How to Regulate Radon: Case Study of Radon Exposure in Korea and Indonesia

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KNS Fall Conference
Yeosu EXCO, October 25th, 2018

Contents

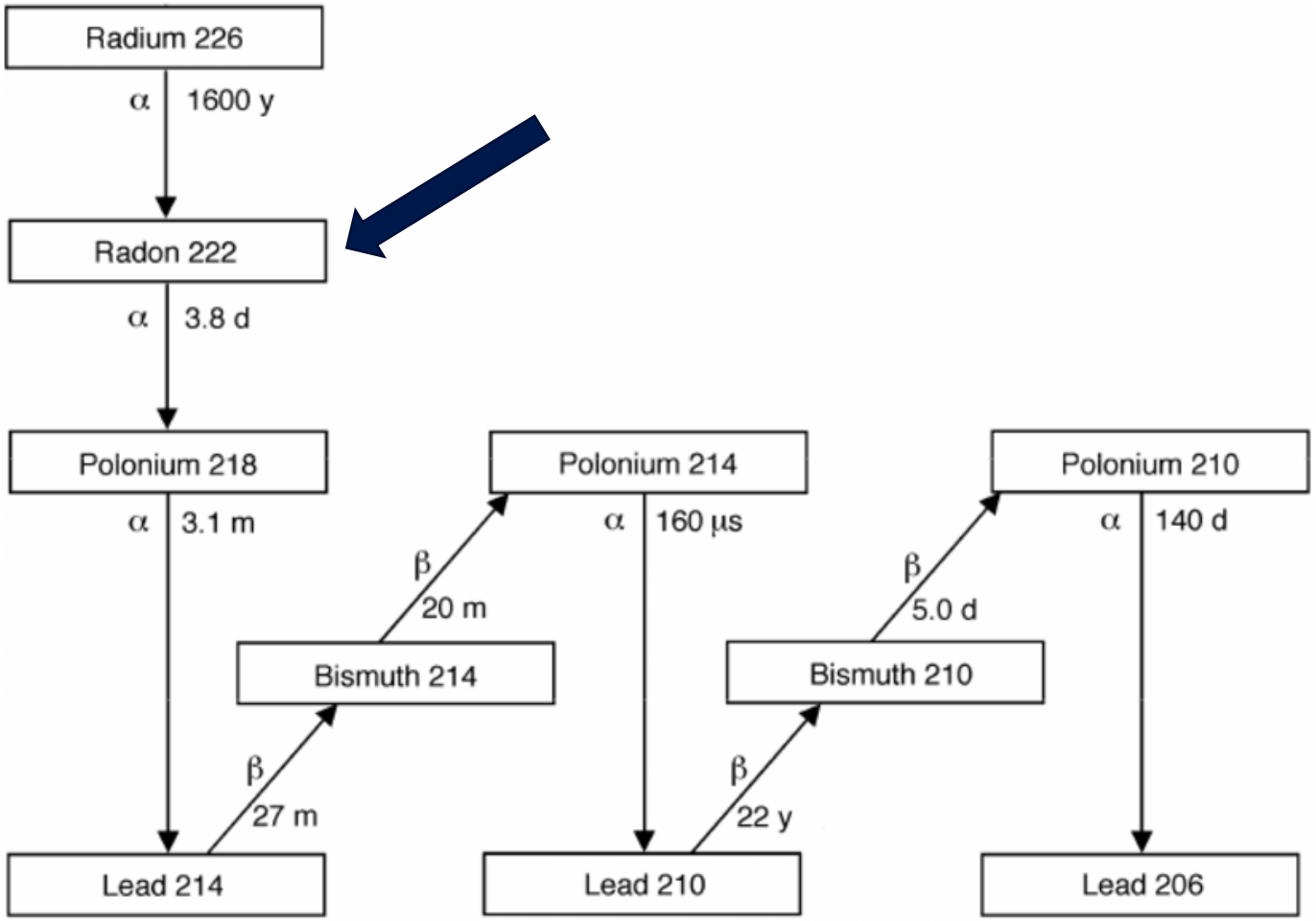
1. Introduction

- Radon (^{222}Rn) is part of the uranium decay chain and, being a noble gas, can escape the matrix of the rock and soil in which it is formed. As a gas or dissolved in water, it moves through fractures in rock or pore spaces in soil. Radon decays with a half-life of 3.8 days.

- When radon reaches open air, it disperses quickly. Typically, the average radon concentration in outdoor air is around 10 Bq/m^3. However, when radon enters an enclosed space, such as a building, it can't disperse as easily, so is usually found at higher levels than outdoors. The worldwide average indoor radon concentration is about 40 Bq/m^3.

- One of the biggest concerns about radon is its health radiological hazardousness. Radon is estimated to be the second main cause of lung cancer after smoking.
- To have a better understanding in regulating radon, case study analysis on radon exposure of Korea and Indonesia has been done. In addition, considerations on natural sources of exposure, international standard, and radiation protection principles were done to see the appropriate way in regulating radon.

Radon decay chain



2. Methods

- Analysis of Radon Exposure in Korea and Indonesia:
  - Radon exposure is influenced by geological characteristics such as altitude variation and earthquake prone areas. Exposure analysis between Korea with less altitude variation and relatively safe from earthquake and Indonesia with significant altitude variation and prone to earthquake were done to learn radon profile.
  - To inspect more detail about radon, three main radon source types were investigated; they were indoor radon, outdoor radon, and radon from building materials.
  - The analysis on radon exposure will be a basic scientific judgment for this study.

- Analysis of Natural Sources of Exposure
  - Since radon is one of the main contributor of all radiation received by human, consideration on natural source of exposure would be very important to find out the best way in regulating and managing radon.
- International Standard Consideration.
- Radiation Protection Principles Consideration
  - Since it deals with radiation and government top priority is safety of public, worker, and environment, the development of radon regulation should prioritize radiation protection principle as well

3. Results and Disscussion

3.1. Radon Exposure in Korea and Indonesia

Province (No. of samples)	Range (Bq/m^3)	Mean + SD (Bq/m^3)
Gangwon.(45)	22.3-133.7	55.0±29.2
Gyeonggi.(56)	19.0-169.3	47.5±23.3
Gyeongsangnam.(42)	19.1-87.3	37.3±14.6
Gyeongsangbuk (66)	18.6-317.7	53.8±40.7
Jeollanam (43)	21.6-194.5	58.8±39.1
Jeollabuk (26)	25.2-103.9	55.8±21.6
Jeju (9)	15.2-53.5	28.2±11.2
Chungcheongnam (37)	24.4-202.5	56.7±33.1
Chungcheongbuk (27)	31.6-236.5	70.0±53.2
Total average	15.2-317.7	52.6±33.1
Effective Dose (mSv/y)		0.37

Table I. Distribution of Radon Concentration by Province in Public Buildings in Korea

Province (No. of samples)	Range (Bq/m^3)	Mean (Bq/m^3)
Lampung (32)	16.0-33.0	23.5
Bengkulu (12)	20.0-125.0	50.0
Riau (29)	33.3-83.3	56.2
Banten (80)	5.5-55.5	28.2
Jawa Barat (187)	3.0-155.0	43.0
Jakarta (255)	2.0-127.3	27.0
Jawa Timur (32)	4.7-168	17.3
Sulawesi Selatan		200
Bali		208.3
Total average		72.6
Effective Dose (mSv/y)		0.52

Table 2. Distribution of Radon Concentration in Public Buildings in Indonesia

- From table 1 and 2, it's showed that the concentration in Korea is relatively uniform while in Indonesia has a significant range/variation of radon concentration

Table 3. Radon and effective dose from indoor, outdoor, and building materials in Korea

	Samples	Mean	Effective Dose (mSv/y)
Indoor	Public buildings Houses College rooms Elementary school	52.6±33.1 Bq/m^3 129.0±29 Bq/m^3 59.7±6.0 Bq/m^3 49.0 Bq/m^3	0.37 0.9 0.43 0.41
Outdoor	Atmosphere	3.2 nGy/h	0.28
Building materials	Frame construction materials Finishing materials	287.8 Bq/m^3 83.81 Bq/m^3	2.07 0.6

Table 4. Radon and or effective dose from indoor, outdoor, and building materials in Indonesia

	Samples	Mean	Effective Dose (mSv/y)
Indoor	Public buildings Research Buildings Caves	35.1 Bq/m^3 40.0 Bq/m^3 200 Bq/m^3	0.37 0.37 >5
Outdoor	Bangka Belitung soil Atmosphere	48.11 mBq/m^2s 351.5 Bq/m^3	- 2.53
Building materials	Bricks Gypsum, <100cm from ceiling	66.6 Bq/m^3 208.3 Bq/m^3	0.48 1.5

- Table 3 shows that most of Korean region have exposure below standard. There are only few areas above standard, however it is still reasonable since it comes from the building materials.
- Table 4 shows that Indonesia has several areas with excessive exposure in each type of exposure, both indoor, outdoor and building materials.

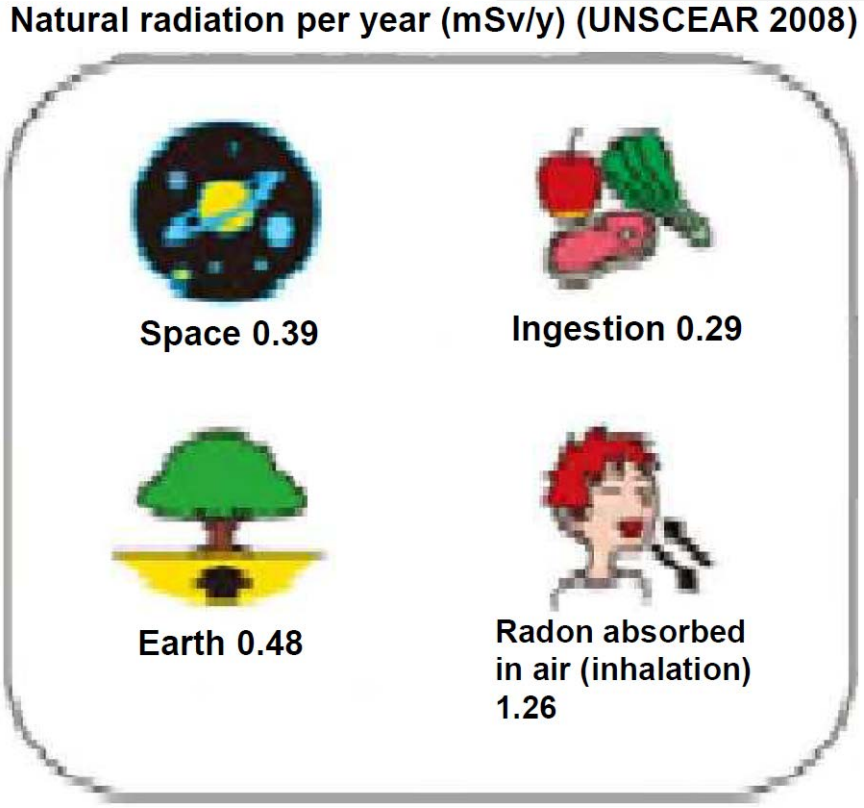
Reference value:

- 1 mSv (ICRP: public dose limit)
- 148 Bq/m^3 (EPA: radon concentration)
- 26.2 mBq/m^2s (UNSCEAR, 2000: radon exhalation)

3.2. Consideration on Natural Sources of Exposure

- Radon is a significant contributor to natural exposure, which is above 50%. The total average of natural radiation is about 2.4 mSv/y (UNSCEAR 2008).
- The radiation dose limit for workers of 20 mSv per year is considered as a safe dose.
- Based on this consideration, regulation of radon can be integrated within the public exposure regulation.

- However, individual radon exposures can vary significantly. Therefore, government should make a provision on real-time monitoring in every area to supervise the updated concentration and/to minimize public concern.



3.3. Consideration on International Standard

- In GSR part 3 paragraph 5, IAEA has differentiated between normal exposures and enhanced exposures, and between natural and exposures to man-made sources. However, it is very difficult to separate them in reality.
- In the IAEA Safety Fundamental 1 Principle 2, government has a role to establish effective legal and framework for safety of public, worker, and environment. On the other hand, government also has a responsibility to increase and stabilize the economy.

- Consequently, the government should act wisely in regulating radon. From radon exposure analysis, especially for Indonesia, it might be better to have a specific regulation to regulate radon in particular areas. The specific regulation can be used to manage some special case like some areas with high exposure.
- Two options in establishing the specific regulation:

1. It can be issued by the top government as a supporting regulation.
2. The establishment of the specific regulation can be mandated to local government

3.4. Consideration on Radiation Protection Principle

- Radiation protection principles should always be the main consideration on radiation-related analysis.
  1. Justification principle: the individual or societal benefit should be more significant than the radon exposure.
  2. Optimization principle: the radon doses should all be kept as low as reasonably achievable, taking into account economic and societal factors.
  3. Dose limit application: the radon exposure to any individual should consider the average background exposure in the country and should not exceed the appropriate limits recommended.

4. Conclusions

1. From radon exposure analysis in Korea and Indonesia, it can be concluded that geological characteristics play a significant contribution in country radon profile.
2. Management of radon is a complex process that should be done by all government. By considering on natural sources of exposure, international standard, and radiation protection principles, it can be inferred that radon regulation can be integrated within the general natural exposure regulation.
3. Establishment of radiation safety regime is one of government role. To maintain it, government can use radon international standards as a secondary safety reference.

Thank you!