

## Radon in the Nature

Dr. Nilesh kumar M Baria,

Associate Professor, Chemistry Department, M.B.Patel Science College, Anand, Gujarat, India  
Corresponding Author: Dr. Nileshkumar M Baria

**Abstract:** Unique Radon-222 is a normally happening radioactive gas that is a piece of the Uranium rot arrangement. Its Presence in the earth is related predominantly with follow measures of uranium and its prompt parent, radium-226, in rocks, soil and groundwater. Around one-portion of the viable dosages from common sources is assessed to be conveyed by inhalation of the fleeting radon off spring. Inferable from this reality, radon is the most prominent subject of concentrates on ecological radioactivity. The nearness of abnormal state of radon in indoor condition comprises a noteworthy wellbeing risk for man. The radon descendants is entrenched as causative specialists of lung malignant growth and different kinds of caners. Radon's special properties as a normally radioactive gas have prompted its utilization as a geophysical tracer for finding covered flaws and topographical structures, in investigating for uranium, and for anticipating tremors. Radon has been utilized as a tracer in the investigation of environmental transport process. There have been a few other utilizations of radon in meteorology, water research and prescription. This paper outlines the wellbeing impacts and the potential advantages of radon and its descendants.

**Key Words:** Radon, Effective Dose, Health Hazard, Geological Structures, Earthquakes

Date of Submission: 13-12-2018

Date of acceptance: 28-12-2018

### I. Introduction

In writing there are a few reports managing radon in our condition [1-6]. The radiation portion from radon inward breath comprise a noteworthy part of the add up to common foundation portion gotten by man. The United Nation Nations Scientific Committee on the Effects of Nuclear Radiation (UNSCEAR) reports that about portion of portion gotten by man from characteristic sources is because of breathing radon and its offspring in the indoor conditions as appeared in figure 1 [7,8]. Radon is a dismal, scentless and dull gas delivered by radioactive rot of uranium what's more, thorium. There are two main isotopes of radon in nature:  $^{222}\text{Rn}$  ( $T_{1/2}=3.82\text{d}$ , here after guest radon) and its fleeting rot items:  $^{218}\text{Po}$ ,  $^{214}\text{Pb}$ ,  $^{214}\text{Bi}$ ,  $^{214}\text{Po}$ ,  $^{210}\text{Pb}$ ,  $^{210}\text{Bi}$ ,  $^{210}\text{Po}$  (uranium arrangement),  $^{220}\text{Rn}$  ( $T_{1/2}=55.6\text{s}$ , likewise called thoron) and its rot items:  $^{216}\text{Po}$ ,  $^{212}\text{Pb}$ ,  $^{212}\text{Bi}$ ,  $^{212}\text{Po}$ ,  $^{208}\text{Tl}$  (thorium series)[8,9]. The radioactive rot chain of radon is appeared in Figure 2 [10].

The radon substance of outside air 1 meter over the ground normally offers  $4$  to  $15\text{ Bq}\cdot\text{m}^{-3}$ . The normal indoor air convergence of radon differs from area to area, contingent on the uranium content and physical attributes of the dirt, dampness, winds and building materials. In many nations the normal indoor radon focus is a couple of several  $\text{Bq}\cdot\text{m}^{-3}$ , be that as it may, amid the reviews hundreds and even thousands could be found. The International Procedures of the 3rd - 45th - Commission on Radiological Protection (ICRP) in this manner prescribed activity levels  $200$ –  $600\text{ Bq}\cdot\text{m}^{-3}$  for homes and  $500$ –  $1500\text{ Bq}\cdot\text{m}^{-3}$  for working environments which compare to yearly dosages of  $3$ –  $10\text{ mSv}$  in either case [6-9].

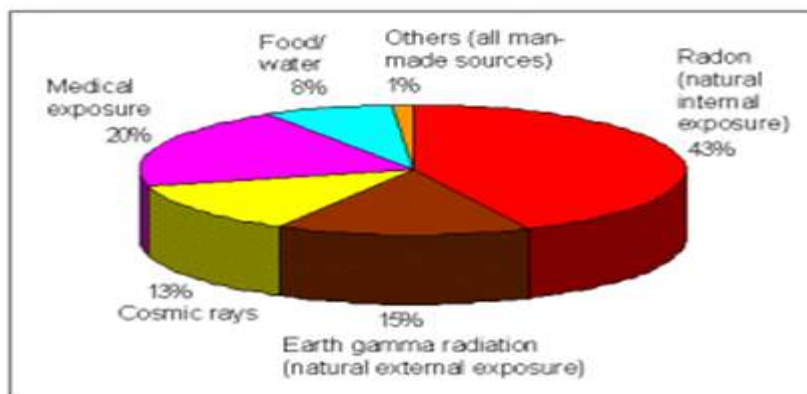
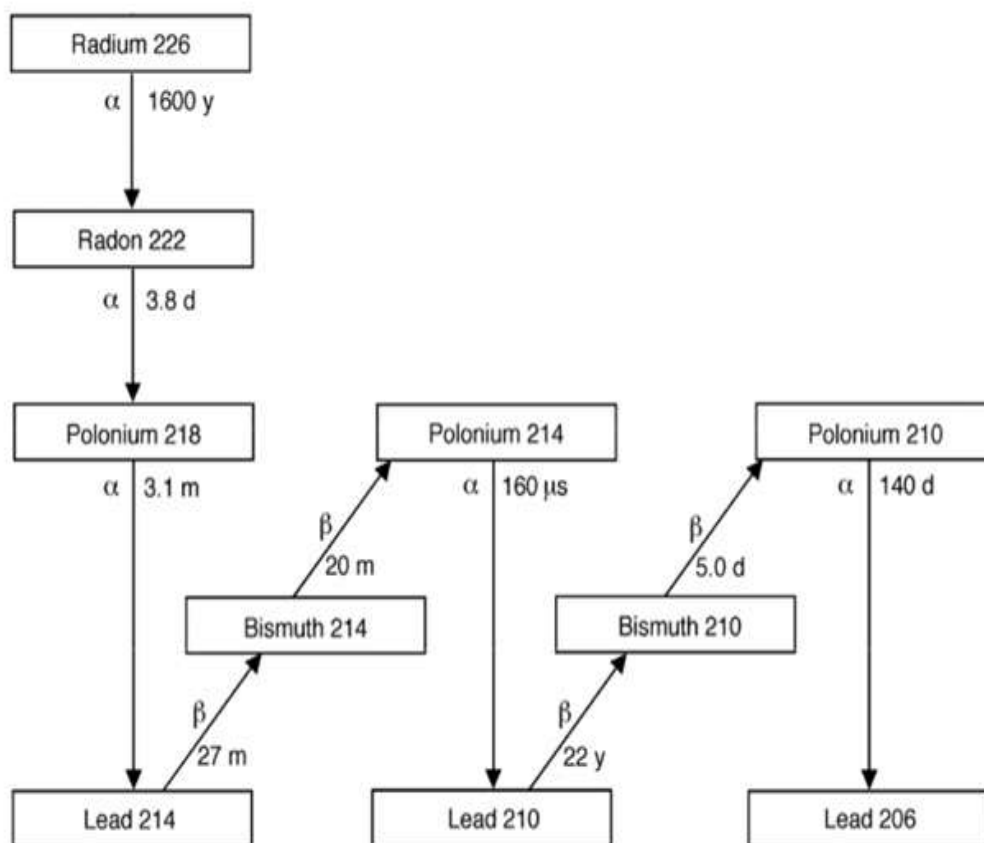


Figure 1: " Sources and average distribution of natural background radiation for the world population



ss

Figure 2:" The radon decay chain. "

There are a few methods that have been utilized for radon estimations .These methods incorporate glitter cells, ionization chambers , strong state atomic track detectors(SSNTDs) , strong state surface boundary indicators, the rmoluminescent dosimeters , electret particle chamber , and electrostatic precipitation system [9] . For creating nations wishing to embrace national review programs in request to screen natural radon levels, the most fitting strategies are those creation utilization of SSNTDs (CR-39 and LR-115) since they are adaptable, straightforward in taking care of and handling, ease and coldhearted to beta what's more, gamma radiation. Additionally these locators fuse the impacts of seasonal and diurnal vacillation of radon focuses because of physical and topographical factors and meteorological conditions [9,12] . Amid ongoing years , various papers have appeared in writing showing the ever enthusiasm for observing radon in the indoor situations in Egypt [13-21] .Radon needs to certainties. It has a noteworthy wellbeing peril for man. The radon offspring is well set up as causative specialists of lung disease and different sorts of malignant growths[6,7,22-25] .On the other hands, it has a potential advantages in earth sciences [1,9] .This paper condenses the wellbeing impacts what's more, the potential advantages of radon and its descendants

### Unsafe Effects Of Radon

Until the late 1970s , radon and its descendants were viewed as radiation wellbeing dangers just experienced in the mining and processing of uranium .This drastically changed subsequently of across the board indoor measurements of radon in parts of the world [2,6,7,22] . Thoughtfulness regarding the issue of radon presentation and the related wellbeing dangers has in this manner been developing around the world [22,25] . These days radon and its descendants, known to be cancer-causing in a high radon focus places, on the off chance that it is inadequately ventilated and if the radon contribution from its sources is high, for example, mines, for example, mines, caverns, basements, old tombs and vitality preserved impermeable houses. The breathed in radon and its descendants go from lungs into the blood and body tissues what's more, may show numerous kinds of delicate tissue diseases, for example, lung malignancy, kidney malignancy and prostatic disease [22-33] . Some radon might be broken up in body fats, and its girl items exchanged deep down marrow. The aggregated portion in more established individuals can be high, and may offer ascent to leukemia. Radon has additionally been connected with melanoma and some adolescence malignant growths [30,34] . There is a positive relationship between coronary illness and radon exposures where a hoisted danger of mortality from

coronary illness was watched among excavators with collective radon introduction surpassing 1000 Working Level Month (WLM) [37]. Radon little girls  $^{218}\text{Po}$  and  $^{214}\text{Po}$  could be respects as potential cancer-causing operators for the enlistment of skin malignant growth [36]. It is likewise seen that the blend of inward breath of radon gas and smoking builds the danger of lung malignant growth [22,35]. The key wellbeing impact in breathing air containing  $^{222}\text{Rn}$  is because of its little girls  $^{218}\text{Po}$ ,  $^{214}\text{Pb}$  and  $^{214}\text{Bi}$  ( $^{214}\text{Po}$ ). Their commitment to the radiation portion to the lung is 2-3 requests of size more noteworthy than that of  $^{222}\text{Rn}$  [38]. Ingested radon broke up in drinking water is a wellbeing hazard, since it might cause a stomach disease. The hazard caused by drinking water containing broke up radon is to a great degree much lower than breathing in radon [26]. Radon and its little girls are a critical wellbeing danger connected to a large number of preventable passing every year [39]. Radon is the second driving reason for lung malignancy after cigarette smoking. It might cause around 15,000 lung cancer deaths every year in the US [22,25]. The World Health Association (WHO) says radon causes up to 15% of lung malignancies around the world [25].

The wellbeing risk from radon can be tended to by distinguishing geographic territories that could deliver lifted dimensions of indoor radon, creating methodologies to decrease introduction, leading look into on powerful medicinal measures to be taken in structures, and giving instructive programs for wellbeing authorities and the general population [5-9,25]. Despite what might be expected, Reports exist on various epidemiological examines exhibiting a negative relationship of lung disease chance with radon in residences, which demonstrates that presentation to low level ionizing alpha radiation has evidently brought about positive wellbeing impacts [40-43]. Likewise, it was accounted for that there was no relationship between private radon and danger of youth intense myeloid leukemia AML [44]. Perceiving the significance of radon as a general medical problem, extensive scale national and global Radon-programs were started around the world, for example, the IAEA co-ordinate look into program CRP 'Radon in the Human Environment' including more than 50 nations [2] furthermore, The International Radon Project (IRP) by WHO on general wellbeing parts of radon presentation. This undertaking appreciates high need with WHO's Department of Public Health and Condition. The key components of the IRP incorporate [25]:

1. Estimation of the worldwide weight of ailment (GBD) related with introduction to radon view of the foundation of a worldwide radon database
2. Arrangement of direction on techniques for radon estimations and alleviation
3. Creating proof based general wellbeing direction for Member States to define arrangement and supports technique including the foundation of radon activity levels
4. Improvement of methodologies for radon hazard correspondence.

### **Radon Benefits In Our Environment**

There is increasingly data cumulating on the advantage impacts of radon at cell natural dimension known as radon treatment [5,9,46-49]. radon estimations can be utilized to illuminate radiation security issues at atomic and modern offices [5,9,11,50-54]. Notwithstanding that radon is imperative for some applications in earth sciences. It can be utilized as a topographical apparatus in mineral investigation [9,11], seismic tremor [9,55-62] what's more, volcanic action expectation [9], look for geothermal vitality source [9]. Radon additionally can be utilized in air thinks about [63,64].

### **Radon As Medicine (Radon Spas And Radon Therapy):**

Or maybe early, the incitement of DNA fix was seen upon radon introduction. Similar DNA fix was shown in lymphocytes of individuals living in expanded radon focus and furthermore the versatile reaction response was incited under 10 mSv "preparing" portion [9,45]. The spas clearly containing radon have been used with accomplishment for a long time for uncommon ailments primarily in the torment treatment of interminable rheumatic illnesses. Radon spas are far reaching in USA, Japan and Europe (Greece, Germany, Austria, Czech Republic, Hungary, Romania, Slovenia, Russia, and so forth). Clinical experience has demonstrated that the enduring agony of the patients was impressively decreased with less analgesic pharmaceuticals. The nearness of radon in spas, in like manner, can not be considered as hazardous to wellbeing, the exact inverse, more what's more, more data cumulate on its positive wellbeing impacts finishing the other advantageous factors present in wellbeing spas [5,9,46-49]. The Environmental Protection office expresses that there is no protected dimension of radon and that any presentation represents some danger of malignant growth. Others bolster the positive or nonpartisan impacts of low portion radiation. The inquiry is whether or how much the radon effects or harms the tissue [(49)]. With the goal that any radon spa medicines should given by a medicinal expert [5].

### **Radon And Radiation Safety In Nuclear And Industrial Facilities:**

Lately, issues of radiation and atomic security have been increased quickly due to the arrival of normal alpha-radioactivity from waste material delivered by power plants, substance and metallurgical industry. Along

these lines the measurements of radon fixation , as well as , radon offspring in air ,soil and water ,have been of extraordinary worry for radiological wellbeing [5,9,11,50-54]

**Radon and Mineral Exploration:**

Throughout the years, expansive number of systems and techniques have been developed to gauge radon focus in the "dirt gas" and in ground water in chosen territories of intrigue. These estimations can yield a considerable measure of data with respect to the subsurface geographical highlights and the nearness of mineral and oil/gas saves [9,11] .

**Radon and Earthquakes Prediction:**

The ongoing radon checking is a broadly considered territory with the end goal to give foreboding signs before quakes. The strain change that happened inside the earth surface amid seismic tremor is relied upon to improve the radon fixation in soil gas and in groundwater. In expansion to constant radon observing in groundwater other geochemical parameters such as electrical conductivity and water temperature ought to be performed [9,55-62] .

**Radon and Volcanic Surveillance:**

Radon has been perceived for long time as a recognizable segment of liquids related with volcanoes (fumaroles, ground waters ,or soil gases). It was accounted for that radon estimations ought to be certainly enhanced by estimations of other physical or substance parameters .Under such conditions , information of the geochemistry of volcanoes could quickly increment in the prompt future [9] .

**Radon and Geothermal Energy Prediction;**

A geothermal source might be characterized as the common warmth of the earth caught close enough to the world's surface to be separated monetarily. Regularly, geothermal sources are related with volcanic districts. High temp water springs and vapors transmission may propose prospecting geothermal vitality sources. The perception of particularly high radon levels may demonstrate the conceivable presence of a geothermal vitality sources lying profound underneath the earth's surface. The technique for utilizing radon signal for finding geothermal vitality sources has met some accomplishment in nations, for example, New Zealand , Mexico and USA [9] .

**Radon Application To Atmospheric Studies:**

The distinct fascination in natural radon observing can be credited to its appealing qualities as a tracer of environmental procedures. Radon is basically of earthbound beginning what's more, its dominating sink is by radioactive rot, since it is a honorable gas it doesn't respond synthetically with different species. Moreover, since radon is moderately insoluble in water and does not append to pressurized canned products, it isn't exceedingly powerless to dry or wet air expulsion forms. The half-existence of radon (3.8 days) is similar to the lifetimes of brief air poisons (e.g. NO<sub>x</sub>, SO<sub>2</sub>, CO, O<sub>3</sub>), and barometrical living arrangement time of water and pressurized canned products. This time scale is additionally practically identical to numerous vital parts of barometrical elements, making radon a helpful tracer at nearby, territorial or worldwide scales. The attributes of radon make it a solid pointer of the degree of air mass contact with land. This is more exact data than can be gotten from back directions alone. Besides, the reenactment of radon transport is right now extraordinary compared to other devices for the assessment of transport conspires in provincial and worldwide models. Because of its short half-life, the vertical circulation of radon in the climate indicates incredible affectability to sub-lattice scale forms. It has likewise been exhibited that follow gas emanations beginning from substantial land zones can be evaluated utilizing radon as a marker for discharge from soil. With the robotized indicators, changes in radon focus can be estimated to high exactness and transient goals an either perpetual stations or on board transports [63,64] .

**II. Conclusion**

In the ongoing years, radon observing and indoor radon fixation levels have been of logical and innovative enthusiasm because of its wellbeing dangers, not exclusively to underground mineworkers yet in addition to individuals in residences and work places with high radon levels, and their various applications; as a helpful device in concentrates in hydrology, topography, sea logy and earth shake expectation . Notwithstanding that, radon estimations can be utilized to illuminate radiation security issues at atomic and mechanical offices. It has ended up being a decent companion and an amazing foe in the meantime or it is both a peril and an assistance. I prescribe to :

- Carry out a national program for evaluating radon levels and successful portions tp people in the indoor conditions in earth and regrouping all endeavors managing it also, swing to an aggregate work.

- Use the instructive projects to educate wellbeing authorities and people in general about the wellbeing risk from radon and about associated risk factors, for example, smoking.
- Apply the Geographical Information System (GIS) innovation in the examination of radon information and the making of an indoor radon guide of Egypt.
- Promote logical researches dealing with radon applications in earth sciences and radiation wellbeing at atomic and mechanical offices.

### References :

- [1]. Haynes, William M., ed. (2011). CRC Handbook of Chemistry and Physics (92nd ed.). Boca Raton, FL: CRC Press. p. 4.122. ISBN 1439855110.
- [2]. Sykes, A. G. (1998). "Recent Advances in Noble-Gas Chemistry". *Advances in Inorganic Chemistry*. 46. Academic Press. pp. 91–93. ISBN 978-0120236466. Retrieved 2012-11-02.
- [3]. Thayer, John S. (2010). "Relativistic Effects and the Chemistry of the Heavier Main Group Elements". *Relativistic Methods for Chemists*. p. 80. doi:10.1007/978-1-4020-9975-5\_2. ISBN 978-1-4020-9974-8.
- [4]. Kusky, Timothy M. (2003). *Geological Hazards: A Sourcebook*. Greenwood Press. pp. 236–239. ISBN 9781573564694.
- [5]. Kusky, Timothy M. (2003). *Geological Hazards: A Sourcebook*. Greenwood Press. pp. 236–239. ISBN 9781573564694.
- [5]. Health effects of exposure to radon, Volume 6 of BEIR (Series). National Academies Press. 1999. p. 179. ISBN 978-0-309-05645-8.
- [6]. Proctor, Robert N. *The Nazi War on Cancer*. Princeton University Press, 2000 p. 99 ISBN 0691070512.
- [7]. Edelstein, Michael R., William J. Makofske. *Radon's deadly daughters: science, environmental policy, and the politics of risk*. Rowman & Littlefield, 1998, pp. 36–39 ISBN 0847683346.
- [8]. Harley, J. H. in Richard Edward Stanley; A. Alan Moghissi (1975). *Noble Gases*. U.S. Environmental Protection Agency. p. 111.
- [9]. Roaf, Susan; Fuentes, Manuel & Thomas, Stephanie (2007). *Ecohouse: A Design Guide*. Elsevier. p. 159. ISBN 978-0-7506-6903-0.
- [10]. "Annex E: Sources to effects assessment for radon in homes and workplaces" (PDF), Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (2006), United Nations, 2, pp. 209–10, 2008, retrieved 17 August 2013
- [11]. Abdelkawi SA, Abo-Elmagd M, Soliman HA. Development of cataract and corneal opacity in mice due to radon exposure. *Radiat Effects Defects Solids*. 2008;163(7):661–671.
- [12]. Abdelkawi SA, Abo-Elmagd M, Soliman HA. Development of cataract and corneal opacity in mice due to radon exposure. *Radiat Effects Defects Solids*. 2008;163(7):661–671.
- [13]. Abo-Elmagd M, Daif MM, Eissa HM. Cytogenetic effects of radon inhalation. *Radiat Meas*. 2008;43:1265–1269.
- [14]. ACGIH. Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists; 2007. Ionizing radiation; pp. 172–173.
- [15]. ACGIH. Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists; 2007. Ionizing radiation; pp. 172–173.
- [16]. Adinolfi M. The development of the human blood-CSF-brain barrier. *Dev Med Child Neurol*. 1985;27(4):532–537. [PubMed]
- [17]. Adlercreutz H. Phytoestrogens: Epidemiology and a possible role in cancer protection. *Environ Health Perspect Suppl*. 1995;103(7):103–112. [PMC free article] [PubMed]
- [18]. AEC. The effect of inhaled radon on the survival, body weight and hemogram of the mouse following single exposures. >Rochester, NY: U. S. Atomic Energy Commission. University of Rochester; 1961. p. UR-593. [PubMed]
- [19]. AEC. The effect of inhaled radon on the survival, body weight and hemogram of the mouse following multiple exposures. Rochester, NY: U. S. Atomic Energy Commission. University of Rochester; 1964. p. UR-624. [PubMed]
- [20]. AEC. The effects on mice of continual exposure to radon and its decay products on dust. Rochester, NY: U. S. Atomic Energy Commission. University of Rochester; 1966. p. UR-669. [PubMed]
- [21]. AEC. The effects on mice of continual exposure to radon and its decay products on dust. Rochester, NY: U. S. Atomic Energy Commission. University of Rochester; 1966. p. UR-669. [PubMed]
- [22]. Agency for Toxic Substances and Disease Registry. Fed Regist. 174. Vol. 54. 1989. Decision guide for identifying substance-specific data needs related to toxicological profiles; Notice. Agency for Toxic Substances and Disease Registry, Division of Toxicology; pp. 37618–37634.
- [23]. Al-Arifi MN, Alkartyf KM, Al-Suwayeh SA, et al. Levels of 210Po in blood, urine and hair of some Saudi smokers. *J Radioanal Nucl Chem*. 2006;269(1):115–118.
- [24]. Alavanja MCR. Biologic damage resulting from exposure to tobacco smoke and from radon: Implication for preventive interactions. *Oncogene*. 2002;21:7365–7375. [PubMed]
- [25]. Alavanja MC, Brownson RC, Lubin JH, et al. Residential radon exposure and lung cancer among nonsmoking women. (Comment in: *J Natl Cancer Inst* 86(24):1813-1814). *J Natl Cancer Inst*. 1994;86(24):1829–1837. [PubMed]
- [26]. Alavanja MC, Lubin JH, Mahaffey JA, et al. Residential radon exposure and risk of lung cancer in Missouri. *Am J Public Health*. 1999;89(7):1042–1048. [PMC free article] [PubMed]
- [27]. Albering HJ, Hageman GJ, Kleinjans JC, et al. Indoor radon exposure and cytogenetic damage. *Lancet*. 1992;340(8821):739. [PubMed]
- [28]. Alberts WM. Diagnosis and management of lung cancer executive summary. ACCP evidence-based clinical practice guidelines (2nd edition). *Chest*. 2007;132:1S–19S. [http://chestjournal.chestpubs.org/content/132/3\\_suppl/1S.full.pdf+html](http://chestjournal.chestpubs.org/content/132/3_suppl/1S.full.pdf+html). October 24, 2011. [PubMed]
- Alter H, Oswald R. Nationwide distribution of indoor radon measurements: A preliminary database. *J Air Pollut Control Assoc*. 1987;37(3):227–231. [PubMed]
- [29]. Altman PL, Dittmer DS. *Biological handbooks: Biology data book*. 2nd ed. Vol. III. Bethesda, MD: Federation of American Societies for Experimental Biology; 1974. pp. 1987–2008. pp. 2041
- [30]. Amabile J-C, Leuraud K, Vacquier B, et al. Multifactorial study of the risk of lung cancer among French uranium miners: radon, smoking, and silicosis. *Health Phys*. 2009;97(6):613–621. [PubMed]
- [31]. Andersen ME, Krishnan K. Relating in vitro to in vivo exposures with physiologically based tissue dosimetry and tissue response models. In: Salem H, editor. *Animal test alternatives: Refinement, reduction, replacement*. New York, NY: Marcel Dekker, Inc.; 1994. pp. 9–25.



- [32]. Andersen ME, Clewell HJ, Gargas ML, et al. Physiologically based pharmacokinetics and the risk assessment process for methylene chloride. *Toxicol Appl Pharmacol.* 1987;87(2):185–205. [PubMed]
- [33]. Anttila A. Lead content of deciduous tooth enamel from a high-radon area. *Acta Odontol Scand.* 1987;45(4):283–288. [PubMed]
- [34]. Archer VE. Epidemiologic studies of lung disease among miners exposed to increased levels of radon daughters. In: Rom W, Archer V, editors. *Health implications of new energy technologies.* Ann Arbor, MI: Ann Arbor Science; 1980. pp. 13–22.
- [35]. Archer VE. Enhancement of lung cancer by cigarette smoking in uranium and other miners. *Carcinogenesis.* 1985;8:23–37. [PubMed]
- [36]. Archer VE, Brinton HP, Wagoner JK. Pulmonary function of uranium miners. *Health Phys.* 1964;10:1183–1194. [PubMed]
- [37]. Archer VE, Gillam JD, Wagoner JK. Respiratory disease mortality among uranium miners. *Ann NY Acad Sci.* 1976;271:280–293. [PubMed]
- [38]. Archer VE, Saccomanno G, Jones JH. Frequency of different histologic types of bronchogenic carcinoma as related to radiation exposure. *Cancer.* 1974;34(6):2056–2060. [PubMed]
- [39]. Archer VE, Wagoner JK, Lundin FE. Lung cancer among uranium miners in the United States. *Health Phys.* 1973;25(4):351–371. [PubMed]
- [40]. ASTM. Standard test method for radon in drinking water. 1999 Annual book of ASTM methods. Vol. 11.02 Water (III). West Conshohocken, PA: American Society for Testing and Materials; 1999. Method D 5072-98; pp. 673–675.
- [41]. Attfield MD, Schleiff PL, Lubin JH, et al. The diesel exhaust in miners study: A cohort mortality study with emphasis on lung cancer. *J Natl Cancer Inst.* 2012;104 [Epub ahead of print] [PMC free article] [PubMed]
- [42]. Auerbach O, Saccomanno G, Kuschner M, et al. Histologic findings in the tracheobronchial tree of uranium miners and non-miners with lung cancer. *Cancer.* 1978;42:483–489. [PubMed]
- [43]. Auvinen A, Makelainen I, Hakama M, et al. Indoor radon exposure and risk of lung cancer: A nested case-control study in Finland. (Erratum in: *J Natl Cancer Inst* 90(5):401-402). (Comment in: *J Natl Cancer Inst* 89(8):584-585). *J Natl Cancer Inst.* 1996;88(14):966–972. [PubMed]
- [44]. Auvinen A, Salonen L, Pekkanen J, et al. Radon and other natural radionuclides in drinking water and risk of stomach cancer: A case-cohort study in Finland. *Int J Cancer.* 2005;114(1):109–113. [PubMed]
- [45]. Axelson O, Sundell L. Mining, lung cancer and smoking. *Scand J Work Environ Health.* 1978;4(1):46–52. [PubMed]
- [46]. Bahtijari M, Stegnar P, Shemsidini Z, et al. Indoor air radon concentration in schools in Prizren, Kosovo. *Radiat Prot Dosimetry.* 2006;121(4):469–473. [PubMed]
- [47]. Bair W. ICRP work in progress: Task group to review models of the respiratory tract. *Radiol Prot Bull.* 1985;63:5–6
- [48]. Band P, Feldstein M, Saccomanno G, et al. Potentiation of cigarette smoking and radiation: Evidence from a sputum cytology survey among uranium miners and controls. *Cancer.* 1980;45(6):1273–1277. [PubMed]
- [49]. Barnes DG, Dourson M. Reference dose (RfD): Description and use in health risk assessments. *Regul Toxicol Pharmacol.* 1988;8(4):471–486. [PubMed]
- [50]. Barros-Dios JM, Barreiro MA, Ruano-Ravina A, et al. Exposure to residential radon and lung cancer in Spain: A population-based case-control study. (Erratum in: *Am J Epidemiol* 157(9):859). *Am J Epidemiol.* 2002;156(6):548–555. [PubMed]
- [51]. Bastide K, Guilly M-N, Bernaudin J-F, et al. Molecular analysis of the Ink4a/Rb1-Arf/Trp53 pathways in radon-induced rat lung tumors. *Lung Cancer.* 2009;63:348–353. [PubMed]
- [52]. Bauchinger M, Schmid E, Braselmann H, et al. Chromosome aberrations in peripheral lymphocytes from occupants of houses with elevated indoor radon concentrations. *Mutat Res.* 1994;310(1):135–142. [PubMed]
- [53]. Baysson H, Tirmarche M, Tymen G, et al. Indoor radon and lung cancer in France. (Comment in: *Epidemiology* 17(1):121, author reply 121-122). *Epidemiology.* 2004;15(6):709–716. [PubMed]
- [54]. Baysson H, Tirmarche M, Tymen G, et al. Indoor radon and lung cancer in France. (Comment in: *Epidemiology* 17(1):121, author reply 121-122). *Epidemiology.* 2004;15(6):709–716. [PubMed]
- [55]. Becker K. Health effects of high radon environments in central Europe: Another test for the LNT hypothesis? *Dose Response Int J.* 2003;1(1):3–35. [PMC free article] [PubMed]
- [56]. Bergdahl IA, Jonsson H, Eriksson K, et al. Lung cancer and exposure to quartz and diesel exhaust in Swedish iron ore miners with concurrent exposure to radon. *Occup Environ Med.* 2010;67:513–518. [PubMed]
- [57]. Berger GS, editor. *Endometriosis: Advanced management and surgical techniques.* New York, NY: Springer-Verlag; 1994. Epidemiology of endometriosis; pp. 3–7.
- [58]. Berger GS, editor. *Endometriosis: Advanced management and surgical techniques.* New York, NY: Springer-Verlag; 1994. Epidemiology of endometriosis; pp. 3–7.
- [59]. Bhat R, Sridhar KR, Rajashkara KM, et al. <sup>210</sup>Po bioaccumulation in coastal and sand dune wild legumes—*Canavalia* spp. of southwest coast of India. *J Environ Monit.* 2005;7:856–860. [PubMed]
- [60]. Biberman R, Lusky A, Schlesinger T, et al. Increased risk for small cell lung cancer following residential exposure to low-dose radon: A pilot study. *Arch Environ Health.* 1993;48(4):209–212. [PubMed]
- [61]. Bignon J, Monchaux G, Chameaud J, et al. Incidence of various types of thoracic malignancy induced in rats by intrapleural injection of 2 mg of various mineral dusts after inhalation of <sup>222</sup>Ra. *Carcinogenesis.* 1983;4(5):621–628. [PubMed]
- [62]. Bilban M, Jakopin CB. Incidence of cytogenetic damage in lead-zinc mine workers exposed to radon. *Mutagenesis.* 2005;20(3):187–191. [PubMed]