Characterization of Ambient Particulate Matter in the Paso del Norte Region

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ABSTRACT

Air pollution in the Paso del Norte region, where West Texas abuts the southern boundary of New Mexico and the northern boundary of Chihuahua, Mexico is a common concern to the residents on both sides of the border. Parts of the region fail to meet the U.S. and Mexican Ambient Air Quality Standards for particulate matter, ozone, and carbon monoxide. The regional air pollution problem is complicated due to arid climate, complex terrain topography, frequently occurring temperature inversions, extensive unpaved urban areas, an aging and poorly maintained vehicle fleet, and a number of other uncontrolled anthropogenic emission sources. The issue is further complicated by concerns arising from recent scientific evidence of the health effects associated with exposures to fine particulate matter.

A study designed to address particulate matter (PM) air pollution problems in the region is currently undertaken by researchers from member universities of the Southwest Center for Environmental Research and Policy and several governmental agencies. The study attempts to 1) characterize the fine fraction of PM; 2) identify and characterize the major regional emission sources; 3) apportion the fine fraction of PM to the source emissions; and 4) establish a regional technological information clearinghouse. The short-term goal of this research is to initiate a research program to characterize, identify, and quantify the sources and nature of the PM in the region. The long-term goal of this study is to establish regional research capabilities to continue air quality monitoring, evaluation, modeling, and control after the implementation of the study.

A scoping study to collect regional PM was conducted in December 1998. Several 2-hour and 24-hr samples were collected on medium-vol samplers, low-vol dichotomous samplers, single-filter Federal Reference Method PM_{10} or $PM_{2.5}$ samplers for chemical speciation and high resolution microscopy. A full-scale study will be performed later to further characterize ambient PM concentrations based on the observations from the scoping study. Emissions profiles for the major sources will be collected, and the full-scale study will include deep characterization of selected samples using inductively coupled plasma mass spectrometry for overall elemental

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composition, confocal microscopy for interstitial particle characterization, and X-ray near edge adsorption spectroscopy for metal speciation. Source apportionment receptor modeling will also be performed. This paper discusses the objectives and plan outlined in the study along with some preliminary results and remarks from the scoping study.

INTRODUCTION

The Paso del Norte (PdN) region is located along the United States - Mexico border where West Texas abuts the southern boundary of New Mexico and the northern boundary of Chihuahua. The area is surrounded by the narrow north-south trending chain of the Franklin Mountains in El Paso and the south-west trending Sierra de Juarez Mountains in Cd. Juarez.[1] The current population in the combined community of El Paso, Cd. Juarez, and Sunland Park exceeds two million. Approximately 333,000 vehicles are registered in El Paso and 420,000 vehicles in Cd. Juarez with an average of approximately 40,000 vehicles crossing the U.S./Mexico border into El Paso each day.[2] Over the past decade, the number of sources emitting air pollutants in the region has increased rapidly as economic activity and the population grows.

Air quality in the region is among the worst along the U.S. – Mexico border and presents a unique air pollution problem different from other urban areas in the U.S. Perhaps the most noticeable evidence of air quality degradation in the region is the tan haze hanging over the region during the morning hours. The lack of rain and vegetation, frequently occurring inversion conditions, complex terrain topography, extensive unpaved urban areas, an aging and poorly maintained vehicle fleet, anthropogenic emissions from the industries, and other environmental factors coalesce to make particulate matter (PM) a serious air pollution problem in the region.

Under the U.S. National Ambient Air Quality Standards (NAAQS) and Mexico's Official Environmental Laws, the region has been classified as "non-attainment" for several criteria air pollutants. Parts of El Paso County fail to meet the NAAQS for particulate less than 10 μm in diameter (PM_{10}), carbon monoxide (CO), and ozone (O_3). Sunland Park, in Southern Doña Ana County, New Mexico, adjacent to west El Paso, exceeds the NAAQS for O_3 and PM_{10}. Cd. Juarez air quality exceeds the Mexican ambient air quality standards for PM_{10} (150 $\mu g/m^3$ for 24-hour average and 50 $\mu g/m^3$ annual average), O_3 (0.11 ppmv for 1-hr average) , and CO (11 ppmv for 8-hr average).[3] According to data collected by the State and Local environmental agencies on both sides of the border, PM is found in greater concentrations near the following areas: 1) south-central El Paso near the UT-El Paso campus at Vilas Elementary School and the Sun Metro Public Transit Terminal (CAMS40); and 2) near the Mexico 68 brickmaking community in central Juarez. All of these sites can regularly be found to report PM concentrations at or above the PM NAAQS for their respective country. For instance, during the last quarter of 1998, the 24-hr average PM_{10} standard was exceeded at least 5 times in Cd. Juarez.[4]

The U.S. Environmental Protection Agency (EPA) recently promulgated new PM air quality standards for atmospheric aerosols with an aerodynamic diameter less than 2.5μm ($PM_{2.5}$). In July 1997, the proposed $PM_{2.5}$ air quality standards were adopted. Specifically, 24-hour average $PM_{2.5}$ shall not exceed 65 $\mu g/m^3$ for a 3-year average of annual 98th percentiles at any population-oriented monitoring site in a Metropolitan Planning Area (MPA) and 3-year annual average $PM_{2.5}$ shall not exceed 15 $\mu g/m^3$ from a single community-oriented monitoring site or the spatial average of eligible community exposure sites in an MPA.[5] Because of the health implication of the new $PM_{2.5}$ standards and the potential impacts on El Paso's non-attainment status, a couple of studies have been conducted in the region attempting to characterize regional aerosols.[6,7] The maximum 24-hr $PM_{2.5}$ concentrations in El Paso remain relatively high among the major cities in Texas. Among the 13 sites in Texas where preliminary $PM_{2.5}$ monitoring was conducted for a period of 11 months (March 1997 through Jaunary 1998), the highest three 24-hr average $PM_{2.5}$ concentrations (71, 40, 40 $\mu g/m^3$) were all recorded at El Paso.[6] Moreover, a higher percentage of organic matter than expected was found in the PdN aerosol.[7]

A multiplicity of factors contribute to and exacerbate the PM problems in the region. Some are unique to the border area; each reduces visibility and increases particulate haze. Some are difficult to prioritize or estimate due to the social, geographic, economic, regulatory, and political differences between the two international jurisdictions. For instance, emissions resulting from the fleet of newer U.S. vehicles could easily exceed that of the generally older model Mexican vehicles due to the high vehicle miles traveled per vehicle and the large number of vehicles utilized. Furthermore, efforts to mitigate air pollution problems could be complicated by disputes as to which country emits more pollutants into the air basin. Under provisions of the Clean Air Act, a non-attainment area is subject to stringent cleanup requirements and may be penalized for failure to meet the requirements specified by the NAAQS. However, a border city such as El Paso may not be penalized if it can demonstrate that it has taken all necessary measures to control sources within the region, and its failure to meet the NAAQS is due to emissions generated outside the U.S.[8] Factors that are commonly agreed on are:

- large quantities of dust from the surrounding desert and undeveloped areas within the community, unpaved roads, and quarry operations as well as wind blown dust during days of heavy winds and sand storms;
- a low per capita and household income which manifests itself in an aged and poorly maintained vehicle fleet and the burning of scrap wood and refuse material for home heating and cooking in the more economically disadvantaged regions of Cd. Juarez, El Paso, and Sunland Park;
- aerosols produced by commercial and industrial activities such as refining, smelting, scrap metal foundries, open-burning batch-type brick making, and agricultural activities;
- other terragenic, anthropogenic, and biogenic sources.

It is estimated that 50% of the urban roads in Cd. Juarez are unpaved.[9] El Paso County has approximately 800 miles of unpaved roads, but these roads encounter very little vehicular traffic and are generally in undeveloped areas of the region.[10] It is worthwhile to note that in El Paso PM concentrations from paved roads far outweigh those from unpaved roads.[11] The significant geological sources in the region make the PM pollution in the region different from that of the East Coast (where sulfates are important) or the Los Angeles basin (which has high nitrate concentration).[6,12]

In light of the new and sometimes controversial findings on the health effects of $PM_{2.5}$, the uniqueness of the PM pollution in the region, and the new NAAQS for $PM_{2.5}$, it is important to characterize the fine fraction of the atmospheric aerosol and determine with a high level of confidence the sources of these air pollutants for the PdN region.

PROJECT STATEMENT

An air research program to characterize the ambient PM pollution in the region is developed by the University of Texas at El Paso (UTEP) in collaboration with four universities (University of Utah, New Mexico State University, Arizona State University, and Universidad Autonoma de Cd. Juarez) and several U.S. and Mexican agencies. In the short term this program seeks to attain four objectives:

- **Objective 1:** Characterize the nature of $PM_{2.5}$ and PM_{10} within the region. Determine the organic and inorganic contents, spatial and temporal distributions and chemical composition of the PM concentrations.
- **Objective 2:** Conduct and support activities to develop and/or refine PM emissions inventories in the region. Determine the fingerprints of PM sources.
- **Objective 3:** Conduct PM chemical mass balance/receptor modeling. Identify the sources of emissions and their relative strengths.
- **Objective 4:** Establish a regional information center or clearinghouse to coordinate other monitoring and research activities in the region. Improve coordination and sharing of data with other programs.

The long-term goal of this research is to establish regional research capabilities to continue air quality monitoring, evaluation, and modeling after the implementation of the study. A scoping study has been completed to determine optimal equipment siting and sample analysis followed by a more comprehensive study. All results obtained from this program will be published and made available to the public. Recommendations from the research team will be outlined for future studies. Benefits that will accrue from identifying and controlling the dominant sources of particulate air pollutants include improved visibility, reduction in mortality due to the decreased concentration of fine particles, and decreased morbidity due to decreased concentrations of particle-borne hazardous air pollutants.

OVERVIEW OF RESEARCH ACTIVITIES

Four technical groups were formed to address the four objectives. A work group coordinator is assigned to coordinate the research efforts and to lead the research team in each work group. A technical advisory board is formed to provide advice, monitor the research activities, review project progress, and ensure that the research is in line with the stakeholders' interests. The technical advisory board consists of eight senior experts representing the EPA, INE, TNRCC, SCERP, CERM, the City of El Paso, Cd. Juarez, and an external research organization.

Objective 1: PM Characterization

Deployment and Analysis. Implementation of Objective 1 requires deployment and operation of an array of PM_{10} and $PM_{2.5}$ samplers; gravimetric analysis of the air samples; and chemical analyses using EPA-referenced methods or other improved methods. Additionally, existing data or archived filters should be reviewed and possibly analyzed prior to any new field measurements. The proposed study contains a scoping study and a full-scale study. The scoping study is designed to determine optimum spatial deployment of the PM sampling equipment and to identify major sources of PM emissions. Based on the results of the scoping study, a full-scale study will be performed to characterize the PM concentrations in the air basin.

In addition to the existing PM monitoring stations (Figure 1) operated by TNRCC, NMED, and EPCCHED, at least 6 $PM_{2.5}$ and PM_{10} sampling sites within the region will be considered. Complete chemical analyses will be performed on the samples collected from some of these sites. The sampling sites should cover locations upwind and downwind of the air basin, preferably one down the Rio Grande, one on the eastern side of the Franklin Mountains, and one in suburban Juarez upwind of the seasonal prevailing wind direction coming into the region. Speciation of the ambient aerosol is necessary to identify emission sources which require special attention and control measures. It will also identify those components which pose special hazards to human health through chronic inhalation exposure, as well as other components which may be unique in the air basin and require further toxicological or dose-response studies. Specific research activities for Objective 1 are:

Experimental Design. An air monitoring plan will be prepared to determine the minimum number and locations of $PM_{2.5}$ and PM_{10} sampling sites based on the meteorological, topographical, and sociological conditions of the PdN basin as well as recommendations made from the scoping study. The air sampling network should be coordinated with other agencies responsible for ambient air quality monitoring to avoid redundancy and to maximize the efficiency of the proposed air sampling network. The air monitoring plan should also include duration of sampling time, sampling methods and procedures, sampling media, frequency of sampling, siting criteria, a data assurance program, and a monitoring program for meteorological parameters. Table 1 identifies the various PM samplers and the agency or organizations responsible for their deployment in the PdN basin. Table 2 identifies the sites where the PM samplers are or will be deployed by the State and Local agencies.

Field Measurement. Air monitoring will be conducted at selected sites in El Paso, Dona Ana County, and Cd. Juarez with the appropriate air sampling protocols for quality control. Necessary technical support and field operation procedures shall be documented to ensure data quality. A control site equipped with a Versatile Air Pollutant Sampler (VAPS) will be deployed at the PAMS site in El Paso. Additional instrumentation, including a multi-stage cascade impactor will be used to collect samples using filters covering various ranges of particle size. Samples collected from the control site will undergo detailed chemical speciation to include "deep" characterization of the PM in the air basin. Based on data obtained from the control site samplers, ambient samples collected from other PM monitoring stations may be selected for "deep" characterization.

Laboratory Analysis. The nature of ambient PM will be characterized by analyzing the air samples using laboratory analytical methods consistent with those promulgated or proposed by EPA and newer emerging techniques such as transmission electron microscopy, scanning confocal microscopy, high-resolution electron microscopy, proton induced X-ray emission, ion chromatography, inductively coupled plasma mass spectrometry, etc. Samples may be analyzed by multiple techniques for overall elemental composition, metal speciation, inorganic solid phases, and solid organic phases.

"Deep" characterization of the PM will be obtained by high-resolution laser scanning confocal microscopy (LSCM) which generates a three dimensional image data set when 2-dimensional images (or slices) at each focal plane are reassembled. The advantage of LSCM over conventional light microscopy is that it incorporates a pin-hole in front of a photo-detector to only admit light that is in a single tightly defined focal plane. This rejection of out-of-focus light allows true 3-dimensional image of a particle, with the resultant images having a good contrast and clarity. The image may be manipulated to analyze and measure surface features of particles.

Data Analysis and Reporting. The mass fraction, spatial distribution, and temporal variation of $PM_{2.5}$ and PM_{10} concentrations, and/or visibility impairment within the air basin will also be determined. Using the results from the laboratory analysis, attempts will be made to further characterize the major sources contributing to chemical components of $PM_{2.5}$ and PM_{10}, including sources that directly emit particles and those that emit precursor gases for secondary aerosol formation. Data analysis shall focus on quantifying secondary aerosol contributions, identifying the limiting precursors, and assessing whether controls on sulfur oxides, nitrogen oxides, volatile organic compounds or ammonia would be effective in reducing aerosol formation. The analysis should also compare $PM_{2.5}$ and PM_{10} data, both mass concentration and chemical constituents. It is expected that the data analysis will help draw general conclusions indicating where the sources are and how they affect the air quality in the region.

Objective 2: Emission Characterization

Over the past decade, the number of sources emitting pollutants in the PdN basin has increased rapidly as the populations of Cd. Juarez and El Paso grew 40 percent and 23 percent, respectively.[2] The majority of emissions information available is obtained using standard EPA AP-42 emission factors, the MOBILE-5 emission model, and screening-level engineering calculations. Information on emission sources in Cd. Juarez is particularly difficult to obtain since data submitted by the facilities is not considered public information. Certain existing emission factors for sources in Mexico require further confirmation because these factors, possibly derived from the U.S. emission data, may not be applicable to the emission configurations in Mexico. Specific research activities for Objective 2 are:

Experimental Design. This aspect of the program will attempt to identify and characterize the chemical composition of air pollutants emitted by major sources contributing to $PM_{2.5}$ and its precursors (VOC, NO_x, SO_x, NH_3) in addition to those identified by TNRCC.[11] The major sources of pollutants in the PdN basin identified by TNRCC are the following: motor vehicles, open-burning of trash, home-fuel consumption, brick kilns, small-scale industrial sources, and fugitive solvents from painting, architectural coatings and manufacturing processes. This program will also determine the methods for estimating emissions from those sources at which samples cannot be collected and prepare an emissions monitoring plan for existing and new sources.

Field Measurement. This program will determine the profile of PM emissions from a variety of existing and new sources in the PdN basin using either a dilution chamber or near-field source sampling.

- Geological sources, including paved and unpaved roads, quarry operations, agricultural tilling, and other selected sources;
- PM emissions from household scrap burning for cooking and heating. It may be desirable to measure hourly PM emissions during the evening hours.
- Characterize the PM emissions from brick kilns, diesel engines, power plants, scrap metal foundries, smelters, refineries, industrial furnaces, and commercial establishments.

Laboratory Analysis. This aspect of the program will be conducted to determine the chemical composition of samples collected from established and newly identified sources. Laboratory methods will be similar as those mentioned above to include chemical speciation and microscopy of PM samples collected at the various sites in the PdN basin.

Data Analysis and Reporting. Analysis on source emissions shall include the following:

- Quantify and characterize the $PM_{2.5}$ and PM_{10} components of geological material, including fugitive dust emissions from the desert (upwind of the air basin), unpaved and paved roads, and quarry and agricultural activities.
- Determine the spatial and temporal distributions of the atmospheric emission loading to the air basin from mobile sources in El Paso and Cd. Juarez.

Objective 3: CMB/Receptor Modeling

As in the case of the $PM_{2.5}$ analyses for Objective 1, Objective 3 requires a variety of standard chemical analysis for characterizing the emission sources. From these analyses researchers could determine the chemical characteristics of major PM sources which will identify the areas or facilities where emissions inventories should be performed or control measures should be considered. Source apportionment of PM concentrations and emission profiles for different emission categories will be analyzed by the chemical mass balance (CMB)/receptor model.[13]

The basic concept of the receptor modeling approach is the apportionment of the contribution of each source, or group of sources, to the measured concentrations without reconstruction the dispersion pattern of the pollutants.[14] In designing and evaluating CMB studies, the use of other receptor modeling techniques, e.g. principal component ("factor") analysis (PCA) based methods, can be highly effective.[15] Not only can PCA techniques provide information about the maximum number of independent source patterns involved ("intrinsic dimensionality") but also about the most informative analytical parameters and their degree of correlation ("collinearity"). Finally, PCA based methods such as target factor transformation can be used to help validate source apportionment values calculated by the CMB model.[16] Specific research activities identified for Objective 3 are:

Field Measurement The field measurements defined under Objective 1 will be jointly performed with the work group of Objective 3. Results of the PM chemical analysis will be used for source apportionment. In addition, as studied in Mexico City, ammonia sources may be a major source for odor and secondary ozone formation. It may be desirable to identify the major ammonia sources and their emission rates in the region. Major physical and chemical signatures collected under Objective 2 will be incorporated into the source apportionment study.

Laboratory Analysis It is also desirable to research into the origin and molecular composition of carbonaceous compounds and to identify the molecular markers that can be indicative of the origin of the particulate matter (as individual markers or as characteristic patterns of multiple markers)[17] and the magnitude of the source. For example, smoke aerosols contain thermally unaltered markers indicative of their respective taxa. Vehicular exhaust can be traced using the markers steranes and pentacyclic triterpanes.[18]

Data Analysis and Reporting Concurrent recording of the regional meteorology, especially the air flow, using routinely collected atmospheric measurements would be necessary. Surface wind, temperature, and humidity measurements are continuously collected hourly at several air quality measurement sites in the region. Hourly surface and twice-daily upper-air meteorological data is collected by the National Weather Service. The data could be used in a diagnostic meteorological model to locate potential sources of emissions by back trajectories. In addition, the following tasks will be performed:

- Estimate source contributions to PM, both with respect to mass concentration and the concentration of significant chemical components, and relate these contributions to different emissions and meteorological conditions.
- Apply the CMB/receptor modeling results, new and existing source profiles, and ambient air speciation data to evaluate the contribution on the ambient air concentrations from major sources such as open burning, household heating and cooking, diesel and gasoline engine exhausts, air traffic, power plants, smelters, tires, biogenic emissions, agricultural processes, and other remote dust sources.
- Among the various receptor modeling techniques described in the literature the chemical mass balance (CMB) model has been particularly successful in providing quantitative source contribution estimates ("source apportionment"). However, in order to obtain reliable results strict attention needs to be paid to experimental design, e.g. with regard to the $PM_{2.5}$ parameters to be measured, and to the identification of all sources contributing more than a few percent of the total $PM_{2.5}$ mass.

Objective 4: Air Quality Information Center and Clearinghouse

This task will provide a clearinghouse for data, publications, and shared information necessary to support the air research program. The clearinghouse will also provide tools and take on a critical role in overall project management and task coordination.

Specific Publications and Data. The clearinghouse will obtain specific publications and data recommended by the research team as critical to the initial work tasks. An initial baseline of information will include, wherever possible, raw data from previous studies and research pertinent to the initially planned tasks. A searchable resource database of related bibliographic information, research databases, experts, and participating organizations will be established. The database will include accumulation and archival of historic and current air pollution related projects. A public-access Internet site will be developed for the overall project to support public inquiries and promote overall education and information about regional air quality.

Project Management System. A secure project management system will be developed to identify and define the various goals, objectives and tasks of each work group, schedule deadlines, milestones, key events. This system will allow project participants to record the status of each task and link to detailed information on each activity.

E-mail List-Server. An interactive E-mail list-server will be developed to facilitate coordination among workgroup participants. A list-server shall be created for the overall project and for each of the workgroups.

Geographic Information Systems Integration and Development. The searchable resource database will be integrated into existing Geographic Information Systems currently being developed by regional institutions and government agencies. The integrated GIS will include standardization of data sets to be consistent with GIS formats and develop metadata for project databases. This task shall also include the establishment of specific GIS database coverages to include the locations of air monitoring stations within the project limits, emission sources, meteorological stations, land use characteristics, and other socio-economic information.

SCOPING STUDY

Prior to implementation of the full-scale study, a scoping study designed to identify major sources of PM emissions and their corresponding key PM characterization parameters, as well as relevant meteorological parameters in the study area, was undertaken. Based on the results of the scoping study, a broader long-term full-scale study will be performed to characterize the ambient PM concentrations and source concentrations and provide the necessary input data for the CMB modeling task. Sampling and monitoring for the scoping study was undertaken during a 72-hour, round-the-clock period between Dec. 2 and 5, 1998.

Experimental Design

Sampling and Monitoring Equipment Deployment Strategy. In order to cover the largest number of major sources with the smallest number of mobile and fixed sampling and monitoring sites the scoping study was designed to encompass a triangular area with the apex pointing upwind of the known PM problem areas and the base sited downwind of these areas. Moreover, by using a triangle-within-a triangle approach, thus surrounding the inner (most highly polluted) area by an outer (less highly polluted) sector for siting scoping study samplers and monitors the stage was set for detecting the same sources at different PM levels. In principle, this approach should facilitate subsequent principal component analysis (PCA) of the data because of the expected presence of clear PM parameter gradients, thereby enhancing correlated behavior between different classes of parameters, e.g. organic and inorganic, affected by the same sources. This dual triangle approach was based on the meteorological and topographical conditions of the region as well as prior PM study results reported by Dattner et al.[12] The large triangle extended from Lindbergh Elementary School in far west El Paso County, to Escontrias Elementary School in far east El Paso County, to a police station in the southeastern section of Juarez. The inner triangle connected the Sun Metro/CAMS 40 station, Well 414 in east El Paso, and the Juarez Technical Institute. The planned dual-triangle scoping study configuration is shown in Figure 1.

Alas, as discussed in subsequent paragraphs, uncommonly high rain precipitation levels during the first 16 hours of the scoping study resulted in unusually low PM levels. This reduced the number of sites that could be effectively sampled and monitored by the two mobile sampling and monitoring stations within 72 hours to only 4, instead of the 6 originally planned. Thus, the shape of the two planned, nestled triangles reduced to a less comprehensive set of more or less parallel lines on both sides of the border (as indicated by the thick lines in Figure 1).

Sampling and Monitoring Regimen The following sampling and monitoring regimen was implemented during the Scoping Study:

- Continuous PM Size Distribution Analysis and Meteorological Monitoring: Four sites (2 in El Paso and 2 in Juarez) were used by the mobile stations. Samples were collected at the Sun Metro/ CAMS40 site and at the Juarez Technical Institute site on Dec 2/3/4 by two mobile stations and at the Well 414 site and Police Station site on Dec. 4/5 after both stations moved approx. 8 miles southeast of the first two sites.
- Two-hourly Interval PM Filter Sampling by the Mobile Stations: Medium-volume (approx. 2,000 L) quartz fiber filter (QFF) and low-volume (approx. 120 L) polycarbonate filter (PCF) samples were collected at 2-hourly intervals at all 4 sites concurrent with the continuous monitoring. QFF samples were analyzed by TD-GC/MS whereas PCF samples were collected for PIXE and scanning electron microscopy (SEM) analyses with X-ray emission spectroscopy, using specially developed streaker samplers.
- 24-hour Sampling Using Hi-volume Graseby Anderson PM_{10} Samplers: Special QFF samples were collected at the Advanced Transformer, 20-30 Club, Juarez Technical Institute and Vilas Elementary School sites in central El Paso, and at the Ivanhoe Fire Station site in east El Paso for organic analysis by solvent extraction GC/MS.
- 24-hr Sampling Using Low-volume Sierra Anderson Dichotomous Samplers: Samples of fine and coarse PM were collected on PCF and PTFEF media at Tillman Health Clinic in downtown El Paso, and Advanced Transformer site in Juarez between Dec. 2 and 4, 1998.
- 24-hr Sampling Using a URG Versatile Air Pollutant Sampler (VAPS): Dichotomous samples using the VAPS were collected on PCF and PTFEF media at the CAMS40 site.
- 24-hr Sampling Using RP2025 Sequential $PM_{2.5}$ Partisol Samplers: $PM_{2.5}$ samples were collected on QFF, PCF and PTFEF media from midnight to midnight at CAMS40, Tillman Health Clinic, Lindbergh School and Escontrias School sites.
- 24-hr Sampling Using Hi-volume PM_{10} and TSP Samplers: In addition, routine monitoring of PM_{10} and TSP samples using QFF media was performed by the State and Local agencies at Sunland Park and La Union, NM.

Preliminary Results and Discussions

The scoping study began on Dec. 2, 1998. Difficult meteorological and technical conditions were encountered on the first day of the study. Technical difficulties were overcame by midnight of the first day and field activities were concluded on Dec. 5 at 12:00 noon.

- A more or less comprehensive physical and mathematical analysis of the hundreds of samples taken will require much more time. However, priority is currently being given to the 2-hr interval QFF and PCF samples obtained by the mobile station teams because of the valuable additional information about source type, e.g. in relation to various diurnal anthropogenic activity cycles that can be obtained from time-resolved data. Moreover, in principle such time series can be directly correlated to continuous particle size distribution, particle aromaticity or meteorological monitoring data, e.g. by means of PCA-based multivariate analysis techniques.

- Figure 2 shows several days worth of continuous $PM_{2.5}$ and PM_{10} concentration profiles at the Sun/Metro and Well 414 sites, together with the PAS2000 particle "aromaticity" data. Note the low PM concentrations early on and the gradual return to "normal" levels as the air purification effects of the extended rainfall period started to wear off. Further note that the PM data has been calculated by averaging the corresponding particle size counts from an 8-channel Climet analyzer (after converting particle size data to the corresponding spherical volume data) and then calibrated (to correct for nonsphericity and average local particle density values) by using hourly density readings from a Beta-gauge system operated by TNRCC at the same site. Also note that the PAS2000 particle data, believed to be dominated by particles rich in aromatic content, e.g. soot and car exhaust particles, reveals a rather different profile than the $PM_{2.5}$ and PM_{10} profiles. Since this appears to be one of the first occasions where a PAS2000 system has been used for receptor type ambient air analyses in conjunction with other particle characterization methods, rather than as a source emissions monitoring device, we hope to learn more about the nature of the chemical information provided by this instrument (based on measuring the total electric current intensity produced by ambient particles after photoionization with a UV light source) which provides one of the very few methods capable of detecting single particles in real time and at an acceptable cost.

- Finally, Figure 3 shows selected PIXE (relative Al concentration) and GC/MS (relative concentration of the PNAH compound chrysene) data on 2-hourly filter samples obtained at the same sites as shown in Figure 2 (Sun/Metro and Well 414), as well as a selected Varimax-rotated PCA profile obtained from a combined data matrix of approximately 30 GC/MS, PIXE, particle concentration and PAS2000 parameters. This factor is currently being interpreted as a mixed "automotive emissions" (e.g. the PNAH signals) and "re-aerosolized road dust (e.g. the Al signal)" component which reached very high values late on Dec. 4 as the regional winds died and slow drainage from the Juarez area reached the Well 414 site. Final interpretation of this transient PM event, which appears to be a common occurrence along the US/Mexico border, awaits further integration with the detailed wind data available from TNRCC's SODAR system at the Well 414 site.

- Government agencies collect 24-hr air samples (both hi-vol PM_{10} and FRM $PM_{2.5}$ samplers) from midnight to midnight. This sampling interval makes it imperative that efforts to correlate PM collected on filters by external organizations should follow a similar sampling protocol in order to reduce the uncertainty in apportioning sources and assessing the temporal and spatial variation of PM at the sampling location. Alternatively, samples collected for continuous time segments at one location may be composited to reduce the uncertainties introduced from the temporal variation at the same location, if a comparison between samples collected from two instruments of different sampling intervals is desirable.

- Mass loss from the filters due to shipping and handling introduces a great deal of uncertainty to the gravimetric weighing results. In addition, static must be neutralized prior to shipment and a detailed QA/QC procedure should be instituted to prevent mass loss from excessive motion and vibration during the shipping and handling of filters. It may be desirable to perform a sensitivity study to evaluate the uncertainties involved in mass concentration measurements due to excessive mass loss during shipping and handling of the filter media.
- While the dichotomous samples are currently being evaluated, the preliminary results indicate that the ratio of the coarse (PM_{10}) to fine ($PM_{2.5}$) fraction of PM in El Paso is much lower than values reported for typical border communities or areas that are considered dominated by geological sources (e.g. approximately a factor of 2 for Brownsville, Texas)[19].

CONCLUSIONS

At the conclusion of this project we expect an improved library of knowledge regarding the aerosol in the PdN region. Information on the chemical content of $PM_{2.5}$ will identify the major sources in the region. Given the recent promulgation of the $PM_{2.5}$ NAAQS and the economic consequences involved in establishing control strategies should this region not attain that standard, this study will lead to an adequate and informative approach to support rational decisions by policy makers. Over the next few weeks and months team members will process and analyze a significant fraction of the samples and data collected during the scoping study in order to produce basic input to understand the chemical and physical nature of the PM and the dominant emission sources. A full-scale study is scheduled to be conducted in the winter of 1999.

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Table 1. Samplers to be Deployed for the Paso del Norte Air Quality Study

Sampler Type	Source	Location	#
Dichotomous PM_{10} / $PM_{2.5}$	UTEP Air Quality Group	El Paso, Juarez, SLP	8
Multi-Orifice Cascade Impactor	NMSU-CEMRC	El Paso, Juarez, SLP	1
Dichotomous PM_{10}/ $PM_{2.5}$	NMSU-CEMRC	El Paso, Juarez, SLP	1
Mobile Monitoring Lab	U of U	El Paso, Juarez, SLP	1
PM_{10} and TSP High Volume	NMED[1]	El Paso, Juarez, SLP	5
$PM_{2.5}$, PM_{10} and TSP High Volume	TNRCC[2]	El Paso	10
$PM_{2.5}$, PM_{10}	EPCCHED[2]	El Paso and Juarez	8
PM_{10} High Volume	NMED[2]	Dona Ana County	3
URG Versatile Air Pollutant Sampler	UTEP Air Quality Group	El Paso, Juarez - Supersite	1

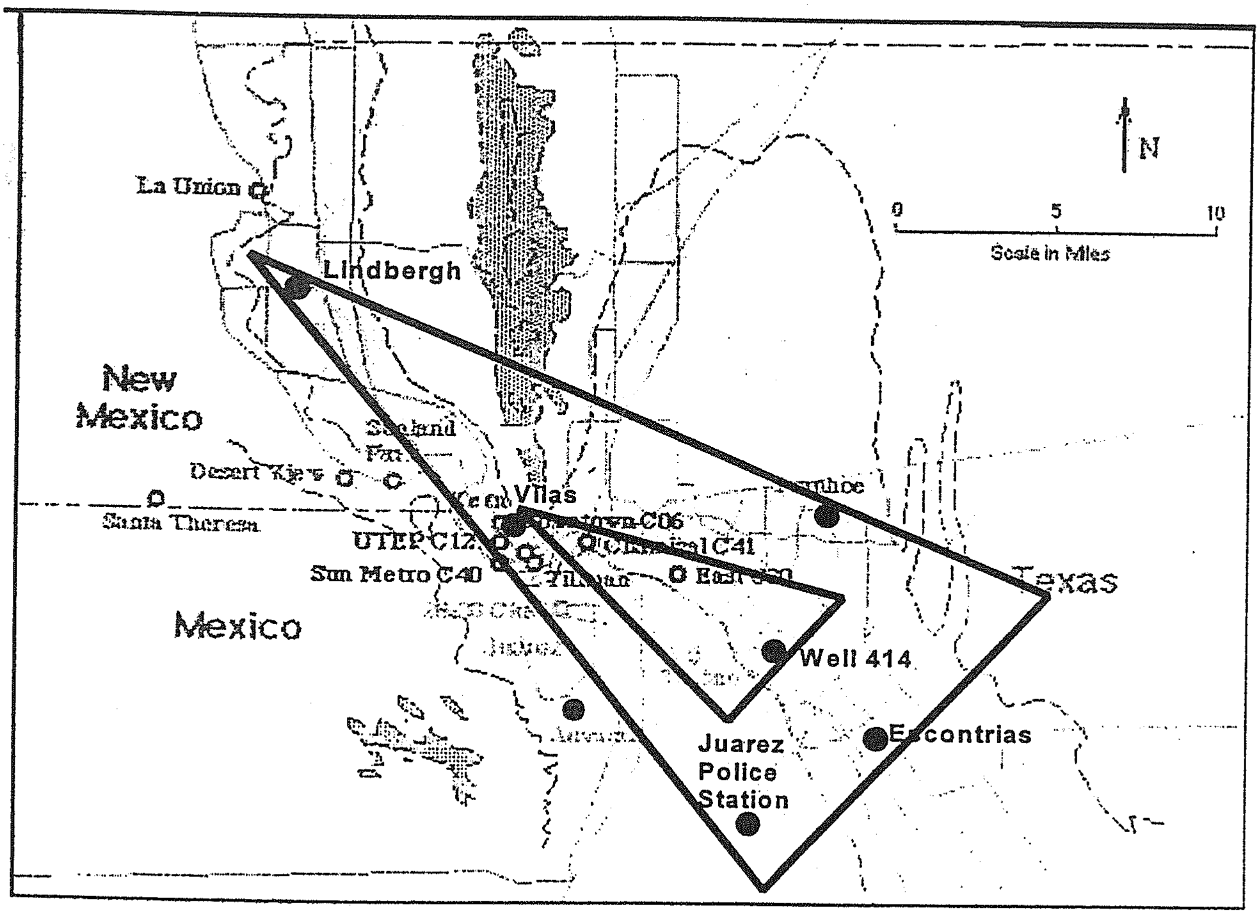
[1]samplers donated for the duration of this study

[2]samples collected and gravimetrically analyzed by the agency

Table 2. Sites currently operating PM_{10} samplers in Paso del Norte Air Basin

Site Name	Instruments
Tillman	PM_{10} / Beta gauge
Kern	TSP / SO_2
Chamizal - PAMS - CAMS 40	$PM_{2.5}$, PAMS / Beta gauge
Riverside School	$PM_{2.5}$, PM_{10}
CAMS 40	PM_{10} / Beta gauge
Northeast Clinic	$PM_{2.5}$, PM_{10}
Ivanhoe	$PM_{2.5}$, PM_{10}
Lindbergh School	$PM_{2.5}$, PM_{10}
Escontrias School	$PM_{2.5}$, PM_{10}
Tecno - Juarez	PM_{10}
Advanced Transformer - Jz	PM_{10}
20-30 Club - Jz	PM_{10}
Pestalozzi - Jz	PM_{10}
Zenco - Jz	PM_{10}
Desert View School, SLP	PM_{10}
SLP City Hall	PM_{10}

Figure 1. Map of the Paso del Norte Region with Local Ambient Monitoring Stations and Scoping Study Sampling Area



Ambient Monitoring Sites for Scoping study:

Cd. Juarez - Juarez Police Station, Advance

El Paso - Sun Metro - C40, Well 414

Supplemental Sites

El Paso - Escontrias, Vilas, and Lindbergh Elementary Schools, Ivanhoe Ambient Monitoring Station

Juarez - Juarez TEC, 20-30 Club

New Mexico - La Union, Sunland Park

FIG. 2 Sun Metro/Well 414 particle concentration profiles and aromatic data from PAS 2000.

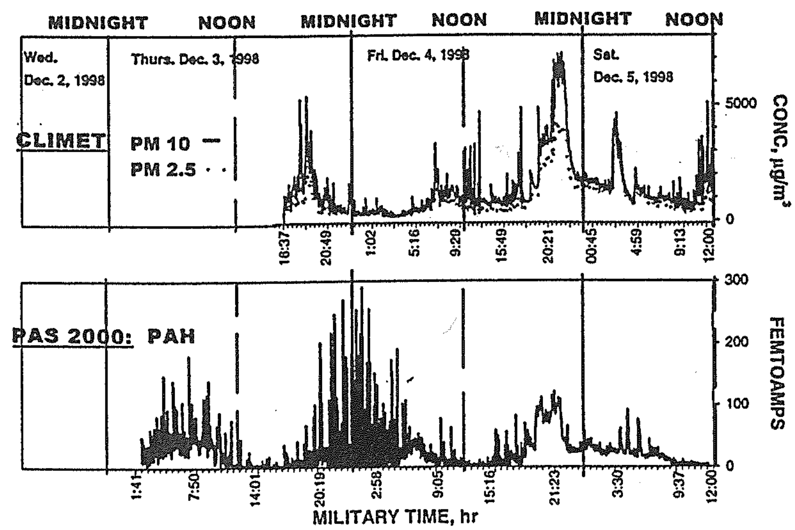


FIG. 3 PIXE, GC/MS, and PCA profiles from Sun Metro/Well 414.