Monitoring of Radon in Taiwan groundwaters

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Measurement of radon-222 in groundwater has been performed for earthquake prediction [1, 2, 3, 4, 5]. Igarashi reported that radon concentration in ground water increased for several months before the 1995 southern Hyogo Prefecture (Kobe) earthquake on 17 January 1995. From late October 1994 to the end of December 1994, radon concentration increased about fourfold. On 8 January 1995, 9 days before the earthquake, the radon concentration reached a peak of more than 10 times that of late October 1994 before starting to decrease.

Motivated by the report of precursory changes in ground-water radon associated with the 1995 Kobe earthquake [5], a survey of radon distribution was conducted in four groundwater areas of Taiwan. A total of 383 wells was sampled; 171wells were in Choshui River Alluvial Fan; 142 wells were in Tainan Plain; 33 wells were in Hsinchu-Miaoli Coastal Area; and 37 wells were from Ilan Plain.

Measurement Method

For the determination of the activity concentration of radon-222 in groundwater, the method described by Prichard and Gesell [6] has been adopted and modified. Radon is partitioned selectively into a mineral-oil scintillation cocktail immiscible with the water sample [7]. The sample is dark-adapted and equilibrated, and then counted in a liquid scintillation counter (LSC) using a region or window of the energy spectrum optimal for radon alpha particles [8].

The results of the TRI-CARB measurements are determined in units of counts per minute (cpm). It is essential to ensure that only the activity of radon-222 is measured. Using the software of Packard 1600TR, it is possible to view the α-spectrum (Fig. 1). The peaks of radon-222 (5.49 MeV), polonium-218 (6.00 MeV) and polonium-214 (7.69 MeV) can be distinguished.

A calibration factor for the LSC measurements of 6 cpm/pCi was calculated using an aqueous Ra-226 calibration solution, which is in secular equilibrium with Rn-222 progeny. For a 50-min count time and 6 cpm background, the detection limit was calculated as 18 pCi/l considering the sample volume of 15 ml [9].

Verification of radon-222 as the radioisotope responsible for activity in the well water tested was obtained by the repeated counting of three samples from two wells. The experimentally determined half-life of 3.841 days for samples of Liu-Ying (I) compares favorably with the accepted value of 3.825 days as shown in Fig. 2. Also half-life times are apparently shorter when the vials are lack of tightness. Fig. 2 shows that Wen-Tsu (II) is an example of such a case.

Results and Conclusion

The distribution of radon in the 383 sampled wells is shown in Fig. 3. As shown, more than 66% of wells have radon concentrations greater than or equal to the detection limit of 18 pCi/l and can be used to monitor radon for earthquake prediction.

Fig. 4 presents the log-normal-distribution probability plot of radon-222 for the four groundwater areas surveyed in this study. The maximum, minimum, median, geometric mean values of radon levels in the four groundwater areas are shown in Table 1.

Acknowledgments

This research has been supported by grants from National Science Council and Water Resources Agency of Taiwan.

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Table 1 Summary of statistical properties of distributions of radon-222 for the four groundwater areas in Taiwan.

Groundwater area	No. of wells sampled	Radon-222 concentration, pCi/l					
		Minimum	75%-GE	Median	Geometric mean	25%-GE	Maximum
Hsinchu-Miaoli Coastal Area	33	<18	30	96	69	192	426
Choshui River Alluvial Fan	171	<18	<18	70	43	96	391
Tainan Plain	142	<18	<18	40	31	91	226
Ilan Plain	37	<18	<18	32	24	50	120

GE: Greater Than or Equal to

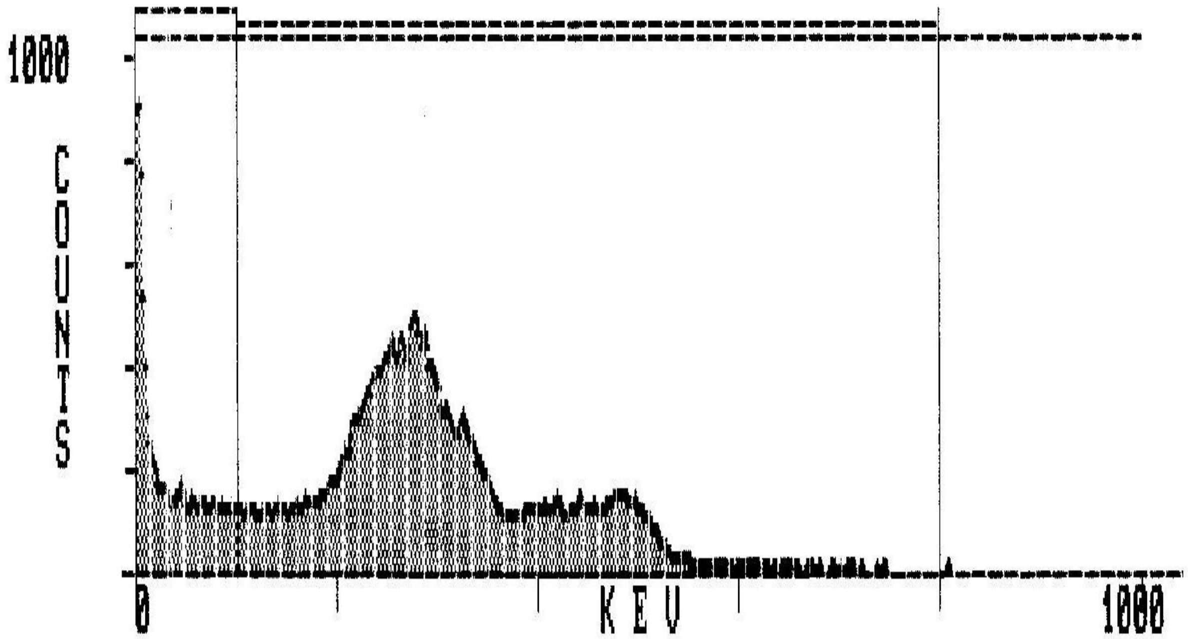

Fig. 1 Alpha spectrum of radon-222 and its daughter nuclides represented by TRI-CARB software.

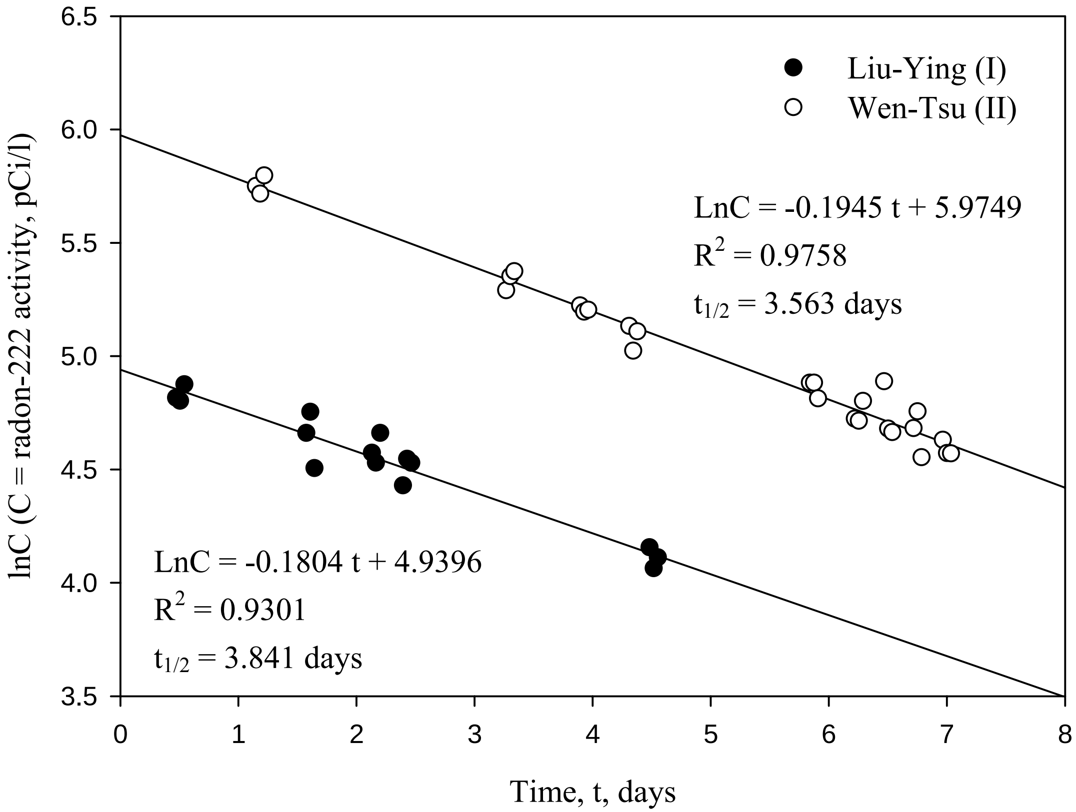

Fig. 2 Measurement of half life from semi-logarithmic decay curve.

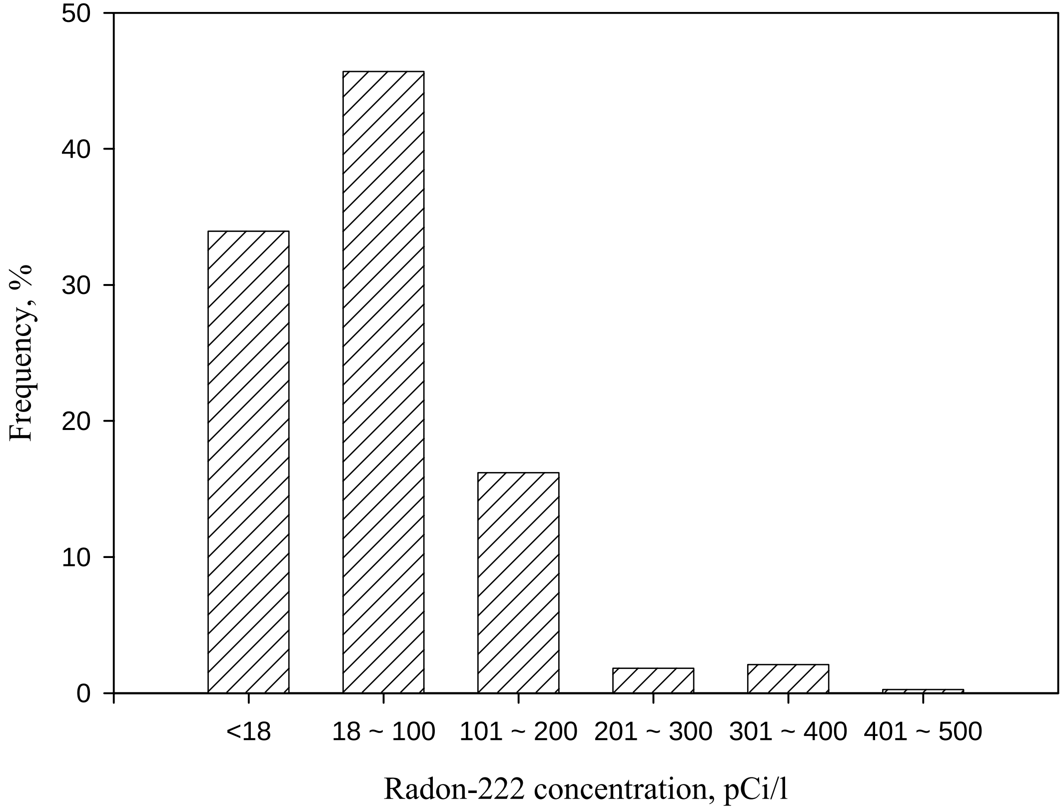

Fig. 3 Frequency distribution of radon-222 for four groundwater areas in Taiwan.

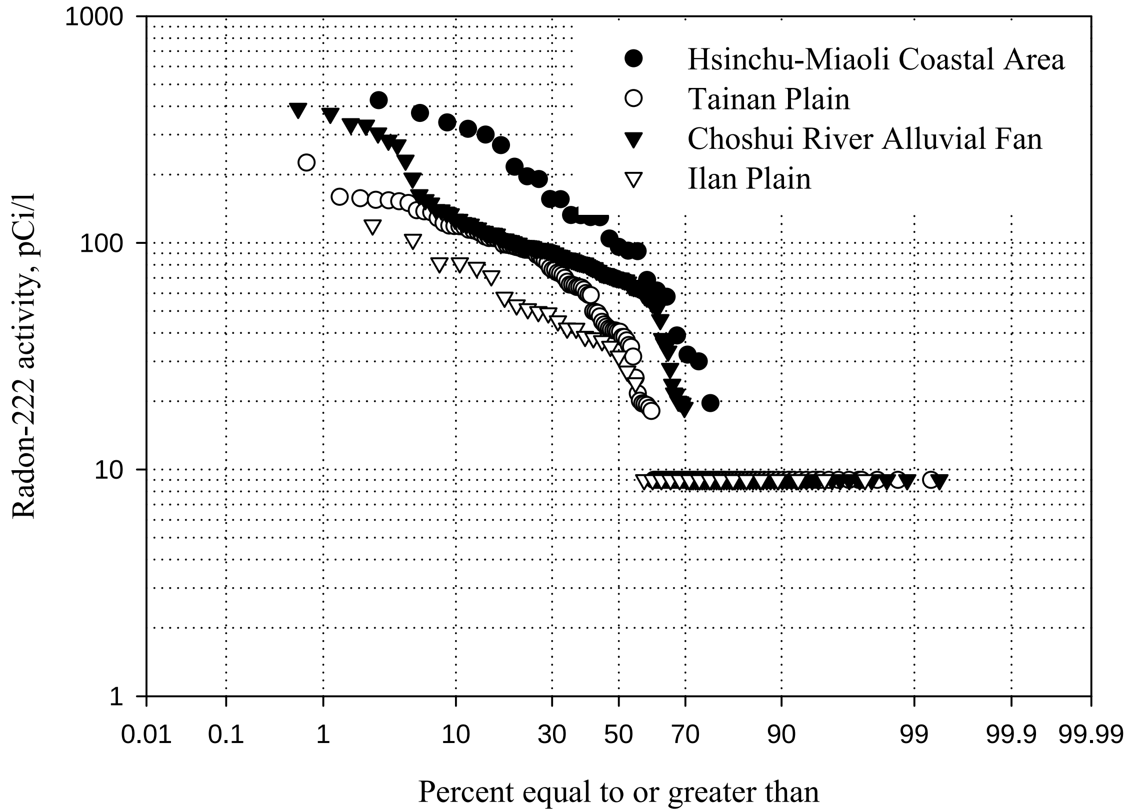

Fig. 4 Probability plot of radon-222 for four groundwater areas in Taiwan.