Correlation analysis between precipitation, soil radon gas and gamma exposure rate at rainfall case

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1. Introduction

Generally, the level of environmental radiation at a certain spot changes following time and weather. A daily monitoring of environmental radiation field in order to find out the ordinary level of the field helps to decipher a sudden change of the radiation field. In the radiation safety and protection field, the monitoring is an important work. Usually, an ERMS (Environmental Radiation Monitoring System) is installed by a government or an operating organization and it continuously monitors the environment radiation field.

Gamma exposure rate is an important measurement parameter for environment radiation monitoring. Usually, an HPIC (High Pressure Ionization Chamber) or an NaI(Tl) scintillation detector is used in order to measure the gamma exposure rate. The contributors of the gamma exposure rate were known to be composed of the cosmic rays and the crust radiations of Earth [1]. Many studies were conducted to explain the reason of radiation field changes including studies of radon gas in soil [2-4].

In this study, to analyze the correlation between the gamma exposure rate and soil radon concentration at rainfall, an active radon detector (RAD7) and 3x3 inch NaI(Tl) scintillation detector were set up at the monitoring post at Daegu. And the data of gamma exposure rate retrieved from IERNet (Integrated Environmental Radiation Monitoring Network) of Korea Institute of nuclear safety was analyzed.

2. Methods and Results

2.1 Methods

The activity radon monitoring device (RAD7) with surface chamber was used to measure the radon concentration of soil surface at rainfall. The RAD7 was set up as a closed-loop system as Fig. 1.

The RAD7 measures the daughter isotopes of ^{222}Rn (Radon) and ^{220}Rn (Thoron), and calculates a radon concentration from the daughters.

The setup of the RAD7 was a sniff mode. And to reduce the systematic uncertainty caused by leakage, all the connections, tubes and the measuring device (surface chamber, desiccant), were sealed.

The device was installed before the rain. The soil surface radon concentration before and after the rainfall was analyzed with the cumulative precipitations.

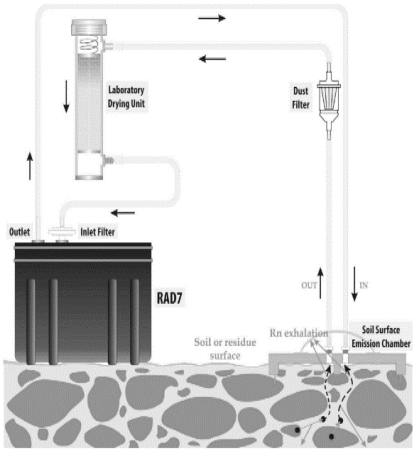


Fig. 1 The closed-loop RAD7 system for radon monitoring.

The measured data of the gamma exposure rate was retrieved from IERNet. To measure gamma radiation field, NaI(Tl) scintillation detector was used at the measurement monitoring post.

Table 1 ERMS monitoring cases in the case of rainfall.

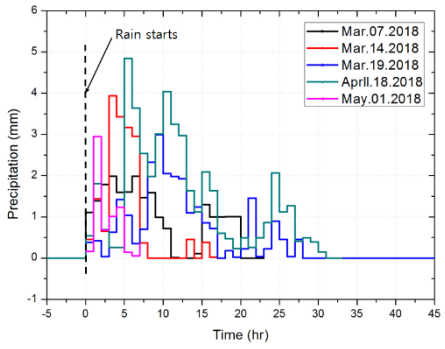
Date (M.D)	Cumulative precipitation (mm)	Total duration of rain (hour)	NaI spectrum meas.
Mar.07	21.5	20	-
Mar.14	17	8	O
Mar.18	24	27	O
Apr.21	47	30	O
May.01	7.5	6	-

The measurements were repeated 5 times as shown Table 1. The first and 5th measurements have no data for the gamma radiation field because NaI detector failed to work.

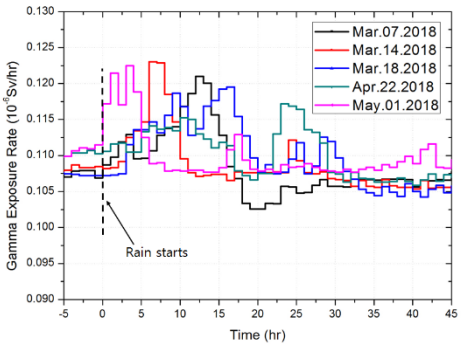
2.2 Results

The measured precipitation and gamma exposure rate were shown in Fig. 2 (a) and (b). And cumulative gamma exposure rates were shown in Fig.3 (a) subtracted ordinary gamma exposure rate from gamma exposure rate measured during the rainfall.

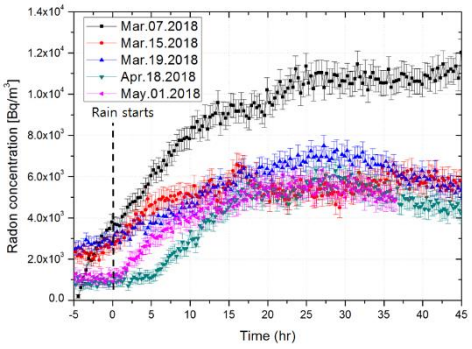
And the change of soil radon gas at rainfall was measured by the active detector, as shown in Fig. 2 (c). An estimated cumulative radon concentration was calculated by subtracting some fit data assumed without rainfall from the real measurement data.



(a)



(b)



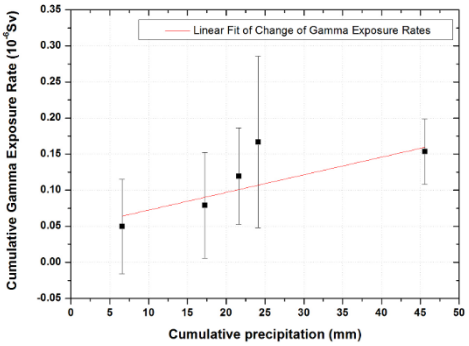
(c)

Fig. 2 Time dependent trends of (a) the precipitations, (b) the gamma exposure rate, (c) ^{222}Rn concentration measured with closed loop RAD7, after rainfall.

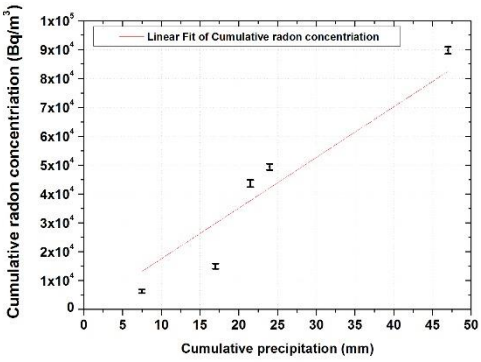
The cumulative gamma exposure rate after rainfall were from 0.05 to 0.17 micro Sv. The cumulative radon concentration were from 26700 to 362000 Bq/m^3 during the rainfall (6 ~ 30 hr).

The correlation of precipitation with other factors were shown in Fig. 3 (a) and (b). From the linear fitting results in Fig. 3, the increase of radon concentration is strongly correlated with cumulative precipitation with R-squared of 0.927, while the increase in gamma exposure rate is somewhat weakly correlated with cumulative precipitation with R-squared of 0.741.

Since this study is only preliminary it is hard to make a strong conclusion at this moment. But the authors think that among many contributors to gamma exposure rate, cosmic rays and direct gammas from earth crust do not change much in the case of rainfalls, but radon gas exhalation from the soil surface may increase a lot because the precipitation entering soil will expel soil air with high radon concentration to the air above the surface, and these expelled high-radon gases from the soil contribute to the increase of gamma exposure rate in a weak fashion.



(a)



(b)

Fig. 3 (a) Correlation of cumulative precipitation with the cumulative gamma exposure rate (Slope is 0.00245, y_0 is 0.0480, RS is 0.741), (b) Correlation of cumulative precipitation with the cumulative radon concentration (Slope is 1755.42, y_0 is 0, RS is 0.927).

3. Conclusions

In this paper, the relation between the gamma exposure rate, the soil radon gas concentration and the amount of precipitation were studied for ERMS monitoring post in Daegu, in the case of rainfalls.

As result of the analysis, the increase of radon concentration is strongly correlated with cumulative precipitation with R-squared of 0.927, while the increase in gamma exposure rate is somewhat weakly correlated with cumulative precipitation with R-squared of 0.741. The linearity seemed weak because in the current study, measurement was performed for only a few cases. We hope this study could contribute to environment radiation monitoring field.

ACKNOWLEDGMENTS

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