PNC TJ 1645 96—001

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分 置

環境中トロン濃度に関する研究

(動力炉・核燃料開発事業団　委託研究成果報告書)

1996年 2 月

滋賀医科大学放射線基礎医学講座

本資料についての問合わせは下記に願います。
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社内資料
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環境中トロン濃度に関する研究

青山　喬※、米原英典※※、馬　吉増※

要　　旨

積分型ラドン測定器のα線検出素子として用いられてきた硝酸セルロース（CN）フィルムの品質低下がみられ、動燃人形事業所においては、バリオトラック（CR-39）への変更を検討している。CNフィルムではα線のエネルギーを弁別するのに対し、検討中のCR-39ではその機能を有していないため、環境中のトリウム系列のラドン（^{220}Rn：トロン）による測定への影響が予測されるため、その影響について実験研究を実施した。その方法としては、一般木造家屋のトロン濃度が高い土壁付近と、トロン濃度が低い部屋の中央付近にバリオトラックを装填した積分型ラドンモニターを設置し、ラドン・トロンが弁別して測定できる他のパッシブ型モニターとの比較測定を行った。その結果、トロン濃度に大きな差がある2地点のラドン濃度測定値に、有意な差はみられなかった。また、他のモニターの結果とも大きな差はみられなかった。

また、一般環境におけるトロン測定手法、および濃度レベル、さらに高い濃度が観測される環境について文献調査を実施した。以上の結果から、積分型ラドンモニターは、一般環境においては、トロンの影響が無視できることが判明した。

本報告書は、滋賀医科大学放射線基礎医学講座　青山喬が動力炉、核燃料開発事業団の委託により実施した研究の成果である。
契約番号：
事業団担当部課室および担当者：人形峠事業所　安全管理課　中島祐治
※　滋賀医科大学放射線基礎医学講座
※※放射線医学総合研究所環境衛生研究部

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Study on Thoron Concentrations in the Environment

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Jizeng Ma*

Abstract

Because the quality of cellulose nitrate (CN) film used for the electrostatic integrating radon monitor (EIRM) was found to be decreased recently, the introduction of CR-39 detector instead of CN film is examined. However there is a possibility of interference by thoron in the measurement with CR-39. The purpose of this study is to examine the influence of thoron gas in the environment on the measurement with EIRM. EIRMs using CR-39 were set up in a traditional Japanese wooden house. The three monitors were set at position near the surface of mud wall where high thoron concentration was expected and other three monitors were set at the middle of the room where thoron concentration was not so high. From the results, there was not a significant difference between results of the measurement in the two positions. The comparison measurement was also carried out and no significant difference in the results was found. The literature on the study for method of measuring thoron, the level of the concentration, and the environment of high thoron concentration were investigated.

The effect of interference of high thoron concentration on the measurement with EIRM in the normal environment was found to be negligible.

Work performed by Department of Experimental Radiology, Shiga University of Medical Science under contract with Power Reactor and Nuclear Fuel Development Corporation.

PNC Liaison:

* Department of Experimental Radiology, Shiga University of Medical Science

** Division of Environmental Health, National Institute of Radiological Sciences

目　　次

1. はじめに

現在動燃人形事業所で実施しているラドン（^{222}Ｒｎ）測定は、α線検出素子として硝酸セルロース（ＣＮ）フィルムを用いた積分型ラドン測定器を用いている。最近、ＣＮフィルムの仕様変更により品質の低下がみられ、バリオトラック（ＣＲ-39）への変更が検討されている。ＣＮフィルムは飛跡が生成させることの出来るα線の入射エネルギーの幅が狭く、検出するα線を弁別し、ラドン崩壊直後の^{218}Poに感度を持つように設計されている。しかし、ＣＲ-39は飛跡が生成できるα線のエネルギーの幅が広く、^{218}Po以外のα線によっても飛跡を生成する。環境中にはトリウム系列のラドン（^{220}Rn：トロンと呼ばれている）が存在し、ラドン濃度の測定に影響を及ぼす可能性が考えられる。本研究は、この可能性について、トロンが実際に高濃度である環境中での実験で調べるとともに、一般環境におけるトロン測定手法および濃度レベル、さらに高い濃度が観測される環境についての文献調査を行う。

2.実験方法

京都府下の木造家屋の土壁の部屋（２階）において、動燃人形事業所が環境モニタリングで採用している積分ラドンモニターに検出器としてバリオトラック（ＣＲ-39）を装填したものを1995年7月20日から10月14日までと10月14日から1996年1月15日までの2期間設置した。比較測定として放医研で開発されたラドン･トロン弁別モニタ、Radtrak とトロンの検出を避けるため換気率の低い容器（215cm^{3}の容器に直径1mmの穴をあけた密封容器）に測定器を入れたものも同じ場所に設置した。ただしこれらの測定器は感度が低いため、1995年7月20日から1996年1月15日までの1期間とした。これらの測定器は、各々6個ずつ設置したが、そのうち3個は壁から20cmの位置に、残りの3個は壁から140cmの位置に設置した。ラドン弁別モニターは、放射線医学総合研究所安全解析においてエッチング・および計数を行った。Radtrak については、長瀬ランダウアを通じて米国ランダウア社によりエッチングおよび計数を行った。トラック密度からラドン濃度への換算は、Pearson and Spangler [1)]が報告したものを用い、容器に入れないものは、ラドン+トロンに対するトラックが生成されたとして算出した。

3.実験結果

トロン濃度測定結果を表1およびFig. 1に、ラドン濃度測定結果を表2およびFig. 2に示す。表1に示すように壁から20cm位置と140cmに位置におけるトロン濃度は、20cmの方が2倍から3倍程度高い。それに対し、ラドン濃度の両位置において、大きな差は見られない。

表1　トロン測定結果

	測定器	ラドントロン弁別モニタ		ラドトラック	
壁からの距離 cm	測定器番号	トロン濃度 Bq/m^3	3測定器の平均 Bq/m^3	トロン濃度 Bq/m^3	3測定器の平均 Bq/m^3
20	1	32.9	39.4±5.7	119.5	126.7±8.4
	2	43.0		124.6	
	3	42.4		136.0	
140	4	16.5	16.6±0.46	39.1	36.4±3.9
	5	16.2		38.1	
	6	17.1		31.9	

表2　各測定器によるラドン濃度測定結果

	測定器	積分型ラドンモニター			ラドントロン弁別モニタ		ラドトラック	
壁からの距離 cm	測定器番号	測定期間	ラドン濃度 Bq/m^3	3測定器、全期間の平均 Bq/m^3	ラドン濃度 Bq/m^3	3測定器の平均 Bq/m^3	ラドン濃度 Bq/m^3	3測定器の平均 Bq/m^3
20	1	前期	12.3±0.6	12.5±1.2	12.5	12.23 ±0.64	4.67	5.19 ± 0.89
		後期	12.2±0.6					
	2	前期	11.8±0.6		12.7		4.67	
		後期	11.2±0.6					
	3	前期	13.1±0.7		11.5		6.22	
		後期	14.6±0.7					
140	4	前期	13.6±0.7	13.9±0.8	12.8	13.8 ±0.87	5.45	7.51 ± 1.95
		後期	12.4±0.7					
	5	前期	13.5±0.7		14.4		9.33	
		後期	14.8±0.7					
	6	前期	14.6±0.7		14.2		7.77	
		後期	14.5±0.7					

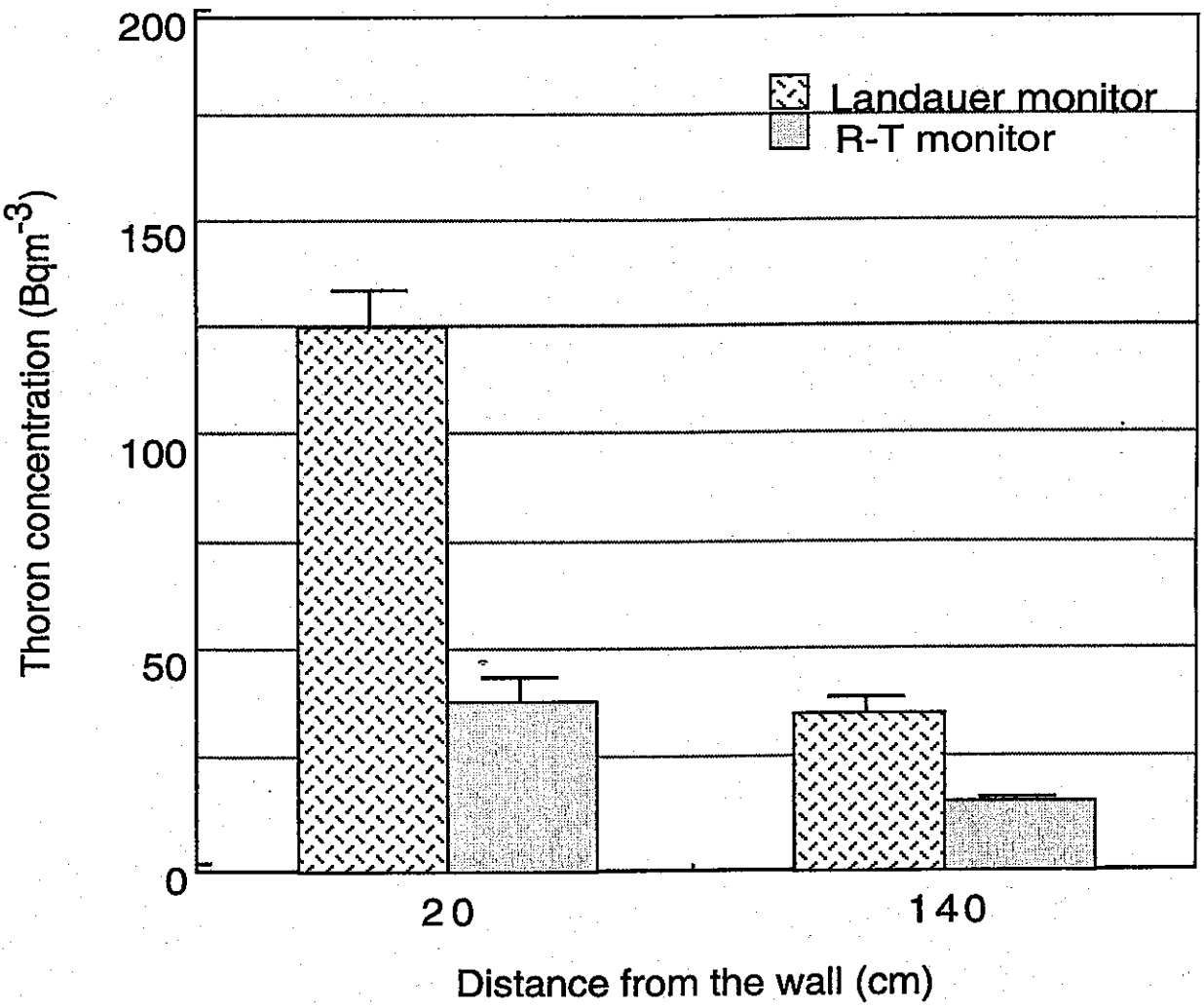

Fig.1 Thoron gas level at the distances of 20 and 140 cm from the wall 10 cm above the floor

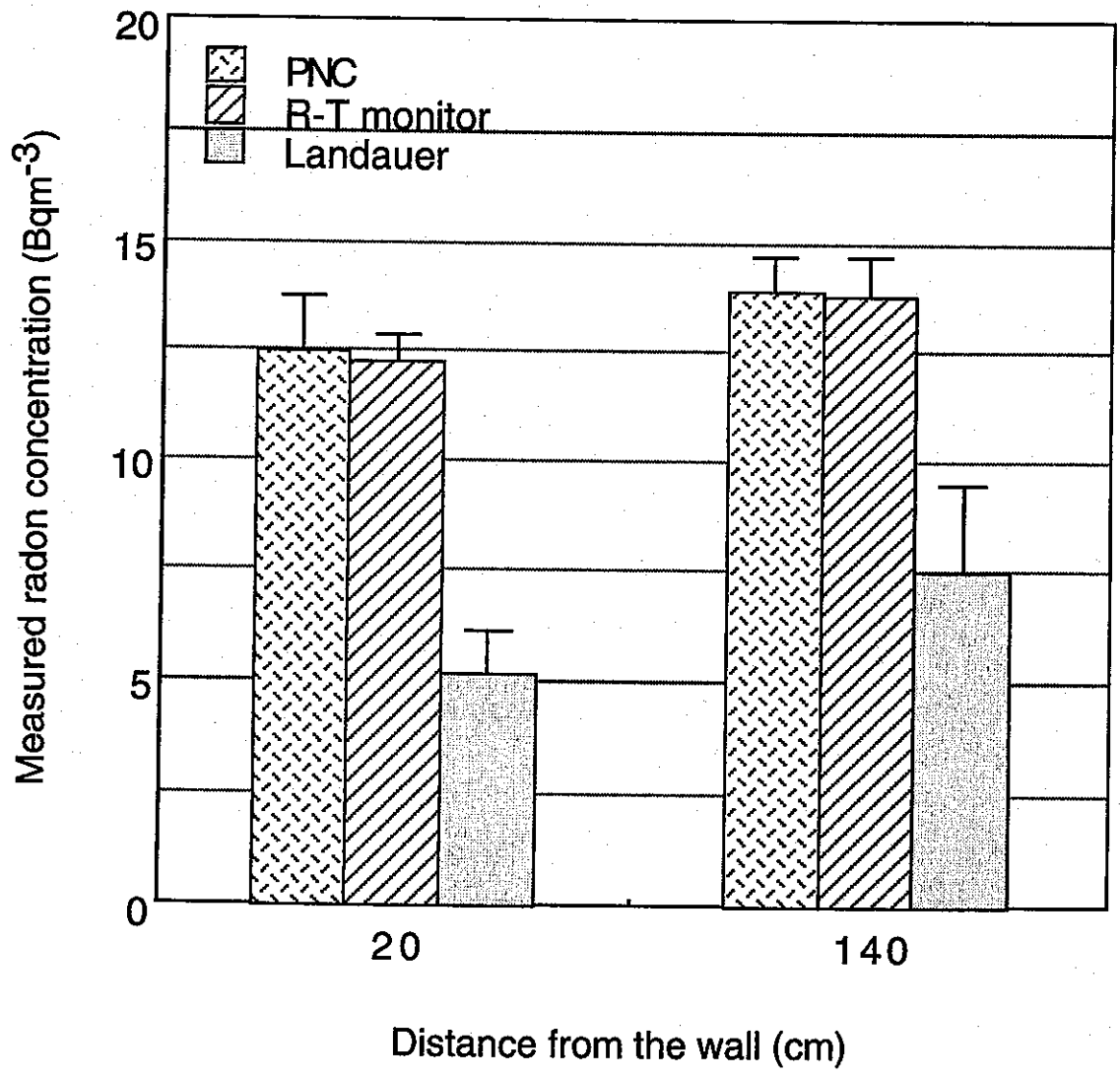

Fig. 2 Comparison of the results of radon by monitor set at 20 and 140 cm from the wall

4.実験結果の考察

表1に示すトロン濃度が、ラドントロン弁別モニターおよびラドトラックの両方の測定値において、壁から20cmの位置での値が、部屋の中央と値に対し、2倍から3倍程度の値であることは一致しているが、トロン濃度の絶対値については、両測定器間に大きな差がある。この差の原因については、測定器の構造や校正の問題等が考えられる。トロンの校正は、トロンガスの空間分布をなくすために、チャンバー内の空気を拡散するが、実際の測定環境では、定常状態に近い状態場合が多いと考えられる。ラドントロン弁別モニターにおいては、測定容器の換気口の外側に風防が取り付けられているため、トロンガスが測定容器内に入りこむ効率が低く、また入り込むまでに崩壊により減衰することが考えられ、定常状態ではこの現象が強調されるため、ラドトラックよりも低い値となる主な原因と考えられる。

積分型ラドンモニターの結果は、トロン濃度の高い壁近傍よりもむしろ部屋の中央での値の方が高い値となっている。したがって、この程度のトロン濃度の条件では、トロンの影響を受けないことが判明した。

5.一般環境におけるトロンに関する文献

5.1文献調査の方法

一般環境におけるトロンに関する文献をおもにMEDLINEを用いて検索し、MEDLINEに収録されていない雑誌の文献を若干加えて、トロン測定手法、濃度レベル、高い濃度が観測される環境、性質・挙動、生体影響に分類した。

略号は以下のとおりである。

TI:論題
AU:著者
AD:連絡先
SO:雑誌名
ISSN:発行番号
PY:発行年
LA:言語
CP:発行国
AB:抄録
MESH:検索語

5.2トロン測定手法に関する文献

TI: Measurements of thoron progeny concentration using a potential alpha-energy monitor in Japan.
AU: Yamasaki-T; Iida-T
AD: Chubu Electric Power Company, Inc., Nagoya, Japan.
SO: Health-Phys. 1995 Jun; 68(6): 840-4
ISSN: 0017-9078

PY: 1995
LA: ENGLISH
CP: UNITED-STATES
AB: It is reported that thoron concentration in Japanese dwellings may be higher than in other dwellings. Therefore, in order to assess the risk for indoor thoron progeny, the portable potential alpha-energy monitor has been developed. The monitor detects alpha-particles from the 212Po collected on the filter using a piece of cellulose nitrate film. The detection efficiency of the alpha-particles has been estimated by Monte Carlo calculation. From the results of measurements, the mean indoor thoron progeny concentration in the dwellings was 1.5 Bq m-3 (ECTn), and ranged from 0.04 to 8.2 Bq m-3. The effects of three typical interior walls (soil-based plaster, concrete, and modern materials) on the thoron progeny supply were considered. The mean annual effective dose equivalent was 0.45 mSv.
MESH: Air-Pollutants,-Radioactive-analysis; Air-Pollution,-Indoor-analysis; Alpha-Particles; Biophysics-; Housing-; Japan-
MESH: *Radiation-Monitoring-instrumentation; *Radon-analysis
TG: Human
PT: JOURNAL-ARTICLE
RN: 0; 10043-92-2
NM: Air-Pollutants,-Radioactive; Radon
AN: 95279121
UD: 9509

TI: A method for determining soil gas 220Rn (thoron) concentrations.
AU: Hutter-AR
AD: Environmental Measurements Laboratory, U.S. Department of Energy, New York, NY 10014-3621, USA.
SO: Health-Phys. 1995 Jun; 68(6): 835-9
ISSN: 0017-9078
PY: 1995
LA: ENGLISH
CP: UNITED-STATES
AB: A technique has been developed to accurately, precisely, and quickly measure soil gas 220Rn using commercially available grab-sample scintillation detectors. The method requires two counting periods for each sample: a 1-min count as soon as the sample has been drawn into a scintillation cell, followed by a 5- or 10-min count at least 5 min after the soil gas sample has been obtained. The 222Rn concentration is determined from the second count. The counts in the first counting period (1-min) due to 222Rn and its progeny are calculated from the known 222Rn concentration and then subtracted from the total

counts obtained in the first counting period. The remaining counts are due to 220Rn and its progeny and are used to calculate the 220Rn concentration. The overall uncertainty when using this method to measure typical soil gas 220Rn and 222Rn concentrations [> approximately 5 kBq m-3 (130 pCi L-1)] was determined to be 19.8% and 10.8% (90% confidence levels), respectively, from analyses of duplicate field measurements. The lowest 220Rn concentrations that can be measured using this technique while maintaining an overall error no greater than about 30% is approximately 500 Bq m-3 (13 pCi L-1), assuming an approximately equal 222Rn concentration. The 220Rn measurement uncertainty at this concentration level decreases to approximately +/- 20% if at least three measurements sampled in series are arithmetically averaged. The uncertainty in the 220Rn measurement at low levels is proportionately affected by the relative concentration of 222Rn present.

MESH: Biophysics-; Evaluation-Studies; Radiometry-methods; Scintillation-Counting-statistics-and-numerical-data.

MESH: *Radon-analysis; *Scintillation-Counting-methods; *Soil-Pollutants,-Radioactive-analysis

TG: Comparative-Study

PT: JOURNAL-ARTICLE

RN: 0; 10043-92-2

NM: Soil-Pollutants,-Radioactive; Radon

AN: 95279120

UD: 9509

TI: Alpha particle spectroscopy in radon/thoron progeny measurements.

AU: Thiessen-NP

AD: U.S. Department of Energy, Grand Junction Projects Office, RUST Geotech Inc., CO 81502.

SO: Health-Phys. 1994 Dec; 67(6): 632-40

ISSN: 0017-9078

PY: 1994

LA: ENGLISH

CP: UNITED-STATES

AB: A comparison is made between the relative variances and counting time requirements for obtaining radon and thoron progeny air concentrations from total alpha count data and from spectroscopically resolved alpha count data collected from air sampling filters. Spectral resolution is shown to have significant advantages, especially in mixed radon/thoron atmospheres. Systematic biases resulting from imperfect energy peak resolution are shown to be subject to accurate mathematical compensation.

MESH: Air-Pollutants,-Radioactive-analysis; Radiation-Monitoring-methods;

Radon-analysis; Time-Factors
MESH: *Alpha-Particles; *Radon-Daughters-analysis; *Spectrum-Analysis-methods
TG: Support,-U.S.-Gov't,-Non-P.H.S.
PT: JOURNAL-ARTICLE
RN: 0; 0; 10043-92-2
NM: Air-Pollutants,-Radioactive; Radon-Daughters; Radon
AN: 95049483
UD: 9502

TI: Discrimination of airborne radioactivity from radon progeny.
AU: Chen-CJ; Weng-PS; Chu-TC; Knutson-EO
AD: Institute of Nuclear Science, National Tsing Hua University, Hsinchu, Taiwan, R.O.C.
SO: Health-Phys. 1994 May; 66(5): 557-64
ISSN: 0017-9078
PY: 1994
LA: ENGLISH
CP: UNITED-STATES
AB: Naturally occurring radon and thoron progeny are the most interfering nuclides in the aerosol monitoring system. The high background and fluctuation of natural radioactivity on the filter can cause an error message to the aerosol monitor. A theoretical model was applied in the simulation of radon and thoron progeny behavior in the environment and on the filter. Results show that even a small amount of airborne nuclides on the filter could be discriminated by using the beta:alpha activity ratio instead of gross beta or alpha counting. This method can increase the sensitivity and reliability of real-time aerosol monitoring.
MESH: *Air-Pollutants,-Radioactive; *Environmental-Monitoring; *Radon-Daughters
PT: JOURNAL-ARTICLE
RN: 0; 0
NM: Air-Pollutants,-Radioactive; Radon-Daughters
AN: 94229991
UD: 9408

TI: Intercomparison of activity size distributions of thoron progeny by alpha- and gamma-counting methods.
AU: Cheng-YS; Yu-CC; Tu-KW
AD: Inhalation Toxicology Research Institute, Albuquerque, NM 87185.
SO: Health-Phys. 1994 Jan; 66(1): 72-9
ISSN: 0017-9078
PY: 1994
LA: ENGLISH

CP: UNITED-STATES
AB: It is difficult to calibrate sampling devices using radon or thoron progeny or particles measuring 1-4 nm; therefore, an interlaboratory comparison is important to verify the performance of graded diffusion batteries for the activity size distributions of the "unattached" progeny. This paper describes the results of an interlaboratory comparison of 220Rn progeny size distributions using graded diffusion batteries by alpha- and gamma-counting methods with different data inversion schemes. Graded diffusion batteries designed at the Inhalation Toxicology Research Institute and at the Environmental Measurement Laboratory were used in the study. Screens and backup filters from the Environmental Measurement Laboratory-graded diffusion batteries were counted simultaneously in alpha counters for total alpha activities, and those of the Inhalation Toxicology Research Institute-graded diffusion batteries were counted in a gamma detector for gamma activities from 212Pb. Because of the different counting methods and data analysis procedures used, this interlaboratory study of 220Rn progeny allows a more rigorous way of testing instrument performance. 212Pb particles generated in well-controlled environments of oxygen, nitrogen, or oxygen with 1 ppm of nitrogen oxide were measured. In general, good agreement in activity size distributions was obtained from these two methods. Some differences observed in individual size spectra were attributable to the data inversion programs used in each laboratory. When the data were analyzed by the same computer program, most differences disappeared.
MESH: Alpha-Particles; Gamma-Rays; Radiometry-instrumentation; Radiometry-methods; Technology,-Radiologic
MESH: *Laboratories-; *Radon-Daughters
TG: Comparative-Study; Support,-U.S.-Gov't,-Non-P.H.S.
PT: JOURNAL-ARTICLE
RN: 0
NM: Radon-Daughters
AN: 94075117
UD: 9403

TI: Thoron activity level and radon measurement by a nuclear track detector.
AU: Planinic-J; Faj-Z; Vukovic-B
AD: Faculty of Education, J.J. Strossmayer University, Osijek, Croatia.
SO: Arh-Hig-Rada-Toksikol. 1993 Mar; 44(1): 21-6
ISSN: 0004-1254
PY: 1993
LA: ENGLISH
CP: CROATIA
AB: Radon activity concentrations in the air were measured with LR-115 nuclear track

detectors at three locations in Osijek. The respective equilibrium factors and the effective dose equivalents were determined. Indoor concentrations were from 9.8 to 58.2 Bq m-3 and relative errors of the track etching method were near 19 per cent. The indoor alpha potential energy of the radon and thoron progenies was measured with an ISD detector. Independent measurements, performed with a Radhome semiconductor detector, showed that the indoor thoron concentration was nearly 20 per cent of the radon one.
MESH: *Air-Pollutants,-Radioactive-analysis; *Radiometry-instrumentation; *Radon-analysis; *Thorium-analysis
TG: Support,-Non-U.S.-Gov't
PT: JOURNAL-ARTICLE
RN: 0; 10043-92-2; 7440-29-1
NM: Air-Pollutants,-Radioactive; Radon; Thorium
AN: 93349271
UD: 9311

TI: Measurement of radon/thoron and its daughter nuclides in room air.
AU: Suppian-R; Vegandraj-S; Kandaiya-S
AD: School of Physics, University of Sains Malaysia, Penang.
SO: Int-J-Rad-Appl-Instrum-A. 1992 Jul; 43(7): 937-8
ISSN: 0883-2889
PY: 1992
LA: ENGLISH
CP: UNITED-STATES
AB: Pumping air through a soft tissue which acts as a membrane is a relatively easy and quick method to collect and measure radon/thoron and its daughter nuclides in air. Analysis of the activity of the radionuclides can be calculated using an alpha counter which has been calibrated. In this method the activity of radon/thoron cannot be separated from the activity of radionuclides already present in the aerosol or dust particles.
MESH: *Air-Pollutants,-Radioactive-analysis; *Air-Pollution,-Indoor-analysis; *Laboratories-; *Radon-analysis
PT: JOURNAL-ARTICLE
RN: 0; 0; 10043-92-2
NM: Air-Pollutants,-Radioactive; Radon-Daughters; Radon
AN: 92332233
UD: 9210

TI: A continuous sampler with background suppression for monitoring alpha-emitting aerosol particles.
AU: McFarland-AR; Rodgers-JC; Ortiz-CA; Moore-ME

AD: Department of Mechanical Engineering, Texas A & M University, College Station 77843.
SO: Health-Phys. 1992 May; 62(5): 400-6
ISSN: 0017-9078
PY: 1992
LA: ENGLISH
CP: UNITED-STATES
AB: A continuous air monitor has been developed that includes provisions for improving the detection of alpha-emitting aerosol particles in the presence of radon/thoron progeny that are unattached to ambient aerosol particles. Wind tunnel tests show that 80% of 10-microns aerodynamic equivalent diameter particles penetrate the flow system from the ambient air to the collection filter when the flow rate is 57 L min-1 (2 cfm) and the wind speed is 1 m s-1. Uniformity of aerosol collection on the filter, as characterized by the coefficient of variation of the areal density deposits, is less than 15% for 10-microns aerodynamic-equivalent-diameter aerosol particles. Tests with unattached radon daughters in a flow-through chamber showed that approximately 99% of the 218Po was removed by an inlet screen that is designed to collect radon daughters that are in the size range of molecular clusters. The inlet screen offers the opportunity to improve the signal-to-noise ratio of energy spectra in the regions of interest (subranges of the energy spectrum) of transuranic elements and thereby enhance the performance of background compensation algorithms.
MESH: Aerosols-
MESH: *Air-Pollutants,-Radioactive-analysis; *Alpha-Particles; *Radiation-Monitoring-instrumentation
TG: Support,-Non-U.S.-Gov't
PT: JOURNAL-ARTICLE
RN: 0; 0
NM: Aerosols; Air-Pollutants,-Radioactive
AN: 92218173
UD: 9207

TI: Calibration of alpha-track monitors for measurement of thoron (220Rn).
AU: Pearson-MD; Spangler-RR
AD: Chem-Nuclear Geotech, Inc., U.S. Department of Energy, Grand Junction, CO 81502-5504.
SO: Health-Phys. 1991 May; 60(5): 697-701
ISSN: 0017-9078
PY: 1991
LA: ENGLISH

CP: UNITED-STATES
MESH: Calibration-
MESH: *Alpha-Particles; *Radiation-Monitoring-instrumentation; *Radon-analysis
TG: Support,-U.S.-Gov't,-Non-P.H.S.
PT: JOURNAL-ARTICLE
RN: 10043-92-2
NM: Radon
AN: 91210067
UD: 9108

TI: Calibration of a decay-product collection and counting apparatus for the determination of exhaled thoron.
AU: Keane-AT; Brewster-DR
SO: Health-Phys. 1983 Sep; 45(3): 801-5
ISSN: 0017-9078
PY: 1983
LA: ENGLISH
CP: UNITED-STATES
MESH: Calibration-; Efficiency-; Mathematics-; Radiometry-instrumentation
MESH: *Radon-analysis
TG: Human
PT: JOURNAL-ARTICLE
RN: 10043-92-2
NM: Radon
AN: 83290195
UD: 8312

TI: An optimized scheme for measurement of the concentrations of the decay products of radon and thoron.
AU: Khan-A; Busigin-A; Phillips-CR
SO: Health-Phys. 1982 Jun; 42(6): 809-26
ISSN: 0017-9078
PY: 1982
LA: ENGLISH
CP: UNITED-STATES
AB: Radon daughter measurement methods have not previously been fully optimized in the presence of thoron daughters, the presence of which leads to an increase in the total potential alpha energy. Taking into account the fluctuations associated with flow rate and concentration as well as the statistics of decay, optimized counting schemes were

determined for the daughters of radon and thoron for different sampling times over a wide range of counting intervals. The counting schemes examined were optimized for maximum precision. Counting schemes corresponding to impractically long counting intervals, and counting times which required measurements beyond an 8 hr working shift were rejected. Under these constraints the most appropriate sampling time was found to be 10 min.
MESH: Air-Pollutants,-Radioactive-analysis; Statistics-
MESH: *Bismuth-analysis; *Lead-analysis; *Polonium-analysis; *Radiation-Monitoring-methods; *Radon-analysis
TG: Comparative-Study; Support,-Non-U.S.-Gov't
PT: JOURNAL-ARTICLE
RN: 0; 0; 10043-92-2; 7439-92-1; 7440-08-6; 7440-69-9
NM: Air-Pollutants,-Radioactive; Radon-Daughters; Radon; Lead; Polonium; Bismuth
AN: 82264848
UD: 8212

TI: An evaluation of unattached radon (and thoron) daughter measurement techniques.
AU: Van-Der-Vooren-AW; Busigin-A; Phillips-CR
SO: Health-Phys. 1982 Jun; 42(6): 801-8
ISSN: 0017-9078
PY: 1982
LA: ENGLISH
CP: UNITED-STATES
AB: The collection efficiencies of parallel plate, inertial impactor and wire screen devices reported in the literature for measurement of the unattached fraction of radon (or thoron) daughters are calculated for collection of the attached fraction of the aerosol, using real uranium mine aerosol activity-size distributions. The attached activity collection efficiencies may be as much as 4.3%, which, given the typically low values of the unattached fraction (a few per cent), results in a very substantial error in the measurement of the latter. Published unattached fraction measurements in the environment may therefore be high and should be interpreted with care.
MESH: Air-Pollutants,-Radioactive-analysis; Statistics-
MESH: *Bismuth-analysis; *Lead-analysis; *Polonium-analysis; *Radiation-Monitoring-methods; *Radon-analysis
TG: Comparative-Study; Support,-Non-U.S.-Gov't
PT: JOURNAL-ARTICLE
RN: 0; 0; 10043-92-2; 7439-92-1; 7440-08-6; 7440-69-9
NM: Air-Pollutants,-Radioactive; Radon-Daughters; Radon; Lead; Polonium; Bismuth
AN: 82264847
UD: 8212

TI: Passive measurement of radon and thoron using TLD or SSNTD on electrets.
AU: Kotrappa-P; Dua-SK; Pimpale-NS; Gupta-PC; Nambi-KS; Bhagwat-AM; Soman-SD
SO: Health-Phys. 1982 Sep; 43(3): 399-404
ISSN: 0017-9078
PY: 1982
LA: ENGLISH
CP: UNITED-STATES
AB: An electret is an electrical analogue of a permanent magnet and it carries a permanent electric charge. Our previous work has shown that such electrets are suitable for collecting decay products of radon and thoron in passive chambers. In the present work, the decay products are directly collected on the surface of a TLD or SSNTD providing in situ registration of the radiation from the decay products of radon and thoron. A 101. chamber, the sides of which were covered with a layer of Whatman No. 1 (W-1) filter paper, showed the following responses: (i) SSNTD (CR-39) recorded 92 +/- 13 tracks per cm2 per pCi/l, hr for radon and 9 +/- 1.5 tracks per cm2 per pCi/l. hr for thoron; (ii) for similar levels TLD (CaF2(Dy)) chips recorded an equivalent of 1.35 +/- 0.16 mR for radon and 0.30 +/ - jk0.09 mR for thoron. Taking advantage of the differential response of the two chambers (one covered with a layer of W-1 filter paper and the other with a 75 mm polyurethene foam), simultaneous measurement of radon and thoron could be achieved.
PY: 1981
LA: ENGLISH
CP: UNITED-STATES
MESH: Radioisotopes-analysis
MESH: *Air-Pollution,-Radioactive-analysis; *Radiometry-instrumentation; *Radon-analysis
PT: JOURNAL-ARTICLE
RN: 0; 10043-92-2
NM: Radioisotopes; Radon
AN: 82007010
UD: 8201

TI: A general formula for the measurement of concentrations of radon and thoron daughters in air.
AU: Yang-FC; Tang-CY
SO: Health-Phys. 1978 May; 34(5): 501-3
ISSN: 0017-9078
PY: 1978
LA: ENGLISH
CP: UNITED-STATES

MESH: Atmosphere-; Half-Life; Models,-Theoretical; Scintillation-Counting
MESH: *Air-Pollutants; *Air-Pollutants,-Radioactive; *Radon-; *Thorium-
PT: JOURNAL-ARTICLETI: [Method for evaluating the concentration of alpha radiation potential energy of thorium Rn-220 in the air]
TO: Metoda oceny stezen energii potencjalnej promienowania alfa produktow rozpadu torunu 220Rn w powietrzu.
AU: Swiatnicki-G; Domanski-T
SO: Med-Pr. 1978; 29(3): 201-13
ISSN: 0465-5893
PY: 1978
LA: POLISH; NON-ENGLISH
CP: POLAND
AB: The paper presents assumptions and a description of an improved method for measuring the potential energy of radon decay products in the air. The method is based on the detection of alpha radiation emitted by ThC', in properly selected time intervals after the process of air filtration, i.e. collecting thoron decay products on the filter has been finished. The method has been worked out for various duration of filtration, i.e. 1--15 min, with measuring time intervals from 10 to 180 min. The method obtained is fit for the measurements of concentrations in a wide range of variation. Radioactivity of the deposit is being calculated on the basis of comparative measurements of 239Pu source of known activity. The sensitivity of the method for the most sensitive range is 0.84 . 10(4) MeV/litre per 1 liter of air filtered.
MESH: English-Abstract; Mathematics-; Methods-; Nuclear-Fission
MESH: *Alpha-Particles; *Radiation,-Ionizing; *Radon-; *Thorium-
PT: JOURNAL-ARTICLE
AN: 79031598
UD: 7902

TI: Modified double filter method for the measurement of radon or thoron in air.
AU: Mayya-YS; Kotrappa-P
SO: Ann-Occup-Hyg. 1978 Aug; 21(2): 169-76
ISSN: 0003-4878
PY: 1978
LA: ENGLISH
CP: ENGLAND
MESH: Filtration-methods; Radioisotopes-analysis
MESH: *Air-analysis; *Radon-analysis

PT: JOURNAL-ARTICLE
AN: 79019814
UD: 7901

TI: Diffusion sampler useful for measuring diffusion coefficients and unattached fraction of radon and thoron decay products.
AU: Kotrappa-P; Bhanti-DP; Dhandayutham-R
SO: Health-Phys. 1975 Jul; 29(1): 155-62
ISSN: 0017-9078
PY: 1975
LA: ENGLISH
CP: UNITED-STATES
MESH: Evaluation-Studies
MESH: *Radiation-Monitoring-instrumentation; *Radon-analysis; *Thorium-analysis
TG: Support,-U.S.-Gov't,-Non-P.H.S.
PT: JOURNAL-ARTICLE
AN: 75210819
UD: 7512

TI: A method for measuring the working-level values of mixed radon and thoron daughters in coalmine air.
AU: Ogden-TL
SO: Ann-Occup-Hyg. 1974 Aug; 17(1): 23-34
ISSN: 0003-4878
PY: 1974
LA: ENGLISH
CP: ENGLAND
MESH: Environmental-Exposure; Radiation-Monitoring-methods
MESH: *Air-Pollution,-Radioactive-analysis; *Coal-Mining; *Occupational-Medicine; *Radiation-Monitoring; *Radon-analysis; *Thorium-analysis
TG: Human
PT: JOURNAL-ARTICLE
AN: 75107579
UD: 7506

TI: The effect of the presence of thoron daughters on the measurement of radon daughter concentrations.
AU: Strong-MC; Duggan-MJ
SO: Health-Phys. 1973 Sep; 25(3): 299-300

ISSN: 0017-9078
PY: 1973
LA: ENGLISH
CP: UNITED-STATES
MESH: Great-Britain; Mining-
MESH: *Air-Pollution,-Radioactive-analysis; *Bismuth-analysis; *Lead-analysis; *Polonium-analysis; *Radioisotopes-analysis
PT: JOURNAL-ARTICLE
AN: 74129739
UD: 7407

TI: Removal of radon and thoron daughter products from glass fibre air sample filters.
AU: Stephenson-J; Stevens-DC; Morton-DS
SO: Ann-Occup-Hyg. 1971 Dec; 14(4): 309-19
ISSN: 0003-4878
PY: 1971
LA: ENGLISH
CP: ENGLAND
MESH: Chlorine-; Filtration-; Methods-; Time-Factors
MESH: *Air-Pollution,-Radioactive; *Radon-; *Thorium-
PT: JOURNAL-ARTICLE
AN: 72208788
UD: 7210

TI: Detection of plutonium on air filters using the alpha-beta ratio of residual thoron daughter activity.
AU: Lindeken-CL; Denham-DH
SO: Health-Phys. 1969 Feb; 16(2): 235-8
ISSN: 0017-9078
PY: 1969
LA: ENGLISH
CP: UNITED-STATES
MESH: Filtration-; Radon-
MESH: *Air-Pollution,-Radioactive; *Plutonium-; *Radiation-Monitoring; *Thorium-
PT: JOURNAL-ARTICLE
AN: 69192809
UD: 6908

TI: A thoron monitor.

AU: Hiller-DM
SO: Health-Phys. 1966 Mar; 12(3): 333-40
ISSN: 0017-9078
PY: 1966
LA: ENGLISH
CP: UNITED-STATES
MESH: Air-Pollution,-Radioactive; Dust-; Tritium-
MESH: *Alpha-Particles; *Radiation-Monitoring; *Radioisotopes-; *Thorium-
PT: JOURNAL-ARTICLE
AN: 67012475
UD: 6702

（ＭＥＤＬＩＮＥ以外の文献）

TI: A twin channel device for the continuous spectrometry of radon daughter
AU: Haider-B
SO:Radiation Protection Dosimetry Vol. 7 No.1-4:211-213

TI: Analysis of radon and thoron daughter concentrations in air by continuous alpha spectroscopy
AU:Peter-JE
SO:Radiation Protection Dosimetry Vol.56 Nos 1-4:267-270

TI: EML thoron gas measurement
AU: Knutson-EO, George-A.C., Shebell-P, Gogolak-CV
SO:Radiation Protection Dosimetry Vol.56 Nos 1-4:263-266

5.3濃度レベルに関する文献

TI: Characterization of Japanese wooden houses with enhanced radon and thoron concentrations.
AU: Doi-M; Kobayashi-S
AD: Safety Analysis Unit, National Institute of Radiological Sciences, Chiba, Japan.
SO: Health-Phys. 1994 Mar; 66(3): 274-82
ISSN: 0017-9078
PY: 1994
LA: ENGLISH
CP: UNITED-STATES
AB: Indoor thoron and radon concentrations were surveyed in the 42 rooms of 21 houses in Hiroshima Prefecture with a radon-thoron discriminative dosimeter in 1992. The survey

estimated the average indoor thoron concentration to be 84.7 +/- 15.6 Bq m-3 and that of radon to be 25.6 +/- 1.1 Bq m-3 at 20 cm from the interior wall. The results indicated the potential risk of indoor thoron in the Japanese style wooden houses. Multivariate regression analysis among some factors which characterize each of the houses examined and concentrations of radon and thoron suggested that enhanced concentration of indoor thoron was often observed in a typical Japanese style room with interior soil wall and tatami flooring. Characterization of the rooms with enhanced levels of thoron showed that mud-based plaster wall material was probably the source.
MESH: Japan-; Wood-
MESH: *Air-Pollution,-Indoor-analysis; *Air-Pollution,-Radioactive-analysis; *Housing-; *Radon-analysis
PT: JOURNAL-ARTICLE
RN: 10043-92-2
NM: Radon
AN: 94148675
UD: 9405

TI: Thoron (220Rn) daughter to radon (222Rn) daughter ratios in thorium-rich areas.
AU: Stranden-E
SO: Health-Phys. 1984 Nov; 47(5): 784-5
ISSN: 0017-9078
PY: 1984
LA: ENGLISH
CP: UNITED-STATES
MESH: Housing-; Mining-; Norway-
MESH: *Air-Pollutants-analysis; *Air-Pollutants,-Radioactive-analysis; *Bismuth-analysis; *Lead-analysis; *Polonium-analysis
PT: JOURNAL-ARTICLE
RN: 0; 0; 0; 7439-92-1; 7440-08-6; 7440-69-9
NM: Air-Pollutants; Air-Pollutants,-Radioactive; Radon-Daughters; Lead; Polonium; Bismuth
AN: 85079263
UD: 8504

TI: Radon and thoron daughters in housing.
AU: Gunning-C; Scott-AG
SO: Health-Phys. 1982 Apr; 42(4): 527-8
ISSN: 0017-9078
PY: 1982

LA: ENGLISH
CP: UNITED-STATES
MESH: Construction-Materials; Ontario-; Soil-Pollutants,-Radioactive
MESH: *Air-Pollution,-Radioactive-analysis; *Bismuth-analysis; *Housing-; *Lead-analysis; *Polonium-analysis
PT: JOURNAL-ARTICLE
RN: 0; 0; 7439-92-1; 7440-08-6; 7440-69-9
NM: Radon-Daughters; Soil-Pollutants,-Radioactive; Lead; Polonium; Bismuth
AN: 82213221
UD: 8210

TI: Activity concentrations of 222Rn, 220Rn, and their decay products in german dwellings, dose calculations and estimate of risk.
AU: Keller-G; Folkerts-KH; Muth-H
SO: Radiat-Environ-Biophys. 1982; 20(4): 263-74
ISSN: 0301-634X
PY: 1982
LA: ENGLISH
CP: GERMANY,-WEST
AB: Measurements of the concentrations of 222Rn, its short-lived decay products and of 212Pb - 212Bi were performed in 150 dwellings and in the open air in the Federal Republic of Germany. The concentrations of 222Rn was measured by electrostatic deposition of 218Po. The concentration of the short-lived decay products were measured by air sampling and alpha-spectroscopy. It was found that inside dwellings the average potential alpha-energy concentration of the short-lived daughters is about three times higher than in the open air. The total potential alpha-energy concentration indoors amounts to 2.6 . 10(-3) Working Level (W.L.). Direct measurements of the equilibrium factor inside dwellings gave a mean value of 0.3. A strong dependence of the potential alpha energy concentration on the ventilation rate in dwellings has been observed. These ventilation effects exceed the effects caused by differences in the activity concentrations due to different building materials. The dose calculation results in an average dose to the whole lung due to the inhalation of short-lived radon daughters of about 0.05-0.2 m/Gy/a. An estimate of risk - based on the risk factors for uranium miners - shows an average lifetime risk of about 6 . 10(-4) for the incidence of lung cancer caused by inhalation of radon and thoron daughters in dwellings in the Federal Republic of Germany.MESH: Germany,-West; Lung-radiation-effects; Mathematics-; Risk-; Ventilation-
MESH: *Housing-; *Radon-analysis
TG: Human; Support,-Non-U.S.-Gov't
PT: JOURNAL-ARTICLE

RN: 10043-92-2
NM: Radon
AN: 83066023
UD: 8303

TI: Radon and thoron working levels from ordinary industrial-hygiene dust samples.
AU: Ogden-TL
SO: Ann-Occup-Hyg. 1977 Jul; 20(1): 49-53
ISSN: 0003-4878
PY: 1977
LA: ENGLISH
CP: ENGLAND
MESH: Coal-analysis; Thorium-analysis
MESH: *Dust-analysis; *Occupational-Medicine; *Radon-analysis
TG: Human
PT: JOURNAL-ARTICLE
AN: 77265060
UD: 7712

(MEDLINE以外の文献)
TI: Thoron daughter concentrations in UK homes
AU:Cliff-KD, Green-BMR, Mawle-A, Miles-JCH
SO:Radiation Protection Dosimetry Vol.45 Nos 1/4:361-366

TI: The study of thoron and radon progeny concentration in dwelling in Japan
AU:Guo-Q, Shimo-M, Ikebe-Y, Minato-S
SO:Radiation Protection Dosimetry Vol.45 Nos 1/4:357-359

5.4高い濃度が観測される環境に関する文献
TI: Measurement of charged and unattached fractions of radon and thoron daughters in two Canadian uranium mines.
AU: Busigin-CJ; Busigin-A; Phillips-CR
SO: Health-Phys. 1983 Feb; 44(2): 165-8
ISSN: 0017-9078
PY: 1983
LA: ENGLISH
CP: UNITED-STATES
MESH: Ontario-

MESH: *Air-Pollution,-Radioactive-analysis; *Bismuth-analysis; *Lead-analysis; *Mining-; *Polonium-analysis; *Uranium-
PT: JOURNAL-ARTICLE
RN: 0; 7439-92-1; 7440-08-6; 7440-61-1; 7440-69-9
NM: Radon-Daughters; Lead; Polonium; Uranium; Bismuth
AN: 83134948
UD: 8306

TI: Mixtures of radon and thoron daughters in underground atmospheres.
AU: Cote-P; Townsend-MG
SO: Health-Phys. 1981 Jan; 40(1): 5-17
ISSN: 0017-9078
PY: 1981
LA: ENGLISH
CP: UNITED-STATES
MESH: Alpha-Particles; Canada-; Spectrum-Analysis
MESH: *Air-Pollution,-Radioactive-analysis; *Mining-; *Radon-analysis; *Thorium-analysis; *Uranium-
TG: Human
PT: JOURNAL-ARTICLE
RN: 10043-92-2; 7440-29-1; 7440-61-1
NM: Radon; Thorium; Uranium
AN: 81167567
UD: 8108

TI: Thoron and radon daughters in different atmospheres.
AU: Stranden-E
SO: Health-Phys. 1980 May; 38(5): 777-85
ISSN: 0017-9078
PY: 1980
LA: ENGLISH
CP: UNITED-STATES
MESH: Bismuth-analysis; Lead-analysis; Polonium-analysis; Radioisotopes-analysis
MESH: *Air-Pollution,-Radioactive-analysis; *Housing-; *Mining-; *Radon-analysis
PT: JOURNAL-ARTICLE
RN: 0; 10043-92-2; 7439-92-1; 7440-08-6; 7440-69-9
NM: Radioisotopes; Radon; Lead; Polonium; Bismuth
AN: 80227319
UD: 8011

5.5トロンの生体影響に関する文献

TI: Thorium lung burdens of mineral sands workers.

AU: Terry-KW; Hewson-GS

AD: Department of Minerals and Energy, East Perth, Western Australia.

SO: Health-Phys. 1995 Aug; 69(2): 233-42

ISSN: 0017-9078

PY: 1995

LA: ENGLISH

CP: UNITED-STATES

AB: Thorium lung burdens have been measured in workers in the dry separation plants operated by the mineral sands industry in Western Australia. The data have been compared with historical employment records of the worker's exposure to thorium-bearing airborne dusts in order to assess the reliability of personal air sampling and with the predictions of the new Task Group lung model. The thoron exhaled in the breath of 62 workers was measured using a double filter tube. Six of the workers also underwent in-vivo gamma counting to determine their thorium lung burden. A thoron exhalation rate of 4.7% was obtained from a comparison of the two data sets. The estimated thorium lung burdens from the thoron-in-breath measurements had a geometric mean value of 10 Bq. The workers had a geometric mean employment period in the industry of 9.2 y and a geometric mean total inhaled alpha activity of 9,000 Bq, estimated from contemporary personal air sampling data and a retrospective assessment of previous workplace conditions. This exposure corresponds to a mean daily intake of 232Th of 0.45 Bq. Predictions from the new Task Group lung model indicate that, for the 45 workers with a thorium lung burden in excess of the minimum detectable level (6 Bq), the daily intake of 232Th is a factor of 1.6 higher than expected. This result suggests that previous intake of radioactive dust was higher than generally assumed for some workers. The application of the new Task Group lung models to the bioassay data results in an estimated mean annual committed effective dose for the workers of 8 mSv. Two workers (3%) were found to have been exposed for many years in excess of the 50 mSv y-1 annual limit for occupational exposure, while eight workers (13%) exceeded the ICRP's proposed new occupational standard of an average of 20 mSv y-1. All eight had been employed for more than 6 y and the majority of their exposure was attributed to early employment years, prior to extensive workplace improvements in dust control.

MESH: Air-Pollutants,-Radioactive-adverse-effects; Air-Pollutants,-Radioactive-analysis; Australia-; Health-Physics; Minerals-; Models,-Biological; Occupational-Exposure; Radiation-Dosage; Respiration-

MESH: *Body-Burden; *Lung-radiation-effects; *Thorium-adverse-effects; *Thorium-analysis

TG: Comparative-Study; Human; Support,-Non-U.S.-Gov't

PT: JOURNAL-ARTICLE

RN: 0; 0; 7440-29-1
NM: Air-Pollutants,-Radioactive; Minerals; Thorium
AN: 95347973
UD: 9511

TI: Hemostatic changes in patients with brain tumors.
AU: Thoron-L; Arbit-E
AD: Department of Surgery, Memorial Sloan-Kettering Cancer Center, New York, New York 10021, USA.
SO: J-Neurooncol. 1994; 22(2): 87-100
ISSN: 0167-594X
PY: 1994
LA: ENGLISH
CP: NETHERLANDS
AB: Abnormal hemostasis is a functional property of cancer. Hemostatic abnormalities are common in patients with systemic malignant disease and brain tumors. However, the incidence of thromboembolism is higher in patients with brain tumors than in those with systemic disease. This raises the question of whether or not hemostatic abnormalities found in the blood of the two groups of patients differs, suggesting different pathogeneses. The purpose of this report is to review abnormalities in blood and clinical manifestations of abnormal hemostasis found in brain tumors and cancer patients in an attempt to answer this question. Normal hemostasis, as currently understood, will be considered with an emphasis on features unique to the central nervous system.
MESH: Blood-Coagulation; Brain-Neoplasms-complications; Disseminated-Intravascular-Coagulation-etiology; Fibrinolysis-; Neoplasms-blood; Neoplasms-complications
MESH: *Brain-Neoplasms-blood; *Hemostasis-
TG: Human
PT: JOURNAL-ARTICLE; REVIEW; REVIEW,-TUTORIAL
AN: 95264201
UD: 9508

TI: Does leukemia result from the presence of radon or thoron in the body? [letter]
AU: Lloyd-RD; Taylor-GN; Miller-SC
SO: Health-Phys. 1993 Oct; 65(4): 439-40
ISSN: 0017-9078
PY: 1993
LA: ENGLISH
CP: UNITED-STATES

MESH: Body-Burden; Dogs-
MESH: *Leukemia,-Radiation-Induced; *Radon-
TG: Animal; Human; Support,-U.S.-Gov't,-Non-P.H.S.
PT: LETTER
RN: 10043-92-2
NM: Radon
AN: 93388258
UD: 9312

TI: Radon: current challenges in cellular radiobiology.
AU: Brenner-DJ
AD: Center for Radiological Research, Columbia University, New York, NY 10032.
SO: Int-J-Radiat-Biol. 1992 Jan; 61(1): 3-13
ISSN: 0955-3002
PY: 1992
LA: ENGLISH
CP: ENGLAND
AB: Radon is by far the most important contributor to the collective dose equivalent. Most of what is known about the hazards of radon daughters comes from epidemiological studies of miners. There are a few well defined areas in which in vitro research can complement such studies: First, more data on the relative effects of differing energy (LET) alpha-particles would help: (1) understand the significance of the depth of sensitive cells in the bronchial epithelium--which varies between individuals, as well as between smokers and non-smokers, and between miners and non-miners; (2) understand the relative hazards of radon and thoron daughters. Second, reliable methods for predicting high LET responses from low LET response, would enable Japanese A-bomb survivor data to be applied with confidence. Third, understanding the effects of single-particle traversals of cells relative to multiple traversals could allow reliable extrapolation of epidemiological miner data to low exposures. Fourth, a better understanding of the nature of the interaction between tobacco and radiation damage would help predict the effect of radon on non-smokers.
MESH: Alpha-Particles; Bismuth-; Cell-Transformation,-Neoplastic; Lead-; Mining-; Occupational-Exposure; Polonium-; Smoking-
MESH: *Cells-radiation-effects; *Environmental-Exposure; *Radon-
TG: Animal; Human; In-Vitro; Support,-U.S.-Gov't,-P.H.S.
PT: JOURNAL-ARTICLE; REVIEW; REVIEW,-TUTORIAL
CN: CA12536CANCI; CA49062CANCI
RN: 0; 10043-92-2; 7439-92-1; 7440-08-6; 7440-69-9
NM: Radon-Daughters; Radon; Lead; Polonium; Bismuth
AN: 92105875

UD: 9204

TI: Radon and thoron associated dose to the basal layer of the skin.
AU: Eatough-JP; Henshaw-DL
AD: H H Wills Physics Laboratory, University of Bristol, UK.
SO: Phys-Med-Biol. 1992 Apr; 37(4): 955-67
ISSN: 0031-9155
PY: 1992
LA: ENGLISH
CP: ENGLAND
AB: The radon related alpha-particle annual dose equivalent to the basal layer of the epidermis has been calculated theoretically and is estimated as 2.5 (range 1.7 to 17) mSv y-1, for the exposed, uncovered skin of the face and neck, at the UK average domestic radon exposure of 20 Bq m-3. The thoron-related annual dose equivalent is estimated as 0.3 (range 0 to 1.9) mSv y-1 at the equilibrium equivalent concentration of 0.3 Bq m-3 estimated for UK exposures. Considerably lower dose equivalents are received by regions of the skin which are habitually covered in clothing. The wide range in the dose estimates reflects the wide range in quoted plateout rates for radon and thoron daughters, and uncertainties in the magnitude of the electrostatic charge of the individual. To improve the dose estimates experimental measurements are needed of radon and thoron daughter deposition on the skin surface in situations corresponding to domestic exposure.
MESH: Bismuth-; Great-Britain; Lead-; Polonium-; Radiation-Dosage
MESH: *Air-Pollution,-Indoor; *Air-Pollution,-Radioactive; *Radon-; *Skin-radiation-effects
TG: Human; Support,-Non-U.S.-Gov't
PT: JOURNAL-ARTICLE
RN: 0; 10043-92-2; 7439-92-1; 7440-08-6; 7440-69-9
NM: Radon-Daughters; Radon; Lead; Polonium; Bismuth
AN: 92270661
UD: 9208

TI: Dose to red bone marrow from natural radon and thoron exposure.
AU: Richardson-RB; Eatough-JP; Henshaw-DL
AD: H. H. Wills Physics Laboratory, University of Bristol, UK.
SO: Br-J-Radiol. 1991 Jul; 64(763): 608-24
ISSN: 0007-1285
PY: 1991
LA: ENGLISH
CP: ENGLAND

AB: The age-dependent radiation dose to the haematopoietic tissue of bone marrow has been calculated for exposure to radon, thoron and their daughter products. The component of dose due to pure radon is dependent on the fat content of the marrow, since the solubility of radon in fat is about 16 times that in tissue. The mean dose equivalent muSv to the total active marrow is estimated for a range of fat cell diameters from 25 to 200 microns, taking account of the percentage cellularity and distribution of active marrow as a function of age. Similarly, the dose due to the inhalation of short-lived radon daughters was estimated, based on measurements in blood and marrow, modified to allow for the greater deposition of daughter products expected in children. An estimate of the age-dependent dose from long-lived radon daughters was made from uranium miner and natural exposure data. Dose estimates were made for the average UK indoor exposure to radon gas of 20 Bq/m3 and an equilibrium equivalent thoron concentration of 0.3 Bq/m3. The annual radon and thoron derived dose to the active marrow of the newborn was calculated as 30 and 40 muSv, respectively. For a 10-year-old child, the radon and thoron derived annual dose are 70 and 40 muSv, and for a 40-year-old adult 90 and 30 muSv, respectively. The above values exhibit wide range limits due principally to uncertainties in the accumulation of 210Pb in bone, and 210Po in marrow. These data indicate that at the average UK exposure, the alpha-particle dose to active marrow is dominated by that derived from inhaled radon and thoron compared with dietary intake. In infants the dose is dominated by thoron daughters. At the UK radon Action Limit of 200 Bq/m3, the radon and associated thoron derived dose is similar to that from all low LET sources. This work shows that the dose to red bone marrow from radon and thoron is significant, and that the possibility of leukaemia induced by these radiation sources warrants further investigation.

MESH: Adipose-Tissue-radiation-effects; Adolescence-; Adult-; Aged-; Air-Pollutants,-Radioactive-analysis; Bismuth-; Child-; Child,-Preschool; Environmental-Exposure; Half-Life; Hematopoietic-Stem-Cells-radiation-effects; Infant-; Infant,-Newborn; Lead-; Mathematics-; Middle-Age; Models,-Biological; Polonium-; Radiation-Dosage; Radioactivity-

MESH: Bone Marrow Radiation effects; Radon

TG: Female; Human; Male; Support,-Non-U.S.-Gov't

PT: JOURNAL-ARTICLE

RN: 0; 0; 10043-92-2; 7439-92-1; 7440-08-6; 7440-69-9

NM: Air-Pollutants,-Radioactive; Radon-Daughters; Radon; Lead; Polonium; Bismuth

AN: 91338939

UD: 9111

SB: AIM

TI: [Occupational pathology of the respiratory organs in miners of highly mechanized ore mines using diesel vehicles]

TO: Professional'naia patologiia organov dykhaniia u gornorabochikh vysokokmekhanizirovannykh rudnykh shakht, ispol'zuiushchikh dizel'noe oborudovanie.
AU: Milishnikova-VV; Loshchilov-IuA; Chebotarev-AG
SO: Gig-Tr-Prof-Zabol. 1990(6): 15-9
ISSN: 0016-9919
PY: 1990
LA: RUSSIAN; NON-ENGLISH
CP: USSR
AB: A medical survey of 2000 miners was performed at industrial sites using high-mechanized self-propelled diesel vehicles in the Far North, South and East regions of the country. All the miners were exhibited to quartz containing polymetal ore dusts and diesel exhausts. 128 miners were medically examined to specify the morphological changes in the bronchi and respiratory sections in case of occupational pathology, as well as to establish specific clinical manifestations. In 81 cases, fibro-bronchoscopy was performed and bronchial mucous and transbronchial pulmonary biopsy. Due to the increased concentrations of benzopyrene and other soot absorbed polycyclic hydrocarbons, thoron and radon, the authors tentatively proposed them as risk-factors for occupational malignant bronchopulmonary diseases development.
MESH: Adult-; Air-Pollutants,-Occupational-adverse-effects; Bronchitis-chemically-induced; Bronchitis-diagnosis; Dust-adverse-effects; English-Abstract; Metals-adverse-effects; Middle-Age; Occupational-Diseases-chemically-induced; Occupational-Diseases-diagnosis; Pneumoconiosis-diagnosis
MESH: *Bronchitis-etiology; *Mining-; *Occupational-Diseases-etiology; *Pneumoconiosis-etiology
TG: Human; Male
PT: JOURNAL-ARTICLE
RN: 0; 0
NM: Air-Pollutants,-Occupational; Metals
AN: 90368012
UD: 9012

TI: Cancer incidence among workers exposed to radon and thoron daughters at a niobium mine.
AU: Solli-HM; Andersen-A; Stranden-E; Langard-S
SO: Scand-J-Work-Environ-Health. 1985 Feb; 11(1): 7-13
ISSN: 0355-3140
PY: 1985
LA: ENGLISH
CP: FINLAND

AB: The aim of this study was to investigate the incidence of cancer among 318 male employees of a niobium mining company which was only operated between 1951 and 1965. Many of the workers, especially underground miners, were exposed to the daughters of radon and thoron and also to thorium. The accumulated doses to the workers from short-lived radon and thoron daughters in the mine atmosphere were assessed to be relatively low; up to 300 working-level months. During the follow-up period 1953-1981, 24 new cases of cancer were observed compared to an expected number of 22.8. Twelve cases of lung cancer had occurred versus 3.0 expected. Among the 77 miners, 9 cases of lung cancer were observed against 0.8 expected. Associations between the occurrence of lung cancer and exposure to alpha radiation and smoking were found. For the radon and thoron daughter exposure, about 50 excess cases per million person-years at risk per working-level month were observed.
MESH: Adult-; Aged-; Lung-Neoplasms-mortality; Middle-Age; Neoplasms,-Radiation-Induced-mortality; Norway-; Occupational-Diseases-mortality; Risk-; Smoking-
MESH: *Lung-Neoplasms-chemically-induced; *Mining-; *Neoplasms,-Radiation-Induced-etiology; *Niobium-poisoning; *Occupational-Diseases-chemically-induced; *Radon-poisoning; *Thorium-poisoning
TG: Human; Male; Support,-Non-U.S.-Gov't
PT: JOURNAL-ARTICLE
RN: 10043-92-2; 7440-03-1; 7440-29-1
NM: Radon; Niobium; Thorium
AN: 85192456
UD: 8508

TI: Lung cancer incidence in a Chinese high background area--epidemiological results and theoretical interpretation.
AU: Hofmann-W; Katz-R; Zhang-CX
SO: Sci-Total-Environ. 1985 Oct; 45: 527-34
ISSN: 0048-9697
PY: 1985
LA: ENGLISH
CP: NETHERLANDS
AB: A survey of inhabitant exposures arising from the inhalation of radon and thoron daughters, and lung cancer mortality has been carried out in two adjacent areas in Guangdong province, China, designated as the "high background" and the "control" area. Annual exposure rates are 0.38 WLM/yr in the high background, and 0.16 WLM/yr in the control area, while age-adjusted mortality rates are 2.7 per 10(5) living people of all ages in the high background, and 2.9 per 10(5) in the control area. From this data we conclude

that we are unable to determine the excess lung cancer rate over normal fluctuations below a cumulative exposure of about 15 WLM. This conclusion is supported by lung cancer mortality data from an Austrian high background area.
MESH: China-; Lung-Neoplasms-etiology; Radon-toxicity; Respiration-; Risk-
MESH: *Lung-Neoplasms-epidemiology; *Neoplasms,-Radiation-Induced-epidemiology
TG: Human; Support,-U.S.-Gov't,-Non-P.H.S.
PT: JOURNAL-ARTICLE
RN: 10043-92-2
NM: Radon
AN: 86096706
UD: 8604

TI: Radiation exposure in German dwellings, some results and a proposed formula for dose limitation.
AU: Keller-G; Muth-H
SO: Sci-Total-Environ. 1985 Oct; 45: 299-306
ISSN: 0048-9697
PY: 1985
LA: ENGLISH
CP: NETHERLANDS
AB: The results of our investigations in the Federal Republic of Germany on the indoor and outdoor exposure to natural radiation from gamma rays and radon and thoron daughters are presented. Indoor the median Rn-222 concentration was approximately four times higher than outdoors. A correlation analysis of the data obtained showed that indoors the equilibrium factor F is almost independent of ventilation, Rn-222 concentration and other parameters. The mean equilibrium factor was measured to be F = 0.3 in dwellings and approximately F = 0.4 outdoors. The results of our investigations on diffusion coefficients and exhalation rates showed, that the activity concentration in dwellings and in cellars can generally be explained by the radon exhalation from the building materials. Only in areas of high radon concentrations, the exhalation from the soil was a decisive factor. The mean effective dose equivalent by residence in dwellings amounted to 0.2 - 0.8 mSv/a for Rn-222 daughters and approximately 0.1 mSv/a for Rn-220 daughters. A relationship has been derived which permits the calculation of the expected average radiation exposure in dwellings by gamma radiation and by radon inhalation as function of the radionuclide concentration in building materials.
MESH: Construction-Materials; Germany,-West; Microclimate-; Radiation-Dosage; Radon-analysis
MESH: *Environmental-Exposure; *Housing-; *Radiation-Monitoring
TG: Comparative-Study; Human; Support,-Non-U.S.-Gov't

PT: JOURNAL-ARTICLE
RN: 10043-92-2
NM: Radon
AN: 86096677
UD: 8604

TI: Ambient monitoring of airborne radioactivity near a former thorium processing plant.
AU: Jensen-L; Regan-G; Goranson-S; Bolka-B
SO: Health-Phys. 1984 May; 46(5): 1021-33
ISSN: 0017-9078
PY: 1984
LA: ENGLISH
CP: UNITED-STATES
AB: Twenty-four hour sampling for airborne radioactivity near a former thorium and rare-earth extraction facility was conducted for approx. 2 months with high-volume and dichotomous air samplers. Thoron (220Rn) daughters were identified in the air and confirmed to be originating from the waste storage site. High-volume samplers near the facility measured average 212Pb concentrations of 177, 43, and 237 pCi/m3 with corresponding ranges of (1.9-1351), (1.5-301) and (0.73-2201)pCi/m3. Simultaneous measurements with dichotomous samplers at the same sites measured average 212Pb concentrations on coarse particulates (2.5-15 microns dia.) of 14, 4 and 10 pCi/m3 and on fine particulates (less than 2.5 microns dia.) of 94, 9 and 214 pCi/m3, respectively. Corresponding ranges were (0.2-109), (0.1-63) and (0.1-94) pCi/m3 for coarse particulates and (0.7-1094), (0.4-101) and (0.5-2685) pCi/m3 for fine particulates. Uranium, thorium and radium radionuclides were not identified as being present in significant concentrations in the particulate samples.
MESH: Bismuth-analysis; Lead-analysis; Polonium-analysis; Radioactive-Waste
MESH: *Air-Pollutants-analysis; *Air-Pollutants,-Radioactive-analysis; *Radiation-Monitoring; *Thorium-
PT: JOURNAL-ARTICLE
RN: 0; 0; 0; 0; 7439-92-1; 7440-08-6; 7440-29-1; 7440-69-9
NM: Air-Pollutants; Air-Pollutants,-Radioactive; Radioactive-Waste; Radon-Daughters; Lead; Polonium; Thorium; Bismuth
AN: 84211627
UD: 8409

TI: Measurement techniques for radium and the actinides in man at the Center for Human Radiobiology.
AU: Toohey-RE; Keane-AT; Rundo-J

SO: Health-Phys. 1983; 44 Suppl 1: 323-41
ISSN: 0017-9078
PY: 1983
LA: ENGLISH
CP: UNITED-STATES
AB: Various techniques are employed to determine the amounts, retention, and distribution of radioactivity in human subjects in vivo. The principal method is gamma-ray spectrometry with large NaI(Tl) scintillation crystals ("whole-body counting"). The geometries used include an arc of 1.5-m radius in which all parts of the body are roughly equidistant from the detector, a reclining chair and a flat bed with detectors placed above and below the subject. When a sufficient amount of radioactivity is present in a subject, scanning techniques assist in determining its distribution in the body. Specialized instruments such as a xenon-filled proportional counter and a dual-crystal (phoswich) detector are used to measure low-energy photon emitters, primarily plutonium and americium. americium. There are three primary methods of calibrating the detectors. The first is analytical, in which a rigorous mathematical treatment is employed; the second involves the administration of tracer amounts of radioactivity to human volunteers; the third consists of determining detector response to known amounts of radioactivity in a phantom. All three methods can be intercompared, and further evaluated by comparing the results of measurements in vivo with those of postmortem analyses. For both radium and thorium cases measured in vivo, the interpretation of the results is complicated by the fact that neither radium nor thorium emit gamma rays of any consequence. Instead, the observed gamma rays result from the decay of 214Bi (RaC) and 208Tl (ThC"), respectively. Since each of these nuclides is preceded in the decay chain by an isotope of the noble gas radon, some of which is exhaled, its activity is not equal to that of the parent radium or thorium. Therefore, breath samples are collected to determine the exhalation rate of the precursor isotope, 222Rn (radon) or 220Rn (thoron). The total body content is then the sum of the gamma activity and the exhaled radioactivity, referred to as the retained and emanating fractions, respectively.
MESH: Americium-analysis; Bone-and-Bones-analysis; Breath-Tests; Calibration-; Gamma-Rays; Illinois-; Mathematics-; Plutonium-analysis; Radiometry-instrumentation; Radiometry-methods; Radon-analysis; Thorium-analysis; Whole-Body-Counting-methods
MESH: *Metals,-Actinoid-analysis; *Radium-analysis
TG: Comparative-Study; Human; Support,-U.S.-Gov't,-Non-P.H.S.
PT: JOURNAL-ARTICLE
RN: 0; 10043-92-2; 7440-07-5; 7440-14-4; 7440-29-1; 7440-35-9
NM: Metals,-Actinoid; Radon; Plutonium; Radium; Thorium; Americium
AN: 83237609
UD: 8310

TI: Mortality among male workers at a thorium-processing plant.
AU: Polednak-AP; Stehney-AF; Lucas-HF
SO: Health-Phys. 1983; 44 Suppl 1: 239-51
ISSN: 0017-9078
PY: 1983
LA: ENGLISH
CP: UNITED-STATES
AB: The long-term health effects of exposure to thorium are of interest because of the possible increased use of thorium as an energy source in reactors using 232Th to produce 233U. Mortality is described in a cohort of 3039 men who were employed between 1940 and 1973 at a company involved in the production of thorium and rare earth chemicals from monazite sand. Based on deaths ascertained by the Social Security Administration and mortality rates for U.S. white males, the standardized mortality ratio (SMR) for all causes was 1.05 with 95% confidence limits (95% CL) of 0.96 and 1.15. Much of the excess mortality was attributable to non-occupational motor vehicle accidents (SMR = 1.64; 95% CL = 1.16 and 2.23), but SMRs were also high for lung cancer (1.44; 95% CL = 0.98 and 2.02), pancreatic cancer (2.01; 95% CL = 0.92 and 3.82), and diseases of the respiratory system (1.31; 95% CL = 0.92 and 1.83). In a subgroup of 592 men who worked for at least one year in selected jobs (indicative of highest exposure to thorium and thoron) that was followed up more intensively, the SMR for pancreatic cancer was significantly elevated (i.e. 4.13; 95% confidence limits = 1.34 and 9.63). The SMR for lung cancer was 1.68 (95% CL = 0.81 and 3.09), while that for respiratory diseases was 1.20 (95% CL = 0.52 and 2.37). Information on smoking habits in a sample of survivors suggested that smoking could have explained at least part of the excess mortality from lung and pancreatic cancer and from diseases of the respiratory system. Continued follow-up of the cohort through morbidity and mortality studies is needed to evaluate further the possible long-term effects of exposure to radioactivity and chemicals in the thorium extraction process.
MESH: Adult-; Aged-; Follow-Up-Studies; Illinois-; Lung-Neoplasms-mortality; Middle-Age; Neoplasms,-Radiation-Induced-mortality; Occupational-Diseases-etiology; Pancreatic-Neoplasms-mortality; Radon-adverse-effects; Respiratory-Tract-Diseases-mortality; Smoking-
MESH: *Occupational-Diseases-mortality; *Thorium-adverse-effects
TG: Comparative-Study; Human; Male; Support,-U.S.-Gov't,-Non-P.H.S.
PT: JOURNAL-ARTICLE
RN: 10043-92-2; 7440-29-1
NM: Radon; Thorium
AN: 83237598
UD: 8310

TI: Measurement of lymphoblastogenic activity from thorium workers.
AU: Serio-CS; Henning-CB; Toohey-RE; Lloyd-EL
SO: Int-J-Radiat-Biol-Relat-Stud-Phys-Chem-Med. 1983 Sep; 44(3): 251-6
ISSN: 0020-7616
PY: 1983
LA: ENGLISH
CP: ENGLAND
AB: Mitogenic stimulation of peripheral blood lymphocyte cultures obtained from 36 thorium workers was studied to determine whether the response of these cells was affected by the individuals' occupational exposure to alpha irradiation. The standard assay involved incubating 2 X 10(5) lymphocytes per test well for 72 hours in the presence of phytohemagglutinin (PHA), concanavalin A (Con A) or pokeweed mitogen (PWM). The results showed that there was a significant decrease in lymphocyte responsiveness of former thorium workers grouped by decade of life when compared with controls of the same decade of life for each mitogen tested with the exceptions of PHA in the 41-50 age group and PWM in the 51-60 age group. We are unable to correlate the decreased response observed with the measured body burdens, external gamma exposure, or thoron exhalation rates in these thorium cases. However, other occupational exposures (i.e., various chemicals used in processing thorium) cannot be eliminated as a possible cause.
MESH: Adult-; Aged-; Alpha-Particles; Middle-Age; United-States
MESH: *Lymphocyte-Transformation-radiation-effects; *Metallurgy-; *Occupational-Medicine; *Thorium-adverse-effects
TG: Human; Male
PT: JOURNAL-ARTICLE
RN: 7440-29-1
NM: Thorium
AN: 84007315
UD: 8401

TI: alpha-Radiation dose at bronchial bifurcations of smokers from indoor exposure to radon progeny.
AU: Martell-EA
SO: Proc-Natl-Acad-Sci-U-S-A. 1983 Mar; 80(5): 1285-9
ISSN: 0027-8424
PY: 1983
LA: ENGLISH
CP: UNITED-STATES
AB: Synergistic interactions of indoor radon progeny with the cigarette smoking process

have been evaluated experimentally. Smoking enhances the air concentration of submicron particles and attached radon decay products. Fractionation in burning cigarettes gives rise to the association of radon progeny with large particles in mainstream cigarette smoke, which are selectively deposited in "hot spots" at bronchial bifurcations. Because smoke tars are resistant to dissolution in lung fluid, attached radon progeny undergo substantial radioactive decay at bifurcations before clearance. Radon progeny inhaled during normal breathing between cigarettes make an even larger contribution to the alpha-radiation dose at bifurcations. Progressive chemical and radiation damage to the epithelium at bifurcations gives rise to prolonged retention of insoluble 210Pb-enriched smoke particles produced by tobacco trichome combustion. The high incidence of lung cancer in cigarette smokers is attributed to the cumulative alpha-radiation dose at bifurcations from indoor radon and thoron progeny--218Po, 214Po, 212Po, and 212Bi--plus that from 210Po in 210Pb-enriched smoke particles. It is estimated that a carcinogenic alpha-radiation dose of 80-100 rads (1 rad = 0.01 J/kg = 0.01 Gy) is delivered to approximately equal to 10(7) cells (approximately equal to 10(6) cells at individual bifurcations) of most smokers who die of lung cancer.

MESH: Aerosols-; Alpha-Particles; Bronchi-radiation-effects; Lung-metabolism; Radon-metabolism; Tissue-Distribution

MESH: *Cocarcinogenesis-; *Lung-Neoplasms-etiology; *Radon-adverse-effects; *Tobacco-Use-Disorder-complications

TG: Human; Support,-Non-U.S.-Gov't; Support,-U.S.-Gov't,-Non-P.H.S.

PT: JOURNAL-ARTICLE

RN: 0; 10043-92-2

NM: Aerosols; Radon

AN: 83144064

UD: 8306

TI: Long term health effects of thorium compounds on exposed workers: the complete blood count.

AU: Conibear-SA

SO: Health-Phys. 1983; 44 Suppl 1: 231-7

ISSN: 0017-9078

PY: 1983

LA: ENGLISH

CP: UNITED-STATES

AB: Two hundred seventy-three men exposed to thorium and other rare earths between 1940 and 1973 at a plant which refined monazite sand were studied at Argonne National Laboratory from 1976 to 1980. In vivo measurements of body burden were made by counting gamma rays emitted by daughter products of retained thorium and by measuring

exhaled thoron. Health status was ascertained through questionnaire, physical examination, and clinical laboratory tests. Measured body burden was found to be higher in those with a history of longer exposure. All parameters of the complete blood count were examined for evidence of an effect due to thorium. Comparisons of high and low body burden groups showed that only age and cigarette smoking had an effect on complete blood count parameters.
MESH: Adult-; Aged-; Blood-Cell-Count; Body-Burden; Middle-Age; Occupational-Diseases-etiology; Regression-Analysis; Time-Factors
MESH: *Blood-Cells-radiation-effects; *Occupational-Diseases-blood; *Thorium-adverse-effects
TG: Comparative-Study; Human; Male; Support,-U.S.-Gov't,-Non-P.H.S.
PT: JOURNAL-ARTICLE
RN: 7440-29-1
NM: Thorium
AN: 83237597
UD: 8310

TI: [Study of thoron-220 exhalation during the intravenous administration of 224Ra]
TO: Issledovanie eksgaliatsii torona-220 pri vnutrivennom vvedenii 224Ra.
AU: Petushkov-AA; Zel'tser-MR; Martakov-VP; Makeeva-LG; Kurnaeva-VP
SO: Med-Radiol-Mosk. 1977 Apr; 22(4): 62-6
ISSN: 0025-8334
PY: 1977
LA: RUSSIAN; NON-ENGLISH
CP: USSR
MESH: Kinetics-; Mathematics-; Radium-metabolism; Rats-; Time-Factors
MESH: *Radium-administration-and-dosage; *Thorium-metabolism
TG: Animal; Human
PT: JOURNAL-ARTICLE
AN: 77211775
UD: 7710

TI: Assessment of airborne hazards in the thorium processing industry.
AU: Kotrappa-P; Bhanti-DP; Menon-VB; Dhandayutham-R; Gohel-CO; Nambiar-PP
SO: Am-Ind-Hyg-Assoc-J. 1976 Nov; 37(11): 613-6
ISSN: 0002-8894
PY: 1976
LA: ENGLISH
CP: UNITED-STATES

AB: Airborne thorium thoron and its decay products contribute significantly to the hazards in the thorium industry. These have been assessed and compared with the standards. Assessment also included the unattached fractions of the decay products, the thoron working levels and the aerodynamic particle size distribution of airborne thorium.
MESH: India-; Particle-Size
MESH: *Air-Pollutants-analysis; *Air-Pollutants,-Occupational-analysis; *Thorium-
PT: JOURNAL-ARTICLE
AN: 77062954
UD: 7703

TI: [The thoron content (Tn220) of the air expired by rats after intratracheal administration of thoron compounds]
TO: Soderzhanie torona (RN220) v vozdukhe, vydykhaemom drysami, posle intratrakheal'nogo vvedeniia soedinenii toriia
AU: Pavlovskaia-NA; Zel'tser-MR; Medvedovskii-AP
SO: Gig-Sanit. 1975 Oct(10): 45-8
ISSN: 0016-9900
PY: 1975
LA: RUSSIAN; NON-ENGLISH
CP: USSR
MESH: English-Abstract; Rats-; Thorium-metabolism; Trachea-
MESH: *Radon-metabolism; *Respiration-
TG: Animal
PT: JOURNAL-ARTICLE
AN: 76140944
UD: 7607

TI: [Maximum permissible concentrations of radon, thoron, actinon and their daughter products in water and in air]
TO: O predel'no dopustimykh kontsentratsiiakh radona, torona, aktinona i ikh dochernikh produktov v vode i v vozdukhe.
AU: Gusarov-II; Andreev-SV
SO: Gig-Sanit. 1973 Feb; 38(2): 55-8
ISSN: 0016-9900
PY: 1973
LA: RUSSIAN; NON-ENGLISH
CP: USSR
MESH: English-Abstract; Health-Physics; Maximum-Permissible-Exposure-Level
MESH: *Actinium-standards; *Air-Pollution,-Radioactive; *Radon-standards;

*Water-Pollution,-Radioactive
PT: JOURNAL-ARTICLE
AN: 74105516
UD: 7406

TI: Experimental absorption applied to lung dose from thoron daughters.
AU: Harley-NH; Pasternack-BS
SO: Health-Phys. 1973 Apr; 24(4): 379-86
ISSN: 0017-9078
PY: 1973
LA: ENGLISH
CP: UNITED-STATES
MESH: Alpha-Particles; Environmental-Exposure; Radiation-Dosage
MESH: *Air-Pollution,-Radioactive; *Bismuth-; *Lung-; *Polonium-; *Radioisotopes-
TG: Human
PT: JOURNAL-ARTICLE
AN: 73160302
UD: 7308

TI: Some aspects of the hazard from airborne thoron and its daughter products.
AU: Duggan-MJ
SO: Health-Phys. 1973 Mar; 24(3): 301-10
ISSN: 0017-9078
PY: 1973
LA: ENGLISH
CP: UNITED-STATES
MESH: Alpha-Particles; Bismuth-; Half-Life; Lead-; Lung-injuries; Mathematics-; Polonium-; Radiation-Dosage; Radiation-Injuries; Ventilation-
MESH: *Air-Pollution,-Radioactive-analysis; *Radon-; *Thorium-
TG: Human
PT: JOURNAL-ARTICLE
AN: 73140464
UD: 7307

TI: The measurement of thoron in the breath of dogs administered inhaled or injected ThO_2.
AU: Ballou-JE; Hursh-JB
SO: Health-Phys. 1972 Feb; 22(2): 155-9
ISSN: 0017-9078

PY: 1972
LA: ENGLISH
CP: UNITED-STATES
MESH: Body-Burden; Dogs-; Half-Life; Injections,-Intra-Arterial; Injections,-Intramuscular; Injections,-Intravenous; Lung-pathology; Metabolic-Clearance-Rate; Methods-; Radon-analysis; Respiration-; Thorium-Dioxide-administration-and-dosage; Thorium-Dioxide-analysis; Time-Factors
MESH: *Lung-metabolism; *Thorium-Dioxide-metabolism
TG: Animal; Female
PT: JOURNAL-ARTICLE
AN: 72144398
UD: 7207
TI: [Uptake and distribution of thoron-decay products following inhalation by the rat]
TO: Aufnahme und Verteilung von Thoronzerfallsprodukten nach Inhalation durch die Ratte.
AU: Hofmann-HP
SO: Strahlentherapie. 1970 Dec; 140(6): 721-30
ISSN: 0039-2073
PY: 1970
LA: GERMAN; NON-ENGLISH
CP: GERMANY,-WEST
MESH: Aerosols-; Bronchi-metabolism; English-Abstract; Intestine,-Small-metabolism; Kidney-metabolism; Lead-analysis; Lead-blood; Lead-metabolism; Liver-metabolism; Lung-analysis; Radioisotopes-; Radiometry-; Rats-; Respiration-; Thorium-metabolism; Trachea-metabolism
MESH: *Gastrointestinal-System-metabolism; *Lung-metabolism; *Radon-metabolism
TG: Animal
PT: JOURNAL-ARTICLE
AN: 71075826
UD: 7104

TI: [The effect of thoron inhalation on the mitotic activity in the kidneys]
TO: Vliianie ingalatsii torona na mitoticheskuiu aktivnost' v pochkakh.
AU: Tadzhikov-MM; Sharipov-FKh
SO: Biull-Eksp-Biol-Med. 1970 Jan; 69(1): 83-5
ISSN: 0006-4041
PY: 1970
LA: RUSSIAN; NON-ENGLISH
CP: USSR

MESH: English-Abstract; Rats-
MESH: *Kidney-radiation-effects; *Mitosis-radiation-effects; *Thorium-
TG: Animal; Male
PT: JOURNAL-ARTICLE
AN: 70239979
UD: 7010

TI: On the yearly course of radon and thoron inductions and the long lasting radioactivity of aerosols in Plovdiv.
AU: Genkov-D; Stefanova-M
SO: Folia-Med-Plovdiv. 1969; 11(3): 214-21
ISSN: 0204-8043
PY: 1969
LA: ENGLISH
CP: BULGARIA
MESH: Bulgaria-; Seasons-; Weather-
MESH: *Radioactivity-; *Radon-; *Thorium-
PT: JOURNAL-ARTICLE
AN: 70232493
UD: 7010

TI: Measurement of thoron in the breath of thorotrast subjects.
AU: Tai-Pow-J
SO: Gruzlica. 1969 Apr; 37(4): 269-75
ISSN: 0017-4955
PY: 1969
LA: ENGLISH
CP: POLAND
MESH: Angiography-; Methods-; Myelography-; Radiation-Monitoring-instrumentation; Radiometry-
MESH: *Radiation-Monitoring; *Radon-metabolism; *Respiration-; *Thorium-Dioxide-metabolism
TG: Human
PT: JOURNAL-ARTICLE
AN: 69243602
UD: 6910

TI: [Animal experimental studies on the problem of irradiation stress due to the thoron content in air]

TO: Tiexexperimentelle untersuchungen zum Problem der Strahlenbelastung durch den Thorongehalt der Luft.
AU: Plattner-H
SO: Strahlentherapie. 1968 Dec; 136(6): 750-7
ISSN: 0039-2073
PY: 1968
LA: GERMAN; NON-ENGLISH
CP: GERMANY,-WEST
MESH: Adipose-Tissue-analysis; Bone-Marrow-Examination; Brain-Chemistry; Guinea-Pigs; Intestinal-Absorption; Kidney-analysis; Liver-analysis; Mice-; Muscles-analysis; Rabbits-; Respiratory-System-analysis; Respiratory-Therapy; Stress-; Testis-analysis; Thorium-analysis; Thorium-blood; Thorium-metabolism
MESH: *Radiotherapy-Dosage; *Thorium-therapeutic-use
TG: Animal; Male
PT: JOURNAL-ARTICLE
AN: 69113892
UD: 6905

TI: [Irradiation stress during inhalation of radon, thoron and products of their catabolism]
TO: Die Stahlenbelastung bei der Inhalation von Radon, Thoron und deren Zerfallsprodukten.
AU: Pohl-E; Pohl-Ruling-J
SO: Strahlentherapie. 1968 Dec; 136(6): 738-49
ISSN: 0039-2073
PY: 1968
LA: GERMAN; NON-ENGLISH
CP: GERMANY,-WEST
MESH: Aerosols-; Balneology-; Radiotherapy-Dosage; Radon-analysis; Radon-metabolism; Respiratory-System-analysis; Respiratory-Therapy; Thorium-analysis; Thorium-blood; Thorium-metabolism
MESH: *Radiotherapy-; *Radon-therapeutic-use; *Thorium-therapeutic-use
TG: Human
PT: JOURNAL-ARTICLE
AN: 69113891
UD: 6905

TI: [Method of assessing the extent of radiation hazards with simultaneous presence of the daaughter products of radon and thoron in the air]
TO: K metodike otsenki radiatsionnoi opasnosti pri odnovremennom prisutstvii v vozdukhe

dochernikh produktov radona i torona.
AU: Gusarov-II
SO: Gig-Sanit. 1967 Apr; 32(4): 68-71
ISSN: 0016-9900
PY: 1967
LA: RUSSIAN; NON-ENGLISH
CP: USSR
MESH: Filtration-; Methods-
MESH: *Air-Pollution,-Radioactive-prevention-and-control; *Radioactive-Waste; *Radon-analysis; *Thorium-analysis
PT: JOURNAL-ARTICLE
AN: 68053715
UD: 68

TI: [On the maximum permissable concentration of thoron (Rn-220) and its daughter products in the air of industrial premises]
TO: O predel'no dopustimykh kontsentratsiiakh torona (Rn220) i ego dochernikh produktov v vozdukhe rabochikh pomeshchenii.
AU: Gusariv-UU; Shchepot'eva-ES; Andreev-SV
SO: Gig-Sanit. 1966 Apr; 31(4): 44-9
ISSN: 0016-9900
PY: 1966
LA: RUSSIAN; NON-ENGLISH
CP: USSR
MESH: Environmental-Exposure
MESH: *Air-Pollution,-Radioactive-analysis; *Occupational-Medicine; *Radon-
PT: JOURNAL-ARTICLE
AN: 68242177
UD: 6808

5.6トロンの性質・挙動に関する文献
TI: Vertical distribution of outdoor radon and thoron in Japan using a new discriminative dosimeter.
AU: Doi-M; Kobayashi-S
AD: Safety Analysis Unit, National Institute of Radiological Sciences, Chiba, Japan.
SO: Health-Phys. 1994 Oct; 67(4): 385-92
ISSN: 0017-9078
PY: 1994
LA: ENGLISH

CP: UNITED-STATES
AB: Passive measurements of outdoor radon and thoron concentrations were conducted from June 1992 to June 1993 at a monitoring station over a soil area (10 m x 6 m) in Chiba city, Japan. The measurement period was divided into 4 parts to investigate seasonal variations of radon and thoron concentrations. Ten passive radon-thoron discriminative dosimeters (R-T dosimeters) were placed in duplicate at 5 different altitudes to show the vertical distributions of outdoor radon and thoron concentrations. Outdoor radon concentrations showed no significant difference within 1.0 m above the ground, and the annual average of outdoor radon concentration was 3.85 +/- 0.19 (SE) Bq m-3. Annual averages of outdoor thoron concentrations at 0.04, 0.15, 0.25, 0.70, and 1.0 m above the ground were 40.5 +/- 4.4, 22.5 +/- 3.7, 13.9 +/- 3.1, 9.5 +/- 2.9 (SE) Bq m-3, and < 9.0 Bq m-3; the lower detection limit of the dosimeter, respectively, and their vertical profiles, n(z) (Bq m-3), were expressed well by the formula n(z) = alpha z beta. Vertical profiles of the atmospheric turbulent diffusion coefficient were also estimated from the observed thoron profiles, as expressed by the power function K(z) = AzB, of which B values were estimated to vary from 1.034 to 1.609 if averaged thoron exhalation rates during the measurement periods were within 0.3 to 2.8 (Bq m-2 s-1).
MESH: Altitude-; Diffusion-; Environmental-Exposure; Japan-
MESH: *Radiation-Monitoring; *Radon-analysis
PT: JOURNAL-ARTICLE
RN: 10043-92-2
NM: Radon
AN: 94364805
UD: 9412

TI: Deposition and clearance of 212Pb in humans.
AU: Pillai-PM; Paul-AC; Bhat-IS; Iyer-MR; Pillai-KC
AD: Health Physics Division, Bhabha Atomic Research Centre, Bombay, India.
SO: Health-Phys. 1994 Mar; 66(3): 343-5
ISSN: 0017-9078
PY: 1994
LA: ENGLISH
CP: UNITED-STATES
AB: Radiation exposure due to the inhalation of 212Pb has been identified as one of the major hazards encountered in the chemical processing of monazite. Volunteers were exposed to 212Pb in the thorium hydroxide storage facility. Personal air samplers were used to determine the concentration of 212Pb in air. The 212Pb in the chest was measured using a whole body counter and the decay in the chest was followed up for 24 h. From the decay, mean effective half-life for the inhaled 212Pb was estimated as 6.63 +/- 0.23 h. A

comparison of the chest burden with the assumed intake indicates that 55-76% of the inhaled 212Pb is deposited in the respiratory system. From the chest monitoring data, it is possible to estimate the working level exposure due to thoron progeny.
MESH: Administration,-Inhalation; Adult-; India-; Lead-Radioisotopes-administration-and-dosage; Metabolic-Clearance-Rate
MESH: *Lead-Radioisotopes-metabolism; *Metals,-Rare-Earth; *Occupational-Exposure
TG: Human
PT: JOURNAL-ARTICLE
RN: 0; 0; 1306-41-8
NM: Lead-Radioisotopes; Metals,-Rare-Earth; Monazite
AN: 94148684
UD: 9405

TI: Spatial distribution of thoron and radon concentrations in the indoor air of a traditional Japanese wooden house.
AU: Doi-M; Fujimoto-K; Kobayashi-S; Yonehara-H
AD: Safety Analysis Unit, National Institute of Radiological Sciences, Chiba, Japan.
SO: Health-Phys. 1994 Jan; 66(1): 43-9
ISSN: 0017-9078
PY: 1994
LA: ENGLISH
CP: UNITED-STATES
AB: A radon-thoron discriminative passive dosimeter has been developed that can estimate both radon (222Rn) and thoron (220Rn) concentrations at the same time. Two polycarbonate films are installed as solid-state nuclear track detectors in the dosimeter housing. One film registers alpha tracks originating from predominantly thoron and its progeny together with a small contribution from radon, and the other film registers alpha tracks originating from radon and its progeny together with a negligible contribution from thoron. The lower detection limit is estimated to be 2.9 Bq m-3 for the radon concentration and 9.0 Bq m-3 for the thoron concentration for 2 mo exposure. Preliminary measurements from 1991-1992, in a traditional Japanese wooden house located in Kyoto, indicated that the indoor thoron concentration increases exponentially as the interior mud (or plaster-coated) wall is approached. A soil-based plaster commonly used in Japanese wooden houses to fill walls (or as a surface coating on the walls) is the probable source of the indoor thoron. Since thoron is not measured by the usual radon measurements, and the majority of Japanese houses are made of wood, attention should be paid to indoor thoron and its decay products, which may give a significant fraction of the total natural radiation exposure to the general public.
MESH: Data-Collection; Japan-; Wood-

MESH: *Air-Pollutants,-Radioactive-analysis; *Air-Pollution,-Indoor-analysis; *Housing-; *Radon-analysis
TG: Human
PT: JOURNAL-ARTICLE
RN: 0; 10043-92-2
NM: Air-Pollutants,-Radioactive; Radon
AN: 94075113
UD: 9403

TI: Soil as a source of indoor 220Rn.
AU: Li-Y; Schery-SD; Turk-B
AD: Physics Department, New Mexico Institute of Mining and Technology, Socorro 87801.
SO: Health-Phys. 1992 May; 62(5): 453-7
ISSN: 0017-9078
PY: 1992
LA: ENGLISH
CP: UNITED-STATES
AB: Two suggestions for sources of indoor 220Rn (thoron) have appeared in the literature: 1) building materials and outside air, and 2) soil beneath the house. Due to the difficulty of 220Rn measurement and limited data, both suggestions lack sufficient supporting evidence. We have investigated sources of indoor 220Rn in seven occupied houses in northern New Mexico, U.S. A two-filter system was used to measure indoor 220Rn levels continuously, and 220Rn progeny were measured with single filters and specialized alpha-track detectors. The amount of 220Rn entry from soil was curtailed by cutting off soil gas flow to the indoor air with subfloor depressurization mitigation systems. Four of the houses showed significant reductions in 220Rn with mitigation systems on. The average effect for these houses was to reduce indoor 220Rn levels by 70%. The other three houses had no clear reductions but in one of these houses, the mitigation system was not effective for stopping soil gas flow. Our results provide some of the most clear evidence to date supporting soil as an important source of indoor 220Rn.
MESH: New-Mexico
MESH: *Air-Pollution,-Indoor; *Housing-; *Radon-; *Soil-Pollutants,-Radioactive
TG: Support,-U.S.-Gov't,-Non-P.H.S.
PT: JOURNAL-ARTICLE
RN: 0; 10043-92-2
NM: Soil-Pollutants,-Radioactive; Radon
AN: 92218183
UD: 9207

TI: Evaluation of Th series disequilibrium in Western Australian monazite.
AU: Kerrigan-GC; O'Connor-BH
AD: Department of Applied Physics, Curtin University of Technology, Perth, Western Australia.
SO: Health-Phys. 1990 Feb; 58(2): 157-63
ISSN: 0017-9078
PY: 1990
LA: ENGLISH
CP: UNITED-STATES
AB: Estimation of inhaled radiation doses associated with mineral sands processing is commonly performed by gross alpha-counting dust collected on air filters. The technique requires knowledge of the extent of disequilibrium in Th-bearing minerals. The daughters which can be expected to give rise to disequilibrium, viz. 228Ra and 220Rn (also designated thoron in the paper), were investigated in a typical Western Australia monazite. The thoron flux from a dry, "infinitely thick" layer of monazite was found to be 41 Bq m-2 s-1. The depth of monazite from which thoron is exhaled is limited to 40-50 mm, and within the first 10 mm is a linear function of bed thickness. The relative loss within the linear region is approximately 0.02% of the equilibrium concentration and progressively less for layers beyond 10 mm. The sample investigated gave no indication of disequilibrium involving 228Ra. The results indicate that secular equilibrium may be assumed when calculating 232Th daughter concentrations in monazite from the gross alpha activity. More extensive work on monazite samples from a number of sites will be necessary before this can be stated as a general conclusion applicable to all Western Australian monazite deposits.
MESH: Dust-analysis; Half-Life; Health-Physics; Lead-Radioisotopes-analysis; Metals,-Rare-Earth-analysis; Radiation-Monitoring-instrumentation; Radon-analysis; Western-Australia
MESH: *Minerals-analysis; *Thorium-analysis
TG: Support,-Non-U.S.-Gov't
PT: JOURNAL-ARTICLE
RN: 0; 0; 0; 10043-92-2; 1306-41-8; 7440-29-1
NM: Lead-Radioisotopes; Metals,-Rare-Earth; Minerals; Radon; Monazite; Thorium
AN: 90129775
UD: 9005

TI: Reduction of airborne radioactive dust by means of a charged water spray.
AU: Bigu-J; Grenier-MG
AD: Elliot Lake Laboratory, CANMET, (ON), Canada.
SO: Am-Ind-Hyg-Assoc-J. 1989 Jul; 50(7): 336-45

ISSN: 0002-8894
PY: 1989
LA: ENGLISH
CP: UNITED-STATES
AB: An electrostatic precipitator based on charged water spray technology has been used in an underground uranium mine to control long-lived radioactive dust and short-lived aerosol concentration in a mine gallery where dust from a rock breaking/ore transportation operation was discharged. Two main sampling stations were established: one upstream of the dust precipitator and one downstream. In addition, dust samplers were placed at different locations between the dust discharge and the end of the mine gallery. Long-lived radioactive dust was measured using cascade impactors and nylon cyclone dust samplers, and measurement of the radioactivity on the samples was carried out by conventional methods. Radon and thoron progeny were estimated using standard techniques. Experiments were conducted under a variety of airflow conditions. A maximum radioactive dust reduction of about 40% (approximately 20% caused by gravitational settling) at a ventilation rate of 0.61 m3/sec was obtained as a result of the combined action of water scrubbing and electrostatic precipitation by the charged water spray electrostatic precipitator. This represents the optimum efficiency attained within the range of ventilation rates investigated. The dust reduction efficiency of the charged water spray decreased with increasing ventilation rate, i.e., decreasing air residence time, and hence, reduced dust cloud/charged water droplets mixing time.
MESH: Air-Pollutants,-Occupational; Time-Factors
MESH: *Air-Pollution,-Radioactive-prevention-and-control; *Dust-prevention-and-control; *Mining-; *Uranium-; *Water-
PT: JOURNAL-ARTICLE
RN: 0; 7440-61-1; 7732-18-5
NM: Air-Pollutants,-Occupational; Uranium; Water
AN: 89333446
UD: 8911

TI: On the effect of a negative ion generator and a mixing fan on the attachment of thoron-decay products in a thoron box.
AU: Bigu-J; Grenier-M
SO: Health-Phys. 1984 Apr; 46(4): 933-9
ISSN: 0017-9078
PY: 1984
LA: ENGLISH
CP: UNITED-STATES
MESH: *Air-Ionization; *Air-Movements; *Air-Pollutants-analysis;

*Air-Pollutants,-Radioactive-analysis; *Bismuth-analysis; *Lead-analysis; *Polonium-analysis; *Radiation-Monitoring-instrumentation
PT: JOURNAL-ARTICLE
RN: 0; 0; 0; 7439-92-1; 7440-08-6; 7440-69-9
NM: Air-Pollutants; Air-Pollutants,-Radioactive; Radon-Daughters; Lead; Polonium; Bismuth
AN: 84161202
UD: 8407

TI: The influence of exhalation, ventilation and deposition processes upon the concentration of radon (222Rn), thoron (220Rn) and their decay products in room air.
AU: Porstendorfer-J; Wicke-A; Schraub-A
SO: Health-Phys. 1978 May; 34(5): 465-73
ISSN: 0017-9078
PY: 1978
LA: ENGLISH
CP: UNITED-STATES
MESH: Construction-Materials; Environmental-Exposure; Lung-radiation-effects; Models,-Theoretical; Respiration-radiation-effects; Ventilation-
MESH: *Air-Pollution,-Radioactive; *Radon-
TG: Human
PT: JOURNAL-ARTICLE
AN: 79047686
UD: 7903

TI: Electrostatic charge on decay products of thoron.
AU: Dua-SK; Kotrappa-P; Bhanti-DP
SO: Am-Ind-Hyg-Assoc-J. 1978 Apr; 39(4): 339-45
ISSN: 0002-8894
PY: 1978
LA: ENGLISH
CP: UNITED-STATES
MESH: Aerosols-; Electricity-; Radioactivity-
MESH: *Radon-
PT: JOURNAL-ARTICLE
AN: 78163184
UD: 7808

TI: Diffusion coefficients for unattached decay products of thoron--dependence on

ventilation and relative humidity.
AU: Kotrappa-P; Bhanti-DP; Raghunath-B
SO: Health-Phys. 1976 Oct; 31(4): 378-80
ISSN: 0017-9078
PY: 1976
LA: ENGLISH
CP: UNITED-STATES
MESH: Diffusion-; Humidity-; Occupational-Medicine; Ventilation-
MESH: *Air-Pollution,-Radioactive-prevention-and-control; *Radon-
PT: JOURNAL-ARTICLE
AN: 77050981
UD: 7703

TI: Seasonal variations in the concentration of airborne radon and thoron daughters. UCRL-50007-66-1.
AU: Lindeken-CL
SO: US-AEC-Univ-Calif-Radiat-Lab-Livermore. 1966 Apr-Aug; 41-3
PY: 1966
LA: ENGLISH
CP: UNITED-STATES
MESH: California-; Radiometry-
MESH: *Air-analysis; *Radon-analysis; *Seasons-; *Thorium-analysis
PT: JOURNAL-ARTICLE
AN: 68245240
UD: 6808

(MEDLINE以外の文献)
TI: Thoron gas concentration and aerosol characteristic of thoron decay products
AU:Reineking-A, Butterweck-G, Porstendörfer
SO:Radiation Protection Dosimetry Vol.45 Nos 1/4:353-356

TI: Characterisation of Indoor Atoosphers
AU:Stoute-JRD, Groen-GCH, de Groot-TJH
SO:Radiation Protection Dosimetry Vol.7 No1-4:150-163

6.屋内トロン濃度について
6.1屋内トロンの基本的特性
トロンの半減期は55秒で非常に短いことから、ラドンのように床下の土壌から室内に侵入することは少なく、屋内トロンの線源は壁等の室内の建材表面に限定される。壁から

の散逸のみを考えた場合のトロンの室内での空間分布は次式で表せる。

$$C(d) = \frac{E}{\sqrt{\lambda_T D}} e^{-\beta \cdot d} \qquad (1)$$

ただし、$\beta = \sqrt{\lambda_T / D}$

C（d）：壁からの距離dにおけるトロン濃度
E：トロンの壁表面からの散逸率
λ_T：トロンの崩壊定数（44.9 h^{-1}）
D：実効（見かけの）拡散係数

上式において見かけの拡散係数Dは、全く空気の動きが無い場合は、分子拡散係数に近い値である0.05 $cm^2\ s^{-1}$程度であり、空気の動きの激しい場合は、10 $cm^2\ s^{-1}$以上に変化すると考えられる。Dを0.05、1、10 $cm^2\ s^{-1}$とした場合のトロン濃度の壁からの距離に対する変化を（1）式で計算した結果をFig. 3 に示す。

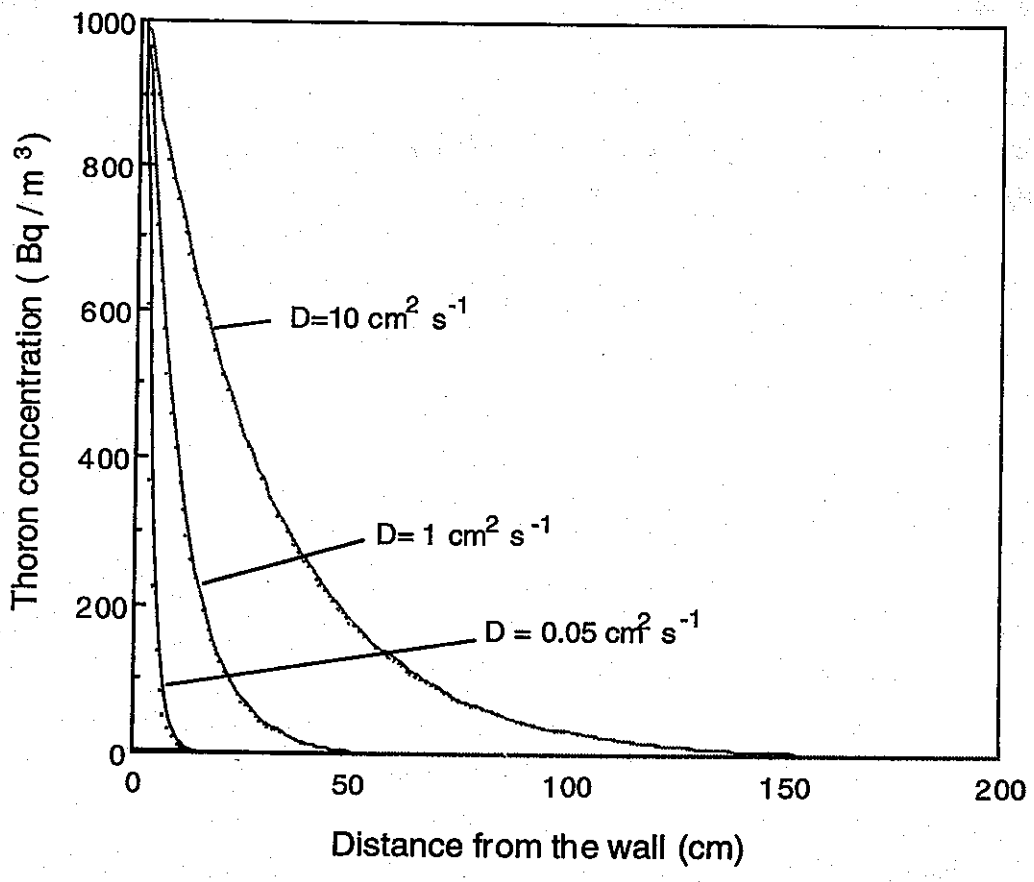

表3 Spatial distributions of thoron concentration derived from a calculation.

この図でわかるようにトロン濃度は壁からの距離とともに指数関数的に減少し、部屋の中央では、検出が困難になるくらいの濃度になることが多い。このように空間分布の変動幅が大きく、壁からどの距離で測定するかが重要であることが明らかである。また、見かけの拡散係数の変化によっても空間分布が大きく変化することもわかる。このように壁際でのトロンガス濃度は非常に高く、有意な被曝の可能性があることが、片瀬ら[2)]によって指摘された。

6.2屋内トロンの測定

屋内トロンの測定には、パッシブ法のカップ法やアクティブ法である二段フィルター法が用いられる場合が多い。カップ法において、検出器として固体飛跡検出器を用いた場合は、二種類のカップを用い、換気回数や検出器のエッチング条件を変えてラドンとトロンを弁別する方法が採られる。またカップ法で表面障壁型半導体検出器を組み込みアルファ線のスペクトルでラドンとトロンを弁別する方法も用いられている。カップ式パッシブ法は、測定容器の換気率がトロンガスの校正定数に大きく影響を及ぼすが、換気率自体、測定空間の空気の動きに依存するので問題がある。測定器の校正においても、校正用のチャンバー内で一定濃度の場を作るためには、空気を撹拌する必要があり、これにより測定容器の換気率や測定容器内でのトロンガスの分布などが変化し、検出感度が通常環境における値とは違った値となる可能性がある。またアクティブ法での測定では、その濃度分布を崩すので、ある測定点での濃度を正確に測定することは困難である。このように屋内トロンの測定には、種々の残された問題があり、違った測定器で測定した結果を単純に比較するときには、注意が必要である。

表3で、これまでに行われた屋内トロン濃度のサーベイ研究の結果を発表順にリストアップした。屋内のトロンの濃度測定の研究は、非常に少なく、1985年Scheryによるもの[3)]が、これまで代表的なものであった。その後日本でも、特に木造家屋の土壁付近で、トロン濃度が非常に高く、一部のパッシブ型ラドンモニターに影響があると報告された[4) 5) 6)]。また、名大や放医研等では、数十軒の家屋でのトロン濃度が測定された[7) 8)]。現在、科学技術庁のラドン濃度全国調査において、ラドン・トロン弁別モニターを用いて、ラドン濃度とともに参考データとしてトロン濃度が測定され、その平均値は、約30 Bq/m^{3}である。この値は、UNSCEAR1993年報告書[9)]における世界の平均値である3 Bq/m^{3}の10倍の値である。このように日本の測定結果は非常に高濃度であるが、日本での研究では、測定器の位置が壁から20cmの位置に設置される場合が多く、 人が呼吸をする部屋の中央付近での値では、これらの平均値よりかなり低いと考えられる。日本の調査研究において壁に近いところで測定されている理由は、測定誤差を少なくするためにある程度トロン濃度が高いところで測定し、その結果から拡散係数を用いて計算で空間分布を推定し、さらに被曝評価に重要な娘核種の濃度も計算しようという試みがあるからである。

表3　トロン測定調査研究の結果

Country, Number of sample, Method	Thoron Concentration (Bq/m^3) A. Mean±SD, (Range)	Tn/Rn	Reference
U.S., 25 houses, Two filter	(0 - 30)	0.23±0.37	Schery, Health Phys. 1985
W.Germany, (Electroprecipitation with SSB) Under ground 5 Car garage 1 Lecture room 1	(3.9 -19.1) 7.6 0.7		Reineking, Radiat. Prot. Dosim., 1992
Japan、Passive (Cup) (at 20cm from wall) Wooden Ferro-concreate Prefabricated	 160 42 23		Okamoto et al. Hoken Butsuri 1994
Japan、Hiroshima, Cup 21houses (at 20cm from wall)	84.7±15.6	3.3	Doi & Kobayashi, Health Phys., 1994
Japan、(cup) 280 houses (14 prefectures)	29.6±47.5 (0 - 425) 13.5 (G. Mean)		National Survey by the Science and Technology Agency
World Average	3 (2 - 20)		UNSCEAR 1993 ICRP Publ.50 (1986)

6.3屋内トロン娘核種の測定

娘核種の測定は、ほとんどの場合、フィルタ捕集によるアクティブ法が用いられる。この方法は確立されたもので測定法による系統誤差の問題はない。ただ、ラドンの娘核種と同時に測定するため、トロン娘核種の濃度が低い場合は、統計誤差の問題がある。また、簡便なパッシブ法がまだ開発されていないので、多サンプルの長期積分測定は不可能である。表４にこれまで行われた屋内トロン娘核種の測定結果を示す。

表4 トロン娘核種測定研究の結果

Country, Number of sample	Equilivlium equivalent thoron concentration (EET) (Bq/m^3) A. Mean±SD	Range	EET/EER	Reference
Laboratory	0.13 (ThB) 0.10 (ThC)			Harly et al.. Health Phys 1973
Germany (Salzburg)	0.89 (ThC)	0.0037-2.3	0.053	Steinhäusler et al. 1975
W.Germany, 32 houses	0.37		0.046	Wick 1979
W.Germany, 250 houses		0.3-0.6		Jacobi 1980
Salzburg, 729 person	1 (ThC)			Steinhäusler et al. 1980
Norway, 22 houses	0.7	0.1-1.1	0.04	Stranden, Health Phys. 1980
Canada, 95 houses (Elliott Lake)	1.5		0.02	Gunning & Scott, Health Phys.1982
W.Germany, 148 houses	0.2 (median)	0.1-0.6		Keller et al. Radiat. Environ. Biophys. 1982
US, 68 houses	0.28±0.04		0.05	Schery, Health Phys. 1985
Hong Kong, 10 houses	0.77±0.33		0.04	Tso & Li, Health Phys. 1987
U.K., 390 houses	0.6 (Estimate whole UK 0.3)			Wrixon et al. NRPB-R190, 1988
U.S. 70 houses (4 States)	0.15±0.11 ～2.6±1.61			Dudney ea al., Health Phys. 1990
U.S. Colorado		0.083-1.9	0.09 - 0.58	Martz et al. Health Phys., 1990
Sweden, 9 houses	0.3	0.1-0.6	0.01	Mjönes et al., Radiat. Prot. Dosim., 1992
Japan, 23 houses	0.72±0.24 (concrete) 3.52±2.48 (mud) 1.72±0.12 (New building Material)		0.007 0.037 0.028	Guo et al., Radiat. Prot.. Dosim., 1992
World Average	0.7 0.5 0.5 0.3	0.2 - 1.2 0.47 - 0.7 0.04 - 2	0.05 (ThC)	UNSCEAR 1982 ICRP Publ. 50 (1986) UNSCEAR 1988 UNSCEAR 1993

この結果を見ると、世界の家屋での値は、0.1 ～ 4 Bq/m^{3}の範囲で、最新のUNSCEAR報

告[9] での平均値は、0.3 Bq/m^3 としている。日本のデータもおおよそこの程度と推測できるが、特に土壁の家屋では、上限値の4 Bq/m^3 程度の家屋も多いと考えられる。ラドンの場合と同様にトロンガスよりもトロンの娘核種の吸入の方が線量への寄与が大きいので、線量評価のためには、娘核種の平均濃度を求める重要性が高い。しかし、トロン娘核種の測定は、現在のところアクティブ法しかないので、長期間で多サンプルの測定は不可能であるため、パッシブ法でのトロンガスの測定結果から娘核種濃度を平衡ファクタを乗じて推定しようという考えもある。しかし、トロン濃度は大きく変化する空間分布を示すので、ラドンのようにガスの濃度から娘核種濃度を推定するには大きな誤差が生じる危険性がある。UNSCEAR報告書では、トロンに関するデータが乏しいので、ラドン娘核種に対するトロン娘核種の濃度比の平均値を求めて、ラドン娘核種の平均値に濃度比を乗じてを世界の平均値を推定するという方法を用いている。表４に平衡等価濃度でのラドン・トロン比の測定結果を示しているが、そのレンジは、0.007～0.01であり、UNSCEAR1982年報告書[10] では、世界の平均値は0.05としている。この値は、平衡等価濃度の比であり、ポテンシャルアルファエネルギーでの比で表すと、約0.7となる。UNSCEAR1988年報告書[11] では、各国のラドン・トロン娘核種の同時測定の結果からポテンシャルアルファエネルギーの比を**表４** のようにまとめている。この結果から、ポテンシャルアルファエネルギーの比の値の平均値は、0.5としている。この値から線量換算係数を乗じて、屋内での実効線量当量での比率に換算すると、約0.17となる。つまりトロンの影響は、ラドンの17％程度であるということになる。

6.4 屋内トロン濃度の決定因子

屋内トロン濃度の決定要因としては、まず線源の濃度が重要である。ラドンの線源としては、土壌からの散逸が最も大きいとされているのに対し、トロンは、その半減期が短いので、土壌から室内に入るまでにほとんど崩壊してしまうので、線源としては、室内の壁、床、天井など建材が重要となる。建材中のトリウム含有量については、UNSCEAR1982年報告書[10] にまとめられている。^{232}Th濃度は北欧、西ドイツのレンガやコンクリートが非常に高く、壁土については、日本が北欧よりも高い。日本の壁土の^{232}Th濃度は、レンガとともに最も高く、北欧のレンガやコンクリートよりは低い。ただし、トロン濃度に直接関連するのは、トロンの散逸率であり、それはこれらの建築材料の多孔性や粒度に大きく依存する。壁土は粒度が荒いと考えられ、トロンの散逸率は高い。また同じ建材でも、含水率や気圧によっても変化する。岡本ら[7] は、トロン濃度は夏季が低く、冬季に高いという季節変化があることを報告しているが、この原因は、土壁の含水率の変化による散逸率の変化が原因と考えられる。壁から散逸したトロンは、室内へ拡散するが、見かけの拡散係数に及ぼす因子として空気の対流、ファンなどによる撹乱が考えられる。

屋内トロン娘核種濃度の決定要因としては、まずトロンの崩壊から生成される際の条件としてトロンガスの空間分布やエアロゾル濃度が考えられる。壁面や床面の表面付近で生成された場合は、部屋の中央付近で生成されるのと比べ、娘核種はそれらの面に沈着する確率が高いと考えられ、また、エアロゾル濃度が高いほど、壁や床面への沈着の確

率を低くし、その結果、室内空気中の娘核種濃度を高める。室内の娘核種の濃度は、換気による希釈の影響もある。ただし屋外の娘核種濃度が、屋内より高い場合も多く、その場合は、換気により屋内濃度が高くなる。

7.おわりに

実験研究において、少なくとも50Bq/m^3程度のトロン濃度では、積分型ラドンモニターへのトロンの影響は無視できることが判明した。また一般環境においては、50Bq/m^3を越えるような場所も存在するが、線源からの距離に対し指数関数的に濃度が減衰することから、測定器の設置場所を線源から距離を取ることを考慮することにより、トロンの影響を取り除く必要がある。

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