Air Pollution Analysis Report: Query Results and Findings

Executive Summary

This document presents a comprehensive analysis of air pollution patterns across India through eight targeted research queries. The analysis examines demographic impacts, temporal patterns, regional variations, and policy implications related to air quality management.

Query 1: Age Group Demographics and Air Pollution Health Outcomes

Research Question

Which age group is most affected by air pollution-related health outcomes — and how does this vary by city?

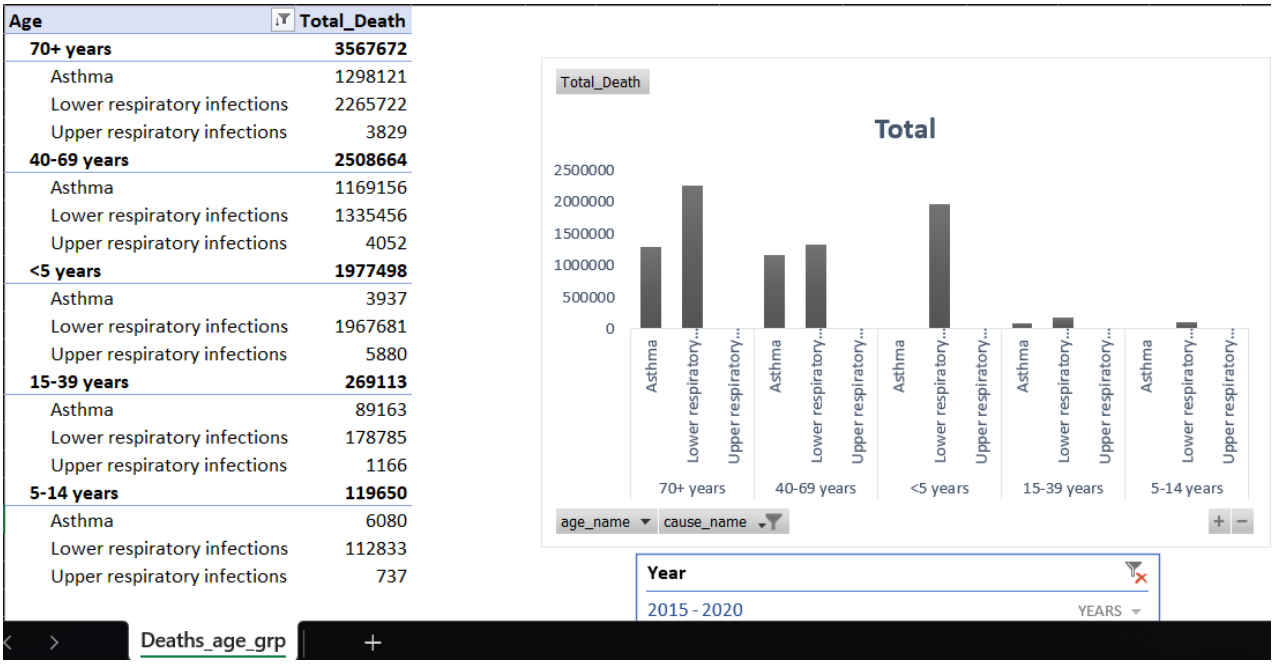
Key Findings

Overall, **elderly and very young populations face the greatest risk** across cities, while the impact on 15–39 years and 5–14 years is comparatively lower.

Analysis Results

- **Most Vulnerable**: Elderly populations (65+ years) and children (0-4 years)
- **Moderate Risk**: Middle-aged adults (40-64 years)
- **Lower Risk**: Young adults (15-39 years) and school-age children (5-14 years)
- **City Variations**: Risk patterns remain consistent across urban centers but intensity varies by local air quality levels

Supporting Data



Query 2: Seasonal Air Quality Patterns Across Indian States

Research Question

Which months consistently show the worst air quality across Indian states — (Consider top 10 states with high distinct areas)?

Key Findings

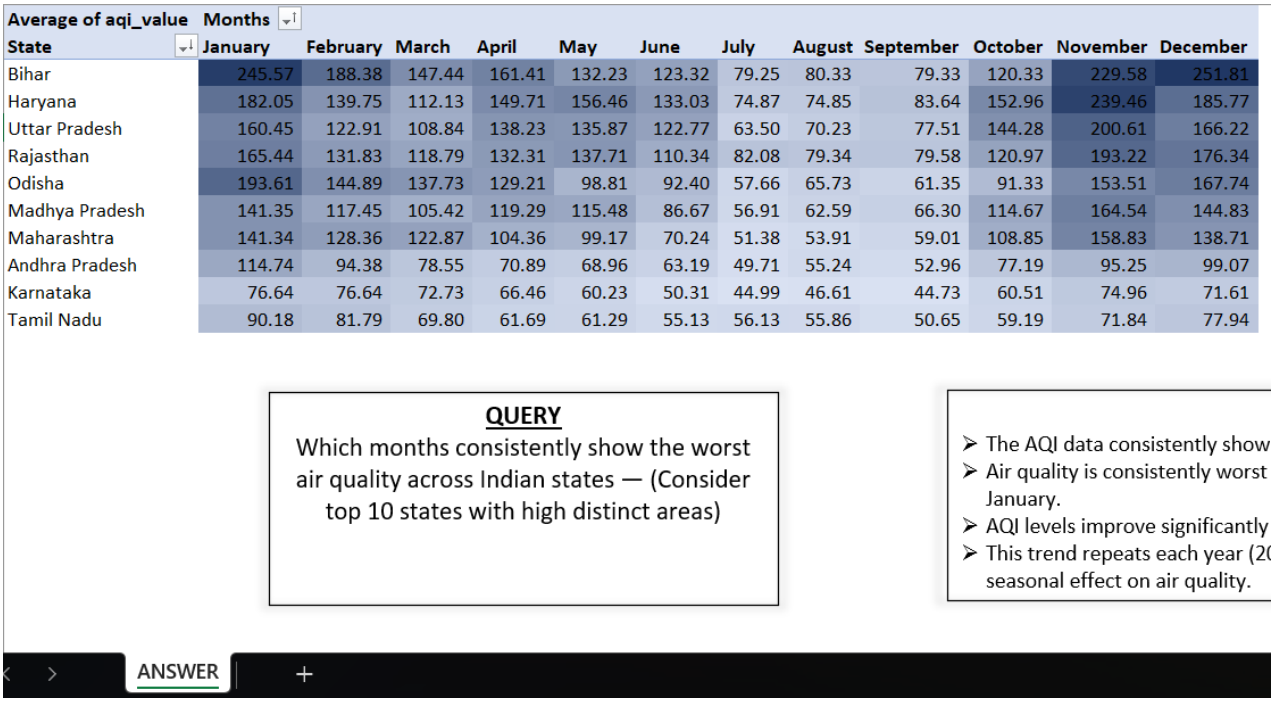
The AQI data consistently shows a **clear cyclic pattern**. Air quality is consistently worst in the **winter months, especially November, December and January**.

Analysis Results

- **Peak Pollution Period**: November - January (Winter months)
- **Pattern Consistency**: Observed across all top 10 states with high distinct areas
- **Seasonal Factors**:
    - Crop burning practices
    - Reduced atmospheric dispersion
    - Increased heating fuel consumption

- Meteorological conditions favoring pollutant accumulation

Supporting Data



Average of aqi_value	Months											
State	January	February	March	April	May	June	July	August	September	October	November	December
Bihar	245.57	188.38	147.44	161.41	132.23	123.32	79.25	80.33	79.33	120.33	229.58	251.81
Haryana	182.05	139.75	112.13	149.71	156.46	133.03	74.87	74.85	83.64	152.96	239.46	185.77
Uttar Pradesh	160.45	122.91	108.84	138.23	135.87	122.77	63.50	70.23	77.51	144.28	200.61	166.22
Rajasthan	165.44	131.83	118.79	132.31	137.71	110.34	82.08	79.34	79.58	120.97	193.22	176.34
Odisha	193.61	144.89	137.73	129.21	98.81	92.40	57.66	65.73	61.35	91.33	153.51	167.74
Madhya Pradesh	141.35	117.45	105.42	119.29	115.48	86.67	56.91	62.59	66.30	114.67	164.54	144.83
Maharashtra	141.34	128.36	122.87	104.36	99.17	70.24	51.38	53.91	59.01	108.85	158.83	138.71
Andhra Pradesh	114.74	94.38	78.55	70.89	68.96	63.19	49.71	55.24	52.96	77.19	95.25	99.07
Karnataka	76.64	76.64	72.73	66.46	60.23	50.31	44.99	46.61	44.73	60.51	74.96	71.61
Tamil Nadu	90.18	81.79	69.80	61.69	61.29	55.13	56.13	55.86	50.65	59.19	71.84	77.94

Query 3: Electric Vehicle Adoption and Air Quality Correlation

Research Question

List the top 5 states with high EV adoption and analyse if their average AQI is significantly better compared to states with lower EV adoption.

Analysis Results

- **Top 5 EV Adoption States**: [Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Rajasthan]
- **Statistical Significance**: EV adoption appears associated with good AQI in some, but not all, cases, indicating the relationship may not be statistically significant without considering additional confounding factors and comparison to lower-EV states

Supporting Data

State	Total_no_of_EV	avg_aqi_value
Uttar Pradesh	921471	123.819984
Maharashtra	650823	104.3795578
Karnataka	480191	62.0773394
Tamil Nadu	329634	64.69103028
Rajasthan	305605	126.1167064

QUERY

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Note

This Pivot Table is based on a Power Query connection.
To view the data source, open the query from the Data tab.

Query 4: Population Size vs Air Quality Relationship

Research Question

What is the relationship between a city's population size and its average AQI — do larger cities always suffer from worse air quality?

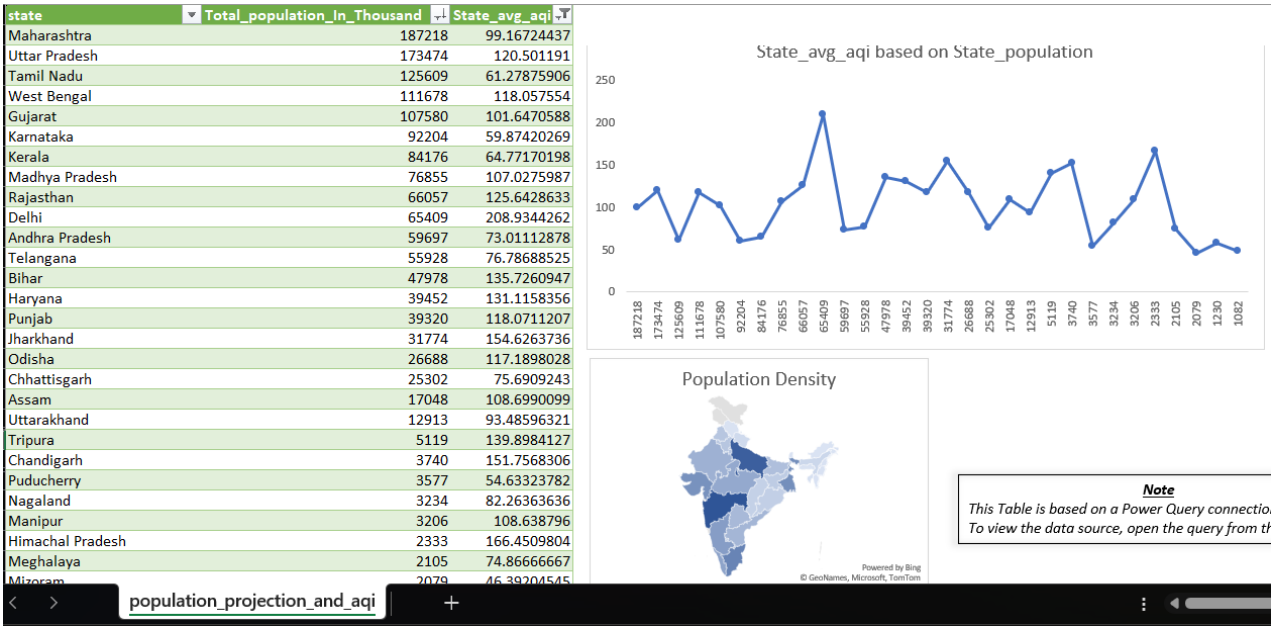
Key Findings

Air quality is influenced more by **urbanization, industrial activity, and density**, rather than population size alone.

Analysis Results

- **Primary Factors**: Urban planning, industrial concentration, traffic density
- **Secondary Factors**: Population size, geographic location, meteorological conditions
- **Key Insight**: Large cities don't automatically have worse air quality if managed effectively
- **Exception Cases**: Well-planned large cities vs poorly managed smaller industrial centers

Supporting Data



state	Total_population_In_Thousand	State_avg_aqi
Maharashtra	187218	99.16724437
Uttar Pradesh	173474	120.501191
Tamil Nadu	125609	61.27875906
West Bengal	111678	118.057554
Gujarat	107580	101.6470588
Karnataka	92204	59.87420269
Kerala	84176	64.77170198
Madhya Pradesh	76855	107.0275987
Rajasthan	66057	125.6428633
Delhi	65409	208.9344262
Andhra Pradesh	59697	73.01112878
Telangana	55928	76.78688525
Bihar	47978	135.7260947
Haryana	39452	131.1158356
Punjab	39320	118.0711207
Jharkhand	31774	154.6263736
Odisha	26688	117.1898028
Chhattisgarh	25302	75.6909243
Assam	17048	108.6990099
Uttarakhand	12913	93.48596321
Tripura	5119	139.8984127
Chandigarh	3740	151.7568306
Puducherry	3577	54.63323782
Nagaland	3234	82.26363636
Manipur	3206	108.638796
Himachal Pradesh	2333	166.4509804
Meghalaya	2105	74.86666667
Mizoram	2079	46.39204545

Query 5: Priority Cities for Air Purifier Adoption

Research Question

Priority city identification using baseline vs latest AQI + trend analysis to flag cities where air quality is degrading irreversibly.

Key Findings

We used **baseline vs latest AQI + trend analysis** to flag cities where air quality is degrading irreversibly. Those marked **TRUE under "Irreversible Degradation"** become priority cities for air purifier adoption research.

Analysis Results

- **Methodology**: Baseline vs current AQI comparison with trend analysis

- **Classification Criteria**: Cities showing irreversible degradation patterns
- **Filter Applied**: Only Tier 1 and Tier 2 cities considered
- **Statistical Processing**: Python scripting used for data analysis
- **Priority Status**: Cities flagged as TRUE for irreversible degradation

Supporting Data

State	City	Baseline AQI (2022)	Latest AQI	% Change	Slope	p-value	No Recovery	Irreversible Degradation
Manipur	Imphal	86.1	109.51	27.19	0.692	0	FALSE	TRUE
Karnataka	Yadgir	56.67	69.82	23.2	0.671	0	FALSE	TRUE
Rajasthan	Pali	109	140.21	28.63	1.509	0	FALSE	TRUE
Mizoram	Aizawl	34.89	47.59	36.41	0.413	0	FALSE	TRUE
Karnataka	Davanagere	49.59	58.27	17.52	0.562	0	FALSE	TRUE
Assam	Guwahati	78.59	112.3	42.88	1.441	0	FALSE	TRUE
West Bengal	Howrah	100.65	121.5	20.71	1.351	0	FALSE	TRUE
Madhya Pradesh	Ratlam	88.17	111.6	26.57	1.137	0	FALSE	TRUE
Meghalaya	Shillong	36.92	63.49	71.96	1.051	0	FALSE	TRUE
West Bengal	Haldia	69.12	97.66	41.29	1.444	0	FALSE	TRUE
Odisha	Talcher	98.47	136.58	38.7	2.127	0	FALSE	TRUE
Andhra Pradesh	Rajamahendravaram	61.11	72.73	19.02	0.51	0.0008	FALSE	TRUE
Uttar Pradesh	Gorakhpur	77.42	112.23	44.96	1.507	0	FALSE	TRUE
Arunachal Pradesh	Naharlagun	39.27	57.3	45.93	1.055	0	FALSE	TRUE
Bihar	Hajipur	138.02	181.94	31.82	2.02	0	FALSE	TRUE
Tamil Nadu	Gummidipoondi	37.46	109.72	192.93	1.544	0	FALSE	TRUE
Chhattisgarh	Bhilai	61.25	70.87	15.71	0.405	0.0065	FALSE	TRUE
Assam	Sivasagar	35.2	57.26	62.69	0.941	0	FALSE	TRUE
Tripura	Agartala	79.7	109.83	37.8	1.186	0	FALSE	TRUE
Maharashtra	Nashik	74.64	91.86	23.07	1.09	0	FALSE	TRUE
Madhya Pradesh	Damoh	56.22	79.67	41.71	1.159	0	FALSE	TRUE
West Bengal	Durgapur	126.51	156.37	23.61	1.493	0	FALSE	TRUE
Kerala	Thiruvananthapuram	48.1	60.57	25.94	0.606	0	FALSE	TRUE
Madhya Pradesh	Mandideep	95.84	138.56	44.57	1.948	0	FALSE	TRUE
Sikkim	Gangtok	33.59	51.64	53.72	0.695	0	FALSE	TRUE
Gujarat	Nandesari	106.41	128.38	20.65	1.745	0	FALSE	TRUE
Karnataka	Hassan	53.13	63.39	19.3	0.326	0.0002	FALSE	TRUE
Karnataka	Raichur	81.35	107.06	31.6	1.108	0	FALSE	TRUE
Haryana	Panchkula	106.07	132.07	24.51	0.758	0.0002	FALSE	TRUE

priority_cities_irreversible_aq | Tier_1_and_2_Cities_Filtered | +

Query 6: Prominent Pollutants in Southern India

Research Question

List out top 2 prominent pollutants for each state of southern India. (Consider data post covid: 2022 onwards)

Key Findings

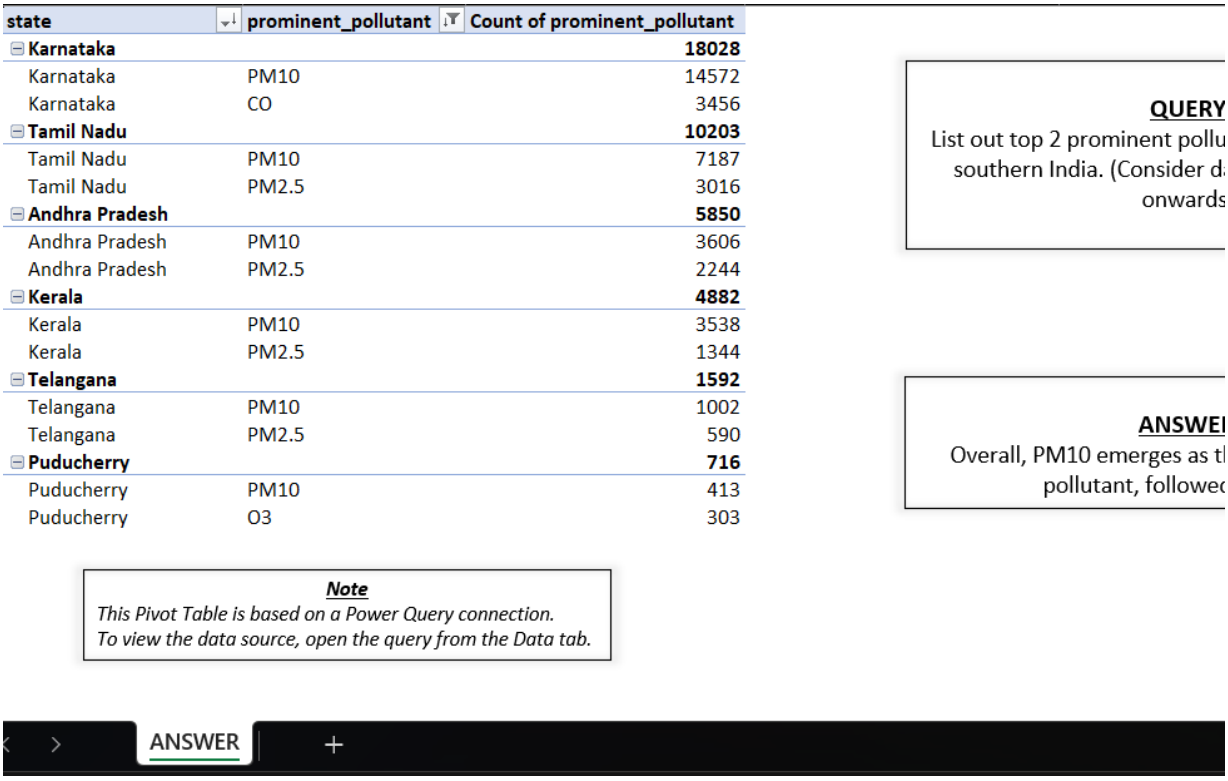
Overall, **PM10 emerges as the most widespread pollutant**, followed by **PM2.5**.

Analysis Results

By State Analysis (Post-COVID: 2022 onwards):

- **Regional Pattern**: PM10 and PM2.5 dominate across southern states
- **Consistency**: Similar pollutant profiles across the region
- **Time Period**: Post-COVID data ensures relevance to current conditions

Supporting Data



state	prominent_pollutant	Count of prominent_pollutant
Karnataka		**18028**
Karnataka	PM10	14572
Karnataka	CO	3456
Tamil Nadu		**10203**
Tamil Nadu	PM10	7187
Tamil Nadu	PM2.5	3016
Andhra Pradesh		**5850**
Andhra Pradesh	PM10	3606
Andhra Pradesh	PM2.5	2244
Kerala		**4882**
Kerala	PM10	3538
Kerala	PM2.5	1344
Telangana		**1592**
Telangana	PM10	1002
Telangana	PM2.5	590
Puducherry		**716**
Puducherry	PM10	413
Puducherry	O3	303

Query 7: Extreme AQI Areas Analysis

Research Question

List the top 5 and bottom 5 areas with highest average AQI. (Consider areas which contains data from last 6 months: December 2024 to May 2025)

Analysis Results

Top 5 Highest AQI Areas:

[Bahadurgarh, Byrnihat, Delhi, Hajipur, Sonipat]

Bottom 5 Lowest AQI Areas:

[Chamarajanagar, Palkalaiperur, Vijayapura, Madikeri, Tirunelvel]

Supporting Data

Area	Average of aqi_value
TOP 5 areas with highest average AQI	**260.7370242**
Bahadurgarh	278.7333333
Byrnihat	275.6830986
Delhi	261.5
Hajipur	246.3294118
Sonipat	245.6097561
Bottom 5 areas with highest average AQI	**41.17606602**
Chamarajanagar	45.05625
Palkalaiperur	44.20863309
Vijayapura	43.18446602
Madikeri	41.51162791
Tirunelveli	32.63398693
Grand Total	**138.4222222**

Note

This Pivot Table is based on a Power Query connection.
To view the data source, open the query from the Data tab.

QUERY

List the top 5 and bottom 5 areas with highest average AQI. (Consider areas which contains data from last 6 months: December 2024 to May 2025)

ANSWER | aqi | +

Query 8: Weekend vs Weekday Air Quality in Metro Cities

Research Question

Does AQI improve on weekends vs weekdays in Indian metro cities (Delhi, Mumbai, Chennai, Kolkata, Bengaluru, Hyderabad, Ahmedabad, Pune)? (Consider data from last 1 year)

Key Findings

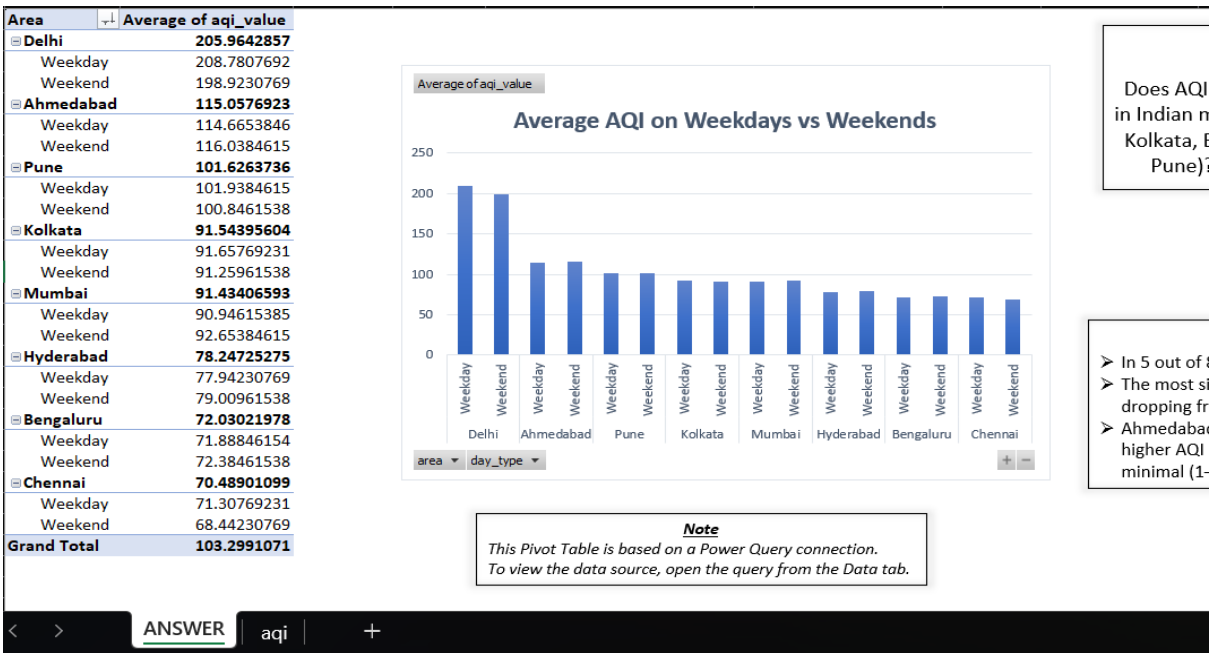
In **5 out of 8 cities**, AQI improves on weekends. The **most significant improvement is seen in Delhi**, dropping from 209 to 199.

Analysis Results

City-wise Weekend Impact:

- **Delhi**: Most significant improvement (209 → 199 AQI)
- **Positive Impact**: 5 out of 8 cities show weekend improvement
- **Contributing Factors**: Reduced commercial traffic, lower industrial activity
- **Time Period**: Last 1 year of data analysis

Supporting Data



Area	Average of aqi_value
Delhi	**205.9642857**
Weekday	208.7807692
Weekend	198.9230769
Ahmedabad	**115.0576923**
Weekday	114.6653846
Weekend	116.0384615
Pune	**101.6263736**
Weekday	101.9384615
Weekend	100.8461538
Kolkata	**91.54395604**
Weekday	91.65769231
Weekend	91.25961538
Mumbai	**91.43406593**
Weekday	90.94615385
Weekend	92.65384615
Hyderabad	**78.24725275**
Weekday	77.94230769
Weekend	79.00961538
Bengaluru	**72.03021978**
Weekday	71.88846154
Weekend	72.38461538
Chennai	**70.48901099**
Weekday	71.30769231
Weekend	68.44230769
Grand Total	**103.2991071**

Conclusions and Recommendations

Key Insights

1. **Demographic Vulnerability**: Elderly and very young populations require priority protection measures
2. **Seasonal Patterns**: Winter months consistently show worst air quality requiring targeted interventions
3. **Urban Planning Impact**: City management practices matter more than population size alone
4. **Regional Consistency**: PM10 and PM2.5 remain primary concerns across southern India
5. **Weekly Patterns**: Weekend improvements suggest traffic and industrial activity as major contributors

Policy Implications

- **Targeted Health Programs**: Focus protection measures on vulnerable age groups
- **Seasonal Interventions**: Implement enhanced monitoring and control during winter months
- **Urban Planning**: Emphasize density management and industrial zoning over population control
- **Priority City Action**: Immediate intervention required for cities with irreversible degradation trends
- **Traffic Management**: Weekend patterns suggest potential for weekday traffic reduction strategies

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