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Student Internship

SRI-VIPRA

Project Report of 2025: SVP-2505

"A Breath of Concern: Unmasking Air Pollution Patterns through Data Analytics "

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SRIVIPRA PROJECT 2025

Title : *A Breath of Concern: Unmasking Air Pollution Patterns through Data Analytics*

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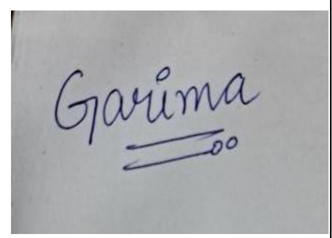
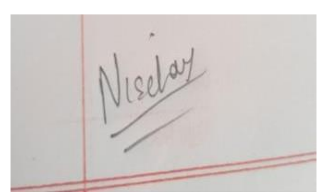
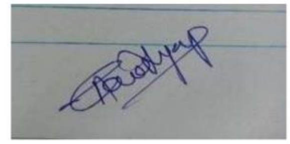
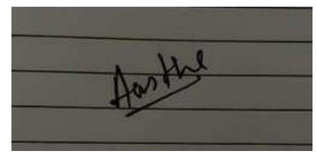
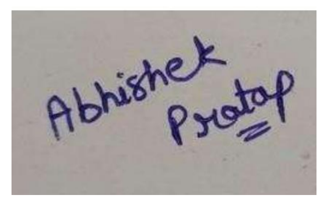
1		Garima	1923022	B.Sc. Honours. Statistics	
2		Nischay Narula	0523015	B.A. Honours Economics	

3		Aradhya Pandey	1023098	B. Com Honours	
4		Aastha Gupta	1023103	B. Com Honours	
5		Abhishek Pratap Singh	1623043	B.Sc. Honours Electronics	
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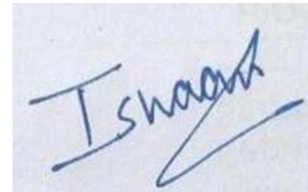
7		Ishaan Jain	1024077	B. Com Honours	
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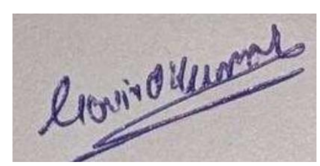
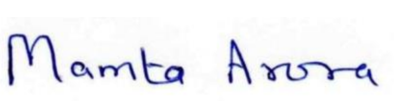
9		Kushagra Pandey	1024043	B. Com Honours	
10		Govind Kumar	0923107	B. Com Programmme	



Signature of Mentor

Certificate of Originality

This is to certify that the aforementioned students from Sri Venkateswara College have participated in the summer project SVP-2505 titled “A Breath of Concern: Unmasking Air Pollution Patterns through Data Analytics”. The participants have carried out the Research project work under my guidance and supervision from 1st July, 2025 to 30th September 2025. The work carried out is original and carried out in a hybrid mode.

Signature of Mentor

Acknowledgements

The successful completion of our research paper would not have been possible without the guidance, encouragement, and support of several individuals who played an integral role throughout our journey. We take this opportunity to express our sincere gratitude to all those who contributed to the realization of this work.

We are deeply thankful to **Prof. Vajala Ravi**, Principal, and **Prof. K.C. Singh**, Vice Principal, for their constant encouragement, leadership, and for providing us with an inspiring academic atmosphere that nurtures innovation and research.

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Finally, we express our gratitude to our institution **Sri Venkateswara college** for providing us with the resources, facilities, and opportunities that made this research possible. We are truly thankful to everyone who directly or indirectly supported us in bringing this work to fruition.

***Date**: 30th September, 2025*

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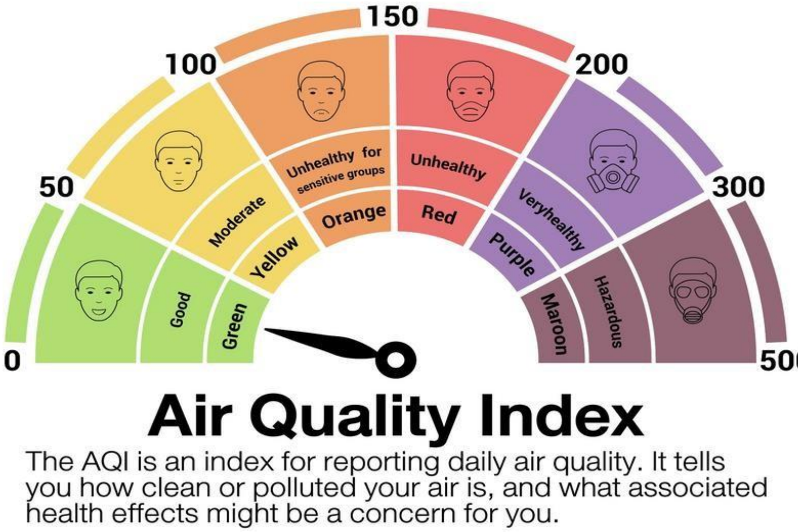
Abstract

This paper gives an in-depth review and quantitative assessment of the trends in air pollution, health effects, and policy measures with a specific focus on India and comparative perspectives of 25 countries. It analyzes the transformation of air pollution as an outcome of industrialization and as an essential environmental health hazard, spelling out the interplay between socioeconomic conditions, policy measures, and environmental effects. Employing Ordinary Least Squares (OLS) regression analysis, the research determines major air quality drivers, including forest cover, income, vehicular population, population, rain, industrial pollution, and wind speed, and finds that increased vehicle and industrial emissions always deteriorate air quality, but increased forest cover and rain improve air quality. The article provides evidence of large health and economic costs associated with poor air quality, especially the rise in respiratory conditions and inequities in life expectancy between Indian states. The research calls for policy interventions of a strategic nature, such as the imposition of emission taxes, encouragement of cleaner technologies, tighter controls on industry, and urban green schemes, along with additional research into long-term effects on health and efficacy of the suggested interventions.

Introduction

Air pollution has undergone drastic changes over the decades, resulting in a multitude of related consequences worldwide. Historically, it was seen as a symbol of development and prosperity, given that it is a direct consequence of urbanisation and industrialisation. With little importance given to the environment and sustainability, there were very few efforts made to combat air pollution. A pattern emerged over the decades of an increase in pollution as a result of society's increasing welfare, followed by an attempt to resist it once the economy was strong enough to afford it. Larger emissions of pollution are more noticeable in developing economies, as they tend to prioritise people's welfare. In contrast, more developed countries often attempt to reverse environmental damage due to their greater economic ability to afford it.

However, it is no longer an issue restricted to a geographical scale. With South Asia, a classic example of transboundary air pollution, it is evident that the consequences of emissions extend beyond the location where the pollution is generated, amplifying the degradation of environments, ozone layer depletion, and the effects of greenhouse gases. Ambient air pollution is one of the greatest killers of this age. Its effects have been far-reaching on the ecosystem and have posed a health risk to human beings, caused economic losses and affected productivity.
Although with a shift in attitude towards this global issue, efforts have been made to shift towards cleaner fuels, establish emission standards and impose emission taxes, these initiatives have been met with short-term victories.



Literature Review

Air pollution is a major environmental and public health issue in India. It greatly affects air quality in cities, human health, and economic productivity. This review looks at trends in air quality, health effects, and economic impacts, noting regional differences, seasonal effects, and policy considerations.

Roychowdthy and An (2025) provide a thorough analysis of Bengaluru's air quality during the winter season of 2024-25. The study identifies areas with high pollution and those that are cleaner, showing variability in space and time. It highlighted days with "poor" and "very poor" AQI categories, especially at RVCE. This indicates ongoing pollution problems, even with overall improvements. The ICMR report, cited in The Hindu (2025), identifies air pollution as India's second most serious health risk, adding significantly to the national health burden. The report points out improvements in life expectancy but also shows large differences between states, with air pollution worsening health disparities.

This connects with findings from Sethi and Singh (2024), which predict that rising levels of PM2.5 and ozone will lead to more hospital admissions and respiratory diseases like bronchitis, especially in children. The health burden includes more days with restricted activities and asthma symptoms, which puts extra pressure on healthcare systems and individual health. The authors advocate for policies such as emission taxes and cleaner technologies, arguing that improving air quality could provide immediate economic benefits and long-term climate advantages.

Horn and Dasgupta (2023) provide a comprehensive review of the Air Quality Index (AQI), tracing its historical development, measurement methods, and policy relevance. They emphasize that the AQI was designed as a communication tool, translating complex pollutant concentrations into a simplified, color-coded scale that the public can easily understand. Their analysis shows that while the AQI has played a crucial role in raising awareness and guiding regulatory action, it has also faced criticism for oversimplifying pollution dynamics by focusing on a single "critical pollutant." Alternative multipollutant indices have been proposed to address this gap, but challenges in data availability and interpretability have limited their adoption. The review further highlights how pollutants such as ozone and PM2.5 remain dominant drivers of AQI exceedances, with seasonal variations reflecting photochemical activity and local emission patterns. This aligns with Indian studies, where PM2.5 and ozone also emerge as critical pollutants influencing both public health and regulatory debates.

Kanchan, Gorai, and Goyal (2015) present an extensive review of air quality indexing systems, emphasizing their importance as communication tools that simplify complex pollutant data into a single, interpretable value. The authors note that AQIs, also termed Air Pollution Index (API) or Pollutant Standards Index (PSI), have been widely adopted by governments to inform the public about air quality status and potential health impacts. However, they highlight that no universal method exists, as different countries apply varying aggregation techniques, pollutant sets, and threshold values, reflecting local environmental and health priorities.

Their analysis shows that early systems, such as the U.S. EPA's Pollutant Standards Index, relied on the maximum value of a single pollutant, which often obscured combined exposures. Later approaches, including the Revised Air Quality Index (RAQI) and the Common Air Quality Index (CAQI), sought to address this by integrating multi-pollutant effects and providing real-time comparability across regions. Other innovations, such as the Oak Ridge AQI, the New Air Quality Index (NAQI), and health-based models like Canada's Air Quality Health Index (AQHI), demonstrate a progression toward indices that better reflect both pollutant interactions and public health risks.

The review concludes that while AQIs have significantly advanced public awareness and policy engagement, limitations remain. Many systems do not adequately account for synergistic pollutant effects, uncertainty, or spatial variability, and often lack flexibility to incorporate new pollutants. The authors argue that future AQI development must strike a balance between scientific rigor and simplicity, ensuring indices remain accessible for the public while capturing the complexity of air pollution and its health implications.

Wu et al. (2021) provide a detailed analysis of the Air Quality Index (AQI) as a key communication tool linking air pollution data to public health awareness. They trace its evolution from the U.S. Pollutant Standards Index (PSI) in the 1970s to the AQI's current global use, highlighting how it simplifies complex pollutant concentrations into categories like "good," "moderate," or "hazardous".

Their review points out that no truly "safe" level of air pollution exists, as long-term exposure to PM2.5—even at concentrations well below many national AQI thresholds—is associated with increased risks of lung cancer and cardiopulmonary mortality. Nonetheless, China and India, for practical reasons, set 24-h PM2.5 thresholds at twice the WHO guideline levels, raising concerns about underestimating health impacts. Wu et al. also emphasize wide international variations in AQI descriptors and warning messages. While some regions, such as the UK and Hong Kong, use neutral labels like "low" or "moderate," others, including the U.S. and South Korea, adopt emotionally valenced terms such as "unhealthy" or "hazardous," which were found to elicit stronger risk perceptions and higher precautionary intentions.

Moreover, their experimental findings show that vague references to “sensitive groups” foster third-person perceptions, whereby individuals underestimate their own risk compared to others, whereas specifying at-risk populations (e.g., children, seniors, or people with respiratory diseases) reduces bias and encourages protective behaviors. Collectively, their work demonstrates that although the AQI is indispensable for public risk communication, its effectiveness depends heavily on the wording and design of descriptors and warnings, with significant implications for promoting individual and collective action against air pollution.

This review emphasises the complex effects of air pollution in India, from seasonal trends in cities to significant health and economic costs. Future research should look into long-term health effects and the effectiveness of proposed policies like emission taxes and green investments.

Data Sources

The data for this study were compiled from multiple secondary sources to ensure comprehensive coverage of environmental, economic, and health-related indicators. Specifically:

- Air Quality Index (AQI): Data was obtained from AQI.in for country-wise annual average AQI.
- Health Indicators: Data on asthma prevalence and life expectancy were collected from the World Health Organization (WHO).
- Carbon Emissions: Data on industrial CO_2 emissions and grid CO_2 intensity were sourced from the Global Carbon Atlas.
- Economic Indicators: GDP per capita and other macroeconomic indicators were extracted from the World Development Indicators (WDI), World Bank.

The dataset thus combined socioeconomic, demographic, and environmental indicators for 25 countries, providing a balanced cross-sectional sample.

Research Methodology

Research Design

This study adopts a quantitative research design using Ordinary Least Squares (OLS) regression to examine the relationship between socioeconomic, environmental, and meteorological factors and air quality. The dependent variable is the Average Air Quality Index (AQI),

The independent variables are:

- GDP per capita (root transformed as GDP_ROOT)
- Vehicles per 1000 people (root transformed as Vehicleroot)
- Population density (log transformed as logdensity)
- Rainfall (log transformed as lograinfall)
- Forest area (root transformed as ForestRoot)
- Industrial CO_2 emissions (IndustrialCO_2Mtyr)
- Mean wind speed (MeanWindSpeedms1)

Data Processing

- Variables were transformed (logarithmic or root) where necessary to reduce skewness and improve normality.
- Missing values were checked and handled where applicable.
- The dependent variable (AverageAQI) was kept in its original form.

Econometric Model

The regression model estimated is:

AverageAQI = $\beta 0 + \beta 1$ GDP_ROOT + $\beta 2$ Vehicleroot + $\beta 3$ logdensity + $\beta 4$ lograinfall + $\beta 5$ ForestRoot + $\beta 6$ IndustrialCO_2Mtyr + $\beta 7$ MeanWindSpeedms1 + ε

Where $\beta 0$ = constant and ε = error term.

Software and Estimation

The analysis was conducted using the GNU Regression, Econometrics and Time-series Library (Gretl) software. The following steps were followed:

1. Data was imported into Gretl in CSV/Excel format.
2. Variable transformations (log, square root) were performed using Gretl's "Define new variable" function.
3. An OLS regression was run by selecting Model → Ordinary Least Squares → specify dependent and independent variables.
4. Diagnostic statistics (coefficients, t-ratios, p-values, R^2, adjusted R^2, F-test, AIC, SC, HQ criteria) were extracted from the output.
5. Significance levels were assessed at 1%, 5%, and 10%.

Model Diagnostics

The model goodness-of-fit was assessed using R^2 (0.756), Adjusted R^2 (0.656), and F-test significance ($p < 0.01$), confirming overall model validity. Further diagnostic tests (multicollinearity, heteroscedasticity, and normality) were considered for robustness checks.

Findings

The regression model achieved an **R^2 of 0.756** and an **Adjusted R^2 of 0.656**, indicating that approximately 66% of the variation in AQI can be explained by the selected independent variables. The **F-test ($p < 0.01$)** confirms that the model as a whole is statistically significant.

Key results:

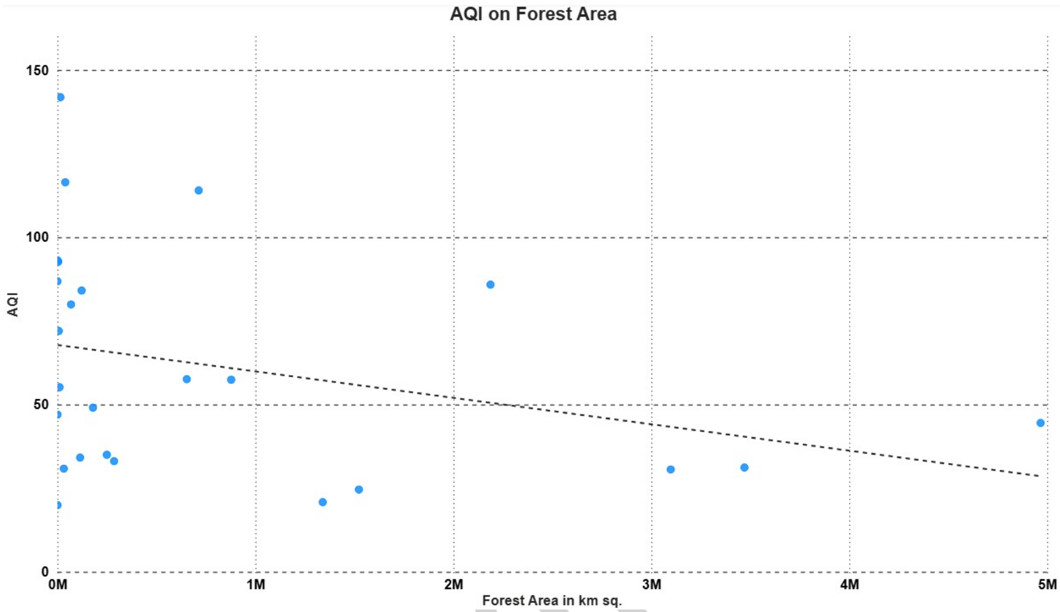
- **GDP per capita (GDP_ROOT):** Showed a weak negative but insignificant relationship withAQI, suggesting income level alone does not strongly determine air quality.High-income countries (e.g., **Qatar, France, Italy**) still face AQI challenges despite wealth, while lower-income ones (e.g., **Nepal, Kenya**) face issues due to lack of controls.
- **Vehicles per 1000 people (Vehicleroot):** Positively associated with AQI and statistically significant ($p < 0.05$), confirming that higher vehicle density worsens air quality.
- **Population density (logdensity):** Positive but marginally significant effect, indicating that densely populated areas tend to have poorer air quality due to higher emissions.
- **Rainfall (lograinfall):** Negative and significant, implying that rainfall helps reduce pollutants in the atmosphere, improving AQI.
- **Forest area (ForestRoot):** Negative relationship, significant at 10%, indicating that larger forest cover contributes to better air quality.
- **Industrial CO_2 emissions:** Strong positive and highly significant ($p < 0.01$), confirming industrialization as a major driver of air pollution.Highly industrialized nations like **China, India, Turkey, and Poland** experience elevated AQI due to factories and coal plants.
- **Mean wind speed:** Negative relationship, significant at 5%, meaning higher wind speed disperses pollutants and lowers AQI.Landlocked or stagnant-air countries such as **Nepal, Mongolia, and Iran** suffer from pollutant accumulation due to low wind dispersion.

Interpretation:

The findings highlight that human activity variables (vehicles, industrial emissions, and population density) tend to worsen air quality, while natural and climatic factors (rainfall, forest area, wind speed)

help mitigate pollution. Policy implications include promoting sustainable transportation, stricter industrial emission controls, and conservation of forest areas to improve urban air quality.

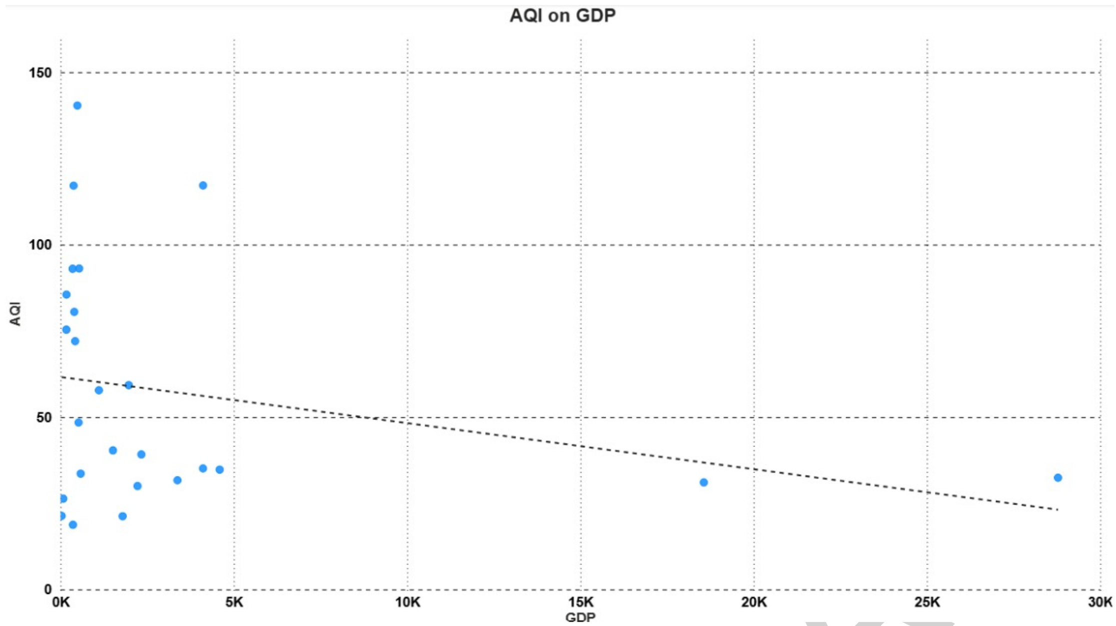
Graphs and interpretation



Total Forest Area vs. Avg. AQI

Greater forest cover is generally associated with cleaner air as regions with more forests tend to have lower AQI, while areas with limited forest cover often face higher pollution levels.
Still exceptions are present. Some countries with little forest area maintain moderate air quality through other means while certain heavily forested regions still experience pollution due to industrial activity, energy use or urbanization.

Low forest cover but moderate AQI (UAE, Kuwait): Strict regulations and advanced pollution controls help manage air quality despite limited greenery.
High forest cover but high AQI (Brazil, Indonesia): Industrial activity, energy reliance and urbanization drive pollution even in forest rich regions.



GDP vs. Avg. AQI

The relationship shows a negative slope: higher GDP per capita is linked to lower AQI suggesting that wealthier countries generally enjoy cleaner air.

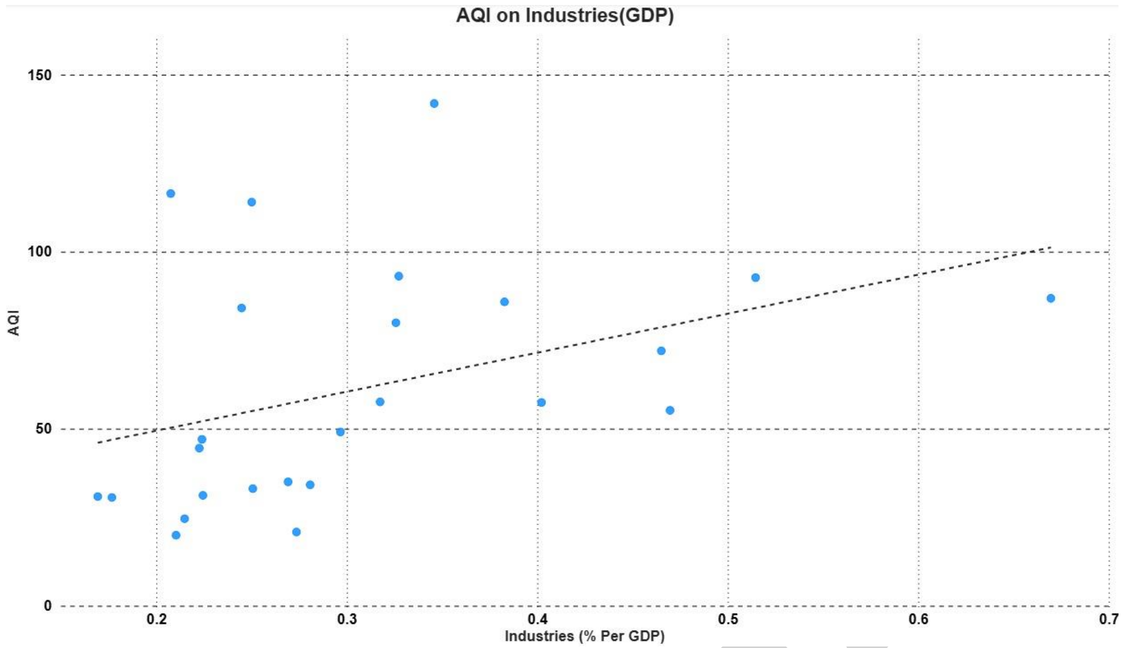
Low GDP nations often record higher AQI reflecting limited pollution controls, reliance on fossil fuels and weaker regulatory frameworks. In contrast high income countries typically report lower AQI due to advanced technologies, cleaner energy and stronger environmental policies.

Outliers:

Some middle income nations achieve relatively low AQI likely through effective regulations or favorable geography. On the other hand certain wealthier countries may still experience moderate AQI, reflecting industrial activity, urban density or regional pollution transport.

High GDP but moderate AQI (USA, Kuwait): Industrial activity, urban density or regional pollution transport raise AQI despite wealth.

Low GDP but relatively lower AQI (Ethiopia, Iceland): Favorable geography, lower industrialization or effective policies help maintain cleaner air.



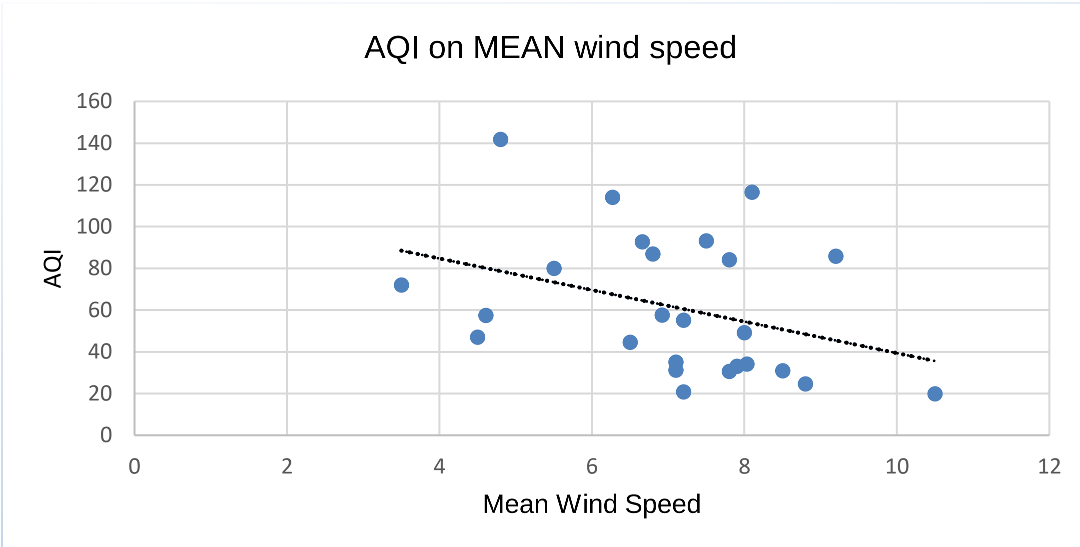
Industrial GDP vs. Avg. AQI

The data suggests a weak positive relationship between industrial CO_2 emissions and air quality: countries with higher industrial output often show somewhat higher AQI though the connection is far from consistent. For example some nations with very high emissions still manage relatively clean air through strong regulations, advanced pollution controls and lower population density.

At the same time, countries with more modest industrial emissions sometimes experience severe pollution, reflecting the influence of factors such as urban transport, biomass burning, coal dependence and weaker enforcement of standards. Outliers highlight these differences, nations with similar emission levels can show widely varying AQI outcomes depending on policy, technology and social conditions.

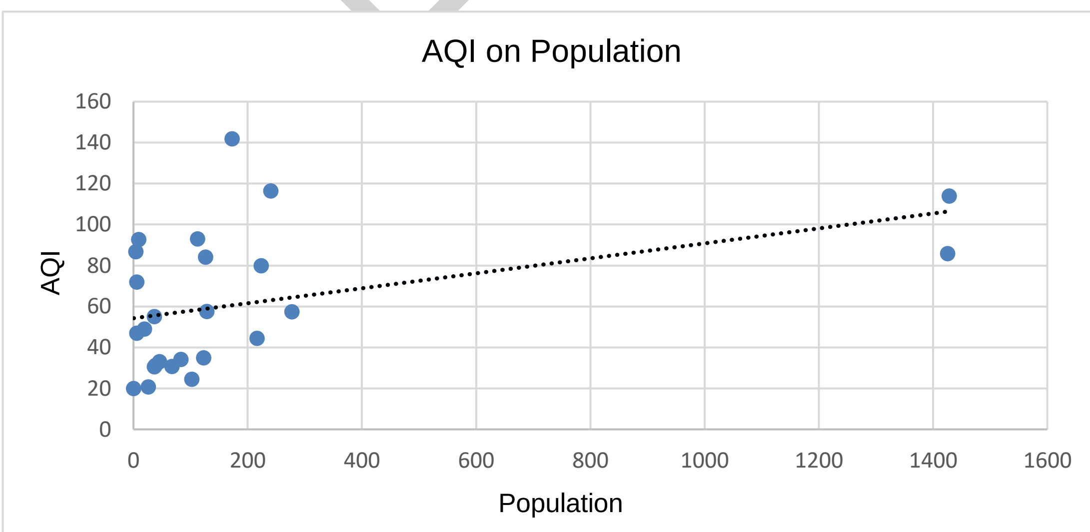
High emissions but moderate AQI (China, USA): Strong regulations, advanced pollution control and cleaner technologies reduce impact.

Low emissions but high AQI (India, Pakistan, Bangladesh): Driven by coal dependence, transport emissions and weak enforcement



Mean Wind Speed vs. AQI

Air quality improves with stronger winds, as higher wind speeds are generally associated with lower pollution levels. In contrast, low wind speeds often correspond with higher AQI values.
Still, there are exceptions. Regions with moderate winds may show high pollution due to heavy industrial or vehicle emissions, while some low-wind areas maintain cleaner air through strict regulations or naturally low emission levels.
Low wind but moderate AQI (Denmark): Strong regulations and low emissions help keep air clean. Moderate wind but high AQI (India, China): Heavy industrial activity and vehicle use outweigh dispersal effects.



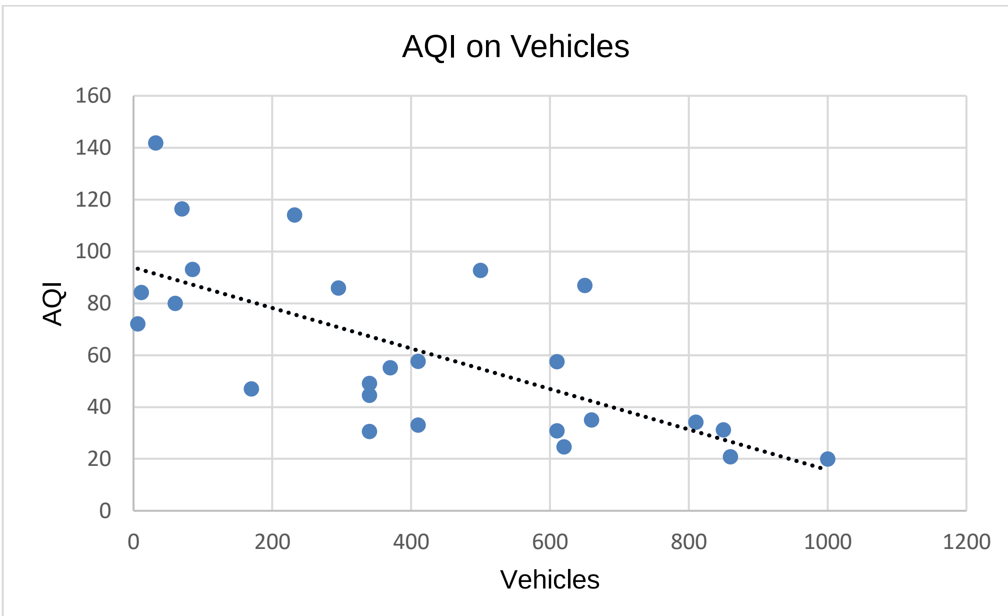
Population vs. AQI

Air quality generally worsens as population size increases. More densely populated areas often face higher pollution levels due to greater vehicle use, industrial activity, and energy demand while sparsely populated regions typically maintain cleaner air.

However exceptions exist. Some moderately populated regions still experience high AQI when industrialization is intense or environmental policies are weak, showing that population alone does not determine pollution levels.

High population but low AQI (Japan, Germany): Effective policies, clean technologies, and strict regulations help control pollution despite dense populations.

Low population but high AQI (Saudi Arabia, Mongolia): Reliance on fossil fuels, mining and weaker environmental enforcement drive pollution even in sparsely populated regions.

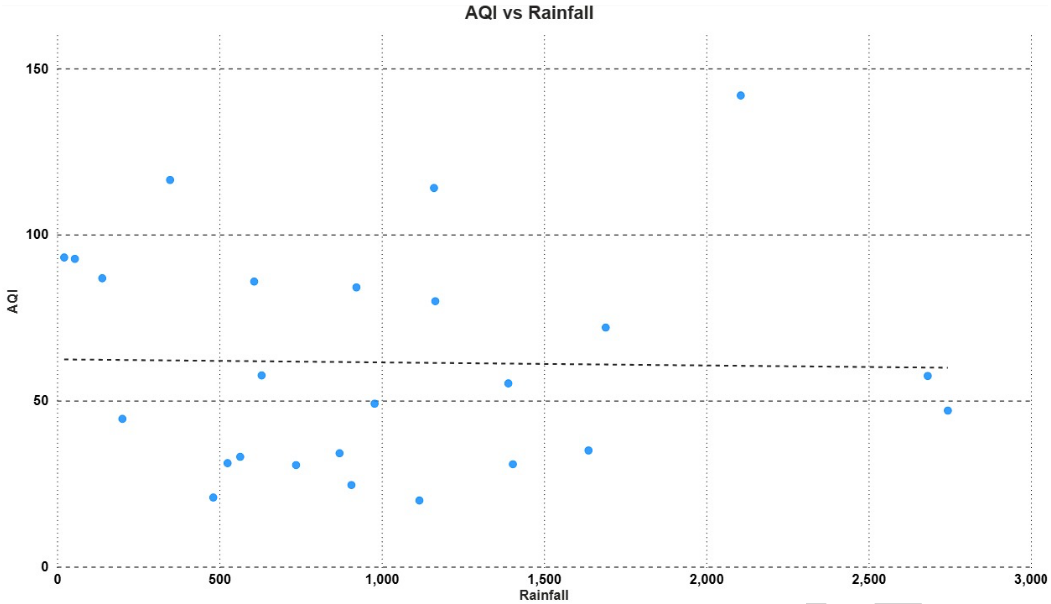


Vehicles vs. AQI

Vehicle numbers alone do not directly determine air quality. Countries with fewer vehicles often show wide variation in AQI as industrial activity, energy sources or biomass burning can drive pollution. In contrast regions with high vehicle density frequently maintain cleaner air, reflecting the impact of stricter emission standards, cleaner fuels and advanced vehicle technologies.

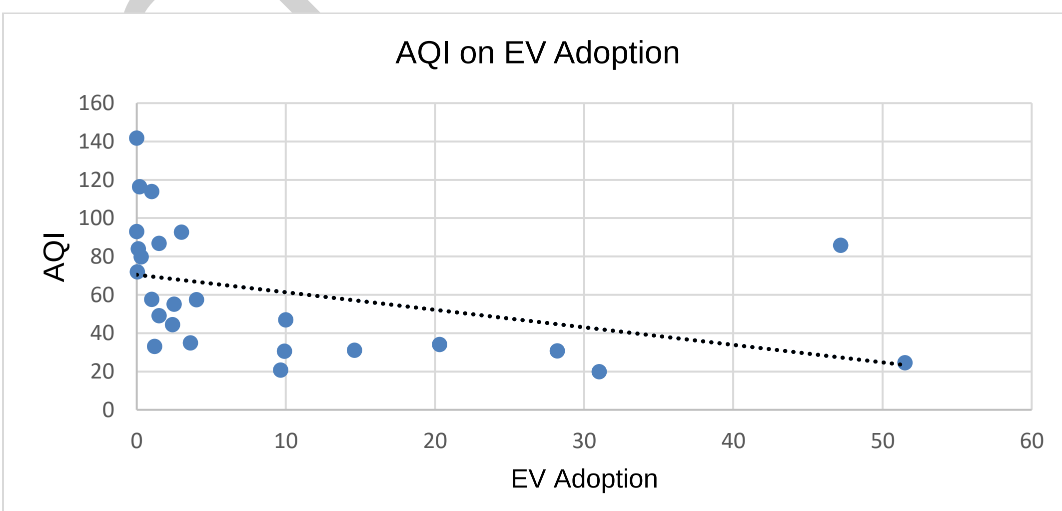
High vehicles but low AQI (USA, Germany): Strict emission norms, cleaner fuels and advanced vehicle technology keep air cleaner.

Low vehicles but high AQI (India, Bangladesh): Coal heavy energy use, weak regulations and biomass burning worsen pollution despite fewer cars.



Rainfall vs. AQI

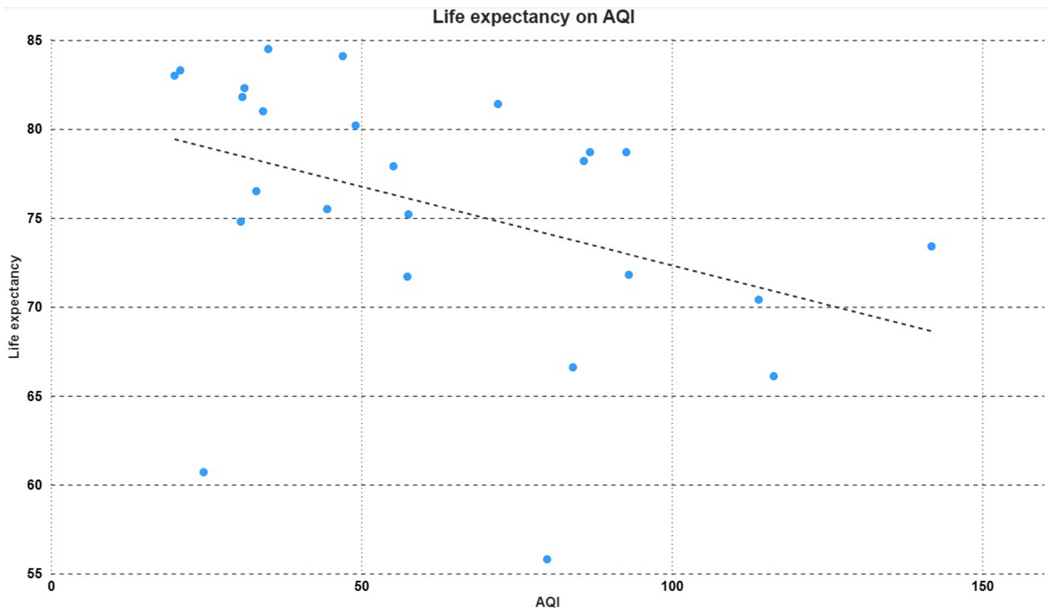
Rainfall has only a minor effect on air quality. Regions with higher rainfall tend to show slightly lower pollution levels as precipitation helps wash out particulates but the overall impact is limited. Low- rainfall areas display wide variation in AQI while very wet regions often maintain moderate levels of pollution. Outliers demonstrate that rainfall alone does not determine air quality: some high rainfall regions still face significant pollution from urbanization and industry while some dry regions maintain cleaner air due to effective regulations or low population density.
High rainfall but high AQI (Indonesia, India): Heavy industry, urbanization and coal use offset the cleansing effect of rain. Low rainfall but low AQI (Australia, Saudi Arabia): Sparse population or strong controls keep pollution low despite limited rainfall.



EV adoption vs. AQI

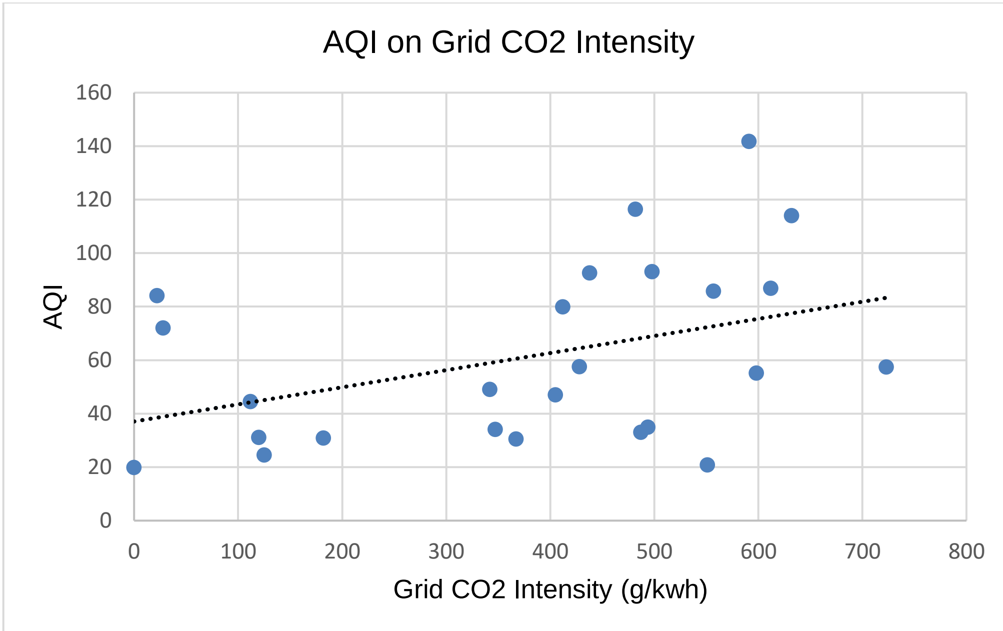
There is a negative relationship between EV adoption and air pollution: as the share of electric vehicles

rises, air quality improves. Low EV adoption is generally linked with higher pollution, while higher adoption corresponds with cleaner air.
Some exceptions exist. Countries with few EVs can still maintain good air quality through strong public transport systems, strict emission standards, or reliance on clean energy. Conversely, some regions with high EV adoption still face moderate pollution, often due to electricity grids that remain dependent on fossil fuels.
Low EV adoption but moderate AQI (Singapore, UAE): Strong public transport, strict emission standards, and clean energy mitigate pollution.
High EV adoption but moderate AQI (China, India): Fossil-fuel-heavy electricity grids limit the benefits of EV adoption.



Life Expectancy vs. AQI

Air quality shows a strong connection to life expectancy:- cleaner air is generally linked to longer lives, while higher pollution levels correspond with shorter lifespans. Countries with low AQI often see life expectancies above 80 years while those with higher AQI tend to have shorter averages.
Still, there are notable exceptions. Some nations with moderate air pollution have low life expectancy due to challenges like poverty, limited healthcare or poor nutrition. Conversely places with moderate AQI can maintain long life expectancy when supported by strong healthcare systems and high living standards.
High AQI but higher life expectancy (Singapore): Strong healthcare and living standards offset pollution.
Moderate AQI but very low life expectancy (Nigeria): Poverty, malnutrition and weak healthcare drive low outcomes.



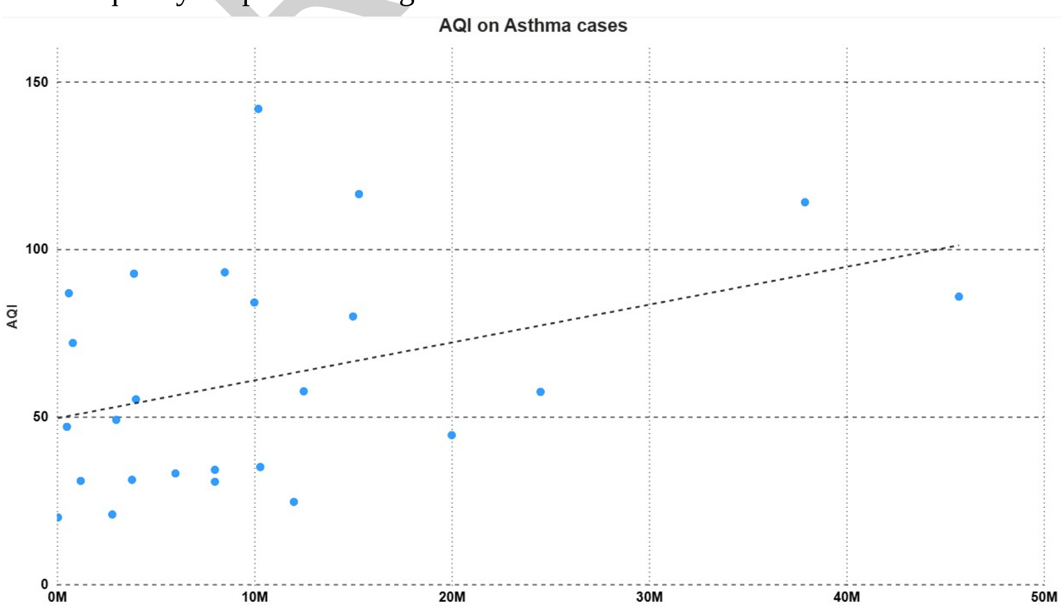
Grid CO_2 Intensity vs. AQI

Air quality tends to worsen as electricity grids become more carbon intensive. Cleaner grids powered by renewables or nuclear energy are generally associated with lower pollution levels while fossil fuel based grids correspond with higher AQI.

There are exceptions: some countries with carbon heavy grids maintain moderate air quality through strong emission controls while others with cleaner grids still face poor air quality due to pollution from transport, agriculture or wildfires.

High CO_2 intensity but moderate AQI (Germany, Canada): Advanced emission controls and cleaner technologies help offset grid pollution.

Low CO_2 intensity but high AQI (Brazil, Indonesia): Other sources like transport, agriculture or biomass burning worsen air quality despite cleaner grids



Asthma vs. AQI

Asthma prevalence rises with worsening air quality, as countries with higher AQI often report more cases. Large populations in highly polluted regions show particularly high burdens, underscoring the strong link between air pollution and respiratory illness.

There are notable exceptions. Countries with moderate AQI, like the U.S. and Brazil, still report large asthma case numbers, reflecting the influence of population size, healthcare reporting and non-pollution factors. In contrast, smaller low AQI countries tend to show minimal asthma burden.

High AQI but low asthma (India, Bangladesh, Pakistan): Likely due to underreporting, weaker healthcare, or younger populations.

Low AQI but high asthma (USA, Brazil): Linked to indoor pollution, genetics, allergens or stronger detection/reporting systems

Conclusion

By applying a regression model on ten countries — Iraq, Qatar, New Zealand, Turkey, South Korea, Afghanistan, Kazakhstan, Uzbekistan, Sudan, Jordan, and Lebanon — with factors including GDP per capita, wind speed, industrial CO_2 emissions, forest area, population density, rainfall, and vehicles per capita, the predicted AQI values showed only about 11% deviation from the actual values. This relatively low deviation indicates that these variables are strong predictors of air quality. Hence, the study suggests that wind speed, industrial emissions, and economic factors can be effectively used to analyze and address AQI-related challenges across diverse regions.

The results also emphasize the robustness and reliability of the developed regression model, demonstrating its capability to capture the complex interactions between environmental and socioeconomic factors influencing AQI. This strengthens the model's potential application for comparative analysis across different countries and for forecasting future air quality trends. The study, therefore, provides a strong analytical foundation for future research and projects focused on understanding pollution patterns and developing data-driven strategies to improve air quality on a global scale.

High-income countries should invest in clean-tech innovation, stricter climate policies, and expand EV subsidies (e.g., Norway). Urban transport should prioritize metro and BRT systems, coupled with vehicle emission checks, carpooling, and promotion of satellite towns to reduce congestion. Green belts, vertical gardens, and smart zoning must be adopted, with industries mandated to use clean technologies and emission filters.

Countries with low rainfall and forest cover should explore artificial rainfall (cloud seeding), enhance dust- storm warnings, enforce stricter emission controls during dry seasons, curb deforestation, and expand community forestry and urban tree planting. Eco-friendly agriculture must be incentivized to prevent forest loss.

Nations with high AQI and industrial CO_2 emissions should shift to renewables, adopt emission trading schemes, modernize coal plants, and deploy real-time industrial monitoring. In low wind speed regions, urban design should integrate ventilation corridors, reduced density in valleys, and air purification zones.

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49. THE EFFECTS OF AIR POLLUTION ON THE ENVIRONMENT AND HUMAN HEALTH
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Appendix

Interpretation of AQI Trends in 25 Countries

The five graphs together provide a comparative view of monthly AQI fluctuations across 25 different countries, showing clear differences in air quality trends worldwide.

Bangladesh, Kuwait, and Pakistan consistently show some of the highest AQI values, with noticeable peaks indicating prolonged periods of poor air quality. These high levels are likely driven by a mix of rapid urbanization, traffic congestion, industrial emissions, and seasonal climatic conditions that trap pollutants, leading to extended durations of unhealthy air.

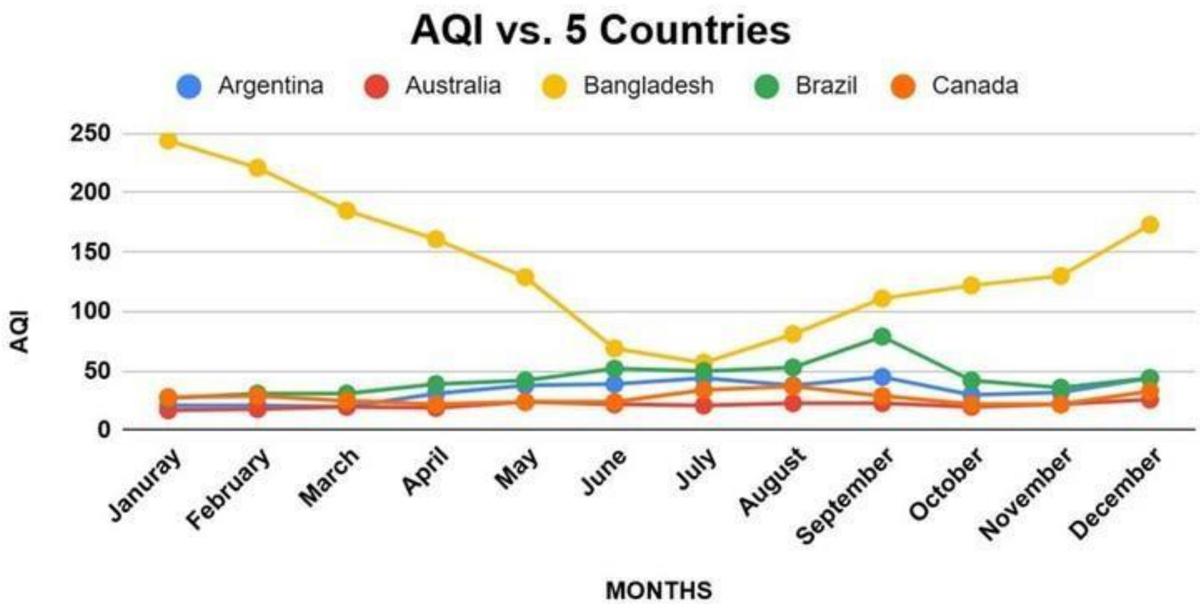
On the other hand, Denmark, Germany, and Iceland reflect consistently low to moderate AQI levels throughout the year, demonstrating relatively cleaner air. Their stability can be attributed to stricter environmental regulations, cleaner energy sources, strong public transport systems, and geographical advantages such as lower population density or favorable weather patterns that aid pollutant dispersion. These nations show minimal seasonal spikes, highlighting their effective long- term pollution control strategies.

India, China, and Nigeria reveal significant variability, with AQI levels rising and falling sharply across months. India, in particular, demonstrates some of the most striking seasonal swings, with pollution surges peaking in winter due to crop stubble burning in northern states, increased coal consumption, vehicular emissions, and weather inversions that trap pollutants close to the ground. Festivals involving firecrackers and rapid urban construction activity further aggravate pollution levels. Conversely, monsoon months often bring temporary relief as rainfall helps in washing away particulate matter. This cyclical pattern underscores how socio-economic activity, agricultural practices, and climatic cycles strongly influence India’s air quality.

Countries such as Australia, the UK, the USA, and Germany remain fairly stable with moderate AQI, suggesting controlled air pollution levels with only limited seasonal spikes.

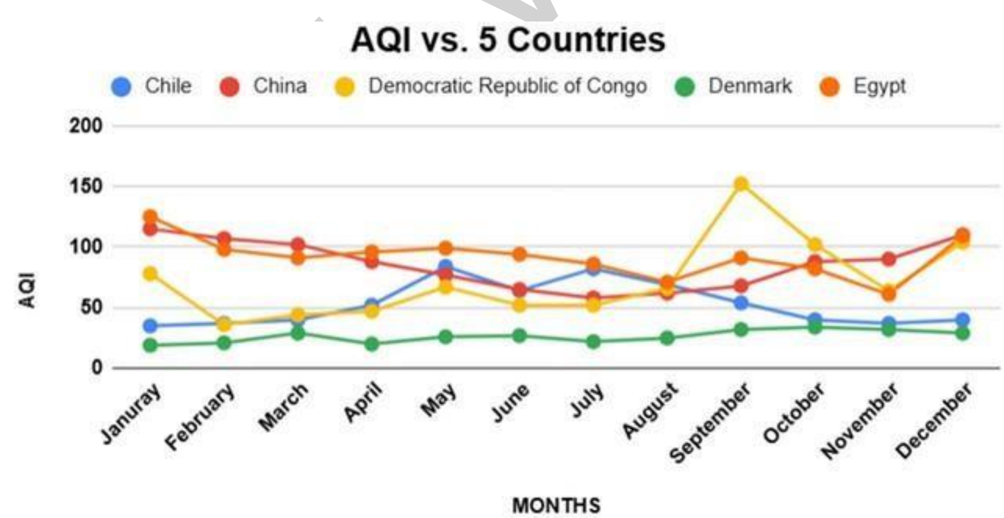
In contrast, nations like Egypt, Saudi Arabia, and the Democratic Republic of Congo show more irregular fluctuations, pointing towards localized factors such as desert dust, industrial emissions, biomass burning, and unregulated urban expansion as dominant contributors.

Overall, the data makes it evident that while developed nations largely maintain moderate to good air quality, several developing and highly industrialized regions experience severe seasonal pollution patterns that push their AQI into unhealthy ranges. This underscores the global disparity in air pollution challenges, where economic growth, industrial activity, and population density continue to strain environmental sustainability in emerging economies.



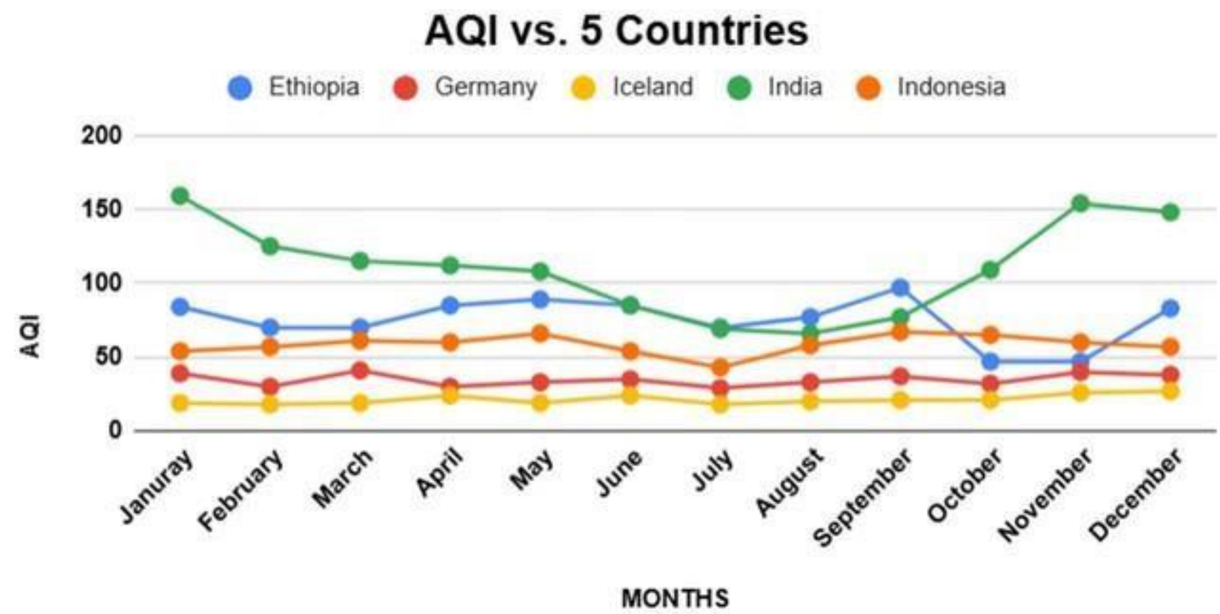
Graph 1: Argentina, Australia, Bangladesh, Brazil, and Canada

This graph shows a sharp contrast between Bangladesh's extremely high AQI with a clear U-shaped seasonal curve, and the relatively stable, low levels in Australia, Brazil, Argentina, and Canada. Canada shows slight wildfire-related peaks, while Bangladesh highlights severe winter smog and crop- burning effects.



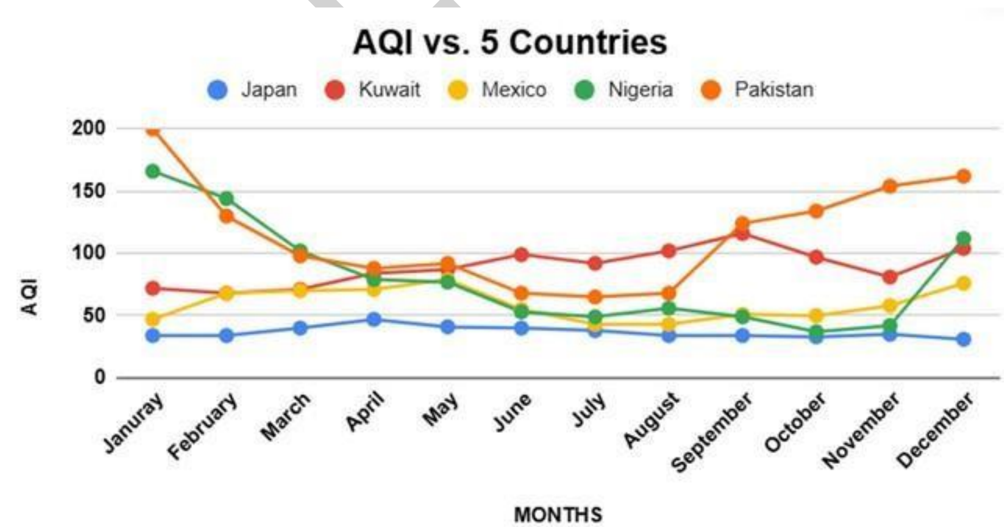
Graph 2: Chile, China, Democratic Republic of Congo, Denmark, and Egypt

China and Egypt follow a winter-pollution pattern with higher AQI in colder months, while Denmark remains consistently clean with minimal fluctuations. The DRC shows irregular mid-year spikes linked to biomass burning, and Chile experiences seasonal increases mid-year. Overall, this graph reflects how industrial emissions, burning, and climatic factors shape pollution differently across regions.



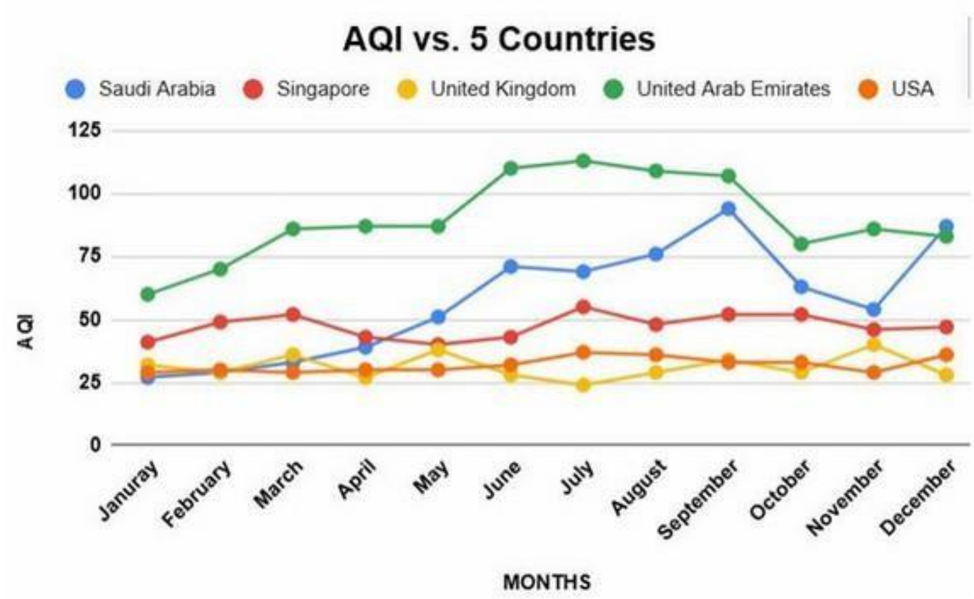
Graph 3: Ethiopia, Germany, Iceland, India, and Indonesia

India dominates this graph with severe seasonal swings, peaking in winter due to smog and stubble burning, while Germany and Iceland remain consistently low, representing clean environments. Ethiopia and Indonesia fall in between, showing moderate variations tied to burning and haze. This graph highlights the stark gap between highly polluted South Asia and cleaner European nations.



Graph 4: Japan, Kuwait, Mexico, Nigeria, and Pakistan

Pakistan records dangerously high winter smog similar to India, while Nigeria also shows sharp seasonal variation due to dust and burning. Kuwait's AQI steadily increases from dust storms, whereas Mexico displays moderate fluctuations. Japan remains consistently clean. This graph underscores the extremes between stable developed nations and pollution-prone regions in South Asia, Africa, and the Middle East.



Graph 5: Saudi Arabia, Singapore, United Kingdom, United Arab Emirates, and USA

The UK and USA maintain consistently clean air, while Saudi Arabia and the UAE show dust- driven peaks in hotter months. Singapore remains moderate but sees haze-related increases mid- year. This graph highlights how Middle Eastern countries face natural dust challenges, while Western nations largely sustain low AQI.