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Smog: Anthropogenic pollution

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ABSTRACT

*The Industrial revolution has been the central cause for the increase in pollutants in the atmosphere over the last three centuries. Among those pollutants major problem, by which the planet is suffering from, is SMOG. The word "***Smog***" was coined in the early 20th century as a portmanteau of the words smoke and fog to refer to smoky fog. Modern smog is a type of air pollution derived from vehicular emission from internal combustion engines and industrial fumes that react in the atmosphere with sunlight to form secondary pollutants. These secondary pollutants has historically been described as two types named after the places where they were first observed, industrial smog (or London smog) and photochemical smog (or Los Angeles smog). In high concentrations, smog can be extremely toxic to humans and other living organisms. In this paper our objective is to highlight the reasons, effects and mitigation measures of Smog.*

Keywords: *anthropogenic pollution, , classical smog, cloud seeding, mitigation, photochemical smog*

I. INTRODUCTION

Air Pollution may be defined as "the excessive concentration of foreign matter in the air, which adversely affects the well being of an individual or causes damage to property". There are two categories of air pollutant (1) Primary Air Pollutant: that harmful substance that is emitted directly into the atmosphere like carbon monoxide and carbonaceous soot, nitrogen oxides, sulphur dioxide, and volatile hydrocarbons (VOCs) combine to change in sunlight in a series of chemical reactions to create secondary pollutants. (2) Secondary Air Pollutant: that harmful substance formed in the atmosphere when a primary air pollutant reacts with substances normally found in the atmosphere or with other air pollutants [1] example: ozone, PANs, sulfate aerosols, nitrate aerosols, organic aerosols, etc. Ozone is produced naturally in the upper atmosphere, it is a dangerous substance when found at ground level.

The 20th century has been characterised by a transition from urban air dominated primary pollutants to one where secondary pollutants are very important. Three major outdoor air pollution problems are industrial smog from burning coal, photochemical smog from motor vehicle and industrial emissions, and acid deposition from coal burning and motor vehicle exhaust [7]

II. LITERATURE REVIEW

The Industrial Revolution has been the main reason for the increase in atmospheric pollutants over the last three centuries. Since the late 1700s, London, the place of origin of the Industrial Revolution, experienced occurrences of smog. The incidents of smog increased in frequency throughout the nineteenth century and the first half of the twentieth century. In the worst reported smog incident – December, 1952 when five days of calm foggy weather created a toxic atmosphere that claimed about 4000 human lives in London due to pulmonary and cardiovascular stress [10]. Smog formed by smoke from coal fires contains a high percentage of particulates. These particles bind with the fine water droplets in fog to create a dirty mist. Its main toxic chemical constituent is sulphur dioxide.

Not only Europe has faced this type of killer smog event. In Donora, Pennsylvania (United States) on 26th October 1948 a smog cloud was formed, that consists of a poisonous mix of sulfur dioxide, carbon monoxide, and metal dust from the smokestacks of the local zinc smelter where most of the town worked. After being exposed to the cloud over the next five days, it killed 20 people and sickened half the town's population about 7000 people due to difficulty in breathing. This type of smog is still quite common in many urban centres of the world, particularly in China, India, the Middle East, and Eastern Europe [5].

The first major photochemical smog event was observed in June, 1943, In the middle of World War II, Los Angeles residents believe the Japanese are attacking them with chemical warfare [7]. A thick fog that makes people's eyes sting and their noses run has taken hold of the city. Visibility is cut down to three city blocks. Later, the event was recognized to be a cloud produced by the photochemical reaction of emissions from automobiles and industrial plants in the Los Angeles air basin. Cities like Los Angeles, New York, Sydney, and Vancouver frequently suffer episodes of photochemical smog [11].

III. CATEGORIES & CAUSES OF SMOG

3.1 Classical ('London-type') Smog

Sulfurous smog results from a high concentration of sulfur oxides in the air and is caused by the use of sulfur-bearing fossil fuels, particularly coal (Coal was the mains source of power in London during nineteenth century. The effects of coal burning were observed in early twentieth century). The typical London smog results from the accumulation of smoke from coal burning, which has high sulfur content. It leads to the production of high concentrations of sulfuric acid in fog droplets. These acidic particles, along with high densities of smoke, inhibit the normal functioning of the lungs and can cause death. This type of smog is aggravated by dampness and a high concentration of suspended particulate matter in the air.

3.2 Photochemical ('Los Angeles-type') smog

Photochemical smog is a widespread phenomenon in many population centers of the World. The components of photochemical smog that are the most damaging to plants and detrimental to human health are the photochemical oxidants. These oxidants include ozone (O3), peroxyacetyl nitrate (PAN), peroxybenzoyl nitrate

(PBN), hydrogen peroxide (H2O2), formic acid (HCOOH), and other trace substances. They are collectively termed photochemical oxidants with ozone and PAN, and are present in the highest concentrations.

Photochemical smog is produced at higher concentrations during the summer time because of the higher solar radiation. Atmospheric ozone levels typically reach their highest in the early afternoon due to the sunlight driven chemistry of this type of smog formation. Although photochemical smog is often invisible, it can be extremely harmful, leading to irritations of the respiratory tract and eyes [3].

IV. EFFECTS OF SMOG

Smog is harmful and it is evident from the components that form it and effects that can happen from it to humans, animals, plants and the nature as a whole. Ozone is powerful oxidising gas readily attacks living tissue. In humans it can cause sore throats. Inflammation and discharges in the nasal passages, and congestion at levels as low as 10 parts per hundred milllion (p.p.h.m.) [2]. Many people deaths were recorded, notably those relating to bronchial diseases. Minor exposure to smog can lead to greater threats of asthma attacks.

Individuals' health and age also influence their sensitivity to smog. Senior citizens, people already suffering from lung problems such as asthma, and children, who spend more time outdoors and have faster heartbeats than adults, are particularly vulnerable to pollutants.

Vegetation is easily harmed main agents of damage are ozone and PAN. Sensitive crops, trees and other vegetation are harmed at lower ozone concentrations than is human health. Ground-level ozone can damage leaves, and reduce growth, productivity and reproduction. It can cause vulnerability to insects and disease, and even plant death. When ozone levels are fairly high over a long period, agricultural crops can suffer significant harm. Smog can also accelerate the deterioration of rubber, plastics, paints and dyes [6].

The pollutants emitted into atmosphere are implicated in numerous environmental problems. Ozone, for example, is not only a major component of smog; it also contributes to the enhanced greenhouse effect, which is predicted to lead to global climate change. Similarly, NOx - one of the building blocks of ground-level ozone - plays a major role in formation of acid rains.

V. MITIGATION MEASURES FOR SMOG

Mitigation of smog with the aid of weather modification can yet be regarded as an effective attempt. Presently, there are three main ways of modifying the weather to mitigate smog, namely artificial precipitation, artificial fog dispersal and physical or chemical methods to eliminate dry haze [4].

5.1 Artificial rain or Cloud seeding or weather modification is an artificial way to induce moisture in the clouds so as to cause a rainfall. In this process, either silver iodide or dry ice is dumped onto the clouds by using an aircraft or an artillery gun which leads to a rain shower. According to experts, artificial precipitation operation heavily depends on the geographical background and natural conditions. Dry weather is not suitable for cloud-seeding. First, some clouds are needed to carry out the seeding process. Secondly, some moisture in the atmosphere is needed to cause precipitation [12].

This measure was recently given the go-ahead by the China Meteorological Administration. The move is part of a $277 billion anti-pollution investment plan that will go live in 2015. While its effectiveness is still not clear, the hope is that cloud seeding will clear the accumulated smog currently plaguing cities across China.

5.2 Nucleation collision or Super-cooled fog dissipation technology is relatively mature; here dry ice grains (solid carbon dioxide, temperature of -78.5 °C, size between 50 µm and 2 mm) are blasted with high-pressurized air at almost sonic speed into the fog. The dry ice grains collide with the fog droplets, collecting them and thereby growing in size. Cooling down the fog leads to condensation growth and thermodynamic instability of the fog. By blasting 1 kg of dry ice up to 50 m into the fog, it is dissipated within 3 minutes, clearing a circle of 200 m in diameter. Using mobile systems, a corridor 200 m wide and 15 up to 25 km long can be dissipated within an hour [13].

5.3 Reduction of nitrogen oxide: Smog formation could be reduced if the amounts of oxides of nitrogen and hydrocarbons released in the atmosphere decrease. This is done by installing efficient catalytic converters in automobiles [14].

5.4 Two-way catalytic converter: consisting of a mixture of platinum and palladium supported on a ceramic or metal honeycomb bed, removes hydrocarbons and carbon monoxide from the exhaust. It is an oxidation catalyst which converts CO to CO2 and hydrocarbons to CO2 and water when the exhaust gases are forced through it.

5.5 Three way catalytic converter: This converter contains an oxidation-reduction catalyst mixture. Hydrocarbons and carbon monoxide are oxidised while nitrogen oxides are reduced. In the exhaust system the nitric oxide reacts with carbon monoxide to give nitrogen and carbon dioxide [3].

5.6 Reduction of VOCs: There are various ways to reduce VOC emissions from motor vehicles. These include the use of liquefied petroleum gas (LPG) or compressed natural gas (CNG) rather than petrol, decreasing distances vehicles travel by using other modes of transport, such as buses and bikes, and implementing various engine and emission controls now being developed by manufacturers. Recently, Bio fuels have been the focus of attention as a possible means of reducing greenhouse gas emissions and noxious urban emissions from transport [15].

VI. CONCLUSION

Classic smog results from large amounts of coal burning in an area and is caused by a mixture of smoke and sulfur dioxide. A new type of smog, known as Photochemical Smog, was first described in 1950s. Ground-level ozone, sulfur dioxide, nitrogen dioxide carbon monoxide are especially harmful for senior citizens, children, and people with heart and lung conditions such as emphysema, bronchitis, and asthma. Hospital admissions and respiratory deaths often increase during periods when ozone levels are high. It is especially prevalent in geologic basins encircled by hills or mountains. It often stays for an extended period of time over densely populated cities or urban areas and can build up to dangerous levels.

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