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AN OVERVIEW OF CURRENT RADON AND RADON DAUGHTER RESEARCH AT LBL

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An Overview of Current Radon and Radon Daughter Research at LBL

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Introduction

This report provides a brief summary of radon and radon daughter research at Lawrence Berkeley Laboratory. This work is one of four areas of indoor air quality research within the Building Ventilation and Indoor Air Quality Program at LBL. (The other three areas are: Passive Monitors and Organics; Combustion; and Indoor Air Quality Control Techniques.) The radon and radon daughter research program has two broad goals: 1) the study of sources of radon and its subsequent transport into houses, and 2) research on the behavior of radon daughters in indoor environments.

In addition to direct laboratory and field work in these areas, additional research effort is directed to several auxiliary areas, including development of instrumentation and monitoring techniques, studies of indoor air movement, and measurement and control of indoor particulate concentrations. This paper summarizes the nine research projects presently underway at LBL.

Current Research Projects

This section briefly discusses each research project. Any data or conclusions presented here are preliminary in nature and should not be referenced or cited without further consultation with LBL staff.

1 Instrumentation and Test Space Development

A radon daughter carousel, an automated radon daughter sampler, has been built, and final testing is nearly completed. The device has seven filter holders mounted on a rotatable platter. Samples are collected in one position, then the filter sample is rotated under a surface barrier

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detector for alpha spectroscopic measurements of the radon daughter activity. Control of the sampling time, delay times, platter rotation and counting sequence is done via a self-contained microcomputer. In tests at the Denver Radon Daughter Intercalibration Workshop, data collected with the carousel gave results comparable to those from grab sampling techniques [1].

A widely used technique for the determination of radon daughters from gross alpha counting has been modified for use in indoor environments [2]. The modified Tsivoglou method has been optimized for the typically low indoor radon daughter concentrations by extending the total measurement time from 35 to 60 minutes. This reduces the minimum measurable concentrations (which we define as the concentration where the relative standard deviation is 20 percent) for ^{218}Po, ^{214}Pb and ^{214}Bi by factors of 3, 7 and 4, respectively.

The radon research house, a two-story multi-room structure, has been instrumented for conducting radon, radon daughter, particulate, and air movement studies [3]. The instrumentation is listed in Table 1. Four rooms on the first floor of the house totalling 58.8 m^2 in area have been completely weatherized to reduce the effective leakage area, as measured with a blower door, to less than 24 cm^2. As a result, the uncontrolled infiltration rate is extremely small and the only significant sources of pollutants or ventilation are those under experimental control.

2 Particulate and Radon Progeny Control

This research project is expected to be one of the major efforts during the present year. The study has several aspects: to investigate particulate removal using active air cleaning devices, including forced-air circulation; to study the aerosol size dependence of the control methods; and to study the effect of particulate removal on radon daughter concentrations. Both ducted and unducted devices will be tested, and the study will also investigate indoor environmental factors, such as temperature and humidity that might affect the control techniques.

TABLE 1

Instrumentation and Equipment
for the Radon Research House

Parameter	Manufacturer; Principle of Operation
Radon and Radon Daughters	
Continuous Radon Monitors (4)	LBL; Flow-thru scintillation cell
Radon Daughter Carousel	LBL; Alpha spectroscopy
Radon Source (100 μCi)	LBL; Radium salt
Unattached Daughters (manual)*	LBL; Wire screen, alpha scintillation
SF_6 Tracer Gas	
Injection Controller	LBL;
Sampling Controller (2)	LBL;
SF_6 Analyzer (2)	Wilks; Infrared absorption
Environmental Monitoring	
Wind Speed/Direction	MRI; Vane and cups
Temperature (inside, outside)*	YSI; Thermistors
Humidity (inside, outside)*	
Environmental Control	
Gas Range (particle source)	
Cigarette Smoking Machine	AD Little;
Mixing Fans (4-5 in each room)	
Range Hood	
Furnace/Furnace Fan (ducted)	
Particulates	
Condensation Nuclei	TSI; Optical scattering
Sub-micron Particle Concentration	TSI; Electrostatic Classification
Respirable Mass	PMS; Optical scattering
Activity Size Fractions* for attached radon daughters	Electrostatic classifier, cascade impactor (?)
"House" Computer and "Particle" Computer*	
Computer	LBL/Intel;
Input Terminal	LSI (adm3a);
Hard-copy Output	Teletype (tty43);
Taped Output	Columbia Data Products (DC300D);

*Under development/acquisition

This research will be conducted at the radon research house. Particulate instrumentation will be located on the second floor above the test space; a manifold system will allow multipoint sampling. Total number concentration and respirable aerosol mass will be measured by a condensation nucleus counter (CNC) and piezobalance, respectively. Size distribution data will be obtained for aerosols from 0.01 to 0.3 μm in diameter using an electrostatic classifier, whose outputs are sampled by a CNC or electrometer. For aerosols in the 0.09 to 3 μm diameter range, a laser-based optical particle counter will be used. Instrumentation control, sampling point selection, and data logging are done using a dedicated microcomputer system. The raw data are stored on magnetic tape for subsequent off-line analysis.

Radon progeny activity distributions will be determined by monitoring the size-selected output aerosol from the electrostatic classifier. Additional data may by acquired by measuring alpha activity of samples collected with a cascade impactor. Unattached daughters will be monitored using a fine mesh wire screen backed by a filter. A four-sample alpha detection and counting system has been built for measuring gross alpha activity on either filter samples or wire screen grids.

Preliminary tests of the effect of air movement on radon daughter concentrations have been conducted, and the results are shown in Figure 1. The drop in ^{214}Pb and ^{214}Bi concentrations with increased air circulation appears to be due to additional particle (and daughter) plate-out. These effects will be investigated in greater detail, especially the response of the unattached daughters.

3 Pollutant Transport/Spot Ventilation

The transport of pollutants within and between two rooms (connected by an open doorway) has been studied using SF_6 tracer gas, and the effectiveness of typical spot ventilation systems in reducing pollutant concentrations has been investigated. Tracer gas concentrations were monitored at six locations within the two-room test space following injection and mixing to achieve uniform concentration. Two typical spot ventilation systems, a

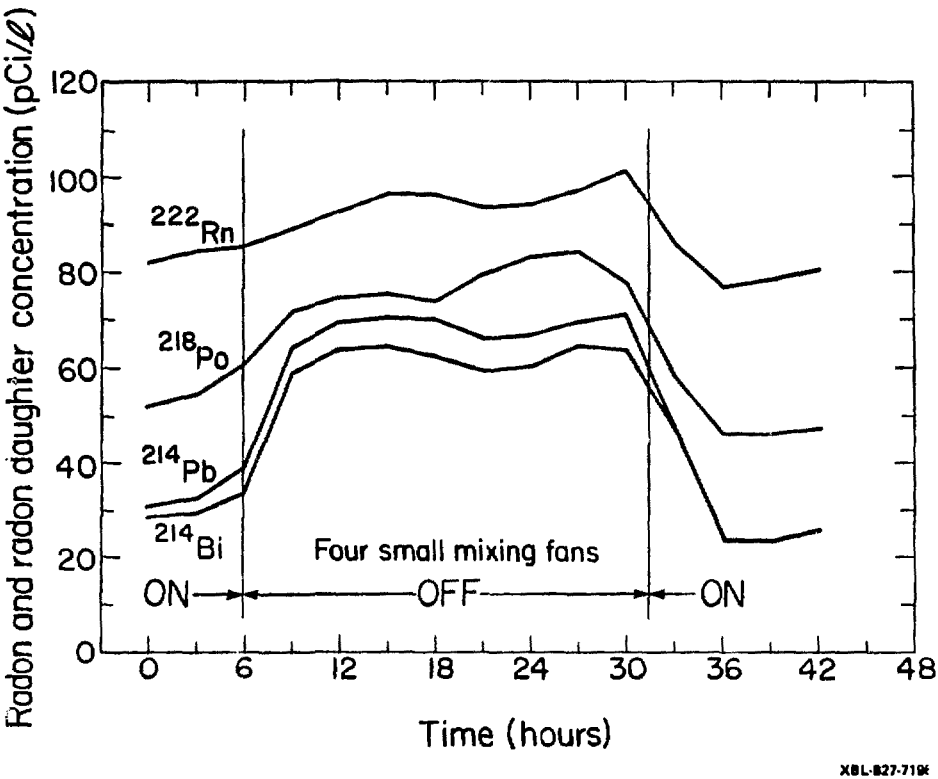

Figure 1. Initial air movement tests at the Radon Research House, showing the effect of air circulation on radon daughter concentrations.

range hood and a ducted window fan were used. In one series of tests, SF_6 was injected at the top of the range to simulate emissions from a gas-fired stove. Tracer gas concentrations were measured following injection with and without the operation of the stove. Emissions at other point source locations were also simulated, and the effectiveness of a window-mounted fan was measured. Data reduction is still underway, although preliminary results indicate a rapid transport of pollutants between rooms even when both the point source and the ventilation fan are in the same room.

4 Physical Modeling of Indoor Air Movement

In order to provide a more comprehensive, theoretical framework for indoor air quality research, a model development effort is currently underway. Such a model will be useful in the interpretation of the results of indoor air quality experiments, in the evaluation of how air quality control techniques or energy conservation measures will affect indoor air quality, and in the assessment of health risks related to indoor air quality. Initially, these models will build on existing forced and natural convection models for air movement in buildings.

The goal of the present effort is to create elements of a realistic, multi-chamber model for residential indoor air quality for predicting:

- transport of combustion-generated pollutants;
- transformation and removal processes for radon and radon progeny, and
- emanation and removal of organics, particularly formaldehyde.

5 Intensive Single-house Radon Monitoring

As part of continuing efforts to collect field-based data, a house near Chicago was monitored for five months in order to study the correlation of radon input rate with meteorological information. The house was a single story, wood frame structure with 1100 ft^2 of area. It also had a full, conditioned basement constructed of poured concrete, which contained a sump

fed by a perimeter drain tile system.

Several parameters were monitored continuously throughout the course of the experiment, including:

- air-exchange rate (using SF_6 tracer gas)
- radon concentrations indoors, at the sump, and in the soil gas
- indoor and outdoor temperatures
- wind speed and direction
- weather data taken at O'Hare airport (via the National Weather Service)
- pressure difference across the house walls

Data were collected using an automated, microcomputer controlled instrumentation package [4] and stored on a magnetic tape. Data analysis is presently underway.

6 Radon Transport Across a Crawl Space

In an effort to understand radon transport and infiltration into houses with no intimate contact with the soil, several homes with crawl spaces will be studied. Three homes in the San Francisco Bay Area have been examined using grab samples. The preliminary data are shown in Table 2. The house in Lafayette is being monitored for an additional four to six week period to gather more extensive data on radon concentrations indoors, outdoors, in the crawl space and from the soil. In addition, data on indoor and outdoor temperatures, wind speed, and wind direction will be collected. The study will be extended to similar housing in the Pacific Northwest, and a limited set of potential control techniques will be evaluated.

TABLE 2

Crawl Space Study: Local Site Assessment Results
(preliminary)

Measurement	Location		
	Albany	Lafayette	Concord
Indoors:			
^{218}Po	0.17 pCi/l	0.36 pCi/l	0.32 pCi/l
PAEC	0.0017 WL	0.0028 WL	0.0027 WL
Crawlspace:			
^{222}Rn	0.6 pCi/l	0.8 pCi/l	2.5 pCi/l
^{218}Po	0.32 pCi/l	0.44 pCi/l	1.6 pCi/l
PAEC	0.0014 WL	0.0030 WL	0.0060 WL
Radon Flux	0.41 pCi/m^2-sec	0.48 pCi/m^2-sec	0.53 pCi/m^2-sec
Soil Emanation (equilibrium)	0.15 pCi/gm	0.19 pCi/gm	0.20 pCi/gm
Outside:			
^{218}Po	0.05 pCi/l	---	0.12 pCi/l
PAEC	0.0016 WL	---	0.0021 WL

7 Regional Survey of Soil Radium Content

This study is designed to assess the potential for locating areas with high radon source strengths in the Pacific Northwest. As a possible method of targeting such areas, the spatial variation of near-surface radium concentrations will be investigated. In order to do this in a systematic way, data from the National Airborne Radiometric Reconnaissance Program (NARR) will be evaluated as a possible screening tool.

The NARR program, part of the National Uranium Resource Evaluation, collected gamma-ray spectra from over 1.1 million line miles of flight path, covering most of the country at 3 or 6 mile spacing between flight lines. The gamma spectra were analyzed for the 1.74 MeV photopeak from ^{214}Bi, a decay product in the uranium-radium decay series.

Ground-truth field validation will be conducted in several areas of the Pacific Northwest where the ^{214}Bi gamma intensities range over a factor of 5 within 35 linear miles along the flight line.

8 Radon Emanation Measurement Techniques

Three commonly used emanation measurement techniques have been compared. The techniques are:

- double count (1.76 MeV peak from ^{214}Bi);
- charcoal adsorption, followed by gross gamma counting;
- radon emanation, followed by trapping in a cold trap, transfer to a Lucas cell, and gross alpha counting.

Final analysis of the results are not completed. The preliminary analysis indicates that while the methods agree to within 15%, there appear to be systematic differences based solely on counting statistics. The double count method gives systematically lower results than the charcoal adsorption-gross gamma count method, which, in turn, yields values that are lower than those obtained with the scintillation flask.

9 Soil Column and Radon Transport

A 218-liter drum has been filled with ~190 liters of soil in order to study the effect of moisture on flux, emanation rate and radon diffusion length. Four sampling probes, evenly-spaced along the vertical axis, extend into the column. In addition to these objectives, the study seeks to validate the charcoal canister flux measurement technique, and to investigate the correspondence between flux measurements in the field, and emanation measurements made in the laboratory.

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