

# **The Effects of Urban Air Pollution on Health, Safety and the Environment in Asia: Case Study Indonesia**

**By**

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## **Abstract**

This research examines the impact of urban air pollution on human health, safety, and the environment in Indonesia, demonstrating that most cities, particularly Jakarta, have significant levels of air pollution in comparison to European Union (EU) air quality regulations. The findings are mostly related to natural or human activities such as waste burning, fossil fuel combustion, car exhaust emissions, land clearance, mining, agriculture, and cement manufacturing. According to the findings, air pollution is mostly responsible for the escalation or exacerbation of asthma, cancer, lung/respiratory disorders, various cardiovascular diseases, and early mortality in Indonesia. The study used a qualitative data collection method, depending solely on secondary sources such as books, academic journals, newspapers, and the Internet.

**Keywords:** *Air pollution, Human Health, Safety, Indonesia*

## **1. Introduction**

Human interactions with nature and the planet's atmosphere are inextricably linked, resulting in the existence of toxic gases and particles from anthropogenic activities that influence human health, safety, and environmental quality. The increase in rural-urban migration has had a tremendous influence on all elements of human civilisation, emphasising the interdependence of humans and the environment. Migration has led to unexpected population growth, causing environmental issues including air pollution (Nyakuma et al., 2022).

The World Health Organisation (WHO) considers air pollution a major threat to human health, safety, and the environment (Geneva: World Health Organization, 2021a). It is known to be the cause of many early deaths, which the Organisation for Economic Cooperation and Development (OECD) expects will double soon (IEA, 2016). Due to its impact on human health and safety, air quality is regarded as the requirement for assessing the state of the environment

in any place. High levels of air pollution globally lead to a 2.2-year reduction in Human Life Expectancy (HLE). This proportion rises to three to four per cent in Southeast Asia, notably in big cities like Jakarta.

Indonesia is ranked third among all nations in the world for air pollution. Approximately 60–70% of air pollution comes from motor vehicle petrol emissions, compared to 10-15% from industrial waste (Gunawan et al., 2017). The remainder comes from through field burning, forest fires, and the incineration of home garbage. These values are higher above both the national level set by the Ministry of Health and the safety criteria set by the World Health Organisation (WHO). Furthermore, there is a wide variation in the concentrations of air pollution, especially in metropolitan regions where pollution levels are higher. Air pollution concentrations in major Indonesian cities are as high as 60  $\mu\text{g}/\text{m}^3$ , which is ten times higher than the WHO air quality safety standard (Geneva: World Health Organization, 2021b).

According to projections, air pollution, including the increase in greenhouse gas (GHG) emissions in Indonesia, is mostly caused by the energy industry (Jeanly Syahputri et al., 2023). Although GHG emissions and air pollution are separate problems, they interact and have different effects on human health. According to the Greenhouse Gas Inventory report, 30% of greenhouse gas emissions in 2020 came from the energy sector (Jeanly Syahputri et al., 2023). Air pollution is also caused by other relevant human-based activities including urbanisation, economic expansion, and fast industrialisation.

Air pollution in Indonesia has been related to noncommunicable diseases (NCDs), imposing major costs on healthcare and the economy. In Jakarta, NCDs were responsible for 79% of overall fatalities in 2019. According to the World Bank, Indonesia lost more than USD 220 billion due to air pollution in 2019 (Syuhada et al., 2023).

Several studies have found that both long- and short-term exposure to air pollution causes a wide variety of health problems. Toxic pollutants can lead to asthma, respiratory and cardiovascular disorders, impaired lung function, and premature mortality. Similarly, the effect of urban air pollution on human health and safety in Indonesia has been studied in the literature. Kusumaningtiar et al., 2020 examined the air pollution of carbon monoxide in a case study on city traffic jams in Jakarta. Haryanto, 2018 examined climate change and Urban air pollution health impacts in Indonesia. Resilience et al., 2024 investigate the perception of air quality and community resilience towards air pollution issues in the province of DIK Jakarta.

Resosudarmo & Napitupulu, 2004 estimate the health and economic impact of air pollution in Jakarta.

Review studies show that, in contrast to many affluent nations, Indonesia lacks a clear strategy and ecological criteria for monitoring air pollution. Effective tactics and monitoring systems are therefore desperately needed to help policymakers, engineers, and scientists by accurately assessing and comprehending the extent of air pollution in different cities.

The purpose of this study is to examine contemporary research on Indonesian urban air pollution, with an emphasis on how it affects public safety and health. It will provide thorough knowledge by identifying, highlighting, and citing the primary air contaminants and their sources.

## **2. The Study Area**

Indonesia is the world's biggest archipelagic state, covering over 17,000 islands and home to more than 260 million people, making it the world's fourth most populous country and a major emitter of greenhouse gases due to deforestation and land-use change. The Indonesian archipelago is situated between Asia and Australia. It is surrounded by the South China Sea to the north, the Pacific Ocean to the north and east, and the Indian Ocean to the south and west. More than 80% of Indonesia's territory is covered by water, while the land area is roughly 1.9 million square kilometres.

The urbanisation rate is high (4.4%). Java is home to two-thirds of the population and more than half of those in need (57%). Forest cover accounts for over 60% of Indonesia's land area. However, deforestation and land-use change are projected to be two million hectares (ha) each year and account for 85% of Indonesia's yearly greenhouse gas emissions.

Indonesia is extremely vulnerable to environmental hazards particularly sea-level rise, and the frequency of natural disasters is increasing. Temperatures have risen by 0.3°C since 1990, with a further 1.5-3.7°C increase expected by 2100. Increased greenhouse gas emissions will also continue to influence natural climatic variability, resulting in more severe weather occurrences. Climate change has caused severe rainfall in Indonesia, which is expected to rise by 2-3% every year. This additional rainfall leads to a shorter rainy season and a higher flood danger.

The Indonesian city with the highest population density is Jakarta. As a result, the ambient air quality has deteriorated over time, due primarily to blatant disdain for public facilities. The rising population and need for social services have exacerbated this dilemma throughout time. Other problems, such as fast and uncontrolled urbanisation, as well as rising population growth, have compounded the challenges of the urban population in the city.

### **3. The concept and classification of air pollution**

Air pollution is referred to as the presence of redundant particles in the atmosphere, which is frequently generated by human activities and may be damaging to human health, vegetation, crop yields, and vegetation properties (Ashmore, 2024). Ghorani-Azam et al., 2016 define air pollution as an unwanted result of decaying compounds that contribute to atmospheric contamination. The substances that pollute the environment are commonly referred to as pollutants. Pollutants include carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), particulate matter (PM), and sulphur dioxide (SO<sub>2</sub>).

Air pollution is a global environmental concern that affects everyone. The study by Enger et al. indicates a link between air pollution, population size, and pollution-emitting developmental technologies. Pollutants must be emitted from numerous sources and chemically combined to generate air pollution. Bernstein et al., 2004 classify air pollution into distinct forms depending on its origin, source, size, chemical composition, and release form into the environment, such as natural or man-made and stationary or mobile pollution based on sources.

Pollution from natural causes includes dust storms, radon gas, pollen grains, forest fires, and volcanic eruptions. Anthropogenic pollution, often known as man-made pollution, results from people's activities in their environment (Appannagari, 2017). It falls into three categories: line, area, and point sources. Point sources are sizable industrial establishments that emit pollutants through chimneys, such as paper mills and power plants. Small yet prevalent industries like petrol stations and agricultural burning are examples of area sources (Khalaf et al., 2006).

Air pollution is divided into two types: primary and secondary pollutants (Rafee et al., 2017). Primary pollutants, such as CO, NO<sub>x</sub>, hydrocarbons, lead, sulphur, and volatile organics, are released by human or natural processes. Secondary pollutants, such as nitric acids and sulphurous acid, are produced by photochemical oxidation or atmospheric components. Air pollution is further classified as particulate matter (PM) pollutants, which can be organic or inorganic components with a diameter of less than 2.5 μm (Fujita et al., 2014).

#### **4. The Major air contaminants and their effects on health**

Air pollutants such as NO<sub>x</sub>, SO<sub>x</sub>, CO, Pb, VOCs, and PM have harmful effects on human health and the environment, depending on their concentration and duration of exposure. The harmful effects vary depending on the kind of pollutant and their impacts.

##### **a. Nitrogen oxide (NO<sub>x</sub>)**

According to Almetwally et al., 2020, NO<sub>x</sub> are a collection of gas pollutants produced by the chemical interaction of nitrogen (N) and oxygen (O). Seok et al., 2013) identified about seven (7) possible byproducts of this reaction: NO, NO<sub>2</sub>, N<sub>2</sub>O, NO<sub>3</sub>, N<sub>2</sub>O<sub>3</sub>, N<sub>2</sub>O<sub>4</sub>, and N<sub>2</sub>O<sub>5</sub>. NO<sub>2</sub> is the primary precursor of ozone and hence a major component of oxidant air pollution. NO<sub>x</sub> chemicals are naturally produced by soil emissions, thunderstorm lightning, chemical fertiliser usage, and volcanic eruptions.

Nitrogen oxides generated by human activities combine with ozone to form nitrogen dioxide (NO<sub>2</sub>). Mobile sources include automobiles, trains, and trucks, whereas stationary sources include generators, plants, and heaters. High NO<sub>2</sub> levels can induce significant lung function abnormalities, such as asthma, neutrophilic infiltration, and pro-inflammatory cytokine secretion, ultimately leading to death. NO<sub>2</sub> has also been connected to acid rain, which is causing harm to both humans and the environment(Han et al., 2017).

##### **b. Sulphur oxides (SO<sub>x</sub>)**

Sulphur oxides (SO<sub>x</sub>) are colourless, acidic, and choking smell gases produced by fossil fuel burning, volcanic eruptions, and power plant generators(Macdonald et al., 2004). They are present in soil, seas, and plants. SO<sub>x</sub> is the most common sulphur-based air pollutant, and it comes in two forms: SO<sub>2</sub> and SO<sub>3</sub>. SO<sub>x</sub> has a significant impact on the chemistry of the Earth's atmosphere, influences weather and climate, and is corrosive. SO<sub>x</sub> exposure may lead to respiratory illnesses in the short term, but long-term exposure can result in asthma, heart disease, lung disease, and early death(Komarnisky et al., 2003).

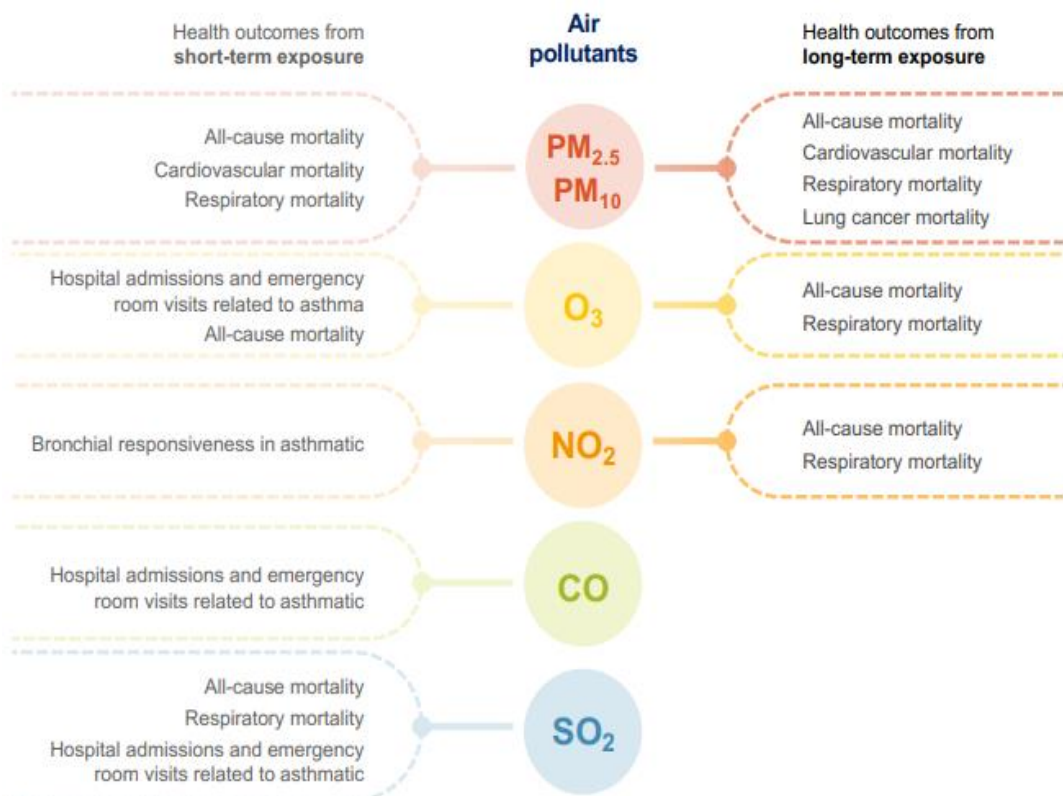
##### **c. Carbon monoxide (CO)**

Carbon monoxide (CO) is a colourless, tasteless, and odourless gas produced by incomplete combustion of fossil fuels. It is a substantial air contaminant that interferes with haemoglobin in the blood and reduces oxygen delivery in tissues. CO is predominantly emitted by man-made and natural sources, including petrol engines, waste incineration, bush burning, volcanoes, natural gas emissions, and seed germination. High concentrations have resulted in accidental death(Hollocher, 1970).

##### **d. Particulate Matters (PMs)**

PMs, which are made up of solid, liquid, and tiny particles, are omnipresent contaminants found in the atmosphere. They can be categorised as tiny particles (2.5–2.5  $\mu\text{m}$ ), ultrafine particles ( $<0.1 \mu\text{m}$ ), or coarse particles (10–20  $\mu\text{m}$ ). Studies indicate that tiny particles are more hazardous and contribute to climate change and that inhaling them can result in high rates of death. Chronic health problems can be caused by breathing in PM<sub>2.5</sub> and PM<sub>10</sub>(Janssen et al., 2011).

Image 1: Major air pollution and its health effects.



Source: (Jeanly Syahputri et al., 2023)

## 5. Health Effect of Air Pollution in Indonesia

Air pollution has been identified as a serious environmental danger to Jakarta people, regardless of socioeconomic background(Haryanto & Franklin, 2011). Transportation accounts for 27% of Indonesia's greenhouse gas emissions, and traffic congestion is a major issue in Jakarta. Diseases resulting from vehicular emissions and air pollution include acute respiratory infection, bronchial asthma, bronchitis, and eye and skin irritations, and it has been recorded that the most common disease in northern Jakarta communities is acute upper respiratory tract infection (63% of total visits to health-care centres)(Zhang et al., 2015)

Acute respiratory infections are more common in 16 provinces than they are nationwide (25.5%). The districts and cities with the highest rates of acute respiratory infections are Kaimana (63.8%), Manggarai Barat (63.7%), Lembata (62%), Manggarai (61.1%), Pegunungan Bintang (59.5%), Ngada (58.6%), Sorong Selatan (56.5%), Sikka (55.8%), Raja Ampat (55.8%), and Puncak Jaya (56.7%). In 2007, there was no discernible difference in the prevalence of cough (45%) and flu (44%), whether in an urban or rural area(Haryanto & Franklin, 2011).

According to the National Basic Health Research 2007 report, 16 provinces had higher rates of acute respiratory infections, cough, flu, pneumonia, TB, and asthma than the country as a whole(Pope et al., 1995). In 2007, there was no discernible difference in cough and flu rates between urban and rural regions (45% and 44%, respectively). 14 provinces had a 2.18% rate of pneumonia, while 17 had a 0.99% rate of TB. Nine provinces had a 4% asthma rate. Pneumonia is the number one killer illness for babies and children under 5 years of age and is in the top 10 diseases causing mortality among the adult population(Haryanto & Franklin, 2011). According to WHO estimates, Indonesian solid fuel consumption resulted in 31,30 ALRI mortality for children under five in 2002, compared to 12,160 COPD deaths(WHO 2016, 2015).

Air pollution from leaded gasoline exposure has resulted in elevated blood lead levels in primary school pupils in Bandung, with 66% above the CDC's 10 ug/dl standard in 2005 and 53% in 2006. In Makassar, 90% of children under the age of five had BLLs more than 10 ug/dL in 2005. Furthermore, 50 per cent of Jakarta professionals experienced ill-building syndrome symptoms five times in three months as a result of poor indoor air quality at work(Haryanto & Franklin, 2011).

Pneumonia is the greatest cause of mortality among newborns (22.3%) and children under the age of five (23.6%), and it is also one of the top ten causes of death in adults. In 2002, the World Health Organisation predicted 3130 ALRI fatalities in Indonesia as a result of solid fuel consumption, whereas 12,160 COPD deaths were estimated for individuals over 30(Haryanto & Franklin, 2011).

Air quality consequences are not restricted to source regions (mainly in Central and Southern Sumatra and Southern Kalimantan) but can travel through the atmosphere and influence transboundary places such as Singapore. Air pollution from forest fire sources in Sumatra and Kalimantan has damaged millions of human health in Sumatra and Kalimantan, as well as neighbouring nations Singapore and Malaysia(Haryanto & Franklin, 2011).

According to research on the health effects of air pollution in Jakarta Province in 2022, the city's air pollution causes over 10,000 yearly deaths and over 5,000 hospital admissions. The annual cost of these health effects is estimated to be over 42 million. A study on air quality in DKI Jakarta using national ambient air quality standards (NAAQS) and the Air Pollution Standard Index (PSI) identified O<sub>3</sub> as a critical pollutant for all AQMS sites. Annual exposure to PM<sub>2.5</sub> causes 6100 stunting instances, 330 infant deaths, 700 poor birth outcomes, and roughly 9700 premature deaths. High levels of O<sub>3</sub> are responsible for roughly 310 COPD fatalities among 25-year-olds, with uncertainty ranges described (Syuhada et al., 2023).

According to 2023 research (Zulfikri, 2023), air pollution would be the cause of 7900 fatalities. According to Breathe Easy Jakarta's 2012 estimate, 20 µg/m<sup>3</sup> of PM<sub>2.5</sub> caused 3700 fatalities. The overall mortality linked to PM<sub>2.5</sub> was 9620 when yearly levels hit 52 µg/m<sup>3</sup>. Pollutants, concentration-response functions, and exposure level estimation techniques are some of the factors causing this discrepancy.

Image 2. Showing the health effects of a long time of air pollution in Jakarta

Hospitalizations	Disease Cause	
	Cardiovascular	Respiratory
<i>PM<sub>2.5</sub></i>		
Total Hospitalizations	150,272	108,560
<i>PM<sub>2.5</sub> Attributable Indicators</i>		
Number of Cases	3043	455
Rate (per 100,000 population)	28	4
<i>O<sub>3</sub> *</i>		
Total Hospitalizations	37,039	12,147
<i>O<sub>3</sub> Attributable Indicators</i>		
Number of Cases	1357	182
Rate (per 100,000 population *)	282	38

Source: (Syuhada et al., 2023)

Daily exposure to air pollution has been linked to about 5000 hospitalisations each year. PM<sub>2.5</sub> exposure has been linked to almost 3500 hospitalisations, with cardiovascular illness accounting for 87% of PM<sub>2.5</sub>-related admissions. On the other hand, exposure to high-level O<sub>3</sub> may cause over 1500 hospitalisations among those aged 65 years and above, of which 83% were related to cardiovascular disorders, while the ranges of uncertainty with 95% confidence intervals of these figures are provided (Syuhada et al., 2023).

Image 3: showing the health effects of short-term air pollution in Jakarta

Hospitalizations	Disease Cause	
	Cardiovascular	Respiratory
<i>PM<sub>2.5</sub></i>		
Total Hospitalizations	150,272	108,560
<i>PM<sub>2.5</sub> Attributable Indicators</i>		
Number of Cases	3043	455
Rate (per 100,000 population)	28	4
<i>O<sub>3</sub> *</i>		
Total Hospitalizations	37,039	12,147
<i>O<sub>3</sub> Attributable Indicators</i>		
Number of Cases	1357	182
Rate (per 100,000 population *)	282	38

Source: (Syuhada et al., 2023)

## 6. Conclusion

The effects of urban air pollution on human health, safety, and the environment in Indonesia were examined in this study. The studied literature revealed that urban air pollution is mostly produced by human activities such as open-air burning, transportation, and agriculture. Other relevant reasons include the fast-expanding urban population caused by rural-urban migration, which severely limits the already fragile infrastructure or deteriorating social facilities in many Indonesian cities and towns.

Numerous incidents of sickness and death among Indonesian residents have been documented as a result of the high levels of air pollution in metropolitan areas. According to a study of the research, air pollution is mostly responsible for the exacerbation or escalation of asthma, cancer, lung/respiratory disorders, various cardiovascular diseases, and, ultimately, premature mortality in Indonesia. With the nation's population expected to increase by 2050, the effects of air pollution on health may become much more severe.

As a result, there is an urgent need to develop a vital plan of action for promoting clean air and the sustainable use of fuel and energy resources that contribute to air pollution, which harms air quality, human health, safety, and the environment.

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