On the Artificial Radioactivity in Rain Water and Fallout Dust

Observed in Kochi-City from March, 1955, to August, 1956

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INTRODUCTION

During the period from March, 1955, to August, 1956, explosion tests of nuclear bombs were made many times. The first was the Nevada series extending from February to March, 1955. The next and the third were carried out in November, 1955, and March, 1956, respectively, which took place reportedly somewhere in Siberia. From May to July, 1956, the Bikini tests were made by USA, and at the end of August in this year, it is reported, some tests were made in USSR.

After each experiment high artificial radioactivities were found in rain water and fallout dust in Japan. In this paper, we are goin to report the results of measurement of these activities made in Kochi-City during this peroid.

SAMPLING AND APPARATUS

Samples of both rain water and fallout dust were collected by poly-vinyl sheet, stretched on wooden frame, 58×77 cm^2. The rain water was taken in fraction at various rainfall amounts for a single rain, 100 cc being used for measurement. Dust, fell on vinyl sheet for about one day, was collected by washing with distilled water, the whole of which, 300~400 cc, was subjected to measurement.

Samplings were also made of dust on water surface in a porcelain basin, 30×33 cm^2, to compare with the case of vinyl sheet.

The G.M counter used was of the type SC-100, manufactured by Kobe Kogyo Corp. with the end window tube 1.68 mg/cm^2 in mica thickness. The samples were placed at a distance of 1.2 cm below the window, with this arrangement the counting efficiency was found to be about 6 percent, that is, 13 cpm was equivalent to 10^{-10} c, by the use of temporary standard $Sr^{90}+Y^{90}$, prepared by the Science Research Institute, Tokyo.

DAILY CHANGE OF ACTIVITY

The observed activities in rain water and fallout dust are given in Fig. 1 and Fig. 2 respectively.

Since the samplings were made in fraction for a single rain at various amounts of rainfall, the measured values of activity of each rain were converted, for the sake of comparison to those at rainfall amount of 1 mm, by interpolation or extrapolation. In the cases when data were insufficient to extrapolate a value, we obtained it with

the use of a curve indicating the observed relation between activity and the amount of rainfall, shown in Fig. 6.

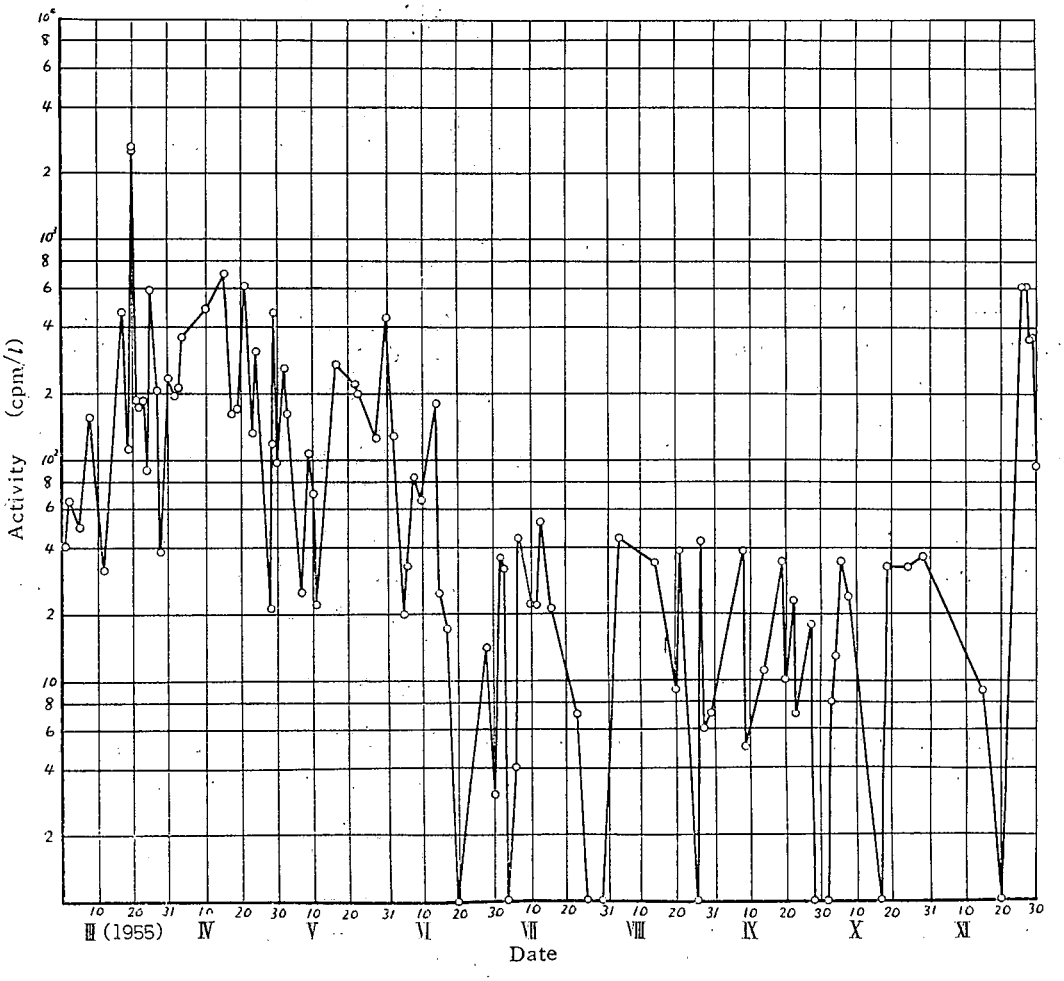

Fig. 1. Daily change of the radioactivity in rain warer

The activity in the dust collected on water surface, in the water basin, is indicated by dotted circles in Fig. 2. The change with time is similar to that in the case of vinyl sheet. The efficiency of water surface to catch dust is slightly good as compared with that of vinyl sheet, but the sampling is interrupted more often by rain than in the latter case, because of the longer period needed in sampling.

In March, 1955, the activity in rain water increased with time from the beginning, and on the 20th of this month it reached the maximum, 2600 cpm/l (20 mμc/l). Thereafter it decreased slowly, untill it recovered, in July, the normal value, that is, 20~30 cpm/l. This increase of activity was believed to be due to the Nevada experiments. From July to the middle of November, 1955, there was nothing to be noticed.

On the 26th of November, 1955, a sudden rise of activity in fallout dust appeared

as high as 360 cpm/m²/day (2.8 mμc/m²/day). As the normal value of activity in fallout dust was of the order of 3 cpm/m²/day, as estimated from the results observed

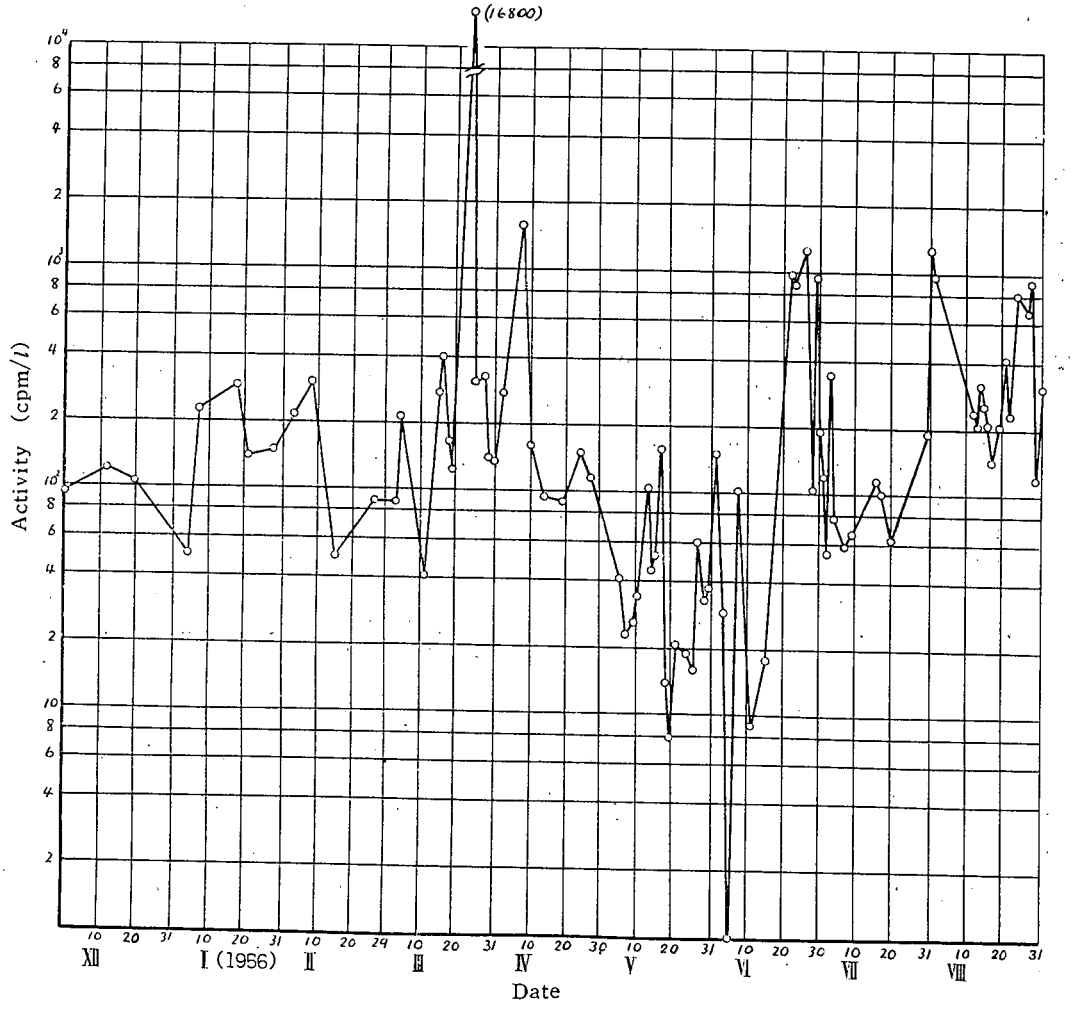

Fig. 1. Continued

from September to this time, the rise of activity at this time reached a value one hundred and twenty times as high as that of normal days. On the next day, 27 th, it rained, and in this rain water an activity of 600 cpm/l (4.6 mμc/l) was detected. This activity was not so strong as expected from that of the dust.

Though the peak in this case was not so high, the following activities, both in rain water and dust, did not decrease till the middle of March, 1956. A comparatively high constant level, ten times as high as the normal, continued. In this season rain was rare, but details of the change of activity were observed by samples of falling dust. It is note worthy that activity in dust after November, continued periodically with some constant period of which there will be some discussion later. From 20 th to 22 nd in March, 1956, an abrupt high activity of 1100 cpm/m²/day (8.5 mμc/m²/day)

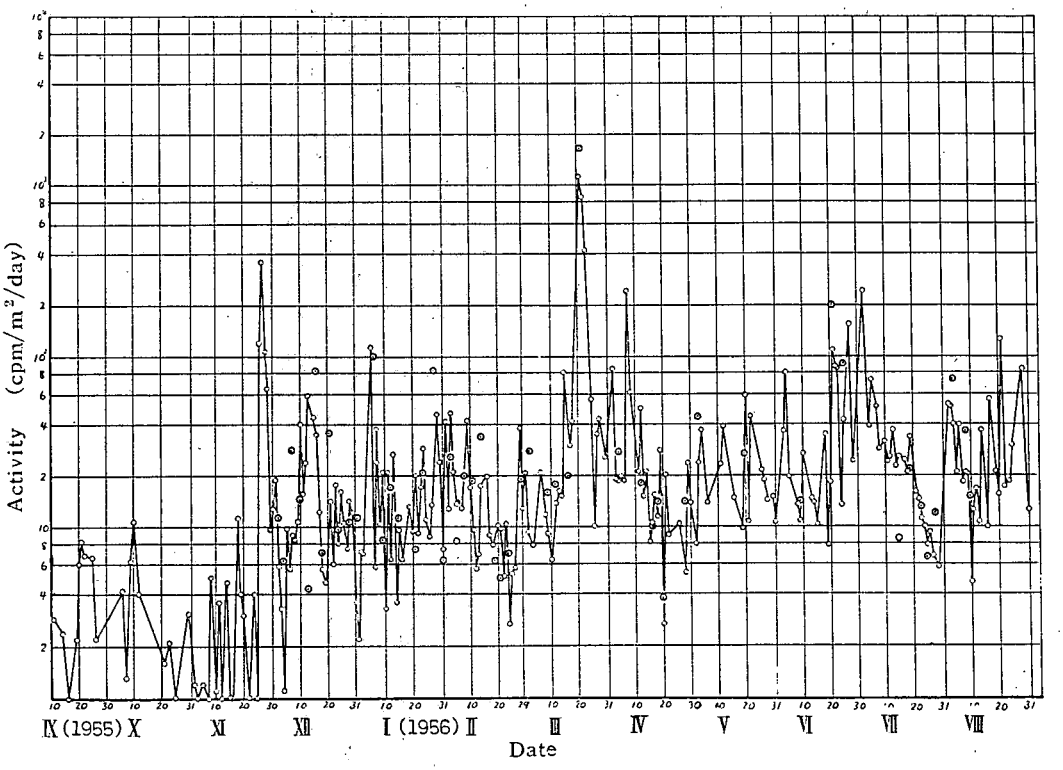

Fig. 2. Daily change of radioactivity in fallout dust.
Blank circles are by vinyl sheet, dotted circles are by water basin.

was found in fallout dust. On 24th a strong activity as high as 16800 cpm/l (130 mμc/l) was observed in rain water. Also on the same day, at Murotomisaki, 70 km south-east of Kochi-City, a high value of 49000 cpm/l was detected in rain water. The value of the maximum activity of this month both in rain water and in dust is the highest, so far observed in Kochi-City. The activity decreased after this and almost died away at the end of April. The increases in this month and November, 1955, were reportedly both aroused by tests in USSR.

The Bikini tests, performed ten times in 1956, began on the 5th of May and finished on the 22nd of July. The effect of these tests began to appear in rain water on June 22nd, the strength being about 1000 cpm/l (7.7 mμc/l), and continued for a week. The same was seen in dust, though some gradual increase, with fluctuation, had been seen from the end of April. The next rise was detected in rain water on the 31st of July and in dust on the 3rd of August. Also at the end of August some rises were observed in both rain and dust. They were considered to be attributable to the reported test in the USSR on the 24th of this month. This details are now under examination.

From the above examination we can conclude that the effect of an explosion test must appear in Japan on any occasion. And though the initial activity remains only for a few days, the following activity cotinues for a month or more. Therefore, if tests are made succesively, the contaminated air may cover our land continuosly.

ESTIMATION OF THE DATE OF DETONATION

The dates of detonation were estimated by decay measurement, assuming the decay law of gross activity proportional to the negative power of the time elapsed after detonation.

The results by the so-called log-log method and the half-decay method[1] are given in Table 1, and shown in Figs. 3, 4, 5. The samples in the first half year of 1955 are omitted, as those were reported in the previous paper.[2]

Table 1. The estimated date and the exponent of decay

Sample and Date		Log-Log Method		Half-decay Method	
		Estimated date of detonation	Exponent of decay	Estimated date of detonation	Exponent of decay
1955					
Dust	Nov. 26	Nov. 23	1.56	Nov. 24	1.06
Rain	Nov. 27	Nov. 24	1.23	Nov. 25	1.01
Rain	Nov. 30	Nov. 15	1.01	Nov. 19	
Rain	Dec. 12	Nov. 25	0.85	Nov. 26	
1956					
Dust	Jan. 6	Nov. 20(1955)	1.22		
Rain	Jan. 18	Nov. 20(1955)	1.13	Nov. 20(1955)	
Snow	Jan. 28	Nov. 20(1955)	1.13		
Dust	Mar. 22	Mar. 14	1.36	Mar. 15	1.28
Rain	Mar. 24	Mar. 14	1.24	Mar. 16	1.07
Rain	Jun. 22	Jun. 14	1.40	Jun. 17	1.16
Rain	Jun. 23	Jun. 12	1.18	Jun. 16	1.09
Rain	Jun. 26	Jun. 11	1.28	Jun. 10	1.22
Rain	Jun. 30	May 28	1.87	Jun. 4	1.47
Rain	Jul. 31	Jul. 18	1.29	Jul. 18	1.30
Rain	Aug. 1	Jul. 18	1.32	Jul. 5	1.88

The accuracy of the determination of the date was not good, due to an inaccuracy in putting the decay curve in log-log paper, and moreover to the irregular distribution of the observed points in both methods. So the error might be 2 or 3 days for most cases.

Considering the dates of sampling and the estimated one of explosion, and referring to the reported dates and sites of explosion, we have known that the time of arrival was 2~3 days for the activity in November, 1955, and 7~10 days in the case of March, 1956. The sites of these tests were both reported to be somewhere in Siberia. In the Bikini tests, the activity reached to Japan after 7~14 days, for example in the cases of June 30 th and July 31 st, 1956. These results may be useful as a reference in future cases that may happen.

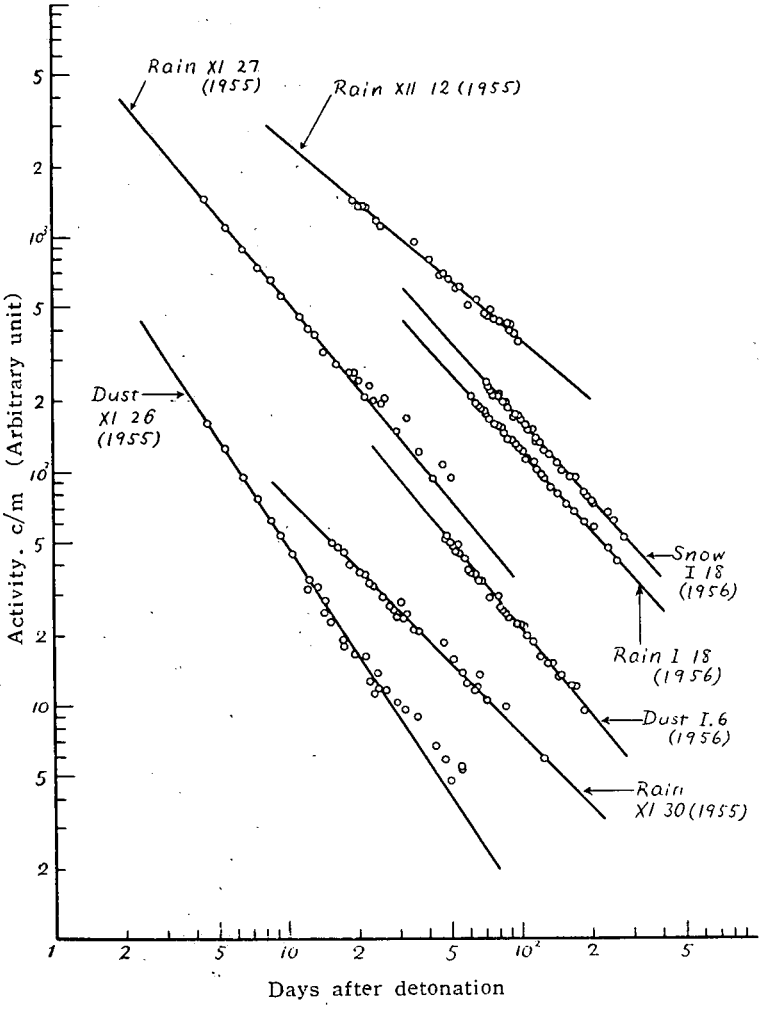

Fig. 3. Decay curves of samples

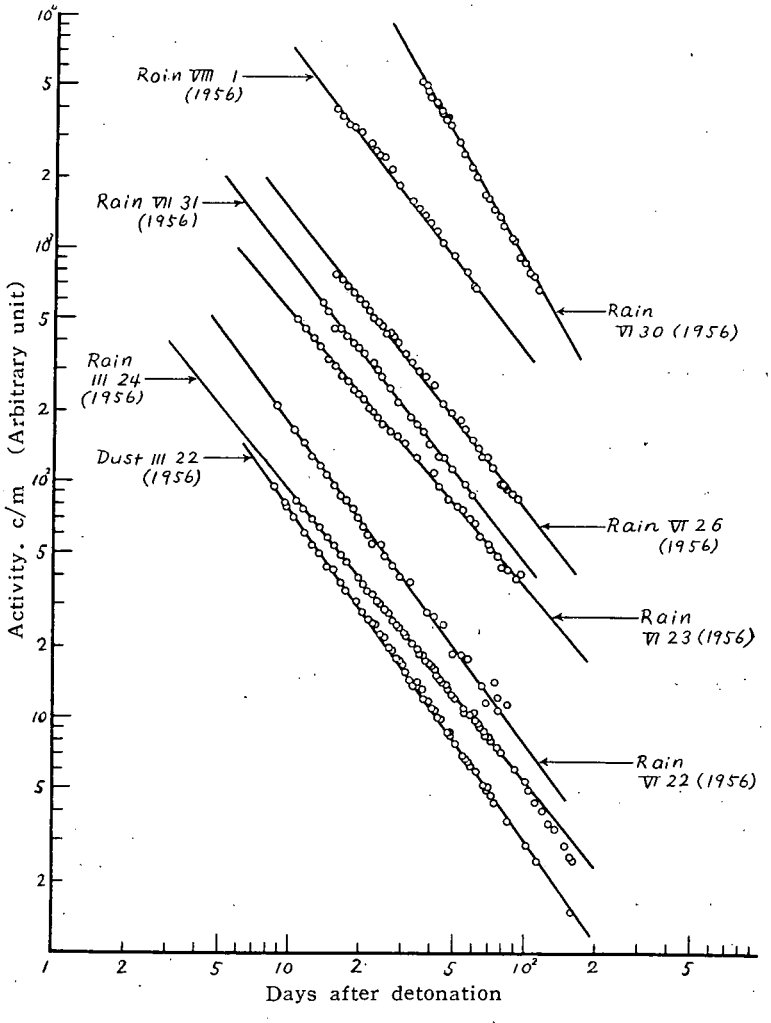

Fig. 4. Decay curves of samples

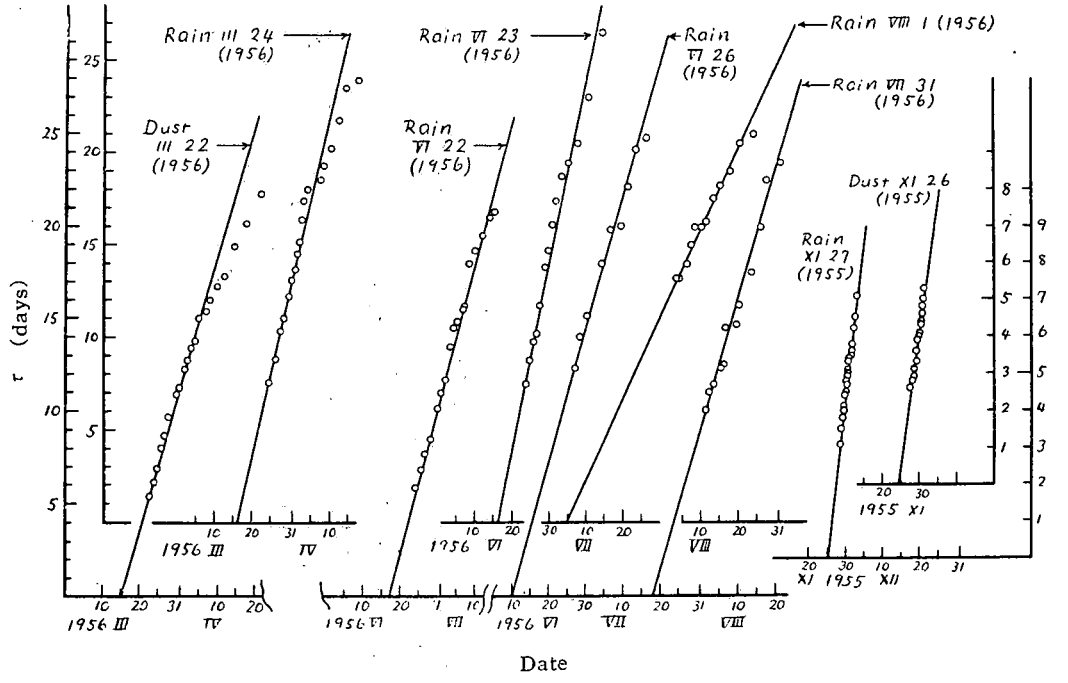

Fig. 5. Estimation of the date of detonation by the half-decay method

CIRCULATION OF RADIOACTIVE DUST ROUND THE GLOBE

In fallout dust, after the abrupt rise of radioactivity in November, 1955, there appeared periodical rises to a considerable high level, and this periodical change lasted till March, 1956, when a new activity appeared.

During this period precipitation was rare, but examining it we found no new activity; and no explosion test was reported either. From these circumstances, we concluded that the rises of activity in dust in this period were not caused by a new activity, although we took no direct decay measurement of activity in dust, owing to the low count of samples. Moreover the last test before November had been far back in May, while, on the other hand, the activity after the period in question had decreased in the middle of June, and the normal value continued until November. From the above considerations all the periodical rises of activity in dust from November, 1955, to March, 1956, are considered to have been due to the same origin as the peak in November. Thus it may be presumed that the fission dusts, originating from the explosion in November, went round the globe with upper air, thus causing in every circulation a rise of activity in fallout.

The period of the rise of activity, which was presumed to be that of the circulation of the upper air, was from 16 days to 28 days, and 22 days was obtained as the mean from five periods. The lags and quickenings of circulation may have been due to complicated atomospheric conditions.

The rise on 7th April, 1956, following the maximum peak on the 21st of March, is known, by decay measurement, to have been caused by a different source from that on 21st of March. As for a similar fluctuation in May and June, its cause may not be explained in the same way, because on the one hand the peak rose with time and on the other the tests at Bikini before this period were frequent.

RELATION BETWEEN RADIOACTIVITY AND THE AMOUNT OF RAINFALL

It is generally believed that the radioactivity in rain water is high at the beginning of fall and decreases gradually, by washing effect, in the course of rain fall. About this there are some investigations and discussions.[3] But as the resulted relation involves some unknown factors such as the radius of rain drop, the collecting rate of dust, the generating level of rain, we intended in this case to obtain some empirical relation

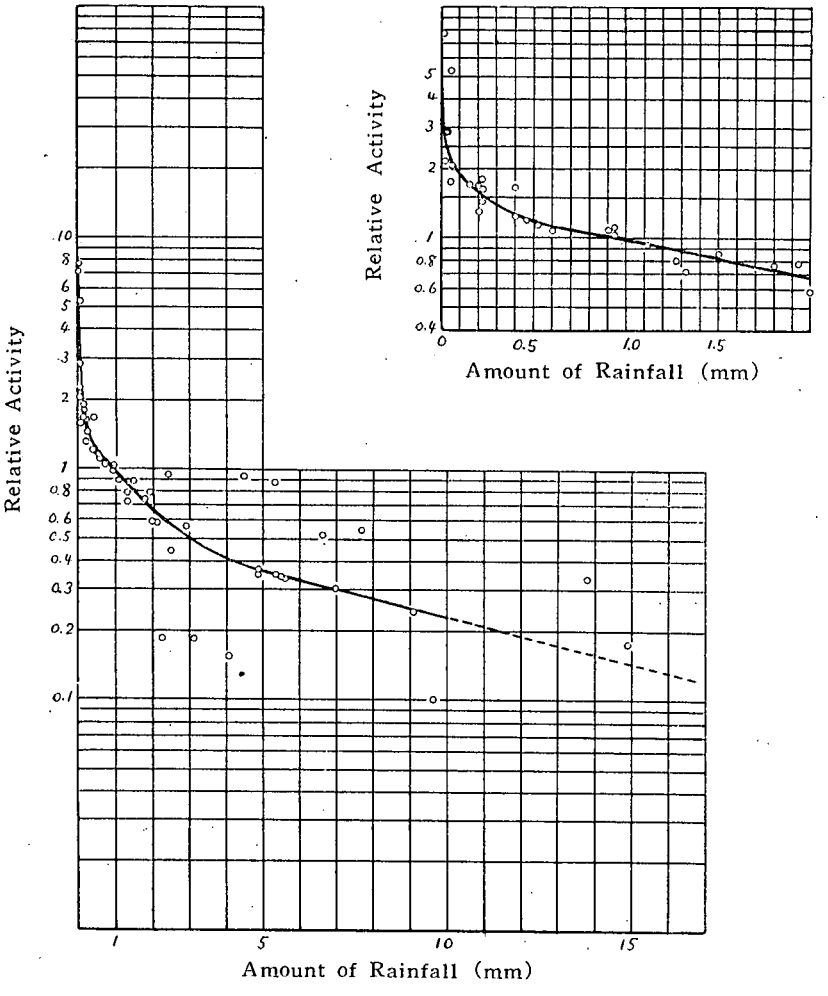

Fig. 6 The relation curve between radioactivity and amount of rainfall

in order to compare the activity of each rain at various rainfall amounts.

In order to study this relation we made samplings of water in fraction for a single rain, and examined the change of activity with the amounts of rainfall. The result thus obtained from fifteen cases is shown in Fig. 6. There may be seen a considerable divergency, especially in the range higher than 2 mm. Even in range lower than 2 mm, many varieties were seen according to the mode of rain. In some rain, the activity increased with rainfall, but after such rain, in fallout dust the activity was found also to increase with time, so that this may be accounted for by contaminated air which had newly flowed in. Such abnormal rain was excepted in obtaining the relation curve. Putting out of account some questionable cases for the moment, we accepted this relation curve as a general one, and converted the observed activity to that at desired amount of rainfall.

CONCLUSION

The daily change of the radioactivity in rain water and fallout dust in Kochi-City was obsreved, from March, 1955, to August, 1956. A rise of activity appeared in all cases, after an explosion test. Since November, 1955, the level of activity has become as high as ten times the value of normal days.

The dates of detonation were estimated by decay measurement and the time required for the arrival at Japan of the activity was obtained.

From the periodical change of activity in fallout dust the circulation of contaminated air round the globe was concluded, the period being 22 days as the average.

The relation curve of radioactivity to rainfall amount was obtained, and used for the convertion of activity to the value at the standard rainfall amount, 1 mm.

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