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Pathological Disorders Caused by Atmospheric Nanoparticles: Review

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Abstract
Nanoparticles (NPs) arouse the interest of researchers around the world because of their ability to induce toxicity in vital organs of the body. These particles are considered one of the most important air pollutants because they remain suspended in the atmosphere for a long time and thus can travel over wide distances due to their extremely small size. NPs are able to effectively reach the bloodstream, cell membrane barriers, settle in organs and tissues, and even penetrate the blood-brain barrier and reach the brain. These particles can cause pathological disorders in the respiratory, cardiovascular, and nervous systems. Due to the lack of relatively adequate archived data related to human exposure to nanoparticles in the atmosphere and their negative effects on health, there is an urgent need to clarify this to contribute to controlling human exposure to nanoparticles in toxic doses. Therefore, this scientific paper reviews the potential pathological effects of inhaled atmospheric nanoparticles on the body.
Keywords: Nanoparticles, pathological disorders, atmosphere, toxic doses.

Introduction

The atmosphere is a vast reservoir whose composition is constantly changing through human activities, and these changes can have significant health and environmental consequences [1]. Air pollution is one of the most important environmental problems that poses a constant threat to the health and quality of life of residents [2,3]. The most important primary air pollutants are nanoparticles [4], which are important precursors for the formation of larger particles and are known to strongly influence global climate, atmospheric chemistry, and the global transport of biological pollutants [5-8]. Besides, these particles in the atmosphere may harm human health due to their association with air pollution [9]. Particles smaller than 300 nm are recognized as atmospheric nanoparticles, and even smaller particle sizes (<100 nm) are represented as atmospheric nanoparticles [10]. Nanoparticles (NPs) are engineering materials ranging in size from 1-100 nm[11,12] and are unique in their larger surface area to volume ratio[13,14], in addition to their unique physicochemical properties[15], which facilitate their employment in various consumer industries and technological and medical applications[16-19].

An increased risk of these particles leaking into the environment, particularly the atmosphere, which poses a threat to human health, has accompanied the rapid development of nanotechnology and the growth of its various applications [20,21]. Therefore, its potential toxicity to environmental health has received more attention [22,23]. It is worth noting that NPs are more toxic to the living body

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compared to larger molecules of the same chemical [24,25]. Inhalation is one of the most important ways for these particles to penetrate the body and then accumulate in the body's vital organs due to their ability to easily cross cell membranes and incite cytotoxicity [26-28]. They pose a particularly high health risk because they are likely to be more reactive and toxic than larger molecules [29-31]. The goal of this article is to review the potential disadvantageous effects of atmospheric nanoparticles on body health.

Sources of atmospheric Nanoparticles

The main sources of atmospheric nanoparticles are summarized in Figure (1) and are either natural or anthropogenic [32]. Nanoparticles are abundant in nature and are mainly released from biogenic emissions, sea spray, forest fires, volcanic eruptions, landslides, and dust storms [33]. Nanoparticles are formed in environments as a result of natural processes and are always present at some concentration levels, even in the atmosphere of environments free from the direct influence of human activities. Meteorological parameters such as wind speed, precipitation, relative humidity, and temperature also affect particle concentrations [34]. Both natural and anthropogenic sources make the ambient air rich in volatile organic compounds, nitrogen oxides, and primary organic aerosols, which eventually react to form secondary organic aerosols. Vehicle exhaust emissions represent the main source of nanoparticle pollution in urban environments. Vehicle emissions depend on many factors, such as the type of engine or fuel [35]. As for the particles resulting from vehicle exhausts, they are either emitted primarily directly from engines or they are formed secondarily in the atmosphere when hot exhaust gases are expelled from the car's exhaust pipe, forming particles of hydrocarbons and aqueous sulfuric acid. Ash emitted during volcanic eruptions plays a crucial role in the global transport of toxic chemical species released from NPs [36].

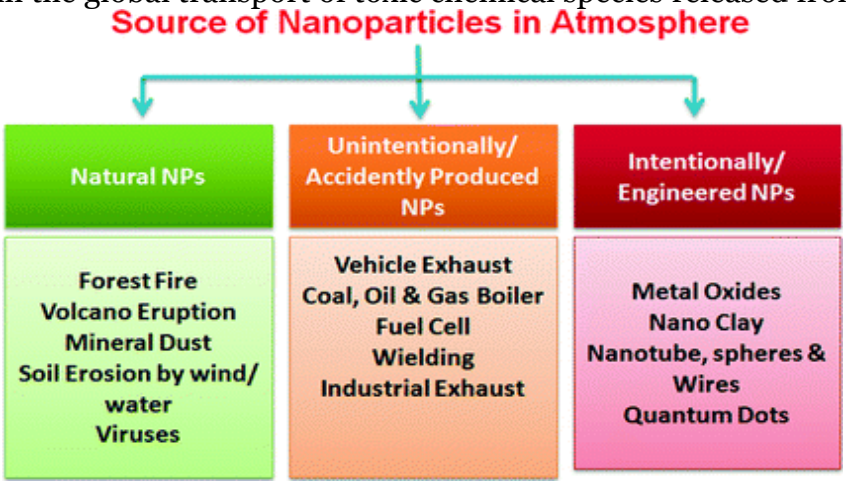

Figure 1: Sources of atmospheric nanoparticles [37].

Adverse effects of NPs on body organs

Nanoparticles can easily enter the body in several ways, including inhalation, orally, or through the skin. By diffusion, these particles deposit in all parts of the respiratory system if inhaled, and smaller particles, more effectively they deposit [38,39]. A tiny portion of the nanoparticles will be eliminated after they are deposited in the alveolar region, but the majority will travel to the lymphatic and circulatory systems [40]. Due to their small size and high specific surface area, nanoparticles are

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extremely reactive; the toxicity of these particles is dependent on their chemical makeup and surface area [41,42]. As a result, they pose a risk of health problems including respiratory, cardiovascular, and neurological disorders [43]. Inhalation of particles can have varying degrees of harmful effects on human health, depending on variables including particle type, dose, concentration, and exposure time [44]. Numerous investigations have verified that the majority of toxic diseases created in the body's organs are caused by particles smaller than 100 nanometers because of their great capacity to infiltrate live cells, move throughout the body, and interfere with the operation of essential organs [45-48], as shown in Figure (2). As air pollution levels rise, it is well established that hospital admissions for a variety of respiratory illnesses rise and may result in more serious problems, such as a marked decline in lung function [49]. Particulate pollution can lead to atherosclerosis, arrhythmia, heart failure, excessive blood pressure, and ischemic heart disease. Living next to major roadways is strongly associated with an elevated risk of cardiopulmonary death, and there is a well-established link between living with air particle exposure and heart disease [50]. Exposure to air pollutants, particularly traffic air pollutants (mostly from diesel exhaust particles), is particularly dangerous for the central nervous system. Impurities in the air might disrupt the central nervous system [51]. The correlation between ambient air pollution and cerebrovascular illnesses has been demonstrated, since exposure to particulate matter and other air pollutants is linked to both elevated epidemiological risk and cerebrovascular occurrences [52]. Air pollution exposure also generates clinical indications of neurological illnesses and damages the brain parenchyma. Chronic activation, oxidative stress, and inflammation are the ways that cerebral capillaries, astrocytes, and particularly microglia react to the constituents of air pollution [53]. Dementia and autism spectrum disorders are two neurodegenerative diseases connected to high concentrations of air pollution, even brief exposure to these pollutants can result in biochemical alterations linked to these diseases [54].

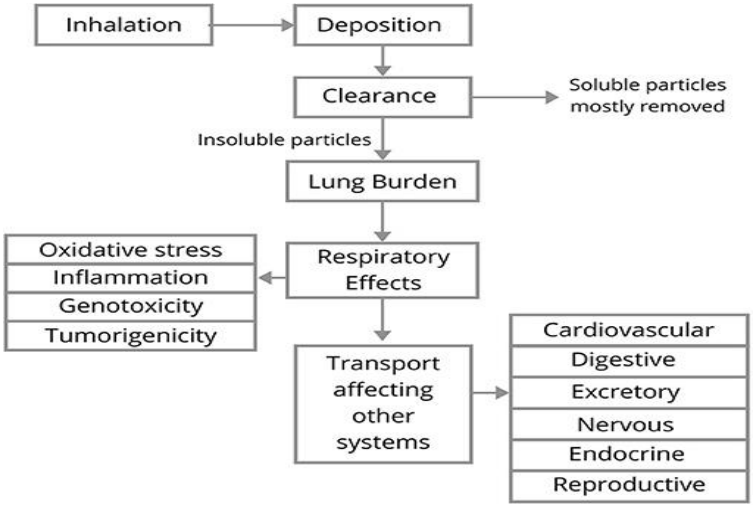

Figure 2: Pathway of inhaled nanoparticles from respiratory system to vital organs[55].

Indoor nanoparticles pollution

Indoor air pollution levels are ten times higher than outdoor air pollution levels, according to the EPA. Since most people spend their time inside, indoor pollution poses a direct threat to human

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health due to the entry of nanoparticles into buildings through ventilation systems [56]. A variety of everyday indoor activities can contribute to the formation of nanoparticles, including smoking, cleaning, cooking, and burning (candles and fireplaces). Other typical sources of nanoparticles include textile fibers, bacteria, and dust mite droppings [57]. In low-income regions of the world, people often die from smoke inhalation from stoves that don't have enough air circulation and burn solid fuels like wood, crop leftovers, manure, and charcoal [58].

Cigarette smoking

Nanoparticles in the smoke from burned tobacco can be anywhere from 10 nm to 700 nm in size, with a maximum of 150 nm. There are more than 100,000 different chemical compounds and components in environmental tobacco smoke [59]. A typical way to NPs expose is through smoking cigarettes, which release about (8.8×109 NPs) every cigarette [55]. Nevertheless, there has been a dearth of research into the specific particle kinds identified in cigarette smoke. Numerous studies have shown that passive smokers are more likely to get cancer, have a higher body mass index, and have worse lung function when compared to non-smokers. Chronic respiratory disorders, genetic abnormalities, and malignancies of the nose, pancreas, and lungs are all linked to cigarette smoking [60]. Exposure to secondhand smoke from cigarettes increases levels of human carcinogens such as benzene, 1,3-butadiene, and 2,5-dimethylfuran (DMF) in non-smokers[61]. Note that cigarette smoke increases the chance of SIDS, middle ear illnesses, and lower respiratory tract problems in children [62].

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