

Impact of roadside pollution on public health

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1. Introduction

With more than 7 million inhabitants, Hong Kong is one of the most urbanized and densely populated cities in the world. The metropolis has a highly developed road network that supports an immense traffic flow on a daily basis and allows its inhabitants easy access to different areas within the city. Though this complex road network offers great level of convenience to its users, it also raises a serious health concern for the public.

Like road networks in many urban areas, Hong Kong's road network is shared between pedestrians and vehicles. Due to compact environments, journeying by foot is a common option for citizens. In busy commercial areas with condensed traffic flow, pedestrians on busy streets become susceptible to the emission generated from the high traffic flow. The population that reside in these areas area also largely affected

2. Impact of air pollution on public health

Over the years, a number of epidemiological studies have shown an association between exposures to atmospheric pollutants and exacerbation of conditions in individuals suffering cardiopulmonary diseases.¹ A variety of pollutants are known or suspected to have an effect over public health, of which, nitrogen dioxide (NO₂), sulfur dioxide (SO₂), respirable suspended particulates (PM), and ozone (O₃) are the main ones.² Most evidence point towards respirable particulates, PM₁₀ particles (the fraction of particulates in air of

¹ Xia, Y, Tong, H. Cumulative effects of air pollution on public health. *Wiley InterScience* 2006

² Xia, Y, Tong, H.

very small size, specifically less than $10 \mu\text{m}^3$), for having the largest effect on public health.⁴ These particles are small enough that they can penetrate deep into the lungs and from there, potentially lead to many significant health risks. However, gaseous pollutants, sulfur dioxide in particular, could also have a significant effect on public health and should not be neglected. SO_2 is poisonous gas by nature, and inhalation of the gas could result in the accumulation of tissue fluid and swelling, bronchial spasms, and shortness of breath.⁵

The potential health risks of air pollution are widely known. These risks include both short term effects and long term effects. Immediate health effects of air pollution include irritation to the eyes, nose, and throat, upper respiratory infections, headaches, nausea, and allergic reactions. These effects can aggravate medical conditions of asthma and emphysema sufferers. In the long run, air pollution can lead to lung cancer, heart diseases, chronic respiratory diseases, and damage to vital organs such as the brain, liver, and kidneys. The extent to which an individual is affected depends on the total exposure to pollutants, which is determined by the duration of the exposure and the concentration of the chemicals. Short term effects are more noticeable and can be estimated statistically. Long term effects, on the other hand, require longer periods of observation in order to isolate the cause the disease.

3. Indicators of the impact of roadside pollution on public health

Generally speaking, the cumulative effect of air pollution on public health is difficult to quantify and measure. Many existing statistical models do not shed light on this. Often, individuals with circulatory and respiratory diseases may experience respiratory

³ Xia, Y, Tong, H.

⁴ Hedley, Anthony Johnson, et al. "Cardiorespiratory and all-cause mortality after restrictions on sulphur content of fuel in Hong Kong: an intervention study." *Lancet* 360, no. 9346 (November 23, 2002): 1646.

⁵ Xia, Y, Tong, H.

stress when exposed to toxic pollutants, and may end up being admitted to a hospital.⁶ Therefore the statistical relation between emergency room admissions for cases of circulatory and respiratory diseases and level of pollutants is often considered as an indicator of the effects of air pollution. In other studies the association between weekly averages of air pollution and daily mortality has been used to demonstrate the effects of long term exposure to air pollution.⁷ It is also important to identify the source of the air pollution; in this review of the literature, focus is placed primarily on roadside pollution.

4. Trends demonstrating the association between roadside pollution and mortality

In July 1990 a restriction on sulfur content of fuel was introduced in Hong Kong. Power plants and road vehicles could not use fuel oil with a sulfur content that was greater than 0.5% by weight. The intervention led to an immediate fall in ambient sulfur dioxide (SO₂). The effect of this intervention on mortality was then assessed. Statistical models were created to show the changes in death trends each month between the years 1985 and 1995. The effects on seasonal deaths were also assessed and done so by measuring the increase in number of deaths from warm to cool season.⁸

Findings from the study indicate a significant reduction in seasonal deaths within the first 12 months upon the introduction of the restriction. However a peak in death rate followed in the cool season between 13 and 24 months. The study also indicates that the intervention had led to a substantial decline in the average annual trend in deaths from all causes (2.1%), respiratory diseases (3.9%), and cardiovascular diseases (2.0%). Exposure

⁶ Xia, Y, Tong, H.

⁷ Schwartz, J. Harvesting and Long Term Exposure Effects in the Relation between Air Pollution and Mortality harvesting. *Am. J. Epidemiol.* 2000 151: 440-448.

⁸ Schwartz, J.

to lower concentrations of the air pollutant had led to an increase in the average life expectancy per year: 20 days for females and 41 days for male.⁹

The outcomes of the intervention introduced in Hong Kong provide direct evidence on the effect of sulfur-rich fuels on the death rates, in particular, on respiratory and cardiovascular deaths. It also demonstrates the importance of control over pollution, which could lead to both immediate and long-term health benefits. Though the study may pertain to a specific air pollutant, it can be assumed that restriction in other pollutants may lead to similar results.

5. Vertical profiles of air pollution

Roadside pollution in compact environments could possibly lead to other implications such as the prevention of natural ventilation and the result of the street canyon effect. In a densely populated area like Hong Kong, roads sandwiched between the tall buildings on either side create a deep street canyon.¹⁰ The street canyon prevents the exchange of air, thus leading to the trapping and accumulation of pollutants induced mainly from vehicle emission.¹¹ These pollutants would then be carried indoors through the windows and doors of buildings located in the surroundings. In a recent study conducted by The Hong Kong University of Science and Technology, results show that buildings affected by street canyons receive higher levels of pollutant penetration (approximately 3% to 4% more) on its leeward side of than to its the windward side.¹² Pollutant concentration was also observed to decrease with the increment of height. Lower levels of buildings

⁹ Schwartz, J.

¹⁰ Karl A, Fung, J, Wong D. "Pollutant Penetration into Idealized Naturally Ventilated Residences by Wind Driven Flow using CFD Approach". 2012

¹¹ Karl A, Fung, J, Wong D.

¹² Karl A, Fung, J, Wong D.

suffered from higher concentrations of pollutants due to the accumulation of these toxic particles over time.

The uneven distribution of pollution concentration over the height of the building leads to a controversial topic of environmental justice. In the case of Hong Kong, typical examples of street canyons can be found in commercialized areas such as Mong Kok and Causeway Bay. Streets in these areas experience an immense flow of traffic daily. Many are surrounded by run-down buildings, which are usually inhabited by low-income families or the elderly. Fresh, clean air is a basic right that everyone should be able to enjoy. It should not be limited to the population that could afford housing in areas with low levels of pollution. Hence, the street canyons in Hong Kong raise an important issue over environmental justice as well as the distribution of land.

6. Further investigations

Vertical profiles of air pollution are an intriguing topic that encourages further investigation. Concentration levels of pollutants not only differ in between areas in Hong Kong, they also range from high to low levels of the building. Studies have suggested that higher levels suffer from a lower concentration of pollutants due to smaller amounts of accumulation and more ventilation. Experiments on this topic can be conducted by measuring the pollutant concentration at different levels of the same building. Measurement of pollutants in the bottom, middle, and top level of a building can be made and compared. Factors such as the number of people in the building, the length of the period of measurement, and other artificial forms of ventilation will all have to be controlled.