expect the two estimates to differ from one another? Why?
  4. What answer do you think is more representative of the real-world emissions in Utah?

1. Ideally, we would have more measurement locations and data. Use the hypothetical data in the CO.site.average.date.2023.csv, calculate the average CO gasoline vehicle emission rate for Utah County with 95% CI.
   1. What are you using as your random, independent variable?

[1] G. A. Bishop and D. H. Stedman, “A Decade of On-road Emissions Measurements,” *Environ. Sci. Technol.*, vol. 42, no. 5, pp. 1651–1656, Mar. 2008, doi: 10.1021/es702413b.

[2] N. J. Sanders and R. Sandler, “Technology and the Effectiveness of Regulatory Programs over Time: Vehicle Emissions and Smog Checks with a Changing Fleet,” *Journal of the Association of Environmental and Resource Economists*, vol. 7, no. 3, pp. 587–618, May 2020, doi: 10.1086/707954.

[3] R. J. Wessel, “Policing the poor: The impact of vehicle emissions inspection programs across income,” *Transportation Research Part D: Transport and Environment*, vol. 78, p. 102207, Jan. 2020, doi: 10.1016/j.trd.2019.102207.

[4] “Table MF-2 / Highway Statistics 2020 - Policy | Federal Highway Administration.” https://www.fhwa.dot.gov/policyinformation/statistics/2020/mf2.cfm (accessed Nov. 05, 2022).

[5] USEPA, “Greenhouse Gas and Energy Consumption Rates for Onroad Vehicles in MOVES3,” Office of Transportation and Air Quality, U.S. Environmental Protection Agency, Ann Arbor, MI, USA, EPA-420-R-20-015, Nov. 2020. [Online]. Available: https://www.epa.gov/moves/moves-onroad-technical-reports