CIVE 202 – Engineering Analysis 2

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Johnathan Sevick

Project 1 Written Report

Introduction:

The client is a group from the University of Nebraska Medical Center (UNMC) composed of health professionals, environmental scientists, and other affiliated engineers that work on issues related to the effects of air, water, and soil pollution. They are concerned with how air pollution can effect the health of people in sensitive groups and have started an initiative with AirPurple to keep track of the air quality across all of Nebraska. Air quality is not the expertise of the UNMC group, so they opened up a request for proposals to help them analyze the air quality data. They want questions answered about the air quality data taken in Nebraska from February 2024 to March 2025.

The UNMC group wants to know if the air in Nebraska is meeting the National Ambient Air Quality Standards (NAAQS). Some things they are interested in understanding how temperature, humidity, elevation, and geographic location influence the air quality. More specifically the client provided a list of tasks to be completed and analyzed.

First, Task 1 wants to know the 5 sensor locations across Nebraska with the highest mean and median concentration of pm2.5, pm10.0, and voc. Next, Task 2 asks on what days did the maximum values of those air pollutants occur and where did they occurred, as well as why those maximums may have occurred. Then, Task 3 wants to see if different humidity and temperature levels affect the air quality. Finally, Task 4 asks if there have been any health risks for sensitive populations at any of the locations for pm2.5 and pm10.0. This is based on the EPA's AQI ratings, and they want to know when and why these may have happened.

Methods:

Before any analysis was done, the first step in the code was loading in "pandas" and making the air data into a data frame for manipulation. This Is necessary for all future methods of completing the tasks because it allows the creation of the tables used to answer the questions the UNMC group had.

Task 1 was completed by using Python to create 6 different tables to display the 5 highest mean or median pm2.5, pm10.0, and voc values and to which sensor they belong. This was done by grouping all the data by sensor and then creating a row for the mean or median air pollutant values. From there it's as simple as reading the sensor names.

The second task only required 3 tables as the goal was to analyze the max value of the three main air pollutants and be able to see where and when they were recorded. Python was used to group the data ID then find the max values. Then the table was created to also show the date and sensor name to be analyzed. This led to it being easy to see a stretch of dates where air pollutants were high in a particular area.

Task 3 only required two tables created in Python to determine whether humidity levels and temperature levels affect air quality. Two functions were created in Python to be able to categorize the temperature and humidity into levels laid out by the client. The data was then grouped by temperature level in the first table and humidity level in the second. This was so after the mean of the three air pollutants were found the values could be compared to when the temperature or humidity levels were different.

The fourth and final task had two tables created for it in Python. The data was filtered to find pm2.5 and pm10.0 values in the EPA's "unhealthy for sensitive groups" AQI rating. It was then grouped by the sensor name where columns to display the dates the values fell into range and how many times the values fell into range were created. From there the dates and names of sensors can be seen and analyzed for the two different air pollutants.

Results and Discussion:

The first task focuses on statistical analysis of different air pollutant values, so using tables created in Python the top mean and median values of voc, pm2.5, and pm10.0 can be seen.

sensor.name	Mean_voc
Swnphd-ogallala	399.434240
FCHD-YPS	372.462720
Three Rivers Public Health Department	370.216208
ELVPHD Norfolk HD 4	360.833744
Swnphd-mccook	353.941581

Table 1.1

sensor.name	Median_voc
Swnphd-ogallala	423.082292
Swnphd-mccook	381.468479
Three Rivers Public Health Department	376.810167
FCHD-YPS	375.383500
ELVPHD Norfolk HD 4	368.580500

Table 1.2

Table 1.1 and Table 1.2 display the 5 sensor locations that had the highest mean and median voc values, sensor Swnphd-ogallala had the highest mean and median voc of 399.4 and 423.

sensor.name	Mean_pm25
Broken Bow	928.710593
#16 - Richardson County Courthouse	700.127342
#18 - Southeast District Health Department- Tecumseh	613.175352
NCDHD O'Neill #11	164.495078
Swnphd-mccook	123.011622

Table 1.3

sensor.name	Median_pm25
Broken Bow	36.050240
#16 - Richardson County Courthouse	11.977344
#18 - Southeast District Health Department- Tecumseh	10.322875
ELVPHD Norfolk HD 4	9.706229
ELVPHD Wisner HD 5	8.464583

Table 1.4

Table 1.3 and Table 1.4 show the 5 highest mean and median pm2.5 values and which sensors recorded them. Similarly to the last two tables, the top value in each of these is shared by one sensor. In this case the Broken Bow sensor recorded a mean of 928.7 and a median of 36.0. Both the mean and median values for Broken Bow are significantly higher than the second largest sensor, over tripling the median value.

sensor.name	Mean_pm10
Broken Bow	929.678512
#16 - Richardson County Courthouse	701.632446
#18 - Southeast District Health Department- Tecumseh	614.227248
NCDHD O'Neill #11	166.132578
Swnphd-mccook	124.227336

Table 1.5

sensor.name	Median_pm10
Broken Bow	43.179094
#16 - Richardson County Courthouse	13.305615
ELVPHD Norfolk HD 4	11.474708
#18 - Southeast District Health Department- Tecumseh	11.433729
ELVPHD Wisner HD 5	10.935958

Table 1.6

The next two tables, Table 1.5 and Table 1.6 once again show the top 5 highest mean and median values for the sensors, this time for the pm10.0 values. Same as for the pm2.5 values, Broken Bow has the highest mean and median values at 929.6 and 43.1 respectively.

From these first 6 tables some conclusions can be drawn about some of the sensors. Broken Bow, for one, is the clear leader in particle matter pollution, being in first by a significant margin for both pm2.5 and pm10.0. In both cases its median value is over triple second place Richardson County Courthouse. Additionally, the mean value is over 30% larger than the next sensor.

Sensor Swnphd-ogallala comes in with the highest volatile organic compound values. This is by a smaller margin than Broken Bow, having a less than 10% higher mean value than second place sensor.

Task 2 proposes the question of what the max values of the air pollutants are, when they occur, and where. Statistical analysis can be used to see what sensors read high max air pollutant values.

	date	sensor.name	voc
2391	06/24/24	Swnphd-ogallala	1209.931571
4795	10/05/24	SWNPHD-Imerial	1135.473000
5774	11/23/24	SWNPHD-Imerial	1041.722000
4948	10/12/24	ELVPHD Norfolk HD 4	884.649000
5024	10/16/24	SWNPHD-Imerial	871.182000

Table 2.1

Table 2.1 allows the observation of where the top 5 voc values were recorded over the course of the whole data period as well as when they were recorded. The highest recorded voc value belongs to Swnphd-ogallala at 1209, followed by two from SWNPHD-Imerial.

	date	sensor.name	pm2.5_atm
7561	02/18/25	#16 - Richardson County Courthouse	3782.823313
7583	02/19/25	#16 - Richardson County Courthouse	3401.999333
7605	02/20/25	#16 - Richardson County Courthouse	3243.746646
6962	01/21/25	#16 - Richardson County Courthouse	3209.817146
6952	01/20/25	Broken Bow	3087.149167

Table 2.2

This next table, 2.2 paints a clear story; The top 4 pm2.5 values were all recorded by the Richardson County Courthouse, the top 3 of those occurred sequentially with a peak pm2.5 value of 3782.

	date	sensor.name	pm10.0_atm
7561	02/18/25	#16 - Richardson County Courthouse	3784.682542
7583	02/19/25	#16 - Richardson County Courthouse	3403.435958
7605	02/20/25	#16 - Richardson County Courthouse	3245.613354
6962	01/21/25	#16 - Richardson County Courthouse	3211.046813
6952	01/20/25	Broken Bow	3088.053896

Table 2.3

A very similar story is told by Table 2.3 that is told by Table 2.2. The peak pm10.0 value was recorded by the same sensor on the same day as the peak pm2.5 value. It is once again held by Richardson County Courthouse with a large value of 3784. Also similarly, Broken Bow recorded the 5th largest value for both pm2.5 and pm10.0.

The main pollutants of pm2.5 and pm10.0 are combustion, agricultural burning, and dust so if any of those are found to be especially prevalent on those days, they are likely the cause. Agriculture is a big industry in Nebraska. Additionally occasional Canadian wildfires can send large amounts of smoke and air pollutants into the Nebraskan air.

More statistical analysis is needed for Task 3 as the question asked by the client is whether the humidity level or temperature level influences the air quality. 2 tables were made to see if there were any obvious patterns in the air pollutants. The humidity levels and temperature levels were laid out by UNMC in the client prompt.

temperature.level	voc_mean	pm25_mean	pm10_mean
Below Freezeing	257.628626	273.698560	276.080794
Cool	285.435146	141.658843	143.074475
Hot	281.957598	72.309380	73.964812
Warm	255.916308	83.102238	84.021411

Table 3.1

Table 3.1 groups the data by the different temperature levels that were laid

out in the client prompt. The columns show the mean values for the different air pollutants. The highest pm2.5 and pm10.0 mean values are found when temperatures are below freezing at over 270, but the voc means are relatively evenly spread across the temperature levels with a range of about 30.

humidity.level	voc_mean	pm25_mean	pm10_mean
High Humidity	252.664069	80.874444	82.561133
Low Humidity	279.329347	76.513935	77.880520
Very High Humidity	19.395555	533.786399	536.520850

Table 3.2

Table 3.2 is very similar to Table 3.1; the difference is the data is grouped by humidity levels opposed to temperature levels. These humidity levels were specified by the client. The values aren't distributed evenly at all. When the humidity is very high the mean voc is very low, conversely, the mean pm2.5 and pm10.0 are much higher than when the humidity is low or high with values over 500.

The main question proposed in Task 3 is whether humidity or temperature influence air quality. Based on the data the answer is certainly yes. We can see in Table 3.1 that as the temperature gets warmer, the mean pm2.5 and pm10.0 values decrease from over 270 to under 75 each.

Now looking at Table 3.2 as the humidity increases both means for pm2.5 and pm10.0 increase, taking a sharp jump from high to very high humidity. Conversely, the mean voc decreases as humidity increases, taking a sharp dive from high to very humidity. There is no discernable trend between temperature level and voc though as the values stay pretty stable.

In Task 4, the client wants to know whether there have been any Air Quality (AQI) Index health risks for sensitive populations at any of the locations in the dataset for PM 2.5 and PM 10 based on the EPA's AQI ratings?

sensor.name	unhealthy_dates	unhealthy_count
#16 - Richardson County Courthouse	[08/20/24]	1
#17 - Otoe County	[08/20/24, 01/09/25]	2
#18 - Southeast District Health Department- Tecumseh	[05/15/24]	1
Ainsworth Public School #9	[07/23/24, 07/24/24, 07/25/24, 07/26/24, 08/20...	7
Broken Bow	[05/14/24, 07/23/24, 07/24/24, 07/25/24, 07/26...	9
Buffalo County TRPHD #26	[05/14/24, 05/15/24, 07/25/24, 07/26/24, 08/20...	7
ELVPHD Norfolk HD 4	[03/29/24, 05/14/24, 05/15/24, 07/09/24, 07/26...	6
ELVPHD Tekamah HD 3	[05/14/24, 08/20/24]	2
ELVPHD Wisner HD 5	[03/29/24, 05/14/24, 05/15/24, 07/09/24, 07/10...	9
FCHD-YPS	[07/25/24, 08/20/24]	2
Laurel High School	[05/14/24, 05/15/24]	2
Loup Basin Public Health Department	[05/14/24, 07/25/24, 07/26/24, 07/27/24, 08/20...	7
Loup Basin Public Health Department	[05/14/24, 07/25/24, 07/26/24, 07/27/24, 08/20...	7
Lower Niobrara NRD Butte 10	[05/14/24, 07/24/24, 07/25/24, 07/26/24, 08/20...	6
NCDHD O'Neill #11	[05/14/24, 08/20/24, 09/05/24]	3
PHS Fairbury JCHL 13	[05/14/24, 08/20/24, 01/09/25, 02/15/25]	4
SWNPHD-Imerial	[07/22/24, 07/23/24, 07/24/24, 07/25/24, 07/26...	5
South Heartland District Health Dept. Hastings office	[05/14/24, 05/15/24, 07/25/24, 07/26/24, 08/20...	6
South Heartland District Health Dept. Superior City Building	[08/20/24, 01/09/25, 02/15/25]	3
Swnphd-Benklemen	[07/22/24, 07/23/24, 07/24/24, 07/25/24, 07/26...	6
Swnphd-mccook	[07/24/24, 07/25/24, 07/26/24, 03/02/25]	4
Swnphd-ogallala	[04/06/24, 07/22/24, 07/23/24, 07/24/24, 07/25...	6
TRPHD Dawson Co. Courthouse 25	[07/24/24, 07/25/24, 07/26/24, 08/20/24, 08/21...	6
TRPHD Harlan Co. Courthouse 24	[04/06/24, 07/25/24, 07/26/24, 08/20/24]	4
Three Rivers Public Health Department	[05/14/24, 08/20/24, 12/24/24, 02/15/25]	4
WCDHD Arthur High School 28	[07/22/24, 07/23/24, 07/24/24, 07/25/24, 07/26...	5
WCDHD Thedford Library 29	[02/15/25]	1

Table 4.1

Table 4.1 displays all the sensors that recorded a pm2.5 values that fell into the EPA's "unhealthy for sensitive groups" AQI rating. Of the 27 sensors in the data frame all but one recorded a value that falls into the range. The only sensor that didn't was the WCDHD City Building sensor. Keeping

with the trend of Broken Bow showing up a lot in these analyses, it recorded 9 values in the range ELVPHD Wisner HD 5 sensor.

sensor.name	unhealthy_dates	unhealthy_count
#16 - Richardson County Courthouse	[12/08/24]	1
Loup Basin Public Health Department	[06/14/24]	1
Swnphd-Benklemen	[06/27/24]	1

Table 4.2

Table 4.2 is much smaller than Table 4.1 as only 3 sensors recorded a pm10.0 value in the unhealthy for sensitive populations range. All those sensors also only recorded a value In range on one occasion.

As the sensors span across all of Nebraska there was no place free from any risk from pm2.5. These tables don't show how many times the sensors recorded values even larger than the range. If those were included the numbers in the unhealthy_count column would be significantly larger.

Also asked by UNMC group what days these were recorded were on. The dates can be seen in the unhealthy_dates column. A few dates stand out though such as late July of 2024, where several sensors recorded pm2.5 values in range several times within a single week.

References:

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