



RADIOLOGICAL SURVEILLANCE REPORT: CLARK SPECIAL ECONOMIC ZONE

INTRODUCTION

On 26 March 1998, a Memorandum of Agreement (MOA) between the Philippine Nuclear Research Institute (PNRI) represented by Dr. Alumanda M. dela Rosa, Acting Director, and the Clark Development Corporation (CDC) represented by Romeo S. David, former CDC President and CEO, was formally signed in Clark. The objective of the MOA was to establish levels of radioactivity within the Clark Special Economic Zone (CSEZ) using radiological methodologies and nuclear instruments in order to assess dose exposure of the population within CDC to radiation.

This report covers the surveillance activity of the PNRI Radiological Surveillance Team in Clark Special Economic Zone from 1998–1999. Assessment of radioactivity concentration in Clark was started in 1998 with the signing of the MOA between CDC and PNRI. The Radiological Team was assisted by the CDC technical staff during the surveillance period. The PNRI carborne gamma-ray spectrometer complete with a global positioning system (GPS) and situated atop the PNRI vehicle was used by the PNRI Team to monitor the grounds of CSEZ for gamma radiation.

Radiological surveillance of CSEZ covered approximately 131 km of road network consisting of 4719 gamma-ray measurements. Specific areas within the CSEZ monitored for gamma radiation include 10 suspected sites, namely, landfill areas, magazine and igloo-type armories, former Military Base Hospital, perimeter road surrounding the entire CSEZ, major Avenues, airport including taxiway, hangar and offices, minor streets within the Mimosa and Air Force City housing area, two dismantled incinerators, heroes cemetery and areas around the Expo Filipino '98 including the Freedom Ring.

METHODOLOGY

The radiological survey was carried out using an Exploranium Gr-650 carborne gamma-ray spectrometric system of PNRI. This system is effective for measurement of both natural radioactivity mapping and environmental monitoring of gamma radiation. The detector is a large volume (4"×4"×16") sodium iodide (NaI) crystal and the system is mounted on top of the vehicle of about 2 meters high. At this strategic position, the detector has a field of view of approximately 5 meters, thus, within this distance, gamma radiation could be detected and measured by the system. The spectrometric system is equipped with a global positioning system (GPS) for reliable navigation and as an aid in map production.

Soil samples were collected within the areas of landfills, armories, hospital and housing facilities. These were brought to PNRI for specific radionuclide analyses. Both anthropogenic and naturally-occurring radionuclides were measured in soil samples.



Ocular inspection of the CABCOM resettlement areas for the Mt. Pinatubo evacuees was done for assessment of contaminated area. Water sample from deep well was collected; this is the same water source used earlier for domestic activities by the residents in the CABCOM area. Water samples from other deep wells suspected of contamination were also collected for radioactivity measurements. These include water sources from faucets normally supplying the entire Clark area. Man-made radionuclides in water samples were measured in PNRI using HPGe detector. Preprocessing of 150 L of water sample was done in-situ to reduce the volume of water for transport to PNRI for Cs-137 analysis in gamma detector (HPGe). Tritium analysis in water was done in liquid scintillation counter.

Empty bullet shells were collected in test ranges formerly used by the us military for firing practices. Uranium-238 was measured in empty bullet shells collected from the area.

RESULTS AND DISCUSSION

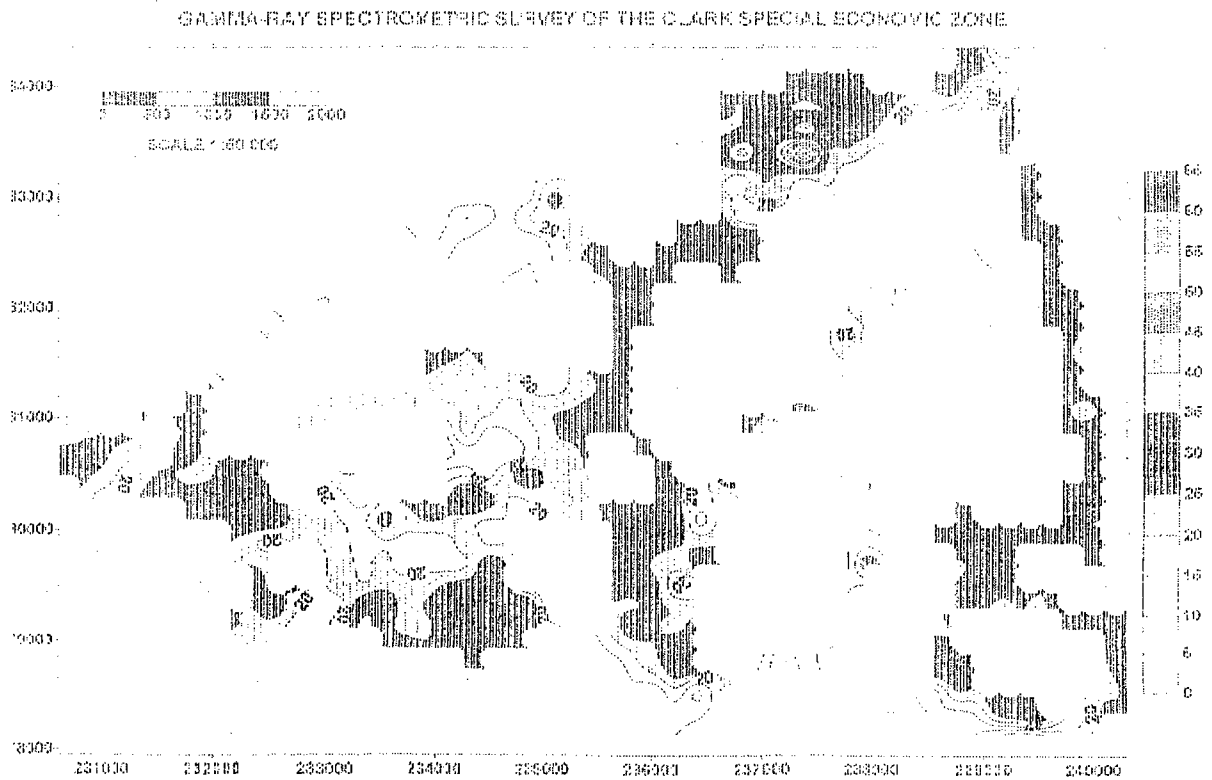


Figure 1. Distribution of absorbed dose rate (nGy/hr)

Approximately 131 km of road network were recorded representing about 4719 gamma-ray measurements which took five consecutive days of monitoring. CSEZ areas monitored were surveyed at least once with the vehicle carrying the gamma-ray spectrometer driven at a speed of about 20 kph. Surveillance tracks used by the gamma-ray spectrometer system are shown in Fig. 1.



Natural sources of radiation such as potassium-40 (^{40}K), uranium-238 (^{238}U) and thorium-232 (^{232}Th) were measured. Average activity concentrations in Bqkg^{-1} and the corresponding air absorbed dose rates in nGy h^{-1} for ^{40}K , ^{238}U and ^{232}Th for each site monitored within CSEZ are shown in Tables 1 and 2, respectively. Activity concentrations of ^{40}K , ^{238}U and ^{232}Th measured using carborne gamma spectrometer are 316 ± 82 , 16 ± 3 and 13 ± 3 Bqkg^{-1} , respectively. The corresponding absorbed dose rates from these gamma emitters ranged from 13.27 to 37.93 nGyh^{-1} with an average of 26.30 ± 6.89 nGyh^{-1} .

The Health Physics Research Section (HPRS) of PNRI has earlier established the average baseline of absorbed dose rate in air received by the Filipino population due to primordial radionuclides (^{40}K , ^{238}U and ^{232}Th) at 23 nGyh^{-1} with ranges from 5 to 74 nGyh^{-1} . This value is well below that estimated in 23 countries representing one-half of the world population with an average outdoor absorbed dose rate of 55 nGyh^{-1} . This was reported in 1982 by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Thus, naturally-occurring radionuclides measured within the CSEZ with average absorbed dose rate of 26.30 ± 6.89 nGyh^{-1} is within background concentration vis-à-vis absorbed dose rate of the whole country. Anthropogenic or man-made sources of radiation within the CSEZ were also measured using the carborne gamma spectrometric system. Evaluation of natural and man-made sources of radiation using this spectrometric system is achieved through measurements of low energy (35– 350 keV) and high energy (350–2800 keV) spectra of gamma radiation. As shown in Table 3, the ratios of low to high energy remain relatively constant (ranging from 17.16 to 25.83) for all sites monitored with average at 19.92 ± 2.42 . The result of carborne gamma spectrometer measurements indicates that radiation exposure from anthropogenic sources is not present within the confines of the CSEZ area monitored.

Analysis of soil samples for both anthropogenic and naturally-occurring radionuclides were measured in HPGe detector. The result of measurements for anthropogenic radionuclide (Cs-137) in soil showed activity concentration at levels ranging from 0.98 to 4.64 Bq/kg dry . Activity concentration for Cs-137 in the country ranges from <0.09 to 12.77 Bq/kg dry .

Table 1. Natural Radionuclides in Topsoil Samples

RADIONUCLIDE	Clark	Country
	AVERAGE ACTIVITY Bq/kg dry	AVERAGE ACTIVITY Bq/kg dry
K-40	316 ± 82	212 ± 115
U-238	16 ± 3	14 ± 11
Th-232	13 ± 3	16 ± 13

Table 2. Absorbed Dose Rate in Air in Specific Areas at CSEZ

LOCATION	n	TOTAL ABSORBED DOSE RATE nGy/h
Landfill 1	55	26.99 ± 3.57
Landfill 2	137	28.67 ± 3.57
Landfill 3	65	30.63 ± 3.43
Igloo Type Armory (inside)	392	37.93 ± 4.67
Igloo Type Armory (outside)	269	26.49 ± 3.06
Magazine Armory (building)	392	30.04 ± 3.70
Abandoned Hospital	140	29.29 ± 3.34
Incinerator 1 (near hospital)	23	25.21 ± 1.86
Incinerator 2	21	31.65 ± 4.15
Mimosa Housing	173	18.58 ± 1.68
PAF Housing	295	15.47 ± 1.36
Freedom Ring	84	13.27 ± 1.27
Heroes Cemetery	110	30.19 ± 3.90
CSEZ Road Network	4719	23.83 ± 2.44
AVERAGE		26.30 ± 6.68

Table 3. Ratio of Low-energy Over High-energy Gamma Count Rate at CSEZ

LOCATION	N	Low/High-Energy
Landfill 1	55	20.36
Landfill 2	137	18.14
Landfill 3	65	19.18
Igloo Type Armory (inside)	392	18.13
Igloo Type Armory (outside)	269	19.16
Magazine Armory (building)	392	17.76
Abandoned Hospital	140	18.50
Incinerator 1 (near hospital)	23	20.04
Incinerator 2	21	18.59
Mimosa Housing	173	21.96
PAF Housing	295	23.48
Freedom Ring	84	25.83
Heroes Cemetery	110	17.16
CSEZ Road Network	4719	20.58
AVERAGE		19.92 ± 2.42



(Table 4). Activity concentrations of naturally-occurring radionuclides in soil samples showed K-40 at 142 ± 45 , U-238 at 12 ± 6 and Th-232 at 14 ± 4 Bq/kg dry with activity averages for the country at 212 ± 115 , 14 ± 11 and 16 ± 13 , respectively (Table 5). Corresponding average absorbed dose rate due to naturally-occurring radionuclides in soil are K-40 at 6 ± 2 , U-238 at 5 ± 2 and Th-232 at 8 ± 2 nGy/h with total absorbed dose rate at 19 ± 2 nGy/h vis-à-vis the country's average dose rate of 8 ± 4 , 5 ± 4 and 10 ± 8 nGy/h with total absorbed dose rate at 23 ± 5 nGy/h, respectively (Table 6). This demonstrates that whatever radioactivity (natural or anthropogenic in origin) present in soil samples collected from Clark are all within background levels as analyzed using an HPGe detector.

Analysis of water samples collected in various deep wells located within Clark including the well from CABCOM area showed non-detectable levels of Cs-137 and H-3 in four (4) well water samples. (Table 7). Public concern has been raised over water contamination especially in the CABCOM area because of suspected contamination from hazardous waste purportedly left behind by the US military. From the results of water analysis on anthropogenic radionuclides (Cs-137 and H-3), it is unlikely that the water system in Clark is contaminated with radioactive materials.

There has been reports that the US military recycles depleted uranium for shell cartridges for use in weaponry. Analysis of U-238 was made on empty cartridge shells collected in areas used formerly by the US military as practice firing ranges. Table 8 shows activity concentrations in mBq/g sample of empty shells at 37 ± 12 . Uranium-238 analyzed in ordinary soil sample taken in the same area shows activity concentration at 14 ± 11 mBq/g with values ranging from 2-53 mBq/g sample.

Table 4. Average Absorbed Dose Rate in Air due to Natural Radionuclides in Soil

Radionuclide	Clark Average nGy/h	Country Average nGy/h
²³⁸ U	5 ± 2	5 ± 4
²³² Th	8 ± 2	10 ± 8
⁴⁰ K	6 ± 2	8 ± 4
Total Absorbed Dose Rate	19 ± 2	23 ± 5

Table 5. Cesium-137 in Soil Samples from Clark

LOCATION	¹³⁷ Cs Bq/kg dry	LLD
Landfill 1	ND	
Landfill 2	0.98 ± 0.29	0.92
Landfill 3	4.64 ± 0.51	1.41
Old Hospital	1.14 ± 0.32	1.00
Old Hospital Incinerator	ND	
Armory	ND	
Firing Range	ND	
CDC Main Office	ND	
Mabalacat Landfill 1 m deep	ND	
Mabalacat Landfill surface	ND	
Old Landfill construction area	ND	

ND = not detected

¹³⁷Cs Activity Range in the Country: <0.09 to 12.77 Bq/kg dry

Table 6. Natural Radionuclides in Soil Samples

Radionuclide	Clark Average Activity Bq/kg dry	Country Average Activity Bq/kg dry
²³⁸ U	12 ± 6	14 ± 11
²³² Th	14 ± 4	16 ± 13
⁴⁰ K	142 ± 45	212 ± 115

Table 7. Analysis of Drinking Water from Clark

LOCATION	¹³⁷ Cs mBq/l	³ H mBq/l
Well water #1	ND	ND
Well water #2	ND	ND
Cabcom well water	ND	ND
CDC Main Office	ND	ND

ND = not detected



From analyses of both anthropogenic and naturally-occurring radionuclides in samples (air, soil and water and empty cartridge shells) collected within the Clark Special Economic Zone, our results show no elevated concentration of radionuclides present in the former us Military Air Force Base in Clark. Radioactivity data in Clark are within normal background levels compared with the radioactivity concentrations measured in the entire country.

Table 8. ²³⁸U Activity Concentration in Bullets Collected from Firing Range

	Activity Concentration mBq/g
²³⁸ U content of empty shells	37 ± 12
²³⁸ U content of ordinary soil	14 ± 11
Range of ²³⁸ U in soil	2 - 53

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