How Do Air Pollution and Acid Rain Affect Vines, Grapes and Wine Quality, and Ultimately Our Health?

By Daniel Pambianchi | Submitted On November 26, 2009

Specific pollutants or classes of pollutants are well known to have damaging effects on the environment, such as ozone (triatomic oxygen) depletion and global warming, and on our health when contaminants are beyond "acceptable" levels. Vineyards are typically situated in areas with low levels of pollution and are therefore not of major concern. This doesn't mean that pollution should be ignored; however, there has been limited research on the impact of pollution on vineyards. It is a very complex area of research. Let's examine the chemistry of pollutants and their impact on vine-growing specifically.

The Earth's atmosphere comprises a number of gases, mainly diatomic nitrogen and oxygen as well as carbon dioxide, and water vapor. And every second of every day, pollutants from car emissions, landfills and industrial processes are released into the atmosphere and react with its constituents. The major pollutants are sulfur oxides, carbon dioxide, nitrogen oxides, chlorofluorocarbons (CFCs), and when they reach the atmosphere, they react with sunlight and atmospheric (diatomic) oxygen to form harmful substances.

Sulfur dioxide is known to have damaging effects to plants when in high concentrations; it is the result of oxidation of elemental sulfur such as in coal-burning processes. It also reacts with atmospheric oxygen to form sulfur trioxide, which then reacts with water vapor to form sulfuric acid in acid rain. A second component of acid rain is carbonic acid, formed in a similar reaction from emitted carbon dioxide. And the most damaging component is hydrofluoric acid, formed from hydrogen fluoride, released from smelter operations and phosphorous fertilizer production, and water vapor in the atmosphere. When acid rain reaches the soil in vineyards, it lowers the pH thereby throwing soil chemistry off balance making it difficult to grow premium grapes. Some of these acids are particularly corrosive and toxic, and detrimental to vine growing.

Nitrogen oxide is found in car exhaust gas and is the result of the high-heat combustion of (diatomic) nitrogen. In the atmosphere, nitrogen oxide reacts with molecular oxygen to form nitrogen dioxide, the reddish-brown gas responsible for smog. Nitrogen dioxide is then photochemically converted back to nitrogen oxide along with an oxygen atom. The oxygen radical then reacts with molecular oxygen to form ozone in the lower atmosphere. Ozone is a strong irritant and is damaging to vines and crops.

Car exhaust also release hydrocarbons that react with nitrogen oxide to form peroxyacetyl nitrate, a compound belonging to the class of peroxyacyl nitrates, or PANs, powerful toxi-irritants present in photochemical smog that cause ozone to accumulate. PANs are highly damaging to vine physiology resulting in reduced yields. And until leaded (tetraethyl lead) gasoline was phased out, wines produced from vineyards located in close proximity to high-traffic roadways demonstrated higher levels of lead, a potent neurotoxin responsible for lead poisoning. If lead enters the bloodstream, it can interfere with and disable delta-aminolevulinic acid dehydratase (ALAD) enzymes responsible for making hemoglobin. Hemoglobin is the iron-containing protein pigment occurring in red blood cells of vertebrates and functioning primarily in the transport of oxygen from the lungs to body tissues. Lead poisoning can then cause irreversible neurological damage as well as abdominal pain, gastrointestinal problems, headaches, anemia, reproductive problems, and a multitude of other effects.

Chlorofluorocarbons (CFCs) belong to the class of haloalkanes-that is, they comprise alkanes, such as methane or ethane, with halogens, such as chlorine or fluorine-and are well known to have harmful effects associated with ozone depletion. The halogen in CFCs reacts with ozone to form an oxide of the halogen plus molecular oxygen.

As for pesticides, it has been clearly proven that, environmental impacts notwithstanding, there are negligible residues in wine. Of course this assumes that pesticides are properly applied and well within the recommended treatment period prior to harvest. And the various winemaking processes, namely, crushing, pressing, fermentation, fining, filtration and aging, cause the pesticide residues to disappear.

And what about the thick and heavy smoke from the devastating wildfires of the summer of 2008 that blanketed Northern California wine country? Some red wines from such hard-hit areas as Mendocino County have a decidedly smoky, charred aromas and burnt-wood, ashy tastes. The compounds responsible for smoke taint are guaiacol and 4-methylguaiacol, volatile phenols which are absorbed into grape skins-especially in thin-skinned varieties, such as Pinot Noir-and then extracted during maceration and exacerbated by fermentation. Whites are mainly spared since there is no skin maceration with the juice. Much research has been carried out on smoke-tainted wines in Australia where, in 2003, smoke from wildfires also greatly affected vineyards.

Using reverse osmosis and nanofiltration technologies, the Australians have been able to reduce the culprit compounds down to non-detectable levels. *VA Filtration (VAF)*, a company specializing in such services as removal of volatile acidity (VA), Brett (yeast infection), and TCA (corked wine), claims that they can now eliminate up to ninety-nine percent of the targeted sensorial characteristics by treating affected wine with a food-grade resin developed in Germany. Interestingly, if not puzzling, VAF's website states that the "offensive compound(s) being removed are still not [known]."

But the astute reader will also know that guaiacol and 4-methylguaiacol are compounds found in toasted oak-aged wines, where they are highly desirable. It's quite the dichotomy!

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