T H E U N I V E R S I T Y O F M I C H I G A N

COLLEGE OF ENGINEERING
Department of Meteorology and Oceanography

Final Report

ATMOSPHERIC POLLUTION BY AEROALLERGENS: METEOROLOGICAL PHASE

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Vol. I

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INTRODUCTION

A major portion of the effort during the grant period has been devoted to the analysis of data obtained not only during the grant period but also during earlier periods. In a multifaceted study such as the present one, it is especially important to attempt at intervals a larger synthesis than has been previously achieved. Such a synthesis of knowledge concerning atmospheric diffusion of ragweed pollen in urban areas, and incorporating a number of new research findings resulting from the present grant, is presented in Volumes II and III of this Report. This synthesis permits us to achieve a fuller understanding of the atmospheric transport and dispersion of ragweed pollen in and near cities than has been available previously.

One of the continuing problems of the research program has been the lack of a general purpose pollen sampler capable of determining, for example, the diurnal variation of pollen concentrations without being serviced every few hours. An accurate yet relatively simple and inexpensive automatic pollen sampler which would determine daily variations with servicing only every 24 hours or more would be most valuable. Our efforts in this direction have led to the development of a Roto-Disc Pollen Sampler. This sampler is described briefly later in this report.

Additional studies were conducted to extend our understanding of the following aspects of the highly diverse problem of air pollution by ragweed pollen:

a. Prediction of the time of occurrence during the ragweed season of modal pollen concentrations based on early season temperature predictors.

b. The cause of the observed secondary evening maximum in atmospheric pollen concentrations.

c. Evaluation of the pollen emission from a plot of preseason ragweed plants.

These undertakings are described in somewhat more detail below, and are being written up for publication in the scientific literature.

EFFECTIVENESS OF POLLEN SAMPLERS

The pollen catch, ξ, of any atmospheric pollen sampler may be expressed as:

$$\xi = \int_0^T F(\eta, u, v, w, u_p, v_p, w_p, \chi, Re)\, dt$$

where

η = collection efficiency of the sampler;

u, v, w = instantaneous wind components; along wind, horizontally cross wind, and vertically upwards, respectively;

u_p, v_p, w_p = corresponding instantaneous pollen velocities;

χ = pollen concentration; and

Re = Reynolds number of sampler with respect to the air.

Examination of these variables showed each of them to be dependent on still another group of variables and parameters. For example, the collection efficiency of a sampler depends on the geometry of the system, the operation of the system, the filter efficiency or adhesive characteristics, and the turbulent structure of the flow field created by the sampler and the dependent pollen field within the sampling volume.[1]

No analytical solution to this problem has been found; hence an experimental approach seemed to be most feasible.

Experimentally, the problem appeared to consist of running the sampler in an environment of known pollen concentration for various values of the independent variables and parameters, counting the pollen catch, and evaluating the collection efficiency. However, no way could be found to establish accurately an atmosphere of known pollen concentration. A wind tunnel was used to obtain an air flow which was directed and known as contrasted with unknown turbulent atmospheric flows. With the emission of ragweed pollen into this air flow, an environment of airborne pollen was achieved, however, its concentration could not be determined *a priori*, but required measurement. Flag samplers[2] were used to measure relative spatial concentrations while an isokinetic membrane-filter sampler was developed to establish the actual concentration at one location. Statistical techniques could then be used to determine the pollen concentration in the vicinity of a sampler under test. However, the wind tunnel had to be relinquished to another group and it was never again available before the termination of the research grant. A measure of success did result from these experiments as the initial 139 runs demonstrated that the data were consistent with the collection efficies measured by Watson[3] (1954), May[4] (1942), and Griffith and Jones[5] (1940).

THE ROTO-DISC POLLEN SAMPLER

The currently available samplers measure a mean concentration over periods of one hour or more and in the case of the gravity slide, as commonly used, a mean over 24 hours. To increase the time resolution for atmospheric pollen-concentration measurements, a sequential sampler (Figs. 1 and 2) with a minimum time resolution of 5 minutes was developed and tested during the 1964 season. The details of the device and its operation are being prepared for publication. The analysis of the 1964 data demonstrates a complex fine structure in the time series of pollen concentration never before observed. The investigation of these time series and their correlations with meteorological variables should be pressed.

THE PREDICTION OF THE POLLEN CONCENTRATION MODE

The prediction of periods of maximum ragweed pollen concentration is necessary for the proper timing of field sampling programs and is of great value to allergists providing guidance and medical assistance to sensitive individuals. To develop a prediction scheme for the annual time of occurrence of the maximum pollen concentration, 14 years of data were analyzed. These data demonstrate a correlation between the date of the last killing frost and the modal day of pollen concentration. This initial analysis is sufficiently encouraging to warrant further studies with additional data.

4. Ten-minute samples taken in succession with 5-minute time lapse between successive sampling periods, door closed, fans on No. 2 speed:

a. Windows closed;

b. Windows open 1 in.;

c. Windows closed, precipitators on during run.

The results of some of these experiments were examined superficially during the course of the season for guidance in establishing the procedures for subsequent experiments. They are at present undergoing more thorough analysis, the results of which will be assembled either for inclusion in our final report or for separate presentation.

B. EXPERIMENTATION PLANNED

No further experimentation is planned, since the final quarterly period will be devoted fully to counting ragweed pollen on the Millipore filters, evaluating meteorological data from the records obtained, and analyzing the results for presentation in the final report.

C. AERODYNAMIC ANALYSIS

The aerodynamic analysis conducted during the report period will be presented in Scientific Report No. 2, "Turbulent Dispersion of Dynamic Particles," by Vi-Cheng Liu, scheduled for October, 1955. It is planned to submit this material for publication in the Journal of Meteorology.

II. PERSONNEL, ADMINISTRATIVE, AND FISCAL INFORMATION

The following changes in student employment on the project occurred:

Name	Position	Employment Dates: Started	Employment Dates: Ended
Gerald C. Gill	Assoc. Research Engineer	21 July	
J. A. Ismaili	Asst. in Research	26 July	25 August
P. Rangaswamy	Asst. in Research	15 August	
J. W. Hardin	Asst. in Research	26 August	2 September

INVESTIGATION OF THE EVENING POLLEN MAXIMUM

Detailed observations of daily pollen concentration show a secondary maximum of pollen concentration between 1600 and 2100 LST in addition to the primary maximum around 0900. To determine whether ragweed plant emission or complex atmospheric transport is responsible for this particular phenomenon an experiment in a closed system was carried out preseasonally in 1963. A control chamber was devised to isolate, consecutively, small populations of the three local varieties of ragweed plants. An automatic sampling, sensing, and recording system provided climatic and relative pollen emission data in the test chamber. A secondary peak was not observed under these controlled conditions. The conclusion was reached that the ragweed plants do not cause the secondary maximum. The various possible atmospheric mechanisms have not yet been examined in detail.

POLLEN EMISSION FROM RAGWEED PLANTS

A knowledge of pollen source strength is necessary for ragweed pollen diffusion studies in the atmosphere. Direct measurements of the airborne pollen flux from a uniform circular plot of greenhouse-grown ragweed plants were made with a novel whirling arm pollen sampler (Fig. 3) developed especially for this purpose. From theoretical considerations, an equation has been developed to relate the pollen catch on the sampling surfaces to the pollen flux from the ragweed plot. Application of this equation to the whirling arm sampler data for the peak emission period of 1959 produced a pollen flux in satisfactory agreement with that estimated by other means. Further development and utilization of this device in a variety of meteorological conditions will lead to further understanding of atmospheric influences on ragweed pollen emission.

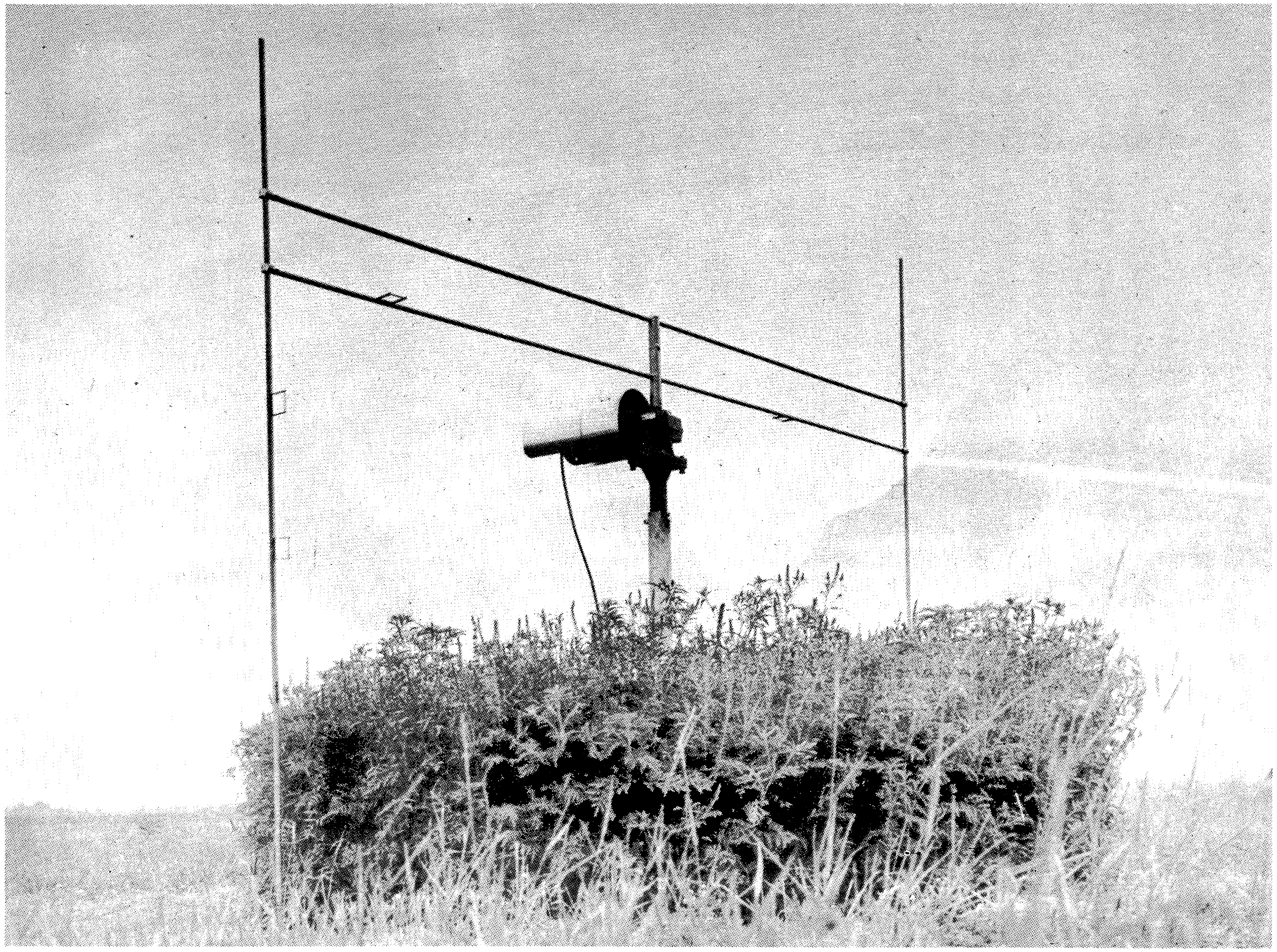

Fig. 3. Whirling arm pollen sampler.

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