RADIOACTIVE FALLOUT IN THE MANILA AREA AND ITS PUBLIC HEALTH SIGNIFICANCE*

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When a nuclear weapon is detonated, fission or fusion products are formed together with the various components of the weapons assembly which are volatilized by the intense heat generated. This mass of luminescent gas, popularly known as the fireball, sucks up varying amounts of dust from the ground and forms eventually the familiar mushroom-shaped cloud so characteristic of these explosions. The radioactive particulate matter that are formed are carried to great heights and are often carried by the atmospheric jet stream all over the world. These particles then begin their slow descent to earth, subject to existing meteorological conditions. Radioactive dust thus accumulated on the earth's surface following nuclear explosions are known as fallout. The increase in radiation background observed following these detonations are due primarily to the deposition of these very fine materials, especially the relatively long-lived ones (1, 2, 3). Up to the present time the exact mechanism by which these particles settle to the earth's surface is not too well understood. However, it is now well accepted that megaton yield weapons (H-bombs) carry radioactive material to the stratosphere (above 50,000 ft.) and are almost entirely responsible for the world-wide fallout, while kiloton yield weapons carry radioactive debris to the troposphere (below 40,000 ft.) and is responsible for localized fallout (4).

Historically, fallout began in 1945 when the first atomic bombs were exploded in New Mexico and Japan. Subsequent

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tests of conventional bombs also produced fallout, but in all these cases it was small in amount and more or less localized in extent. Numerous studies have been and are being undertaken in other countries on the extent of this problem, and all indications point to the fact that nuclear detonations definitely cause an increase of radioactive debris in the upper layers of the atmosphere, the debris floating down very slowly to the earth's surface. This fact principally has led to the general agitation of peoples all over the world to ban further nuclear testing.

In this country no such studies have yet been undertaken save perhaps a few samples examined every now and then as reported by the world-wide gummed film network of the U.S. Atomic Energy Commission (3). The purpose of this study then, is to obtain some data on the fallout in the Manila area as measured at the Institute of Hygiene building, resulting from the various nuclear explosions that have recently occurred. These detonations started on April 28, 1958 and lasted till about the first week of November when no more explosions were reported in the papers. It is hoped that this paper may stimulate others in undertaking or initiating further studies along this line.

Fallout measurements are generally given in disintegration rate (curie) units because of technical difficulties and expense that would be involved in making continuous low-level rediation dose measurements. Actually it would have been better to give the results in dose rate units — rads, roentgen, rems — since these are the expressions that are of genetic and biological importance. Approximate indirect methods have been devised to express fallout measurements in terms of dosage, but the literature and equipment available at the present does not permit us to do this.

SAMPLING AND MEASUREMENT

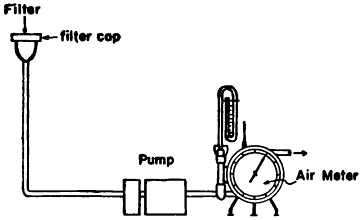
Three methods of sampling were used. The first method consists of drawing air through an ordinary filter paper and the accumulated dust coming from the atmosphere is measured for radioactivity. Results are then expressed as disintegration per minute and converted to millicuries per cubic meter of air sampled. An ordinary baby milk glass bottle with plastic screw cap and inverted rubber nipple was connected to a suction pump through a gas meter as shown in Figure A. The area of the exposed filter paper was approximately 0.8 square inch.

The second method makes use of filter paper of known area exposed to the air for 24 hours and the measured activity is then expressed in disintegration per minute transformed into millicuries per square mile per 24 hours. This method has been lately improved by using the 1 foot square of gummed film (similar to Scotch tape) provided by the Philippine Atomic Energy Commission. Whenever this supply is exhausted, use is made of a 10 inch x 10 inch ordinary filter paper coated with vaseline (petrolatum) in order for the settled particulate matter to adhere to the paper. The latter method is used by the Japanese (5).

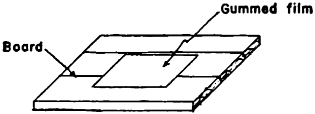
In both methods, the collecting media (filter paper or gummed film located in the roof of the Institute of Hygiene building about 70 feet above ground level) are then ashed in an evaporating dish at 550°C. (about 1000°F.), washed with distilled water to a 1-inch stainless steel planchet, dried to constant weight and counted for activity by a Tracerlab Geiger-Muller (GM) Tube of about 1.8 mg. per sq. cm. window thickness. A matched decimal Scaler records the activity of the sample which is placed about 8.7 mm. from the thin end window of the GM tube whose diameter is 27 mm.

Another method tried utilized the electrostatic precipitator to gather the airborne dust particles. These are collected by drawing air into a chamber where a potential of 12 kilovolts is applied. Once collected, the dust particles are washed into a container with distilled water and filtered through the membrane microfilter. The filter is then ashed and counted for activity as in the other two methods, the results being expressed in disintegrations per minute per unit volume of air. Use of this method in this study was limited to days when there were noticeably high counts in the other two methods and served mainly as a check.

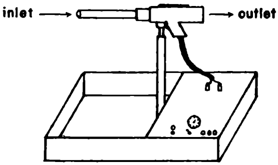
The above methods referred to collection of airborne particles directly. Mention should also be made of the attempt to determine the radioactivity brought down by precipitation. Here, a measured amount of rainfall, as collected in a beaker,



(a) Filter Paper - Suction Pump



(b) Gummed Film Method



(c) Electrostatic Precipitator

FIG. 1 - DIAGRAM OF SAMPLING SET-UP

is slowly evaporated directly into a planchet and counted. Results are then expressed in disintegrations per minute and converted to micromicrocuries per liter of water sample.

RESULTS AND INTERPRETATION

The results of the various measurements made are given in the tables and figures. Table 1 shows the air dust radioactivity in net counts per minute per cubic meter of air sampled. This activity is then divided by the efficiency of the counter (0.186 as determined by using 2 reference standards: simulated I^{131} with an activity of 2.30 x 10^{-5} microcuries and Bi^{210} with

Table 1. RADIOACTIVITY, INSTITUTE OF HYGIENE, MANILA, PHILIPPINES, JUNE-NOVEMBER, 1958 in Net CPM/cu. m. AIR, FILTER PAPER-SUCTION PUMP SAMPLE

DATE	Air Dust Activity, Net cpm/cu. m.	DATE	Air Dust Activity, Net cpm/cu. m.	DATE	Air Dust Activity, Net cpm/cu. m.
June 4	3.0	July 10	2.2	Sept. 1	0.1
5	3.7	11	1.3	3	0.0
6	1.9	12	3.1	4	0.5
8	3.4	17	0.3	5	0.8
9	2.7	22	0.7	10	0.4
10	2.2	23	4.8	16	0.0
12	0.0	24	3.3	17	0.4
13	0.5	28	0.8	Oct. 8	0.2
14	0.9	30	3.1	9	0.8
16	0.2	31	1.1	10	1.8
17	0.1	Aug. 1	1.7	14	0.2
20	1.3	5	2.3	15	0.1
23	0.4	7	2.2	16	0.7
24	0.7	8	0.8	Nov. 3	3.0
25	1.9	11	2.0	4	0.1
26	7.2	12	1.2	9	0.0
27	8.4	13	1.5	10	0.3
28	3.4	14	2.5	17	0.9
30	9.2	15	2.4	19	0.0
July 1	15.7	18	0.9	20	1.1
2	3.3	20	0.6	21	2.1
3	16.6	21	1.1	22	3.2
5	5.3	22	0.7	25	1.5
7	7.0	26	0.2	29	3.1
8	4.6	27	1.0		
9		28	0.9		

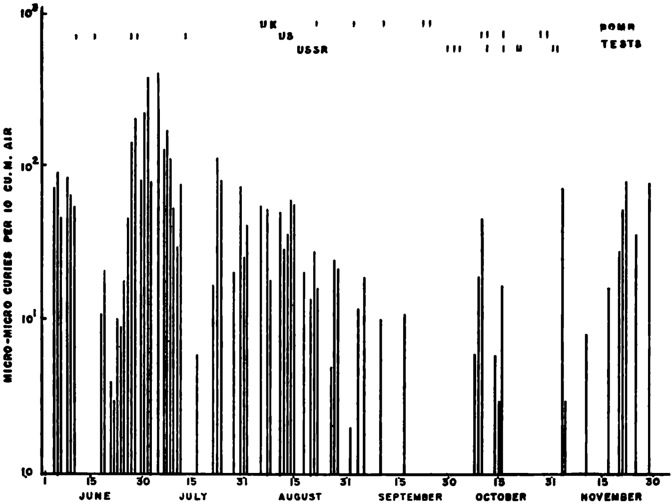


FIG. 1-RADIOACTIVITY, INSTITUTE OF HYGIENE, MANILA, PHILIPPINES, JUNE-NOV., 1958 IN MICRO-MICROCURIES PER 10 CU.M. AIR (FILTER PAPER-SUCTION PUMP SAMPLE)

an activity of 1.50 x 10^{-5} microcuries, both beta emitters) and converted into micromicrocuries per 10 cu. meters and plotted in Figure 1. Table 2 shows the net counts per minute of settled dust per sq. foot of exposed area per day. This is converted into millicuries per square mile per day and plotted in Figure 2. Table 3 presents the rainwater activity. A few decay curves of unusually high activities obtained are plotted in Figure 3.

The results obtained in these studies on gross activities of sampled fallout may be summarized as follows:

1. Using our instrument, the background count in the Manila area apparently increased from about 22 counts per minute (September 1957 to June 1958) to about 27 counts per minute (July 1958 to present), an increase of almost 23%.

2. The natural (or normal) radioactivity in the Manila atmosphere is estimated to be about 2 x 10^{-12} curies per cubic meter. This compares with the 5 x 10^{-11} curies per cubic meter observed in New York (1) and about 10^{-11} curies per cubic meter in Tokyo, Japan (5).

3. The apparent natural activity of settled dust in Manila is about 3.5 x 10^{-11} curies per square foot or roughly 1 mc/sq. mile. This is approximately half of the U.S. figures, and about the same as Japanese findings.

4. Radioactive fallout may be detected in Manila from about 3 days to as long as two weeks after a nuclear detonation, depending largely upon local atmospheric conditions and energy yield of the weapon tested as suggested by the Report of the U.N. Scientific Committee on Atomic Radiation (6). A nuclear explosion somewhere in the world however, cannot always be detected in Manila from fallout measurements alone. Nevertheless, an unusually high activity locally recorded means a detonation especially of high yield weapons such as hydrogen bombs. Showers and rainfalls also usually bring about an apparent increase of atmospheric radioactivity.

5. Several peaks were observed during the announced test explosions and these peaks represented high activities from about twice to 60 times the natural activity. The maximum activity was estimated on July 3-6 when settled dust registered an activity of about 40 mc per square mile (using only a plan-

chet as sample holder). Two other peaks were observed using the one-foot square gummed film: one on September 16 with

Table 2. RADIOACTIVITY, INSTITUTE OF HYGIENE, MANILA PHILIPPINES, AUGUST-DECEMBER, 1958 in Net CPM/sq. ft., GUMMED FILM SAMPLE

DATE	Air Dust Activity, Net cpm/sq. ft.	DATE	Air Dust Activity, Net cpm/sq. ft.	DATE	Air Dust Activity, Net cpm/sq. ft.
Aug. 16	25	Sept. 23	44	Nov. 3	1
17	8	24	53	4	3
18	8	25	6	5	4
19	26	26	3	6	33
20	18	27	7	7	9
21	28	28	17	8	3
22	32	29	17	9	2
23	5	30	9	10	2
24	5	Oct. 1	3	11	1
25	15	2	35	12	3
26	34	3	9	13	8
27	29	4	1	14	7
28	21	5	6	15	4
29	21	6	7	16	4
30	17	7	5	17	5
31	6	8	2	18	9
Sept. 1	6	9	9	19	12
2	29	10	0	20	6
3	11	11	10	21	11
4	9	12	1	22	1
5	2	13	1	23	1
6	15	16	4	24	9
7	15	17	15	25	13
8	15	18	15	26	16
9	23	19	21	27	16
10	13	20	21	28	26
11	11	22	6	29	7
12	9	23	4	30	7
13	29	24	1	Dec. 1	7
14	12	25	3	2	6
15	13	26	7	3	5
16	388	27	7	4	21
17	30	28	1	5	31
18	20	29	13	6	10
19	25	30	220	7	10
20	8	31	23	8	8
21	5	Nov. 1	1	9	5
22	5	2	1	10	10

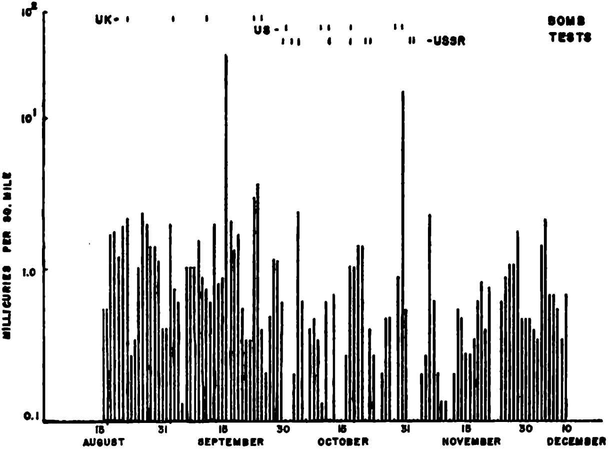


FIG.2-RADIOACTIVITY, INSTITUTE OF HYGIENE, MANILA, AUG-DEC, 1958, MILLICURIES PER SQ. MILE (GUMMED FILM)

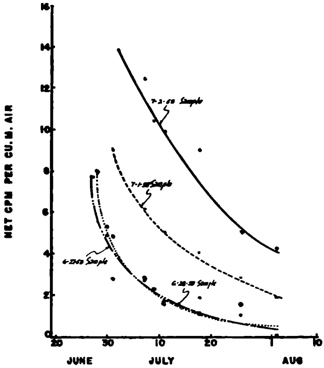


FIG.3-DECAY CURVES HIGH-COUNT SAMPLES

an activity of about 26 millicuries per square mile and a second on October 30 which showed about 15 millicuries per square mile.

Table 3. RAIN WATER RADIOACTIVITY, INSTITUTE OF HYGIENE, HERRAN, MANILA, JULY-OCTOBER, 1958

DATE	Rain Water Activity Net cpm/100 ml.
July 11	2
12	34
13	38
14	25
15	21
16	11
18	16
Aug. 3	8
22	2
25	1
Sept. 15	6
16	8
22	4
23	4
Oct. 7	6
14	3
26	6

6. Japanese scientists have suggested that air which had been over the Bikini Atoll at noon on May 8, 1954 (3 days after a bomb explosion) passed by the Philippines sometime between May 12 and 13 and caused an increase of activity in Tokyo and other cities (7). This is probably what occurred again in June 29, 1958 when a high yield weapon was exploded and which resulted in an unusually high atmospheric radioactivity on July 3-6, assuming similar atmospheric conditions existed. An announced H-bomb test by the United Kingdom in Christmas Islands in the Pacific on August 2, 1958 did not result in any unusual activity on September 16. Russian explosions on October 21 and 22 and on November 1 and 2 also resulted in a high activity 4 to 8 days later.

7. The natural radioactivity of tap water in Manila averages about 2 cpm per liter or 5 micromicrocuries per liter. Rain

water activity on July 11-18 showed from 112 to 382 cpm or 275 to 930 micromicrocuries per liter, the maximum occuring during the rain of July 13, 1958. Due to laboratory difficulties, however, there were only a few rain samples studied.

Lack of equipment has prevented us from determining the concentration of strontium-90 and cesium-137, long-lived radioactive nuclides that are of principal biological importance. Libby (4) has reported that from March 1955 to November 1957 the cumulative Sr^{90} fallout as recorded in Pittsburgh, Pa. was about 23 millicuries per square mile which is even greater than the gross activity peak recorded in Manila on October 30, 1958. Undoubtedly it is even higher today since there have occurred at least 20 nuclear explosions since then. In the one period, from November 1956 to October 1957, Libby estimates that the Sr^{90} cumulative fallout varies from less than a millicurie per square mile in Penya, Africa as reported by the U.S. Atomic Energy Commission to almost 12 millicuries per square mile as observed in Salt Lake City, Utah. In Nagasaki, Japan, the figure is about 7 mc per square mile. Eisenbud and Harley (3) has reported that as of June 1957 the cumulative Sr^{90} in Manila is about 17 mc per square mile and about 23 mc per square mile in Tokyo, Japan, with a maximum of about 54 mc per square mile in the Nevada area and 78 mc square mile in Bikini area.

PUBLIC HEALTH SIGNIFICANCE

As public health workers we are interested in the possible harmful effects of these ionizing radiations to our country and people. Just what is the magnitude of the problem posed by these local findings and as reported in foreign scientific journals and how would we react to such problems?

Before proceeding to answer these questions let us first state some facts concerning radiation in general (6):

Fact 1: Even the smallest amounts of radiation are liable to cause deleterious genetic effects — that is, limited to descendants — and perhaps also somatic effects, those limited to the irradiated organism itself. A Study Group convened by WHO categorically states that all man-made radiation must be regarded as harmful to man from the genetic point of view.

Fact 2: There are three principal sources of these radiations to which mankind in general is exposed:

Natural sources — cosmic rays, atmospheric and terrestial radiation and the naturally occurring radionuclides.

Man-made sources — medical uses of X-rays and radiotracers, industrial uses of X-rays and others such as luminous dials, TV sets, etc.

Environmental contamination — due to nuclear explosions, radioactive waste disposal and accidents.

Fact 3: Of these three sources, the first is outside of human control while the second and third are controllable. The second source is of great importance in science and industry and exposures can be reduced by perfecting protection and safety techniques. The third source constitutes a growing increment to world-wide radiation hazards and are beyond control of the exposed persons.

With these in mind let us now try to get a quantitative comparison of the exposure dosages resulting from these sources.

The following table, based on world-wide averages, summarizes these estimated dosages that may be applied to Philippine conditions (6):

Sources	Genetically Significant Dose — 30 year maximum in rems	Per Capita Mean Marrow Dose — 70 year maximum in rems
Natural	3	7
Man-made sources except environmental contamination and occupational exposure	0.5 — 5	Ranges beyond 7
Occupational exposure	Less than 0.06	0.1 — .2
Environmental contamination		
Tests end 1958	.01	.96
Tests continue	.06 — .12	7.5 — 17

It is evident from the above data that even without the advent of the nuclear age we would be receiving some 3 rems of radiation during our reproductive period and about 7 rems throughout our life span. This dose we easily assimilate, since it has always been with us and our bodies have been used to these normal radiations. In the United States, an upper limit of 10r for a 30-year genetic dose has been set with a balance between possible harm and possible benefit.

It may be mentioned in passing that an acute dose of up to 25 rems over the whole body produces no obvious injury while dosages of more than 600 rems are fatal (9). The usual maximum permissible tissue dose has been set at 300 m rems per week (10) by the International Commission on Radiological Protection. The exposure due to natural sources has therefore practically an insignificant effect, the body capable of repairing any injury that may have resulted.

The Advisory Committe on Biology and Medicine of the National Academy of Science sums up the problems of radioactive fallout thus:

"Radioactive fallout in the surface of the earth can deliver radioactivity to animals and man in two ways: (1) by the external route in which case the penetrating gamma radiation is of chief importance, and (2) by the internal route when the material is taken into the body with food, water, air, in which case the radiation of low penetrating powers can also reach the internal organs and is of chief concern. Therefore the problem is to estimate what harm may possibly result to man from the general increase in background radiation and from radioactive substances introduced into the body. This requires quantitative data on the accumulation of radioactive material on the ground and in the body."

This then is the problem and the available literature seems to point out that at the moment, exposure due to fallout is of lesser order of magnitude than that due to natural radiation, and hence of even less concern.

It may be concluded that all steps designed to minimize irradiation of human population will be to the benefit of human health. Such steps include the avoidance of unnecessary exposure resulting from man-made sources and the cessation of environmental contamination by nuclear weapons explosion. The citizens of any country, however, are primarily concerned about the military safety of their country and hence the authorities are expected to keep abreast of new weapons development. In terms of their own national security, therefore, countries undertaking nuclear weapons are justified especially if it is recalled that estimated damage resulting from such tests is well within tolerable limits. However, in fairness to all, it is only proper that these tests be held to a minimum consistent with scientific and military requirements, if it is not possible to eliminate them entirely.

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