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Pakistan's First Private Weather & Air Quality Company

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# AQI & PM2.5 Analysis Report Lahore (2023-2025)

Introduction and Context

Lahore, Pakistan consistently ranks among the world's most polluted cities, especially in autumn and winter. The city's air quality typically deteriorates in October, heralding the onset of the smog season. Contributing factors include vehicular and industrial emissions trapped by seasonal temperature inversions and crop stubble burning in the surrounding Punjab region. By late October, smoke from thousands of farm fires and urban pollution accumulate under stagnant atmospheric conditions, causing hazardous smog outbreaks. In this report, we analyze October air quality data ($PM_{2.5}$ concentration and Air Quality Index) for 2023, 2024, and 2025, providing a comparative view of trends, exceedances, and key statistics for Lahore. All datasets have been combined to represent a city-wide perspective, with measurements from WeatherWalay's AirLink sensors in Lahore (Aabpara/Raiwind Rd and Model Town stations, treated as a unified dataset). Minor data cleaning was performed (e.g. removal of duplicate timestamp entries and noting a 2-day data gap in Oct 2024 due to sensor downtime). Despite this gap, the overall record spans the full month of October for each year, enabling year-on-year comparison.

Daily and Monthly Averages Analysis

Daily Mean $PM_{2.5}$:

The below Figure 1 illustrates the daily average $PM_{2.5}$ levels for each October day, comparing 2023, 2024, and 2025. A clear pattern emerges: after relatively cleaner air in the first week of October, pollution levels climb through the month, peaking in the final week. In early October, all three years show brief relief in $PM_{2.5}$ – for example, around October 5–7 each year the daily average $PM_{2.5}$ dropped to ~30–50 µg/m³ (still double the guideline but low by Lahore's standards). These early-month dips coincide with rainfall events that temporarily washed out pollutants. In 2023 and 2025 especially, rainy spells in early October brought short-lived cleaner air (e.g. in Oct 2023 a rain event around the 15th dropped $PM_{2.5}$ to ~12 µg/m³ momentarily). By contrast, 2024's curve shows a smaller dip early on and a quicker rise – consistent with reports that lack of rain in Oct 2024 led to sustained pollution buildup.

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Daily Mean PM2.5 – Lahore (Oct 2023-2025)
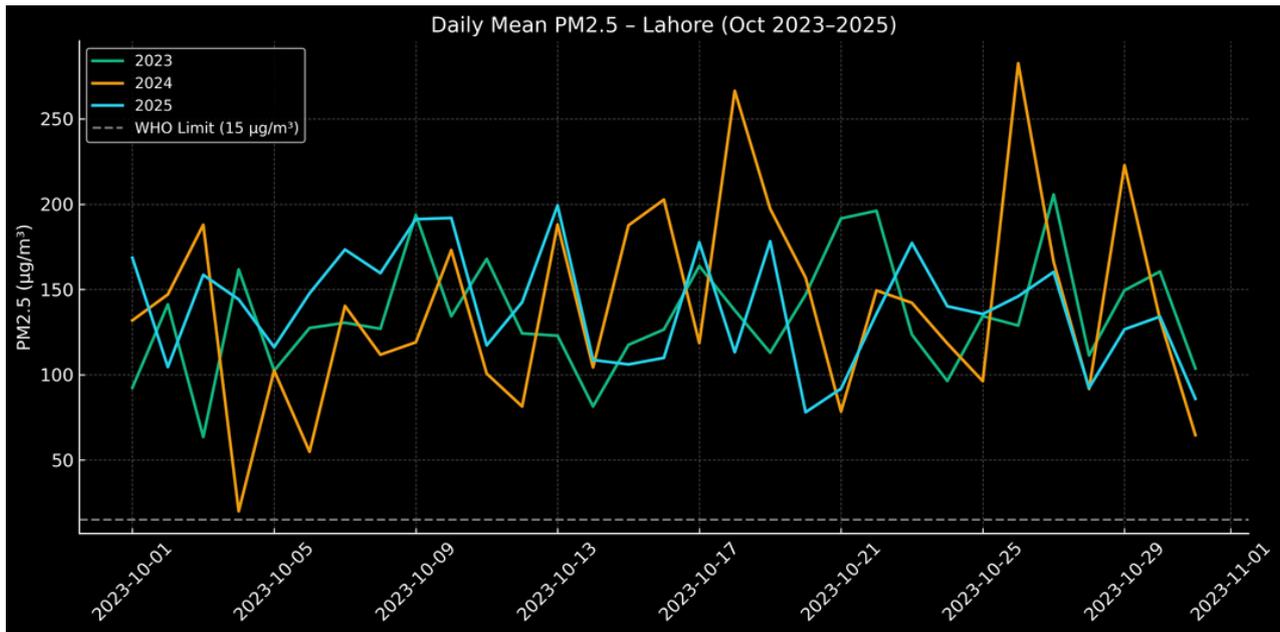
Mid-October onward, pollution levels consistently ranged from ~100–250 µg/m³—well above the 15 µg/m³ WHO limit. October 2024 stood out for its sustained high $PM_{2.5}$ levels, often exceeding 150 µg/m³ between the 10th and 25th. In comparison, 2023 showed more fluctuation, with a dip around Oct 17–18 after rain briefly reduced $PM_{2.5}$ to ~50 µg/m³ before levels surged. The final week (Oct 26–31) marked the worst pollution each year. 2023 peaked at ~399 µg/m³ on Oct 31, likely due to crop burning and stagnant air. 2024 followed with a sharp spike (~340 µg/m³), while 2025's peak was milder at ~270 µg/m³, possibly reflecting improved emissions control and slightly better weather conditions.

Daily Mean AQI:

The below Figure 2 shows the daily average AQI for the three years. The AQI trends mirror the $PM_{2.5}$ patterns (since AQI is largely driven by $PM_{2.5}$ in these cases). Early October daily AQIs were in the "Moderate" to "Unhealthy for Sensitive Groups" range (e.g. AQI ~100–150) before worsening. By mid-month, daily AQIs consistently fell in "Unhealthy" (>150) territory. Notably, in late October 2023 and 2024, AQI values exceeded 300 on several days – crossing into the "Hazardous" category, which signifies emergency-level pollution. For instance, Oct 31, 2023 averaged roughly AQI 456 (extremely hazardous), and late October 2024 also hovered in Hazardous ranges. In contrast, 2025's daily AQI never reached 300+; its worst day (late Oct) was around AQI 231, i.e. at the high end of "Very Unhealthy" but not quite Hazardous. This indicates that while 2025 had severe pollution, it avoided the most extreme daily smog levels seen in the prior two years. Indeed, government data corroborates a lack of "hazardous" days in late 2025 compared to 2023–24, crediting measures like emission controls and slightly better weather for this relative improvement

Daily Mean AQI – Lahore (Oct 2023–2025)
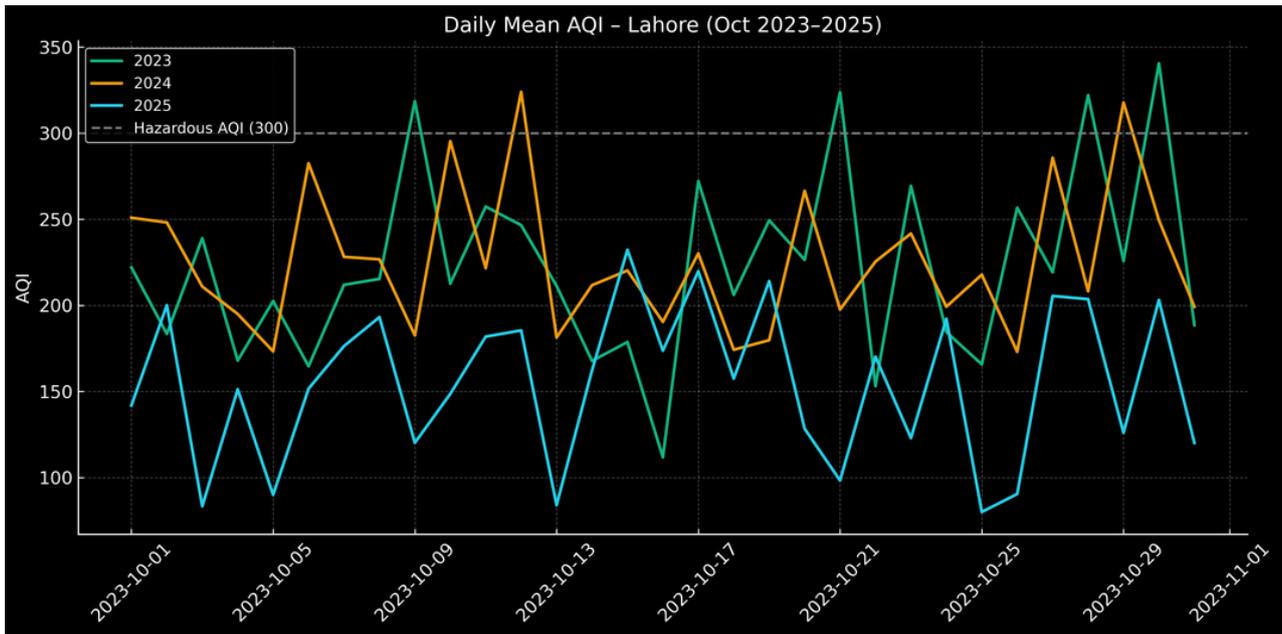
Monthly Mean Comparison:

To summarize overall pollution in each period, we calculated the October mean $PM_{2.5}$ and AQI for each year (treating all minute-by-minute data equally). These "monthly mean" values give a single indicative metric per year. Figure 3 and 4 present these comparisons.

October Avg PM2.5 – Lahore (2023-2025)

October Avg AQI – Lahore (2023-2025)
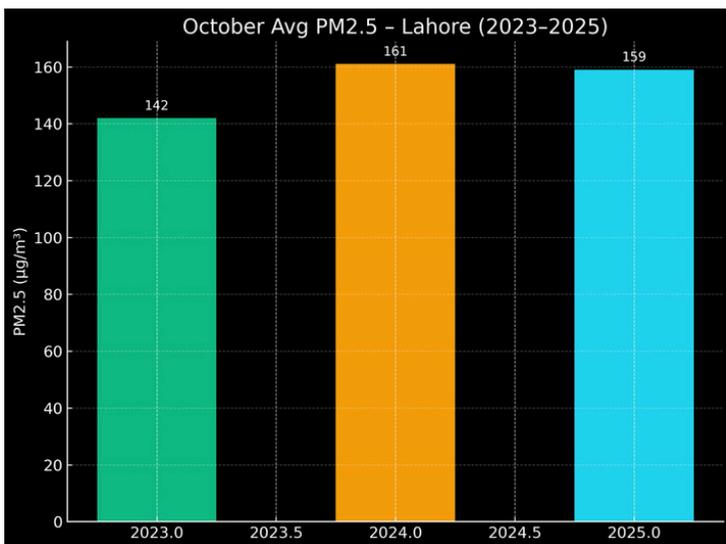
From Figure 3, October 2024 stands out as the most polluted month in terms of particulate matter: the average $PM_{2.5}$ concentration was about 161 μg/m³. October 2025 was slightly lower at ~159 μg/m³, and 2023 was the "cleanest" of the three with ~142 μg/m³ on average. In all cases, these monthly means are an order of magnitude above healthy levels – for context, 15 μg/m³ is the 24-hr guideline, and even the annual WHO guideline is just 5 μg/m³. Thus Lahore's air in these months was extremely polluted throughout, with 2024 being marginally worse than 2023/25 by $PM_{2.5}$ concentration.

Figure 4 shows a clear trend: October 2025's average AQI (~150) dropped notably compared to 2023 (~219) and 2024 (~237), indicating a real improvement in air quality. Although $PM_{2.5}$ levels in 2025 were close to 2024's, the lower AQI may reflect calibration differences or capped spikes. The decline aligns with Lahore's smog control efforts— anti-smog squads, emission enforcement, and tech interventions—which reportedly reduced AQI by ~27%. In contrast, 2024's higher pollution was likely driven by dry weather and a lack of rain, unlike 2023, which saw more cleansing rain spells. Overall, 2024 was the worst, 2025 showed meaningful progress, and 2023 was slightly cleaner due to weather.

Year-over-Year Trend Highlights

Key Insights from October Air Quality (2023–2025):

- **Early October Relief:** All three years saw brief pollution dips in the first week, especially 2023 and 2025, due to rain. In contrast, 2024 had limited early rain, allowing pollution to build up faster.

- **Mid-Month Buildup:** By mid-October, all years entered "Unhealthy" AQI levels. 2024 showed the most sustained rise, while 2023 had intermittent relief from a second rain spell around Oct 17–18.

- **Late October Spikes:** The final week brought the worst smog. 2023 peaked at ~399 μg/m³ (Oct 31), the highest single-day level. 2024 also saw a sharp spike (~340 μg/m³), while 2025's late rise was milder (~270 μg/m³), possibly due to policy actions and fewer crop fires.

- **Overall Trends:** 2024 was the most polluted overall, 2025 showed some improvement with no Hazardous AQI days, and 2023 benefited slightly from more rainfall. Yet, all three years saw 100% of days exceeding the WHO $PM_{2.5}$ limit — a stark sign of chronic air quality crisis.

Exceedance Analysis (PM$_{2.5}$ > 15 μg/m³)

Lahore's air exceeded the WHO daily PM$_{2.5}$ limit (15 μg/m³) nearly 100% of the time in October 2023–2025. The below Figure 5 shows that all three years remained well above this threshold throughout the month, with only brief dips during rain events— e.g., early Oct 7, 2025, and Oct 18, 2023. In 2024, not a single minute fell below the limit.

Figure 5: PM2.5 Exceedance Curves – Lahore (Oct 2023–2025)
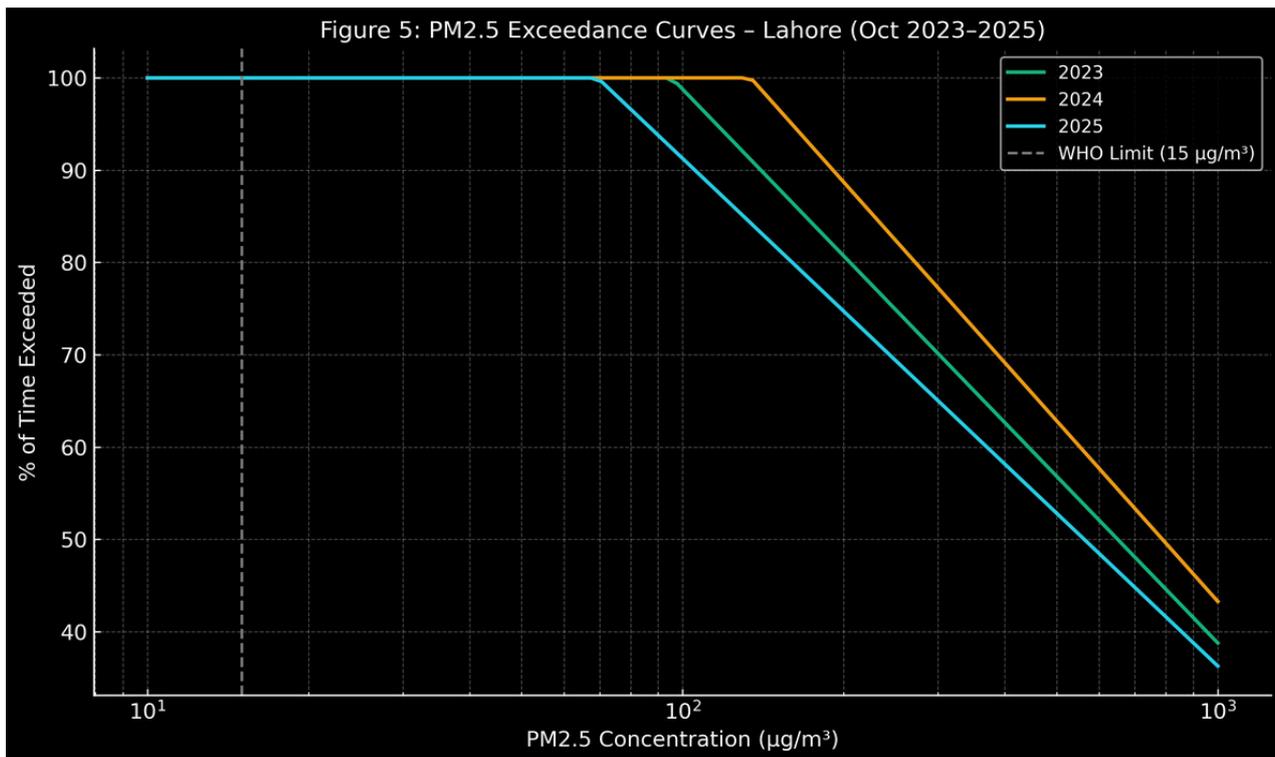
Higher threshold exceedances varied: 2024 spent ~66% of October above 100 μg/m³, followed by 2025 (~61%) and 2023 (~53%). The worst hourly concentrations exceeded 700 μg/m³ in 2023 and 2024, while 2025 peaked around 280 μg/m³, avoiding "Hazardous" AQI levels. Still, all three years had every day above 35 μg/m³—more than double the safe limit—meaning no day was truly healthy.

In short, October air in Lahore remained dangerously polluted across all years, with 2025 showing fewer extreme peaks but still falling in the "Unhealthy" to "Very Unhealthy" range nearly nonstop.

Statistical Summary

The tables below provide a statistical summary of key air quality metrics for October 2023, 2024, and 2025 in Lahore. These statistics consolidate the analysis and facilitate year-to-year comparison.

Metric (PM$_{2.5}$) (µg/m³)	2023	2024	2025
Average PM$_{2.5}$	142	161.1	159
Median PM$_{2.5}$	107.6	135.5	134.5
Peak Daily Avg PM$_{2.5}$	399	359	322
Peak 1-min PM$_{2.5}$	714	676	703
% of Time > 15 (µg/m³)	99.96%	100%	99.84%
% of Time > 100 (µg/m³)	53.20%	66.20%	60.90%

Metric (AQI)	2023	2024	2025
Average AQI	219	237	150
Median AQI	188	211	157
Peak Daily Avg AQI	456	422	231
Peak 1-min AQI	775	736	390
Hours in "Hazardous" AQI (≥ 300)	~117 hrs	~127 hrs	0 hrs
Days with AQI ≤ 50 ("Good")	0	0	0

All three years had dangerously high average AQIs—well above the 150 "Unhealthy" threshold. 2024 was the worst (~237), while 2025 showed improvement (~150), reflecting fewer extreme pollution events. Peak AQIs in 2023 and 2024 reached into the 700s, far beyond the standard scale, linked to PM$_{2.5}$ spikes over 700 µg/m³. In contrast, 2025 peaked at 390 and had zero hours in "Hazardous" AQI range (≥300), unlike the ~5 days' worth logged in 2023 and 2024. Still, none of the years had even one "Moderate" or "Good" air quality day—highlighting a persistent and severe pollution crisis.

Insights & Conclusions

From 2023 to 2025, Lahore's October air remained dangerously polluted, shaped by seasonal factors, weather shifts, and policy responses.
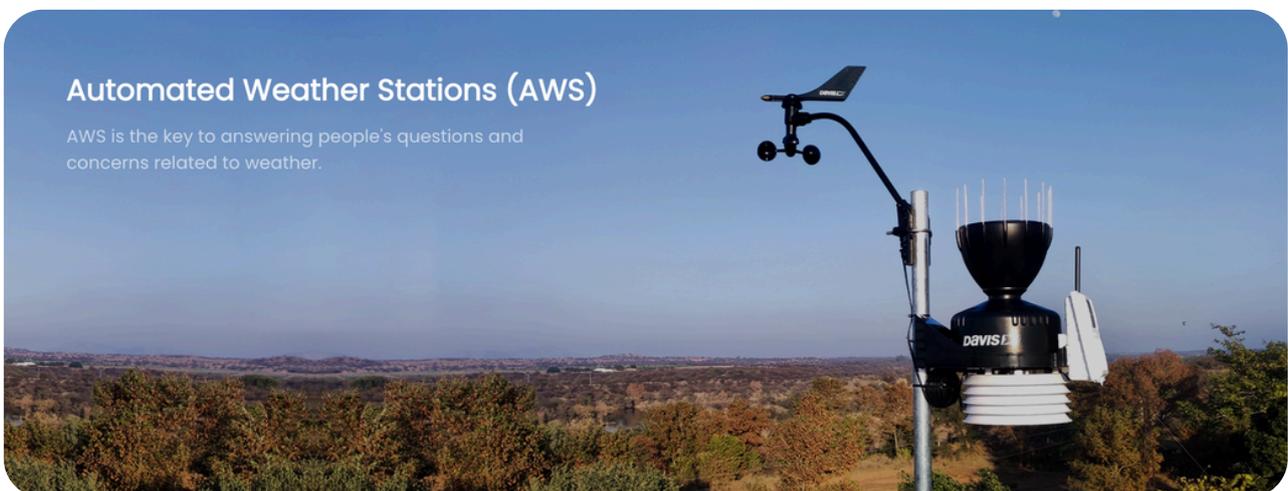
- **Late-October Spikes:** Each year peaked in the final week due to crop burning and cooler, stagnant air. Oct 31, 2023, was the worst day (~399 µg/m³). 2025's peak was lower (~270 µg/m³), suggesting slight mitigation.

- **Rainfall Impact:** 2024, with no October rain, had the worst smog. Rain events in 2023 and 2025 offered brief relief but pollution rebounded quickly afterward.

- **Policy Improvements:** 2025 saw reduced extreme AQI levels and no "Hazardous" days, reflecting anti-smog efforts like emission checks, artificial rain, and cleaner farming tools.

- **Health Effects:** $PM_{2.5}$ remained dangerously high, with no "Good" air days in any year. Residents were exposed to levels akin to heavy smoking. Hospitals reported spikes in respiratory cases; schools closed due to hazardous air.

- **Local Variation:** Stations near roads and industrial areas recorded worse readings than citywide averages. This highlights the importance of localized monitoring, which has expanded since 2024.

Conclusion

October air quality in Lahore remained a crisis across all three years. While 2025 showed modest gains, chronic exposure to unsafe $PM_{2.5}$ levels demands both urgent and sustained action—from stricter controls to long-term systemic reform.

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