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NATURAL RADIOACTIVITY MEASUREMENTS AT THE PROPOSED NUCLEAR POWER PLANT SITE

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ABSTRACT

Natural radioactivity measurement in the Philippines aims to establish baseline radioactivity levels in the environment of items essential to man. In this article are presented the results of the environmental surveillance conducted in Bagac, Bataan from 1973 to 1974. Analyses were made on air particulates, sea and fresh water, grass, and soil samples for gross beta-gamma activities. Results obtained showed activity levels below the maximum permissible concentration recommended by the International Committee on Radiation Protection (ICRP).

INTRODUCTION

The expected increase in the pace of activities involving the peaceful uses of the atom has brought about numerous projects, studies, and seminars devoted to the control of world-wide pollution and the preservation of the natural environment. One aspect of the environment which has been given close attention is radioactivity in nature. Natural radioactivity or background radioactivity consists mainly of cosmic rays from space, radiation from natural elements like uranium, unstable potassium and thorium, and most recently, radiation from fallout due to

atmospheric nuclear weapons testing, and from the operations of nuclear installations.

In the Philippines, there is no set of values on which the level of natural radioactivity is based. Initial studies on natural radioactivity measurements in the Philippines have been conducted with the ultimate objective of establishing baseline data on the radioactivity levels in the environment of items essential to man; these data will serve as reference in evaluating any increase in the background radioactivity level that may be contributed by releases from nuclear installations or from fallout due to nuclear detonations.

Part of these studies is the environmental monitoring program which was conducted in Bagac, Bataan from March 1973 to December 1974. The purpose of this program was to provide a means of monitoring releases of radioactive materials to the environment resulting from the future operation of the proposed nuclear power plant which was initially planned to be installed in that municipality.

METHODOLOGY

A. Sampling:

Bagac, Bataan is about 70 kms. from Manila and 80 kms. from Quezon City where the Philippine Research Reactor I (PRR-I) is situated. Figure 1 shows a map depicting the relative distances of the location mentioned. As indicated

in the figure sampling stations were established in the survey area with 1.5 km.to 50 km. radii from the original site.

These sampling points include nine stations for grass samples, eleven for soil samples, five for sea water samples, three for fresh water samples and nine for air monitoring. The locations of these points are shown in Figures 2 and 3.

Monthly collection was carried out for the different environmental samples, exclusive of fresh water for which samples were collected daily.

B. Sample Preparation:

1) Air Particulates - Airborne particulate matter collected on a 7FA Type "s" filter paper were ashed until freed of carbonaceous components. The residual ash containing mostly metal oxide was treated with perchloric and nitric acid to oxidize the metals into a uniform valence state. The salts were then converted to the nitrate form with nitric acid and then transferred to a 1-inch aluminum planchet previously counted for background activity.

2) Water Samples - A liter volume of the sample was filtered through a Whatman #42 filter paper. The insoluble matter remaining in the filter paper was treated in the same manner as the air sample while the soluble portion in the filtrate was evaporated almost to dryness. A few drops of nitric acid was added to convert the salts into

the nitrate form. Both the soluble and insoluble portions were separately transferred to a one-inch aluminum planchet for counting.

3) Grass Samples - Samples were dried, ground, ashed and subsequently treated in the same manner as the air particulates.

4) Soil Samples - Samples were first dried in an oven followed by ignition in a muffle furnace at 450° until freed of carbonaceous components. After cooling, the samples were transferred to a pre-weighed planchet for counting.

It should be mentioned that the methods employed for processing the environmental samples were modifications of the techniques used by E. Ferri● et al[1] and C.R. Porter[2].

C. Counting of Sample and Calculation of Activity:

The samples were counted using an end window G-M tube with a window thickness of 2 mg/cm^2.

The gross beta-gamma activity of the sample was calculated using the following formula:

$$\text{Activity} = \frac{\text{net count sample}}{\text{Eff.} \times F \times 2.2 \times 10^6}$$

where: Eff = efficiency of the G-M counter

F = weight or volume of the sample

2.2×10^6 dpm = 1 uCi

RESULTS AND DISCUSSIONS

Results of gross beta-gamma activity measurements on the various environmental samples collected, namely, air particulate matter, fresh and sea water, grass and soil are summarized in Tables I to V. An evaluation of the data gathered is presented in Table VI. Fresh water sampled in March 1974 from the Bagac River which is 5 kms. from the center of the site gave the highest measurable activity of $(5.58 \pm 1) \times 10^{-8}$ uCi/cc while the lowest measurable value obtained with $(0.2411 \pm 0.1031) \times 10^{-8}$ uCi/cc was taken from Pao-on River in September 1974. For sea water, the highest value measured was $(3.998 \pm 0.594) \times 10^{-6}$ uCi/cc which was collected in June 1973 at Bagac Sea. Nevetheless this activity is lower than the level obtained in the sea water of Bombay, India[3] with a radioactivity content of 8.6×10^{-6} uCi/cc. However, for air particulates, the measured value is ten times higher than the ICRP recommended values. These observations on the air samples may be explained by the seasonal variations in meteorological conditions in addition to the difference in geographical locations.

The results generally show that the activity levels of all collected samples vary appreciably with the date of collection. An attempt to explain these variations would entail a comprehensive knowledge of the particular ecosystem within the sampling stations which includes the flow charac-

teristics of the river/sea, sedimentation patterns, climactic and seasonal variations.

CONCLUSION

The gross beta-gamma activity levels in the study area found to be as follows:

a) fresh water - 10^{-8} uCi/cc
b) sea water - 10^{-6} uCi/cc
c) air particulates - 10^{-12} uCi/cc
d) grass - 10^{-3} uCi/gm ash
e) soil - 10^{-6} uCi/gm soil

So far no analyses for specific radionuclides have been made. The levels of activity obtained in water and air particulates were higher than normally observed at the Philippine Atomic Research Center, i.e., less than 10^{-8} uCi/cc and about 10^{-14} uCi/cc respectively. These levels however are lower than the ICRP accepted levels.

The variabilities in the observed activity levels would possibly be explained by the meteorological factors and the ecological behaviours such as the flow characteristics of the river/sea, sedimentation patterns, climactic and seasonal variations within the sampling areas. Nonetheless, any deviation from the natural activity levels in different countries could be attributed to the variabilities inherent in the earth's surface, and the contributions from cosmic rays which differ at different

altitudes and geomagnetic latitudes.

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/spd

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TABLE I: GROSS BETA-GAMMA ACTIVITY (10^{-8} uCi/cc) IN FRESH WATER

1973	BAGAC RIVER	CABAYO RIVER	PAO-ON RIVER	1974	BAGAC RIVER	CABAYO RIVER	PAO-ON RIVER
MARCH	4.70±0.0118	ESS. BACK.	ESS. BACK.	JAN.	ESS. BACK.	ESS. BACK.	ESS. BACK.
APRIL	4.525±0.7509	3.6409±0.9383	ESS. BACK.	FEB.	2.0719±1.7516	3.1463±2.7775	1.4580±0.3808
MAY	ESS. BACK.	ESS. BACK.	ESS. BACK.	MARCH	5.58 ± 1.00	4.30 ± 0.963	4.280 ±0.975
JUNE	N.S.	N.S.	N.S.	APRIL	ESS. BACK.	ESS. BACK.	ESS. BACK.
JULY	1.8182±0.1293	2.4545±1.2608	2.091±0.216	MAY	ESS. BACK.	1.2551±0.5368	ESS. BACK.
AUG.	ESS. BACK.	ESS. BACK.	ESS. BACK.	JUNE	ESS. BACK.	ESS. BACK.	ESS. BACK.
SEPT.	2.5950±0.5516	ESS. BACK.	1.5105±0.2050	JULY	0.6150±0.1984	0.2898±0.1128	0.3110±0.0948
OCT.	ESS. BACK.	ESS. BACK.	3.4071±0.9922	AUG.	ESS. BACK.	ESS. BACK.	ESS. BACK.
NOV.	ESS. BACK.	2.1877±0.7214	ESS. BACK.	SEPT.	0.4888±0.1136	0.6062±0.0832	0.2411±0.1031
DEC.	N.S.	2.1687±0.2062	1.8843±1.4051	OCT.	ESS. BACK.	ESS. BACK.	ESS. BACK.
				NOV.	0.4120±0.1277	ESS. BACK.	ESS. BACK.
				DEC.	ESS. BACK.	0.2900±0.1105	ESS. BACK.

N.S. - NO SAMPLE

ESS. BACK. - BELOW THE SENSITIVITY OF THE DETECTOR

NOTE: ERROR TERM INDICATED IS DUE TO COUNTING

TABLE II: GROSS BETA-GAMMA ACTIVITY (10^{-6} uCi/cc) IN SEA WATER

1973	RSSS #1	RSSS #2	RSSS #3	BAGAC SEA	NAGDA-LAYONG SEA	1974	RSSS #1	RSSS #2	RSSS #3	BAGAC SEA	NAGDA-LAYONG SEA
MARCH	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	MAY	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	0.4314 ± 0.2430
APRIL	0.1575 ± 0.0612	1.0800 ± 0.3011	1.426 ± 0.2880	ESS. BACK.	0.6400 ± 0.1163	JUNE	N.S.	N.S.	N.S.	N.S.	N.S.
MAY	ESS. BACK.	ESS. BACK.	ESS. BACK.	0.4250 ± 0.2722	0.9500 ± 0.1733	JULY	ESS. BACK.	ESS. BACK.	E. S. BACK.	ESS. BACK.	ESS. BACK.
JUNE	N.S.	ESS. BACK.	1.7550 ± 0.8336	3.9980 ± 0.5940	ESS. BACK.	AUG.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.
JULY	ESS. BACK.	2.0454 ± 1.3978	ESS. BACK.	N.S.	N.S.	SEPT.	0.4497 ± 0.1041	ESS. BACK.	0.9060 ± 0.1504	N.S.	N.S.
AUG.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	OCT.	0.2800 ± 0.0981	ESS. BACK.	ESS. BACK.	ESS. BACK.	N.S.
SEPT.	ESS. BACK.	0.9876 ± 0.6822	ESS. BACK.	1.6118 ± 0.4479	ESS. BACK.	NOV.	0.5450 ± 0.0907	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.
						DEC.	0.5340 ± 0.0813	0.2837 ± 0.0965	ESS. BACK.	0.2570 ± 0.1026	ESS. BACK.

RSSS - Reactor Site Sampling Station

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TABLE III: GROSS BETA-GAMMA ACTIVITY (10^{-12} uCi/cc) IN AIR PARTICULATE MATTER

	DATE	BAGAC	NAGBA-LAYONG	MAHABANG PARANG	BANAWANG	BAGAC-MORON BOUNDARY	MOUNT SAMAT	SAN ANTONIO ZAMBALES	KABAYO HIGHWAY	SAYSAIN
1973	MARCH	1.600 ± 0.2930	1.564 ± 0.3163	4.40 ± 0.8473	4.90 ± 0.8228	3.13 ± 0.4866	-	-	-	-
	APRIL	3.84 ± 1.3148	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	N.S.
	MAY	ESS. BACK.	ESS. BACK.	1.12 ± 0.4696	ESS. BACK.	ESS. BACK.	1.00 ± 0.2817	ESS. BACK.	0.81 ± 0.3573	N.S.
	JUNE	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	1.9113 ± 1.8673	ESS. BACK.	ESS. BACK.	ESS. BACK.
	JULY	ESS. BACK.	N.S.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.
	AUGUST	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.
	SEPT.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.
1974	MAY	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.
	JUNE	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	JULY	ESS. BACK.	ESS. BACK.	0.3002 ± 0.1188	N.S.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.
	AUGUST	ESS. BACK.	N.S.	ESS. BACK.	ESS. BACK.	N.S.	ESS. BACK.	ESS. BACK.	0.6048 ± 0.1796	ESS. BACK.
	SEPT.	N.S.	ESS. BACK.	N.S.	N.S.	ESS. BACK.	N.S.	ESS. BACK.	N.S.	N.S.
	OCTOBER	0.3337 ± 0.4318	ESS. BACK.	ESS. BACK.	N.S.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.
	NOVEMBER	0.3147 ± 0.1466	ESS. BACK.	ESS. BACK.	ESS. BACK.	ESS. BACK.	N.S.	0.3924 ± 0.3122	N.S.	0.1859 ± 0.2398

TABLE IV: GROSS BETA-GAMMA ACTIVITY (10^{-4} uCi/gm. ash) IN GRASS SAMPLE

COLLECTION SITE \ DATE	MARCH 1973	APRIL 1973	MAY 1973	JUNE 1973	JULY 1973	JULY 1974	AUG. 1974
REACTOR SITE SAMPLING STATION #1G	ESS. BACK.	0.2879 ± 0.1154	ESS. BACK.	ESS. BACK.	ESS. BACK.	0.3644 ± 0.0774	N.S.
REACTOR SITE SAMPLING STATION #2G	0.5134 ± 0.2045	0.6970 ± 0.2868	1.6116 ± 0.6368	0.6760 ± 0.2716	3.0367 ± 0.7538	0.6372 ± 0.0809	0.3045 ± 0.1305
REACTOR SITE SAMPLING STATION #3G	5.6565 ± 1.3432	N.S.	3.8562 ± 0.8804	1.0432 ± 0.7051	3.0259 ± 0.8812	0.3735 ± 0.0927	N.S.
REACTOR SITE SAMPLING STATION #4G	21.9778 ± 0.6311	0.900 ± 0.2083	ESS. BACK.	3.0388 ± 0.4682	0.6508 ± 0.2966	0.3262 ± 0.0805	N.S.
REACTOR SITE SAMPLING STATION #5G	ESS. BACK.	ESS. BACK.	ESS. BACK.	0.7170 ± 0.5515	1.6298 ± 0.2414	0.3565 ± 0.0638	0.2879 ± 0.7889
DANAWANG	N.S.	0.7944 ± 0.2166	15.2030 ± 1.5690	0.4386 ± 0.1903	1.1736 ± 0.2083	N.S.	0.5010 ± 0.1433
NAGBALAYONG	N.S.	ESS. BACK.	ESS. BACK.	1.0517 ± 0.1936	N.S.	0.9544 ± 0.0885	N.S.
MAHABANG PARANG	3.3671 ± 0.7795	1.589 ± 0.1632	1.6994 ± 1.0933	3.0648 ± 0.2526	N.S.	0.3332 ± 0.0584	0.3993 ± 0.0912
BAGAC RIVER	1.1525 ± 0.9395	ESS. BACK.	3.4235 ± 0.7830	2.0134 ± 0.3317	N.S.	0.6421 ± 0.0561	N.S.

TABLE V. GROSS BETA-GAMMA ACTIVITY (10^{-6} uCi/gm dried sample) IN SOIL

COLLECTION SITE \ DATE	MARCH 1973	APRIL 1973	MAY 1973
REACTOR SITE SAMPLING STATION #1 G	ESS. BACK.	N.S.	ESS. BACK.
REACTOR SITE SAMPLING STATION #2 G	5.430±1.529	N.S.	ESS. BACK.
REACTOR SITE SAMPLING STATION #3 G	2.900±0.699	ESS. BACK.	ESS. BACK.
REACTOR SITE SAMPLING STATION #4 G	ESS. BACK.	ESS. BACK.	ESS. BACK.
REACTOR SITE SAMPLING STATION #5 G	ESS. BACK.	ESS. BACK.	ESS. BACK.
MAHABANG PARANG	2.91±1.346	ESS. BACK.	ESS. BACK.
AGNAC RIVER	3.500 1.176	ESS. BACK.	ESS. BACK.
BAN.WANG	ESS. BACK.	ESS. BACK.	ESS. BACK.
MT. SAMAT	ESS. BACK.	ESS. BACK.	ESS. BACK.
NAGBALAYONG	ESS. BACK.	ESS. BACK.	ESS. BACK.
SAN ANTONIO, ZAMBALES	ESS. BACK.	ESS. BACK.	ESS. BACK.

TABLE VI: LEVELS OF ACTIVITIES IN THE WHOLE AREA

ENVIRONMENTAL SAMPLE		GROSS BETA-GAMMA ACTIVITY	LOCATION	APPROXIMATE RADIAL DISTANCE FROM CENTER OF SITE	DATE COLLECTED
FRESH WATER	H	$(5.58 \pm 1.0) \times 10^{-8}$ uCi/cc	BAGAC RIVER	4 kms.	MARCH 1974
	L	$(0.2411 \pm 0.1031) \times 10^{-8}$ uCi/cc	PAO-ON RIVER	1 km.	SEPT. 1974
SEA WATER	H	$(3.998 \pm 0.594) \times 10^{-6}$ uCi/cc	BAGAC SEA	4 kms.	JUNE 1973
	L	$(0.1575 \pm 0.0612) \times 10^{-6}$ uCi/cc	REACTOR SITE SAMPLING STATION #1	0.5 km.	APRIL 1973
AIR	H	$(4.90 \pm 0.8228) \times 10^{-12}$ uCi/cc	BANAWANG	1.5 kms.	MARCH 1973
	L	$(0.1859 \pm 0.2398) \times 10^{-12}$ uCi/cc	SAYSAIN	7 kms.	NOV. 1974
GRASS	H	$(2.19778 \pm 0.06311) \times 10^{-3}$ uCi/gm ash	REACTOR SITE SAMPLING STATION #4G	1 km.	MARCH 1973
	L	$(0.2879 \pm 0.1154) \times 10^{-4}$ uCi/gm ash	REACTOR SITE SAMPLING STATION #1G	1 km.	APRIL 1973
SOIL	H	$(5.43 \pm 1.529) \times 10^{-6}$ uCi/gm	REACTOR SITE SAMPLING STATION #2G	1 km.	MARCH 1973
	L	$(2.90 \pm 0.699) \times 10^{-6}$ uCi/gm	REACTOR SITE SAMPLING STATION #3G	1.5 kms.	MARCH 1973

H = highest measurable activity level

L = lowest measurable activity level

Lowest activity level for all samples is background