

Preliminary Radiological Survey on High Rare-earth Containing Area in San Vicente, Philippines

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Erawan Beach area in San Vicente, Palawan Island, Philippines contains rare-earth elements and natural radioactive nuclides at high levels. If the development of mineral resources starts, environmental impacts will be a significant concern for residents in the area. In this study, a preliminary radiological survey on ambient dose equivalent rate and dust concentration was performed in the Erawan Beach area. The ambient dose equivalent rates in each site ranged from 0.060 to 0.81 $\mu\text{Sv h}^{-1}$. External gamma radiation exposures estimated from these values were lower than the reference level range (1–20 mSv y^{-1}) for abnormally high levels of natural background radiation described in the ICRP Publication 103. The dust concentrations in each site ranged from 0.40 to 0.76 mg m^{-3} , which were relatively higher than the typical dust concentration in air (0.05 mg m^{-3}). Based on estimation from the results of the ambient dose equivalent rates and dust concentrations, inhalation radiation exposure due to natural radioactive nuclides in dust will likely be less than external gamma radiation exposure.

Keywords: dose rate, high-level environmental radiation areas, natural radioactive nuclides

An area containing natural radioactive nuclides at high levels exists in the Philippines. Because this area – which is located in Erawan Beach in San Vicente, Palawan Island – is composed of the mineral resource called allanite, including rare-earth elements mainly, investigations of metal resources have been performed so far (Reyes *et al.* 2013). If the development of mineral

resources starts in the Erawan Beach area, environmental impacts might be resident's strong concerns. Therefore, it is essential to obtain radiological data in the Erawan Beach area so that residents feel a sense of safety, and workers develop mineral resources safely. In this study, a preliminary radiological survey on ambient dose equivalent rate and dust concentration was performed in the Erawan Beach area.

Surveys were taken in Erawan Beach area, San Vicente,

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Palawan, Philippines. The places permitted by the local government and residents were chosen as measuring sites (Figure 1). The positions of measuring locations are shown in Table 1.

The ambient dose equivalent rate was performed at measuring sites (A1–A10) in Figure 1 and Table 1, while dust concentration was performed at measuring sites (B1–B3) in Figure 1 and Table 1.

A 3-in (diameter) × 3-in (thickness) NaI(Tl) scintillation survey meter (SAM940; Berkeley Nucleonics Corp., San Rafael, CA, USA) was used for measuring the ambient dose equivalent rate in each site. The measurements of the ambient dose equivalent rate were performed at a height of 1 m from the ground.

Two-stage impactors (NL-4-10A; Tokyo Dylec Corp., Japan) – which can collect dust below Particulate Matter (PM)-10 at a sampling flow rate of 4 L min⁻¹ – was used by referring to a method in Iwaoka *et al.* (2013). The dust concentrations were calculated from the differences in the weights of filters before and after the dust collection.

The ratio of external gamma radiation and dust inhalation exposures was estimated by the typical values and equations described in RP-122 (EC 2002).

Table 1. Longitude and latitude in measuring sites.

ID	Longitude	Latitude
A1	119.330325	10.653739
A2	119.330031	10.653942
A3	119.330117	10.653022
A4	119.329892	10.652558
A5	119.329778	10.652125
A6	119.329731	10.651992
A7	119.329919	10.652117
A8	119.329778	10.649831
A9	119.330444	10.649869
A10	119.326775	10.609269
B1	119.329963	10.652600
B2	119.330188	10.649628
B3	119.329885	10.651952

Results of the ambient dose equivalent rates and dust concentrations are shown in Table 2. The ambient dose equivalent rates in each site ranged from 0.060 to 0.81 μSv h⁻¹. The values of the ambient dose equivalent dose rates in A1–A7 were higher than those in other areas. This reason might be due to a large amount of

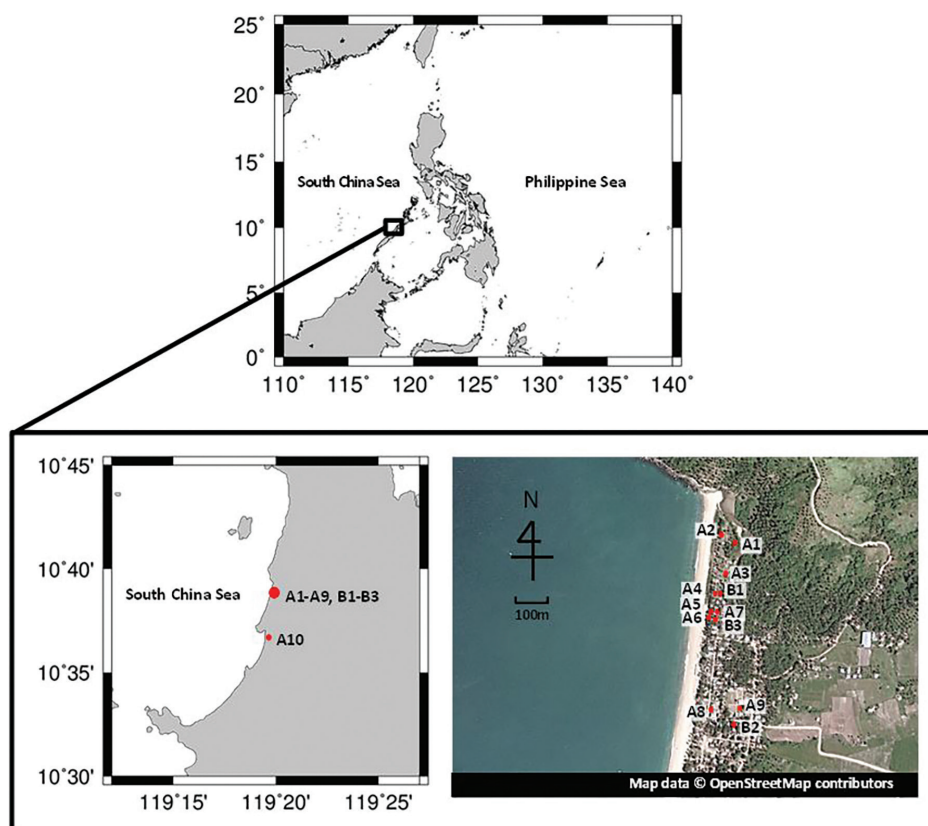


Figure 1. Locations of this study.

deposition of allanite because there is a river in the area around A1–A7 flowing from the allanite dikes (Ramos *et al.* 2001). Based on the assumption that ambient dose equivalent/absorbed dose in air is 1.2 (Bossey *et al.* 2017), the values of the ambient dose equivalent rates in some sites were higher than an average value of those in the Philippines ($0.052 \mu\text{Gy h}^{-1}$) (Nazarea *et al.* 2004) and world ($0.059 \mu\text{Gy h}^{-1}$) (UNSCEAR 2008). On the other hand, based on the assumption that effective dose/ambient dose equivalent is 0.7 (Saito *et al.* 1998), annual (8760 h) effective doses for external gamma radiation exposure in this study ranged from 0.37 to 5.0 mSv y^{-1} – which was lower than the reference level range ($1\text{--}20 \text{ mSv y}^{-1}$) for abnormally high levels of natural background radiation described in the ICRP Publication 103 (ICRP 2007).

The dust concentrations in each site ranged from 0.40 to 0.76 mg m^{-3} . These values were relatively higher than the typical dust concentration in air (0.05 mg m^{-3}) (UNSCEAR 2008). The dust concentrations in each site might originate from several sources such as marine aerosols, resuspension of soil particles, and fossil fuel and wood combustions (Wilson *et al.* 1997) due to the presence of beach and sea and residents living near each site. Based on the conservative assumption that the dust concentrations in each site originate from only the resuspension of soil particles (*i.e.*, $C = 0.76 \text{ mg m}^{-3}$ without dilutions due to other dust sources), the ratios of external gamma radiation and dust inhalation exposures estimated by the typical values and equations described in

RP-122 (EC 2001) were 0.12 for the ^{238}U series and 0.13 for the ^{232}Th series. Therefore, inhalation exposure due to dust will likely be less than external gamma radiation exposure in this survey site.

A preliminary radiological survey on ambient dose equivalent rate and dust concentration was performed in the Erawan Beach area, San Vicente, Palawan, Philippines. The ambient dose equivalent rates in this study were higher than an average value of those in the Philippines. The dust concentrations in this study were relatively higher than the typical dust concentration in air. Based on estimation from results of the ambient dose equivalent rates and dust concentrations, inhalation exposure due to dust will likely be less than external gamma radiation exposure.

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Table 2. Results of ambient dose equivalent rate and dust concentration.

ID	Ambient dose equivalent rate ^a ($\mu\text{Sv h}^{-1}$)	Dust concentration (mg m^{-3})
A1	0.81	–
A2	0.58	–
A3	0.40	–
A4	0.42	–
A5	0.30	–
A6	0.21	–
A7	0.31	–
A8	0.12	–
A9	0.088	–
A10	0.060	–
B1	–	0.76
B2	–	0.76
B3	–	0.40

^aThe value of the ambient dose equivalent rate was determined by averaging five measurements for 60 s each.

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