Natural Radioactive Isotopes

soil atmospheres high in radioactivity when compared with the open atmosphere due to releases by soils and rocks

P. R. Stout and C. C. Delwiche

G. B. Jones, C.S.I.R.O., Division of Biochemistry and General Nutrition, University of Adelaide, participated in the studies on which the following article is based.

Recent studies have confirmed the work of an Italian investigator of 50 years ago who concluded that a certain type of atmospheric radioactivity, constituting 50–70% of the total activity, escaped from the earth to the atmosphere through the disintegration of the short-lived radioactive isotope thoron—which is a radon isotope—Rn^{220}.

Radioactive disintegration—degradation—of uranium and thorium proceeds through separate radium isotopes to radon isotopes which are chemically inert gases capable of diffusion out of soils and rocks into the atmosphere. On further degradation these emanations are transmitted to radioactive polonium—lead and bismuth isotopes. Because these metallic isotopes are charged they become quickly attached to air-borne particles, and measurable quantities may be collected by simply passing air through a filter-paper disk. The radioactive disintegrations of these unstable nuclei proceed inevitably through a chain of short-lived isotopes of lead, bismuth, and polonium, and that progression—by the nature of radiation and the rates of emission—makes possible the recognition of the various isotopes.

Radioactive polonium, lead and bismuth isotopes in the atmosphere may be detected simply and effectively by drawing air through a dry filter paper, and measuring directly by means of a thin-window Geiger tube the radioactivity that becomes deposited on the paper.

The maximal amount of radioactivity collected on the filter pad is a direct function of the volume of air passing the filter per unit time. If two filters are placed in tandem the activity captured by the second filter is 1% or less of that captured by the first one. Radon gas is not caught on the filter in detectable quantities, but its particulate daughter products are retained efficiently.

During filtration activity builds up rapidly with an apparent maximum being reached in four hours. If the flow of air is stopped the activity falls fairly rapidly during the first three hours, but from then on it falls more slowly. After decaying 24 hours activity can still be measured from isotopes governed by a 10.6 hour half life. Not infrequently, this longer lived activity has been three to four times background, 24 hours after ceasing filtration.

To establish beyond all doubt that the long lived isotope was lead—Pb^{212}— it was isolated chemically from other elements and freed from its immediate radioactive daughter bismuth—Bi^{212}.

After drawing a large volume of air through filter paper for 20 hours, and extracting the lead, some 1,800 Geiger counts per minute were measured at first. The decay rate was followed for 24 hours, and from that decay rate the half life was found to be 10.6 hours.

To further confirm that the activity with the 10.6 hour half life was due to $lead^{212}$, the daughter product $bismuth^{212}$ was isolated chemically and its half life of 60 minutes was proven.

During April 1955 daily measurements were made of catches collected over periods of 16 to 24 hours. Actual counts per minute and the distribution of activity between daughter products of radon and thoron show that in these samples, thorium-derived activities were equally as important as the activities derived from uranium through the long-lived radon.

After allowing decay for 24 hours, a second measurement was made. During this time lapse the activity of $lead^{214}$ had decayed effectively to zero so that only $lead^{212}$ and its daughters remained. From the second measurement the initial activity of $lead^{212}$ was calculated.

Reasons for the magnitude of activities of $lead^{212}$ were obscure as it is difficult to conceive that the short-lived—54.5 second half life—thoron could escape from soils and rocks in sufficient quantities to account for the figures obtained.

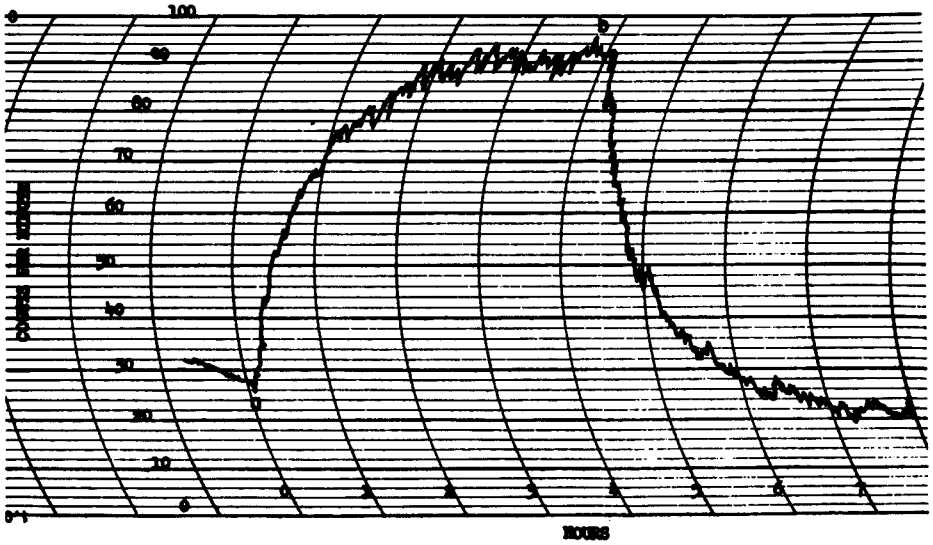
To investigate whether the burning of coal might be a contributing factor to atmosphere radioactivity, filtration caches were made at a railway yard. Although those contained at least 20 times the amount of soot particles, they had no greater activity than catches made at the same time some two miles away. There appeared to be no correlation between the blackness of the deposit on the filter pads and the degree of radioactivity that accumulated there.

In calm weather the haze and smoke increased and the air catches had higher radioactivity due no doubt to atmospheric stagnation.

Another series of measurements were

Concluded on page 11

Automatic recording of radioactive daughter isotopes from atmospheric radon captured by drawing air through dry filter paper. At point *a* suction was started. Four hours later radioactivity had attained a maximum. At point *b* air flow was stopped. The ensuing curve shows the rate at which the captured particles decay.



California lemons—the order could provide a mechanism for controlling the supply pressure of juice products. Significant leakages from supply sources outside of California apparently were not fully envisaged. The importation of lemon stock for the domestic manufacture of juice products has tended to increase and—because of the increased value of processing lemons—areas in the United States that had not produced lemons previously became potential suppliers.

As the state marketing order has been operating in most years, a price floor has been established for California lemons processed into juice products. In addition, the order has indirectly afforded price protection to such competing areas as Italy, Florida, and Arizona, where growers enjoy lower lemon-producing cost structures than do most growers in California.

Interlocking Markets

These developments not only bear upon the lemon-juice products market but also on the fresh lemon market because of the consumption competition between the two markets. Further, as juice supplies originating outside California assume increasing volume, there develops a relatively restricted market outlet of value for California lemons for juice products.

The current situation in which the California lemon industry operates—in conjunction with potential developments—emphasizes the importance of considering the fresh and processed markets and their respective marketing orders as closely interrelated dimensions of an essentially single economic market.

The California lemon industry faces the problem of developing an integrated system of operating that is oriented toward the dynamic economic setting in which the industry finds itself.

Sidney Hoos is Professor of Agricultural Economics, University of California, Berkeley.

This series of five articles will be available as a reprint early in 1957, and may be obtained without cost by addressing a request to The Giannini Foundation of Agricultural Economics, 207 Giannini Hall, University of California, Berkeley 4.

ISOTOPES

Continued from page 3

made in the center of Australia, as far from the sea as possible and where the situation was not complicated by coal burning industrial operations. There, in cloudless clear weather, the highest activities in these experiments were recorded.

The air was generally calm at night so the sampling program was changed to separate the catches made in daytime from those at night. The fraction of lead^{212} accumulated during 10 hours or more proved to be in the neighborhood of half of the total activity. The data point to the conclusion that calm weather in inland areas tends to produce high burdens of atmospheric radioactivity. Yet the high proportion of lead^{212} could not be attributed to industrial activities, so it was postulated that its parent isotope—thoron—was delivered continuously from the soils to the atmosphere. To test this assumption, a plot of soil 18″ × 40″ was dug over and covered by a galvanized iron lid leaving one end open and placing the filter at the other end. The rate of air flow was arranged so the air traveled over the 40″ path of loosened soil in a period of two minutes before passing through the filter. If thoron were to escape from the soil, its half life of 54.5 seconds should allow a considerable proportion of it to be converted to polonium^{216}—0.14 second half life—and thence to lead^{212}. Even though it is assumed that radon also diffused from the soil its half life of 3.8 days would require that most of the gas should pass on through the filter without disintegrating to lead^{214}. For comparison a parallel filter was run filtering the same quantity of air from the open atmosphere. It was demonstrated that air in close contact with loosened soil accumulated considerably more activity and the higher proportion of this activity was due to the presence of lead^{212} derived from thorium decay.

Samples of 120 different soils representative of the great soil types of the world were examined and radon was found to be an important component of all of the soil atmospheres.

In the absence of any direct information on health hazard features from natural radioactivity in the atmosphere, a test was conducted with a sheep. On the 20th and 21st of April 1955, two record high counts of radioactive lead^{212}—444 and 417 counts per minute—were measured. On the second day of high activity a sheep which had been penned for two weeks close to the site of measurement was slaughtered and its respiratory organs examined.

From the lead isotopes recovered from the sheep's lungs it was concluded that approximately 18% of the lead^{212} inhaled by the sheep during the preceding 24 hours was retained in the respiratory system. Unfortunately this experiment could not show where the balance of the activity had gone. It may have been returned to the atmosphere, or it may have been distributed throughout the body.

The steady intake of lead^{214}, which decays to lead^{210} with a 22 year half life, may be retained by the body. Lead^{210} would accumulate and reach half its maximal value in 22 years, 75% in 44 years, and 87½% in 66 years.

The principal findings of this series of investigations are that radioactivity is always present in the atmosphere in the form of decay products of uranium and thorium and that the short-lived thoron—54.5 second half life—and its daughter products assume equal importance with those of radon.

P. R. Stout is Professor of Soil Science, University of California, Berkeley.

C. C. Delwiche is Professor of Plant Biochemistry, University of California, Berkeley.

METABOLITES

Continued from page 4

soak period, storage, and growth in soil after treatment are currently under study. The multiple effects of the gibberellins on dormancy, growth, flowering, and fruiting suggest a critical study of their effects on dormancy of pome fruit seeds as well as on dormancy, growth, fruit set and development of pomological crops.

Although the results of these studies are highly suggestive, the practical significance of the gibberellins as agricultural chemicals requires extensive evaluation.

Lawrence Rappaport is Junior Olericulturist in Vegetable Crops, University of California, Davis.

C. A. West, B. O. Phinney and Anton Lang of the University of California, Los Angeles, and S. H. Wittwer and M. J. Bukovac of Michigan State University conducted the additional research on gibberellins referred to in the above article.

Dr. F. D. Stodola, Northern Utilization Research Branch, USDA, Peoria, Illinois, supplied the gibberellins used in these studies.

The above progress report is based on Project 1175 D.

CLOVER

Continued from page 8

Plants receiving 300 pounds of superphosphate produced twelve times as much clover and contained 0.157% phosphorus. They were clearly deficient since more applied phosphorus gave a large additional yield increase.

Clover from the 600-pound treatment produced 94% of the maximum yield and contained 0.190% total phosphorus. Further application of fertilizer in the 1,200-pound treatment caused no significant increase in yield, though phosphorus content did increase.

At the control and at the low rates of application the phosphorus content curve follows the yield increase. The yield approached maximum with the 600-pound

Concluded on next page