Investigation of Water Runoff and Leaching Impacts from Dust Suppressants

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ABSTRACT

This project was funded by USEPA's Office of Research & Development through allocation of Regional Applied Research Effort funds. Supplemental funding and staff resources were provided by Clark County DAQEM and Maricopa County AQD. Six different dust suppressants, including four surfactants, one synthetic organic, and one synthetic polymer were evaluated for their impact on water quality, both runoff potential to surface water and leaching potential to ground water. From each County, one bulk sample of about 5 cubic yards and five one-gallon samples were collected. These soil samples were delivered to the San Diego State Soil Erosion Research Laboratory (SERL) for testing.

Soils were selected using soil maps contained in PM-10 plans and rules for the Las Vegas Valley and Phoenix for PM10 non-attainment areas. Staff from Clark County DAQEM and Maricopa County DAQM recommended specific locations from which the soil samples were collected.

SERL conducted: 1) pilot tests, 2) surface leaching (water runoff) tests, and 3) vertical migration tests. The surface leaching and column migration tests involved two soils in bulk quantity. The pilot tests involved both a pre-test of the bulk quantity soils and a separate test of 10 soils in small quantities.

1. INTRODUCTION

Fugitive dust accounts for 80% or more of particulate matter less than 10 microns (PM-10) in desert areas such as the Las Vegas Valley (Clark County, Nevada) and the Phoenix Metropolitan Area (Maricopa County, Arizona). Desert soils that tend to resist water have particularly high propensity for creating fugitive dust. These types of soils are prevalent in Clark County, Maricopa County, and other arid areas. The use of dust suppressants other than water can be beneficial, and in some cases necessary, to adequately control fugitive dust at earthmoving/construction sites. They also reduce the quantity of water needed for adequate dust control, thereby contributing to water conservation. Without the use of dust suppressant products, earthmoving of soils with high potential to create fugitive dust in hot temperatures may require constant watering to comply with fugitive dust regulations.

The purpose of this research was to identify dust suppressant products with minimal to no adverse impacts on water quality and aquatic life relative to use of water alone. Simulated stormwater runoff from small-scale soil plots treated with six dust suppressant products was evaluated for water quality and aquatic toxicity. The study also evaluated the quality of water leached through soils treated with dust suppressant products.

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2. STUDY DESIGN

The study design replicated, to the extent possible, conditions under which dust suppressants are typically applied at construction sites in desert climates. This included use of soils from Arizona and Nevada, a simulated 5-day earthmoving period with soil disturbance and repeated product applications, and heating soils to desert temperatures during the day. Emphasis was placed on dust suppressant applications to control dust during active earthmoving, e.g., rough grading. Surface runoff tests incorporated different combinations of two product application scenarios, three rainfall intensities, and three rainfall time periods (up to 2 months following product application).

2.1 Soil Selection and Collection

Clark County DAQEM and Maricopa County AQD recommended specific locations for soils collection by reviewing soil maps contained in PM-10 plans and rules for their respective areas. The maps classify soils by texture and corresponding severity of dust-emitting potential. The following soils were collected for use in the study:

- Two (2) five cubic yard soil samples -- from one site in Maricopa County, Arizona and one site in Clark County, Nevada
- Ten (10) one gallon soil samples -- from 5 sites in Maricopa County and 5 sites in Clark County

Soil for the surface runoff and vertical migration experiments was collected "in bulk" from a single site in Maricopa County and a single site in Clark County. Approximately 5 cubic yards was removed from each site by backhoes digging to a depth of 1 foot. Soils for the pilot experiment were collected from five sites in Maricopa County and five sites in Clark County. The ten sites are intended to represent a general survey of random soil types and particulate emissions potential. At each of the ten sites, 1-2 quarts of soil to a 1-inch depth were collected.

Once the soils were delivered to SERL, the two bulk soils were re-mixed to ensure homogeneity for segmenting into individual test trays and columns. Each bulk soil was placed on a clean tarp, spread into a square approximately 1 foot deep. The soil was then divided into four equal quadrants using stakes and string lines. Next, 30-gallon plastic garbage cans (previously cleaned with reverse osmosis water) were filled with equal parts of soil from each quadrant. The garbage cans were labeled, covered and transferred inside for storage.

2.2 Dust Suppressants and Application Scenarios

USEPA Region 9, Clark County DAQEM, Maricopa County AQD, and EQM selected 6 dust suppressant products with good potential for minimal impacts on water quality and aquatic life. Table 1 shows the products selected, along with product-to-water ratios and application rates recommended by the manufacturers (for Jet-Dry, the product-to-water ratio and application rate were recommended by a representative of the construction industry).

Table 1. Dust Suppressant Products and Recommended Product Application Rates

Product	Manufac-turer	Suppress-ant Type	Product-To-Water Ratio	Applica-tion Rate
Chem-Loc 101 (CL)	Golden West Industries, Inc.	Surfactant w/ ionic and anionic properties	1.0 gal per 5,000 gal water	4,000 gal per 2 acres
Enviro RoadMoisture 2.5 (ERM)	Envirospeci alists Inc.	Surfactant (non-ionic alcohol ethoxylate)	1.0 gal per 2,500 gal water	4,000 gal per 2 acres
Durasoil (DS)	Soilworks, LLC	Synthetic Organic	Product not diluted with water	1 gal/30 ft^2 & 1 gal/185 ft^2
Jet-Dry (JD)	Reckitt Benckiser	Surfactant	1.0 gal per 2,000 gal water	4,000 gal per 2 acres
Haul Road Dust Control (HR)	Midwest Industrial Supply	Surfactant	1.0 gal per 2,000 gal water	4,000 gal per 2 acres
EnviroKleen (EK)	Midwest Industrial Supply	Synthetic Polymer	Product not diluted with water	1 gal per 40 ft^2 & 1 gal per 250 sq. ft^2

Two application rates were provided for Durasoil and EnviroKleen, one in lower quantity appropriate for an earthmoving activity, the other in higher quantity appropriate for soil stabilization. Product manufacturers provided samples of their dust suppressants for use in the study

Half of the dust suppressants were designated for testing on the Arizona bulk soil (CL, ERM, and DS) and the other half for testing on the Nevada bulk soil (JD, HR, and EK) in the surface runoff and vertical migration experiments.

In order for the study to replicate real-world dust suppressant use, an experimental design was developed to assess the effects of repeated product applications and simulated soil disturbance. A 5-day period was selected as a typical length of time to accomplish rough grading at a construction site. The study design included raking of soil to a 1-inch depth in order to simulate disturbance necessitating product re-application.

Two re-application scenarios for the 5-day period were developed for each dust suppressant product, to which we refer as “Application Scenario A” and “Application

Scenario B". For the surfactants (all products except EnviroKleen and Durasoil), Application Scenario A involved applying product each day throughout the 5-day period while Application Scenario B involved applying product only on Days 1, 3 and 5. Soil was raked once a day for both application scenarios at approximately 90 degrees relative to the direction of the previous day's raking. For the synthetic products (EnviroKleen and Durasoil), Application Scenario A involved applying a lower quantity of product each day (see Table 2-5) along with soil raking once per day. Application Scenario B involved applying a higher quantity of product (see Table 2-5) in a one-time application and no soil raking.

All soils in the test trays were heated during the day to mimic desert conditions. This was done with appropriately spaced heat lamps to increase the temperature of the soils to approximately 86-104 degrees Fahrenheit for 12 hours each day. Soils were heated during both the 5-day dust suppressant application period and throughout the aging periods (up to 2 months).

2.3 Surface Runoff, Surface Leaching, and Pilot Experiments

The study analyzed surface runoff and subsurface leaching from soils treated with dust suppressants for nine standard water quality parameters: (1) pH, (2) Total Dissolved Solids (TDS), (3) Electrical Conductivity (EC), (4) Dissolved Oxygen (DO), (5) Total Organic Carbon (TOC), (6) Total Suspended Solids (TSS), (7) Nitrate, (8) Nitrite, and (9) Phosphate. In addition, surface runoff was tested for toxicity to aquatic life (fish, algae, and invertebrates). Furthermore, pilot tests with soils collected from multiple locations in Arizona and Nevada were conducted to gauge the potential of dust suppressant products to mobilize pre-existing salts and/or metals in soils.

2.3.1 Surface Runoff Experiment

The surface runoff tests were performed on a 3-meter wide by 10-meter long tilting test bed with overhead rainfall simulators. The test bed was outfitted with eight platforms designed to hold removable soil trays (i.e., "test plots") 14 inches wide, 25 inches long, and 4 inches deep. The soil trays were suspended in the center of the platforms and, during the experiment, tilted to a 33% slope. Rainwater was applied to the soil trays using a Norton Ladder Rainfall Simulator, developed at the USDA-ARS National Soil Erosion Research Laboratory. Nozzles are spaced 1.1 meters apart and at least 2.5 meters above the soil surface.

The rainwater used in the experiment was tap water treated with reverse osmosis, henceforth referred to as "RO-water". RO-water was used for three purposes: 1) as artificial rainwater to generate surface runoff from soil test plots; 2) as a dust control alternative applied to soil test plots to represent "untreated" control scenarios; and 3) to dilute products where specified in the dust suppressant application scenarios.

The surface runoff experiment involved 3 simulated rainfall events representing a range of desert climate precipitation capable of creating stormwater runoff (0.7 in/hr for a duration of 150 minutes, 1.3 in/hr for a duration of 80 minutes, and 2.4 in/hr for a duration of 44 minutes). The rainfall events were timed to occur at three different periods, i.e., "ages", following dust suppressant application.

AGE 0 - immediately following the 5-day application period
AGE 1 - one month following the 5-day application period
AGE 2 - two months following the 5-day application period

The purpose of including rainfall event scenarios one or two months following product application was to capture any biodegradation effects that may occur over time. Given the combination of the various test parameters, a total of 126 soil trays were prepared -- 18 for each of the six dust suppressants plus 18 untreated (RO-water alone applied).

Following application of dust suppressants according to either Application Scenario A or B, the soil trays were placed on the tilting test bed to undergo one of the three simulated rainfall events at one of the three aging cycles. The untreated soil trays were subject to the same experimental parameters as soil trays treated with dust suppressants.

Surface runoff from each soil tray was directed into a plastic flume discharging into a 4 liter, wide-mouth sample bottle. Thus, a water runoff sample was generated for each of the 126 trays.

2.3.2 Vertical Leaching Experiment

The vertical leaching tests were conducting using 4-inch diameter vertical flow columns. The vertical leaching tests were conducted using the same 5-day application scenarios as in the surface runoff tests (including dust suppressant re-application, soil raking, and soil heating), except dust suppressants were applied in lower quantity due to the smaller container size. Another difference was that RO-water was applied to the top of each soil column and held at constant head. This simulates a circumstance in which rainwater has collected into a puddle or pond and gradually infiltrates.

A total of 80 soil columns were prepared -- 12 for each of the six dust suppressant products plus 8 untreated columns (RO-water alone applied). Effluent from the bottom of each soil column was collected in 4-liter, wide-mouth sample bottles.

2.3.3 Pilot Experiment

For the pilot tests, 1-2 quarts of soil collected from five locations in Arizona and from five locations in Nevada were placed into 4-inch diameter by 2-inch depth cylinders. The intent of these tests was to evaluate sensitivity of select water quality parameters to differences in soil chemistry to gauge the potential of dust suppressant products to mobilize salts and/or metals that may pre-exist in soils.

Dust suppressants were applied to each of the soil cylinders. Following this one-time application, the cylinders were stored for 24 hours. Next, 300 ml of RO-water was applied to each cylinder and the entire soil-water mixture was transferred to a 1-liter sample bottle. The soil-water mixture was then analyzed for pH, Electrical Conductivity, and Total Dissolved Solids.

All six dust suppressant products plus water-only control tests were evaluated on all 10 soil samples. The pilot experiment generated a total of 140 results for each of the 3 water quality parameters tested.

3. STUDY RESULTS

Overall, water quality results for the dust suppressant products were favorable, showing concentrations similar to water-only control tests on untreated soils for the majority of parameters evaluated. For a subset of parameters and dust suppressant products, average results were higher relative to control tests. However, considerable variation among control sample values warrants conservative data interpretation, particularly in cases where average results for dust suppressant products were only marginally higher.

A trend was observed for Total Suspended Solids (TSS) values in surface runoff from soils treated with Durasoil and EnviroKleen. TSS reflects the quantity of sediments suspended in water and resulting water clarity. TSS concentrations corresponding to these two products were significantly higher relative to control samples (on average, five times higher in Durasoil runoff and twice as high in EnviroKleen runoff). The higher TSS values appear to relate to the products' soil binding characteristics and the tendency for larger dirt clumps to form and be released in surface runoff relative to tests involving untreated or surfactant-treated soils. In a real-world setting, overland runoff typically travels some distance, creating opportunity for heavier dirt clumps to settle out prior to reaching a water body. Also, use of an on-site retention pond as a stormwater best management practice would likely prevent off-site runoff.

Results from the subsurface leaching tests show no potential impact from the dust suppressants on groundwater quality for the parameters evaluated. (While subsurface leaching TSS results from a couple of products were higher than control samples, TSS is generally not a concern for groundwater quality.)

In pilot tests on multiple soil types that examined the water quality of a soil/water/product mixture (as opposed to surface runoff), Total Dissolved Solids (TDS) concentrations for two products -- Enviro RoadMoisture 2.5 and Durasoil -- were significantly higher than control samples. TDS refers to inorganic solids dissolved in water, such as mineral salts. In contrast to these results, TDS values observed in surface runoff tests involving Enviro RoadMoisture 2.5 and Durasoil were not higher relative to control samples. The high

TDS pilot test results may be a facet of experimental design rather than an effect that would occur in surface runoff. Additional research could assess the actual potential of the two products to mobilize salts in surface runoff from multiple soil types.

Aquatic toxicity results were also generally favorable. No toxicity to fish was observed in any dust suppressant product runoff. No significant inhibition of algae growth was observed in the two or more samples per dust suppressant product that were successfully tested. A caveat to this favorable outcome is that the algae test protocol required fine filtration of samples that removed significant quantities of sediment to which the dust suppressant products may have adhered.

Toxic effects to the invertebrate *Daphnia magna* were observed in some samples, however, most runoff samples from the surfactants showed no significant impact. For the limited instances when an adverse effect on daphnia survival was observed in surfactant runoff relative to control test runoff, variability among control test results renders the effect inconclusive.

Runoff from Durasoil and EnviroKleen showed a significant impact to *Daphnia magna* survival rates across all tests. This effect was not a classic toxic response but related to physical entrapment of the daphnia in an insoluble product layer. However, the entrapment observed within small laboratory test containers does not represent an effect likely to occur in an open water body, given various potentially mitigating factors. Furthermore, any such effect would likely be localized to a small area. Pure product tests with Durasoil and EnviroKleen showed that the physical entrapment effect does not extend to a smaller invertebrate also commonly used in toxicity testing, *Ceriodaphnia dubia*.

The results of this study should in no way be construed to support the use of substitute dust suppressant products that have not undergone similar testing and may have other and/or more significant potential impacts to water quality or aquatic life than the limited effects observed in this study.