Agricultural publication G1885 — New October 31, 1999

Fugitive Dust: Nonpoint Sources

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Fugitive dust is a relatively new term for an old problem. Simply put, fugitive dust is a type of nonpoint source air pollution - small airborne particles that do not originate from a specific point such as a gravel quarry or grain mill. Fugitive dust originates in small quantities over large areas. Significant sources include unpaved roads, agricultural cropland and construction sites. Most rural Missouri citizens, particularly those living near unpaved roads, are familiar with the nuisance of fugitive dust (Figure 1). Recent research indicates that there are significant health considerations involved as well.

Figure 1. Unpaved roads produce about 10 million tons of particulate matter air pollution each year in the United States.

History

A small amount of fugitive dust occurs naturally. Wind erosion occurs continuously, especially in arid, open areas with sparse vegetation. Human activity coupled with unfavorable weather conditions can dramatically increase fugitive dust levels. The most remarkable example is the "dust bowl," which affected large portions of the United States during the 1930s. Heavy tillage of marginally productive land combined with the extended drought to create a fugitive dust problem of huge magnitude. The dust bowl was the major impetus behind the formation of the Soil Conservation Service (now the Natural Resources Conservation Service, NRCS) as a major technical assistance agency under the United States Department of Agriculture.

In more recent years, improved agricultural practices and increased paving of rural roads have resulted in a decrease in the total amount of fugitive dust. Accurate measures before 1985 are not available. Data from the U.S. Environmental Protection Agency (EPA) show an estimated 55 million tons of fugitive dust in 1988, a drought year. By 1990, this level had decreased to about 25 million tons and remained near that level through 1997.

Importance

Fugitive dust is included in the larger category of particulate matter (PM). Particulate matter includes the solid particles and liquid droplets suspended in the air. Sources of particulate matter include smokestacks and vehicle exhaust, but the largest single source is unpaved roads (see Figure 2). The EPA classifies particulate matter as one of six principal air pollutants, including carbon monoxide, lead, nitrogen dioxide, ozone and sulpfur dioxide.

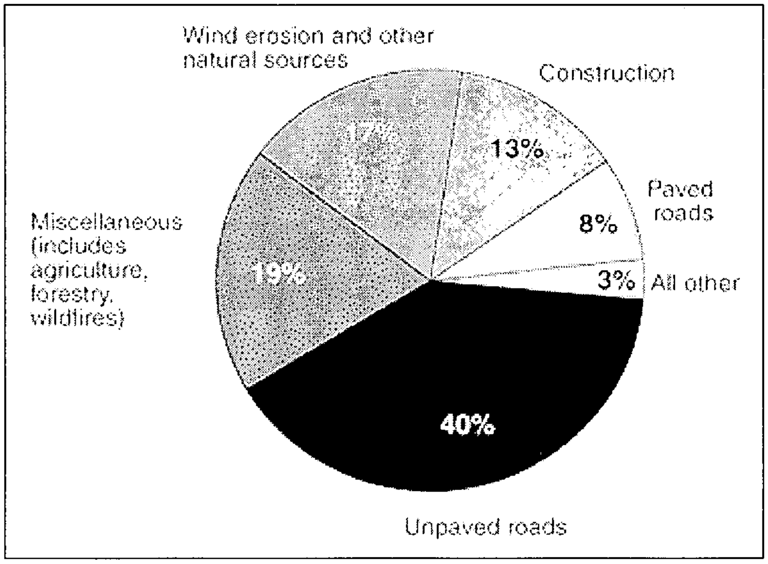

Figure 2. Particulate matter emissions originate from many sources. The Environmental Protection Agency estimates total fugitive dust emissions at about 25 million tons per year. Source: EPA, National Air Quality and Emissions Trends Report, 1997.

Besides causing additional cleaning of homes and vehicles, fugitive dust can cause low visibility on unpaved roads. In severe cases, it can interfere with plant growth by clogging pores and reducing light interception. Dust particles are abrasive to mechanical equipment and damaging to electronic equipment such as computers. Although generally not toxic, fugitive dust can cause health problems, alone or in combination with other air pollutants. Infants, the elderly and people with respiratory problems such as asthma or bronchitis are most likely to be affected.

Regulations

New and more stringent air quality regulations being implemented by EPA set strict standards for allowable levels of particulate matter. As municipalities develop air quality plans for meeting EPA standards, fugitive dust is likely to be scrutinized more closely as a part of overall air quality conditions.

Individual dust particles are measured in microns. Ten thousand microns equal one centimeter, or 0.3937 inch. EPA classifies particulate matter in two sizes. Particles smaller than 2.5 microns are referred to as $PM_{2.5}$. Larger particles up to 10 microns in diameter are designated PM_{10}. The PM_{10} classification includes most types of fugitive dust (Figure 3).

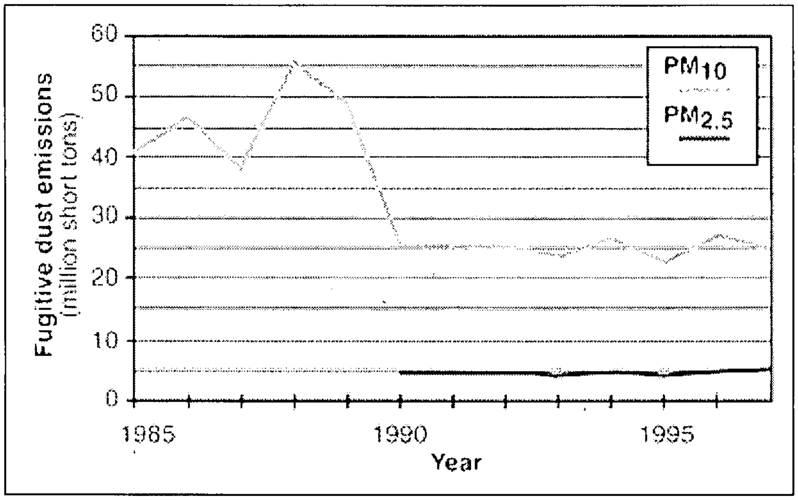

Figure 3. Fugitive dust levels peaked during the drought years of 1988 and 1989. Measurement of 2.5-micron particulate matter ($PM_{2.5}$) began in 1990. $PM_{2.5}$ emissions, which have remained at about 5 million tons per year, are included in the PM_{10} total. Source: EPA, National Air Quality and Emissions Trends Report, 1997.

The current EPA standard for PM_{10} is an annual average of no more than 50 micrograms per cubic meter. For comparison, an enclosed area 100 feet long by 100 feet wide and 20 feet tall would be allowed a total of 0.2832 gram, or 0.0091 ounce of suspended dust particles in the air to meet the annual average.

Additionally, there is a standard of 150 micrograms per cubic meter in any 24-hour period. This is the maximum acceptable acute level; communities are allowed to exceed this level only once a year over a three-year period to stay in compliance with clean air standards.

Estimating wind erosion from farmland

The NRCS has long been the lead agency for providing technical assistance to address soil conservation on private lands. In Missouri, water erosion is considered the primary problem in soil conservation. Most efforts have been directed toward control of sheet, rill, and gully erosion caused by water. Fortunately, many of the practices used to control sheet and rill erosion are also effective in reducing wind erosion.

As with water erosion, the degree of wind erosion that occurs depends on several changing conditions of climate, land and vegetation. *Climate* includes average wind velocity and the ratio of rainfall to evaporation. Areas of high wind and low humidity are the most likely to have wind erosion problems. Soil *erodibility* is determined chiefly by soil texture and topography. In general, heavy clay soils are less susceptible than loamy soils; flat areas or long, gentle slopes are more easily eroded than more rolling slopes. *Field length* is the unsheltered distance across the field in the direction of the prevailing wind. *Ridge roughness* refers to the height of ridges created by field tillage equipment and the orientation of the ridges to the direction of the prevailing wind. *Vegetation* considerations include the kind, amount and orientation of vegetation on the surface of the soil. The NRCS uses a wind erosion equation that combines these factors to calculate soil loss by wind erosion in tons per acre per year from specific sites.

Control strategies for farmland

Climatic conditions and soil erodibility cannot be modified for a given location. Vegetation and ridge roughness can be easily modified with "best management practices." Any farming practice that reduces the exposure of bare soil to the wind is a good control method. No-till and reduced tillage operations are effective. Ridge tillage is also effective if performed at right angles to the prevailing wind direction. However, if you are farming on the contour or across the slope as a method of water erosion control, the water erosion should probably take precedence.

Field length can also be modified. Practices that affect field length include windbreak establishment, strip cropping and trap strips. For maximum effect in reducing wind erosion, these control measures should be oriented at nearly a right angle to the prevailing wind. A row of vegetation will protect downwind land for approximately ten times its height. Trees make the most effective windbreak. They provide the widest area of protection, so the row spacing can be wider.

Strip cropping involves alternating strips of row crops with strips of close-grown crops such as forage or small grain. Forage strips can be permanently established; small grain can be used in a rotation with row crops. If this practice is used on land subject to water erosion, the strips should follow the contour of the hill slopes. On nearly level ground, strips should be oriented at a right angle to the prevailing wind for maximum wind erosion protection.

A variation on strip cropping is the use of crosswind trap strips. This practice consists of establishing narrower strips of grass at the windward side, and at intervals across the field. The grass selected should be tall with rigid stems to provide the best protection.

Alley cropping is a comprehensive wind and water erosion control practice that combines strip cropping, windbreaks and tree production. Rows of trees are planted in the center of permanently established grass strips across the field. If water erosion control is the first priority, the strips should be planted on the contour. For wind erosion control on more level ground, the strips can be oriented according to the prevailing winds. The areas between the strips can be used for row crop or forage production. The trees can be managed as an alternative enterprise to provide additional farm income.

The keys to reducing fugitive dust originating from wind erosion on agricultural land are: reducing the amount of bare soil exposed, reducing the amount of time the soil is exposed, and reducing exposure by intercepting some of the wind.

Control strategies for unpaved roads

Several products are available for controlling dust from unpaved roads. These products work by attracting moisture, binding dust particles together, sealing the surface, or some combination of these effects.

Chloride salts are the first category of dust suppressant. These chemicals are moisture attractants, which work by drawing moisture out of the air during periods of high humidity, particularly at night. They also reduce the evaporation rate of water during hot dry periods. This tends to hold the dust on the road surface, although there is no physical bonding.

Calcium chloride or magnesium chloride are the most effective moisture attractants. Sodium chloride, or common salt, is cheaper but not very effective alone. It can be mixed with the calcium chloride in equal parts to reduce the cost, however. Calcium chloride is the same material commonly used for fluid ballast in farm tractor tires and is readily available in a flake or pellet form. Calcium chloride should be mixed into a solution and sprayed on the surface at a rate of 1 to 1.5 pounds of salt per square yard. At this rate, it would require about 75 pounds of dry flake to treat 100 linear feet of road, 20 feet wide. A follow-up treatment at half to 2/3 of the initial rate is usually needed.

Magnesium chloride is a by-product of potash production and is available as a liquid solution. This complicates transport and storage, and generally requires ordering a tanker truckload. It should be applied at a rate of 0.5 gallon of 30 percent solution per square yard. Thirty-seven gallons of this product would treat the same amount of road surface as in the example above. Again, a follow-up treatment at half the original rate is often needed.

The applied cost of calcium or magnesium chloride is typically between 30 cents and 50 cents per running foot of road. All three chloride salts are corrosive to metals, toxic to plants, and irritating to human skin. They should be used with care. Also, they may result in a slippery coating on the road surface. This is not usually a problem on a gravel surface, but care should be taken to avoid spreading the solution on bridge floors. There is potential for some off-site plant damage during periods of heavy rainfall.

Another approach to dust control involves the application of organic or synthetic compounds that physically bind the dust particles together and to the larger aggregate. Some of these materials produce a surface that resembles pavement, but at a lower cost.

One class of material is formulated from a by-product of soybean oil extraction. Several soy-based commercial products are available and are referred to collectively as soybean feedstock (SBF). These products are noncorrosive and are not toxic to plants or animals. Since SBF products are organic-oil based, they are not as likely to wash or leach away as the salts. One application is reported to be effective in controlling dust for three to four months. Applied SBF products typically cost 40 to 50 cents per linear foot of road.

Problems with odor and stickiness sometimes occur on roadways treated with SBF products, particularly in the first few days after application. These products will also track onto paved driveways under certain conditions. Although SBF products are nontoxic, they will suppress weeds and grass in the roadbed. There is no residual effect, however, and little chance of movement during rainfall. SBF products are sold by the tanker load, one of which will treat approximately two miles of road. It is usually necessary for several neighbors to cooperate on an order to use a tanker load of feedstock.

Lignin is similar to SBF in performance and may cost less in some areas. Lignin is a by-product of the pulp and paper industry and has been used as a binder in feeds and fertilizers for many years. Several commercial road stabilization products use lignin as a base.

Another class of products uses polyvinyl acrylic polymer emulsion, or PVA, as the binding material. These long-chained synthetic polymers generally cost less than SBF. They perform best when blended with the top two to four inches of roadway material, followed by compaction.

Whatever product is used, it is necessary to have the roadbed in good condition before application. Again, work with your local road maintenance authorities to make the necessary preparations. The road should be graded and crowned, and potholes should be eliminated. Grading after application will partially destroy the effect of the dust suppressants. Surfaces treated with the binding products should not be graded afterward until necessary, although some adhesion will still occur after disturbance.

The application of waste motor oil for dust control is illegal in Missouri. Although this method of dust control was often used in years past, the hazards to the environment and the legal risks are too great to consider this an acceptable practice.

Control strategies for construction sites

Major construction projects often leave large areas of disturbed earth unprotected for long periods. These sites can be a significant source of fugitive dust as well as water erosion. Since construction sites are usually located in or near cities, they can be major contributors to overall air quality problems for the metropolitan areas and are likely to be addressed in plans for meeting EPA air quality standards.

Usually, the goal of the contractor is to complete the construction project as quickly as possible and reestablish protective cover, either vegetation or pavement. In one way, this goal is compatible with fugitive dust control: the shorter the period of exposure, the less opportunity for wind and water erosion to occur. However, contractors sometimes view additional steps for dust control as costly and time consuming and therefore incompatible with their primary goal.

EPA currently regulates fugitive dust on construction sites larger than five acres. Contractors must file a fugitive dust emission control plan to be in compliance. Smaller sites may be subject to local regulations, which vary from city to city.

Water is often used as a control method on construction sites. This can be effective if applied often enough. Some of the control methods for unpaved roads discussed above may be more economical in the long term. This depends on the amount of area disturbed and how long it will take to reestablish adequate cover. The application of polymers or soybean feedstock can have the added benefit of reducing the amount of mud tracked out of the site by vehicles.

For sites that will not be paved, timely revegetation is very important. Placing sod is the quickest approach, but the cost is usually prohibitive for large areas. For areas that will be seeded, the use of mulch provides some immediate protection and improves the chance of getting a good grass stand quickly. Light mulches such as straw should be tacked in place, either mechanically or by application of a chemical tacking agent.

Additional information

More information on federal standards and regulations regarding fugitive dust can be obtained from the Environmental Protection Agency, Office of Air and Radiation. If you have access to the Internet, the Web site www.epa.gov/oar/oarhome.html is a good starting point. It includes links to other applicable sites. A report on air quality trends can be found on the World Wide Web at www.epa.gov/oar/aqtrnd97/.

State regulations and information on monitoring are available through the Missouri Department of Natural Resources, Division of Environmental Quality. The Web site www.dnr.state.mo.us/deq/apcp/homeapcp.htm includes information on air quality programs. The DNR Technical Assistance Program (TAP) also provides recommendations on specific problems. TAP is a nonregulatory service provided by DNR; more information is available at www.dnr.state.mo.us/deq/tap/hometap.htm.

Your local USDA-NRCS office can provide information about the soils on your property, and can provide technical assistance in controlling both wind and water erosion on farmland.

For more information on incorporating trees into traditional farming practices, contact the Center for Agroforestry, in the School of Natural Resources, Anheuser-Busch Natural Resources Building, University of Missouri, Columbia, MO 65211.

If you wish to do additional reading, the following sources may be helpful:

Goff, Kate. 1999. Fugitive dust. *Erosion Control* (March 1999). P.O. Box 21647, St. Paul, MN.
U.S. Environmental Protection Agency. 1998. *National Air Quality and Emissions Trends Report, 1997.* Office of Air and Radiation, U.S. EPA, Research Triangle Park, NC 27711.

This publication was printed with funds provided to the University of Missouri by the U.S. Department of Agriculture through Grant no. U-5-37989, Air Quality Regulations and Missouri Agriculture.

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