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Effects of inorganic powders on occupational health and safety

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Abstract

Occupational diseases, particularly those affecting the respiratory system, represent a significant and persistent challenge in working life globally. Among the primary risk factors, exposure to airborne dust in occupational settings is a leading cause of morbidity and mortality, yet its severe health impacts are often underestimated due to the long latency period of associated illnesses and an insufficient safety culture. This review study was conducted to evaluate the effects of inorganic dusts on the respiratory system and to synthesize current occupational health and safety (OHS) approaches. Through a comprehensive review of existing literature and relevant legislation, this paper classifies various dusts based on their chemical origin and biological effects, detailing fibrogenic, toxic, carcinogenic, and allergic categories. It specifically examines the mechanisms and incurable outcomes of prevalent inorganic dust-related diseases, such as silicosis and asbestosis. The findings underscore that since most occupational respiratory illnesses have no effective cure, prevention through proactive dust control is paramount. This study concludes that enhancing OHS measures, establishing a robust safety culture, and implementing comprehensive, industry-specific employee training are essential strategies to mitigate exposure, prevent incurable diseases, and ensure a safer working environment.

Keywords: Occupational health and safety; Inorganic dust; Occupational lung diseases; Dust control; Pneumoconiosis; Silicosis

1. Introduction

In our country and around the world, one of the most significant problems in working life is occupational accidents and diseases (Erol, 2020). Occupational diseases are defined as "all diseases resulting from exposure to risk factors arising from work activities" (ILO, 2013) under the International Labour Organization (ILO) Occupational Health and Safety Convention No. 155 of 1981 and the 2002 ILO protocol. Occupational diseases are among the risk factors that can sometimes have fatal consequences due to inappropriate working conditions (Akkurt, 2014). Because the causative agent of the disease is located at the workplace, there is a causal relationship between the work performed and the disease. Occupational risks such as dusty, noisy, excessively hot/cold, humid, or oxygen-deficient workplace conditions eventually manifest as occupational diseases (Erol, 2020). To prevent occupational diseases, proactive measures must be taken regarding risk factors (Akkurt, 2014).

Despite increased public awareness, the desired level of prevention has not been achieved. Furthermore, it has been determined that the number of diagnosed occupational diseases and fatal cases increases each year (Akkurt, 2014). According to the World Health Organization (WHO)/ILO Joint Estimates of the Burden of Work-Related Diseases and Injuries, 2000-2016: Global Monitoring Report, 1.9 million deaths occurred due to work-related diseases and injuries in 2016. One of the leading causes of death is chronic obstructive pulmonary disease, which, with 450,000 deaths, is due to workplace air pollution (Kahraman and Özdemir, 2022). The most frequently diagnosed occupational diseases

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worldwide are occupational respiratory/lung diseases (Şensöğüt, 2015). Lung diseases caused by airborne dust were the first occupational diseases identified in the 17th century (Ören and Şensöğüt, 2017). Dusts generated by mechanization, which negatively affect work quality, can cause significant discomfort to workers operating machines in environments where multiple machines are operated simultaneously. High dust levels negatively impact workers' health and productivity (Kodaloğlu et al., 2021). This study was conducted to evaluate the effects of inorganic dusts on the respiratory system and occupational health and safety approaches.

For this purpose, the literature and relevant legislation were reviewed, and measures for preventing occupational diseases, general diagnostic approaches, and occupational health and safety practices to be implemented within the scope of dust control were included.

2. What is Dust? Classification of Dust

Solid particles of various sizes that can remain suspended in the air for a certain period of time are called "dust." Dusts are particles formed from various organic and inorganic substances as a result of abrasion, fragmentation, grinding, and combustion, and range in size from 1 micrometer to 100 micrometers.

Dusts are classified into three categories: chemical dust, biological dust, and dust based on particle size (Anonymus, 2025b).

2.1. Dusts of Chemical Origin

Organic Dusts: Organic dust is a mixture rather than a single, pure dust. This mixture may contain plant debris, pollen, animal feces, insects, bird feathers, microorganisms, pesticide residues, and antibiotics. These dusts include: dusts of plant origin (cotton dust, wood dust, flour dust, straw dust, etc.), animal dusts (feather, leather, etc.), and dusts of synthetic compounds (DDT, trinitro toluene, etc.) (Anonymus, 2025b.).

Inorganic Dusts: Inorganic dusts tend to accumulate in the lungs. Among these, dusts that carry the risk of causing fibrosis (hardening of lung tissue) can cause tissue damage to the alveoli, the air sacs in the lungs, leading to chronic lung diseases. These dusts: Metallic dusts (Iron, copper, zinc dust, etc.), Non-metallic dusts (Sulfur, coal dust), Dusts of chemical compounds (Zinc oxide, manganese oxide, etc.), Dusts of natural compounds (Minerals, clays, ores, etc.). Minerals: respirable, crystalline silica dust, Dusts containing asbestos fibers, Man-made mineral fibers (Aluminum silicate fibers) (Anonymus, 2025b).

2.2. Major Dust Groups in Terms of Biological Effects

Fibrogenic Dusts: Fibrotic alterations in the lungs happen when dust particles of specific chemicals with fibrogenic fiber capability are inhaled and build up in the lungs. The lung's natural active tissues are progressively replaced by this fibrotic tissue. It gradually deteriorates the lungs, reducing life expectancy and making it harder for patients to work. Silica, asbestos, talc, and aluminum dusts are the most well-known types of these dusts. The disorders known as silicosis, asbestosis, talcosis, and aluminoses, respectively, are caused by dust deposition in the lungs and result in pneumoconiosis. Worker disease is influenced by a number of factors, including body resistance, exposure length, and the concentration of these dusts in the environment. Because of this, employees—particularly those who work underground in coal mines—must take regular breaks (Erol, 2007).

Toxic Dusts: This class includes dusts that can harm the neurological system, liver, kidneys, stomach and intestines, respiratory organs, and blood-forming organs either acutely or chronically when consumed. Depending on the type of material, its percentage in the dust, the concentration of the dust in the air, and the quantity of dust inhaled, one or more of the dust's constituents may be poisonous and result in poisoning. Among these, heavy metal dusts like manganese, cadmium, and lead are the most common. Manganese is harmful to the central nervous system, whereas cadmium is poisonous to the kidneys. Numerous systems, including the neurological, digestive, excretory, and circulatory systems, can be poisoned by lead dust (Kaplan, 2016).

Carcinogenic Dusts: Due to a number of internal and external variables, these dusts can cause cancer in people. Cancer is believed to be influenced by a number of factors, including exposure at work, environmental pollutants, living situations, and diet. Today, asbestos, arsenic and its compounds, beryllium, chromates, nickel, and their compounds are among the dusts that are known to cause cancer (Erol, 2007).

Radioactive Dusts: Ionizing rays from radioactive materials in airborne dust harm human cells and tissues, leading to the development of tumors and hereditary diseases. The most significant of them are tritium and radium salts, as well as compounds of uranium, thorium, cerium, and zirconium, though they are not many (Erol, 2007).

Allergic Dusts: For those who are vulnerable, these dusts can result in a variety of allergic reactions, including dermatitis, fever, and asthma. Similar effects can also be produced by different molds, pollens, yeasts, and bacteria. Inhaling moldy dust from animal feed, hay, grass, grain, and pulp that has been kept in hot, humid warehouses and stables for extended periods of time can cause allergic respiratory disorders. Allergic reactions include bronchial asthma in bakers caused by wheat and byssinosis in workers in textile mills and cotton, linen, and hemp. This group also includes wood dusts (Kaplan, 2016).

Inert Dusts: Although they can build up in the body, inert dusts don't have any harmful or fibro genic properties. Through respiration and the respiratory system's self-cleaning mechanism, inhaled and settled particles are removed from the body; in the worst situation, they accumulate permanently in the lungs without having a significant negative pathogenic impact. Examples in this group include marble, limestone, gypsum dust, and tobacco dust (Anonymous, 2025b).

2.3. Dusts by Particle Size

- Respirable Dusts: This group of dusts enters the respiratory tract and reaches the alveoli due to their size. These dusts pose the greatest danger in terms of lung disease.
- Total Respirable Dust: This group of dusts is trapped in the nose, throat, and upper respiratory tract.
- Total Dust: This group of dusts includes all particles in the air, regardless of dust size or composition (Anonymous, 2025b).

3. Inorganic Dust-Related Occupational Illnesses

- Depending on the type of dust, particle size, air concentration, and length of exposure, inhaling inorganic dust can cause a number of health issues. The following are some of the most prevalent health issues linked to exposure to inorganic dust:
- Silicosis, which can be dangerous or even lethal in severe circumstances, can result from breathing in crystalline silica dust. Silica dust causes scar tissue in the lungs, which hinders the lungs' ability to absorb oxygen. There is no known therapy for silicosis. Because it impairs immunity, silica exposure raises the risk of lung infections including tuberculosis. Additionally, smoking harms the lungs and intensifies the consequences of exposure to silica dust.
- The majority of research on respiratory conditions brought on by dust exposure in agricultural settings has been on inorganic dust-induced allergy disorders, specifically hypersensitivity pneumonitis and occupational asthma.
- Pulmonary fibrosis (mixed dust pneumoconiosis) has been reported in agricultural workers, and in these cases, lung dust samples reflect the composition of agricultural soils, strongly suggesting inorganic agricultural dust as a cause.
- Asbestos and Mesothelioma: Asbestos dust can cause asbestosis, a chronic lung disease, and mesothelioma, a type of cancer affecting the lungs or peritoneum. According to the study, the prognosis for mesothelioma is poor. Unfortunately, only 50% survive beyond one year, and only one in 10 people survive more than five years after diagnosis.
- Exacerbation of Preexisting Conditions: Exposure to inorganic dust may exacerbate symptoms for people who already have respiratory disorders including bronchitis or asthma.
- Numerous lung conditions, such as respiratory disorders, lung cancer, parenchymal disorders, and pleural disorders, can be brought on by inhaling inorganic dust. Reactive oxygen species generation may be linked to the general lung damage caused by cadmium and mercury (Anonymous, 2025a).

4. Ways to Prevent Occupational Illnesses

- Substitution is the best way to prevent hazardous emissions (e.g., substituting less hazardous substances for hazardous materials—do not use silica sand or other materials containing more than 1% crystalline silica as abrasive blasting material).

- Implementing rigorous engineering controls is the second-best way to prevent airborne exposure. These control measures include ventilation and process design that prevents particles from becoming airborne (e.g., welding). Routinely maintain dust control systems to ensure their effectiveness.
- Maintain personal hygiene to prevent unnecessary exposure to other contaminants in the workplace (e.g., do not allow food or drink, as well as cups, teapots, etc., in the workplace, as this could also lead to ingestion of airborne dust).
- The least effective strategy for reducing occupational respiratory exposures is the use of respirators and protective gear. Only after previous approaches have failed to remove the issue or hazard can this approach be employed.
- Make sure that protective gear is either washable or disposable (if dealing with asbestos). Employees should, if at all possible, take a shower and change into clean clothes before leaving work to avoid contaminating cars, residences, and other workspaces.
- Employee health should be monitored on a regular basis (Anonymous, 2025b).

5. Results

Dust-related respiratory illnesses are the most prevalent occupational diseases in the system, and their negative health impacts are frequently disregarded and undervalued in many sectors. Additionally, workers are inadvertently exposed to detrimental consequences, and the impacts of dust are not fully known because dust-related illnesses take time to manifest. This is because neither the firm nor its employees have a culture of occupational health and safety.

The majority of occupational respiratory illnesses have no known cure; therefore, dust control is a significant issue. Occupational health and safety measures, the establishment of a safety culture in businesses, and awareness campaigns are all necessary to lessen the impacts of dust and avoid occupational diseases. In this context, training in occupational health and safety as well as instruction on dusts unique to the industry and associated hazards are essential. Employee awareness can be raised through occupational health and safety training, which will lower exposure to dust.

6. Conclusion

This review confirms that occupational exposure to inorganic dust remains a critical, often underestimated, health hazard in numerous sectors. The investigation highlights that the primary challenge lies in the incurable nature of resultant respiratory diseases, such as silicosis, meaning proactive prevention through effective dust control is the only viable strategy. This study benefits society by synthesizing the extensive risks of inorganic dusts and reinforcing the necessity of strict OHS protocols. The way forward demands a cultural shift within businesses towards prioritizing occupational health, supported by continuous, industry-specific training and the rigorous enforcement of preventive safety measures to protect the workforce from these latent and irreversible dangers.

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