The indoor Rn-concentration: schools, kindergartens and official buildings versus homes.

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The Problem

Within the Austrian Radon Project (ARP) Rn measurements were performed in homes and from these measurements municipalities were grouped into 3 classes of Rn potential (low, medium, high). In some municipalities only very few measurements were performed. However, in some parts of Austria a relatively large number of additional measurements exist, namely from schools, kindergartens and official buildings.

The question was: Can these data be used in a similar way as the data from dwellings and can these data be used to improve the Rn potential map deduced from measurements in homes?

And: Are indoor measurements reliable sources for estimating the geogenic radon risk for an area?

Investigated area: **Upper Austria**

Available data:

Comparable !

Data from homes (ARP): approx. **3300** buildings

Data from schools: approx. **950** buildings

Data from kindergartens: approx. **700** buildings

Data from official buildings: approx. **440** buildings

} approx. **2100** buildings

But:

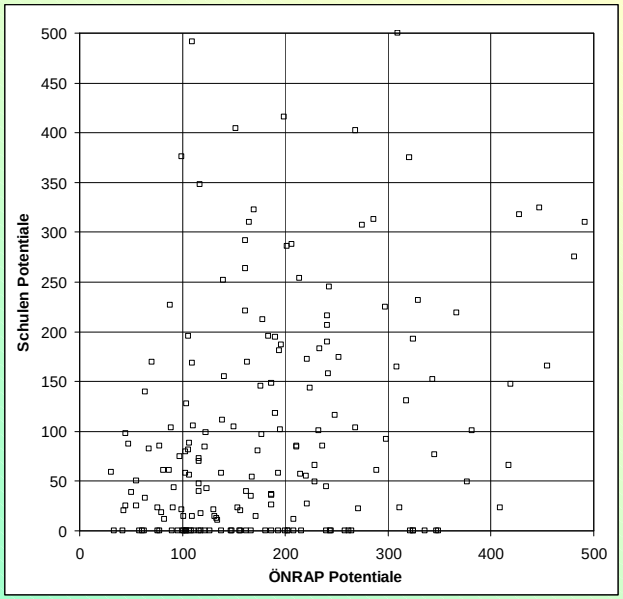
- Houses are quite differently used;
- The comparison with the Rn concentration in homes must be done separately for schools, kindergartens and official buildings;
- Each group for itself is small compared with the number of data from homes;
- Generally, a wide variation in indoor Rn-concentration exists even in homogeneous areas;
- In ARP each municipality was categorized according to a mean Rn-potential; however, in many municipalities only one additional measurement is available.

First approach: Comparison of municipality means

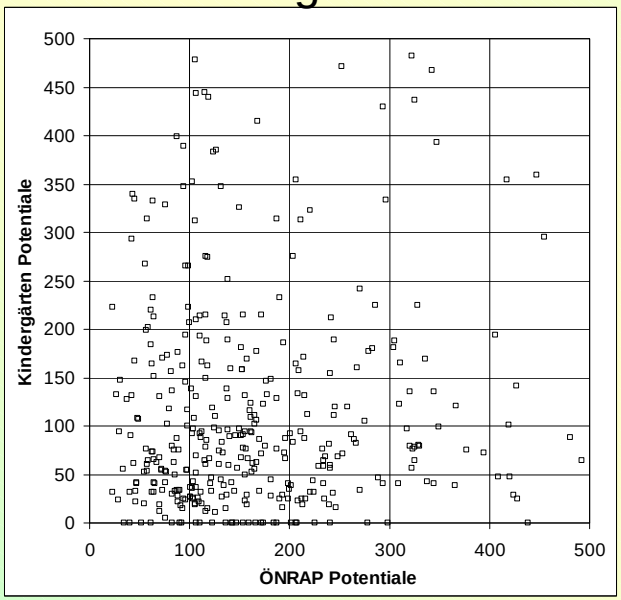
The Rn potential (Rn concentration in a standard situation) was computed in the same way as in homes. If there is one significant parameter substantially different to that used in homes, then the Rn potential computed from the additional data should at least be proportional to the Rn potential derived from the measurements in dwellings.

=> The computed Rn potentials for municipalities should in all cases be proportional to the potentials computed from the ARP data.

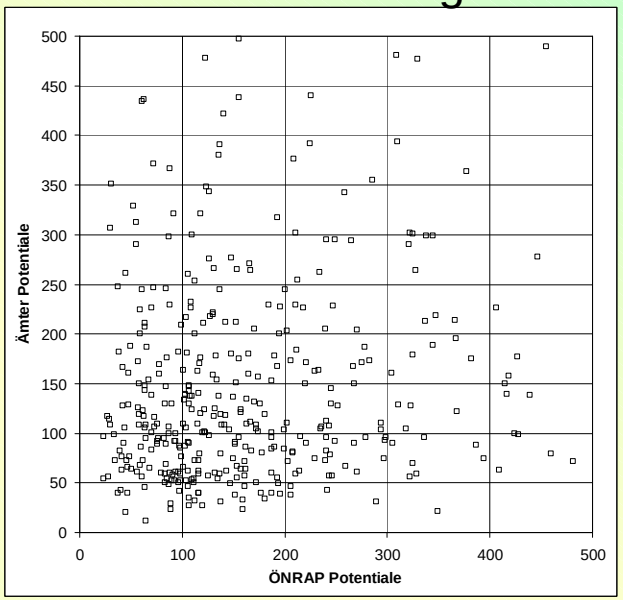
Schools



Kindergartens



Official buildings

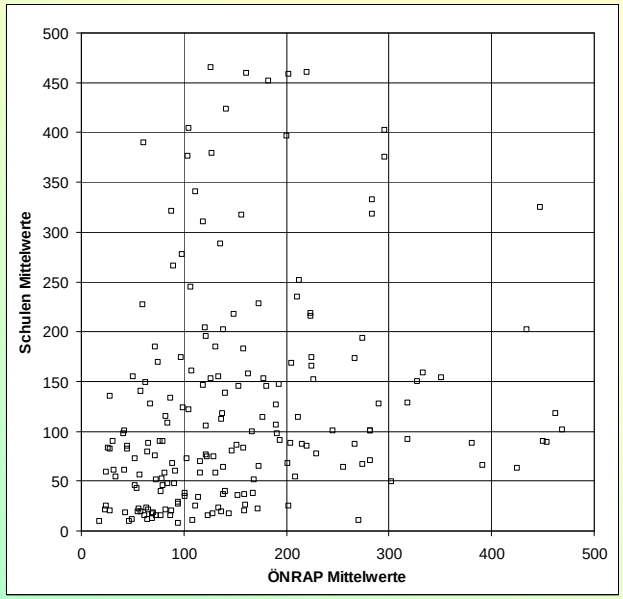


→ Rn potential for municipalities computed from homes →

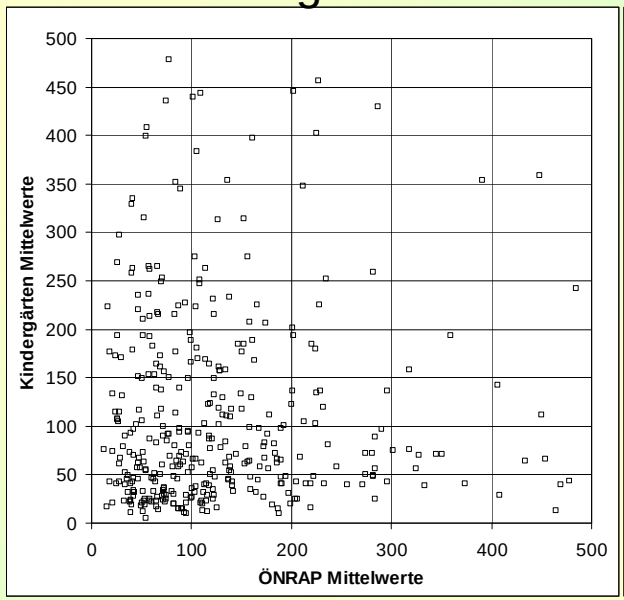
Is there an important factor missing in the conversion of the measured data into the Rn potential?

At least a very rough correlation between the annual mean values should exist:

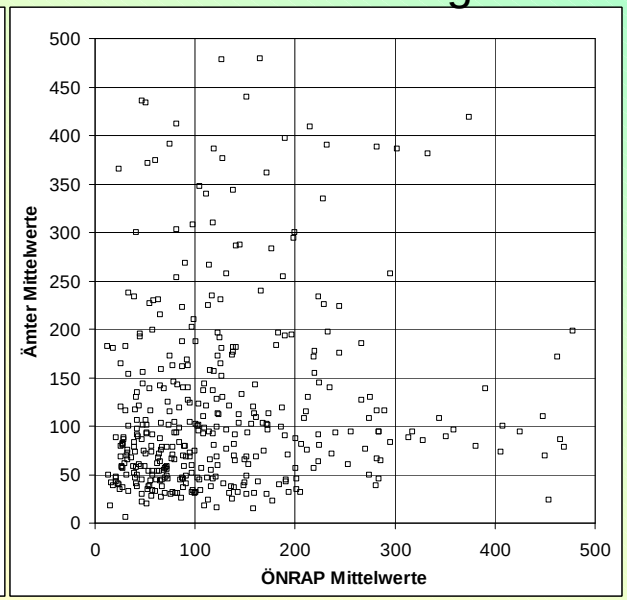
Schools



Kindergartens



Official buildings



→ Annual mean Rn concentration for municipalities computed from homes →

Again: **No correlation is visible!**

Maybe the scatter in the data is too large for the low number of data within a municipality.

Second approach: Comparison of county means

Problem: The scatter of the Rn potential (and the annual mean) will be larger than within municipalities because of more geological differences within a county. In addition the county mean will depend on the distribution of the number of measurements on different geological settings. This distribution will be different for each set of data.

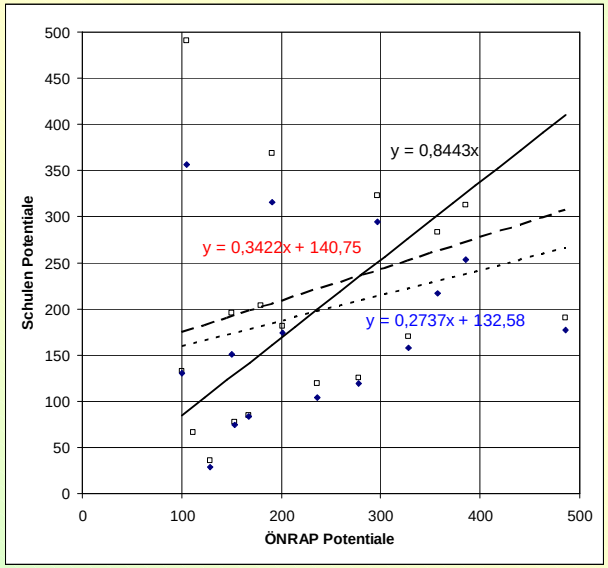
These drawbacks must be accepted to achieve a better statistical basis.

To check for a distortion of the results by outliers a “reduced” Rn potential was computed by eliminating the smallest and the largest value during the calculation of the county mean.

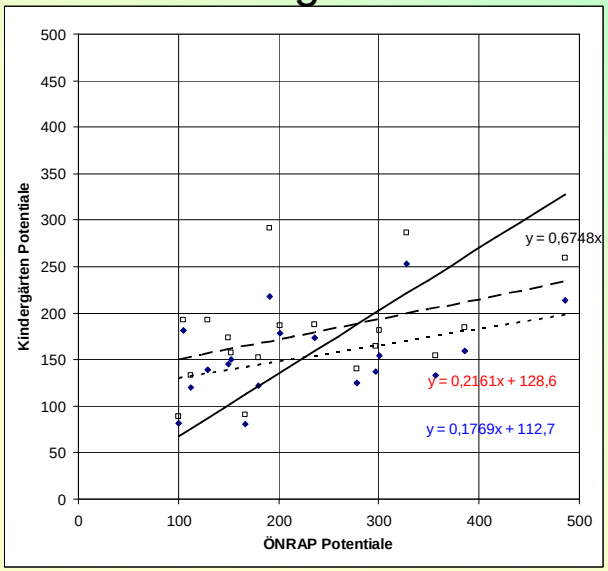
The county means give slightly better correlations, however far away from being convincing. Nevertheless, regression lines were computed.
One should expect that these regression lines cross (close to) the origin. But this is not the case! This is not an artificial effect which was proven by reversing the mathematical dependencies. Finally three regression lines were computed:

1. Rn potential
2. Reduced Rn potential
3. Rn potential forced to cross the origin.

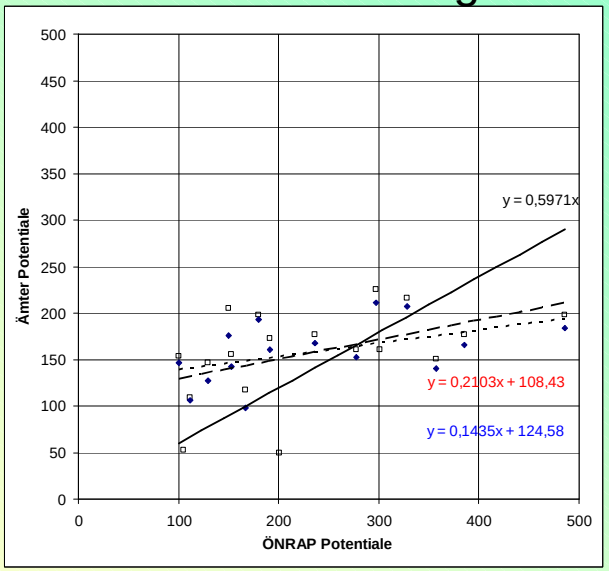
Schools



Kindergartens



Official buildings



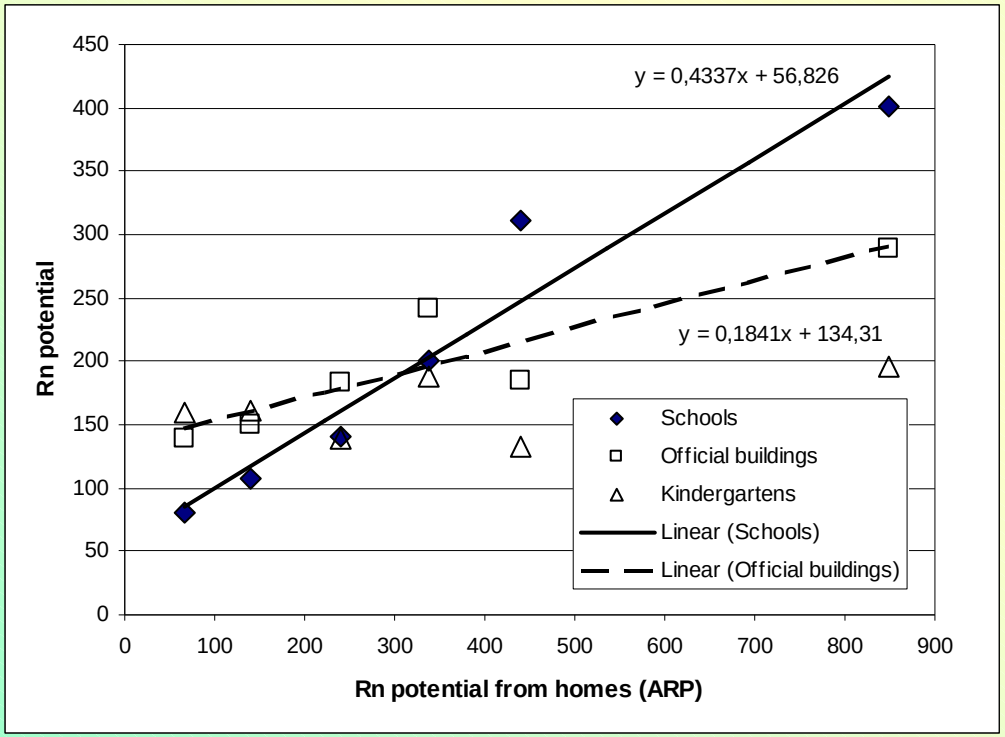
Rn potential for counties computed from homes

Looking for systematic bias:

- No systematic differences between schools, kindergartens and official buildings can be seen: In some counties the results from the schools are high (e.g. 491, 596, 360 Bq/m³) while the results for kindergartens are lower (193, 181, 291 Bq/m³) and the results for official buildings are still lower (53, 161, 173 Bq/m³). Vice versa, the results in other counties are quite opposite: (S: 190, 36, 125 Bq/m³) – (K: 259, 193, 142 Bq/m³) – (OB: 198, 146, 161 Bq/m³).
- No systematic differences could be found when measuring the Rn concentration only in opening times. In some buildings the Rn concentration is lower during the opening time compared with measurements around the clock and in some it is higher.

Third approach: Combining municipalities into groups

Municipalities were grouped according to their Rn potential:
<100 Bq/m³, 100-199 Bq/m³, 200-299 Bq/m³, 300-399 Bq/m³, 300-499 Bq/m³, ≥500 Bq/m³.
The data were combined and a mean Rn potential was computed for every group. Then for each group a mean potential was computed from the data for schools, kindergartens and official buildings belonging to the group.



Result:
Schools: relatively good correlation, small offset;
Official buildings: relatively good correlation, large offset;
Kindergartens: nearly no correlation.

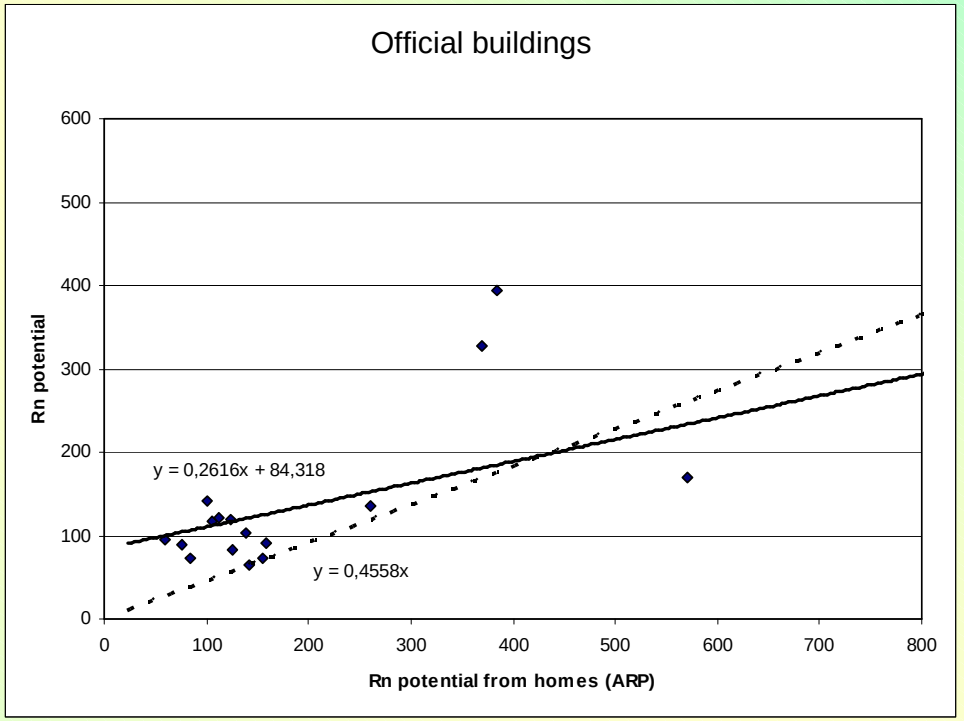
Suspicion: Measurements in kindergartens were not always made properly.
(There were some problems with other investigations too)

But what is the difference between schools and official buildings?

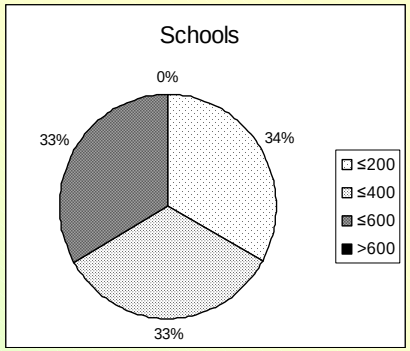
One point is the age of the buildings:
Most school buildings are relatively new, but many official buildings were built before 1945.

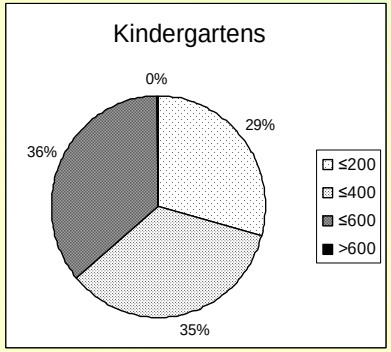
Thus, it was tried to correlate only official buildings which were erected after 1945. (Also most dwellings were built after 1945.) Unfortunately there are not so many newer buildings, therefore only few municipalities could be used for a correlation.

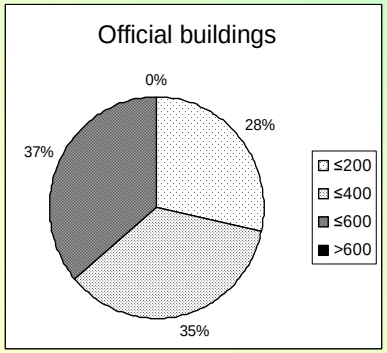
From the diagram it can be seen that the offset becomes much smaller than before.



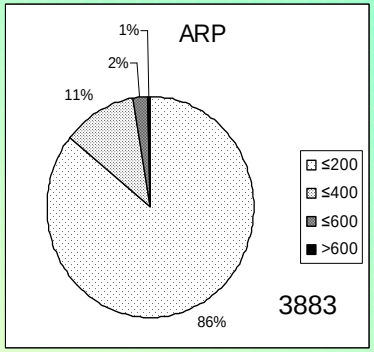
Distributions within Rn potential classes

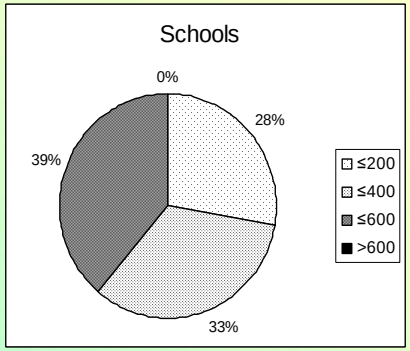


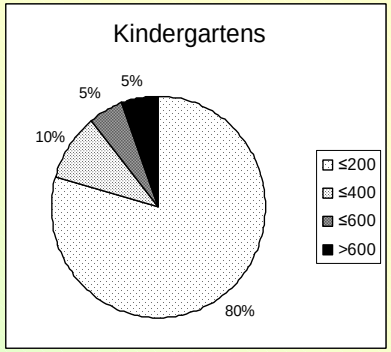


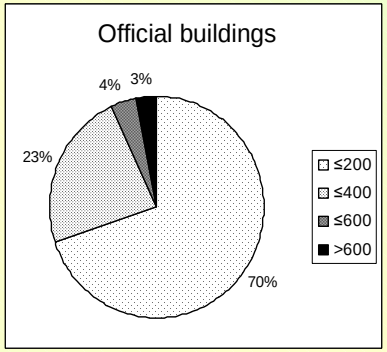


Class 1
"low"

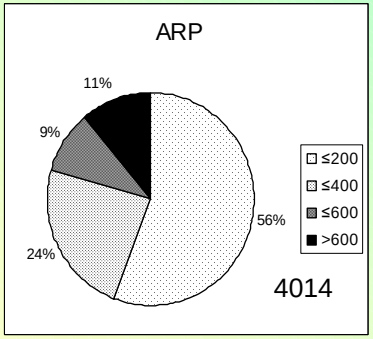


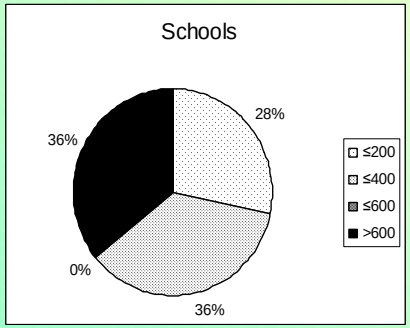


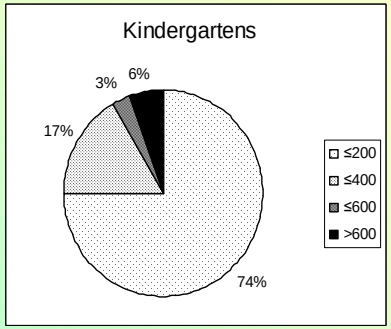


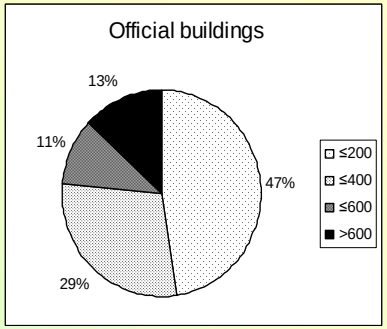


Class 2
"medium"

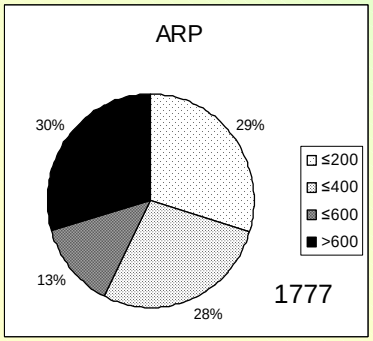








Class 3
"high"



Changes in the potential class of municipalities

The radon potential values were multiplied with the factors 1.18 for schools and 1.68 for administrative buildings (values derived from linear fits crossing the origin) and then integrated into the radon potential calculation from homes.

School data added:

Class ↓	-1	0	+1	>+1
1	-	72	1 (1,4%)	0
2	7 (11%)	59	0	0
3	1 (8,3%)	10	1 (8,3%)	-
>3	4 (29%)	10	-	-

Official buildings data added:

Class ↓	-1	0	+1	>+1
1	-	253	16 (5,9%)	1 (0,4%)
2	6 (5,3%)	104	4 (3,5%)	0
3	2 (9,5%)	17	2 (9,5%)	-
>3	1 (5,0%)	19	-	-

The tables show the number of municipalities which changed the radon class (-1,0.+1,>1).

Result:

The changes were not very large, but this is certainly a consequence of the relatively low number of data added.

Conclusions:

- The large scatter in the data causes a wide uncertainty for the mean Rn potential. This makes a clear classification of municipalities rather difficult;
- Schools and official buildings showed generally higher Rn potentials in municipalities with high Rn potential;
- No correlation could be found in kindergartens;
- Linear correlations between the ARP data and the additional date gave an offset, which could not be explained definitely;
- The existing data from the kindergartens cannot be used to improve the Rn potential map of Austria;
- The data from schools and official buildings could (with some precautions) be used to broaden the basis for the Rn potential map.

The general trend for the radon potential in schools and official buildings confirms the original classification in low, medium and high radon potential areas. This proves the possibility to estimate the geogenic radon risk from indoor data. However, it also shows the limits of the method. The main problem concerns

- The **transformation formula** from indoor measurement results into a radon potential with all the relevant parameters (measurement point, construction types, house use, human behaviour etc.) and
- The relatively **large number of measurements** which are necessary to classify an area according to its geogenic radon risk.

THANK YOU

FOR YOUR ATTENTION