Comparative Air Quality Analysis: Hong Kong (HK) vs. Mexico City (MC) - January 2024

Insights, Indices, and Research Opportunities

SEE4994
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- Why compare? Both cities face major air quality challenges, but with different geography, policies, indices and polution sources.
- What can MC learn from HK?

MOTIVATION & RESEARCH QUESTION

How do pollutant characteristics and their health risk indices (AQHI vs IAS) compare between Hong Kong and Mexico City, and what lessons can be drawn for improving public awareness and policy design in urban environments?

- Goal: Identify actionable insights and new research directions for MC.

DATA & SELECTION RATIONALE

City	Dataset(s)	Period	Pollutants	Health Index
Hong Kong	hk_air_cb_tm_202401.csv, hk_aqhi_202401.csv	Jan 2024	NO_2, O_3, PM10, PM2.5	AQHI
Mexico City	mc_CAM_MER_PED_202401.csv, mc_IAS_2024.csv	Jan 2024	NO_2, O_3, PM10, PM2.5	IAS

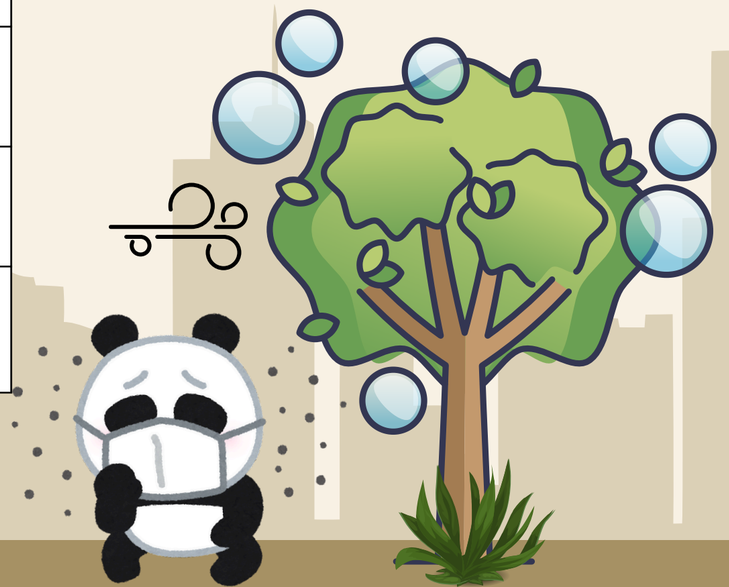
- Data sources: official air quality monitoring networks
- Period: January 2024 (recent, available for both cities)
- Why these stations?
  - 2 in Hong Kong (urban: Causeway Bay, rural: Tap Mun)
  - 3 in Mexico City (industrial: Camarones, central urban: Merced, peripheral/green: Pedregal)
  - Chosen to capture spatial variability and contrast urban/rural/industrial/green environments
- Why these pollutants?
  - NO_2, O_3, PM10, PM2.5: most relevant for health and regulation in both cities
  - SO_2 and others excluded to keep analysis focused

DESCRIPTIVE STATISTICS

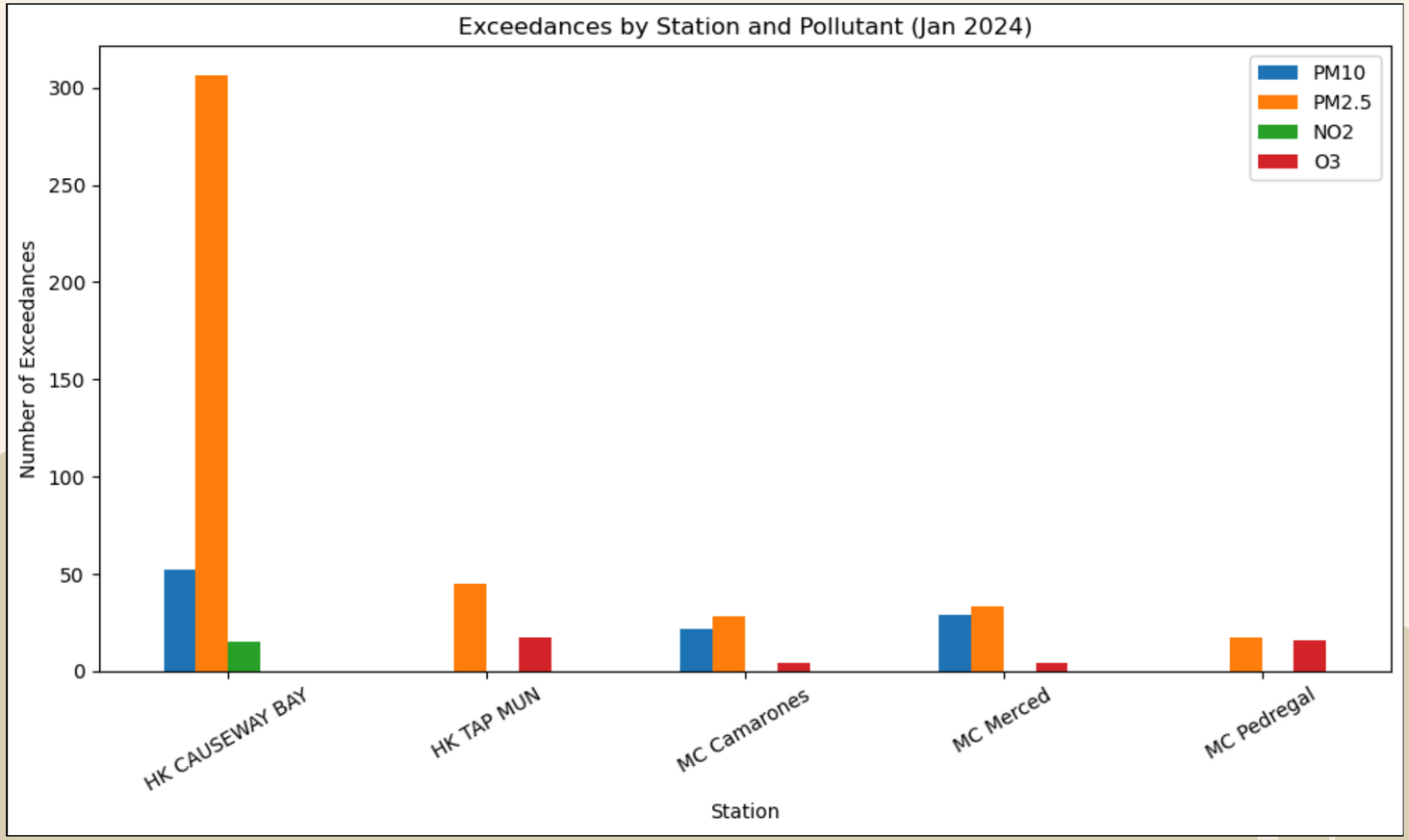
Summary statistics for each station and pollutant (μg/m³)

Station	NO_2 Mean	O_3 Mean	PM10 Mean	PM2.5 Mean
HK Urban	75.52	43.35	52.23	33.82
HK Rural	13.14	85.11	33.18	20.86
MC Industrial	34.5	19.33	45.08	20.98
MC Urban	38.89	18.32	43.05	21.62
MC Peripheral	25.13	29.07	29.9	14.49

- Urban/industrial stations: higher NO_2/PM.
- Rural: higher O_3.
- Similar patterns in both cities.



EXCEEDANCES OF REGULATORY LIMITS

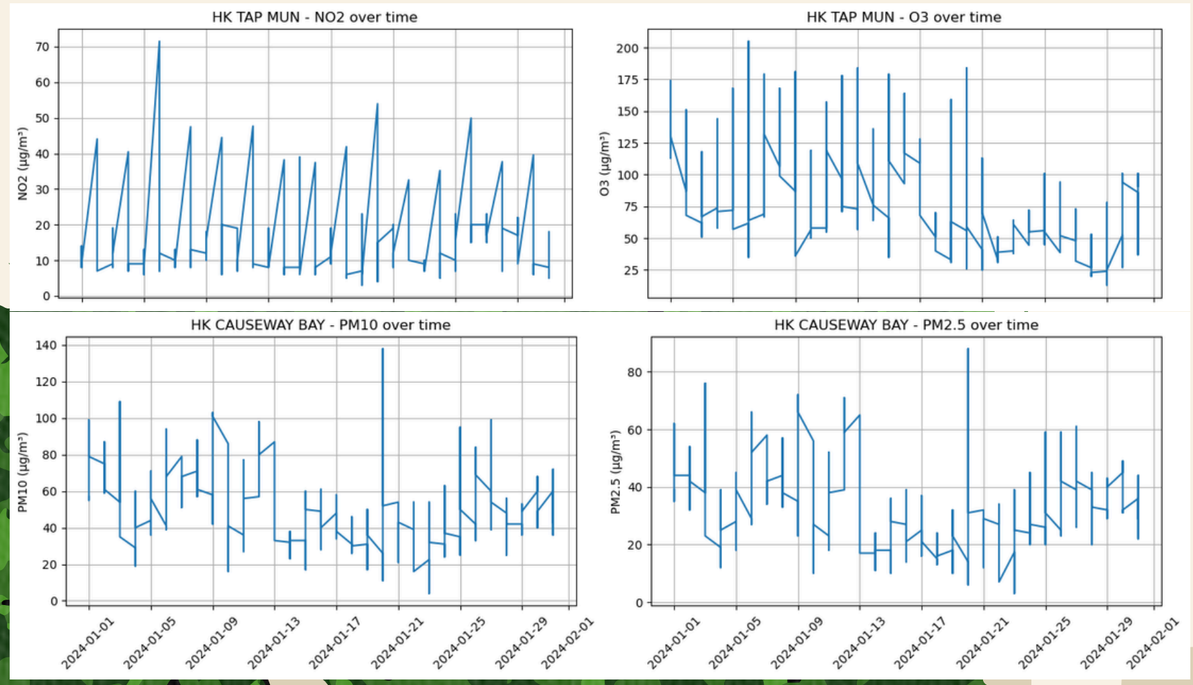


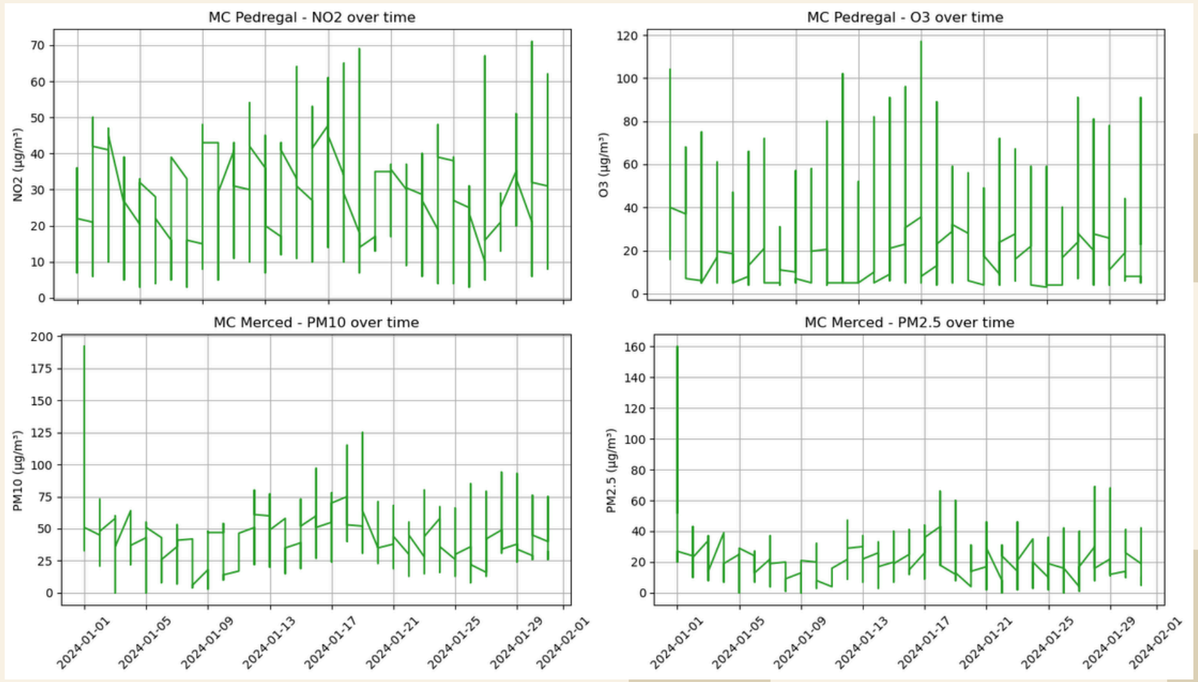
Pollutant	Hong Kong Limit (Averaging Time)	Mexico City Limit (Averaging Time)
PM10	75 µg/m³ (24h), max 9 exceedances/year	75 µg/m³ (24h)
PM2.5	37.5 µg/m³ (24h), max 18 exceedances/year	45 µg/m³ (24h)
NO_2	200 µg/m³ (1h), 120 µg/m³ (24h)	395 µg/m³ (1h)
	max 18 (1h) & 9 (24h) exceedances/year	
O_3	160 µg/m³ (8h), max 9 exceedances/year	0.070 ppm (8h avg) ≈ 140 µg/m³ (8h)
		0.095 ppm (1h max) ≈ 180 µg/m³ (1h)

Note: Mexico City does not specify a maximum number of allowed exceedances per year.

- Urban stations exceed PM limits most; O_3 exceedances more rural/peripheral. HK often above regulatory limits
- Why exceedances matter? They indicate pollutant levels above what is considered safe, increasing health risks and signaling the need for stronger air quality management.

TIME SERIES ANALYSIS

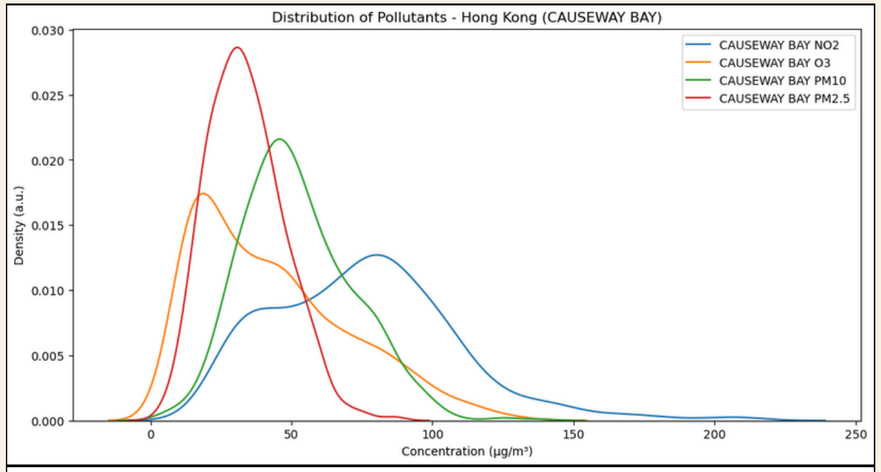


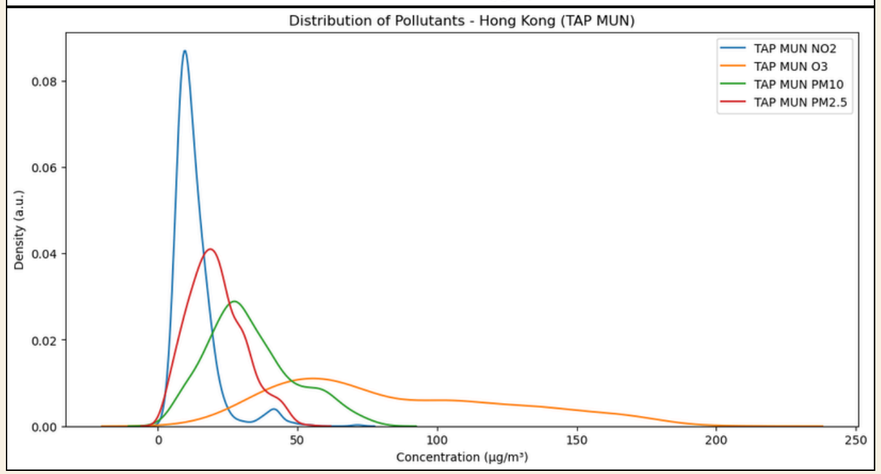


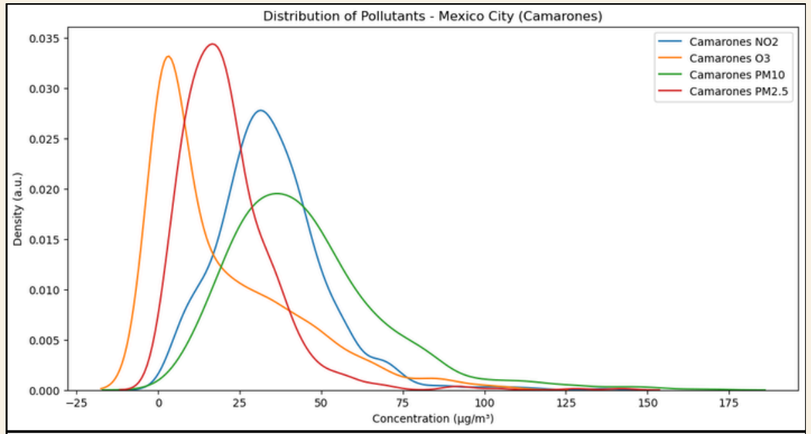
- Temporal patterns and notable episodes
  - Urban vs. rural/peripheral differences
  - Example: New Year peaks in Mexico City
- O_3 variable in rural/peripheral; frequent PM peaks in urban sites

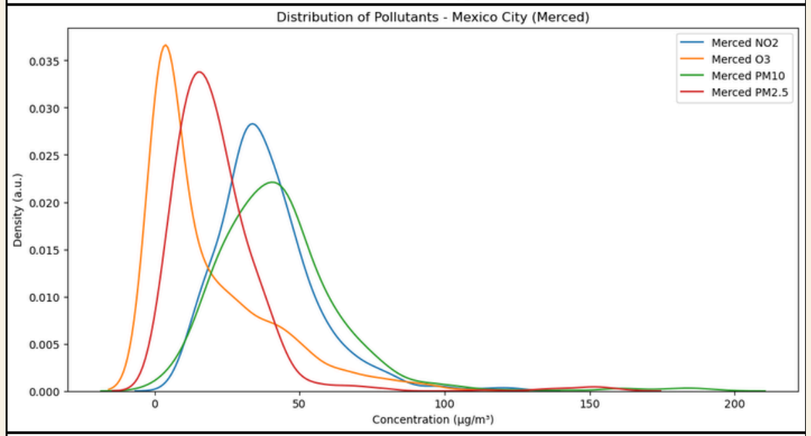
DISTRIBUTION ANALYSIS

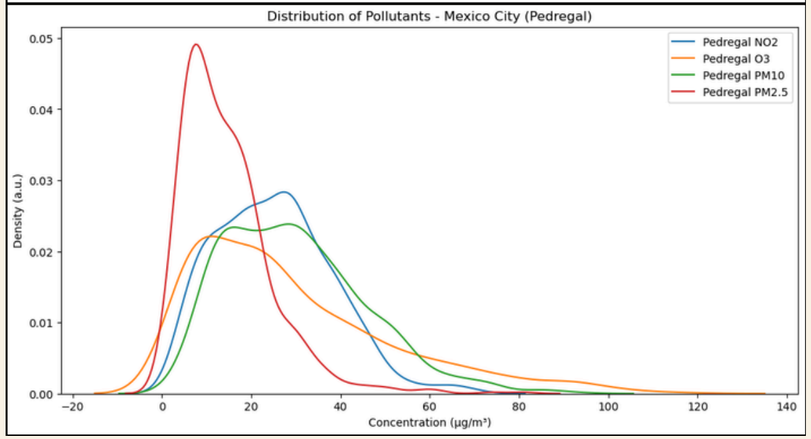
Using KDE plots





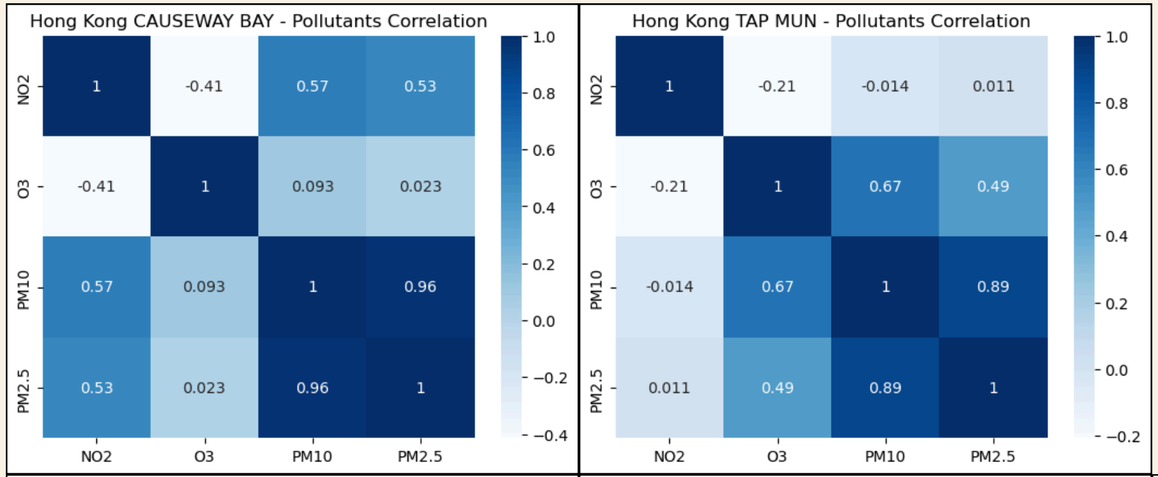


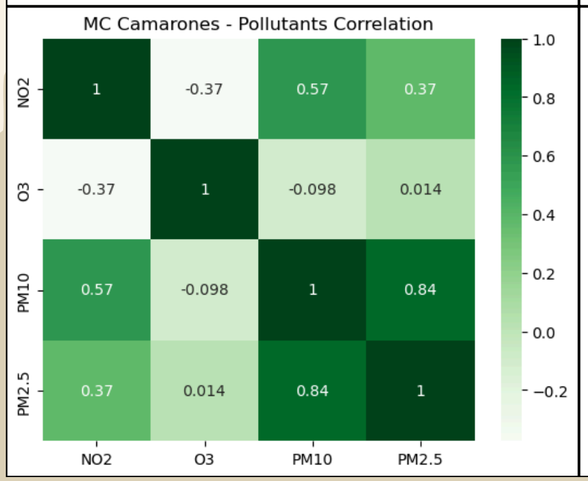


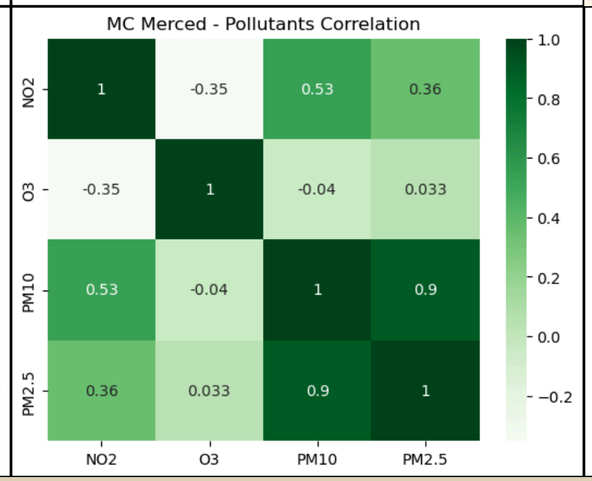


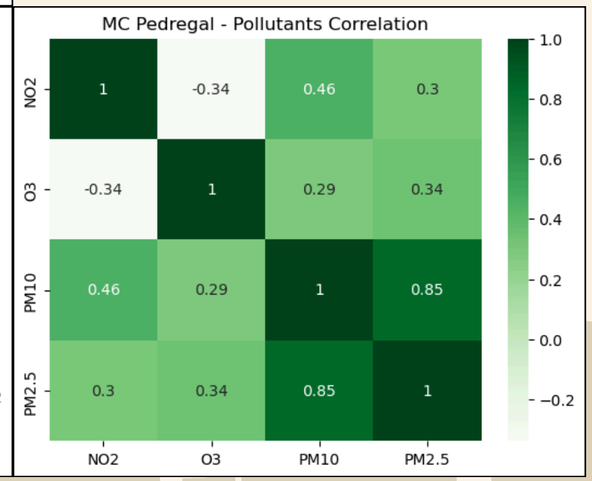
- Differences in pollutant distributions between station types
- Urban: higher, more variable PM and NO_2
- Rural/peripheral: higher O_3

CORRELATIONS





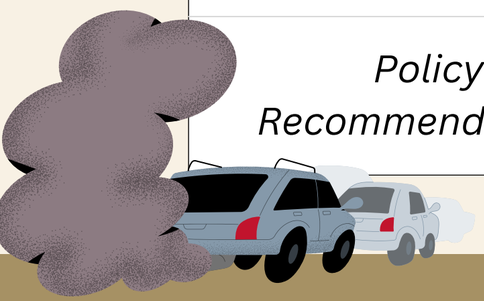




- **Main findings from correlation analysis:**
  - Strong PM10–PM2.5 correlation (common sources)
  - Negative NO_2–O_3 correlation: strongly so in urban areas (due to titration), and weaker in rural sites; they rarely increase together

INSIGHTS, POLICY IMPLICATIONS & COMMUNICATION LESSONS

Aspect / Station Type	Urban/Industrial (HK & MC)	Rural/Peripheral (HK & MC)	Communication & Policy Lessons
Main Issues	Frequent PM10, PM2.5, NO_2 exceedances	Higher O_3 episodes	**HK**: Numerical AQHI, real-time alerts, strict limits; **MC**: Categorical IAS, less direct communication
Health Risks	Respiratory & cardiovascular from particulates/NO_2	Ozone-related respiratory effects	Clear, real-time risk communication (i.e. apps) improves public response
Needed Actions	Targeted emission reductions (traffic, industry)	Regional/photochemical ozone management	Harmonize indices, improve public apps, set clear exceedance limits
Policy Recommendations	Stricter controls in urban centers	Regional strategies for ozone	Tailor messages: urban = PM/NO_2, rural = O_3



RESEARCH OPPORTUNITIES & NEXT STEPS

Actionable summary:

1. Develop a numerical version of the IAS for Mexico City, modeled after Hong Kong's AQHI, and assess its impact on public risk perception and communication by piloting the new index and surveying user understanding.
2. Identify and analyze extreme pollution episodes in both cities, linking them to meteorological conditions (e.g., wind, temperature, humidity) using event-based data analysis and cross-city comparison.
3. Build and test simple machine learning models (e.g., regression, decision trees) to predict poor air quality episodes, evaluating which variables are most predictive in each city.
4. Compare urban and rural/peripheral stations to uncover spatial pollution patterns and design targeted management strategies based on observed differences.
5. Review successful air quality policies and communication tools from Hong Kong, and adapt or pilot similar interventions (e.g., alerts, apps) for Mexico City.
6. Simulate the effects of emission reduction scenarios (e.g., fewer cars, more public transport) using Hong Kong as a benchmark, to set realistic policy goals for Mexico City.

Further opportunities:

1. Develop a numerical index for Mexico City's IAS:
   a. How can the Mexican IAS evolve into a numerical index and what benefits would this bring for air quality management and communication?
2. Analyze critical episodes and meteorology:
   a. What factors explain extreme events and how can they be anticipated or mitigated?
3. Apply machine learning for prediction:
   a. How can predictive analytics improve air quality management in Mexico City?
4. Deepen spatial analysis (urban vs. rural):
   a. What differentiated policies can be implemented depending on the type of area?
5. Evaluate policy and communication strategies:
   a. What communication and control strategies can be transferred from Hong Kong to Mexico City?
6. Simulate "what if" emission reduction scenarios:
   a. What impact would different emissions reduction policies have on air quality in Mexico City?

THANK YOU!

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