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ENVIRONMENTAL RADIOACTIVITY

RADIOLOGICAL SURVEILLANCE OF THE FORMER U.S. BASE: PORO POINT, SAN FERNANDO CITY, LA UNION

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ABSTRACT

The Philippine Task Force on Hazardous Waste in Former U.S. Military Installations (PTFHW) was created in 1998 to look at possible presence of chemical as well as radioactive waste materials in former US bases. The Philippine Nuclear Research Institute (PNRI), being a member of the PTFHW, performed radiological surveillance studies at two major former U.S. facilities, i.e., Subic Bay Naval Base and Clark Air Base and found no evidence of site-specific radioactive contamination (Duran *et al.,* 1992). With the current plans of the Bases Conversion Development Authority (BCDA) to convert the former US Communications Facility at Poro Point into a Special Economic and Freeport Zone, it is deemed prudent and necessary to determine if there is any radioactive contamination in the area. A radiation map showing ambient gamma dose rates at Poro Point Communications Facility indicated dose rates ranging from 29.07 to 92.81 nGy/h (81 sites) with an average rate of 44 nGy/h. PNRI had earlier established the normal background radiation in the country at an average value of 52 nGy/h with dose rates ranging from 21–124 nGy/h. This finding strongly suggests that there is no site specific radioactive contamination within Poro Point Communications Facility in San Fernando City, La Union, associated with its use as a former US military base.

INTRODUCTION

The possible presence of toxic and hazardous wastes, including radioactive materials, in former U.S. military bases in the Philippines has been an issue of public concern since 1991, when these bases reverted back to the Philippine government. In response to this concern, the government created the Philippine Task Force on Hazardous Waste in Former U.S. Military Installations (PTFHW) in 1998. This inter-agency, multi-disciplinary Task Force was chaired initially by the Secretary of the Department of Foreign Affairs and currently by the Secretary of the Department of Environment and Natural Resources. Both the Philippine Nuclear Research Institute (PNRI) and the Bases Conversion Development Authority (BCDA) are members of this PTFHW.

The PNRI, as part of its commitment to the PTFHW, performed a radiation survey at the major former U.S. facilities, i.e., Subic Bay Naval Base and Clark Air Base. Results of extensive surveys conducted at these former U.S. military installations indicated normal background radiation levels similar to those found in other parts of the country, and no evidence of site-specific radioactive contamination (Duran, *et al.,* 1992).

Among the former U.S. military bases, Poro Point located in San Fernando City, province of La Union, was used as a Communications Facility. Although unlikely,

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there is still some concern that radioactive materials could have been used or stored in the premises during its use for military purposes. With the current plans of the BCDA to convert this former military base into a Special Economic and Freeport Zone, it is deemed prudent and necessary to determine if there is any radioactive contamination in the area.

METHODOLOGY

Two sampling strategies were undertaken: (1) collection of soil and water samples from probable or suspected sites for specific radionuclide analysis and (2) measurement of external radiation dose rates using a portable (sodium iodide) gamma spectrometer.

SOIL AND WATER ANALYSES

Soil Analysis

Eighteen (18) top soil samples were collected at selected sites within the facility. Approximately one kilogram of topsoil samples was collected from 1x1 m sampling-size area and placed in properly labeled plastic bags. Top-soil samples were brought to PNRI for gamma spectral analysis using a sensitive, high purity germanium detector (HPGe) attached to a multi-channel analyzer.

Soil samples were sifted to remove pebbles, plant roots and other materials, dried to constant weight at 105°C and ground using a Wiley mill. Ground soil samples were mixed well for homogeneity, weighed, placed in containers of specific size (1 kg beaker or 250 ml vial), and covered tightly. The vial was set aside unperturbed for 1 month for in-growth of radioactive decay products and analyzed for activity concentrations of specific radionuclides. (HASL-300, 1992).

After equilibration for one month, the sample in a Marinelli beaker or 250 ml vial was counted using HPGe co-axial detector (EG & G Ortec) attached to a Nucleus Personal Computer Analyzer (PCA-II) card (or a multi-channel analyzer card) cooled down with liquid nitrogen. Counting time was for 24 hours. The concentrations of specific radionuclides present in the sample were calculated. The equipment was calibrated for efficiency using the same geometry (Marinelli beaker or 250 ml vial) as that used for the sample, and a traceable counting standard.

Water Analysis

Water samples (about 150 liters) were collected and preprocessed *in situ* by volume reduction using precipitation method with cesium ammonium molybdo-phosphate (Cs-AMP) for ^{137}Cs measurements. Cs-AMP water precipitates were brought to PNRI and oven-dried at 80°C to constant weight. The activity concentration of ^{137}Cs, an anthropogenic radionuclide, was also measured using the HPGe system.

Measurement of tritium activity concentration in water was done using liquid scintillation counter (LSC) (Packard Tricarb Model 3171). Tap water samples from the housing facility (GH), Voice of America water (VOA) and inside the Wallace Air base (WAB) were collected and brought to PNRI for analysis. Water sample (10 ml) pipetted into polyethylene vial was mixed with equal amount of Packard Instagel scintillation cocktail. The vial was shaken vigorously until homogeneous and transparent. The solution was dark-adapted for 12 hours at 8-15 °C. Sample was counted for tritium activity concentration using LSC at 10 min cycle mode for a total counting time of 100 min. Counts were done in replicates. Background used was ultrapure distilled water.

External Radiation Dose Rate Measurements

Measurements of external radiation or absorbed gamma dose rate in air for radiation mapping using portable gamma spectrometer with sodium iodide crystal detector (BNC-SAM 935) were made in 81 sites along a 15 km road network and open fields within the facility. A Global Positioning System (Magellan GPS Field Pro V) instrument was used to determine the coordinates of the monitoring sites for generation of the radiation map. Sixty-one sites were measured using the road network and 20 sites were taken in the open fields where soil and water samples were collected.

Measurements were done at approximately 1 meter above ground surface using a Surveillance and Measurement System Model 935 (BNC-SAM 935). BNC-SAM 935 consists of a thallium-activated 2x2 inch sodium iodide (NaI(Tl)) detector calibrated against 10mCi ^{137}Cs and 1mCi ^{152}Eu standard sources and a built-in spectrometer. BNC-SAM 935 is capable of measuring ambient gamma radiation dose rates ranging from 0.5mR/hr (4.38nGy/h) up to 10mR/hr (87.6mGy/h) and can detect background levels as low as 1nR/hr (8.7pGy/h). Radiation readings (mR/hr) were taken at 3 min intervals, six times at 30 second intervals, or 18 times at 10 s intervals by capturing the specific dose rate at that particular time.

RESULTS AND DISCUSSION

Sources of Radiation in the Philippines

Radioactive materials in the country are from natural and man-made sources. Naturally-occurring radiation are categorized as extraterrestrial (cosmic radiation) and terrestrial sources (radionuclides present in the earth's crust) and are considered to be the main contributor to our radiation dose. The concentration of most of natural radionuclides are constant in space and time and independent of future practices and activities (UNSCEAR, 1988). In contrast, radiation of man-made origin results from practices that release radioactive materials into the environment.

Man-made sources of radiation in the environment include radioactive materials released from nuclear weapons detonation, nuclear power generation, industrial and medical practices (in decreasing order of relative contribution to environmental radioactvity). From 1945 to 1980, the major source of radioactive materials released into the environment came from nuclear weapons testing in the atmosphere. This resulted to global fallout, increasing the levels of radionuclides in the environment throughout the world. (Environmental Impact of Radioactive Releases, IAEA Proceedings of Symposium, 1995).

Background radiation in the Philippine environment is due mainly to naturally-occurring radioactive materials (NORM) from the earth's crust and to a more limited extent, atmospheric nuclear weapons tests. Since 1980, only underground weapons testing were conducted, resulting to more confined radioactive releases, e.g. tests at Mururua Atoll, Pakistan and India. With no additional atmospheric global fallout from nuclear weapons testing and in the absence of an operational nuclear power plant, Filipinos are exposed only to background environmental radioactivity. Based on a nationwide survey conducted by PNRI (1685 sites throughout the Philippines), the average gamma dose rate in air is 52 nGy/h with values ranging from 21-124 nGy/h. This value is close to the average value of background radiation of 55 nGy/h reported by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) with values ranging from 24 to 85 nGy/h obtained from 23 countries surveyed (UNSCEAR, 1988).

Possible Sources of Radiation in Poro Point

The US military uses radioactive materials in its various operations, e.g. nuclear powered submarines, casings for bullets (depleted uranium), and for industrial and medical applications. The Mt. Pinatubo eruption in 1991 caused the sudden closure of the US military bases in the Philippines without proper turnover of documents including inventories of radioactive materials to the government. Thus, a possibility exists that radioactive materials could have been left behind when the US military abandoned the US facilities.

During the U.S. occupation of bases in the Philippines, the military enjoyed exclusive use of these areas. Hence, the PNRI nationwide survey did not include the former US facilities and radioactivity data from any of the former US bases were not available before 1991.

Poro Point encompasses approximately 220 hectares which includes the seaport, Wallace Air Station and Voice of America. The entire facility, although segregated into individual development areas by fences, is easily accessible via excellent road network. At present, very few residents occupy the communications facility except at the Wallace Air Station where housing facilities are available for the Philippine Air Force (PAF).

Dose Rate Measurements

A radiation survey of Poro Point Communications Facility in San Fernando City, La Union included measurement of outdoor gamma dose rates in air from all sources, i.e., both natural and man-made. Any radionuclide present in the soil or in the area surveyed will give off radiation which can be measured in units of gamma dose rate in air (nGy/h) by the sensitive equipment used (BNC-SAM 935). The source of the radiation, whether it is man-made or natural, and the identity of the radioisotope can also be distinguished using this equipment. Any significant reading above normal background radiation will indicate possible radioactive contamination of a specific site. PNRI

Table 1. Mean outdoor air gamma dose rates measured in Region I (Ilocos Region) from1982-2003 using Studsvik Gammameter 2414 A, high pressure ionization chamber(HPIC), and BNC-SAM 935.

Province	n	Absorbed Dose Rate(nGy/h) Range	Mean
Ilocos Norte	15	30 - 69	44 ± 11
Ilocos Sur	9	49 - 62	56 ± 5
La Union	24	38 – 78	49 ± 10
Pangasinan	30	29 - 78	48 ± 13
Total Mean Exposure Dose Rate = 48 ± 4 nGy/hr			
Total n = 78			
Range = 29 – 78 nGy/hr			

Table 2. Mean outdoor air gamma dose rates measured in regions of Luzon (1982-2003).Gamma detectors used were Studsvik Gammameter 2414 A, high pressure ionization chamber (HPIC), and BNC-SAM 935.

Region	n	Absorbed Dose Rate (nGy/h) Range	Mean
National Capital Region	318	30 - 88	50 ± 2
Cordillera Administration Region	49	36 - 72	53 ± 2
Region I – Ilocos Region	78	29 – 78	49 ± 5
Region II – Cagayan Valley	128	34 - 124	59 ± 16
Region III – Central Luzon	250	32 - 91	49 ± 8
Region IV – Southern Tagalog	170	23 - 115	59 ± 9
Region V – Bicol Region	26	44 - 91	58 ± 5
Total Mean Exposure Dose Rate = 54 ± 5 nGy/hr			
Total n = 1019			
Range = 25 – 124 nGy/hr			

had earlier established that the normal background radiation in the country has an average value of 52 nGy/h and ranges from 21–124 nGy/h. The process of radiological assessment applied consisted of several steps:

- First, the dose rate in air is measured at a randomly selected site.

- Second, this measured value is compared with benchmark values (normal background radiation levels) measured in other parts of the country. If the measured value is not significantly higher than the benchmark value or range, there is no evidence of site-specific radioactive contamination. If the measured value is anomalously high, the radionuclide is identified and determined whether it is from natural or man-made sources. If it is due to a man-made source, then there is radioactive contamination and the area is further surveyed to delineate the area affected.

- Third, the radiation dose associated with the dose rate measured is calculated and compared with either the dose from background radiation globally as determined by UNSCEAR or with the recommended dose limits for members of the public by the ICRP.

A radiation map showing ambient gamma dose rates throughout Poro Point Communications Facility (81 sites) is shown in **Figure 1.** The coordinates of the 81 sites were obtained through GPS (Magellan). Relatively higher gamma dose rates were measured in two sites only although the values are still within range of the Philippine background radiation dose rates.

The average gamma dose rate in the Philippines due to background radiation is 52 nGy/h. **Figure 2** shows the frequency distribution of the gamma dose rates measured within the Poro Point facility. About 86% of the sites surveyed (or 70 sites) have gamma dose rates lower than the country average. The average gamma dose rate in Poro Point is 44 nGy/h with values ranging from 29.07 to 92.81 nGy/h (81 sites).

Background radiation levels differ from one area to another and are largely dependent on the amount of natural radionuclides and man-made radionuclides (from global fallout associated with nuclear weapons tests) deposited in soil and the migration characteristics of these radionuclides. This is evident in **Figure 3** which shows the frequency distribution of gamma dose rates in air in the country measured from 1982 to 2003. Although in most areas (75%), the gamma dose rate in air was less than 59 nGy/h, higher dose rates were observed in 25% of the 1,685 sites surveyed. The relatively high dose rate of 124 nGy/h was measured in an area where there are traces of uranium deposit. In the case of Poro Point, the measured dose rates are well-within this normal range of background radiation observed in areas outside of the former US base. Thus, the data indicate that the radiation

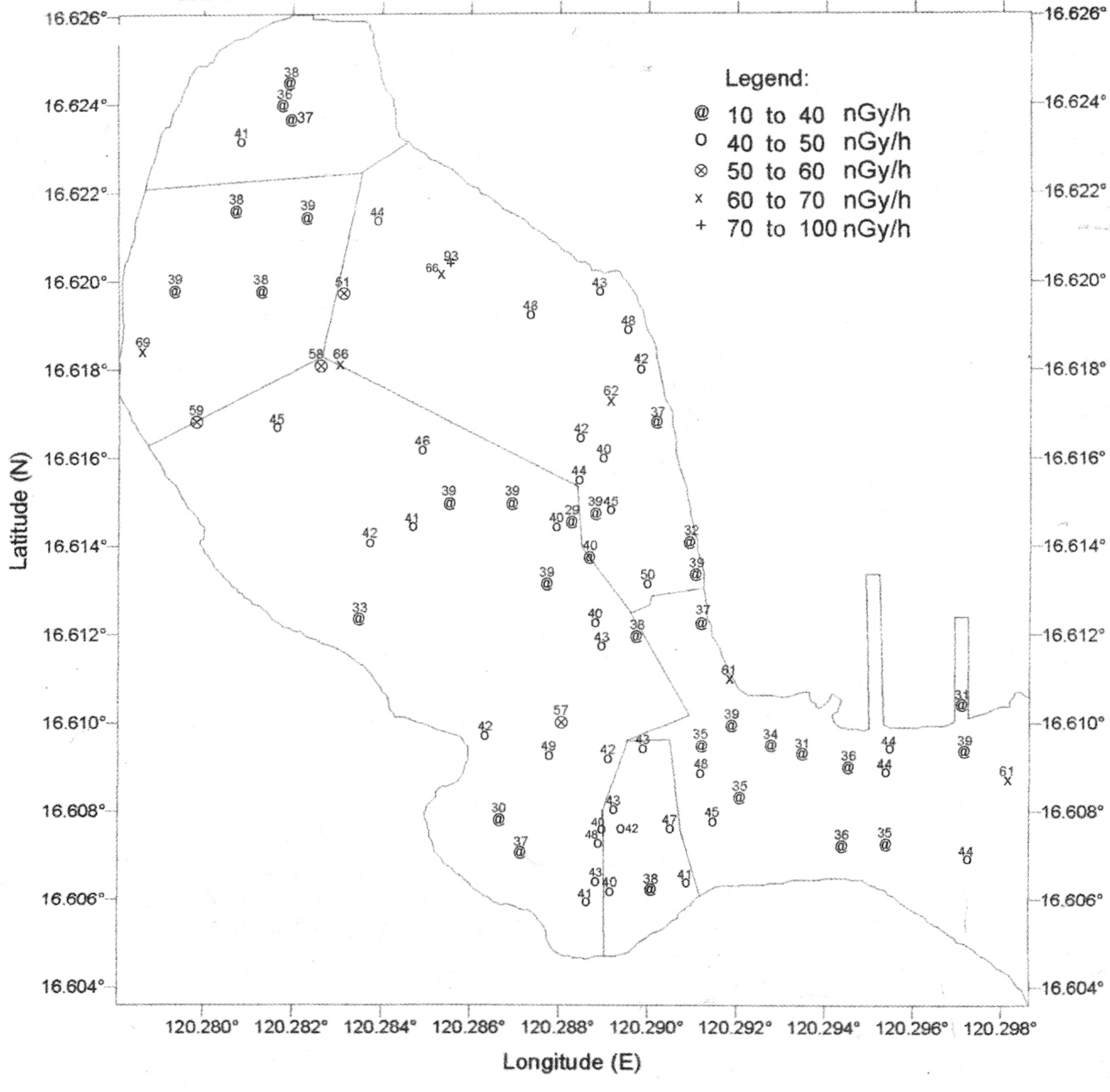

Figure 1. Radiation map of Poro point Communications Facility, San Fernando City, La Union indicated by composite outdoor gamma dose rates ranging from 29 to 93 nGy/h. Measurements of dose rates from 61 points utilizing approximately 15 km of road network and 20 points from open field made up the radiation map. A portable gamma spectrometer (BNC-SAM 935) and a global positioning system (Magellan GPS Field PRO V) were used to measure dose rates and specific coordinates, respectively.

Table 3. Mass Activity Concentrations of specific radionuclides in soil samples analyzed using HPGe detector (Oxford Instruments) in Bq/kg dry weight. The corresponding outdoor air gamma dose rates in nGy/hr was measured using portable gamma spectrometer, BNC-sam 935.

Sample Code	Location	Dose Rate (nGy/hr)	Activity Concentration, Bq/kg			
			Uranium-238	Thorium-232	Potassium-40	Cesium-137
1. PPS1	Seaport Area,Pier	33.57	3.32 ± 0.17	2.06 ± 0.13	139.15 ± 1.03	0.07 ± 0.01
2. PPS2	Golf Course, WAS	58.28	6.96 ± 0.28	1.26 ± 0.14	NA	0.11 ± 0.02
3. PPS3	Open field,rt. side of Hangar,WAS	92.81	27.39 ± 0.46	3.52 ± 0.17	55.51 ± 0.77	5.71 ± 0.11
4. PPS4	Former municipal landfill,Brgy.Canauay	NA	40.47 ± 0.53	7.23 ± 0.21	60.94 ± 0.84	0.64 ± 0.06
5. PPS5	RO-3 transmission base, VOA	31.29	38.52 ± 0.60	4.55 ± 0.22	80.03 ± 0.95	3.92 ± 0.10
6. PPS6	RF-2 transmission base, VOA	35.49	18.08 ± 0.49	2.72 ± 0.23	57.26 ± 8.89	2.44 ± 0.11
7. PPS7	RF transmission base, VOA	48.73	44.77 ± 0.59	5.18 ± 0.20	70.31 ± 0.88	2.36 ± 0.09
8. PPS8	RE-4 transmission base, VOA	47.33	36.12 ± 0.58	4.76 ± 0.20	107.37 ± 1.22	2.30 ± 0.09
9. PPS9	Cottage 929 (Guesthouse), VOA	40.93	54.15 ± 0.77	6.58 ± 0.27	81.69 ± 1.07	1.28 ± 0.11
10. PPS10	Golf Course near radar stations, WAS	69.15	66.24 ± 4.88	18.43 ± 0.25	128.21 ± 2.05	0.85 ± 0.04
11. PPS11	Open field near lighthouse, WAS	65.82	89.88 ± 7.91	16.84 ± 3.30	131.81 ± 8.31	5.62 ± 0.05
12. PPS12	Firing Range, WAS	40.66	69.63 ± 5.71	17.59 ± 3.44	130.48 ± 2.08	0.86 ± 0.04
13. PPS13	Left side of hangar, WAS	37.86	37.21 ± 2.28	9.08 ± 0.79	93.97 ± 2.82	2.06 ± 0.07
14. PPS14	Open field near main gate, VOA	49.78	10.85 ± 0.50	3.33 ± 0.27	123.26 ± 1.79	1.59 ± 0.11
15. PPS15	Open field facing VSAT antenna, VOA	44.61	31.69 ± 2.26	8.48 ± 0.47	51.76 ± 2.54	0.51 ± 0.04
16. PPS16	RK-2 transmission base, VOA	62.31	84.88 ± 13.21	21.43 ± 4.29	113.29 ± 1.94	3.10 ± 0.05
17. PPS17	Near drainage, VOA	69.41	35.55 ± 0.91	5.86 ± 0.40	97.06 ± 1.62	2.85 ± 0.17
18. PPS18	Side of Building 919, VOA	40.40	16.21 ± 1.43	4.52 ± 0.26	37.17 ± 3.38	3.25 ± 0.10
	Mean	51.33	39.55 ± 25.31	7.97 ± 6.23	91.72 ± 37.73	2.20 ± 1.68
	(Range)	31.29-92.81	(3.32±0.17-89.88±7.91)	(1.26±0.14-21.43±4.29)	(37.17±3.38-139.15±1.03)	(0.07±0.01-5.71±0.11)

WAS = Wallace Air Station
VOA = Voice of America
NA = data not available

levels inside the base are not due to US military activities during its use as a base but are due to natural and man-made radionuclides in our general environment, attributable to the same sources as the radionuclides found outside the base.

The Poro Point radiation values are also within range of background radiation measured by PNRI in different towns and provinces of Region 1 (Ilocos Region) from 1982 to 2003 (**Table 1**) (Duran *et al.* 1999). This clearly demonstrates that no additional radioactive materials were released into the local environment at Poro Point.

The same is true if we extend the area to the Island of Luzon. **Table 2** shows the outdoor air gamma dose rates measured in different provinces and regions in Luzon using various portable gamma detectors (Studsvik Gammameter 2414 A, high pressure ionization chamber (HPIC), and BNC-SAM 935 (Duran *et al.,* 1993). The mean dose rate in Luzon is 54 ± 5 nGy/h with n = 1019 sites, with values ranging from 25 - 124 nGy/h measured from 1982 to 2003.

Activity Concentrations of Specific Radionuclides in Soil and Water

Soil

The capability of HPGe, a high purity germanium detector which is a very sensitive nuclear instrument, to measure a specific radionuclide at very low levels made it possible to verify the measurements of absorbed dose rates in outdoor air using BNC-SAM 935. Soil samples collected from 18 sampling sites within the facility and analyzed for the natural radionuclides, uranium 238 (^{238}U), thorium 232 (^{232}Th) , potassium 40 (^{40}K) and the man-made radionuclide, cesium 137 (^{137}Cs), showed activity concentrations similar to those observed in other parts of the country, outside the former U.S. base.

Table 3 shows concentrations of specific radionuclides in soil samples expressed in Bq/kg and the corresponding absorbed dose rates in nGy/h for gamma-emitting radionuclides in outdoor air. Mean activity concentrations of naturally-occurring radionuclides ^{238}U (39.55 ± 25 Bq/kg), ^{232}Th (7.97 ± 6.2 Bq/kg) and ^{40}K (91.7 ± 37 Bq/kg) are well within the normal range of

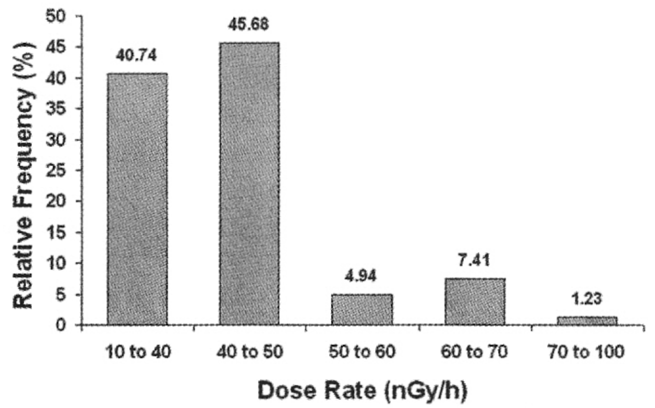

Figure 2. Relative Frequency Distribution of outdoor air gamma dose rates measure in Poro Point Communications Facility using BNC-SAM 935 portable gamma spectrometer. Total number of sites involves 81 points

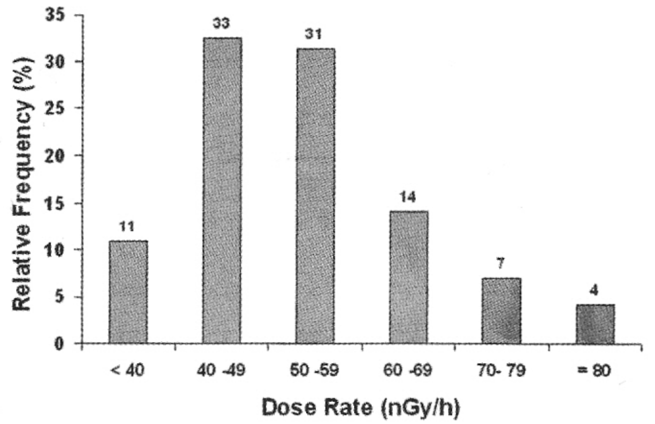

Figure 3. Relative Frequency Distribution of country-wide outdoor air gamma dose rates measured using various portable gammameters, Studsvik Gammameter 2414 A, high pressure ionization chamber (HPIC), and BNC-SAM 935 from 1982-2003.

countrywide mean concentrations for these radionuclides. For man-made radionuclide, ^{137}Cs, the mean radioactivity concentration was measured at 2.2 ± 1.7 Bq/kg which is also within range of activity concentration of ^{137}Cs measured elsewhere in the country.

The highest dose rate in outdoor air (92.81 nGy/h) measured at the open field area right side of hangar (VOA sample # PPS3) is attributable to higher concentrations of ^{137}Cs (5.7 Bq/kg) measured in soil sample collected at the same site. For the area near the lighthouse where the dose rate measured was 65.8 nGy/h, the relatively higher dose rate is attributable to natural ^{238}U at 89.9 Bq/kg in soil sample. The highest dose rate in air measured (92.81 nGy/h) will lead to an effective dose of 0.81 mSv/y received by exposed persons. This is lower than the dose limit of 1 mSv/y for members of the public recommended by the ICRP. Thus, there is little and insignificant risk associated with even the highest dose rate observed in Poro Point.

Water

Drinking water was also analyzed for radioactive content. Cesium-137 (^{137}Cs) which is a gamma emitter and tritium (^{3}H) which his a beta emitter were analyzed in drinking water samples using HPGe and liquid scintillation counting, respectively. Both radionuclides, ^{137}Cs and ^{3}H, are of low concentrations or below detection limits (**Table 4**) and at these levels can be attributed to normal background radiation.

CONCLUSION

In conclusion, the data obtained indicate that there is no radioactive contamination in Poro Point associated with its use as a US military base. The radiation levels in the base, both in terms of gamma does rates in ambient air and radionuclide concentrations in soil and water are within the range of values observed in other parts of the country. The mean gamma radiation dose rate within Poro Point at 44 nGy/h is lower than the mean gamma radiation dose rate for Region 1 at 49 nGy/h or for the entire Philippines (52 nGy/h). This indicates that the sources of radioactivity within the base are from natural sources

Table 4. Activity concentrations of tritium and ^{137}Cs in tapwater collected in Poro Point. ^{3}H was measured in Liquid Scintillation Counter (LSC) while ^{137}Cs was measured using HPGe detector.

137 (Sample)	^{3}H, Bq/L	^{137}Cs, Bq/L
Guest House (GH)	2.77	< LLD = 0.00082
Voice of America (VOA)	< BKGD	Not available
Wallace Air Station (WAS)	2.77	< LLD = 0.00082

and global fallout from nuclear weapons tests in the late 50s to early 60s conducted elsewhere in the world. During the radiological surveillance of the facility, no additional radionuclides beyond normal background radiation are found using the PNRI sophisticated nuclear detectors. The highest dose rate of 92.81 nGy/h measured in one of the 81 sites is due to relatively higher concentrations of ^{137}Cs , a man-made radionuclide associated with global fallout. The annual dose equivalent corresponding to this highest dose rate is only 0.81 mSv/y which is less than the dose limit set by ICRP for members of the public. Thus, based on the results of the radiation survey conducted at Poro Point in San Fernando City, La Union, radioactive contamination is not a concern.

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