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GEOGRAPHICAL DISTRIBUTION OF THE RADIOACTIVITY OF THE ATMOSPHERE

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NRL REPORT 3862

GEOGRAPHICAL DISTRIBUTION OF THE RADIOACTIVITY OF THE ATMOSPHERE

I. H. Blifford

October 11, 1951

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ABSTRACT

Measurements of the natural radioactivity of the air have been made at several widely separated locations. On the average, radium products comprise from 50 to 90 percent of the total activity. Most locations exhibit a definite minimum during the year which may be associated with seasonal changes. Marked short-term variations were noted at all locations. No direct correlation between dust and nuclei counts was found at Washington, D.C., where the radioactivity concentration appears to follow changes in the ground-level temperature and humidity.

PROBLEM STATUS

This is an interim report on the problem; work is continuing.

AUTHORIZATION

NRL Problem C10-02R

Manuscript submitted for publication July 2, 1951

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GEOGRAPHICAL DISTRIBUTION OF THE
RADIOACTIVITY OF THE ATMOSPHERE

INTRODUCTION

The radioactivity of the air has been the subject of a large number of investigations and until quite recently has been considered mainly from the standpoint of its contribution to the electrical conductivity of the atmosphere (1, 2). Among the earliest observations were those of Elster and Geitel (3) who used a long charged wire to collect radioactive material from the air. The collection was measured by placing the rolled-up wire inside an ion chamber and identifying radium and thorium decay products from the rate of discharge. Since these early measurements, many investigators have contributed to a constantly increasing body of knowledge. Recent advances in collecting and measuring techniques have made it possible to add to the available information on the geographical distribution and to indicate some of the meteorological aspects of the variations.

Radium and thorium are widely distributed and present to a certain extent in all soil and rocks. Sea water also contains small quantities of both elements. The average amount of radium in rock is given as 23×10^{-12} gm/gm and that of sea water less than 1×10^{-15} gm/cc (2). The radioactive matter in the air has been estimated at about 1.2×10^{-18} Curie/cc.

The radium and thorium in the soil undergo transformations and produce the radioactive gases radon and thoron. These gases diffuse into the atmosphere and form the elements of the characteristic decay series.

Most of these products (isotopes of bismuth, lead, and polonium) become highly charged by the recoil effect and attach to particulate matter.

PROCEDURE

Radon and thoron can be collected by adsorption on charcoal. The charcoal is then heated and the adsorbed gas counted in an ion chamber. An alternative method is to fill an ion chamber with a predetermined quantity of air and measure the radon and decay products directly.

Among the indirect methods of collection are the charged wire of Elster and Geitel and the filtration of air through filter pads of known transmission characteristics which are then examined for radioactivity with a Geiger counter. The present investigation employed the latter method almost exclusively. It has the advantage of requiring only simple measuring equipment which can be operated by relatively untrained personnel.

A complete field station is shown in Figure 1. A powerful vacuum pump (A) draws air at a constant rate through a two-inch-diameter disc of filter paper. The collected dust is

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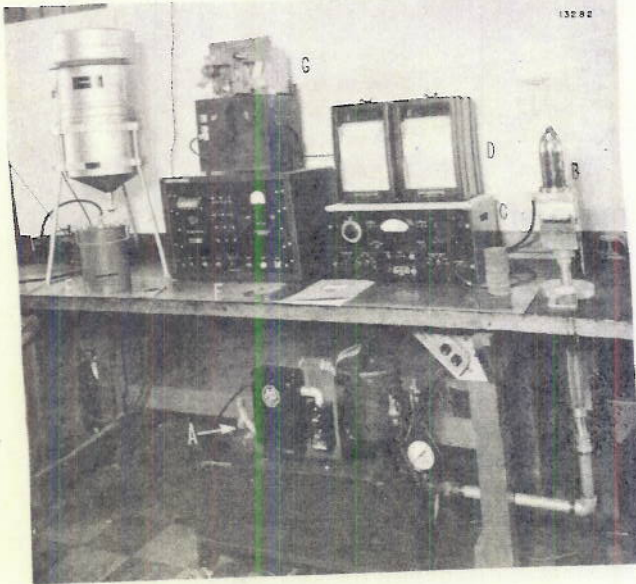


Figure 1 - Field station for radioactivity monitoring

continuously monitored for activity with a standard thin-window Geiger counter suspended above the filter paper (B). The counter tube output is fed to a rate meter (C) and pen recorder (D). After a 24-hour collecting period, the filter is placed beneath a second Geiger counter (E) which measures the half-life of the collected decay products of radon and thoron using a scaler (F) and printing tape recorder (G).

Seven of these stations are in operation at the following locations:

Washington, D. C., USA
 Glenview, Illinois, USA
 Kodiak, Alaska
 Pearl Harbor, Territory of Hawaii
 Subic Bay, Phillipine Islands
 Tutuila, Samoa
 Port Lyautey, French Morocco

All maintenance and operation is accomplished by Naval personnel at each base. Monthly summaries along with the data taken each day are sent to NRL periodically.

RESULTS

Figure 2 shows a typical daily record taken in the vicinity of Chicago, Illinois. All locations for which data are available show similar characteristic diurnal variations which are presumably associated with the stability of the atmosphere, giving maximum activities during the early morning hours with minima in the afternoon. Other workers (4) have discovered a high degree of correlation between the relative atmospheric activity content and the low altitude inversion conditions determined from temperature measurements made at ground level and on a high tower. At Washington, D. C., the variations in activity seem to correspond to changes in the ground-level temperature and relative humidity (Figure 3). Up to the present time, weather information from all locations where equipment is in operation has not been available and correlations have not been attempted. At most places the

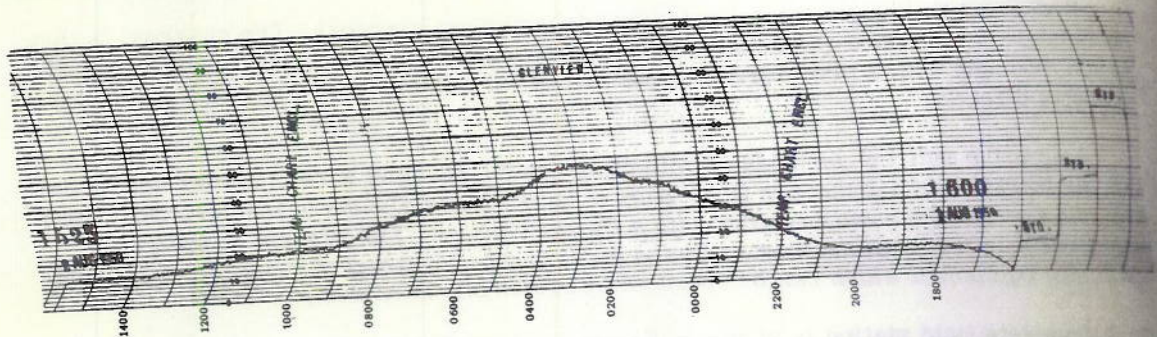


Figure 2 - Daily radioactivity chart for Glenview, Illinois

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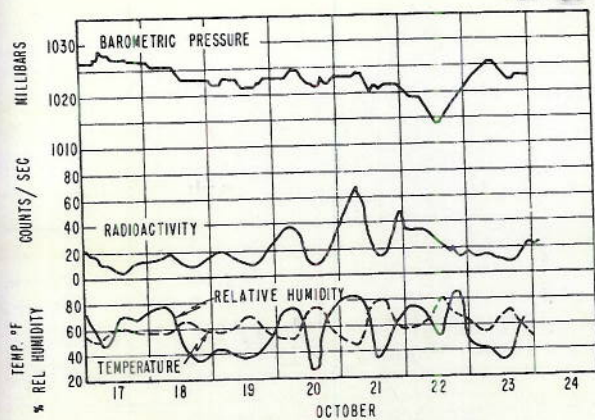


Figure 3 - Comparative variations of radioactivity with temperature, pressure, and humidity

associated with calm and pleasant weather while the lowest readings were obtained on windy days.

Figure 5 gives a similar plot of the average count from the filter at 14 hours after the end of the collection and is a measure of the amount of ThB present since the shorter-lived products have decayed. The curves are similar to those for the total activity and are presumably the result of the same phenomena.

In general the activity at island locations is considerably lower than for areas where the prevailing winds blow over land. The record of the daily counts from Tutuila, American Samoa (Figure 4) shows the lowest average rate, while Glenview, Illinois reports the highest activity. These records are believed to be typical and representative of the geographical locations. Rather pronounced and sudden variations in the general level of activity from day to day are observed at all locations. The factors underlying these variations are undoubtedly extremely complex, and little headway has been made toward determining a universally applicable system for accounting for them.

The relative amount of ThB as compared with the radium series is higher in general for the island locations at great distances from large land masses, for example, Pearl Harbor and Tutuila. On the other hand, the ratio is more or less the same for such widely separated points as Port Lyautey, Glenview, and Subic Bay.

The higher ratios far at sea may be explained by the difference in the half-lives of thorium B (10.6 h) being much longer than that of any of the radium products except RaD and RaE which can be neglected in the short collections considered here. The high ThB count at sea was noticed on one of the cruises

radium products make up from 50 to 90 percent of the total activity, with the balance mainly thorium B.

Figure 4 shows the average total daily count at several locations for 1950. There is a marked annual minimum for all the locations except Pearl Harbor. The generally more uniform climate in the Hawaiian Islands may account for the absence of maxima or minima. It has been suggested that cold and wet weather with saturated or snow covered soil would tend to inhibit the exhalation of radon and thoron (5). However, Burke and Nolan (6) in Dublin have found high relative activities during prolonged wet periods and when snow has lain on the ground for several weeks. Their high readings seem to be

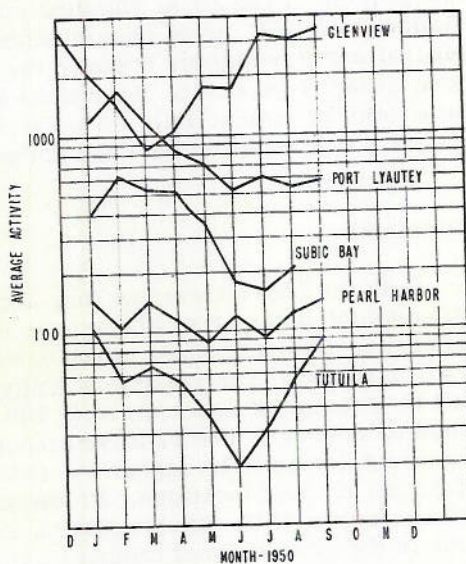


Figure 4 - Comparative radioactivity levels

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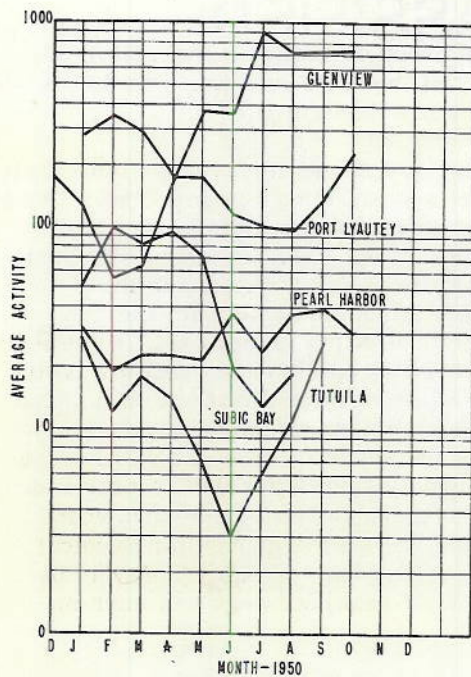


Figure 5 - Average radioactivity count at 14 hours after collection. (Relative amount of thorium B.)

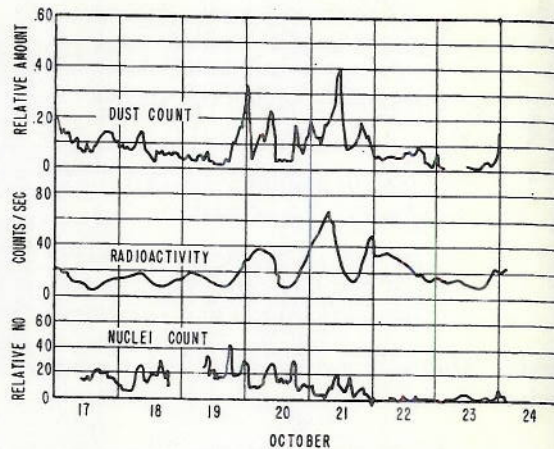


Figure 6 - Comparative variations of radioactivity with dust and nuclei counts

of the CARNEGIE, and Swann (7) ascribed it to the fact that most of the short-lived products would have decayed in the journey from distant land areas.

During the week of October 17 to October 24, 1949, the condensation nuclei count and dust content of the air at Washington, D.C. were measured by the Optics and Chemistry Divisions of NRL, using photoelectric devices (Figure 6). While there appears to be some general correspondence between the amount of dust in the air and the activity, the agreement is far from exact. Variations in nuclei count show little if any correspondence with variations in radioactivity. This is in agreement with Burke and Nolan (6) who have found that as a rule equilibrium does not exist between ions and nuclei.

SUMMARY

Both the short-term and long-term variations in the normal atmospheric radioactive dust content of the atmosphere have been measured in several widely separated geographical areas. Characteristic sharp variations from day to day and hour to hour are observed at all locations. The relative activity apparently is determined mainly by location, being less by a factor of approximately 100 for islands far at sea (Samoa) than for mid-continental areas (Glenview). The relative amount of thorium product activity as compared with that of radium seems to be higher for island locations. There appears to be a definite annual minimum at most locations. No direct correlation was found between dust and nuclei counts at Washington, D.C. At this station the activity variations appear to follow closely variations in the ground-level temperature and humidity.

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