

BUILDING AND ENVIRONMENTAL FACTORS ASSOCIATED WITH ELEVATED RADON LEVELS IN KINDERGARTENS IN SLOVENIA

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INTRODUCTION

In the winter periods of 1990/91 and 1991/92, the 730 Slovenian kindergartens and play schools that together care for more than 66,000 children, instantaneous indoor radon concentrations were measured using alpha scintillation cells. In 528 (72%) of the kindergartens and play schools radon concentrations below 100 Bqm⁻³ were found. In 16 buildings (2.2%) the concentrations exceeded 800 Bqm⁻³ (1).

Parameters that can affect radon concentrations are geological location, structural characteristics, climate, building material, and the occupancy patterns within these buildings. However, the most important parameter affecting radon concentrations is source. Without source material, there can be no radon. In certain areas of Slovenia, uranium, radon's source material, is abundant (2).

Each building possesses its own dominant parameters for elevated radon concentrations. Sampling and evaluation provide the best opportunity for advising mitigation measures in buildings. New buildings can be constructed utilising radon resistant techniques. Possible building sites can be evaluated with soil testing for radon, and evaluation the porosity of the soil and drainage from the site.

METHODOLOGY

For radon measurements alpha scintillation technique (3) was applied. Grab samples were collected from one groundfloor playroom, closed overnight, at each building. At the same time a short questionnaire concerning construction characteristics and working regime was filled.

In an effort to further define the extent and possible centers of elevated radon concentrations Slovenia was divided into nine units (regions) on the basis of telephone codes and four geographic units for evaluation. The nine regions are: Ljubljana, Maribor, Celje, Kranj, Nova Gorica, Koper, Postojna, Novo mesto and Murska Sobota (1). The four geographic units are: Alps, Fore-Alps, Dinarides and Pannonian basin (4). For each unit the mean and median value was calculated. All analyses were performed using SAS (5) and SigmaStat (6) software packages.

RESULTS AND DISCUSSION

The distribution of radon concentrations in Slovene kindergartens is lognormal with a geometric mean of 58 Bqm⁻³ and geometric standard deviation of 2.5. Data from previous studies indicate that grab samples collected with alpha scintillation cells may over estimate continuous radon levels by as much as a factor of two (7), therefore the information presented here should be considered as the "worst case scenario".

The mean and median radon concentrations for four geographic units are plotted in Figure 1. The Alps (the Julian and Savinja Alps, Karavanke and Pohorje) occupy the northern part of Slovenia. The Julian and Savinja Alps are built predominantly of carbonate rocks, the Karavanken and Pohorje from metamorphic and volcanic rocks. The Fore-Alps occupy the

central part of Slovenia and are mostly built of clastic sediments. The Dinarides, a well known as “dinaric karst” region, represent southern parts of the country and are predominantly built of carbonates and flysch deposits. The Pannonian basin occupies the flat-lands and hilly regions in eastern Slovenia, built of alluvial deposit as sand, gravel and clay (4). Statistically significant differences were found between groups. The Dinaric unit was statistically different from both, the Pannonian basin and the Alpine unit, but did not vary statistically from Fore-Alps. A statistically significant difference existed between the Fore-Alps and the Pannonian basin, but no statistical difference existed between the Fore-Alps and Alps. There was no statistical difference between the Alps and the Pannonian basin.

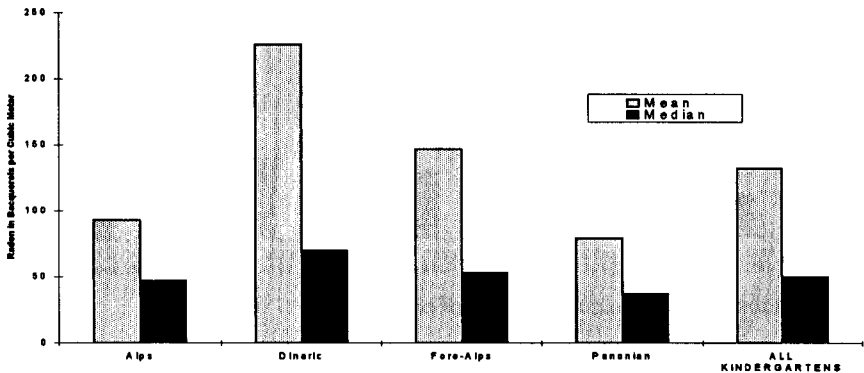


Figure 1. Mean and median radon levels in Slovene kindergartens by geographical regions

Radon concentrations in kindergartens within eight regions on the basis of telephone codes were below 200 Bqm⁻³ with an exception in Postojna region (the Dinarides), with the highest radon exposure risk.

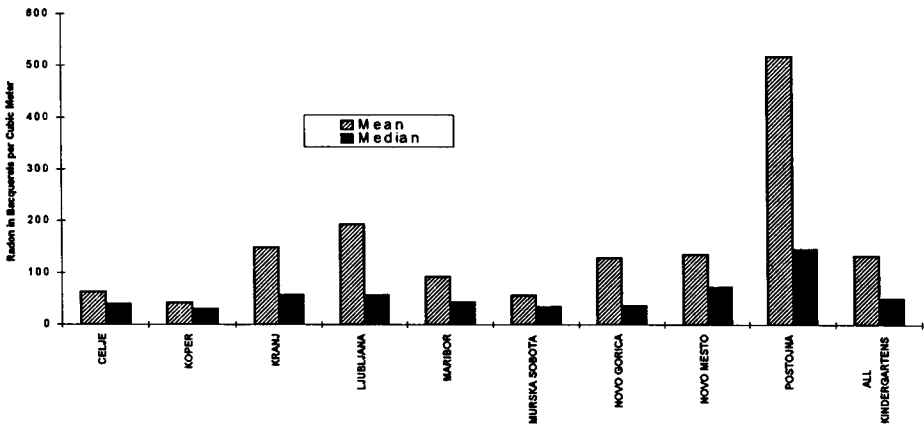


Figure 2. Mean and median radon concentrations in nine Slovene regions

The relationship between radon concentration and age of the building was looked but not found (Figure 3). The majority of the kindergartens are 20-30 years old single story buildings, built of bricks. In some older buildings, built of stone, higher radon levels were found and the mean reason was bad building construction. In years around 1960 fly ash bricks

were used as building material, but not extremely high radon levels in these buildings were found.

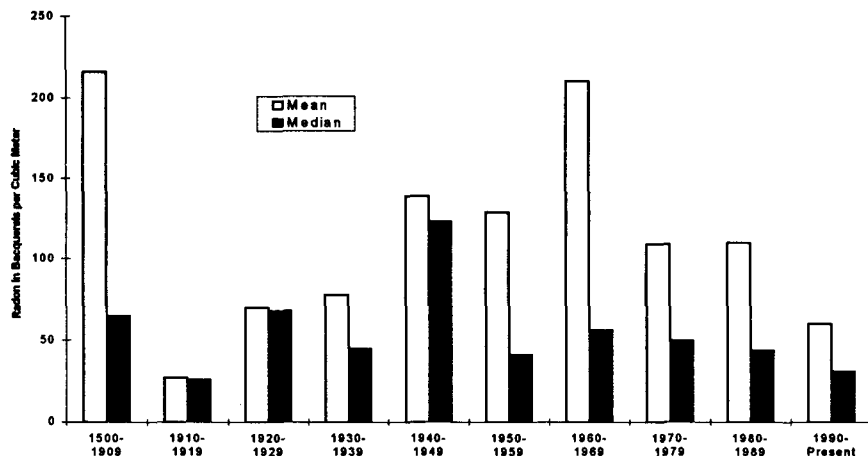


Figure 3. Mean radon levels in buildings by year of construction

CONCLUSIONS

What is important is that radon levels in Slovene kindergartens and play schools were evaluated using consistent techniques and conducted with trained personnel, so that proper evaluations could be made. Most important, all kindergartens and play schools were sampled for radon. Although geographic region, age, construction type and construction material can affect radon levels, sampling is the only technique which will determine actual radon levels within a particular building. Data from this study indicates that 5085 (7.68%) children attend a kindergartens and play school with radon levels which exceeded 400 Bqm⁻³, the proposed Slovene Radon Action Level. 12,719 (19.2%) of kindergarten and play school children attended a kindergarten in which the radon level exceeded 150 Bqm⁻³, the current US-EPA radon action level. In 16 buildings radon concentrations exceeded 800 Bqm⁻³, affecting 1719 (2.59%) children (1).

Data from this study has been used to determine both need and method of mitigation in the buildings affected most by elevated radon levels. Mitigation has begun or been completed on five of the kindergartens effectively lowering radon concentrations to more acceptable levels.

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