Global Air Quality

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Abstract

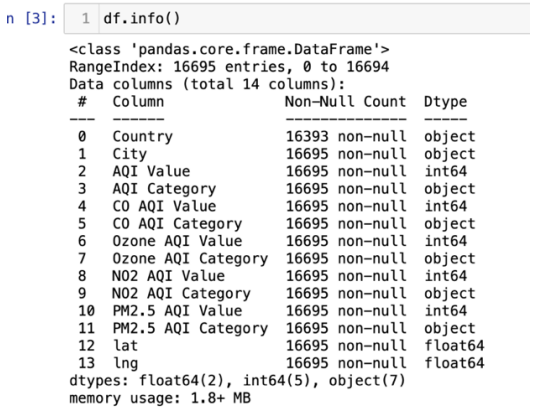
Project 3 encompasses a data visualization and data engineering track for students to showcase their skillset. Team 2 has found an open-source Kaggle dataset to manipulate and answer Project 3 requirements. A story will be revealed by using visualizations and skills learned throughout the course to design a robust database.

Global Air Quality

According to the World Health Organization (WHO), air pollution is one of the greatest environmental risks to health that affects people from all different backgrounds. Specifically, outdoor air pollution in both cities and rural areas were estimated to have caused 4.2 million premature deaths worldwide per year in 2019; this mortality is due to exposure to fine particulate matter (PM2.5), which causes cardiovascular and respiratory disease, and cancers. In addition, air pollution is considered the second highest risk factor for noncommunicable diseases and examining it is key to protecting public health. Most sources of outdoor air pollution are well beyond the control of individuals, and this demands concerted action by local, national, and regional policymakers working in sectors like energy, transport, waste management, urban planning, and agriculture to develop initiatives and counteract the negative effects of air pollution.

Data Visualization/Engineering

The dataset was transformed into visualizations by first cleaning it and creating a data frame that could be used for queries. Python was utilized to drop null values reflected in the raw data as shown in the figure below. The column titled “Country” only had 16,393 values and the other columns reflected 16,695. There was a total of 302 rows of data that did not have a Country associated with it and 2 null values. These values were dropped from the data set to have more consistency.



```
In [3]: 1 df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 16695 entries, 0 to 16694
Data columns (total 14 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   Country             16393 non-null  object
 1   City                16695 non-null  object
 2   AQI Value           16695 non-null  int64
 3   AQI Category        16695 non-null  object
 4   CO AQI Value        16695 non-null  int64
 5   CO AQI Category     16695 non-null  object
 6   Ozone AQI Value     16695 non-null  int64
 7   Ozone AQI Category  16695 non-null  object
 8   NO2 AQI Value       16695 non-null  int64
 9   NO2 AQI Category    16695 non-null  object
 10  PM2.5 AQI Value     16695 non-null  int64
 11  PM2.5 AQI Category  16695 non-null  object
 12  lat                 16695 non-null  float64
 13  lng                 16695 non-null  float64
dtypes: float64(2), int64(5), object(7)
memory usage: 1.8+ MB
```

Figure 1: Image of df.info on dataset

The dataset did have some other quality issues to include it containing some incorrect latitude and longitude points that do not correspond to the country or city they are supposed to be identifying. In addition, the last update for this dataset was performed 9 months ago.

The team then used mySQL to filter the data with queries. Those filters were then transposed to a JavaScript file that allows users to interface with the dashboard by choosing a country or city to see its AQI values. The HTML and JavaScript files created by Team 2 can be found in the eda and app folders in their project GitHub. A link was also provided (kokimber.pythonanywhere.com) to show a successful broadcast of data to the web interface. The data was broken out by these data points for the user to view it by Country or City. The data visualizations were created in response to these three questions:

1) Which Countries have good and bad air quality ratings?
2) How do big cities compare with more rural areas?
3) What are the main pollutants affecting air quality?

In [15]:
```
Country = "All"

# allow the user to select ALL or a specific state
if Country == "All":
    where_clause = "1=1"
else:
    where_clause = f"Country = '{Country}'"

query = f"""
    SELECT
        Country,
        "AQI Value",
        "AQI Category"

    FROM
        "AQI and Lat Long of Countries"

    Where
        {where_clause}

    GROUP BY
        Country

    ORDER BY
        "AQI Value" desc;

 """

df_bar = pd.read_sql(text(query), con=engine)
df_bar.head(10)
```

Out[15]:

	Country	AQI Value	AQI Category
0	Pakistan	500	Hazardous
1	Republic of Korea	421	Hazardous
2	India	247	Very Unhealthy
3	Saudi Arabia	196	Unhealthy
4	Bahrain	188	Unhealthy
5	Viet Nam	181	Unhealthy
6	Senegal	176	Unhealthy
7	United Republic of Tanzania	171	Unhealthy
8	Qatar	164	Unhealthy
9	Aruba	163	Unhealthy

Figure 2: Image of query for countries with the worst AQI

```
]: 1  Country = "ALL"
   2
   3  # allow the user to select ALL or a specific state
   4  if Country == "ALL":
   5      where_clause = "1=1"
   6  else:
   7      where_clause = f"Country = '{Country}'"
   8
   9  query = f"""
  10      SELECT
  11          Country,
  12          "AQI Value",
  13          "AQI Category"
  14
  15      FROM
  16          "AQI and Lat Long of Countries"
  17
  18      Where
  19          {where_clause}
  20
  21      GROUP BY
  22          Country
  23
  24      ORDER BY
  25          "AQI Value" asc
  26
  27      LIMIT 10;
  28  """
  29
  30  df_bar = pd.read_sql(text(query), con=engine)
  31  df_bar.head()
  32
```

]:

	Country	AQI Value	AQI Category
0	Myanmar	15	Good
1	Palau	16	Good
2	Argentina	17	Good
3	Solomon Islands	18	Good
4	Maldives	19	Good

Figure 3: Image of query for countries with the best AQI

	Country	City	AQI Value	AQI Category
0	Ecuador	Macas	7	Good
1	Ecuador	Azogues	8	Good
2	Papua New Guinea	Tari	8	Good
3	Peru	Huaraz	9	Good
4	Peru	Huancavelica	10	Good

Figure 4: Second image of query result for countries with good AQIs

Findings

After exploring the data, Team 2 had six findings to highlight. Various locations around the world were picked to analyze for a global spread of AQI values. Before proceeding with the findings, it is important to know that AQI values range from 0 to 500 with 0 falling under the “Good” Air Quality Category and 500 falling under the “Hazardous” Category (Figure 7 shows the range of values for AQI).

Finding 1 was that India is one of the countries with the worst ratings for air quality. Nine of the top 10 cities in the world with the worst ratings are in India. In addition, 40.7% (Figure 6) of its cities fall under the “Unhealthy” category. This makes sense considering multiple cities in India have AQI values of 500 which means they have “Hazardous” air quality conditions. Despite these findings, there are a handful of cities with “Good” ratings with AQI values under 50 such as Port Blair (an island far from the mainland), Chengam, and Hindupur. Below are some visual representations of Finding 1:

Top 10 Cities in the World with worst AQI values

	Country	City	AQI Value	AQI Category
0	Russian Federation	Tynda	500	Hazardous
1	India	Sardulgarh	500	Hazardous
2	India	Rohtak	500	Hazardous
3	India	Ratangarh	500	Hazardous
4	India	Pokaran	500	Hazardous
5	India	Phalodi	500	Hazardous
6	India	Nohar	500	Hazardous
7	India	Nawalgarh	500	Hazardous
8	India	Maur	500	Hazardous
9	India	Malaut	500	Hazardous
10	India	Mahendragarh	500	Hazardous

Figure 5: Cities with the worst AQI

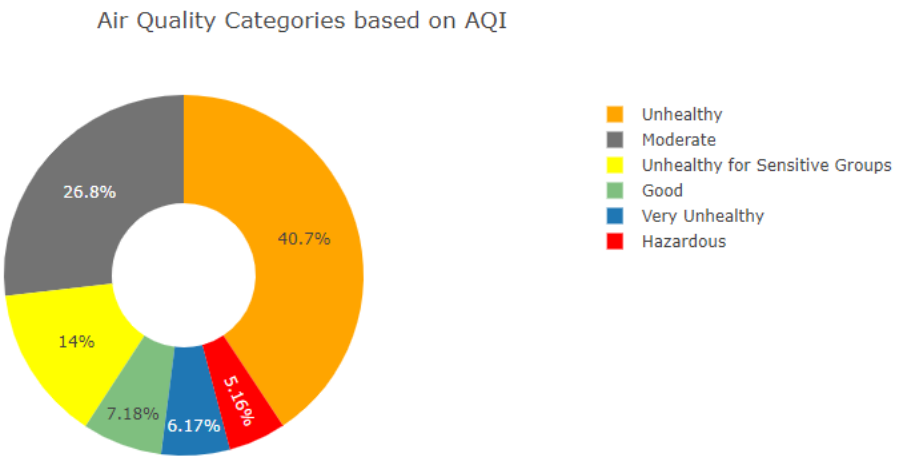


Figure 6: AQI Categories of India

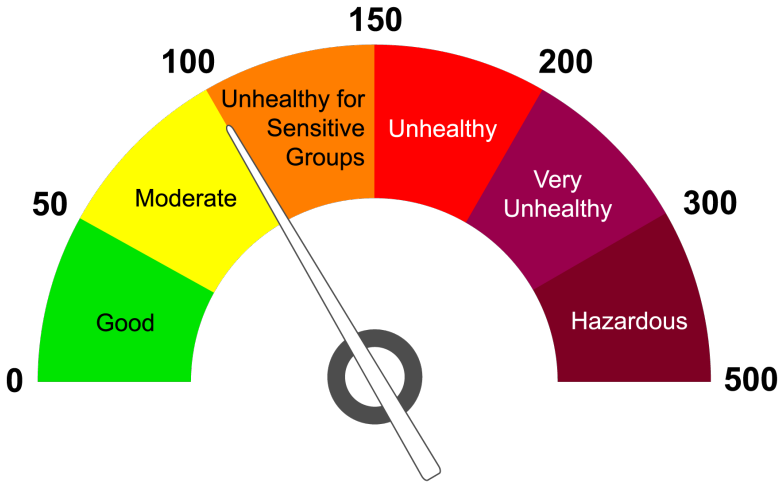


Figure 7: AQI Categories

Finding 2 explored SMU's location in Dallas, TX. Team 2 found downtown Dallas as having a moderate Air Quality Index value of 70. Interestingly a city 50 miles north of Dallas called Celina, TX had a much lower AQI value of 39. This makes it fall under the "Good" air quality category. This supports the research question on how AQI values compare between rural areas and cities. The specific values of these two locations show how AQI values are higher in bigger cities compared to more rural areas.

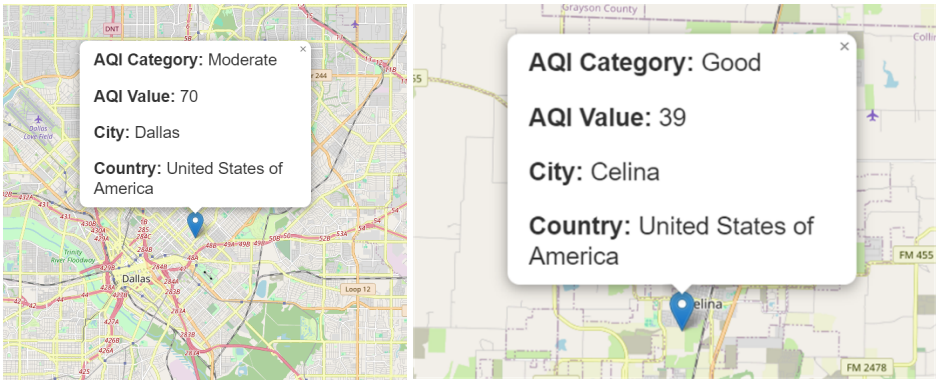


Figure 8: AQI of each Texas city location

Finding 3 revolved around Argentina. It found that 84.7% of cities in Argentina fall under the "Good" air quality category. The city with the worst AQI value rating ended up being Villeta, which has a

rating of 90 (moderate air quality). The issue of limited datapoints on cities per country would affect any conclusions made on whether Argentina has an overall average AQI value of “Good”. More research should be done on more cities to give an accurate depiction of the country’s average status.

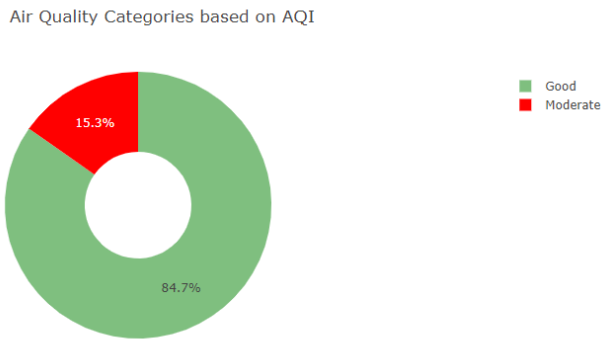


Figure 9: AQI Categories of Argentina

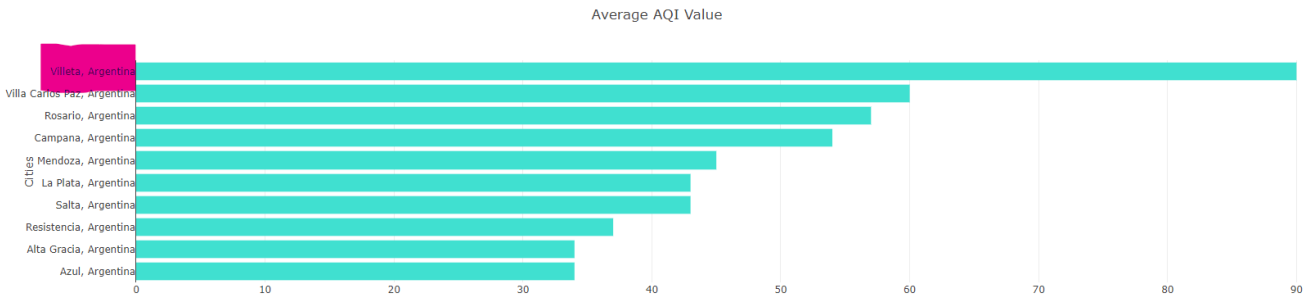


Figure 10: Average AQI of cities in Argentina

Finding 4 focused on Iceland and it has “Good” air quality ratings. This conclusion cannot be taken as 100% accurate since there was only a single rating that was reported. More research should be completed on multiple cities throughout the country to reach the conclusion that Iceland has an overall “Good” air quality.

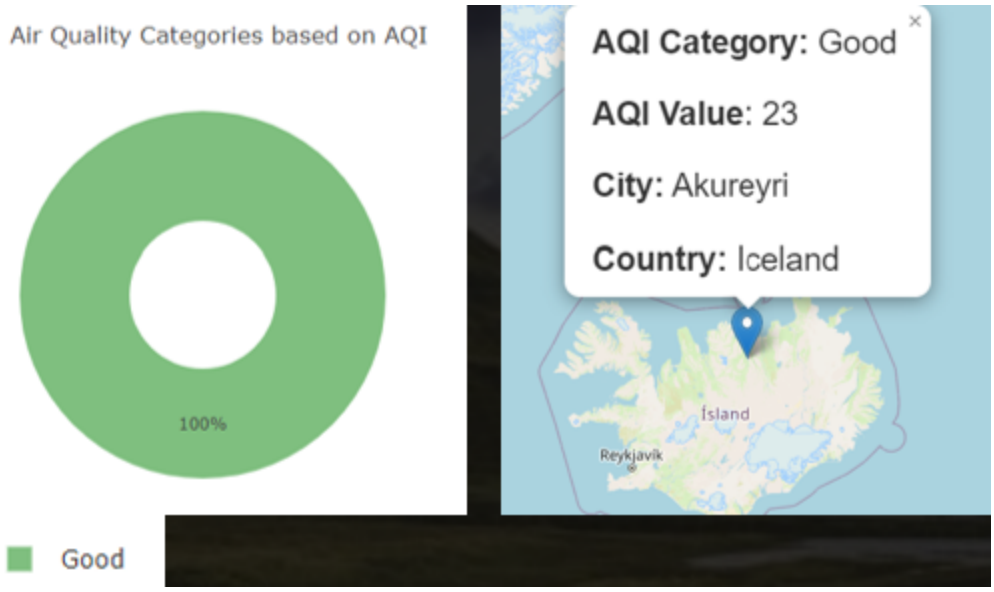


Figure 11: AQI Categories and values of Iceland

Finding 5 was completed on Chihuahua City (Misha's hometown) which has a much better air quality compared to Mexico City. Again, this proves how bigger cities experience worse air quality compared to rural areas. Team 2 found a pattern overall that countries located away from industrialized ones (Pacific and other isolated islands) as well as rural areas that were not near big cities tended to have lower AQIs.

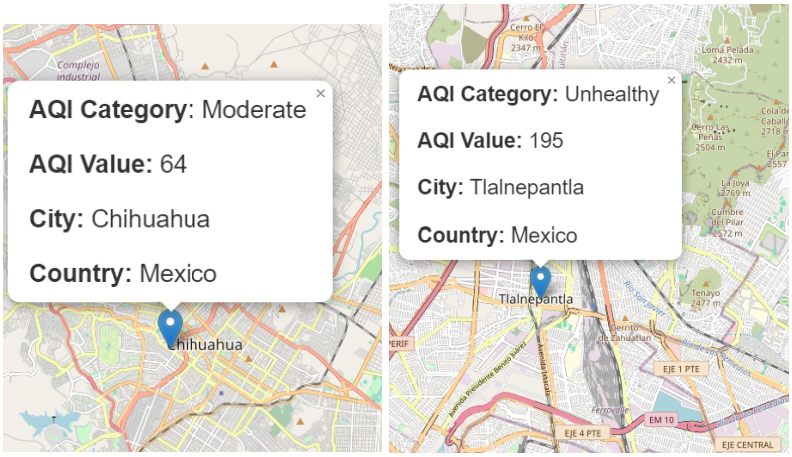


Figure 12: AQI values of cities in Mexico

Finding 6 explored the United States and discovered that based on this dataset, the main pollutant affecting air quality was fine particulate matter (PM 2.5) with 60.6% and it is followed by Ozone with 29%. On average, the United States has “Good” to “Moderate” air quality. Overall, 94.8% of the ratings fall under the above two categories.

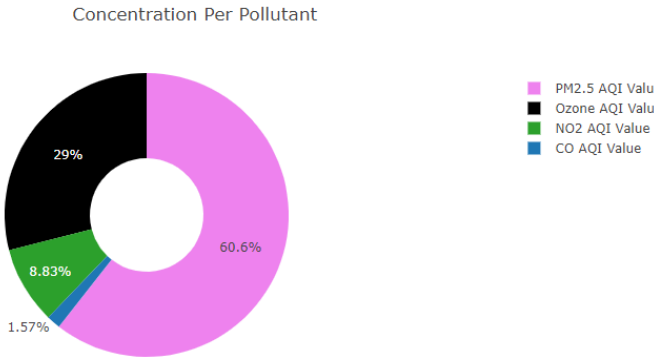


Figure 13: Concentration of Pollutants in The United States

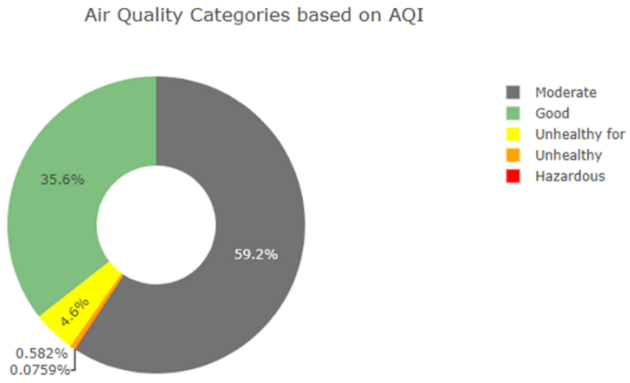


Figure 14: AQI Categories of The United States

Dashboard

The Dashboard that was created to have an approachable way for people to explore Air Quality across the world and it includes 4 different tabs. The first tab is the Home page with useful information about Air Quality. The second tab is the actual Dashboard with an interactive map, and two donut charts

that are adjusted and modified accordingly to a location filter. The third tab includes information about Team 2, and lastly the fourth tab includes links to works cited. The colors chosen by the AQI Category donut chart range from red to green to visually represent “Good” AQI values (in green) and “Hazardous” AQI values (in red). For the pollutant percentage donut chart, very distinct colors were chosen to clearly differentiate each unique pollutant. The use of these distinct colors ensured that the user would not interpret these values with being relational to the other diagrams on the dashboard. For the Bar Chart, blue was the color of choice since it is usually the color associated with air.

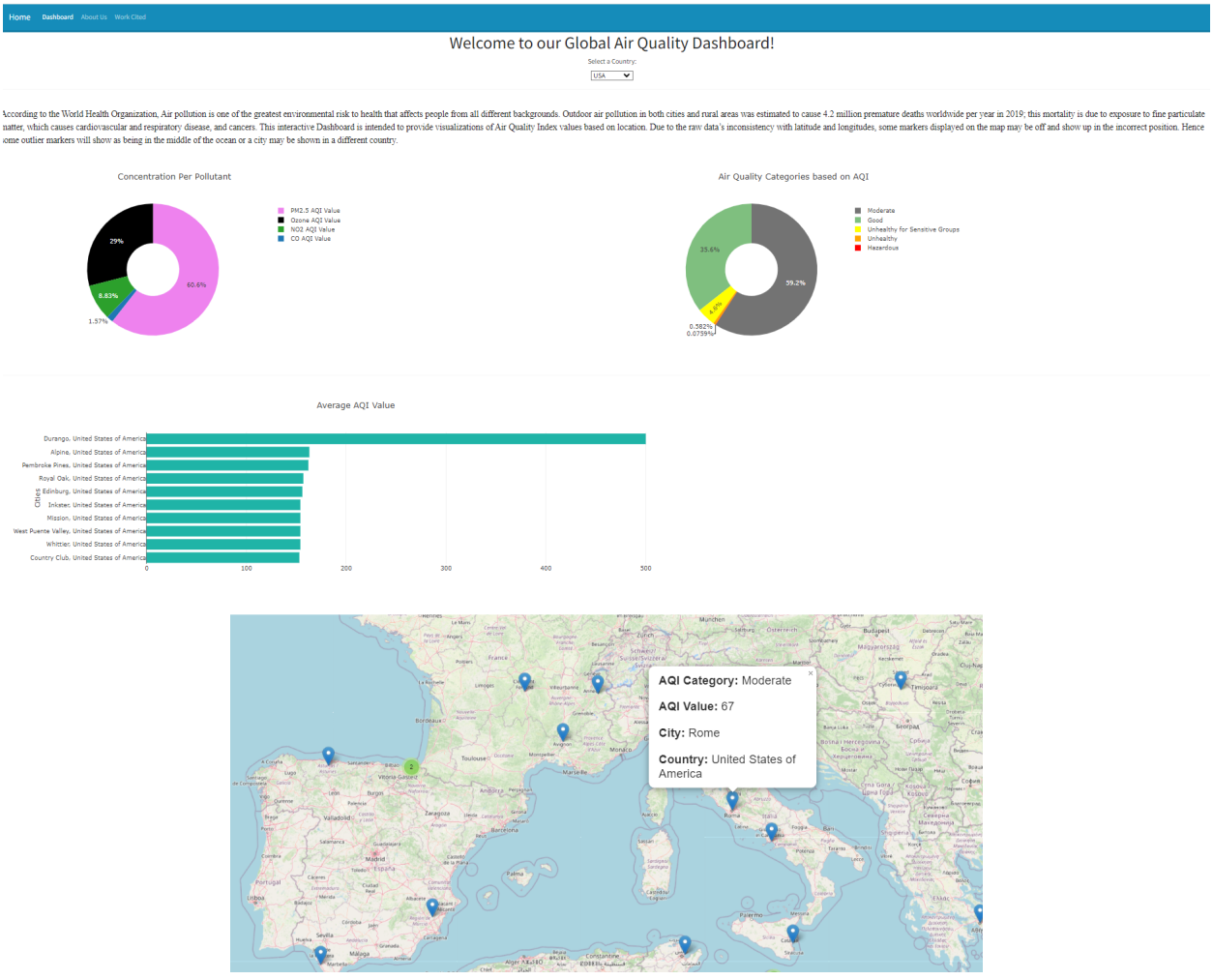


Figure 15: Screenshot of the Dashboard

Limitations and Bias

This study was performed with some limitations due to the data available. One limitation was that not all air quality pollutants are included in this data set such as Sulfur Dioxide (SO_2). There was also no date and/or time information included therefore it is unsure if the readings were all coming from the same point in time or over a span of different dates. Finally, an additional limitation was that some Cities have multiple entries while others only have one. A more accurate analysis could be made if all locations had the same count of readings done on the same date.

Future Implementation

Naturally this study is intriguing due to its global effect and further research should be done to determine any global trends as well as forecast and future implications from air pollution. Some questions to consider are:

1) Can AQI readings fluctuate during the same day?
2) Does temperature influence AQI values?
3) What age range is more sensitive to bad Air Quality?
4) Which Country has been the most successful in improving their overall air quality?
5) What industries are being more proactive in implementing solutions?

In a broader aspect, Team 2 could delve into health data to see which ailments are more sensitive to a bad AQI or use these measurements to determine if a country or industry is impacting an AQI value for the good or bad. This could support conclusions on if initiatives to save the environment are positive or negative.

Conclusion

Team 2's web interface provides an opportunity for individuals to explore their air quality in an easy-to-read dashboard. It also brings awareness to the importance of maintaining clean air and the importance to tracking air quality. Overall, a dashboard was created to provide three views

(Concentration Per Pollutant, Air Quality Categories based on AQI, and Average AQI Value) by filtering per Country.

References

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Terminology

Air Quality Index (AQI): Index is used for reporting daily air quality. It tells you how clean or polluted the air is in a region.

Particulate matter (PM2.5): Fine Particulates such as sulfates, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water.

Carbon monoxide (CO): Toxic gas produced by the incomplete combustion of carbonaceous fuels.

Ozone (O_3): Ozone at ground level – not to be confused with the ozone layer in the upper atmosphere – is one of the major constituents of photochemical smog and it is formed through the reaction with gases in the presence of sunlight.

Nitrogen dioxide (NO_2): NO_2 is a gas that is commonly released from the combustion of fuels in the transportation and industrial sectors.