Fission Product Radioactivity in the Air along the 80th Meridian — January—June 1957

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Abstract

Measurements of gross fission product radioactivity in the air at a number of sites along the 80th meridian (west) are reported for the period January—June 1957.

The concentration of long-lived radioactive products (primarly fission products) in the air continues to remain considerably higher in the Northern than in the Southern Hemisphere. Among the more interesting developments, there has been obtained a definite inverse relation between the air concentration of radioactivity and rainfall during the dry and rainy seasons at Panama.

The use of "radioactivity profiles" (plots of latitude vs fission product concentration) to represent a cross section of the average air concentrations of fission products along the 80th meridian for any given period offers a ready means to obtain the total burden of such activity in the atmosphere for such a period and to follow its increase or decrease with time.

1. Introduction

The program of measurement of fission product radioactivity in the air along the 80th meridian (west), initiated in early 1956, has been continued and expanded during 1957.

Collections of radioactivity have been made by (a) air filters employing a positive displacement pump with a free-air capacity of about 40 cfm and an efficient filter paper, (b) cloth screens (cheesecloth) of one square foot area mounted in a vertical position and held normal to the air stream by a vane, and (c) the standard AEC gummed-film collector for fallout particles. Comparisons of such collections at the U. S. Naval Research Laboratory have indicated the latter two devices to be unsuitable due to the difficulty of interpreting the results. Further, the extremely low levels of activity obtained by the latter two devices, even when significant amounts of radioactivity were being collected by the air-filter method, make inconclusive any comparisons made on such days.

During the International Geophysical Year, the major effort is being placed on the collection of radioactivity by the air-filter method, with subsequent measurement at this Laboratory. The elimination of the gummed-film and cloth-screen collections has enabled the NRL counting facilities to be employed to give coverage of more geographical locations along the 80th meridian.

This report covers a final comparison of three collecting methods and traces the changes in the gross fission product radioactivity o the air that have occurred during the period January—June 1957.

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2. Collection and measurement of samples

Samples of atmospheric radioactivity were collected at the various cooperating collecting sites and forwarded to the U. S. Naval Research Laboratory via air mail. Here the samples were ignited to an ash at 650° C and measured for gross β activity two weeks after collection. At the time of measurement, the natural radioactive materials in the air has decayed to insignificance.

3. Comparison of collecting techniques

In Fig. 1, a comparison of the weekly totals of the radioactivity of samples collected by the three techniques is presented for the four sites where relatively complete sets of such data were available: Santiago, Chile; Guayaquil, Ecuador; Miraflores, Panama Canal Zone; and Washington, D.C. All weekly totals of 100 disintegrations per minute or less have been omitted because of the lack of significance of such data.

At Santiago (Fig. 1a) the radioactivity collected by the air filters showed a downward trend from January through May, then increased sharply in June following the British atomic tests at Christmas Island. The cloth-screen collections gave no significant indications of activity except for June 11—17,

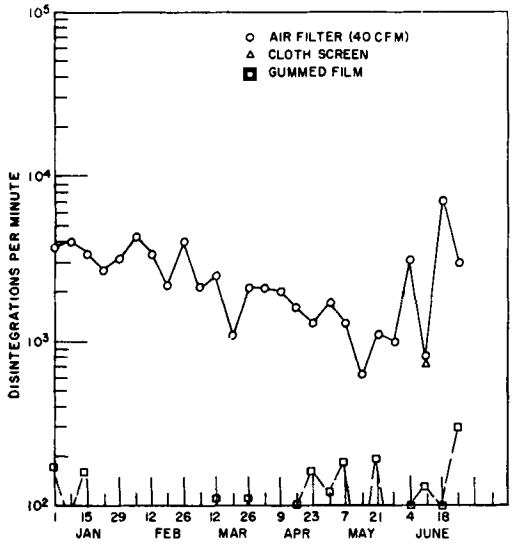
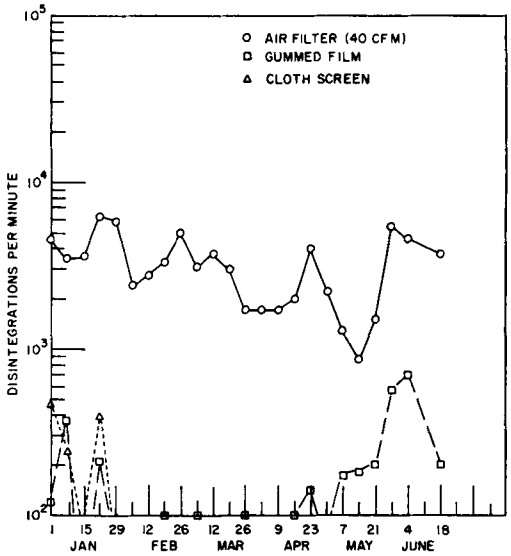


Fig. 1. Weekly collections of radioactivity during January-June 1957. The dates along the abscissas are the initial days of the weekly collections. (a) Santiago, Chile;



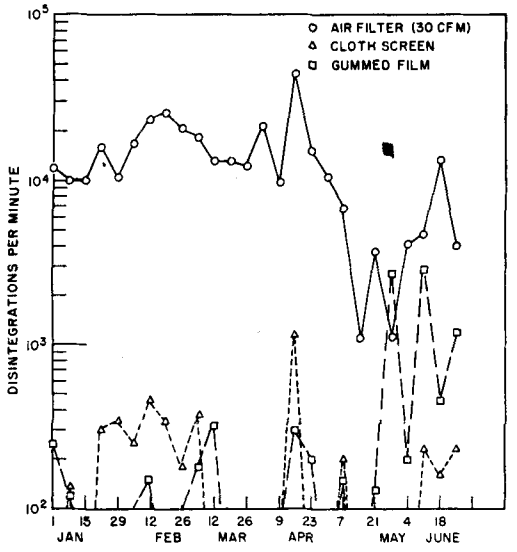
(b) Guayaquil, Ecuador;

which corresponded to a minimum in the concentration of fission product radioactivity in the air. The gummed-film collections, too, were generally low in radioactivity and showed no correlation with the air-filter collections.

At Guayaquil (Fig. 1b) the radioactivity of the air-filter collections showed the same downward trend as at Santiago. The cloth-screen collections were of no value because of their low activity. The gummed-film collections were generally of little significance except during May and June. These collections showed a rise in radioactivity prior to the British tests; however, the time of maximum activity of the gummed films did correspond roughly to that of the highest air concentrations shown by the filter collections.

At Panama (Fig. 1c) the fission product radioactivity of the air was generally high from January through April, then decreased markedly in May following the onset of the rainy season. The strong relationship between the air concentration of fission products and the rainfall, as described later, makes it difficult to assign rises in the activity level to any particular atomic test during the rainy season. Both the cloth-screen and gummed-film collections showed extreme variations in radioactivity which seldom coincided with variations in the radioactivity of the air.

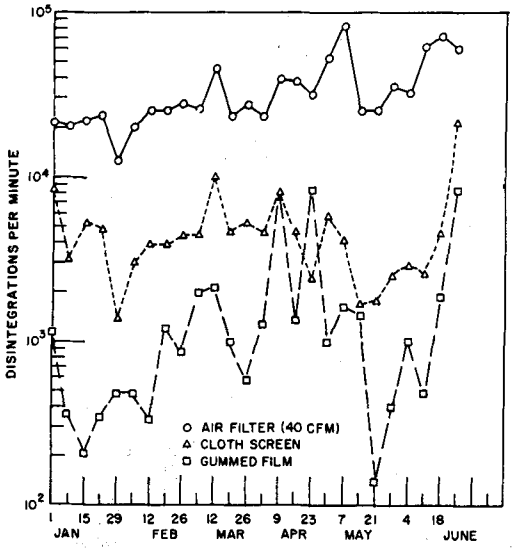
At Washington, D.C. (Fig. 1d) the radioactivity of the air-filter collections showed a



(c) Miraflores, Panama Canal Zone;

general increase from January through June. In general, also, the cloth-screen collections gave parallel indications of radioactivity, but the quantity collected was much lower. The gummed-film collections showed considerably less correlation with the other collecting methods.

To generalize, the cloth-screen and gummed-film collections of radioactivity have no simple relationship to the actual air concentration of fission products. If, in the future, some presently unrecognized factors can be taken into account which seem to explain these present inconsistencies, the data accumulated during the past year will serve as a testing area. At the present time, however, it is evident that further collections by cloth screen or gummed films would serve no useful purpose, except where no other collecting technique is available.



(d) NRL, Washington, D. C.

4. Effect of rainfall on the radioactivity of the air

Many measurements have shown that radioactive materials are swept from the air by rain with a resulting decrease in the radioactivity of the air. Previous work at NRL has shown rainfall to be the agent principally responsible for removal of natural radioactive products from the atmosphere in the Washington, D.C. area (BLIFFORD, 1952).

The data collected by the air-filter method at Panama on the fission product radioactivity of the air during the dry and rainy seasons (Fig. 2) gives a clear picture of the inverse relation between rainfall and atmospheric radioactivity. During the wet period from June through November 1956, the fission product radioactivity of the air was rather low in spite of a large number of atomic tests taking place in the Northern Hemisphere. The few peaks of activity coincided both with periods of less than normal rainfall and with periods of intensive atomic testing. It is remarkable that such a low response to the U.S. tests held in the Pacific during May-June 1956, was obtained, particularly since the prevailing high altitude winds from the test area normally pass near Panama.

With the slackening of the rains in December, an immediate increase in the radioactivity of the air was observed. At this season the intertropical convergence zone moves to the south of Panama, permitting this area to receive ground-level air from the Northern Hemisphere with its higher radioactivity. Following the cessation of the rains at the end of December, the fission product count approached that at Washington, D.C., and remained high until the start of the rainy season in May. During this entire period there was only one peak of radioactivity that appeared to be due to any particular atomic test series. The maximum radioactivity

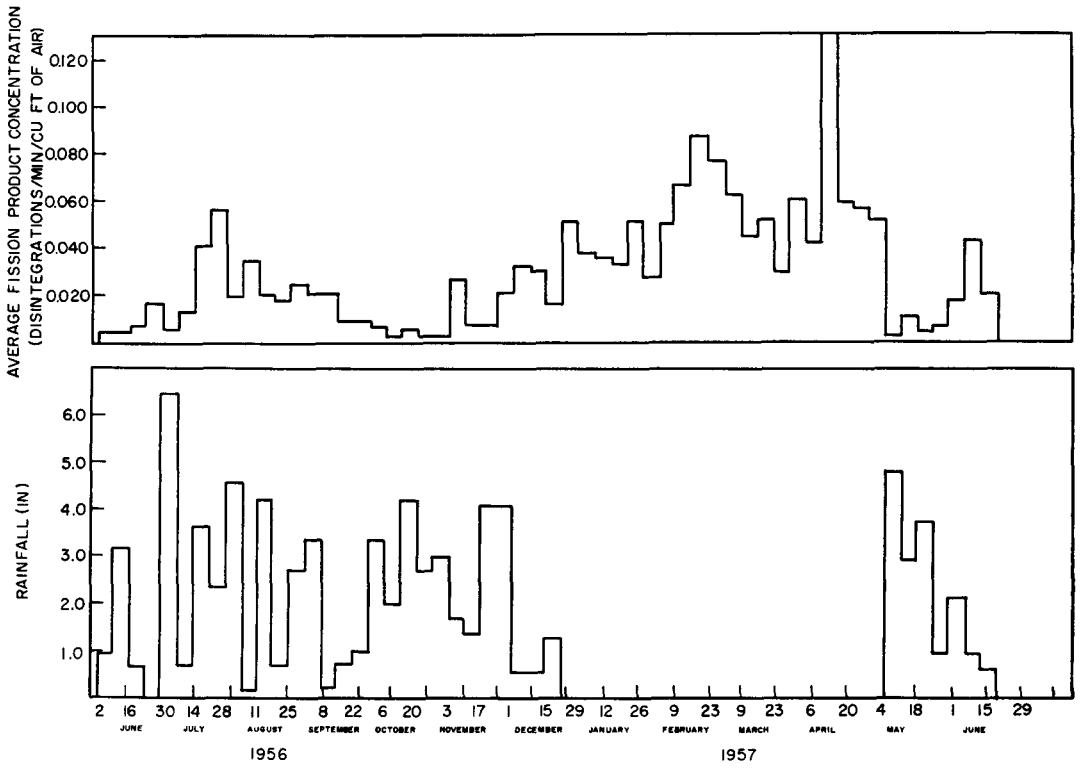


Fig. 2. Relationship between rainfall and the radioactivity of the air at Miraflores, Panama Canal Zone

measurement of the year at this location was obtained for the week of April 13—19 following the Russian tests of early April 1957. These tests and other nuclear explosions reported during January-June 1957 are listed in Table 1. Since the Washington, D.C. collections showed no great increase in radioactivity during this period and since the time was insufficient for debris from any but the first two Russian tests to arrive in the Panama area, it is rea-

Table 1. Date and Location of Nuclear Explosions Recorded During January-June 1957

Date	Location	Government responsible	Type of test
Jan 19	USSR	Russia	
Mar 8	USSR	Russia	
Apr 3	USSR	Russia	
Apr 6	USSR	Russia	
Apr 10	USSR	Russia	
Apr 12	USSR	Russia	
Apr 16	USSR	Russia	
May 15	Christmas Island	United Kingdom	Fusion (megaton)
May 28	Nevada	United States	Small Fission
May 31	Christmas Island	United Kingdom	Fusion (megaton)
June 2	Nevada	United States	Small fission
June 5	Nevada	United States	Small fission
June 18	Nevada	United States	Small fission
June 19	Christmas Island	United Kingdom	Fusion (megaton)
June 24	Nevada	United States	Small Fission

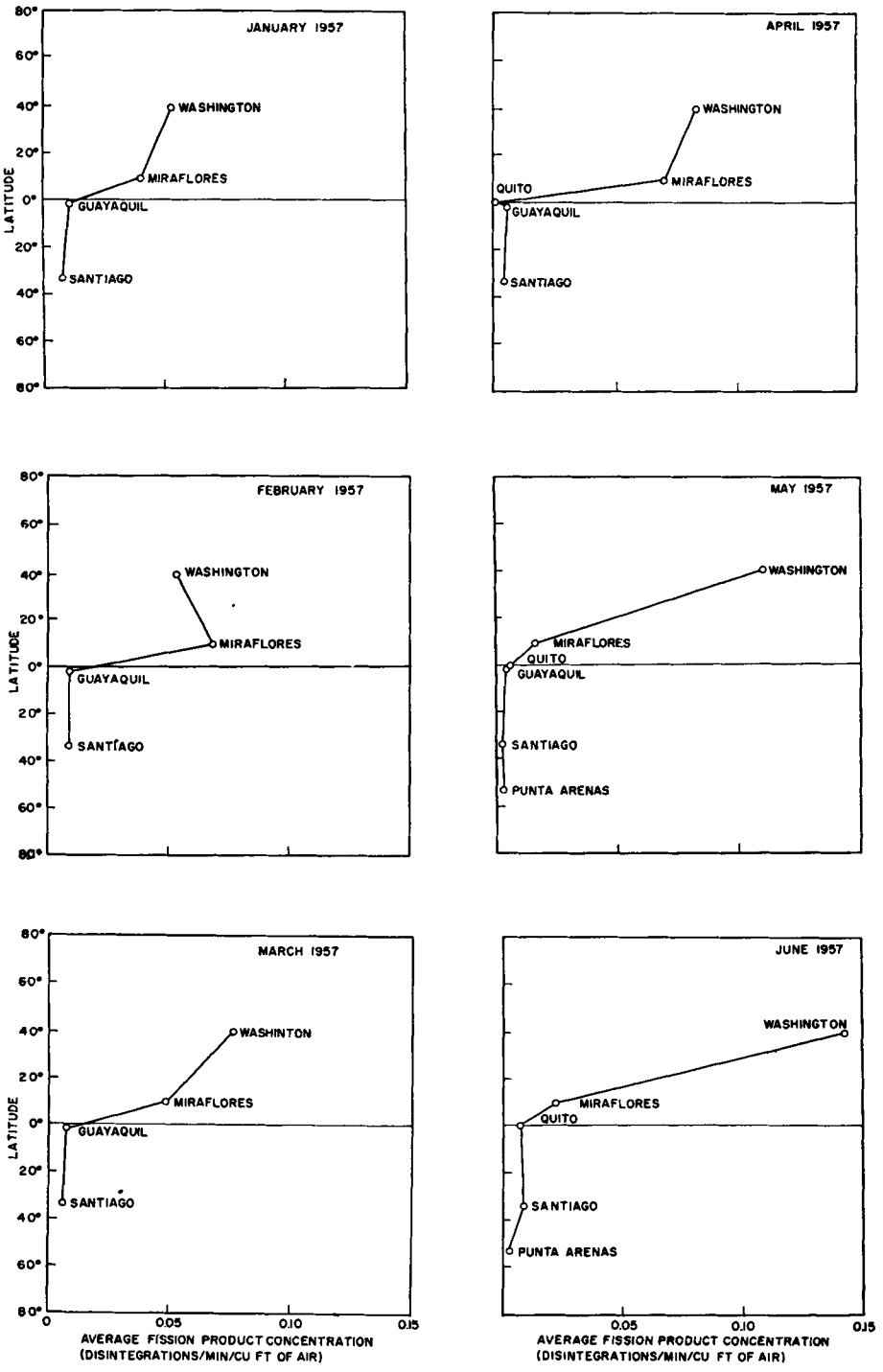


Fig. 3. Radioactivity Profiles of the air along the 80th meridian during January-June 1957.

sonable to consider that this high reading is due principally to the accumulation of older debris in the atmosphere, possibly by diffusion from the stratosphere. Radiochemical analyses of such collections during the coming year should serve to clarify this question.

5. Radioactivity profiles along the 80th Meridian

Comparisons of the average air concentrations of fission products at the various collecting sites along the 80th meridian for the same periods of time are shown in Figs. 3 and 4. In Fig. 3, these "radioactivity profiles" are based on monthly air concentrations of fission products. During January through May the monthly profiles were generally representative of the individual weekly profiles. Following the increased nuclear test explosions in May and June both in the United States (Nevada) and at Christmas Island, large fluctuations in the activity levels occurred at most collecting sites. The radioactivity profiles during June are, therefore, presented also as weekly averages (Fig. 4).

During the period January-May, the general level of radioactivity in the air decreased in the Southern Hemisphere and increased in the Northern Hemisphere. The activity level at Panama was variable depending on the rainfall as discussed in a previous section. In general the fission product radioactivity of the air is higher by a factor of 5 or more in the Northern Hemisphere throughout this period.

A great increase in the fission product level in the air in both hemispheres during June 1957 is apparent from the weekly June profiles. The increases taking place south of Panama are due to the Christmas Island tests; those north of Panama are due primarily to the Nevada tests; those at Panama are presumably due to both test series.

The low levels of activity encountered near the Equator during June were unexpected in

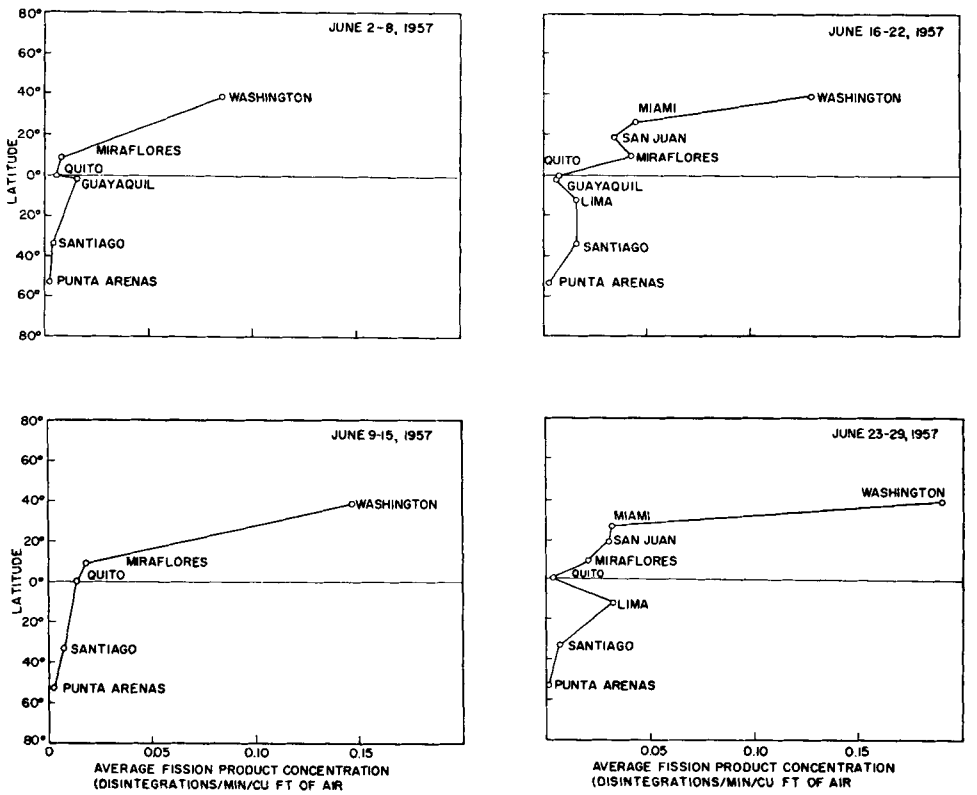


Fig. 4. Radioactivity profiles of the air along the 80th meridian during June 1957

Table 2. Monthly Averages and maxima of Fission Product Radioactivity During January-June 1957

Location	Radioactivity (curies/cc of air)					
	Monthly Average	Maximum*	Monthly Average	Maximum	Monthly Average	Maximum
	January		February		March	
Washington	8.0×10^{-19}	1.2×10^{-18} (26—28)†	8.6×10^{-19}	1.8×10^{-18} (20'	1.2×10^{-18}	3.0×10^{-18} (15)
Miami+						
San Juan+						
Mirafores	6.4×10^{-19}	1.5×10^{-18} (24)	1.1×10^{-18}	1.9×10^{-18} (18)	7.8×10^{-19}	1.4×10^{-18} (10)
Quito						
Guayaquil§	1.8×10^{-19}	3.5×10^{-19} (26)	1.4×10^{-19}	4.5×10^{-19} (2)	1.1×10^{-19}	2.9×10^{-19} (4)
Lima+						
Santiago	1.3×10^{-19}	2.2×10^{-19} (10)	1.4×10^{-19}	3.8×10^{-19} (5)	8.0×10^{-20}	2.1×10^{-19} (1)
Punta Arenas						
	April		May		June	
Washington	1.3×10^{-18}	2.5×10^{-18} (19)	1.8×10^{-18}	4.0×10^{-18} (9)	2.2×10^{-18}	7.4×10^{-18} (27)
Miami+					6.4×10^{-19}	1.5×10^{-18} (17)
San Juan+					5.1×10^{-19}	1.6×10^{-18} (20)
Miraflores	1.4×10^{-18}	3.8×10^{-18} (18)	2.5×10^{-19}	8.9×10^{-19} (6)	3.3×10^{-19}	3.7×10^{-18} (18)
Quito	1.6×10^{-20}	9.6×10^{-20} (8)	9.6×10^{-20}	9.2×10^{-19} (27)	1.1×10^{-19}	6.4×10^{-19} (12)
Guayaquil	8.5×10^{-20}	5.1×10^{-19} (26)	6.4×10^{-20}	2.1×10^{-19} (30,31)	1.8×10^{-19}	6.0×10^{19} (3)
Lima+					3.3×10^{-19}	2.2×10^{-18} (25)
Santiago	6.4×10^{-20}	1.1×10^{-19} (2,11)	3.2×10^{-20}	9.5×10^{-20} (1,2,8,26)	1.3×10^{-19}	7.2×10^{-19} (19)
Punta Arenas			4.8×10^{-20}	1.3×10^{-19} (21)	3.2×10^{-20}	1.6×10^{-19} (1,22)

* The day (or days) on which the maximum occurred is given in parentheses below the value
† Average for a 3-day collection
\+ Data available June 14—30 at Miami and San Juan, June 13—30 at Lima
§ No data available June 25—30

view of the nuclear explosions of several megatons yield having taken place previously at Christmas Island (2° N, 157° W). It will be most interesting in the future to see if this position of minimum activity changes seasonally, what is its relationship to the intertropical convergence zone, and perhaps whether a band of heavy rainfall near the Equator serves to bar passage from one hemisphere to the other of activity contained in the lower atmosphere.

When more complete coverage of the 8toh meridian is obtained, integration of the area to the left of the profile curves will give useful information on the burden of radioactivity in the atmosphere at different times. In the absence of fresh debris and the resulting nonuniform distribution of this radioactivity, such calculations should prove useful for estimating worldwide fallout rates. The results of radiochemical analyses for specific isotopes such as Cs^{137} and Sr^{90} can be presented in a similar form and may be useful for determining fallout rates or accretion rates of these isotopes in the lower atmosphere.

In Table 2, the maxima readings of the

concentration of fission products in the air for each month and the monthly averages for each collecting station are compared in terms of curies per cc of air. The average fission product activity of the air at Washington during this period is about ten times that recorded on monitor equipment at NRL in early 1954 (BLIFFORD, 1956) during a period of relative quiet. The highest activity recorded at NRL this year (7.4×10^{-18} curies per cc) may be compared with the maximum of 6.1×10^{-17} curies per cc of air recorded here in May 1953 following a test in Nevada. The maximum activity recorded at any location in the Southern Hemisphere this year (2.2×10^{-18} curies per cc of air at Lima, Peru, June 1957) is far below the U. S. Atomic Energy Commission tolerance of 1×10^{-15} curies per cc of air for continuous exposure to unidentified β emitters.

6. Conclusions

In view of the inadequacy of correlations of radioactivity measurements made by use of the three collecting techniques (air filters, cloth screens, and gummed films), it is concluded that for the present only the air-filter method should be used for routine atmospheric radioactivity sampling. The air-filter method can be used to determine directly the gross concentration of fission products in the air, and further, radiochemical analysis of the filters can give concentrations of individual radioisotopes in the air.

The gross radioactivity of the air during the period January-June 1957 continues to be considerably higher in the Northern than in the Southern Hemisphere. There has been no evidence yet found that indicates transport of radioactivity in the lower atmosphere across the "equatorial barrier". Debris from the Christmas Island test, however, apparently did appear on both sides of the Equator. The low air concentration of fission products in Panama during the rainy season indicates the possibility that the barrier to transport of debris may be due, in part, to a continuous belt of rain in the tropics which effectually removes radioactivity from air that might cross from one hemisphere to the other.

As more and more collecting stations are added to this 80th meridian air sampling program, the data obtained gives every indication of being extremely valuable in estimating long-range processes operating to modify the gross radioactivity of the atmosphere.

Acknowledgment

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