Proceedings of the Iowa Academy of Science

Volume 69 | Annual Issue Article 70

1962

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Recommended Citation
Schulhof, Michael P. and Wolfson, James (1962) "Detection and Measurement of Air-Borne Radiation at Grinnell, Iowa," *Proceedings of the Iowa Academy of Science, 69(1),* 446-450.
Available at: https://scholarworks.uni.edu/pias/vol69/iss1/70

Detection and Measurement of Air-Borne Radiation at Grinnell, Iowa

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Abstract. A relatively simple method is presented for the detection and measurement of total air-borne radiation. It employs only a scintillation counter, and ordinary laboratory materials. Using this method, a monitoring station was established for the period from the Fall of 1961 through the Spring of 1962. The results from this study, when compared with the results published by the United States Public Health Service, indicate a high degree of reliability in the method used.

In recent years there has been a great deal of interest in the amount of radiation to which the human body is daily exposed. In addition to the background radiation present at the earth's surface, due to naturally radioactive elements and cosmic rays, there is now the radiation from the waste products of nuclear explosions. In September of 1961 Russia announced that she was going to detonate a large series of such explosions, and proceeded to test over thirty nuclear devices, ranging in size up to 50 megatons. These tests were expected to have noticeable effects on the amount of radioactive particles in the atmosphere. In order to detect the relative change in the amount of air-borne radiation due to this particular series of tests, a monitoring station was established on the campus of Grinnell College. This station began operating in late October of 1961, and will continue to operate at least through May of 1962. This paper will explain the method of sampling used, and present the results of this monitoring for the period from October 26, 1961 through April 11, 1962.

The United States Public Health Service, which maintains forty-five monitoring stations throughout the country, has paid the greatest amount of attention to the ionizing beta emissions of four of the principal waste products of a nuclear explosion—Iodine 131, Strontium 89, Strontium 90, and Cesium 137. All of the weather maps which have been so popularly reproduced in the news media refer only to beta intensity. Very little information has been gathered concerning the amount of gamma radiation present in the atmosphere. While the effects of gamma radiation on human health are relatively unknown, this type of radiation is of sufficient interest to warrant further study. It is not the purpose of this paper, however, to go into the biological ef-

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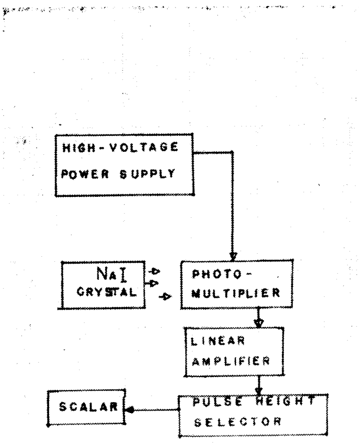
fects of gamma radiation, but rather to present the results of a study of the total radiation to which the area of Grinnell, Iowa, has been exposed in the last five months, in order to determine the immediate and short range effects of the Russian tests on this area.

To guarantee detection of the total radiation, and not just the ionizing radiation, a scintillation counter employing a 1.5 cubic inch sodium iodide crystal is used. This type of counter is over 95% efficient in the counting of gamma radiation, as compared with a Geiger-Muller tube's 1% efficiency in detecting the same radiation.[1] It is also highly efficient in the detection of any alpha and beta particles which reach the crystal. The counter is attached to a pulse-height analyzer, which is used as a discriminator to accept all particles with more than 15 K.E.V. of energy. This eliminates a large proportion of noise from the system, since any particles below this energy would not reach the counter.



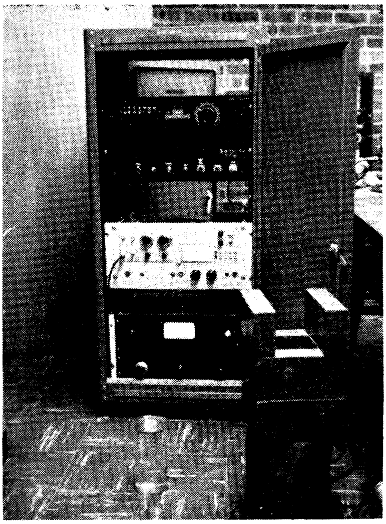


Figure 1. A block diagram of the scintillation counter used for the measurement of the radioactive dust.
Figure 2. A photograph showing the beaker, lead house, and counting apparatus used.

Several methods for obtaining a sample were tried. In the one finally chosen, dust is allowed to settle on a flat surface, from which it is collected and then measured for radioactivity. For the actual collection of this sample two plastic screens, each with a surface area of nine square feet, have been constructed and placed in a sheltered area. This area is fairly well protected from the wind, so that a relatively constant amount of air passes over the screens. Once every twenty-four hours each screen is washed down with 400 ml of distilled water. The resulting mixture of the water and the dust which has washed off the screens is then placed in a 1000 ml beaker, and left undisturbed for another day. This allows the dust to settle to the botton of the beaker. This natural sedimentation produces the same results as a more cumbersome and time-consuming filtration of the water. The beaker and a scintillation crystal mounted on a photo-multiplier are then completly enclosed in two inches of lead to minimize the effects of background radiation. The beaker is placed so that the residue which has settled to its bottom is separated from the crystal by the thickness of the glass, about 1mm. This minimizes any loss due to absorption of beta particles. A ten minute count is then taken. This count, minus the background count still present in the closed lead "house" is considered the excess radiation carried in the air by dust.

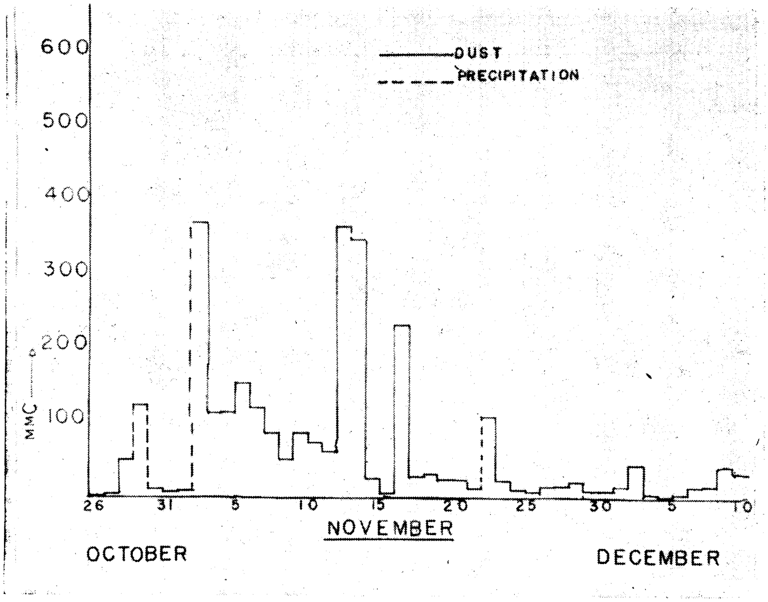


Figure 3. A graph of the radiation level for the first month and a half of the study.

Readings have been taken daily for the period involved. These readings have been converted to micro-micro curies (mmc), and put into graphical form. On days in which it rains, the rain water is treated exactly the same as the regular collections, and the dust which the rain carries down with it is the measured quantity. We have found that the twenty-four hour wait between collection and counting of the rain also serves to allow radioactive elements, always present in "normal" collections of rain, to go through a sufficient number of half-lives to make their intensity negligible. Readings from rain water, however, are represented by dashed lines on the graphs. Snow is simply melted and treated the same as rain.

The first notable rise occurred two days after the observations were started. At that time the count, which had been at almost background level, suddenly rose to 56 mmc. This was followed on the next day by an even sharper rise in the rain water collected. Both of these rises occurred at about the time predicted for the main body of low altitude radioactive debris from Russia's 25 megaton explosion, on October 23rd, to reach this country. The same thing occurred four days after their 50 megaton explosion of October 30th. After the radiation from that explosion had reached this locality, the level of radiation gradually decreased until November 12th. On that date, however, the count again rose sharply, and remained high for two days. On November 16th the radiation level again took a sharp rise. These rises seem in no way connected to any large Soviet tests, but were probably the result of radioactive dust clouds, from one of the previous tests, which had not yet settled to earth. The United States Public Health Service's daily maps, which give the gross beta activity in all parts of the country, and were used as rough comparisons to the figures obtained at Grinnell, also showed this area to be in a high concentration of radiation.

After November 16th, by which time the Russian test series had been concluded, the radiation level again began to drop, and for the remainder of the winter varied roughly between 10 and 40 mmc. The only major exception was when it rained on November 21st, and the radiation level again took a sharp rise. This rise in activity seems to be characteristic of the rain water which was measured. This agrees with the theory that a nuclear explosion injects most of its waste products high into the atmosphere, where they may remain for months or years, until precipitated by moisture which forms around them. Because some rain forms at relatively high altitudes it is able to precipitate some of this radioactive debris with it. Snow, which generally forms at much lower altitudes, will not do this, and thus does not show the marked increased in radioactivity characteristic of rain. It is the debris which remained at a relatively low altitude which was detected at the immediate time of the tests, but by mid-November most of this had apparently settled out of the air and consequently the radiation level remained low.

With the coming of spring the amount of radioactivity again began rising. This is expected because during the spring, rain clouds are coming from the equatorial regions of the earth. At these regions rain clouds are formed when warm air, which has

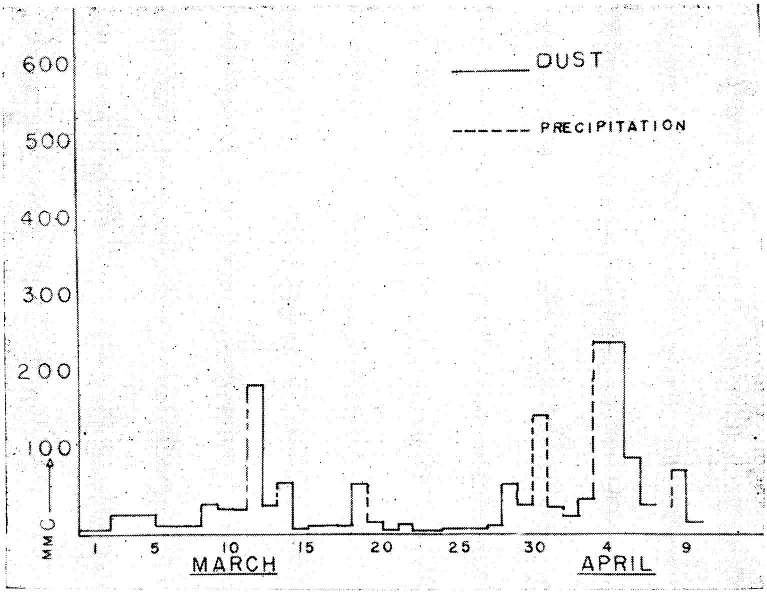


Figure 4. A graph of the radiation level for the Spring of 1962.

been blown to extremely high altitudes, combines with water vapor from the ocean. Because of the high altitude to which this air has been carried, it contains a large amount of radioactive dust, which is then carried as part of a cloud to the Northern Hemisphere.

The results obtained from this study were carefully checked against the published "weather maps", and it was found that the changes in the radiation level shown on these maps, although only beta activity, agreed very closely with the relative changes recorded at Grinnell. This indicates that even though simple methods were employed for collecting a sample, the results were indicative of the change in activity for this area.

ACKNOWLEDGMENT

We wish to express our appreciation for the cooperation given us by the United States Public Health Service, Radiation Surveillance Center, Mr. Arve H. Dahl, Chief.

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