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Man and Dust--A Unique Perspective from Southeastern New Mexico/West Texas

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Introduction

Results of two studies involving humans' influences on dust in the New Mexico/West Texas region will be presented. The first study deals with aerosol particles from the vicinity of the Waste Isolation Pilot Plant (WIPP), which is located near Carlsbad, NM and is the first permitted deep underground repository for defense-related nuclear waste in the U.S.A. This study was funded by a grant from the U.S. Department of Energy, and it was designed to provide an objective and independent means for evaluating the potential effects of the WIPP on the environment. The second study focused on emissions from a cattle feedyard located near Friona, TX. That study was sponsored by a seed grant from the U. S. Department of Agriculture, and it was a collaborative effort involving scientists from Texas A & M Agricultural Extension Service, the Carlsbad Environmental Monitoring & Research Center (CEMRC), the Department of Biology, New Mexico State University, Las Cruces and Texas A & M University. The objectives of the feedyard study were to begin an evaluation of the physical, chemical and microbial characteristics of fugitive particulate matter from cattle feedyards in the southern High Plains.

The WIPP Environmental Monitoring Project: Aerosols

Methods As part of an environmental monitoring program focusing on the WIPP, aerosol samples were collected and analyzed to characterize the spatial and temporal variations in the activities and concentrations of selected radionuclides and inorganic substances in the atmosphere around the WIPP. High-volume aerosol sampling was conducted at three sites which were named (1) On Site, (2) Near Field, and (3) Cactus Flats. ^{239,240}Pu was determined by alpha spectrometry following chemical separations.

A separate set of low-volume aerosol samples was collected and analyzed for major ions and trace elements, using ion chromatography and inductively-coupled emission spectrometry and mass spectrometry for the analyses, respectively. Gravimetric determinations were made only for the high-volume radionuclide filters.

Results The average ^{239,240}Pu activity concentrations in total suspended particles (TSP) samples (1.2 to 1.8×10^{1} nBq m^{-3}) were similar to those previously reported (Lee et al., 1998), but they varied substantially with season, with the highest values generally in spring. Further, the ^{239,240}Pu activity concentrations were comparable among the three sites, and therefore there was no evidence for elevated ^{239,240}Pu activities due to WIPP operations. The partitioning of ^{239,240}Pu activity concentration in PM_{10} (particles less than 10 µm diameter) samples relative to TSP (50-55% of the^{239,240}Pu was in the PM_{10} fraction) was slightly lower than the corresponding PM_{10}/TSP ratios of high-volume mass or several inorganics (e.g., sulfate, aluminum or lead), indicating that ^{239,240}Pu tends to be on relatively large particles. The aerosol mass loadings
(µg m$^{-3)}$ and the ^{239,240}Pu activity concentrations were correlated for all sets of samples, but there was a clear difference at On Site where the TSP samples showed a higher mass to ^{239,240}Pu concentration ratio than the other sites. This indicates that activities or processes occurring at or near the WIPP site produced aerosols that contributed to the mass loadings but contained less ^{239,240}Pu than ambient aerosols.

Regression models showed that about 63% of the variability in ^{239,240}Pu activity concentrations could be explained by wind travel, sampling location, length of the sampling interval and aerosol mass. The ^{239,240}Pu activity concentrations also were correlated with aluminum (an indicator of mineral dust), implicating the resuspension of contaminated soils as an important determinant of ^{239,240}Pu concentrations in the aerosols. The ^{239,240}Pu/Al ratios for the aerosols were substantially higher than in soils, and this could be explained by the preferential binding of ^{239,240}Pu to small soil particles that have large surface area to mass ratios and also have higher aluminum contents than larger particles.

Ambient Air Quality Issues Related to Confined Animal Operations

Methods Three sampling trips were made to the Paco Feedyard, near Friona, TX, and on each trip, several types of samplers were used for different purposes. FRM PM_{10} samplers were used to collect aerosols and Whatman 41® filters were used as sampling substrates for the studies of trace elements and major ions presented here. Inductively-coupled plasma mass spectrometry (ICP-MS) and graphite-furnace atomic absorption spectroscopy (AAS) produced data for more than thirty elements (Ag, Al, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Dy, Er, Eu, Fe, Gd, Hg, K, La, Li, Mg, Mn, Mo, Na, Ni, Pb, Pr, Sb, Sc, Si, Sm, Sn, Sr, Th, Ti, Tl, U, V and Zn) in acid digests of the filters. The detection limits for the ICP-MS and AAS analyses are in the low parts per billion range and uncertainties are typically 10 to 20%. The concentrations of major ions (chloride, nitrate, phosphate, sulfate , sodium, ammonium, potassium, magnesium, and calcium) in aqueous extracts of the samples were determined by ion chromatography (IC).

Samples of feedyard soils also were collected, and they were analyzed by AAS for As and by ICP-MS for the same suite of elements as in the aerosol samples. Aqueous extracts of the these soil samples were filtered through a 0.45μm syringe filter and then analyzed for the same suites of anions and cations as the aerosol samples using the same IC methods.

Results The concentrations of thirty-four elements and nine ions were determined in the majority of the aerosol samples. Of the trace elements readily determined by ICP-MS, only Sn was below detection in all of the aerosol samples, but the data for As, Be, Cd, Hg, La, Se either were sparse or below detection in the soil samples (see below), and therefore those results will not be presented here. Most of the elements (Ba, Ca, Ce, Dy, Er, Eu, Fe, Gd, K, Li, Mg, Mn, Mo, Na, Nd, Pr, Sc, Si, Sm, Sr, Th, Ti, Tl, U, and V) in the aerosol samples were associated with mineral dust particles, i.e., they were correlated with Al, an indicator of dust, and they exhibited ratios to Al similar to those in crustal material. In contrast, several elements Ag, Cr, Cu, Ni, Sb, Zn, and to a lesser extent Co and Pb, were enriched in the feedlot atmosphere over the levels expected from mineral dust, suggesting there are important non-crustal sources for these elements.

In general, the concentrations for the trace elements in the upwind and the downwind aerosol samples were comparable, with differences in the arithmetic mean concentrations typically less than 30%. None of the elements analyzed had concentrations that were more than 50% lower in the downwind samples relative to the upwind samples. However, K, Mo and Na had mean concentrations that were 2-fold higher in the samples collected downwind of the feedyard, and Ni and Mg were 40% to 70% higher in the downwind samples. While these differences are not statistically significant at probabilities for chance occurrence of 5% or less, they are generally consistent with trends in the soil data.

The major ion data for aqueous extracts of the aerosol samples also show some differences related to their orientation relative to the feedlot. For nitrate, sulfate, ammonium, and calcium, the differences between the upwind and downwind were small, less than 30%, but chloride, phosphate, sodium, potassium, and magnesium were 2- to nearly 5-fold higher in the downwind samples relative to the upwind ones. As was true of the elemental data for the acid digests of the aerosol samples, these downwind/upwind differences in aerosol ion composition are generally consistent with patterns evident in soils.

The concentrations of most elements (expressed as mass of the element per unit mass of soil) in the upwind soil sample were either about same or higher than those in the downwind samples. This is precisely what one would expect if there were a substantial amount organic material in the downwind samples, a situation that would lead to an effective "dilution" of the elements of interest on a per unit mass soil basis. There are several notable exceptions to the downwind/upwind depletion of trace elements however: K, Mg, Na, Ni and Zn exhibited concentrations that were ~2-fold higher in the downwind samples. Although the available sample set is small, the concentrations of these elements were quite comparable in the three independently collected downwind samples, suggesting a reasonable degree of homogeneity among those soil samples. Calcium was higher in acid digests of the downwind soils by about 50% compared with the upwind sample, and Mo was higher by ~25%. Ca, K, Mg and Zn are all essential nutrients that are either naturally elevated in feed components for the cattle or are routinely included as dietary supplements in feedyard rations. Zinc, in particular, is added to feedyard diets as a micronutrient owing to its involvement in protein and carbohydrate metabolism as well as immune system function. The slight enrichment of Mo is likely not be significant while the elevated concentrations of Ni in the downwind samples may be due either to some mechanical aspects of the feeding operations in which metal particles are shed, or to some unknown cause.

Interestingly, the major ions showed some even larger differences than the trace elements between upwind versus downwind soils. All of the ions except calcium and nitrate in the aqueous soil extracts (this includes chloride, phosphate, sulfate, sodium, ammonium, potassium, and magnesium) were enriched in the downwind soils compared with the one from upwind of the feedyard; these major ion enrichments ranged from ~7X to more than 100X, but most were around 10 to 20X. Soluble calcium also was enriched in the downwind samples, but the difference was less than 2-fold and thus probably not significant. Nitrate was measurable in the upwind sample but below quantitation limits in the downwind samples--this is equivalent to a difference of more than 1000X, and at present is difficult to explain.

Conclusions

The WIPP EM studies indicate that the resuspension of mineral particles contaminated with radioactive fallout from nuclear weapons tests is a major, if not controlling, influence on the concentrations of $^{239,240}Pu$ in the atmosphere. No effects from the WIPP itself could be detected, but continued monitoring serves a useful purpose, i.e., maintaining public confidence that the WIPP is operating safely. In contrast to the WIPP, the effects of confined animal operations on visibility are readily observable even to the untrained eye, and the odors emanating from feedyards often are considered a nuisance. The preliminary study of the Paco cattle feedyard is a first step in developing a scientific understanding of the chemical and health effects and socioeconomic implications of airborne particulate matter emitted from feedlots.

References

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