Impacts of air pollution on human health in Lahore city, Pakistan: a review

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Abstract:

An alarming global environmental disaster that harms public health is air pollution. Given that an adult breathes in between 10-15 m^3 of air each day on average, it is clear that inhalation is the primary way that humans are exposed to airborne pollutants. Lahore, Pakistan's second-largest city, is the most polluted metropolis in the country and is increasing at a pace of 4% yearly. Pakistan is thought to be the fastest urbanizing country in South Asia. Haze frequently affects urban areas in Asia, and Lahore is a rapidly growing metropolis. This review focused on examining and comparing Lahore's air quality index (AQI) values under various sites and conditions, such as smog, traffic, industrial estates and

brick kilns and their relationship to adverse effects on human health. The provincial capital of Punjab, Lahore, has been designated as the world's most polluted city when its AQI exceeded 400 in November, 2021. Lahore's air pollution is caused by a variety of factors, including industrial and automobile emissions, haze, smoke from brick kilns, burning of crop residue and other garbage, and dust from building sites. Carbon monoxide (CO), nitrogen dioxide (NO2), sulphur dioxide (SO2), aerosol optical depth (AOD), methane (CH4), and formaldehyde are the main primary and secondary air pollutants that contaminate the air (HCHO). The signs and symptoms of air pollution are moderate cough, persistent cough, dyspnea, eye problems, low-grade fever, pulmonary diseases, peribronchial shadows and lung fibrosis. Living in an environment with high amounts of pollution may make a person more vulnerable, making it more probable that infectious agents will cause long-lasting respiratory issues. The following suggestions should be implemented in order to improve the air quality in Lahore. The transition to electric vehicles for all public transportation must be gradual. All automobiles must be able to use catalytic converters, and affordable substitutes must be created. It is necessary to avoid these backups, which can be done by offering alternate pathways. Despite having the most LTVs (light transport vehicles), Ferozepur Road was the cleanest. Priority must be given to implementing a frequent and ongoing MOT check system for HTVs (heavy transport vehicles). It is necessary to implement restrictions on the import and use

of such fuel. Industrial estates must be relocated outside of the city since they cause a high concentration of pollutants, endangering human life. Local governments must urge businesses to employ the appropriate scrubbers or other smog-control tools.

Keywords: Air pollution, Pollutants, Industrial, Vehicle, Lahore

Introduction:

Our bodies require oxygen to survive, which is found in the air we breathe. Some of the compounds released into the atmosphere by human activity are harmful to humans, plants, and animals. In a rapidly growing era of urbanization and industrialization, each problem has a significant impact on human health, well-being, and the environment. An alarming global environmental issue that harms public health is air pollution. Given that an adult breathes in between 10-15 m^3 of air each day on average, it is clear that inhalation is the primary way that humans are exposed to airborne pollutants. The presence of pollutants produced by human activity in the atmosphere that endanger vegetation and animals or interfere with human health, safety, or comfort is referred to as air pollution. It can also be described as the occurrence of one or more pollutants in the atmosphere that is harmful or have the potential to be harmful to human health or welfare, animal or plant life. (1)

The Industrial Revolution in Europe during the 19th century launched the current era of air pollution, which was formerly a localized and minor issue due to Earth's

capacity to absorb and clean up small amounts of contaminants. In 1851-60, industrial pollution accounted for 30-40% of the association between mortality and population density, and it increased to 60% of the relationship in 1900. Issues with increasing air pollution, urbanization, the advent of motor cars, and population growth are the main contributors to mortality, decreases life expectance and substantial costs to health. (2,3)

Air Pollution in Lahore, Pakistan:

Pakistan is regarded as the country in South Asia that is urbanizing most quickly, and Lahore, the country's second-largest city, is among the most polluted due to its 4% annual increase. In Asia, pollution regularly affects urban communities, and Lahore is an example of it. (4,5)

A metric known as the Air Quality Index is used to assess air quality (AQI). The AQI functions similarly to a thermometer with a range of 0 to 500 degrees (Figure 1). The AQI is a technique of displaying variations in the quantity of pollution in the air, not temperature changes.

Air Quality Index Categeory	1-Hour average Conc. PM2.5 (µg/m3)	Air Quality Index (AQI) Value	Health Effect
Good	0.0 – 40.0	0.0 – 50	None
Moderate	40.1 – 80.0	51 – 100	Unusually sensitive people should consider reducing prolonged or heavy exertion.
Unhealthy for Sensitive Groups	80.1 – 175.0	101.1 – 150	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Unhealthy	175.1 – 300.0	151 – 200	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion; everyone else should reduce prolonged or heavy exertion.
Very Unhealthy	300.1 – 500.0	201 – 300	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.
Hazardous	500 +	301 – 500	Everyone should avoid all physical activity outdoors; people with heart or lung disease, older adults, and children should remain indoors and keep activity levels low.

Figure 1: Air quality index categories, values, and health effects (Source: Al-Harbi M and BuHamra S. The level of particulate matter $PM_{2.5}$ in several indoor public venues) (6)

Lahore, one of the most polluted cities Air Quality Index exceeded passed 400 in the month of November 2021. Metropolitan settlements frequently suffer from smog and vehicle & industrial emissions, and Lahore is an example of it. (5,7) The air quality meter is a measuring device for measuring temperature, levels of polluted gases (CO, CO_2, SO_2, NO_2, HCHO), relative humidity, and particulate matter ($PM_{2.5}$ & PM_{10}). (8)

Lahore is one of the world's 26 most inhabited cities, with a total population of 1.12 million. Since 1998, Lahore's population has nearly doubled. There is a hot,

rainy summer from May to September and a cold, dry winter from November to February. The mean annual temperature is 23.3 C, and the mean annual rainfall is 2398 mm. (5)

Smog is rapidly increasing and causing some health issues and raising concerns as to its long-term negative effects on the health of the community. Because the government lacks an aggressive response strategy and the failure of the relevant authorities to recognize the seriousness of the situation, it is anticipated that the current situation will get worse. (7) A study showed that smog has been reported at high levels in Lahore, particularly at three sites, Mall Road, Gulberg, and Township. The concentration of NO_x, which was about Seventeen times greater than the reference limit, was the highest pollutant tested during smog. The additional pollutants like SO_2 and O_3 were four times greater than the baseline range. CO, VOC, and $PM_{2.5}$ were twice as high, and PM_{10} was six times higher. (9)

Brick kilns, industries, and tailpipe emissions are among the main sources of air pollution in the city. The rapid increase in the number of vehicles in Pakistan, as well as the widespread use of low-quality fuel, are major sources of air pollution. Vehicle emissions (carbon and lead) contribute the most to air pollution in urbanized areas such as Islamabad, Lahore, Faisalabad, and Karachi. Globally, the situation remains unchanged, with a 29% increase in atmospheric CO_2 since the beginning of industrialization, while its production has accumulated to 6-8 billion

tonnes per year. A study selected 2 industrial estates, 4 heavily traffic roads, and 8 brick kilns as study sites. These sites cover almost the entire city of Lahore and are spread out across the city. Jail Road (within roads), Sherwani (within brick kilns), and Quaid-e-Azam Industrial Estate were the top CO contributors (within industrial estates). As a result, in the future, when mitigation is implemented or surveillance is required, CO filters will be required in these areas. In terms of NO_2 contribution, Ferozpur road was the cleanest, but all other sites had equally high contributions when compared to other activities. It had the highest SO2 contribution, but it did not contribute as much CO or NO2. Similarly, the CO contribution of brick kilns was relatively low on average, while in the Quaid-e-Azam Industrial Estate, it was high. Jia Bagga and Kot Abdul were the leading SO_2 contributors in brick kilns. Even though the many industries working there were ISO 14001 certified, Sundar Industrial Estate contributed the most to SO_2 emissions (Table 1). (5)

Table 1: Emission source and major air pollutants in Lahore (5)

Site and Location of Emission Source	**Major Air Pollutants**
1. Sundar Industrial Estate	SO_2 (93%), NO_2 (40%), HCHO (27%)
2. Quaid-e-Azam Industrial Estate	CO (100%), HCHO (73%), NO_2 (60%), SO_2 (7%)
3. Ferozpur Road	SO_2 (37%), CO (3%), HCHO (10%)

4. Multan Road	HCHO (33%), NO_2 (30%), SO_2 (27%), CO (13%)
5. Gulberg Road	CO (40%), HCHO (37%), NO_2 (33%), SO_2 (23%)
6. Jail Road	CO (44%), NO_2 (37%), HCHO (20%), SO_2 (13%)
7. Kot Abdul Malik Bk. Kilns	SO_2 (31%), HCHO (15%), CO (1_2%)
8. Jia Bagga Bk. Kilns	SO_2 (31%), HCHO (15%), CO (4%)
9. Sherwani Bk. Kilns	CO (76%), NO_2 (64%), HCHO (42%), SO_2 (8%)
10. HajiCoat Bk. Kilns	HCHO (8%), SO_2 (7%), CO (4%)
11. Sikanderabad Bk. Kilns	HCHO (11%), NO_2 (4%), CO (4%)

Air pollutants and Sources of Air Pollution:

The key primary and secondary air pollutants that contaminate air include carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), methane (CH_4), formaldehyde (HCHO), and aerosol optical depth (AOD). (5,10)

The natural sources of air pollution include smoke and carbon monoxide from wildfires. On warmer days, flora in some locations generates environmentally significant levels of volatile organic compounds (VOCs). The seasonal haze of secondary pollutants is generated when VOCs react with primary pollutants (NO_2, SO_2, and organic carbon molecules). Other natural sources

include volcanic activity producing sulfur, chlorine, and ash particulates, dust storms from large areas of land, methane produced by animal digestion, and radon gas produced by radioactive decay within the Earth's crust. (11)

Artificial sources include burning of different kinds of fuel, mobile sources like motor vehicles and aircraft, stationary sources like smokestacks of power plants, manufacturing facilities (industries) e.g, waste incinerators and furnaces, and domestic sources like combustion of coal, wood, or oil, tobacco smoke, waste deposition in landfills, fumes from paint and aerosols and military equipment such as nuclear weapons and toxic gases. (11)

Major air pollutants such as NOx, O_3, and SO_2 have also increased dramatically in Pakistan over the past two decades. The main factors responsible for causing pollution of air in Lahore included vehicle and industrial emissions, smog, the burning of waste and crop residue, smoke from brick kilns, and dust from construction sites. Five air pollutants were measured to be the biggest contributors at ten fixed air monitoring stations in Lahore, including carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), and particle matter ($PM_{2.5}$ and PM_{10}). During the year 2019, $PM_{2.5}$ concentrations in the city of Lahore exceeded the WHO and national air quality guidelines practically every day. (12–14)

Air pollution impact on human health:

Air pollution causes several harmful impacts on human health especially long-term respiratory and cardiovascular diseases. The signs and symptoms observed due to air pollution encompasses mild cough, persistent cough, breathlessness, wheezing, asthma, dry eyes, irritation, lid erosion, corneal diseases, uveitis, lacrimation, conjunctivitis, anosmia, low-grade fever, and pulmonary diseases. On chest findings, signs included lung damage, peri-bronchial shadows, and lung fibrosis. (9,15–17)

Living in an environment with high amounts of pollutants may make a person more vulnerable, rendering it more probable that infectious agents will cause long-lasting respiratory issues. (17)

Recommendations:

Several recommendations should be followed to make Lahore a better place in terms of air quality. The transition to electric vehicles for all public transportation must be made gradually. All automobiles must be able to use catalytic converters, and affordable substitutes must be created. In the areas of heavy road traffic, traffic jams can be avoided by offering alternate pathways. Priority must be given to implementing a recurrent MOT check (vehicle safety test) by the Ministry of Transportation for HTVs (heavy transport vehicles). Due to their use of poor-grade fuel, buses were the largest source of SO_2 emissions. There must be

limitations on the import and use of gasoline of low grade. As the presence of industrial estates makes a high centralization of contamination, they should be moved outside the city to stay away from harm to human existence. The adoption of appropriate scrubbers or other smog-control equipment by industries must be promoted by local authorities and the government. (5)

Another study suggested that to meet the per capita infrastructure needs of a rising megacity of more than ten million people, Lahore must address the issues of connectivity, traffic congestion, and public infrastructure. Lahore may learn from the layout of Rawalpindi, which is considered to be the second-best city in Punjab in terms of livability. Individual well-being, urban economy, and urban environment are the primary positive contributing aspects of Rawalpindi city. Additionally, the study offered significant policy repercussions for decision-makers to highlight the regions that require revision for improvement in terms of the chosen indicators and dimensions. (18)

Furthermore, according to another study, addressing urbanization can help reduce air pollution. For the creation of a healthy urban Environment and for balancing urban green spaces it is recommended to buck up green architects, Environmentalists, Climat Scientists and legislators to work and develop climate resilient structures, policies and decisions. (19)

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