Main Sources of Air Pollution in Jakarta

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For further details, visit www.vitalstrategies.org/source-apportionment-report.

Vital Strategies

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Main Sources of Air Pollution in Jakarta

Policy Brief

Indonesia has the highest number of premature deaths (more than 50,000) associated with air pollution in Southeast Asia in 2017.[1] With annual average $PM_{2.5}$ concentrations in Jakarta routinely four to five times higher than World Health Organization (WHO) health-based Air Quality Guidelines,[2] the capital city observed the largest number of deaths (nearly 36) per 100,000 attributed to ambient $PM_{2.5}$ pollution, compared to 20 per 100,000 nationwide. An estimated 5.5 million cases of air pollution-related illness were reported in 2010 (nearly 11 cases per minute) in Jakarta, costing an equivalent of IDR 60.8 trillion in 2020 in direct medical expenses.[3]

Effective air quality management for Greater Jakarta requires knowing the leading sources of pollution in the city. Information on what share of the air pollution problem is attributable to different sources (e.g., traffic) allows effective clean air actions to be prioritized.[6] In general, this involves two complementary approaches: the source-based approach using emissions inventories to model air pollution levels, and the receptor-based approach using air filter samples to chemically characterize the sources that contribute to air pollution.

Reliable and recent information on leading sources of air pollution in Jakarta is scarce. Over the past decade, two ad-hoc air pollution emissions inventories were developed by civil society and academia, in 2012 and 2015, respectively,[7,8] and no receptor-based source apportionment data are available. To address this major evidence gap, Vital Strategies worked with the Bandung Institute of Technology to expand an ongoing receptor-based source apportionment study to identify the leading sources of ambient $PM_{2.5}$ levels in and around Jakarta. The findings will inform policymakers on the leading sources of air pollution in the city, and provide a check on findings from earlier emissions inventory results.

Particulate matter with a diameter of 2.5 microns or less ($PM_{2.5}$) poses the greatest risk to health. $PM_{2.5}$ causes and worsens chronic heart disease, lung disease, diabetes and cancer, and also impacts child health through adverse birth outcomes, slowing lung growth and causing pneumonia and stunting.[4,5]

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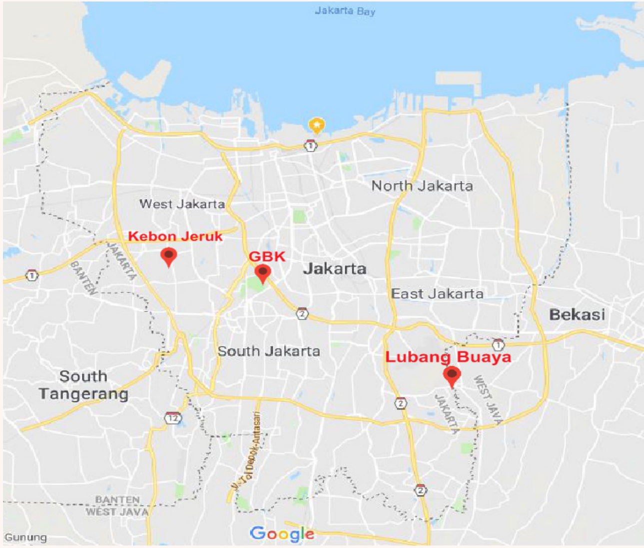
The Approach



Where PM$_{2.5}$ was collected on filters at three air quality monitoring sites across the city: Gelora Bung Karno (GBK), Kebon Jeruk (KJ) and Lubang Buaya (LB). These sites were selected based on land use features, weather and other considerations to capture potential variation in air pollution sources.

When One wet season (October 2018–March 2019) and one dry season (July–September 2019).

How PM$_{2.5}$ were collected on filters and analyzed for their chemical composition. Two statistical methods (receptor models) were used to estimate the source contribution to ambient PM$_{2.5}$ concentrations, and results were compared to increase confidence in the findings.

Findings

Air Pollution Levels in Jakarta

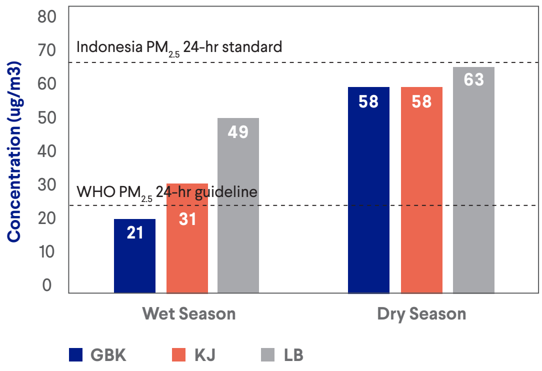
Most average daily $PM_{2.5}$ levels in Jakarta across the city and seasons exceed the WHO health-based Air Quality Guideline (see Figure 1).

Daily pollution levels are significantly higher in the dry season than the wet season.

The variation in pollution levels in different areas of the city was greater in the wet season than during the dry season.

Figure 1

Average daily $PM_{2.5}$ concentration in Jakarta



Primary aerosols occur as a result of direct emissions from an air pollution source. Sea salts, a natural marine emission, are formed due to wind action at the ocean surface.

Secondary aerosols (e.g., ammonium nitrate or sulfate) are formed when precursor gaseous pollutants, such as sulfur oxides and nitrogen oxides, undergo chemical reactions within the atmosphere.

Vehicle exhaust, coal combustion, open burning, construction, road dust, and resuspended soil particles are the main sources of air pollution in Jakarta.

- Gasoline and diesel vehicles contributed to 32%–57% of $PM_{2.5}$ levels, though it is unclear how much of these came from on-road vehicles and how much from off-road emissions (e.g., logistic vehicles).
- Non-vehicular primary sources accounted for 17%–46% of ambient polluted air across sampling sites and seasons, including contribution from anthropogenic sources such as: coal combustion, open burning, construction (non-combustion) activities and road dust; and natural sources such as: soil and sea salt.
- Secondary inorganic aerosol accounted for 1%–16%.
- The contributions of leading sources to outdoor $PM_{2.5}$ concentration varied across seasons and by location. This may be explained by variation in local activities, or regional sources of pollution, depending on weather conditions (e.g., upwind emissions from adjacent cities).

Differences in pollution sources by season were observed.

Figure 2a

Source contribution (%) to $PM_{2.5}$ concentrations in Jakarta

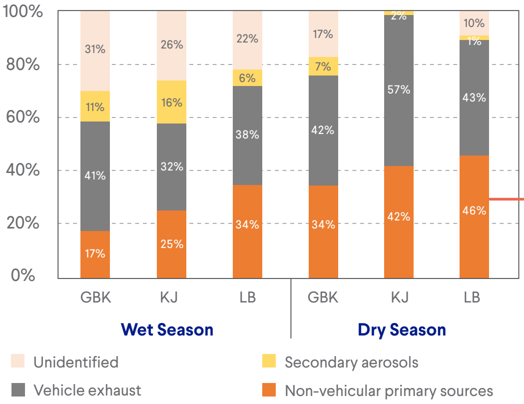
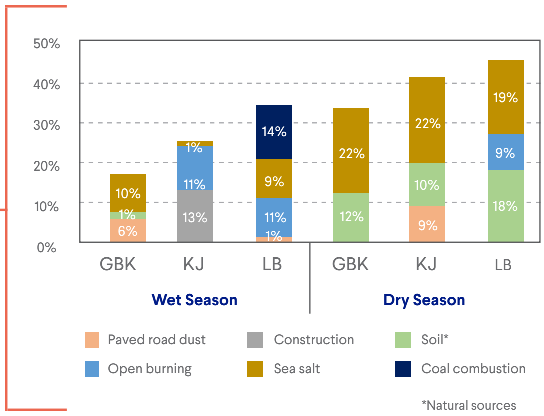


Figure 2b

Non-vehicular primary source contribution (%) to $PM_{2.5}$ concentrations in Jakarta



Major sources of pollution in wet season

Vehicle exhaust 32–41% The highest vehicular emissions were observed at the city center (GBK).

Coal combustion 14% in the east (LB)

Construction activities 13% in the west of the city (KJ).

Open burning of biomass or other fuels: 11% in the outskirts of the city (KJ and LB).

Paved road dust: <1%–6% was observed in the center (GBK) and east of the city (LB).

Secondary aerosol (6%–16%) and **sea salt** (1%–10%) were found across the city.

Major sources of pollution in dry season

Vehicle exhaust 42%–57% across the city

Open burning: 9% in the east (LB)

Paved road dust: 9% in the west of the city (KJ)

Sea salt 19%–22%

Resuspended soil particles 10%–18% were observed across the city, most evidently in the east (LB), due to dry conditions.

Secondary aerosol: 1%–7%

This study was conducted within the Jakarta city boundary. While the results cannot directly differentiate contributions from local and regional emissions, existing knowledge on emission activities and locations of point- and area-sources around the sampling sites and neighbourhood area (e.g., Greater Jakarta) may shed light on the potential contributing emission sources. For instance, biomass burning activities in paddy fields west of Kebon Jeruk may explain the source contribution from open burning in that site; similarly, coal-fired power plants operating outside of the city boundary, and to a lesser extent, manufacturing industries in Jakarta, may contribute to source contribution from coal combustion at Lubang Buaya. Secondary aerosols represent mainly long-range, transboundary contribution to ambient $PM_{2.5}$ pollution.

Policy Recommendations

To rapidly improve air quality in Jakarta, reduce the burden of air pollution on health and save lives, Vital Strategies recommends implementing the following proven solutions to tackle the emissions sources identified through this source apportionment study:

Limit Vehicle Exhaust

Reduce vehicular emissions through comprehensive and synergistic vehicle pollution control strategies that target: fuel quality and emissions control standards, compulsory emissions testing of all vehicles, alternative technologies (e.g., hybrid or electric vehicles), and road maintenance. In addition, continuing and accelerating the expansion of integrated public transit systems in Jakarta can reduce the dependence on private vehicles and subsequently reduce vehicle emissions. Modernizing emissions requirements for vehicles to the latest standards along with mandatory and incentivized retirement of older vehicles has proven effective in many cities.

Reduce Coal Combustion

About 80% of coal consumed in 2018 was used to generate electricity[9], with the remaining used by the industrial sector. The impact of coal combustion on air quality in Jakarta can already be detected, despite the fact that none of the coal-fired power plants are within the city limits. Given that Indonesia plans to construct more coal-fired power plants within 100 kilometers of Jakarta, their contribution to ambient $PM_{2.5}$ pollution in Jakarta will increase over time.

To reduce emissions from coal combustion in the near term, install scrubber and filter systems and cleaner production technologies, and introduce stringent emissions standards for coal-fired power plants and industries. To promote compliance, it is critical to enforce standards through regular inspection schedules to monitor and control air pollution emissions levels. Mandatory installation of continuous emissions monitoring systems for all power plants and industries will also provide actionable data for enforcement and enable plants to improve their efficiency and compliance. For longer-term pollution control measures, the city should consider switching to cleaner fuel (e.g, natural gas), and expanding to increasingly affordable solar, wind and other zero-emissions options.

Enforce Open Burning Bans

Enforce the ban on open burning of biomass (Local Government Regulation No 2/2005). To prevent trash burning, introduce interventions to improve solid waste collection, management and recycling, and conduct regular clean-up and awareness campaigns. Open burning of other fuels or materials may also contribute to ambient air pollution, and should be included in the ban

Control Construction Dust, and Paved Road Dust, and Exposed Soil

Minimize resuspension of dust and soil particles by the wind by using abatement measures such as: watering all exposed surfaces (e.g., construction sites, road and soil surfaces); applying dust suppressant/dust binders (e.g., chemical reagents) to maintain a wet surface; covering vehicles transporting soil/sand; and planting appropriate vegetation to maintain soil moisture.