This is part two in a series on the “Science-based steps of the cleaning process.” Each step contains scientific concepts and principles explaining cleaning’s effectiveness in putting unwanted matter in its proper place.

Locating, identifying and understanding the physical, chemical and biological characteristics of the unwanted matter being removed.

When is matter most effectively removed?
Matter is most effectively managed and moved once it is identified and its behavior is understood.
Matter comes from the Latin word, materia, which describes anything of substance.
Substances are living or non-living, solids, liquids or gases.
Matter is a mass-energy that moves with velocities less than the speed of light.
Its mass is attracted by gravitational force.

What is pollutant exposure?
Most pollutant exposure occurs indoors. Pollutants only are a concern outdoors in greater concentrations and with longer exposure periods.
They get inside several ways.
Outside pollutants, are blown, leaked or tracked inside.
Indoor activities, man-made products and environmental conditions also create indoor pollutants.
A wide range of pollutant concentrations are generated by different sources.
Risk from these pollutants varies greatly, depending on hazard level, exposure length and how man responds.
Dosage and exposure time are critical, particularly indoors.
The physics of enclosed spaces prohibits pollutants from diffusing and dispersing like in open air.
Instead, they are trapped by the built environment’s envelope.
Within this closed system pollutants accumulate, become concentrated and may be nurtured by existing conditions.
Biological contaminants may grow and prosper indoors.
Common indoor pollutants posing the greatest potential for harm are: Biological contaminants, particles and dust, fibers, gases and pesticides.
They all possess their own special management process.
Effective cleaning, however, significantly reduces the risks associated with each category.
Depending on their toxicity and concentration, a category’s pollutants contribute to mortality, morbidity, reduced productivity, property damage or a combination.
Following are the ranges of health effects these pollutants cause from most to least severe:
• Mortality
• Cancer
• Asbestosis
• Chronic obstructive lung disease
• Allergic alveolites
• Neurotoxicity
• Hepatotoxicity
• Humidifier fever
• Decreased pulmonary function
• Aggravated cardiovascular/pulmonary disease
• Hypersensitivity reactions
• Increased incidence of respiratory disease
• Irritated eyes and mucous membranes
• Monday or early week occupant complaints
• Sick building syndrome
• General malaise.
What are biological pollutants?

Biological contaminants or pollutants are harmful substances that are living organisms or a derivation.

Indoor contaminants include bacteria, viruses, actinobacteria, algae, fungi, pollen, protozoa, arthropods, volatile agents and vertebrae-derived materials.

Common indoor sources are heating and air conditioning systems, moisture, proteins, shower heads, pets, contaminated foods, humans, mites, cockroaches, water damage and outdoor pollutant sources entering indoors, especially flood or sewage backup.

Biological contamination is widespread. In many built environments exposure is great and the health impact serious.

Organisms or harmful substances derived from organisms are found in most micro-environments.

They originate from a form of fungi, bacteria, mites, cockroaches or cat saliva.

An individual’s physical response to these organisms is predictable, especially at-risk populations like asthmatics.

It is likely that over 10 percent of those exposed respond significantly to biological contaminants.

The most vulnerable are low-income individuals, the young and elderly and others with sensitive or immunologically compromised health conditions.

Controlling biological pollutants indoors provides considerable health benefits.

Traditionally, this control was achieved by managing moisture, cleaning, disinfecting and sanitizing.

These cleaning methods are known to:
- Reduce mortality due to biological pollutant exposure, such as Legionella, and other deadly bacilli
- Reduce hospital visits made by asthmatics exposed to allergens, such as fungi and mites
- Increase productivity when inhabitants are healthy.

What is the difference between particles and dust?

The most comprehensive, up-to-date particle and dust information is found in the Air Quality Criteria for Particulate Matter.

Another cleaning data source is the International Flooring Science Resource Center’s website.

The following information is based on these references.

Indoor particles and dust damage health and soil property.

These particles come from natural and man-made sources.

Health effects from dusts are directly related to the size and amount of inhaled particles.

Particles larger than 30 µm in diameter have a low probability of entering the lungs beyond the nasal passage.

Particulate smaller than 2 µm, however, can be distributed in the lungs’ lower alveolar region.

Very fine particles are produced in cigarette smoke, by combustion and materials breaking apart or weathering.

Cancer is the most serious health consequence of inhaling combustion particles.

The most common particle, soot, is carcinogenic.

It is adsorbed to the surfaces of fine particles that can be inhaled deeply into the lungs.

Particles, by virtue of their size and shape, may increase the risk of cancer.

They carry carcinogens when these cancer-causing agents are adsorbed onto the particle.

When the particle enters the lung, that agent stays in contact with the lung cells longer than if it was a gas.

The particles act similar to a time-release capsule.

Composition of these cancer-causing agents, particles and gases varies with fuel and burning conditions.

Inhaled particles also irritate respiratory tissue and eyes.

The irritation’s severity depends on the particles’ concentrations, which is contingent, in part, on its chemical species.

Lung function decreases when respirable particles occur alone, with gases or in concentrations >300 µg/m³.

When deposited on surfaces dust dirties floors, carpets and windows.

Some scatter, absorb light and reduce visibility.

They can damage precision machinery and soil and discolor artwork.

Particle size determines the damage inflicted.

There are many ways dust forms indoors: Condensation, combustion, breaking down materials and tossing suspended particles into the air through activity and spraying.

Sources of indoor particles and dusts

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include plants, animals, minerals, combustion and aerosols.

Each comes in different sizes.

Non-biological particles are Total Suspended Particles (TSP) or Respirable Suspended Particles (RSP).

TSP are all sizes. RSP measure no more than 10 microns in diameter.

These present the greatest health concern because they can be inhaled deep into the lungs.

Most RSP are produced by cigarette smoke and using combustion appliances indoors.

Cancer is the most serious health hazard associated with small particles.

Others include impaired lung function and allergic responses or asthma.

When measured for short periods of time indoor particle concentrations are in the 10-1,000 µg/m$^3$ range.

Based on the National Ambient Air Quality Standards concentrations >100 µg/m$^3$ are considered unsanitary.

Biological aerosols also consist of particles originating in living plants or creatures.

Plant particles include pollens, spores, molds and plant parts.

Most enter the built environment through doors, windows and air handling systems.

Animals and humans also produce minute amounts of biological aerosols that remain in the environment, including bacteria, viruses, hair, insect parts and skin cells.

Ambient soils are common indoor sources of particulate matter that are organic, humic or mineral.

Each has different particle construction and life support properties.

Mineral dusts result from weathering or breaking down inorganic matter, such as sand, silt, clay, talc, carbons and asbestos.

Other well-known dusts come from heavy metals, like lead, and man-made mineral fibers, such as fiberglass insulation.

They are blown or tracked indoors or produced inside.

Deemed the largest group of indoor dusts, some are carcinogenic.

As a class, however, they are most damaging in soiling materials.

Burning produces combustion dusts called products of incomplete combustion or PICs.

These PICs come from tobacco products, cooking, heating appliances and outside industrial sources.

Most are small enough to be inhaled into the lungs causing serious health damage. PICs are a major source of indoor pollution.

Any matter left behind poses health hazards and damages materials.

Many of these also are carcinogenic. Some are oily and sticky and adhere to surfaces.

Proper ventilation and cleaning manage these products when emitted into the indoor environment.

Gases, particles and organics are products of combustion.

Principal combustion gases are nitrogen and sulfur dioxide and carbon monoxide. Combustion particles form when burned solids do not enter the gas phase.

Common combustion organics are formaldehyde and polynuclear aromatic hydrocarbons (PAH).

Indoor sources for these contaminants include improperly ventilated combustion appliances, such as gas, cooking and wood burning stoves, water heaters, dryers and gas or kerosene space heaters.

Second-hand cigarette smoke also is a contamination source, containing over 4,500 compounds or products of incomplete combustion.

Many PAHs that may cause cancer, cardiovascular problems and irritate mucous membranes are present indoors.

Soot also has been associated with cancer. These black substances are by-products of incomplete combustion materials containing carbons.

They often possess highly toxic polycyclic aromatic hydrocarbons, resins and incompletely carbonized fuel fragments.

Consequently, special care is required to prevent inhaling, ingesting or making dermal contact.

Most soot contains inorganic matter, such as oxides, salts, metals, absorbed liquids, gases, sulfurs and nitrogen compounds.

Chimney sweeps, heating unit service staff, firefighters and fire damage restoration staff are most susceptible to occupational soot exposure.

The general public also is potentially exposed because soot is a widespread environmental contaminant.

Cleaning is essential in removing these potentially toxic substances.

Among the non-combustion particles in the indoor air that cause concern are man-made cleaning dusts, health and beauty sprays and cooking aerosols.

Concentrations vary depending on the activity’s duration and intensity.

Surprisingly, humidifiers, generally considered a health aid, also generate undesirable particles.

Tap water may produce mineral particles, which if not removed through cleaning can produce biological pollutants that are sprayed into the air.

Many heavy metals are carcinogens. Metals and metal compounds of most concern are those found in house dusts: arsenic (salts, arsenates, arsenites), beryllium, cadmium (oxide, bromide, chloride), chromium (hexavalent), nickel (carbonyl, subsulfide) and selenium (sulfide).

Indoor dusts are tracked in by surface soil and deposits of airborne particles originating outside.

They also originate from indoor mechanisms and activities, such as smoking, normal wear and tear and household products containing heavy metals.

Tobacco smoke is a primary source of cadmium.

When metal concentrations, such as lead, are measured indoors there are alarmingly high levels of heavy metal contamination, mainly from outside sources.

It is safe to expect that many indoor metal concentrations relate to outdoor pollutants.

Studies of metal smelting identify surface soils as the greatest contributors to specific indoor particles.

Sometimes the average metal concentration in house dusts is similar to that in the soil.

A common misperception about particle sizes — known as the small particle paradox — needs clarification to effectively manage indoor allergens.

There is a misconception that only indoor particles <2.5-10 µm are a concern. Actually all size particles are important to varying degrees.

Generally, the size of allergen particles is larger than this small range.