Correlation of CO₂ Emissions and Water Toxins

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CO$_2$ - Water Toxins Global Impact

- What are the biggest factors contributing to global CO$_2$ emissions?
  - Fossil fuels - coal, oil and gas
  - Industry, transportation and electricity

- In 2019 the Global CO$_2$ emissions were at 33.2 gigatonnes (Gt)

- In 2022, globally, at least 1.7 billion people use a contaminated drinking water source

Carbon Dioxide is released from the combustion of hydrocarbons as a main source of energy.


Total CO2 Emissions by Year

Total World Population by Year
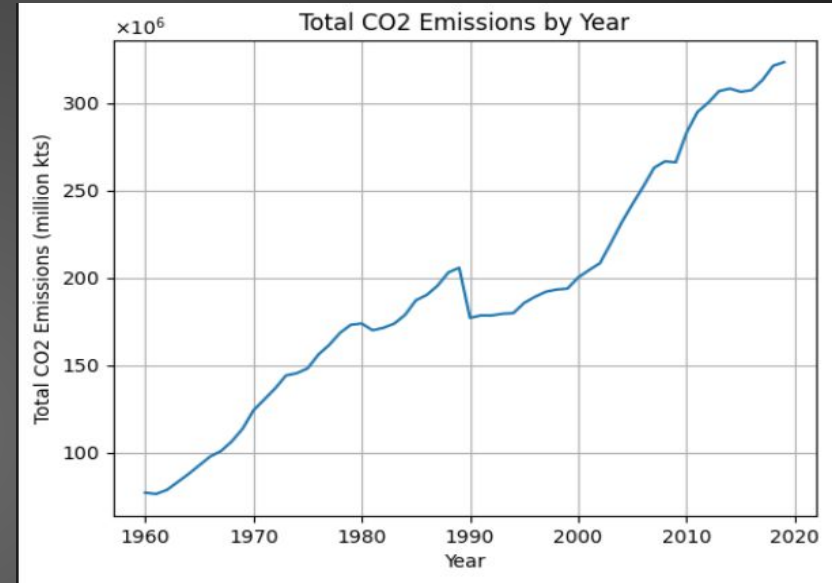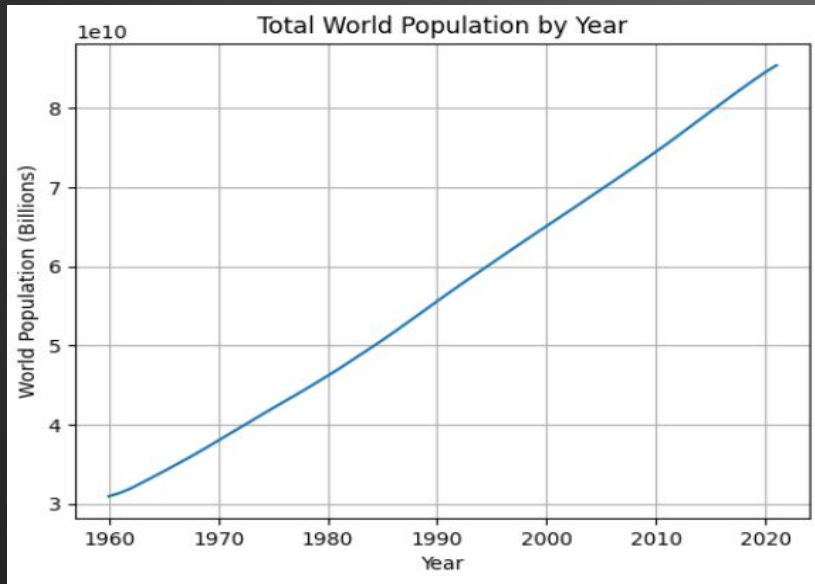
Is there a correlation between CO_2 emissions and toxins in waterways?

Hypothesis:

Within countries with high CO_2 emissions there will also be moderate to high levels of toxins in their water catchments.

Data Collection Sources:

https://www.kaggle.com/datasets/ulrikthygepedersen/co2-emissions-by-country

https://portal.gemstat.org/applications/
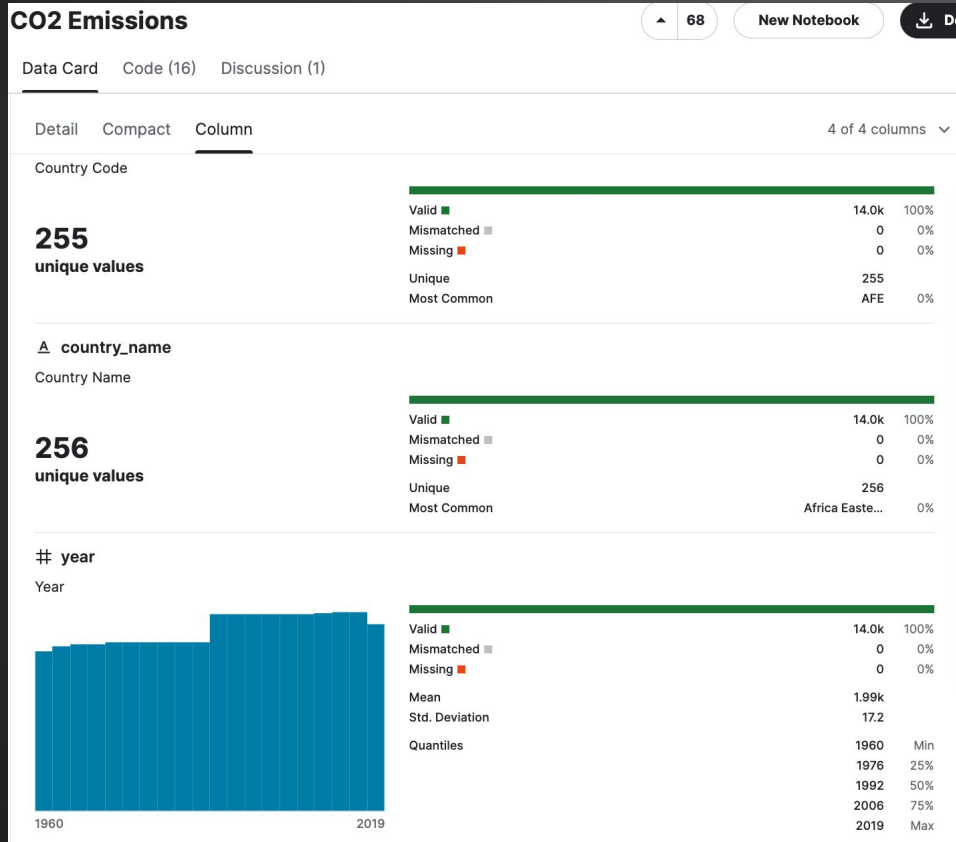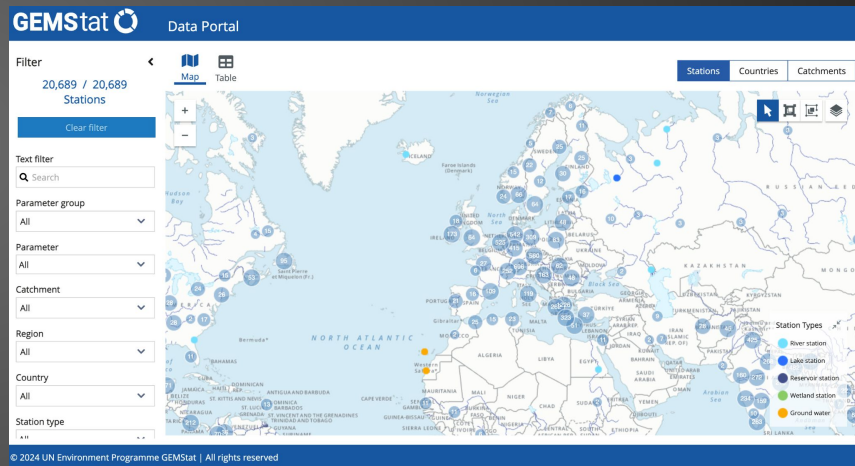
- Calculate emissions per capita
- Limit to 2019 data
- Highest 3 emitters*
- Lowest 3 emitters*

*water toxins data available

The Data:

Netherlands



Japan

The Data:

The Data:

Czechia

Burundi

The Data:

pH by Country
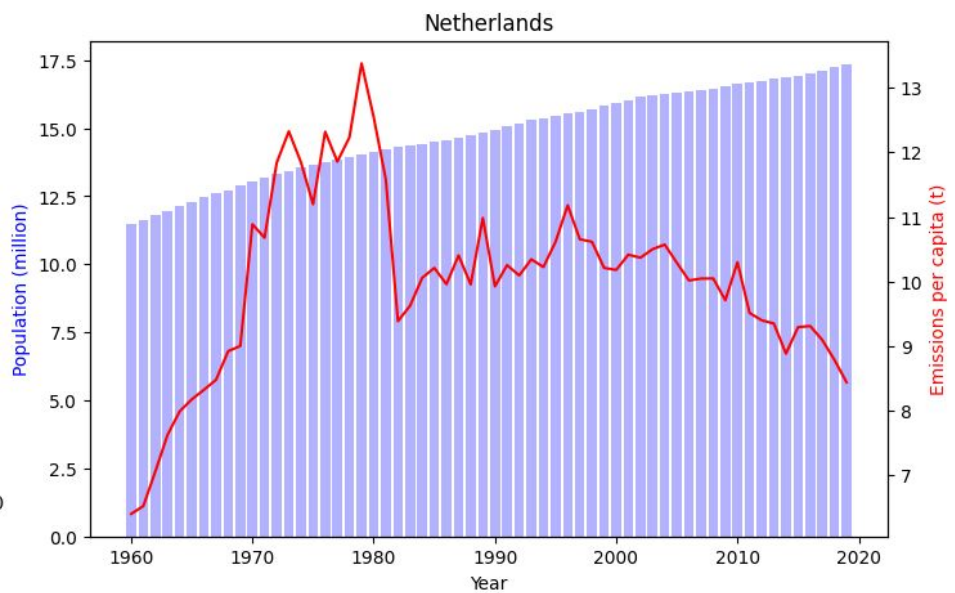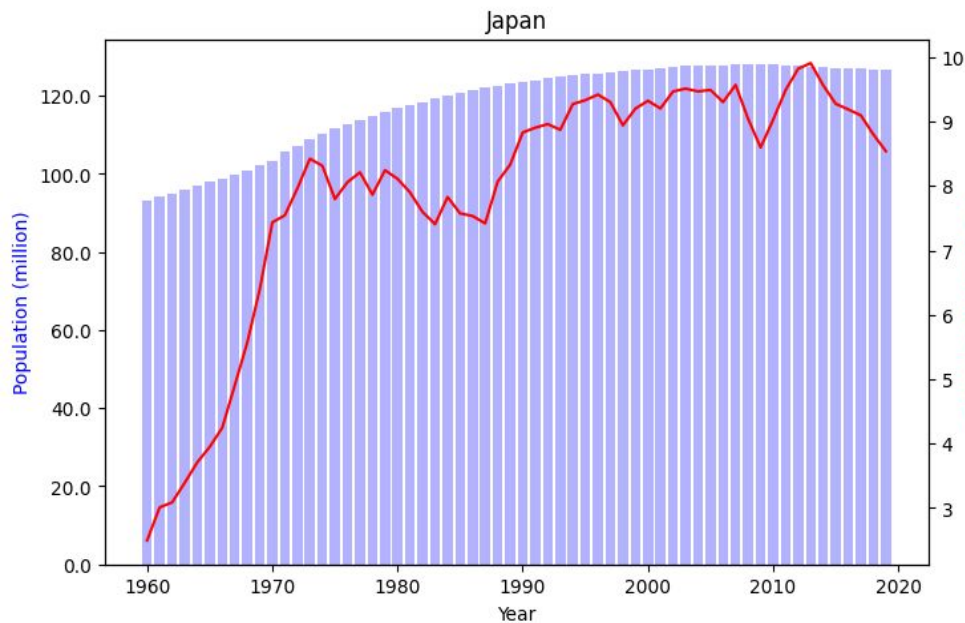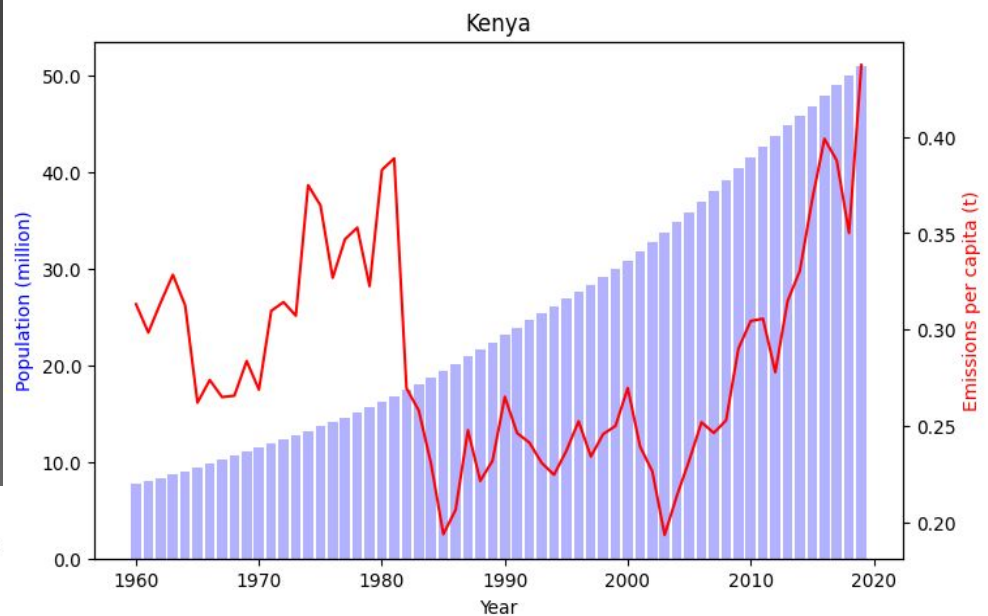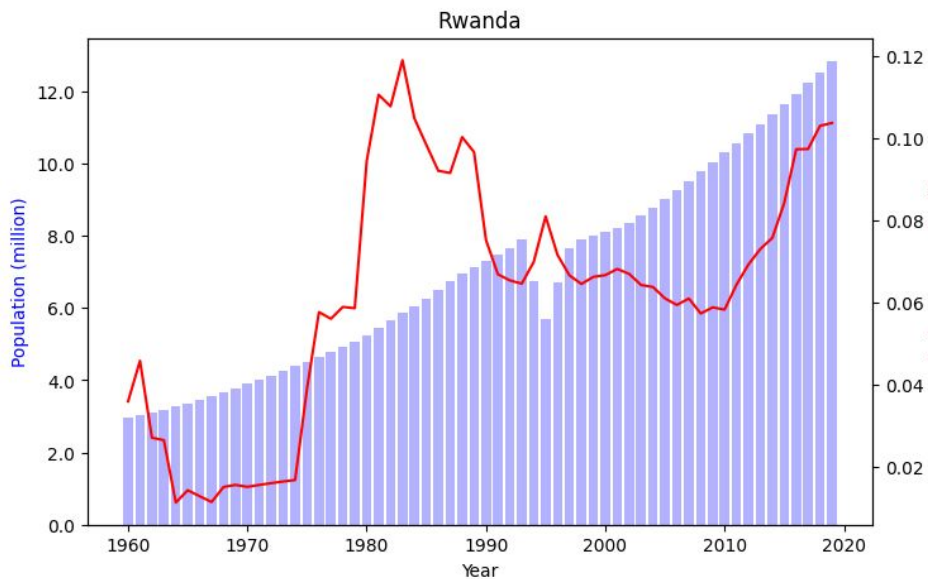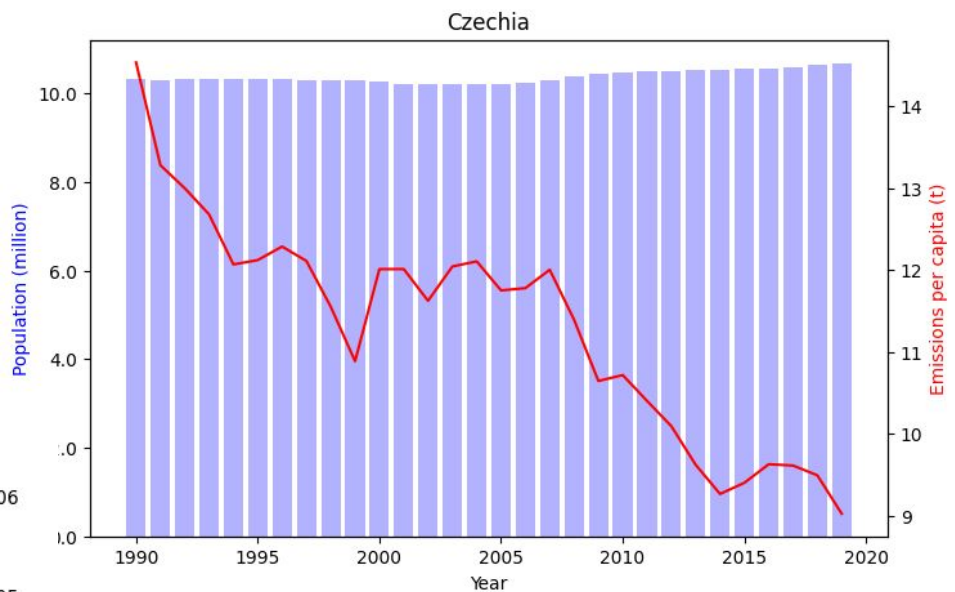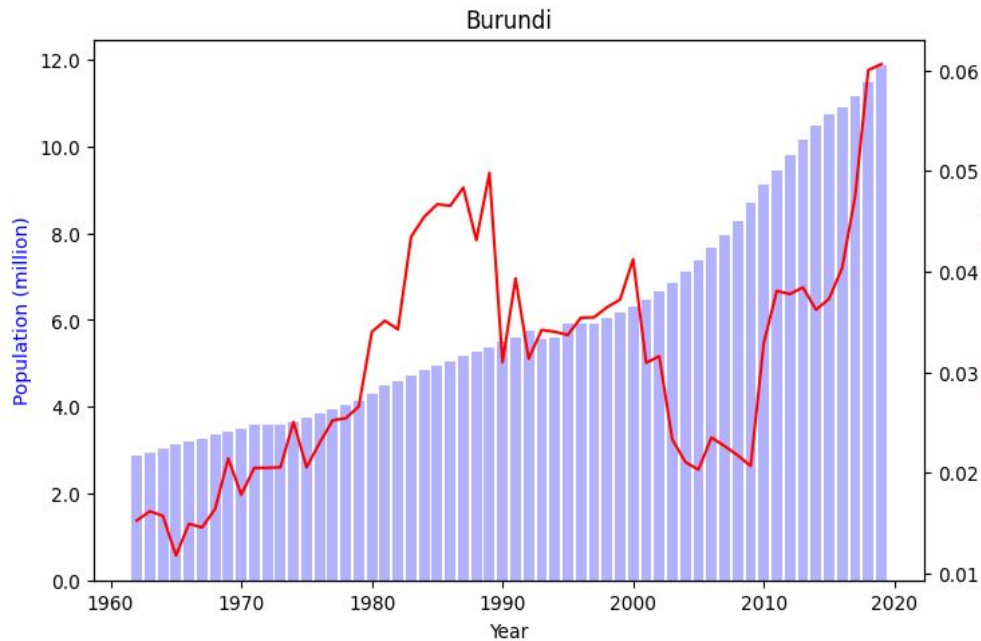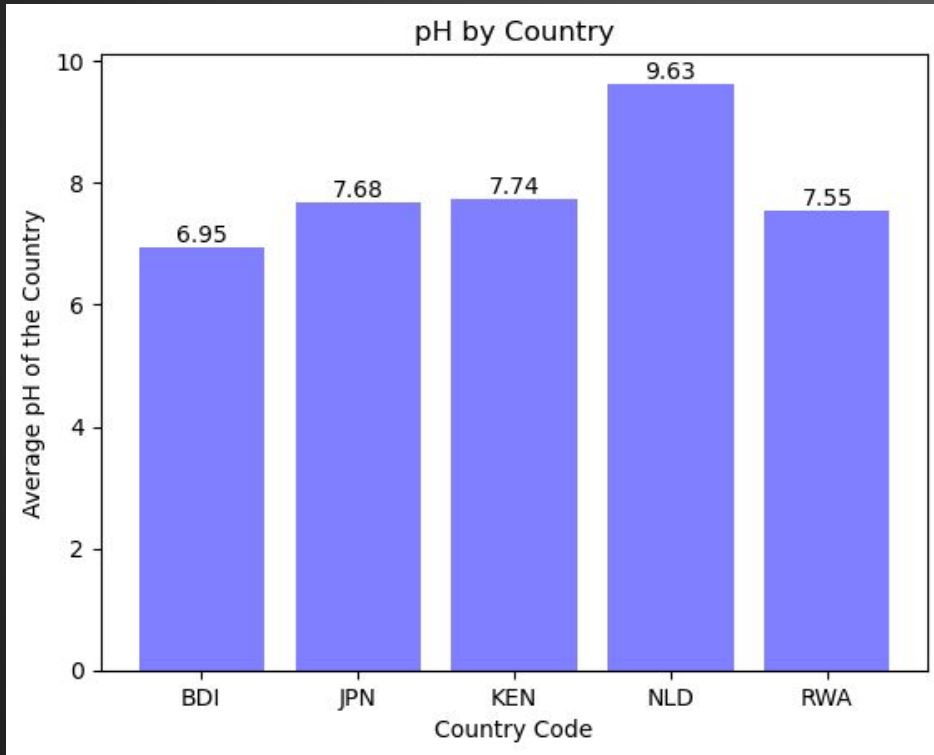
What can pH tell us?

Czechia pH data was not available.
7.61 pH*

Everything but the
Netherlands is in a
normal pH range:
6.5-8.5

The Data:

Country Codes:
BDI: Burundi
CZE: Czechia
JPN: Japan
KEN: Kenya
NLD: Netherlands
RWA: Rwanda

Average CO2 emissions in 2019
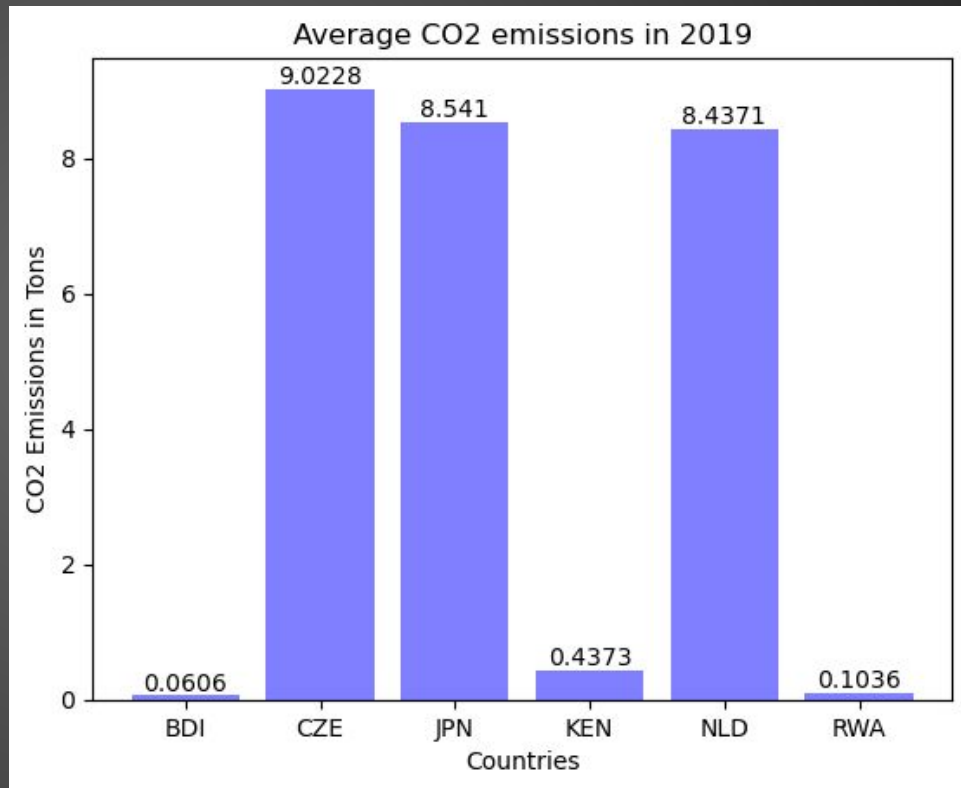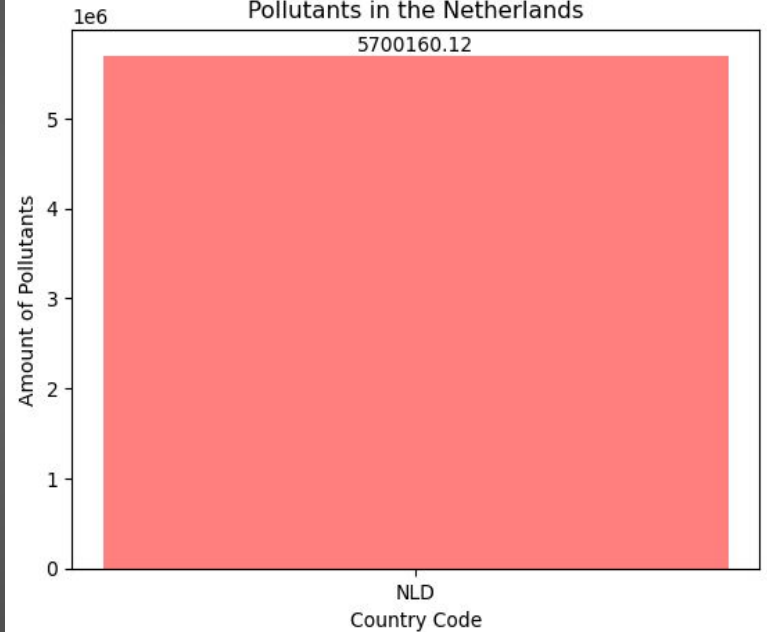
The Data:

The Data:
Average Water Pollutants by Country

The Data:

Average Pollutants Per Country - No Netherlands

Average Pollutants Per Country - With Netherlands
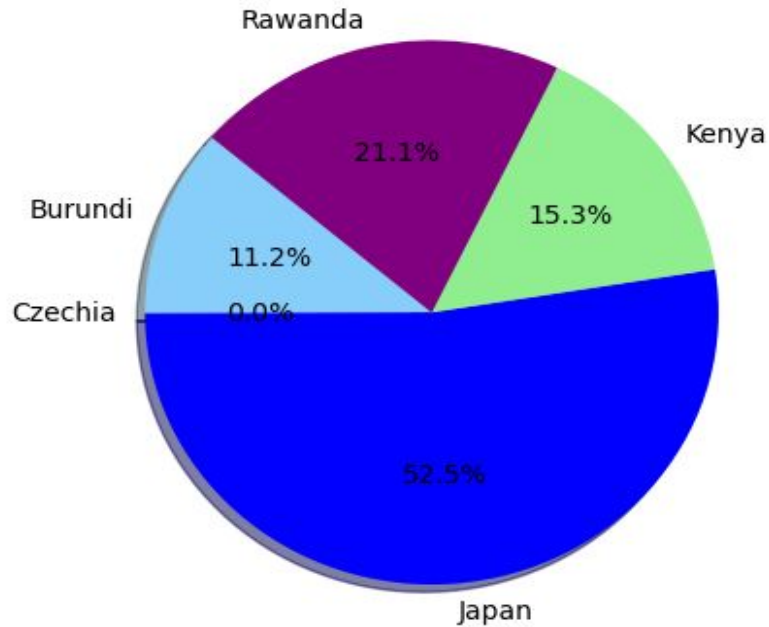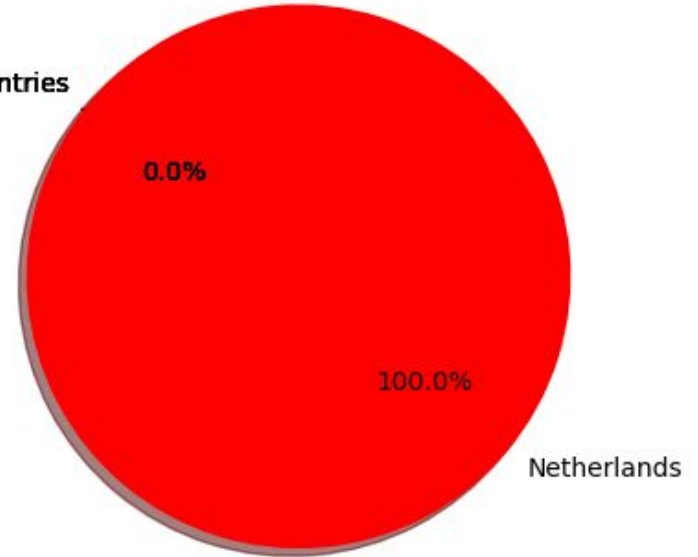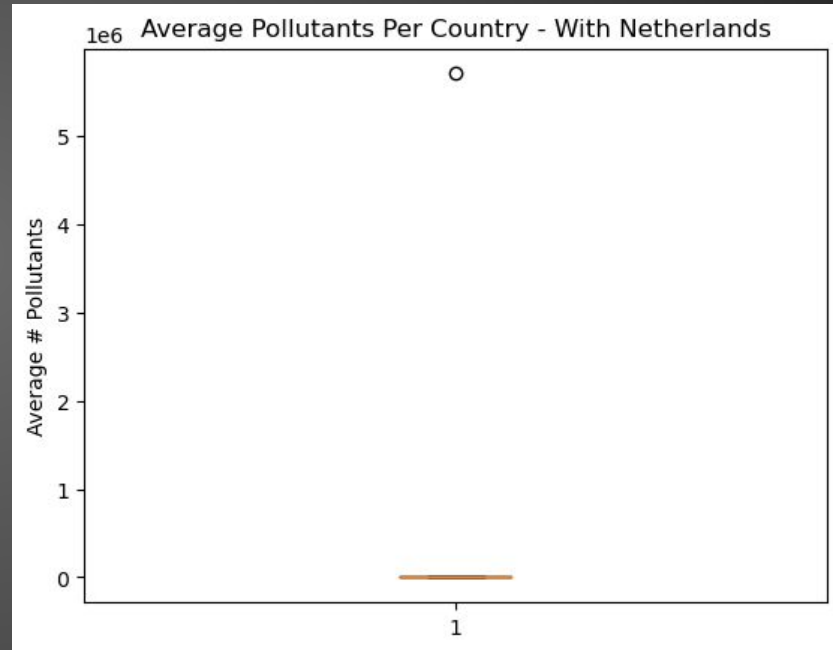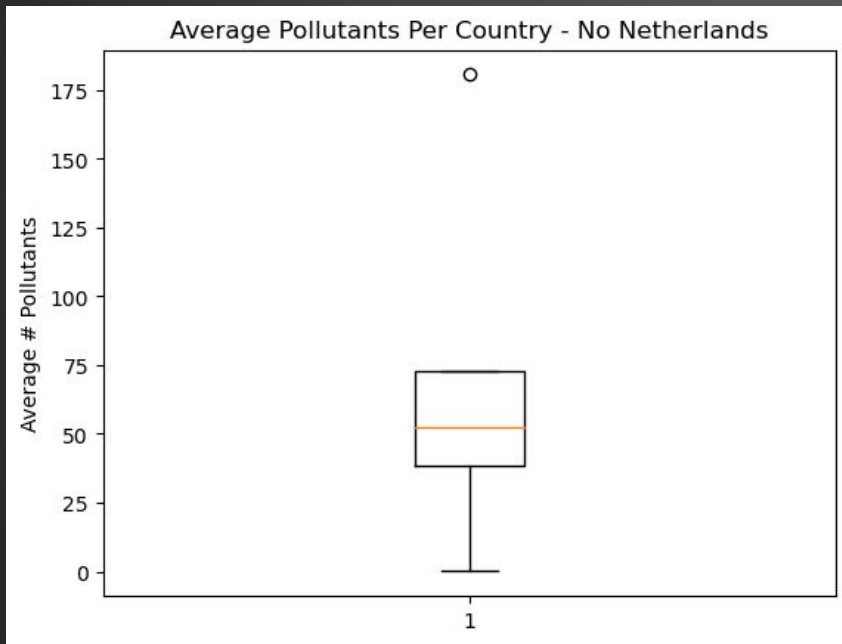
The Data: No Outliers


Average Pollutants - No Outliers
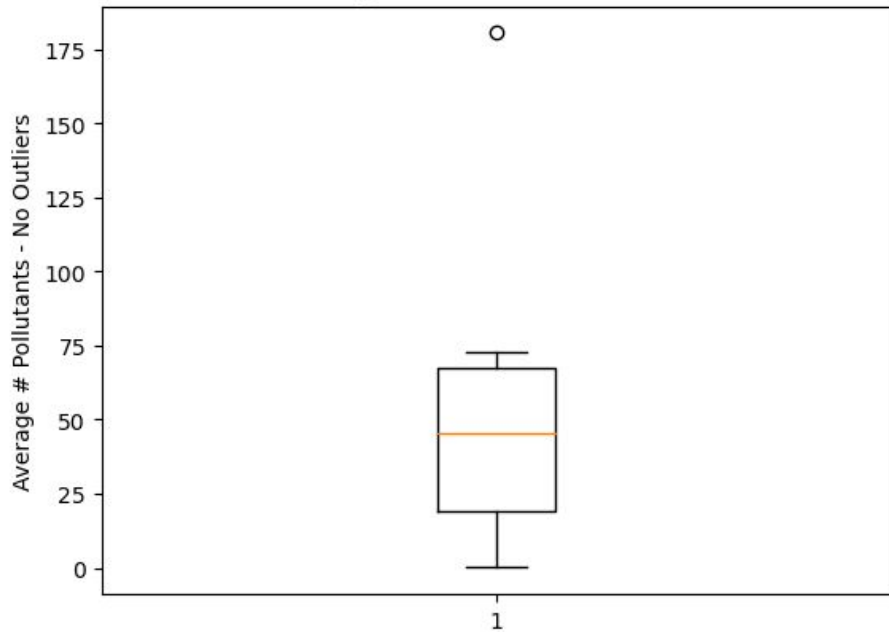
Average Emissions
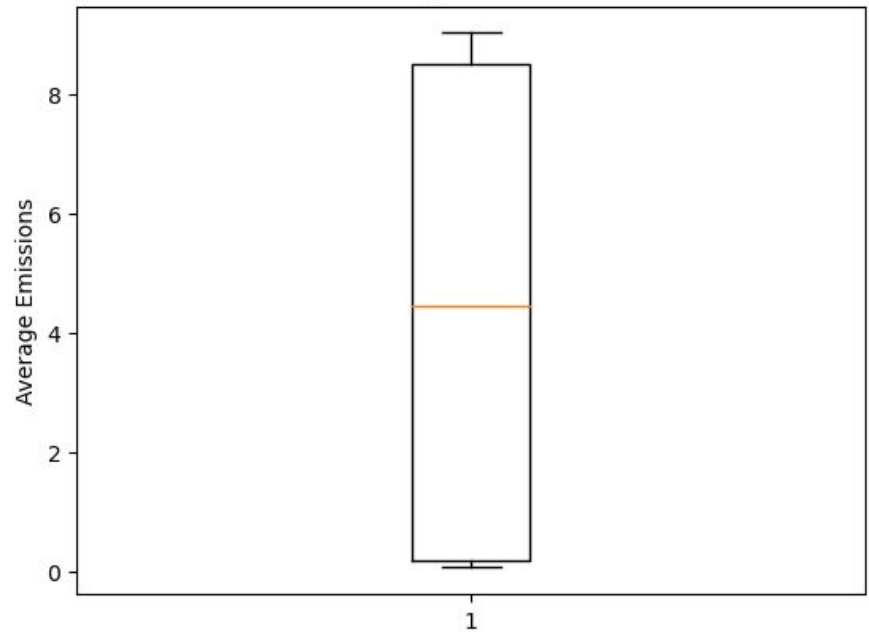
The Data: Quartiles

Average # of Pollutants:
Lower Quartile: 19.31
Upper Quartile: 67.57
Interquartile Range: 48.26
Median: 45.47
Lower Bound: -53.08
Upper Bound: 139.97

Emissions per capita(tons):
Lower Quartile: 0.19
Upper Quartile: 8.52
Interquartile Range: 8.33
Median: 4.44
Lower Bound: -12.31
Upper Bound: 21.01

The Data: No Outliers

Pollutants by Country, No Outliers

- BDI: 38.42
- CZE: 0.02
- JPN: 180.61
- KEN: 52.52
- NLD: 12.94
- RWA: 72.59

(Average Pollutants (No Outliers) vs Country Code)

Average CO_2 emissions in 2019

- BDI: 0.0606
- CZE: 9.0228
- JPN: 8.541
- KEN: 0.4373
- NLD: 8.4371
- RWA: 0.1036

(CO_2 Emissions in Tons vs Countries)
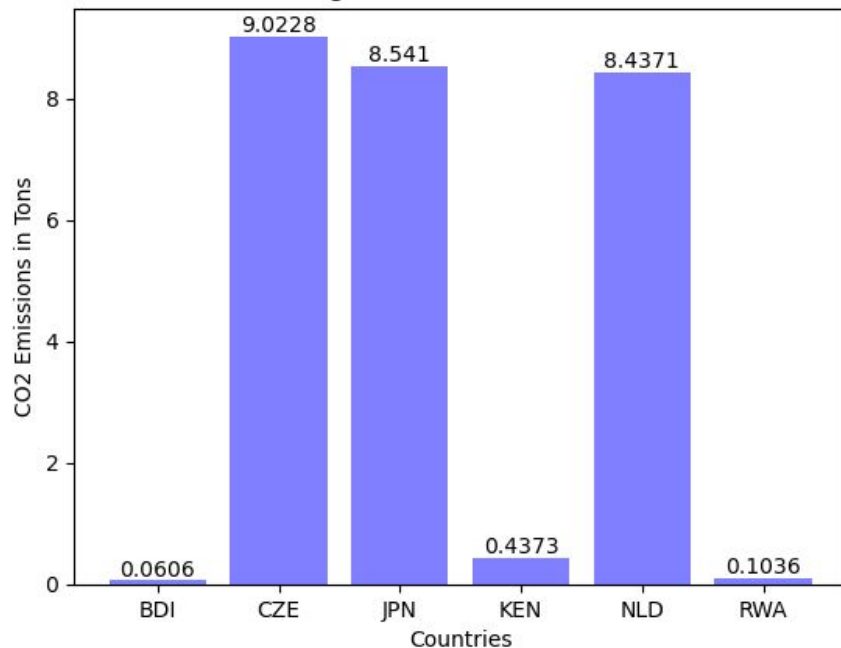
The Data: Stats

Let X_1 represent the pollution and X_2 represent emissions. Then:

$\mu_1 = 59.52$, $\sigma_1 = 64.87$, and
$\mu_2 = 4.43$, $\sigma_2 = 4.64$.

Computing the two-sample t-test, we get:

$$t = \frac{59.52 - 4.43}{\sqrt{\frac{(64.87)^2}{6} - \frac{(4.64)^2}{6}}} = \frac{55.09}{697.77} \approx 0.085$$

Since the p-value is greater than 0.05, we cannot reject the null hypothesis.

Hence, we have not proven a correlation between CO_2 emissions and water pollution.

Conclusion:

- The survey of pollutants (water toxins) within water catchments of top 3 CO_2 emitting countries compared to lowest 3 countries was **not statistically significant**.
- Therefore, our hypothesis of a correlation between CO_2 emissions and moderate to high levels of water toxins cannot be proven or disproven due to **inconclusive data**.
- Why?
  - Possible that high energy producing, industrialized nations have stricter laws against water pollution.
  - Data collection of pollutants across all countries may not be uniform.

Challenges:

- Decision to exclude high CO_2 emitting countries based on being oil rich with very small populations in 2019.

```
country_name
Bahrain                22.259581
Burundi                 0.060632
Czechia                 9.022786
Japan                   8.540980
Kenya                   0.437279
Kuwait                 20.861949
Netherlands             8.437075
Oman                   16.518321
Qatar                  32.761775
Rwanda                  0.103623
United Arab Emirates   20.502283
Name: emissions per capita (t), dtype: float64
```

2019 Populations:
Qatar 2,760,385
Bahrain 1,477,469
Kuwait 4,360,444
Japan 125,244,761
Netherlands 17,434,557
Rwanda 13,146,362
Kenya 51,985,780

Challenges:

- Unable to use the true top 3 CO_2 emitting countries due to lack of water toxins data. Libya 8.65 tons of CO_2 emissions per capita but no data possibly due to geopolitical reasons.
  - Replaced with Netherlands (8.43) which has its own challenges.
  - Not every water pollutant recorded in every country.

- Netherlands "Bill Gates" water pollutant outlier skews data beyond recognition.

If We Had More Time:

- Deeper dive into specific pollutants that are found within all 6 countries.
  - Create scatter plots for each pollutant across top 3 and lowest 3 countries.
  - Calculate Pearson correlation coefficients, coefficients of determination and linear regression lines.

- Focus on water catchments only near major cities of the 6 countries. Retest hypothesis based on these specific data sets.

Questions?