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Air Quality and Agriculture

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Air pollution comes from many sources including power plants, factories, cars, trucks, volcanoes, and windblown dust. Air pollutants are regulated by the Environmental Protection Agency (EPA) as part of our national ambient air quality standards (NAAQS). Poor air quality can negatively affect the health of all people, but it is especially problematic for infants, children, and people with respiratory issues. Air quality also affects vegetation, ecosystems, and contributes to climate change.

Agriculture also affects air quality. Livestock production, fertilizer application, biomass burning, and land use changes are major sources of particulate matter and reduced nitrogen-, sulfur-, and carbon-containing gasses. Livestock production is also a principal source (~18%) of greenhouse gas emissions[1]. Cropping systems that lead to long-term plant and root production can sequester carbon, countering greenhouse gas emissions. Additionally, many best management practices (BMPs) can help reduce gaseous emissions.

Air Quality Pollutants

The primary ambient air quality issues involving agriculture include:
1) Three of the six criteria pollutants regulated as part of NAAQS; 2) precursors to some of the criteria pollutants such as ammonia (NH_3) and volatile organic compounds (VOCs); and, 3) the greenhouse gases (GHGs).

Criteria Pollutants

The Environmental Protection Agency (EPA) has identified, and regulates under NAAQS, six criteria pollutants[2] – ozone (O_3), particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NO_X), sulfur dioxide (SO_X), and lead. Of these, agricultural emissions primarily affect ozone, particulate matter, and nitrogen oxides.

Ozone – occurs both in the upper atmosphere (good ozone) where it protects us from the sun's ultraviolet rays, and at ground level (bad ozone). Ozone at the ground level can trigger a variety of respiratory health problems such as asthma and reduced lung function, and affect vegetation and ecosystems. Ozone is the result of chemical reactions between NO_X and volatile organic compounds and is primarily a byproduct of combustion engines. Since ozone is easily transported by the wind, even rural areas can have ozone problems.

Agriculture contributes directly to ozone production through burning of fields and the use of combustion engines in tractors, pumps, etc. Reducing the number of field operations, using less energy-intensive tillage operations, and proper maintenance of combustion engines are practices that help reduce ozone production.

Particulate matter – is a complex mixture of small particles and liquid droplets. Particles that are 10 micrometers in diameter or smaller (PM_{10}) can be inhaled and affect the heart and lungs. Particles from dusty areas (e.g., tillage, wind erosion) are typically between 2.5 and 10 micrometers in diameter. Particles smaller than 2.5 micrometers ($PM_{2.5}$) are found in smoke or formed from chemical reactions in the atmosphere.

Agriculture is responsible for ~18% of PM_{10} production through wind erosion, tillage operations, animal movement (e.g., feedlots), and vehicle traffic (road dust)[1]. Wind breaks, perennial cropping systems, cover crops, reduced tillage and maintenance of crop residue on soil surfaces are agricultural practices that can reduce PM_{10} emissions.

Nitrogen Oxides (NO and NO_2) – are highly reactive gases primarily arising from power plants and vehicle exhaust. NO_X contributes to the formation of ground-level ozone and $PM_{2.5}$ pollution, which adversely affect the respiratory system. NO_X is also produced as part of the nitrogen cycle, especially under anaerobic conditions.

Agriculture contributes to NO_X through direct combustion (e.g., burning of fields, equipment operation) and inefficiencies in the nitrification/ denitrification process in soils and manures. The implementation of Tier 4 standards on diesel engines significantly reduces one source of NO_X emissions. Alternatives to burning, feed management, and managing manure and inorganic fertilizer to conserve nitrogen (e.g., increased C:N ratio, incorporation into soil) can reduce NO_X emissions.

Precursors

Ammonia and volatile organic compounds (VOCs) are instrumental in the production of ozone and particulate matter, two of the criteria pollutants. Agriculture is the primary source (~90%) of total ammonia emissions[1].

Ammonia – combines with NO_X to form ammonium nitrate, a small particulate matter ($PM_{2.5}$). Ammonium nitrate is the primary source of haze in northern Utah (Figure 1). Ammonia also contributes to acid rain. Fertilizer and animal waste are the primary agricultural sources of ammonia. The addition of carbon sources such as straw to manure, and rapid incorporation of fertilizer and manure reduce ammonia emissions.

Figure 1. Haze in Logan, Utah. (Photo from usuextensionsustainability.blogspot.com)

Volatile Organic Compounds – are organic chemicals that volatilize at normal temperatures. VOCs are found everywhere, and can be classified into categories such as alcohols, aldehydes, etc. VOCs act as precursors for ozone production. VOCs also act as catalysts speeding up the conversion of ammonia and NO_X to form ammonium nitrate ($PM_{2.5}$). Vehicle exhaust and industry are the primary sources of VOCs. Agriculture produces VOCs through the breakdown of biological materials. Manure, silage production, and pesticides are some of the primary agricultural sources of VOCs[3]. Practices that minimize exposure of silage and manure to the atmosphere such as the use of impermeable covers (e.g., HDPE flexible membrane), and permeable covers (e.g., straw, cornstalks, or foam on lagoons) reduce VOC emissions.

Greenhouse Gases

The greenhouse gases (GHGs) of primary concern are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Other greenhouse gases include ozone, chlorofluorocarbons (CFCs), and water vapor. GHGs in the atmosphere trap energy and warm the earth's surface. Human activity releases GHGs into the atmosphere and reduces the earth's ability to sequester CO_2.

Carbon Dioxide. The burning of fossil fuels is the primary source of CO_2 emissions, but industry and some agricultural practices such as deforestation and cultivation of grasslands also release CO_2. Plants, their roots, and soil can sequester CO_2. Agricultural practices that encourage long-term

plant and root production can help counter the impact of climate change.

Methane – is produced as organic sources decompose. Natural sources of methane include wetlands, volcanoes, and wildfires. Agriculture is a primary source of human-caused methane[5] (Figure 2). Ruminant livestock produce large amounts of CH_4 as part of their normal digestive process (enteric fermentation). Since domestic livestock are primarily raised for food, this is considered a human-caused activity. Methane is also released from manure as organics decompose. Covering manure storage structures and capturing methane for energy production (anaerobic digestion) and dietary changes (e.g., addition of tannins) are practices that can help reduce methane emissions.

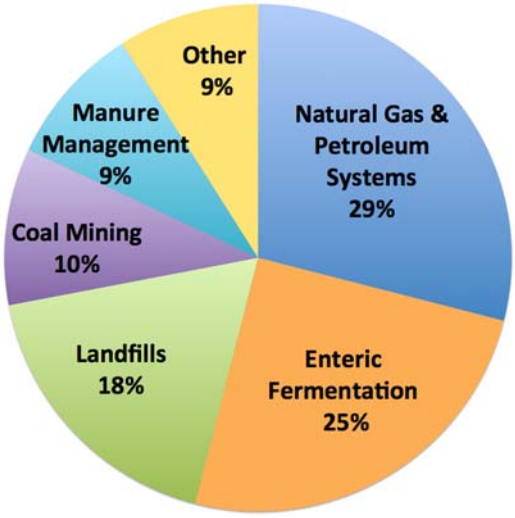

Figure 2. Sources of methane emissions[4].

Nitrous oxide – is produced by both natural and human activities. Nitrous oxide is formed as part of the nitrogen cycle. The majority of nitrous oxide production is from nitrogen that is broken down by bacteria in soils and the oceans. Fertilizer use in cropping systems is a primary source of nitrous oxide. Other sources include fuel burning, the production of synthetic fertilizers and fibers such as nylon, and livestock manure[6]. Practices that encourage nutrient conservation such as reduced and more efficient inorganic fertilizer use, immediate incorporation of manure, and practices that minimize runoff and leaching reduce nitrous oxide emissions.

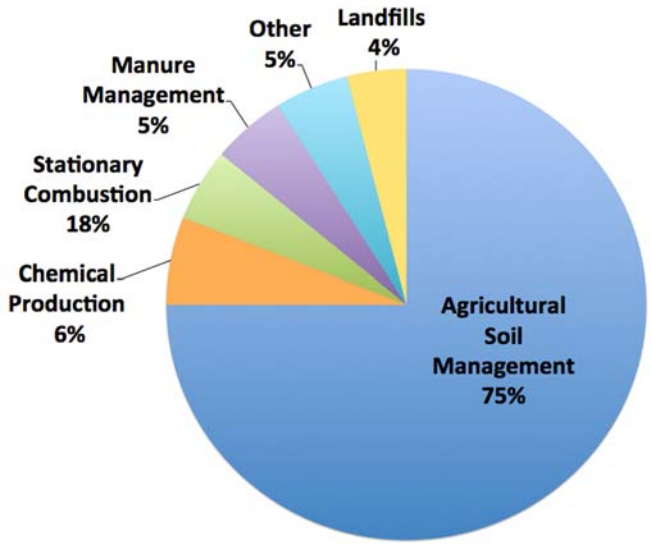

Figure 3. Sources of nitrous oxide emissions[5].

Summary

There are many human factors that contribute to poor air quality, and agriculture is no exception. Best management practices such as the immediate incorporation of manure, nutrient conservation, reduced fertilizer use, reduced tillage, keeping silage covered, covers on manure storage structures, and alternatives to burning can help minimize emissions of air pollutants. Although livestock production is a significant contributor of greenhouse gases, long-term cropping systems can sequester carbon which reduces greenhouse gas emissions.

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