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RADON MONITORING : OPPORTUNITIES, CHALLENGES AND PITFALLS

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ABSTRACT

According to W. jacobi: "The radon saga is a scientific thriller with tragic features and political confounders. The historical roots of this saga reach back to the 15th century. It is a field of dilemmas, controversies and frustrations, some of which still persist".

Considering the implications of the above statement of W. Jacobi at its face value an attempt is made to highlight the pitfalls in radon monitoring if proper care is not taken for calibration/ standardisation/normalisation of recorded radon data.

A brief history of radon origin and some important facts about it are given as an introduction. The opportunities and scope of radon research is mentioned without any elaboration. Similarly, it is understood that the intelligent reader is well-versed with radon-monitoring techniques. The paper is based on author's own experience of working in the radon field for nearly two decades. The purpose of this brief write up is not to pass judgement on any author, agency or company but to learn a lesson from failures by self-criticism.

HISTORICAL REVIEW

1898 : Marie & Pierre Curie discovered ^{226}Ra and ^{210}Po and extracted them from pitchblende ore.

1899 : Rutherford discovered a gaseous radioactive emission from thorium compounds and called it *emanation.* In fact, it was ^{220}Rn, commonly known as thoron.

1900 : Dorn discovered a similar emanation from radium compounds and called it radon (^{222}Rn).

1901 : Elster and Geitel monitored radon concentration in the air of mines at Schneeberg and jachymov for the first time which led to correlation of high radon concentration to the lung cancer risk of the miners.

1902 : Elster and Geitel studied the radioactivity of air in caves and attributed it to radon.

1903 : Marie Curie and Laborde discovered that radium was always at a higher temperature than its surrounding medium which led Rayleigh to calculate the age of the earth from radium decay.

IMPORTANT FACTS ABOUT RADON

(a) Radon concentrations in air are determined by a number of factors such as : (i) ground cover, (ii) height above ground, (iii) soil porosity and grain size, (iv) temperature, (v) atmospheric pressure, (vi) Soil moisture, rainfall and snow cover; (vii) meteorological conditions, and (viii) season.

(b) Globally, ground level concentrations are considered to be maximal during autumn and early winter, and minimal during spring (UNSCEAR, 1997).

(c) Diurnally, radon concentrations are prone to be greatest during the early morning hours. Radon concentration will be least in the afternoon and increases towards the sunset.

(d) The mean ^{220}Rn emanation from the soil is 1.5 Bq/m^2s and the corresponding value for ^{222}Rn about 100-fold lower, only 17 mBq/m^2s.

(e) The total worldwide release of radon (^{222}Rn) into the atmosphere has been estimated to be about 9×10^{19}Bq. This corresponds to an average global surface conc. of radon ~ 2.5 Bq/m^3 (including oceans). Overland conc. is about 5-10 Bq/m^3.

(f) Inhaled radon and daughters deliver a radiation does to the epithelial cells lining the bronchial tree. ^{222}Rn contributes only 2% of the total dose while 98% is attributed to radon daughters.

(g) ICRP 65 (1994) prescribes the annual exposure levels of radon concentration inside the dwellings from 200-600 Bq/m^3, delivering a dose of 3-10 mSv to the residents for an equilibrium factor of 0.4 and an yearly occupation of 7000 hours. Action level is justified above annual effective dose of 10 mSv.

Opportunities & Scope of Radon

(i) Radon as a tracer for radioactive minerals.

(ii) Locating oil and natural gas deposits.

(iii) Underground fluid motion and water resources.

(iv) Earthquake prediction and volcanic eruption.

(v) Radiation health hazard to miners and public.

(vi) Geothermal resources.

(vii) Delineation of hidden/active faults.

Radon Monitoring Techniques

(i) Activated charcoal.

(ii) Plastic SSNTDs

(iii) Scintillation counters (Lucas Cell)

(iv) Ionisation counters

(v) Surface-barrier junction detectors

vi) Thermoluminiscence detectors

(vii) Electrets

(viii) Nuclear emulsions

Pitfalls of Radon Monitoring

(i) Calibration of detectors

(ii) Failure of the system

(iii) Standardisation of data

(iv) Inter - laboratory comparison

(v) Global/national/regional comparisons

(vi) Updating of radon risk and mitigation levels

(vii) Inventory of radon data

(viii) Disaster management

DISCUSSION OF PRACTICAL PROBLEMS

(a)Use of Spark Counter

The alpha tracks of radon and its progeny appear as etched-through holes in the LR-115 type II plastic detector used, if the standard etching conditions are followed strictly. However, the counting of the alpha track-etched will depend upon the quality of spark counter used. For sake of comparison, we have shown the two curves (Figs. 1&2) for track density versus voltage plot. It is obvious that the spark counter without any visible plateau (Fig. 1) must be discarded otherwise it will lead to spurious counting of track holes.

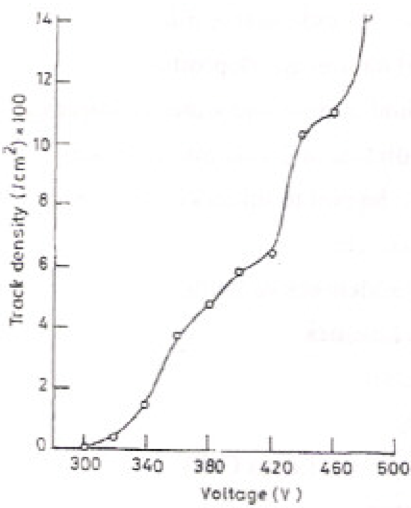

Fig. 1. Plot of track density Vs. voltage for spark counter-I (without plateau)

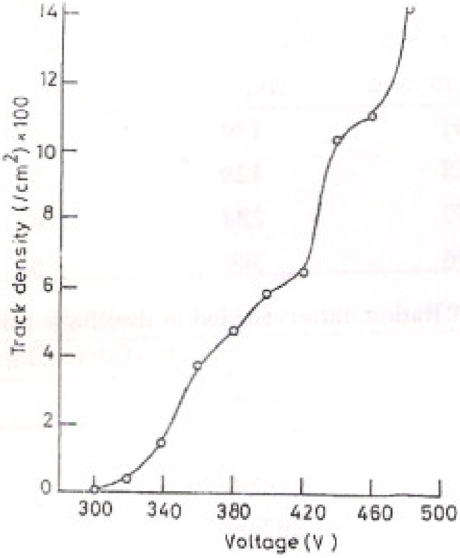

Fig. 2. Plot of track density Vs. voltage for spark counter-II (with plateau)

(b) Use of Plastic Detector

Care should be taken to procure plastic detector sheets from standard sources, preferable of the latest batch, with minimum background. Detector sheets need proper storage facilities and protection from contaminated environment of the laboratory. A comparison of track densities and radon concentrations measured by two sets of plastic detector sheets, one exposed to radiation environment of the laboratory and the other procured fresh and kept in safe custody, is given in Table 1. The results indicate the failure of detector material and its obvious impact on the radon concentration measured.

(c) Use of Electronic Counters

It is observed that plastic detector is quite rugged for field survey and use in radon monitoring in comparison to electronic counters which are very sensitive but radon useful for real-time data analysis. Electronic counters need proper handling and calibration before and after field trials. An inter-comparison of two sets of radon alpha probes for indoor air of dwellings is given in Table 2. It is obvious that overuse of these sensitive detectors in the field renders them unfit for radon monitoring. A similar inter-comparison (Table) 3 shows the mis-match between two helium probes used for monitoring helium concentration in thermal springs. Both these faulty instruments were repaired and recalibrated by the supplier firms. So, one obvious lesson to learn from this episode; it is always better to have two or more sets of electronic counters for sake of inter-calibration and comparison.

Table 1. Radon Conc. in the houses of G.N.D. University Campus (March, 1997)

House No.	LR-115 (old batch films) Track Density Tracks/cm²/30d	LR-115 (old batch films) Radon Conc. (Bq/m³)	LR-115 (New batch films) Track Density Tracks/cm²/30d	LR-115 (New batch films) Radon Conc. (Bq/m³)
A-4	181	188	65	68
A-5	123	128	51	53
A-7	277	288	63	65
A-9	336	349	56	58

Table 2. Comparison of Radon data recorded in dwellings using two Alpha probes

House	Radon Conc. (Bq/m3) Probe-I	Radon Conc. (Bq/m3) Probe - II
A	231±51	45±38
B	165±45	55±39
C	297±60	33±37
D	899±43	115±10

Table 3. Comparison of Helium content in Thermal Springs of Parbati valley

Thermal Spring Location	Helium Content (ppm) Probe-I	Helium Content (ppm) Probe-II
Manikaran	50	0.3
Tegri	15	0.2
Kasol-1	60	0.1
Kasol-2	70	0.2
Kasol-3	90	0.5

(d) Standardisation of Radon data

It is desirable to set up a central calibration facility to calibrate all radon monitoring equipment supplied to various groups and laboratories in India. It is the prerogative of all participating universities in the co-ordinated radon survey project in India undertaken by BRNS, DAE to use the standard protocol for inter-comparison of radon results. To achieve this purpose, nodal centres have been set up at Jodhpur, Kalpakkam and Jaduguda in addition to central facility at EAD, BARC, Trombay.

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