

Ethiopian Meteorology Institute (EMI)

Summary of Gaseous Pollutants (NO₂, CO, SO₂ and O₃) and Fine and coarse PMs (PM_{2.5} and PM₁₀)

Overview

Air pollution is the leading environmental issue and stands as the second-largest cause of premature deaths in the world, after non-communicable diseases ([Stet of global air, 2024](#)), it contributes a lot to climate change ([IPCC,2021](#)) damages property, and negatively affects the global economy (World Bank, 2022). Ethiopia, observing rapid urbanization and economic growth, which are major contributors to increasing levels of air pollution. The deterioration of air quality in particularly its capital city, Addis Ababa, has resulted in significant public health challenges, with respiratory illnesses becoming one of the leading health burdens in the city ([US EPA, 2021](#)). This trend underscores the critical need for effective air quality management to protect public health and mitigate associated economic losses. Historical data show that air quality in Addis Ababa has declined by 1.6 times since the 1970s ([Embiale et al., 2021](#)). Key pollutants, such as PM₁₀ and CO, peak in the late afternoon, while O₃ levels are highest at midday ([Etyemezian et al., 2005](#)). Furthermore, PM_{2.5} concentrations in the city exceed WHO guidelines by 1.7 times ([Kumie et al., 2021](#)). The varying sources of pollution and environmental conditions across Addis Ababa's sub-cities lead to significant differences in pollutant concentrations. Accordingly, Ethiopia needs to work on enhancing air quality monitoring, enforcing strict regulations, encouraging cleaner energy and sustainable urban planning, and investing in public awareness. Interventions, including sectorial collaboration, international organizations, targeted health interventions, and research, are very crucial to decrease pollution, preserve public health, and make sure the country attains its goal of sustainable development. Thus this report proved summary of both Gaseous basic pollutants (NO₂, CO, SO₂ and O₃) and SPMs (PM_{2.5}) in city. To study, the Federal Equivalent Method (FEM) device of EMI monitored the measurements on an hourly, weekdays and daily basis in µg/m³ from 1-31 March 2025 at Black Lion, EMI monitoring station. The measured concentrations are comparing with both Ethiopian EPA standards and WHO Air Quality Guidelines and statistical interpretation for a range of air pollutants.

Ethiopia EPA and WHO Air quality guideline (AQG)

The principal air pollutants, even at very low concentrations, have serious effects on human health and the environment. A threshold, identified in the table 1 below, is a concentration above which an influence on human health or the environment occurs. Therefore, to achieve the lowest concentration of the pollutant NO₂, O₃, CO, SO₂, PM_{2.5}, and PM₁₀ the Ethiopian EPA at the national level and the WHO at the global level have set guidelines (WHO, 2021 and EPA, 2018).

Table 1. Ethiopian and global AQG

Pollutants	(Averaged over a period)	2003 Ethiopian AQG	2021 WHO AQG
SO ₂ (µg/m ³)	10 minutes	500	-
	24 hour	125	40
	Annual	50	-
NO ₂ (µg/m ³)	1 hour	200	-
	24 hour	-	25
	Annual	40	10

CO (mg/m ³)	15 minutes	100,000	-
	30 minutes	600,000	-
	8 hour	10,000	-
	24 hour	-	4
O ₃ (µg/m ³)	Peak season 8 hours	-	60
		120	100
PM ₁₀ (µg/m ³)	Annual	50	15
	24 hour	150	45
PM _{2.5} (µg/m ³)	Annual	15	5
	24 hour	65	15
Lead (µg/m ³)	Annual	0.5	-

Hourly Statistical Summary of pollutants for March 2025

The analysis of hourly air pollution data provides valuable insights into the distribution and variability of key pollutants, including PM_{2.5}, PM₁₀, O₃, NO₂, and SO₂. Understanding these statistical measures helps assess air quality trends, potential health risks, and pollution sources.

Thus, the hourly pollutant concentration of March 2025: O₃ indicates quite stable concentrations with a low range, between 11.27 µg/m³ and 17.00 µg/m³, reflecting low day-to-day variability. SO₂ varies from 16.59 to 17.32 ppb over the interquartile range, reflecting a uniform pattern with a modest hourly mean of 17.08 µg/m³. By contrast, PM_{2.5} and PM₁₀ concentrations demonstrate significant variability, with PM_{2.5} peaking at 287.29 µg/m³ and PM₁₀ at 268.37 µg/m³, both more than double the WHO limits. Their median levels (67.00 µg/m³ and 63.66 µg/m³) and high interquartile ranges suggest repeated spikes in pollution, presumably attributable to traffic or meteorological influences. Overall, particulate matter pollution is the dominant problem in the hourly profile.

Table 2.Hourly summery of pollutants for March 2025

Summary	O ₃	NO ₂	CO	SO ₂	PM _{2.5}	PM ₁₀
Min	11.27	No data	No data	17.04	0	0
25%	10.82			16.59	51.031250	48.060000
50%	11.02			16.94	67.00	63.66
Mean				17.08	88.21	63.66
75%	11.26			17.32	88.20	81.80
Max	17.00			32.97	287.29	268.37

The figure 1 below shows the hourly variation March 2025 PM_{2.5} and PM₁₀, with peaks: morning (6–9 AM). The morning peak is driven by rush-hour traffic and due to vehicular emissions. Pollutant levels drop in the afternoon (12–15 PM) due to strong atmospheric mixing and dispersion. The pattern highlights the need for targeted pollution control measures during peak hours to improve air quality.

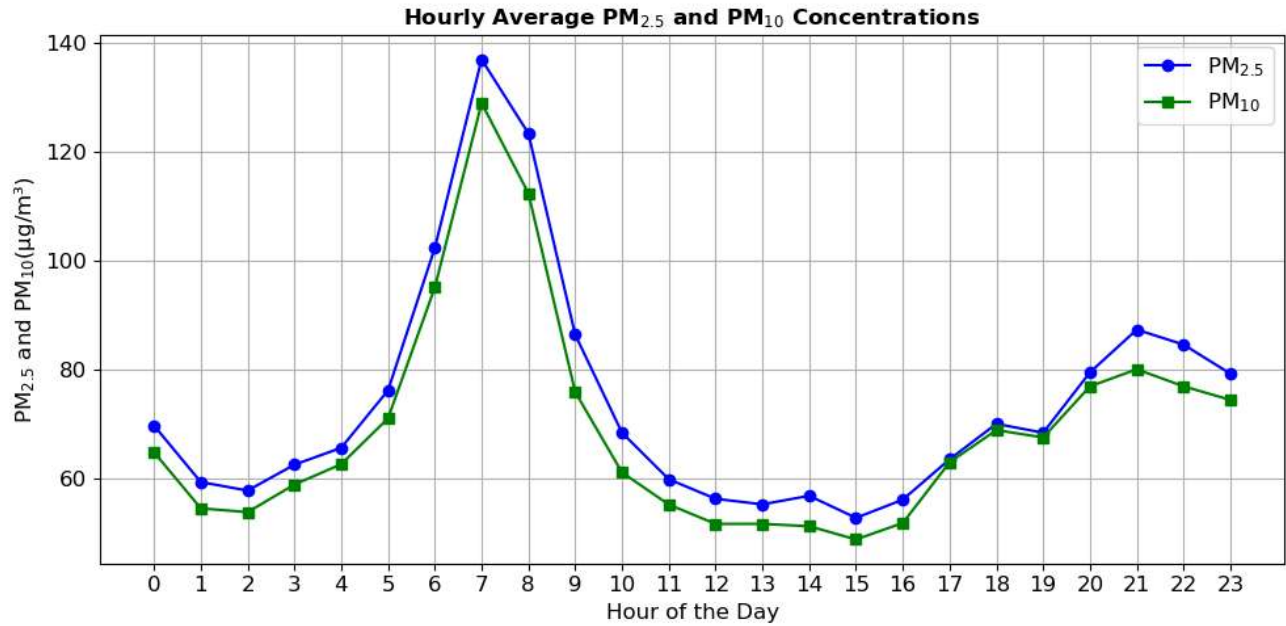


Figure 1. Hourly average of 24 hour mean for PM_{2.5} and PM₁₀

Levels by the week of the days for March 2025.

Figure 2 emphasizes the mean concentration of PM_{2.5} (red) and PM₁₀ (blue) across each day. The trend peak values observed on Saturday (PM_{2.5} greater than 80 µg/m³). The lowest mean levels occur midweek (Tuesday–Wednesday).

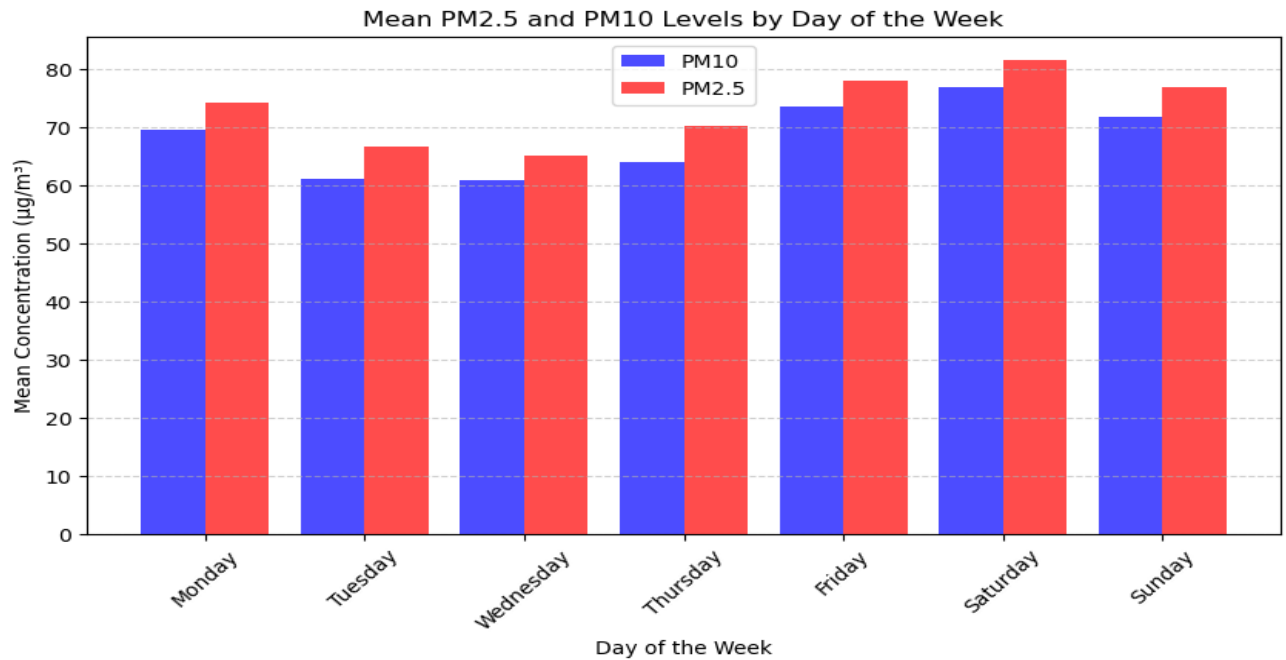


Figure. PM₁₀ and PM_{2.5} concentrations variation throughout the week

Daily Statistical summary of pollutants for March 2025

Air combustion of Fine particulate matter (PM_{2.5}) and coarse particulate matter (PM₁₀), in the March 2025 daily summary (Table 3), shows that levels of particulate matter (PM_{2.5} and PM₁₀) were far too high, PM_{2.5} averaging 67.25 µg/m³ and reaching 105.73 µg/m³ at its peak, and PM₁₀ averaged 72.09 µg/m³ with a peak of 110.78 µg/m³, both well above the WHO suggested rate. The wide range between the minimum and maximum, particularly for PM_{2.5} (7.99 to 105.73 µg/m³), indicates high variability, possibly affected by vehicles emission sources or meteorological conditions. O₃ and SO₂ were very stable with narrow interquartile ranges; O₃ mean was 11.92 µg/m³, and SO₂ mean was 17.05 µg/m³, indicating low daily variation. These patterns show that March was extremely impacted by particulate pollution, with possible human health impacts, especially on top days.

Table 3. Daily summery pollutants for March 2025

Summary	O ₃	NO ₂	CO	SO ₂	PM _{2.5}	PM ₁₀
mean	11.91521			17.05414	67.24818	72.09116
min	10.84475			16.41056	7.998301	10.85899
25%	10.97771			16.74251	57.3284	61.10154
50%	11.03271			17.00717	69.9977	73.60974
75%	11.07194			17.33957	80.43218	88.52606
max	36.23694			18.14222	105.7337	110.7779

Conclusion

In March 2025, O₃ and SO₂ concentrations were low and constant, whereas PM_{2.5} and PM₁₀ exhibited extreme hourly fluctuations and regular exceedance of WHO thresholds, especially during morning rush hours and Saturdays. Afternoon concentrations decreased because of atmospheric dispersion, and the midweek interval had the lowest averages. These patterns indicate traffic and local emissions as major contributors to poor air quality, calling for time-specific and source-oriented mitigation measures.