New Techniques for the Prevention Control of Smog and Air Pollution in Pakistan

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New Techniques for the Prevention Control of Smog and Air Pollution in Pakistan

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***Abstract*—** *This research paper aims at exploiting efficient ways to control Smog and Air pollution in Pakistan. Smog in Pakistan is a challenge that can be overcome with the right solutions. This noxious mixture of smoke and mist is the result of air pollution from NO_x, SO_x, ground-level ozone, mist, and water vapors. We have thoroughly investigated the causes, effects, and new strategies available to control and eliminate pollutants. Our research has uncovered a highly effective solution in water showering, which has achieved a remarkable success rate of 70 to 80 percent in removing harmful contaminants from the air. Furthermore, we have identified several other innovative techniques, such as DME, gas to liquid, Liquid Air, Hydrogen additive, and others that can help prevent smog formation and reduce air pollution. The major contributors to air pollution and smog are a high number of buses, non-renewable energy sources, unburnt combustion engines, and factories that release pollutants into the environment, especially during temperature reversal seasons like winter. The damage caused by these issues includes human fatalities, damages, and other dangerous diseases. However, with the right approach, Pakistan can overcome the challenges of smog and improve the health and well-being of its citizens. We are confident that our research provides the framework for effective solutions to eliminate smog and combat air pollution in Pakistan.*

***keywords*—** *Smog, Environmental effects, Global warming, Health hazards, Technologies, Air Pollution, Flue gas*

1. Introduction

Smog is a mixture of smoke and fog, but it's not just a natural occurrence. It's mainly caused by human activities like burning coal, driving cars, and running industries. When these activities release pollutants into the air, they create a thick haze that hangs over cities. This haze is made up of gases, tiny particles, and water vapor.When sunlight hits this mix of pollutants, chemical reactions happen, forming even more harmful compounds.[1,2] This polluted air can be really noticeable, especially in cities like Lahore, Pakistan, where the pollution gets trapped close to the ground.There are two main types of smog: reducing smog and oxidizing smog. Reducing smog happens when pollutants mix with fog, and it's often seen throughout the year. It's mainly made of substances like sulfur dioxide, which can easily react with other chemicals. This type of smog can have a big impact on air quality.Oxidizing smog, which was first noticed in California in the 20th century, is even more harmful. It's aggressive, irritating, and toxic, and it can seriously affect people's health.[1,3] So, smog is a serious problem in many cities around the world, including those in Pakistan. It's not just about dirty air - it can also have harmful effects on our health and the environment.

1.1. How smog is formed:

Smog forms when certain pollutants and gases, like those from burning coal or fuel in vehicles and factories, mix with the air. When sunlight hits these pollutants and fine particles in the air, chemical reactions occur[1,4]. This leads to the release of harmful substances like ground-level ozone and tiny particles.These pollutants mainly come from activities like driving cars, running factories, and using heating systems. Things like high temperatures, heavy traffic, and low wind speeds during winter can make smog worse. When there's little wind to disperse the pollution, it stays close to the ground, creating a thick haze that can be harmful to breathe and makes it difficult to see clearly outside.So, smog isn't just about dirty air; it's a complex mix of pollutants[1,4,5] that can cause health issues and reduce visibility, especially when certain weather conditions trap it near the ground. Reactions of smog formation:

$$\mathrm{NO} + \text{UV radiation} \rightarrow \mathrm{NO} + (\mathrm{O})$$
$$\mathrm{O} + \mathrm{O_2} \rightleftharpoons \mathrm{O_3}$$
$$\text{Ozone so formed oxides NO to } \mathrm{NO_2} + \mathrm{O_2}$$
$$\mathrm{NO} + \mathrm{O_3} \rightleftharpoons \mathrm{NO_2} + \mathrm{O_2}$$
$$\mathrm{O} + \text{Hydrocarbons} \rightarrow \mathrm{RCO} + \mathrm{O_2} \rightarrow \mathrm{RCO_3}$$
$$\mathrm{RCO} + \text{Hydrocarbons} \rightarrow \mathrm{CH} = \mathrm{O} + \text{Ketones}$$
$$\mathrm{RCO_3} + \mathrm{O_2} \rightarrow \mathrm{RCO_2} + \mathrm{O_3}$$
$$\mathrm{RCO_3} + \mathrm{NO} \rightarrow \mathrm{RCO_2} + \mathrm{NO_2}$$
$$\mathrm{RCO_3} + \mathrm{NO_2} \rightarrow \mathrm{RCO_3NO_2}\ (\mathrm{PAN})$$

1.2. EFFECTS:

Smog has a wide range of harmful effects on both human health and the environment.

Health Impact: Smog contains various pollutants and toxic chemicals that can seriously affect human health. Breathing in smoggy air can lead to respiratory problems such as irritation in the throat and lungs, coughing, wheezing, and shortness of breath. Long-term exposure to smog increases the risk of developing chronic respiratory conditions like asthma, bronchitis, and even lung cancer[4]. It can also exacerbate existing health conditions, particularly in vulnerable populations such as children, the elderly, and those with pre-existing heart or lung diseases[1,6].

Reduced Sunlight: Thick smog can block sunlight, reducing the amount of UV radiation that reaches the Earth's surface. This can lead to a deficiency in vitamin D production in humans, which is essential for bone health. In severe cases, reduced sunlight exposure due to smog can contribute to conditions like rickets, especially in children.

Environmental Impact: Smog can have detrimental effects on plants and wildlife. Exposure to pollutants in smog can damage plant leaves, inhibit photosynthesis, and reduce crop yields. It can also harm sensitive ecosystems and wildlife habitats. Additionally, certain pollutants in smog contribute to acid rain, which further damages vegetation, soil, and aquatic ecosystems[6].

Traffic Accidents: Reduced visibility caused by dense smog can significantly increase the risk of traffic accidents. Poor visibility makes it difficult for drivers to see other vehicles, pedestrians, and road signs, leading to an increased likelihood of collisions and fatalities on the roads.

Economic Impact: The health impacts and disruptions caused by smog-related illnesses can have significant eco-

nomic consequences. Healthcare costs rise due to increased hospital admissions and medical treatments for respiratory ailments. Moreover, smog-related disruptions to transportation and outdoor activities can impact productivity and economic output[7].

Overall, the effects of smog are multifaceted and can have far-reaching consequences for human health, ecosystems, and economies. Efforts to reduce smog pollution are crucial for protecting public health and the environment.

Table 1. *Health and Environmental Factors[21]*

Health & Environmental Factors	Number of Deaths
High blood pressure	1M
High fasting plasma glucose	3M
High total cholesterol	4M
Ambient particulate matter	5M
High sodium	6M
High body mass index	7M
Low whole grains	8M
Low fruit	9M
Household air pollution	10M
Low glomerular filtration rate	11M
Alcohol use	12M
Low nuts and seeds	13M
Low vegetables	14M
Low physical activity	15M

1.3. Reasons of increasing the air pollution in Pakistan:

There many different factors behind the increasing of air pollution in Pakistan some of them are given below:

1. Increasing the pollution day by day
2. Globalization
3. Urbanization
4. Usage of heavy transport
5. High temperature or sunny climate
6. Bricks making fireplace
7. Lack of gardening

Table 2. *Air Pollution Levels and Health Implications in Cities[22]*

City	Air Pollution Level	Health Implications
Karachi	134	Good (Little or no risk)
Lahore	186	Unhealthy for sensitive groups
Rawalpindi	170	Unhealthy for sensitive groups
Peshawar	142	Moderate
Quetta	153	Moderate
Islamabad	89	Good (Little or no risk)

1.4. Sources of Air Pollution:

Air pollution happens when harmful substances are released into the air. This can occur when we burn things like coal, wood, gasoline, or diesel. Here are some common sources of air pollution:

Vehicles: Cars, trucks, trains, and other vehicles that run on gasoline or diesel release pollutants.

Industries and Factories: Places where things are made or produced can also release pollutants into the air.

Power Plants: These facilities generate electricity, but they also emit pollutants.

Fireplaces: Burning wood or other fuels in fireplaces can release pollutants.

Engines with Incomplete Combustion: When engines don't burn fuel completely, they release pollutants.

Additionally, pollutants can get into the air through evaporation. For example:

Paint and Solvents: When paints and solvents are used, they can release pollutants into the air.

Fuel Stations and Refineries: Places where fuel is stored or refined can also release pollutants.

Transportation of Petroleum: Tanker trucks carrying petroleum can release pollutants.

During hot and sunny days, air pollution can worsen, contributing to climate change. Pollution from vehicles, factories, and other sources can react with each other to form ozone, which is a major component of smog. In the winter, temperature inversions can trap pollutants close to the ground, where people live, leading to poor air quality.

2. Methods

2.1. Methods to clean the flue gases and control of air pollution

In response to increasingly stringent air pollution regulations, various methods and technologies have emerged to clean flue gases and control air pollution. These approaches can be categorized into three main strategies: additional controls, reformulation, or process change. Additional control devices such as furnaces, condensers, carbon absorbers, scrubbers, and fabric filters are commonly used to capture pollutants from industrial processes. While effective, these devices can be costly to purchase, operate, and maintain, and may sometimes trade one pollution issue for another.[10,11]

For specific pollutants like volatile organic compounds (VOCs) and acidic/basic fogs/particulates in metal-finishing processes, tailored control technologies are available. VOCs can be managed through oxidation, condensation, or absorption using carbon absorbers, while acidic/basic fogs are typically removed using wet collectors or scrubbers. The choice of scrubber type depends on factors such as gas-liquid interaction and pollutant solubility.

However, the most environmentally sustainable and cost-effective approach to pollution control often involves process modification. This strategy entails altering production processes to reduce or eliminate pollutant emissions. For example, industries may use less polluting materials or replace harmful processes with cleaner alternatives. Despite its benefits, process modification can be challenging due to the multitude of options available and the lack of regulatory guidance.

When selecting pollution control methods, factors such as initial cost, physical and chemical properties of pollutants, maintenance, service, and operating costs must be considered. Process modification, although requiring considerable effort and innovation, is often the most environmentally friendly and financially viable option. By continually evaluating and

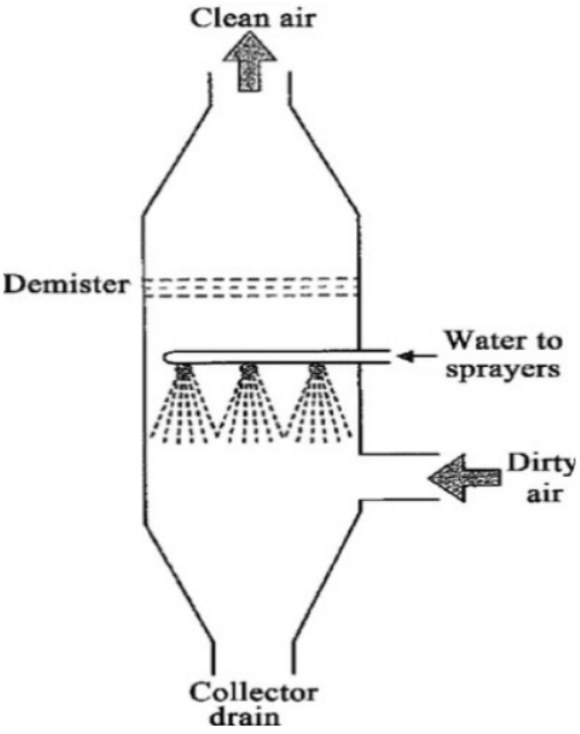

Figure 1. *Astrolex Spray Tower Scrubber* [19]

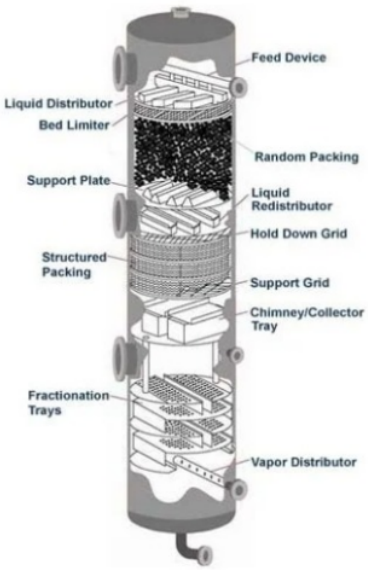

Figure 2. *Packed Bed Scrubber[20]*

implementing these methods and technologies, industries can mitigate their environmental impact and comply with increasingly stringent air quality regulations.[9,12]

2.2. Technologies for the control of air pollution

The methods described offer comprehensive strategies for combating air pollution caused by gases and vapors, addressing various pollutants and employing different mechanisms to mitigate environmental impact.

Wet scrubbers are versatile air pollution control devices, capable of removing pollutants through adsorption, absorption, and chemical oxidation processes. Adsorption involves pollutants adhering to a solid material, while absorption entails dissolution into a liquid absorbent. Chemical oxidation within wet scrubbers utilizes chemical reactions to convert pollutants into less harmful compounds.

Bio filtration introduces microorganisms like bacteria or fungi to degrade pollutants biologically. These microorganisms metabolize pollutants, converting them into harmless byproducts. Scrubbing physically removes pollutants by passing polluted gas through a scrubbing solution, where pollutants are absorbed or chemically reacted with the solution.

Chemical reactions of ozone by ultraviolet light offer an effective method for pollutant removal. Ozone, generated by exposing oxygen molecules to UV light, acts as a powerful oxidizing agent. It reacts with pollutants in gas streams, breaking them down into less harmful substances. UV light initiates ozone generation by breaking oxygen bonds, allowing ozone molecules to form. These methods demonstrate a comprehensive approach to air pollution control, offering diverse techniques to address pollutants and mitigate their adverse environmental effects.[16,17]

2.3. New Methods and Technologies for Flue Gas Cleaning and Air Pollution Control

Six new technologies which can be improved the air quality [18]

1. Gas-to-Liquids Technology
2. Dimethyl Ether (DME) as a Diesel Replacement
3. Hydrogen Fuel Additives
4. Autonomous Vehicles for Improved Fuel Efficiency
5. Liquid Air Technology for Zero-Emission Transportation
6. Photo-catalytic Materials and Air Purification Technologies

Gas-to-Liquids Technology: In the realm of air quality improvement, Pakistan faces significant challenges, necessitating innovative solutions to combat air pollution. One promising avenue is the adoption of gas-to-liquids technology, offering a cleaner alternative to traditional fossil fuels. This process involves converting natural gas into high-quality liquid fuels, which can significantly reduce emissions of pollutants such as NO_x and particulate matter.

Dimethyl Ether (DME) as a Diesel Replacement: The emergence of dimethyl ether (DME) as a diesel replacement showcases potential benefits for Pakistan's air quality. DME offers reduced emissions and improved air quality compared to conventional diesel fuels. By exploring DME as an alternative fuel source, Pakistan can mitigate the adverse effects of diesel combustion on air pollution [18].

Hydrogen Fuel Additives: Hydrogen fuel additives present another avenue for emission reduction in Pakistan. These

additives enhance combustion efficiency in existing vehicles, leading to reduced release of pollutants such as NOx and carbon dioxide. By incorporating hydrogen fuel additives, Pakistan can improve air quality while optimizing the performance of combustion engines.

Autonomous Vehicles for Improved Fuel Efficiency: The integration of autonomous vehicles represents a transformative technology for Pakistan's air quality improvement efforts. These vehicles promise improved fuel efficiency and reduced local pollutant emissions through optimized driving patterns. By embracing autonomous vehicle technology, Pakistan can mitigate transportation-related air pollution while enhancing mobility efficiency.

Liquid Air Technology for Zero-Emission Transportation: The development of liquid air technology offers an innovative solution for emissions reduction in Pakistan's urban environments. By transitioning towards liquid air as a transportation fuel, zero-emission solutions can be realized, particularly targeting sources such as air conditioners and refrigerated vehicles. This transition holds promise for significantly reducing urban air pollution in densely populated areas.

Photo-catalytic Materials and Air Purification Technologies: Photo-catalytic materials and air purification technologies further contribute to Pakistan's air quality improvement efforts. These solutions harness sunlight to remove pollutants from surfaces and actively purify the air, offering cost-effective means of reducing particulate matter and NO_x pollution. Technologies like smog-free towers demonstrate tangible solutions for urban environments, actively removing pollutants from the atmosphere to deliver cleaner air to surrounding communities.

3. Conclusion and results:

The paper explores smog and air pollution in Pakistan, defining smog as a mix of smoke and mist from burning coal and vehicle emissions. It discusses how pollutants interact with sunlight to form ground-level ozone and fine particles, impacting human health and visibility. Urbanization, industrialization, and heavy transport are cited as major contributors. Various sources such as vehicles and industries are identified, along with control methods like scrubbers and condensers. Numerous methods exist to mitigate air pollution. Scrubbers and condensers remove pollutants from industrial emissions. Gas-to-liquid conversion turns harmful gases into liquid fuels. Hydrogen fuel additives decrease emissions from combustion. Emerging technologies like autonomous electric vehicles and liquid air systems reduce transportation pollution. Portable air purifiers enhance indoor air quality. These strategies offer hope for improving air quality, protecting public health, and preserving the environment for future generations.Key issues such as setting emission limits, identifying sources, modifying processes, defining problems, and selecting appropriate control systems are crucial steps in combating air pollution. Innovative technologies like gas-to-liquid conversion, hydrogen fuel additives, autonomous vehicles, liquid air technology, photo-catalytic materials, and air purifiers offer promising solutions. Implementing these techniques could significantly improve air quality and mitigate the adverse effects of pollution on public health and the environment. Collaboration between experts, policymakers, and industries is essential to effectively implement these measures and safeguard the well-being of communities across Pakistan.

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