CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Discussion

In order to reduce the effect of house types on indoor radon prediction using soil parameters, the houses in the study area were grouped into four types. For each house type, indoor radon concentrations were correlated with soil-gas radon concentrations, soil-gas permeability, the product of soil-gas radon concentration and soil-gas permeability, and thoron/radon ratios. However, there still was little evidence of a correlation between indoor radon concentration and soil-gas radon concentration. The same lack of correlation occurred between indoor radon concentration and soil-gas permeability. Soil-gas permeability in both winter and summer varied by several orders of magnitude within one house and even in an area of a few square meters. The influence of the product of soil-gas radon concentration and soil-gas permeability, which is called radon availability, on indoor radon concentration was very difficult to justify for all house types. This situation resulted from the fluctuation of soil-gas permeability at the start and when later multiplied by soil-gas radon concentration. In any case, as shown in Figure 4.28 (d), there seemed to be some sign of correlation between soil-gas radon and thoron/radon ratio for type IV houses, although the correlation factors were very weak, the best r-squared value being 0.26. However, when the correlation between the year-round average indoor radon concentration and thoron/radon ratio of all type IV houses is considered, as shown in Figure 4.35, the least squared plot formed a r-squared value of 0.526, which is a better r-squared value than in Figure 4.28 (d).

As a final step, soil-gas permeability and soil-gas radon concentration logarithmic values of houses of each type were plotted as radon risk diagrams. The result was that all houses of the four types were randomly located in medium and high risk zones. These findings were contradicted to the values of year-round average indoor radon concentration found in all houses, which varied from 21.14 to 110.80 $Bq.m^{-3}$. The U.S. Environmental Protection Agency recommends that action be taken to reduce indoor radon only if its concentration exceeds 148 $Bq.m^{-3}$. Other than for type IV houses, for which there is a relation between indoor radon and radon coming out of the ground, radon risk diagrams are not applicable. Thus, soil-gas radon concentration and soil-gas permeability were also not useful in estimating radon risk for this study. The indoor radon prediction methods proposed by other investigators, either using the positive correction between soil-gas radon concentration and indoor radon concentrations (Kunz and others (1996), Talbot and others (1998), and Varley and Flowers (1998)), or using the radon risk diagram (Surbeck, 1993), were not useful in this study. However, a sign of positive correlation between thoron/radon ratio and indoor radon values for type IV houses is worth further detailed study. Assuming that the area under investigation has constant radon and thoron production rates, the radon flux that comes out of the ground and becomes indoor radon depends only on the apparent diffusion coefficient. For this case, theoretically, higher values of diffusion coefficient give higher indoor radon concentrations and higher thoron/radon ratios, but lower soil-gas radon values. The positive correlation between indoor radon concentration and thoron/radon ratio, as well as the negative correlation between indoor radon concentration and soil-gas radon concentration, are the main characteristics of this area where radon and thoron production rates are constant.

Since the investigated area was small, it is likely that the above assumption can be applied. However, the reasons that the correlation factors of the plots of indoor radon against thoron/radon ratio were not consistent for different types of houses, and were also very weak, can be explained as follows:

1. Type IV houses are the only houses to which the positive correlation between radon flux coming out of the ground and indoor radon concentration can be, more or less, applied. This is because, unlike other types of houses, they were built close to the ground surface and simply constructed with many ventilating slots. Therefore, the correlation between indoor radon and thoron/radon ratio for other types of houses is not likely.

2. Radon and thoron production rates may not be constant throughout the area, even for the same rock formation. The amount of this variation may be less compared to that in an area having different rock formations, but it could still be significant.

3. Meteorological parameters, such as soil moisture, precipitation, atmospheric pressure, and wind speed, may cause adverse effects on soil-gas radon concentration as well as on other soil parameters.

4. Difference methods and errors of measurements, indoor radon concentrations were measured by time-integrated method which took long period of time. While, soil radon and thoron values, were obtained by grab sampling which took only a short period of time. The correlation between indoor radon concentration and soil-gas radon concentration and thoron/radon ratio in this study were used the values of difference methods, this differences would be a significance of weak relationships.

5. The relationships between indoor radon concentration and soil-parameters represented weak correlations, these situations would be came from the small among of data quantity from field works in this study, which is consider unreliable statistically.

5.2 Conclusion

1. Correlation between indoor radon concentration and most soil parameters, such as soil-gas radon, soil-gas permeability, and radon availability, could not be established in this study, with or without taking into account house types. Therefore, indoor radon prediction is not possible using these parameters.

2. Radon risk diagrams based on plots of soil-gas concentration and soil-gas permeability are not useful for indoor radon prediction in the study area.

3. Very weak relationships between indoor radon concentration and thoron/radon ratio exist for type IV houses in winter and summer. The maximum correlation factor of r-squared is 0.26. If only the year-round average indoor radon concentration is correlated with the summer values of thoron/radon ratio at 0.5-meter depth for type IV houses, the r-squared value is 0.526. This higher value represents better relationships.

4. According to the theory of transportation of soil radon and thoron, it is worth investigating whether thoron/radon ratio coupled with soil-gas radon concentration can be a useful tool for indoor radon prediction in an area where both variations of radon and thoron production rate, as well as apparent radon and thoron diffusion coefficients, are significant.

In spite of these efficiencies, the result obtained from this research works may be a good starting point for further investigation in this field.