Project Number: 90-Z11

PROGRESS REPORT:

Air Quality Aspects of the Production of Almonds and Walnuts

Almond Board Project Number 90-Z11

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From the limited time and budget of the 1990-1991 workyear, we were able to perform a small pilot study on PM-10 emissions from almond harvesting. The key details learned from this study were:

1. Tested almond harvest operations increased PM-10 concentrations from 50 to 450 micrograms per cubic meter. For comparison, the California State Air Quality Standard for PM-10 mass concentration is 50 micrograms per cubic meter (averaged over a 24 hour period).

2. Forty rows downwind of the test orchard, PM-10 levels dropped by a factor of about 2. This was due to the larger particles falling out as well as particles being filtered by the downwind tree canopy.

3. As almonds were sweeped into the center of rows (windrows) for pickup, the almond canopy was fairly effective in trapping and filtering dust in both the horizontal and vertical. Although the sweeping operation caused the dustiest conditions during almond harvesting, the tree canopy kept the dust at low levels not allowing the dust to travel as far downwind. Surprisingly, the downwind dust from the nut pickup operation and the sweeping operation were about the same (the pickup operation injected dust particles higher into the air).

4. Most of the PM-10 mass was geologic soil material (about 40-60% by mass) but there was a substantial amount of non-soil material. Most of this material was probably organic matter (eg. decomposed vegetation, fertilizer, etc.) and is estimated to be about 20-30% of the PM-10 mass in the dust from almond harvesting.

5. 80 to 90% of the measured mass was in the coarse mode (between 2.5 and 10 microns aerodynamic diameter).

From the work of our pilot study on almond harvesting, we now have information that will help us better quantify PM-10 emissions from nut harvest production (as well as any other agricultural operation) much more accurately and efficiently. During the rest of 1991, our approach of measuring upwind and downwind PM-10 concentrations by size and composition to calculate PM-10 emissions from their source will be used in a larger study in the San Joaquin Valley. We will perform the study for the Unified San Joaquin Valley Air Pollution Control District and is entitled "Study of Fugitive PM-10 Emission from Selected Agricultural Practices on Selected Agricultural Soils" (see summary included).

The objectives in this San Joaquin Valley study are identical to our work for the California Almond Board and the two studies can almost be treated as one. This will allow our 1991-1992 work for the California Almond Board to be much more extensive with enhanced equipment and methodologies. Our plan for this year is to use the sampling array proposed in the San Joaquin Valley study (5 sampling sites) which will provide us much more data than last year's work in almond harvesting (3 sites). Sample collection will probably again take place at the Steffen Ranch near Fresno during August and September. We plan to sample from 8 to 10 separate days during all phases of almond harvesting. Some objectives which we hope to accomplish include the following:

1. Improved sample collection array.

The key to this study is the manner in which the samples are collected. With the additional funding of the San Joaquin Valley study, more equipment has been purchased which will allow more detailed data and study (eg. 2 additional PM-10 filter samplers, 2 new meteorological stations, etc).

Under ambient conditions, all sampling sites should be the "same" in order to calculate PM-10 emissions from the source by subtracting the upwind from the downwind measurements. Last year's work taught us that our upwind sampling site was too close to the test orchard and it will be moved farther upwind. This year our downwind sites should be in a clear field (or field with small grains) that will not be a sink (or source) for dust particles as was the tree canopy last year.

Since most of the PM-10 particles from almond harvesting are larger than 2.5 microns, we will use our size segregating aerosol sampler (DRUM impactor) to resolve PM-10 concentrations into more appropriate size regions than our normal DRUM size-cuts. We plan to use 2 DRUM samplers (1 more than last year) to separate particles into the following size regions with an improved 2 hour time resolution: 0 to 2.5, 2.5 - 5.0, 5.0 - 10, 10 - 15 microns aerodynamic diameter.

2. All phases of almond harvesting must be considered.

Last year we were only able to collect samples for the sweeping and nut collection operations. This year all almond harvest operations must be sampled, analyzed, and interpreted

3. More detailed analyses of PM-10 sources to better resolve the soil and organic components (by size) in PM-10 emissions from almond harvesting.

This entails detailed elemental analyses (H, Na-Pb) of soil and almond samples to derive the composition of the soil and organic components in PM-10 aerosols. This will be done using a soil resuspension system that separates soils into 5 different size regions. This system takes into account that similar soil compositions may have different suspension characteristics (larger particles may not be as easily suspended in air).

4. Vertical sampling.

The higher a particle is injected into the air, the longer it will take to fall out. Therefore, we intend to take above ground PM-10 filter samples using a tethered balloon allowing our PM-10 emission calculations to take particle injection height into consideration. This will be especially important for the pickup of nuts in the field and into trailers.

5. More sophisticated methodologies and models.

With more detailed samples and data, there will be more accurate results but only with more sophisticated methodologies and models.

Study of Fugitive PM-10 Emissions

from Selected Agricultural Practices on

Selected Agricultural Soils

A Study for the

San Joaquin Valley Unified Air Pollution Control District

to be Performed by the

Air Quality Group
Crocker Nuclear Laboratory
University of California, Davis
Davis, California 95616-8569

Principle Investigator - Robert G. Flocchini
Investigator - Thomas A. Cahill
Project Manager - Robert T. Matsumura
Staff - Omar Carvacho and Zhiang Lu

May 20, 1991

Summary of Study

Reason for Study

Particles inhalable into the human respiratory system are at elevated levels in the San Joaquin Valley. The effect of agriculture on the concentration of these fugitive dust particles is unknown.

Overall Goal of Study

Determine impact (local and valley-wide) of agricultural practices on PM-10 levels. This will allow the San Joaquin Unified Air Pollution Control District to form and verify control strategies that reduce PM-10 emissions.

Short-term Goal

Develop methods for accurately measuring fugitive PM-10 emissions and emission rates from an individual site or operation.

Mid-term Goal

Identify practices, conditions and soils that have the highest propensity for PM-10 emissions.

Long-term Goals

Identify validated (field tested) best management practices which minimize PM-10 emissions.

An accurate inventory of fugitive PM-10 dust sources by individual farming emissions.

Workable and validated models for predicting PM-10 emissions, based upon operationable parameters.

1991 - 1992 Workyear

Our primary focus for this workyear is to form a foundation of work that will allow long terms goals to achieved in the most accurate and efficient manner possible. Much of the work will be in refining our methodologies.

Overall Approach

We propose to measure PM-10 from a source using a very direct model-independent analysis via aerosol mass gradients. This technique will yield data directly comparable to the calculations of existing models to reduce the uncertainties in the models and guarantee relevance to the San Joaquin Valley.

Our technique has been used at U.C. Davis since 1973 on a variety of scales, but the basic concepts are the same:

1. Measurement of upwind aerosol concentrations to separate the background from the source, with full compositional analysis for PM-10 mass and all its major components.

2. Measurement of aerosols close-downwind of the potential source with full size-time-compositional analysis.

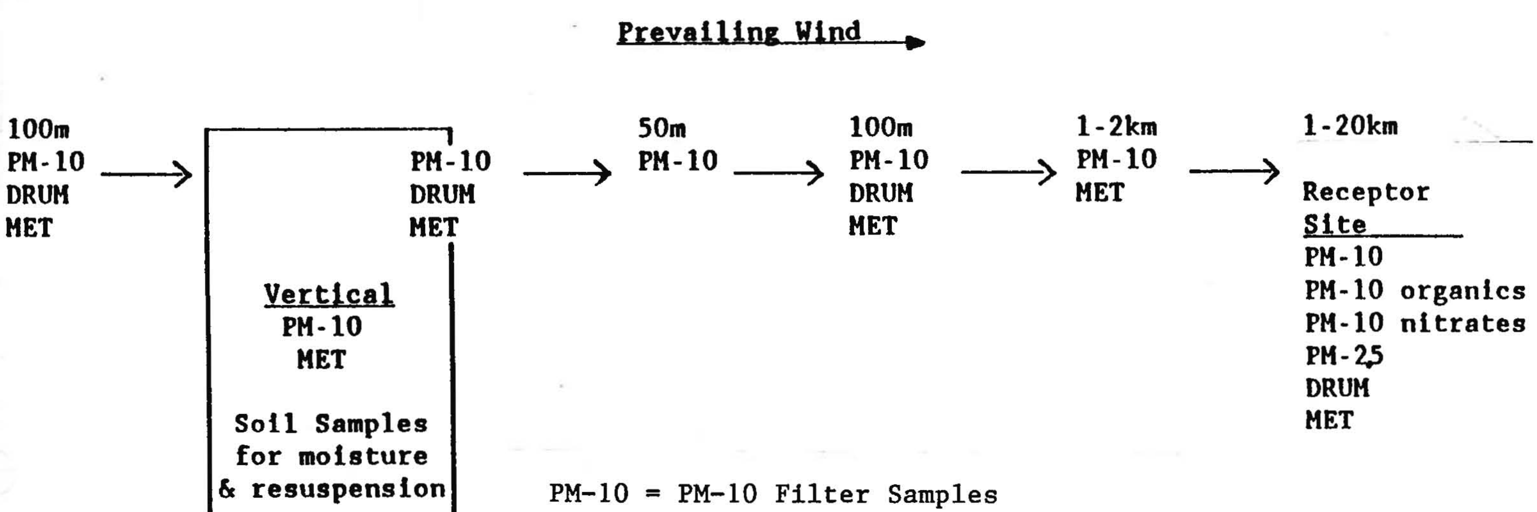
3. Measurement of meteorology in real time.

4. Measurement of far-downwind aerosol concentration, with full compositional analysis for PM-10 mass and all it's major components.

5. Direct calculation of source contribution by subtracting upwind from close-downwind aerosols with a "sliding box" model.

6. Calculation of aerosol concentration fall-off versus distance using the close-downwind size-time-composition and meteorology, for comparison to the far-downwind site.

Ideal **Sample Collection Array for Agricultural Field (not drawn to scale).**



PM-10 = PM-10 Filter Samples
DRUM = Size-Time-Compositional Samples
MET = Meteorological Measurements
PM-2.5 = PM-2.5 Filter Samples

Outline of Tasks

The tasks listed below form a general picture of the proposed work:

Task 1. Selection of sampling equipment and analysis methods to be used. (May - June)

Task 2. Analysis of valley PM-10 gradients (mass and agricultural component) and quality assurance comparison of proposed equipment with other commonly used samplers and equipment. (sampling: September - October; analysis: November-January)

Task 3. Consult with the PM-10 Screening Committee to select agricultural sites to be evaluated. (May)

Task 4. Collect data in the field and analyze for agricultural and non-agricultural signatures. (sampling: June - until rains and Spring, 1992; analysis: August - February)

Task 5. Generalize data and interpret results to form basis for predictive models estimating PM-10 emissions. (November - May)

Task 6. Identify key factors responsible for greatest PM-10 emissions. (February - May and Future)

Task 7. Formulate and test from actual measurements, reasonable ways to minimize and quantify reductions in PM-10 emissions. (Future)

Program Management for 1991 - 1992

Unified San Joaquin Valley
Air Basin Authority

Robert G. Flocchini
Thomas A. Cahill
Principal Investigators
Robert T. Matsumura
Project Manager

Ambient Air
Analysis
(Preliminary Tasks)
Cahill, Flocchini
Lu

Equipment/Methods
(Task 1, May to June)
Cahill, Flocchini
Matsumura, Carvacho
Teague, Raabe, Beveridge

Selection Of Sites
(Task 3, May)
Cahill, Flocchini, APCD
Matsumura, Outside Support

Valley Data Collection/Qual. Assur.
(Task 2 - Sept. to Oct.)
Matsumura, Carvacho
Lu, Students, Outside Support

Collect Data and Analyze
(Task 4, June to Feb.)
Carvacho, Matsumura
Lu, Students
Feeney, Wakabayashi

Valley Analysis And Interpretation
(Task 2 - Part 2, Nov. to Dec.)
Flocchini, Cahill
Matsumura, Carvacho, Lu, Students
Feeney, Wakabayashi

Interpretation and Modeling
(Task 5, Nov. to May)
Flocchini, Cahill
Matsumura, Lu, Carvacho

Identify PM-10 Factors and Mitigation Techniques
(Task 6 and 7 <u>in Future</u>)
Flocchini, Cahill
Matsumura, Lu
APCD, Agricultural and Soil Consultants

Methods

Portable Sample Collection	Analysis
A. PM-10 Aerosol Samples using IMPROVE Filter Samplers	A. Gravimetric Mass Elemental Composition (H, Na-Pb) Optical Absorption
B. Size-Time-Compositional Aerosol Samples using DRUM Impactor with 4 Size Regions (0 - 2.5, 2.5 - 5.0, 5.0 - 10, 10 - 15 microns)	B. Elemental Composition by Size (Na to Pb)
C. Meteorological Stations	C. Wind Speed & Direction, Temperature Relative Humidity
D. Soil Samples	D. Moisture Content at Site Elemental Composition (Na to Pb) by Size after Re-suspension
E. Vertical Filter Samples	E. Gravimetric Mass Elemental Composition (H, Na-Pb) Optical Absorption

Tentative Schedule of On-Site Sampling:
Agricultural Practices & Unpaved Roads

Agricultural Operation	County	Time of Year
Almond Harvest	Fresno	August - September
Preparation of Harvest	" "	" "
Shaking Trees	" "	" "
Windrowing	" "	" "
Picking up Nuts	" "	" "
Ambient Conditions	" "	" "
Cotton Harvest	Kern	October - November
Harvest - 1st & 2nd Picking		
Shredding of Stalks		
Stalk Incorporation		
Ambient Conditions		
Land Preparation	Any	Spring, Summer, Fall
Deep Tillage		
Discing		
Land Planing		
Bed Formation		
Ambient Conditions		
Land Leveling	Any	Spring, Summer, Fall
Unpaved Roads	Fresno Loguluso Ranch	June - July

Task 2. PM-10 in the San Joaquin Valley and Quality Assurance

Purpose

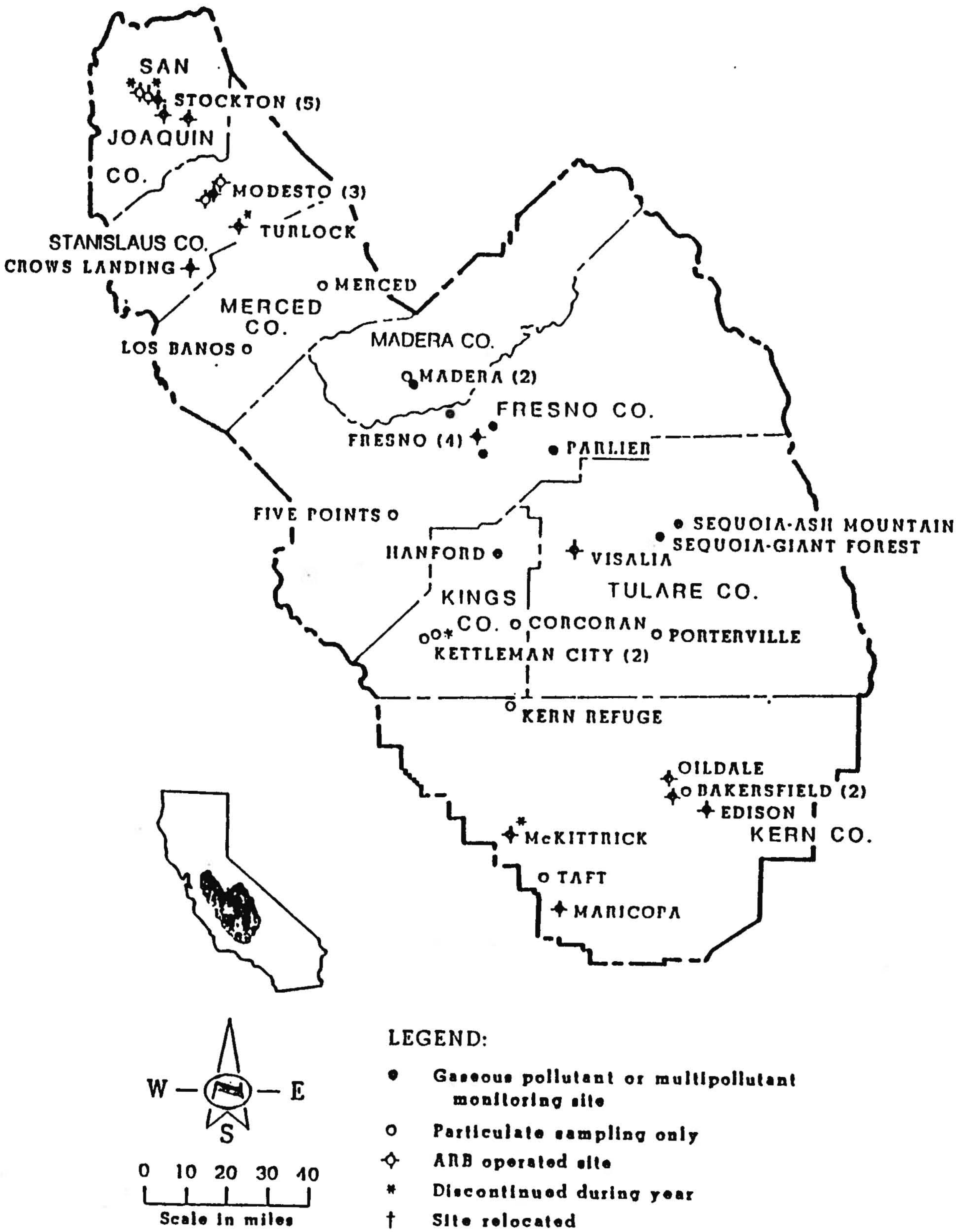
Evaluate impact of agriculture upon valley PM-10 gradients over a 2 week period when PM-10 levels are high.

Valley Sample Collection

- PM-10 Filter Samples (twice per day, 5 sites)
- Size-Time-Compositional Samples (4 size-cuts, 3 sites)
- Meteorology
- Air Resources Board Measurements (one day in 6 filter samples) for additional data and quality assurance comparisons

Valley Analysis and Interpretation (Optional)

- Analyze Samples for Composition (H, Na - Pb)
- Isopleth maps of PM-10 and soil component in the San Joaquin Valley (night and day)



Existing San Joaquin Valley Air Basin PM_{10} Sampling Sites.

Site Requirements For
Sampling Agricultural PM-10 Emissions

The basic requirement of a site for this study is that the only measurable source (or sink) of PM-10 emissions located in our sampling array is the one being tested. Ideally, ambient PM-10 concentrations should be the same for all upwind and downwind sampling sites when there is no PM-10 source.

1. Cooperation between farmers and U.C. Davis

   There will have to be the coordination of our sampling schedules and the agricultural operations being tested. This will require some flexibility in the timing of the ag operations but can <u>not interfere</u> with farm management.

   Possible diversion of traffic.

   Our sampling technique may require a systematic approach to the ag operation being tested (ie. an test field must be done in only one time period, only one ag operation can take place at once, etc.).

2. Size of test area (ag field) must be of adequate size.

   Minimum area: 1/4 mile x 1/2 mile

   Maximum area: 1 mile x 1 mile

3. Entire sampling area must be away from local combustion sources, such as diesel generators, automobiles, chimneys, and dumps.

4. Entire sampling area should contain a fairly uniform soil type.

5. Area surrounding test field

   No any detectable sources of manmade dust or pollution.

   No tall canopy that could be a sink for dust (short grains such as alfalfa or oats would be ideal)

6. Areas for sampling equipment

   Each of five sampling areas will require approximately a 15 x 15 foot area. The area must not have obstructions that would hinder sampling representative aerosols, such as tall trees or buildings.

7. Power

Our equipment works on typical AC power, 110 Volt, 60 Hz. Any power available would be of great help. We will have transformers to step down from 440 volt, three phase power (at many well pumps) or we can wire directly to a 220 volt line. We then have to run electrical cable to our equipment (on top of the ground or buried) which can extend to about the length of a football field.

AC power is not an absolute requirement at all sampling locations. We also have the alternatives of propane generators for AC power (available in July) as well as two 12 volt DC powered PM-10 samplers. These alternatives can be used in any combination allowing our samplers to be completely portable.

8. Security

The threat of theft or vandalism should be kept to a minimum. We will take as many precautions as possible, one of which is choosing a site with little history of theft or vandalism.

9. Access

Twenty-four hour access to all of our equipment should be available. Most of our work will take place during daylight hours and farmers will be notified of our work schedules. If 12 volt battery powered samplers are used, a nearby area to charge our batteries would be convenient.

Crocker Lab Air Quality Program

We have a large program with around 20 scientists primarily concerned with measuring the airborne particles that impair visibility and produce acid precipitation.

Visibility

Monitoring Network: We monitor the particles that impair visibility at 60 National Parks and Wilderness Areas. This is the major national network. We are responsible for the total program:

- designed the samplers
- supervise the sample collection
- analyze the filters
- interpret the results.

We are able to determine both the major components that directly cause visibility impairment and the trace elements that can help fingerprint the sources.

The program is called IMPROVE, for Interagency Monitoring of Protected Visual Environments.

The program is sponsored by

- the National Park Service
- the Environmental Protection Agency
- the Forest Service
- the Fish and Wildlife Service
- the Bureau of Land Management
- several interstate agencies

Special Studies to look at specific problems

- Grand Canyon National Park: winters 1987, 1989, 1990, 1991, July 1991-Sept 1992.
- Canyonlands National Park: winter 1990
- Mount Rainier National Park: summer 1990
- Shenandoah National Park: summer 1991, 92

California

We have two major programs within California and several special studies.

- Impact of Agriculture on Air Quality
  We will be starting a major study in the San Joaquin Valley this summer. We have completed a small study of the air pollution effects of vacuum-collection of almonds.

- Impact of Air Quality on Acid Deposition

- Special Studies
  Lake Tahoe: Impact of urbanization on air quality in the Tahoe basin
  Mono Lake: Impact of dry lake beds on air quality
  Sequoia: Impact of ozone on the forest
  Los Angeles Air Basin: How bad is it?

International

We are assisting several other nations in understanding and improving air quality.

- Currently we are working with Australia, Canada, Denmark, Finland, and Mexico.

- Future work is expected in Brazil, Chile, China, Hungary, India, Ireland, Japan, South Africa, and the USSR.

SampleCollection and Sampler Development

All particle samplers operate by drawing air through the sampler and depositing the suspended particles on plastic or paper.

We have designed all the samplers we have used. The first two samplers draw air through very thin filters, after first removing all larger particles.

- Stacked Filter Unit (SFU): a very dependable and inexpensive unit used for monitoring throughout the United States since 1979.
- IMPROVE sampler: This flexible sampler is becoming the standard for the nation. We are in the process of helping several other countries in developing identical units for their programs.

We have also developed a family of samplers that operate by having the airstream bend just before reaching a thin plastic strip. The particles then deposit on the plastic.

- Davis Rotating Unit Monitor (DRUM) sampler: This is the only sampler ever designed that gives both good size resolution (9 size ranges) and good time resolution (down to 4 hours).
- IMPROVE DRUM sampler: This is a variation of the 8-stage DRUM sampler that is designed for routine monitoring. This sampler will separate the particles into 3 size ranges and provide good time resolution (down to 4 hours). We believe this sampler will eventually be the national sampler for monitoring.
- Solar Monitor for Aerosols in Remote Terrains (SMART): We have recently developed a new sampler for the Forest Service that will require only solar panels and operate unattended for one month.

Analysis Methods

The filters are handled at our laboratory, with three full-time scientists and several students.

Gravimetric Analysis: We have extremely delicate electrobalances to weigh the material on the filters. We can weigh samples of less than a millionth of an ounce (5 micrograms).

Laser Integrating Plate Method: We have developed a method for measuring how much light is absorbed by the particles. These particles are mostly elemental carbon.

PIXE: The major analytical system is called Particle Induced X-ray Emission. The protons from the Crocker cyclotron passing near an atom in the sample will cause the atom to emit an x-ray whose energy characterizes each element. By counting the x-rays corresponding to each element, we can measure the concentration of all elements heavier than fluorine. Each analysis generally takes two minutes. We have made around 200,000 PIXE analyses since we began in 1972, which makes us the most prolific aerosol/x-ray laboratory anywhere. Fortunately, the system is automated.

PESA: Concurrently with the PIXE analysis, we also measure the concentration of hydrogen. This is done by a nuclear physics method called Proton Elastic Scattering Analysis. The primary value of the hydrogen measurement is that it permits us to calculate the concentration of organic particles.