Addressing Ozone and Particulate Matter from Agricultural Sources

NRCS Air Quality and Atmospheric Change Team

Ozone

There are two primary air emissions that contribute to ground-level ozone formation: oxides of nitrogen (NOx -- essentially nitric oxide [NO] and nitrogen dioxide [NO_2]) and volatile organic compounds (VOCs). For those areas of the country that the EPA has ruled exceed the standards set for ozone (a.k.a. nonattainment areas) NOx tends to be the emission that is most easily targeted because it's usually the limiting factor.

NOx is primarily a product of combustion, so any practice or activity that either reduces the amount of combustion or makes combustion more efficient will reduce NOx emissions. This includes finding alternatives to burning, using prescribed burns to manage combustion, utilizing less energy-intensive tillage (e.g., conservation tillage), combining operations and/or passes, and performing recommended maintenance and repairs on combustion equipment.

NOx can also be formed due to inefficiencies in the natural nitrification/denitrification process in soils and manures. Obviously, a major key here is to minimize the amount of nitrogen available to be lost by managing nitrogen inputs to these systems. Practices and activities like feed management, nutrient management for both manure and inorganic fertilizer, and managing manure to conserve nitrogen and/or convert it to a non-volatile form can be very beneficial tools for managing NOx emissions from these sources.

VOCs are emitted by every living thing, and there are literally thousands of different types of VOCs. VOCs are formed as intermediate compounds during the combustion, decomposition, or breakdown of longer-chain carbon compounds to either carbon dioxide (CO_2) or methane (CH_4), as well as during the photosynthesis process in vegetation. Many odorous compounds are also VOCs. Practices and activities that promote the efficient combustion and/or decomposition of organic materials, or prevent combustion and/or decomposition, will help to reduce VOC emissions. These practices and activities include those described above for managing NOx emissions from combustion; proper composting management (e.g., maintain correct moisture, C:N ratio, etc.); cleaning up spilled feeds, manure, and other organic material; and covering/enclosing manure storages and then controlling the vented emissions. Additionally, reducing volatilization of VOCs can be accomplished by such practices and activities as pest management to reduce the amount of pesticides applied or increasing the efficiency of pesticide application and managing organic liquids like fuels, oils, etc., by cleaning up spills, painting storage tanks a lighter color to reduce the temperature of the stored liquid, filling the tanks during cooler parts of the day, and installing vapor recovery devices on the tanks.

$PM_{2.5}$

Fine particulate matter, often referred to as $PM_{2.5}$, can be either emitted directly or formed in the atmosphere by either condensation or chemical reactions of other gases. Directly-emitted $PM_{2.5}$ includes unburned hydrocarbon particles from combustion, as well as the smaller size fraction of particles emitted from such sources as wind erosion, vehicle and animal traffic, soil disturbance, etc. Fine particulate matter that is directly emitted from these sources other than combustion is relatively minor in relation to the overall concentrations of $PM_{2.5}$ in the atmosphere, however. The predominant agricultural contributions to $PM_{2.5}$ concentrations are from combustion emissions and secondary formation of $PM_{2.5}$ from such gases as ammonia, oxides of nitrogen (NOx - essentially nitric oxide [NO] and nitrogen dioxide [NO_2]), and volatile organic compounds (VOCs).

Directly-emitted $PM_{2.5}$
For directly-emitted $PM_{2.5}$, the most beneficial practices and activities are those that either reduce the amount of combustion or make combustion more efficient, such as finding alternatives to burning, using prescribed burns to manage combustion, utilizing less energy-intensive tillage (e.g., conservation tillage),

combining operations and/or passes, and performing recommended maintenance and repairs on combustion equipment. Other practices, such as residue and tillage management, windbreaks, and covering of solid material storages will have minimal impacts to direct emissions of $PM_{2.5}$.

Secondary Formation of $PM_{2.5}$
Ammonia can combine in the atmosphere with other molecules, such as volatile nitrates (i.e. NOx) and sulfates, to form fine particulate. Agricultural ammonia emissions result from microbial and enzymatic activity in soils and manures. Practices and activities that minimize the amount of nitrogen available to be lost by managing nitrogen inputs to soils and manures are the most effective in managing ammonia emissions. These practices can include feed management, nutrient management for both manure and inorganic fertilizer, and managing manure to conserve nitrogen and/or convert it to a non-volatile form. Other practices that can disrupt the microbial and enzymatic activity, such as moisture management, applying amendments to change chemical and physical properties, etc., can also be effective.

NOx is primarily a product of combustion, so any practice or activity that either reduces the amount of combustion or makes combustion more efficient will reduce NOx emissions. This includes finding alternatives to burning, using prescribed burns to manage combustion, utilizing less energy-intensive tillage (e.g., conservation tillage), combining operations and/or passes, and performing recommended maintenance and repairs on combustion equipment.

NOx can also be formed due to inefficiencies in the natural nitrification/denitrification process in soils and manures. As with ammonia, a major key here is to minimize the amount of nitrogen available to be lost by managing nitrogen inputs to these systems. Practices and activities like feed management, nutrient management for both manure and inorganic fertilizer, and managing manure to conserve nitrogen and/or convert it to a non-volatile form can be very beneficial tools for managing NOx emissions from these sources.

Volatile organic compounds can condense to form fine liquid and solid particles. VOCs are emitted by every living thing, and there are literally thousands of different types of VOCs. VOCs are formed as intermediate compounds during the combustion, decomposition, or breakdown of longer-chain carbon compounds to either carbon dioxide (CO_2) or methane (CH_4), as well as during the photosynthesis process in vegetation. Many odorous compounds are also VOCs. Practices and activities that promote the efficient combustion and/or decomposition of organic materials, or prevent combustion and/or decomposition, will help to reduce VOC emissions. These practices and activities include those described above for managing NOx emissions from combustion; proper composting management (e.g., maintain correct moisture, C:N ratio, etc.); cleaning up spilled feeds, manure, and other organic material; and covering/enclosing manure storages and then controlling the vented emissions. Additionally, reducing volatilization of VOCs can be accomplished by such practices and activities as pest management to reduce the amount of pesticides applied or increasing the efficiency of pesticide application and managing organic liquids like fuels, oils, etc., by cleaning up spills, painting storage tanks a lighter color to reduce the temperature of the stored liquid, filling the tanks during cooler parts of the day, and installing vapor recovery devices on the tanks.

PM_{10}

Inhalable coarse particulate matter, or PM_{10}, is typically emitted directly as either solid or liquid particles. Most PM_{10} is emitted from such sources as wind erosion, vehicle and animal traffic, soil disturbance, etc.

Because PM_{10} is typically generated by erosive or mechanical/disturbance forces on dry materials, those practices and activities that attempt to minimize these forces are generally the most effective in reducing PM_{10} emissions. These practices and activities can include residue and tillage management; windbreaks and shelterbelts; applying dust suppressants, water, gravel, wood chips, and/or mulches to high-traffic and heavy-use areas; reducing speeds on unpaved roads; establishment of vegetation; covering dry manure and other materials; removing excess dry manure from pens; combining operations; precision farming; and applying mulches and soil amendments.

Recommended Practices to Reduce Air Quality Impacts

Practice	Practice Code	Direct PM - PM10	Direct PM - PM2.5	Ammonia	Volatile Organic Compounds (VOCs)	Oxides of Nitrogen (NOx)
Waste Storage Facility	313	x	x	x	x	x
Composting Facility	317			x	x	x
Conservation Cover	327	x	x			
Conservation Crop Rotation	328	x	x			
Residue and Tillage Management, No Till/Strip Till/Direct Seed	329	x	x		x	x
Prescribed Burning	338	x	x		x	x
Cover Crop	340	x	x	x		x
Residue and Tillage Management, Mulch Till	345	x	x		x	x
Waste Facility Cover	367	x	x	x	x	
Windbreak/Shelterbelt Establishment	380	x	x	x		
Prescribed Grazing	528	x	x			
Stripcropping	585	x	x			
Nutrient Management	590			x		x
Amendments for Treatment of Agricultural Waste	591	x	x	x		
Feed Management	592			x	x	x
Waste Treatment	629	x	x	x	x	x
Waste Utilization	633			x	x	x
Windbreak/Shelterbelt Renovation	650	x	x	x		
Engine Replacement	CA 723	x	x		x	x
Dust Control on Unpaved Roads and Surfaces	CA 729	x	x			
Also consider:						
Practice	**Practice Code**	**Direct PM - PM10**	**Direct PM - PM2.5**	**Ammonia**	**Volatile Organic Compounds (VOCs)**	**Oxides of Nitrogen (NOx)**
Agrichemical Handling Facility	309				x	
Alley Cropping	311	x	x			
Contour Buffer Strips	332	x	x			
Critical Area Planting	342	x	x			
Residue Management, Seasonal	344	x	x		x	x
Residue and Tillage Management, Ridge Till	346	x	x		x	x
Waste Treatment Lagoon	359			x	x	x
Anaerobic Digester, Ambient Temperature	365			x	x	
Anaerobic Digester, Controlled Temperature	366			x	x	

Fuel Break	383	x	x		x	x
Firebreak	394	x	x		x	x
Hedgerow Planting	422	x	x			
Irrigation System, Microirrigation	441	x	x			
Irrigation System, Sprinkler	442	x	x			
Irrigation System, Surface & Subsurface	443	x	x			
Irrigation Water Management	449	x	x		x	x
Anionic Polyacrylamide (PAM) Erosion Control	450	x	x			
Access Control	472	x	x			
Mulching	484	x	x			
Cross Wind Ridges	500	x	x			
Range Planting	550	x	x			
Drainage Water Management	554	x	x			
Heavy Use Area Protection	561	x	x			
Cross Wind Trap Strips	589c	x	x			
Pest Management	595				x	
Herbaceous Wind Barriers	603	x	x			
Surface Roughening	609	x	x			
Solid/Liquid Waste Separation Facility	632			x	x	