# A RADON SURVEY IN ISRAEL INVOLVING SCHOOL CHILDREN USING THE "RADONTEST" ONLINE SYSTEM

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## OBJECTIVES

1. The main requirements for representative sampling of buildings are:

(i) the random sampling principle,

(ii) the distribution of test points in proportion to the population density.

2. Involving school children in the radon test in their homes solves both (i) and (ii) challenges, and additionally provides:

(iii) simple passive sampling and recording test conditions,

(iv) information to the public about the "radon problem".

3. Selection of the most appropriate measurement method.

4. Organizing and conducting mass radon measurements throughout Israel.

5. Adequate and understandable display of test results on the Radon Map.

6. The principle of regulation of indoor radon based on a scientific approach.

## METHODS

To implement the radon survey in Israel the following actions were required:

- participation of researchers from the Technion **(https://nbri.net.technion.ac.il/en/radon-project/)** as project initiators supported by the European Commission in the framework of the "RadonACCURACY" grant,
- permission from the Israeli Ministry of Education to attend school children in a survey, subject to the consent of their parents and the protection of personal data,
- participation of the Taking Citizen Science to School (TCSS) Center **(https://www.tcss.center)** as a communicator between representatives of the educational system and the Technion team,
- development of the recommendations for teachers on the distribution and exposure the samples for indoor radon measurements,
- development of the "RadonTest Online Data Collection and Analysis System" ("RadonTest" online system) for conducting mass measurements of indoor radon based on a special mobile application associated with a laboratory database via a web-site,
- selecting the miniature charcoal flacons for passive sampling and labeling them with QR-code that is scanned by a mobile phone to access a web-site,
- logistics support.

The radon survey in Israel uses a citizen science approach for data collection, in which the public (in this case school students) assist scientists.

One of the most important recommendations relates to conducting a test in bedrooms, where the occupant spends most of the lifetime. Usually the radon levels in basements and sealed shelters are higher then in the living zone, however those rooms are rarely occupied. Therefore, the radon test in the basement or shelters, which is not a bedroom, should not be carried out. A failure to follow this recommendation will reduce the representativeness of the sample.

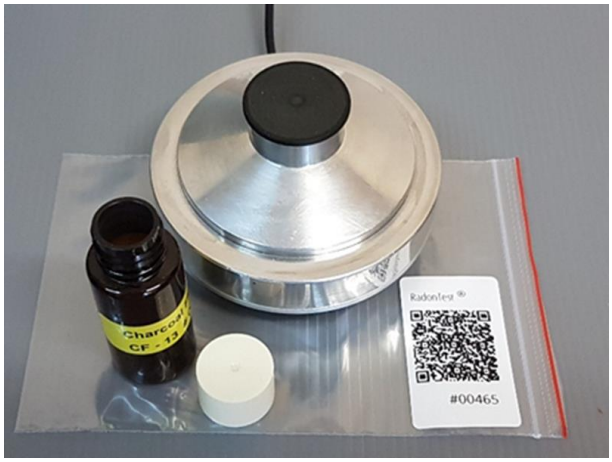
We use the charcoal measurement method that consists of three main steps:

1. Regeneration of the activated charcoal at the temperature about 150 $^{O}$C and preparation of the samples (weighing and packaging),

2. Passive exposure of the CF-13 from 3 to 6 days,

3. Measurement of the activity of radon adsorbed by the charcoal, and calculation of the radon concentration considering the sampling conditions.

Exposed charcoal can be reused. The number of regeneration cycles is practically unlimited.




***Equipment for measuring indoor radon using the charcoal method consisting of the detector type BDB-13 and set of samples (usually 20-40), each of which includes the type CF-13 charcoal flacon and the package labeled with the QR-code. The volume of the bottle (charcoal) is 20 (13) mL.***

For activity measurements, the charcoal is removed from the CF-13 into the detector. The detectors are connected to the WiFi unit and controlled via the Web using the interface integrated into the "RadonTest" online system.

This detector with the CF-13 ensures the measurement uncertainty of indoor radon is about 12(16) Bq/m$^3$ at low (as outdoor) radon concentration, if the duration of activity measurement is about 60(30) min and exposure time is about 4 days. Methodical (systematical) uncertainty does not exceed 25%.

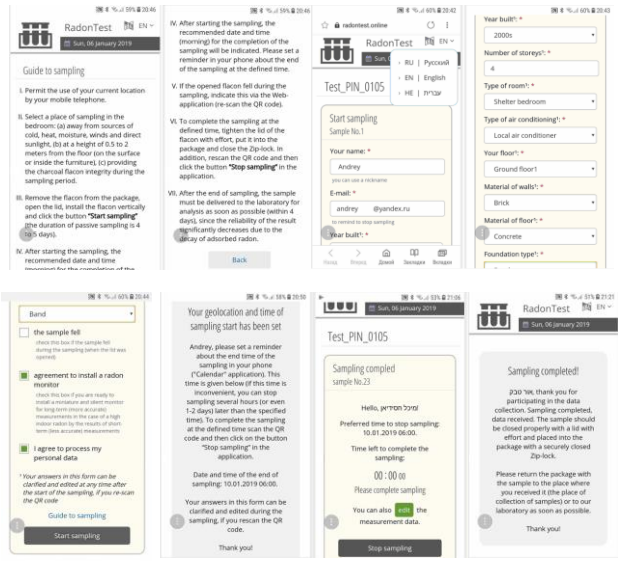
Before indoor radon tests, the number and initial mass of the CF-13, as well as the corresponding QR-code, are registered in the "RadonTest" online system in the Technion lab. Then a box containing 40-80 prepared samples is transferred to the school.

Scanning QR codes by a mobile phone allows to identify the sample, the geolocation of the test object, the start and the end of sampling. In addition to the detailed sampling guide, the mobile application includes a questionnaire for collecting information about building characteristics and testing room.

Our experience shows that the use of the mobile application is not difficult, even for school children.

After returning the exposed samples to the lab of the Technion, the professionals perform their identification and measurement of the radon activity in the charcoal flacons. The measurement results are stored in a secure database and displayed on the Radon Map.

## METHODS




***The mobile application including Guide to sampling and Questionnaire, and the most important messages after the start and stop of sampling (English version).***

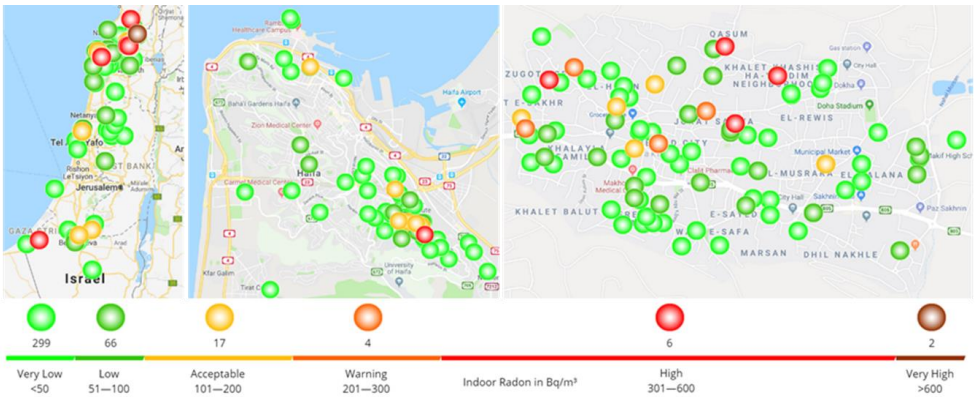
The "RadonTest" online system is a cloud service available for use anywhere in the world, which allows to organize the work of laboratories in a single information space, and to monitor the data keepers and actions of all participants of radon tests.

**Thus, the "RadonTest" online system can be used in different laboratories from any countries and serve different methods (https://radontest.online).**

## RESULTS

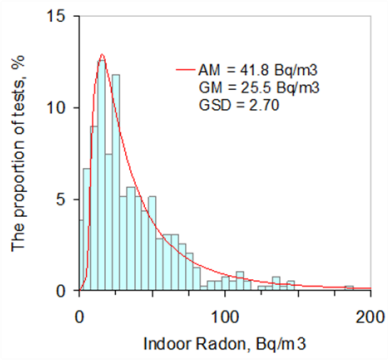
Initially, indoor radon measurements were carried out in Haifa. After the approval of the Ministry of Education (January 2019), radon tests began to be conducted in the dwellings of school children throughout Israel. Before the beginning of the summer (school holidays), about 400 tests were made in different regions of Israel as shown in the Radon Map **(https://radonmap.online/indoorradon/).**

The test results are displayed in the public Radon Map as markers in the form of circles with a diameter of about 120 m at the maximum scale of the map in order to maintain anonymity of the test participants.




Each marker contains the information about radon concentration (and instrumental uncertainty) for the test period, as well as the duration and date of the test start. Thus, the constructed Radon Map does not contain any personal data, but at the same time displays the spatial distribution of radon in buildings and its extreme values. This way of displaying test results contains more information and is also more understandable to test participants and any other.

The spatial distribution of the indoor radon in Israel based on the survey in Dec. 2018 – May 2019 corresponds to the lognormal law (AM=41.8 Bq/m$^3$).




Detailed surveys of buildings with abnormally high levels of radon in sealed shelters and basements showed that the radon concentration in the residential area (living rooms and bedrooms) is not high.

Therefore, summarizing this and previously accumulated experience, we recommend taking measurements, first of all, in the bedrooms where the occupants spend most of their time.

**How to find the buildings with high radon?** To solve this problem, we offer the same approach with the participation of school children, but with the difference that older school children could perform not only sampling in their homes, but also carry out measurements of radon activity in charcoal under the guidance of their teachers in the laboratory lessons. The organization of such laboratory lessons is not particularly difficult, when using the "RadonTest" online system, as well as the simple charcoal method based on low-cost equipment described above. This approach will significantly increase the number of tests per year, and at the same time will reduce the cost of the radon survey.

## CONCLUSIONS

The radon survey in Israel involving school children by means of the "RadonTest" online system using the charcoal method was conducted for the first time. This experience seems to be quite successful, so the radon survey in Israel will continue and develop to reliably assess the impact of radon on the population, as well as to identify buildings with elevated radon levels. We are confident that such an organization of mass radon survey is most effective in terms of time and costs in any other country or single region. In addition, the involvement of school children is an important educational process, which contributes to the wide and rapid dissemination of information about the risks from radon among the population and administrations of different levels.

***Fragments of the public Radon Map with test results in Israel (Dec. 2018 – May 2019)***


## ACKNOWLEDGEMENTS

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## CONTACTS


**Feedback and connecting your laboratory to the "RadonTest" online system: https://radontest.online**