The Effects of Moisture on Other Air Pollutants

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I will be talking about the effects of moisture on other pollutants. In covering this narrow topic, I will not discuss the health effects of the water itself, but just how the water affects the other pollutants, which may affect one's health. There are various problems that can be caused by too much or too little water.

Some apparent correlations that we notice in Seattle and other places relate the effects of humidity to other pollutants. When humidity is high outdoors and therefore higher indoors, the carbon monoxide decreases, the smoke and particles decrease, and formaldehyde decreases. It is important to note that these are correlations, not cause and effect. When humidity is high, we are often having stronger winds from the south and so we are simply diluting some of the polluted air in the building.

It is impressive how much water we put into a house all the time. Most of this comes from people, primarily from breathing, but it also comes from bathing, cooking, and other sources. How much water is in the air? It is important to remember that one mole of water is eighteen grams (or 18 cc), approximately a heaping tablespoon, containing one million, million, million, million molecules. We put several kilograms (liters) of water into the air each day. That is a big driving force to move pollutants, to change them, to cause them to act differently.

As to what types of change happen, think of the effects of moisture in terms of some of the basic sciences: there are physical, chemical, and biological changes that water can cause. Physical changes do not change the actual chemical compounds that are present. For example, gases can dissolve in water droplets and travel with the water into, out of, or within the home, but no chemicals are really destroyed or created. A chemical change that might occur, on the other hand, involves urea-formaldehyde. In this chemical process, water gets in, breaks a chemical bond, and releases formaldehyde. For biological changes, water provides the means for various microbes to grow and thrive and, perhaps, move within the home with the moisture.

Formaldehyde (HCHO)

First, I want to talk about formaldehyde, which is often the worst of all the effects of moisture. It is a very real effect; it is happening all the time; many homes have particle board and other potential sources of formaldehyde. While the effects of moisture on some of the other pollutants I will be talking about later may not be very important, formaldehyde coming from

particle board, and other urea-formaldehyde resins, is a very important effect.

The basic effect of water on urea-formaldehyde is that it breaks the bond between the urea and the formaldehyde and gives off formaldehyde gas [1]. That formaldehyde gets into the air and can cause health problems. Another interesting effect of moisture can result in cycles of formaldehyde gas in the air. If moisture is condensing on certain surfaces in the home, it might trap some formaldehyde gas from the air and decrease the concentration of formaldehyde gas in the air. Then, as the furnace goes through its heating cycle, for example, the condensation evaporates and the formaldehyde comes off with it [2]. The formaldehyde can come off and be present in the air either as a gas or dissolved in water droplets.

Interestingly, formaldehyde, whether as a gas or dissolved in water droplets, affects the body about the same. We have such high humidity in our lungs that any formaldehyde gas that comes in immediately becomes an aerosol droplet with formaldehyde dissolved in it. Those droplets impact in the lungs just like other particles. Yet, we also use the interaction of water and formaldehyde to measure the total formaldehyde in the air with a water bubbler impinger. This device collects both formaldehyde gas and formaldehyde in aerosol particles or droplets.

Radon (Rn)

Radon is the first gas in a long chain of the radioactive decay of uranium. Radon and moisture are always coming up from the earth. Most radon enters the home as a gas from the soil [3]. Ground water can also leak into the house and evaporate; any radon in that water is then released indoors. Here we have a physical process.

Radon itself soon decays to form charged radon decay products. Usually these charged products attach themselves to particles in the air, which can then impact in the lungs and be trapped. Another effect can happen if there are only a very few particles in the air: the water vapor in the air can be attracted to these charged products of radon decay. Clusters of several hundred water molecules can form around a radon product [4]. Starting with a molecular weight of about 200 for the radon and some of its products, by adding 100 water molecules we have added a couple of thousand mass units. Our lungs trap more radon products because these larger, heavier mass particles cannot turn corners fast enough: they impact. Even if we have a very efficient filter in the house to remove particles, there is still a mechanism to help the radon products impact in our lungs.

Aerosol Particles

Moisture combines with some particles in the air. Many particles then become more corrosive to materials such as metals or paints [5]. Some particles grow large enough to scatter light.

Outdoors we know when we have particle problems, because we have a long sight path to see the haze caused by the light scatter. Indoors we are not really so aware of the problem unless there is a very high concentration of particles in the air, such as a smoky room.

Much of the haze that we see outdoors is from particles of deliquescent or hygroscopic salts. They take up water, grow larger, and scatter light. Suspended salt particles in the air might come from sea salt, or sulfates from combustion of sulfur in fuels. When they take up moisture from the air and become larger, they impact more efficiently in the lung. Some salts only combine with moisture at humidity levels higher than we normally find indoors.

Sulfur dioxide and nitrogen dioxide are both readily soluble in water and much of their corrosive action depends on having water present. If we have a wet particle in the air, it can pick up some of these gasses and make them more corrosive to materials, or to our eyes or lungs [6]. There is some chemistry going on in the particles, such as sulfur dioxide dissolving into particles, being oxidized, and ending up as sulfuric acid. It is a more irritating particle, though not much more irritating than just sulfur dioxide dissolved in water, acting like sulfurous acid.

Another effect of moisture has to do with solid particles. For example, synthetic carpet fibers will degrade under ultraviolet light, but they show more cracking when they are moist [7]. That process can produce more airborne fibers from normal wear.

Minerals from Concrete

Moisture can cause minerals from concrete to become particulate pollutants. In a basement we might see a wall that has had apparent water damage. One thing we notice out around the ring is mold growth. This can encourage mold spores to get into the air. Around the center, we might find very fine crystals of salts. (Different salts, such as calcium and magnesium, with sulfate or carbonate, are in the concrete itself). As the moisture moves through the concrete, it dissolves these salts and deposits them inside in a very fluffy, loose layer that can be brushed off and get suspended in the air. This is not considered a common problem, but a lot of those salts in concrete are very alkaline, and are thus very irritating to the airways. Such a condition in a damp basement could mean more than just a mold problem.

Ozone (O_3)

Ozone decomposes indoors by reacting with gases or surfaces, such as walls, fabrics, or furniture. The lifetime of ozone depends on relative humidity (R.H.): it remains active four times longer at a dry 30% R.H. compared to a humid condition of 70% R.H. [8]. In larger rooms with fewer furnishings, the ozone has a longer life before reaction and decay [9].

Ozone causes textile dyes to fade. Moisture causes more fading in humid air [10]. Moist fabrics also deteriorate and fibers lose breaking strength [11]. Tests were done on textile strips put outdoors in different parts of the country. They showed much more degradation in a clean, humid environment than in a polluted, dry environment. Control is more important in some environments than others: museums, for example, must control both humidity and ozone to protect their exhibits.

Nitrogen Dioxide (NO_2)

Certain textile dyes fade and turn red when exposed to moisture and nitrogen dioxide. This is called "gas fading". It is noticed most in rooms and clothes dryers heated with natural gas (which produces nitrogen dioxide) [5].

Polyurethane

Moisture speeds the breakdown of polyurethane plastics. We worry about polyurethane because it is made from isocyanates, which are very toxic. Installers of polyurethane foam insulation have had health problems caused by isocyanates. The temperature is an important factor in breaking down polyurethane. As far as I know, we do not get high enough temperatures in homes for the polyurethane degradation and giving off of isocyanates to be a big problem. Yet, near and electric heater, the high temperatures needed for these effects might be reached. Whatever the temperature, breakdown does happen faster in the presence of moisture. More humid air would degrade the polyurethane foam faster, especially at higher temperatures [12].

Microbes

Moisture makes us think first about mold, because of the obvious problems that are caused: we can see where mold is growing. For example, a flower pot can hold moisture and allows black or gray visible mold to grow. The time we get obvious problems in homes, and the homeowner also knows it, is when we start getting a lot of condensation on the windows. Over time that will accumulate mold and do some structural damage. We might be more concerned about the mold itself that is growing there.

Mold sends out fibrous mycelia and those, as they dry, break up into small pieces and get airborne. The mold also puts out spores as part of its reproductive process. Both spores and mycelia come from the mold and cause various health problems. So the effect of water on microbes is, first of all, allowing them to grow. One way to reduce the mold problem is to dry out an area, because water is often the limiting ingredient to mold growth. This is true with spores especially, because the mold sends out the spores in response to different humidity changes.

Most of the damage done from these microbes is from the mold that gets into the air. We also worry about materials damage, as in

paint, because we often see the little black spots that are showing through. Microbes cause paint damage at high humidities, especially in paints with much raw linseed oil and in latex-emulsion-based paints [5].

Organic Vapors

A group of chemicals that is gaining in public concern is organic chemicals (other than formaldehyde). What we typically find in indoor air are two groups: (1) saturated hydrocarbons, with 9, 10, 11, or 12 carbon atoms; and (2) aromatic solvents such as toluene or xylene. I have not talked about these chemicals because they are not very soluble in water. As a result they are not very strongly affected by humidity levels.

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