Chemicals and Materials

What are the Effects of Dust on the Lungs?

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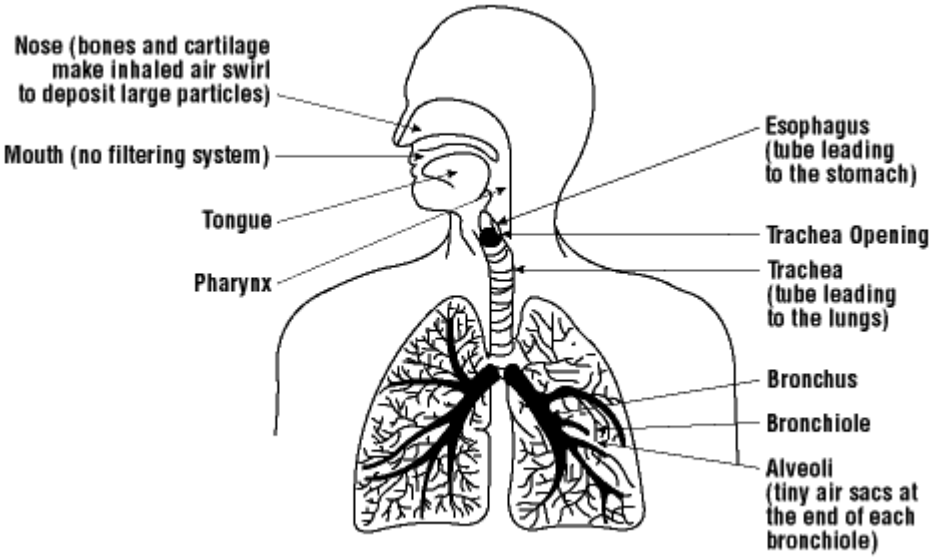
What are the lungs?

The lungs are the organs of breathing: they are responsible for bringing oxygen from the atmosphere into the body through a series of branching air tubes (Figure 1) and exchanging it for carbon dioxide that is released back into the atmosphere.



The lungs are constantly exposed to danger from the dusts we breathe. Luckily, the lungs have another function - they have defence mechanisms that protect them by removing dust particles from the respiratory system. For example, during a lifetime, a coal miner may inhale 1,000 grams of dust into their lungs. When doctors examine the lungs of a miner after death, they find no more than 40 grams of dust. Such a relatively small residue illustrates the importance of the lungs' defences and certainly suggests that they are quite effective. On the other hand, even though the lungs can clear themselves, excessive inhalation of dust may result in disease.

What is dust?

Dusts are tiny solid particles scattered or suspended in the air. The particles are "inorganic" or "organic," depending on the source of the dust. Inorganic dusts can come from grinding metals or minerals such as rock or soil. Examples of inorganic dusts are silica, asbestos, and coal.

Organic dusts originate from plants or animals. An example of organic dust is dust that arises from handling grain. These dusts can contain a great number of substances. Aside from the vegetable or animal component, organic dusts may also contain fungi or microbes and the toxic substances given off by microbes. For example, histoplasmosis, psittacosis and Q Fever are diseases that people can get if they breathe in organic dusts that are infected with certain microorganisms.

Dusts can also come from organic chemicals (e.g., dyes, pesticides). However, in this OSH Answers document, we are only considering dust particles that cause fibrosis or allergic reactions in the lungs. We are not including chemical dusts that cause other acute toxic effects, nor long-term effects such as cancer, for example.

What happens when we breathe in dust?

A series of defence mechanisms in different regions of the respiratory tract protect the lungs.

When a person breathes in, particles suspended in the air enter the nose, but not all of them reach the lungs. The nose is an efficient filter. Most large particles are stopped in it until they are removed mechanically by blowing the nose or sneezing.

Some of the smaller particles succeed in passing through the nose to reach the windpipe and the dividing air tubes that lead to the lungs [more information about how particles enter the lungs].

These tubes are called bronchi and bronchioles. All of these airways are lined by cells. The mucus they produce catches most of the dust particles. Tiny hairs called cilia, covering the walls of the air tubes, move the mucus upward and out into the throat, where it is either coughed up and spat out, or swallowed.

The air reaches the tiny air sacs (alveoli) in the inner part of the lungs with any dust particles that avoided the defences in the nose and airways. The air sacs are very important because, through them the body receives oxygen and releases carbon dioxide.

Dust that reaches the sacs and the lower part of the airways where there are no cilia is attacked by special cells called macrophages. These are extremely important for the defence of the lungs. They keep the air sacs clean. Macrophages virtually swallow the particles. Then the macrophages, in a way which is not well understood, reach the part of the airways that is covered by cilia. The wavelike motions of the cilia move the macrophages, which contain dust, to the throat, where they are spat out or swallowed.

Besides macrophages, the lungs have another system for the removal of dust. The lungs can react to the presence of germ-bearing particles by producing certain proteins. These proteins attach to particles to neutralize them.

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What are the reactions of the lungs to dust?

The way the respiratory system responds to inhaled particles depends, to a great extent, on where the particle settles. For example, irritant dust that settles in the nose may lead to rhinitis, an inflammation of the mucous membrane. If the particle attacks the larger air passages, inflammation of the trachea (tracheitis) or the bronchi (bronchitis) may be seen.

The most significant reactions of the lung occur in the deepest parts of this organ.

Particles that evade elimination in the nose or throat tend to settle in the sacs or close to the end of the airways. But if the amount of dust is large, the macrophage system may fail. Dust particles and dust-containing macrophages collect in the lung tissues, causing injury to the lungs.

The amount of dust and the kinds of particles involved influence how serious the lung injury will be. For example, after the macrophages swallow silica particles, they die and give off toxic substances. These substances cause fibrous or scar tissue to form. This tissue is the body's normal way of repairing itself. However, in the case of crystalline silica, so much fibrous tissue and scarring form that lung function can be impaired. The general name for this condition of fibrous tissue formation and scarring is fibrosis. The particles which cause fibrosis or scarring are called fibrogenic. When fibrosis is caused by crystalline silica, the condition is called silicosis.

What are the factors influencing the effects of dust?

Several factors influence the effects of inhaled particles. Among these are some properties of the particles themselves. Particle size is usually the critical factor that determines where in the respiratory tract that particle may be deposited. Chemical composition is important because some substances, when in particle form, can destroy the cilia that the lungs use for the removal of particles. Smoking may alter the ability of the lungs to clear themselves.

Characteristics of the person inhaling particles can also influence the effects of dust. Breathing rates and smoking are among the most important. The settling of dust in the lungs increases with the length of time the breath is held and how deeply the breath is taken. Whether breathing is through the nose or mouth is also important.

What are the diseases of dusty operations?

Workers can be affected by a variety of illnesses caused by dusts they inhale in their work environments. For practical purposes, we do not take into consideration combined effects arising from exposures to dusts, gases, fumes and vapours in this document.

Some types of lung diseases caused by the inhalation of dust are called by the general term "pneumoconiosis." This simply means "dusty lung."

The changes which occur in the lungs vary with the different types of dust. For example, the injury caused by exposure to silica is marked by islands of scar tissue surrounded by normal lung tissue. Because the injured areas are separated from each other by normal tissue, the lungs do not completely lose their elasticity. In contrast, the scar tissue produced following exposure to asbestos, beryllium and cobalt completely covers the surfaces of the deep airways. The lungs become stiff and lose their elasticity.

Not all inhaled particles produce scar tissue. Dusts such as carbon and iron remain within macrophages until they die normally. The released particles are then taken in again by other macrophages. If the amount of dust overwhelms the macrophages, dust particles coat the inner walls of the airways without causing scarring, but only producing mild damage, or maybe none at all.

Some particles dissolve in the bloodstream. The blood then carries the substance around the body,, where it may affect the brain, kidneys and other organs.

The table below summarizes some of the most common lung diseases caused by dust.

The OSH Answers document Extrinsic Allergic Alveolitis has more information about diseases from exposure to organic dusts.

Table
Some types of pneumoconiosis according to dust and lung reaction

Inorganic Dust	Type of Disease	Lung Reaction
Asbestos	Asbestosis	Fibrosis
Silica (Quartz)	Silicosis	Fibrosis
Coal	Coal Pneumoconiosis	Fibrosis
Beryllium	Beryllium Disease	Fibrosis
Tungsten Carbide	Hard Metal Disease	Fibrosis
Iron	Siderosis	No Fibrosis
Tin	Stannosis	No Fibrosis
Barium	Baritosis	No Fibrosis
Organic Dust		
Mouldy hay, straw and grain	Farmer's lung	Fibrosis
Droppings and feathers	Bird fancier's lung	Fibrosis
Mouldy sugar can	Bagassosis	Fibrosis
Compose dust	Mushroom worker's lung	No Fibrosis
Dust or mist	Humidifier fever	No Fibrosis
Dust of heat-treated sludge	Sewage sludge disease	No Fibrosis
Mould dust	Cheese washers' lung	No Fibrosis
Dust of dander, hair particles and dried urine of rats	Animal handlers' lung	No Fibrosis

How can we protect the lungs from dust?

To avoid respiratory or other problems caused by exposure to dust, controls must be implemented. As per the hierarchy of control, the first consideration should be hazardous substances substituted with non-hazardous substances. Where substitution is not possible, other engineering control methods should be introduced. Some examples are:

- use of wet processes
- the enclosure of dust-producing processes under negative air pressure (slight vacuum compared to the air pressure outside the enclosure)
- exhausting air containing dust through a collection system before emission to the atmosphere
- use of vacuums instead of brooms
- good housekeeping
- efficient storage and transport
- controlled disposal of dangerous waste

The use of personal protective equipment may be vital, but it should nevertheless be the last resort of protection. Personal protective equipment should not be a substitute for proper dust control and should be used only where dust control methods are not yet effective or are inadequate. Workers themselves, through education, must understand the need to avoid the risks of dust. A respiratory protection program is discussed in OSH Answers - Personal Protective Equipment, and specifically Respirator Selection, Respirator Care, Respirators - Wearing a Respirator and Respirators - Respirator Versus Surgical Masks.

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