Abstract

A study for occupational exposure and OELs of radon

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1. Objectives

Radon is Naturally Occurring Radioactive Material(NORM) from the decay of uranium and thorium. By inhalation over a period of time, these may lead to malignant transformation and the formation of lung cancer. The phosphogypsum contained NORM is used as a raw material of building materials such as cement or gypsum board.

Recently, the causes of lung cancer reported in the media was estimated to be generated by radon. The biggest risk of exposure to radon and radon decay products in homes and workplaces will be ionizing radiation exposure. EPA reported that thousands of people was dying every year because of exposure to radon and its decay products (EPA, 2014). However, It takes a reasonable cost by reducing the radiation risk due to radon. To achieve these goals, regulatory agency must be limited exposure to radon and noticed where the sites will be the risk of high exposure and established the guidelines and it is important to inform the workers about the risks associated with radon.

The internal exposure dose by inhalation is largely dependent on the properties of the particles. Typically, the aerosol in the air was classified as the size of particles, ultrafine particles (1 to 100 nm), fine particles (100 to 1,000 nm), and coarse particles (> 1,000 nm). But, the radon progeny aerosol in the atmosphere is formed the attached particles. The attached particles can have a trimodal activity size distribution which can be described by a sum of three lognormal distributions (Porstendofer, 2001). These comprise the nucleation mode with an activity median aerodynamic diameter (AMAD) between 10 nm and 100 nm, the accumulation mode with AMAD values 100 to 400 nm and a coarse mode with an AMAD > 1 μm. Generally, the greatest activity fraction is in the accumulation mode which has a geometric standard deviation of about 2. The HRTM(Human Respiratory Tract Model for Radiological Protection) are to provide a qualitative and quantitative description of the respiratory tract as a route for radionuclides to enter the body and a method to calculate radiation doses to the respiratory tract for any exposure and a method to calculate the transfer of radionuclides to other tissues(ICRP Publication 66, 1994).

Therefore, it is necessary to monitor the exposure level of radon and management states of the manufacturing processes that the phosphogypsum was directly handled, and to provide the basic data need to establish OELs of radon for protecting workers' health. To do this, first was surveyed the developed countries and regulatory institutions that are setting the management standards(TLVs) for radon.

2. Methods

We selected four processes handling the phosphogypsum such as storage house, hopper, feeder, cement mill at 7 cement manufacturing companies and evaluated radon concentrations in the work area and office rooms(Background concentration). We placed short-term radon detectors(Model 1030, Sun nuclear Co., USA) at indoors in the office buildings. The radon measurements were recorded at 30-minute intervals over approximately 24 hours. The limit of detection of this instrument is 0.1 pCi/L(3.7 Bq/m^3). Also, we placed long-term radon detectors(α-track, Rn-tech Co., Korea) in the work area of target process; these detectors were collected on August 22, 2014, and analyzed by the manufacturer. Our detectors were exposed for 60～90 days, resulting in a lower limit detection of 0.4 pCi/L(14.8 Bq/m^3). Detectors were placed 50cm above the floor, also was collected two field blanks per site.

Radium-226 concentration measured was to wear a pump mounted on a PVC filters or membrane filters at the respiratory position of the workers were collected for 8 hours a day. Samples were analyzed by HPGe(highly pure germanium) Gamma-ray Spectroscopy.

The size of particles measured were used Nanoparticle Sizer(TSI NanoScan SMPS Particle Size Range: 10-420 nm, Model 3910, USA) and Optical particle counter(GRIMM Dust Monitor 1108; Particle Size Range: 300 nm-20 μm, Germany).

3. Results

○ Radon concentrations of 7 cement manufacturing plants were 24.0±13.8 Bq/m^3 in arithmetic mean with range 1.0 to 144.3 Bq/ m^3, and were 21.9 Bq/

㎥ (GSD 1.7) in geometric mean. Radon concentrations of study processes showed a storage areas 27.5±19.7 Bq/㎥, hoppers 19.7±10.9 Bq/㎥, feeders 21.2±14.7 Bq/㎥, cement mills 15.0±10.9 Bq/㎥ in arithmetic mean, and were a storage areas 23.2 (GSD 2.2) Bq/㎥, hoppers 20.2 (1.6) Bq/㎥, feeders 16.8 (2.5) Bq/㎥, cement mills 11.9 (2.7) Bq/㎥ with geometric mean, respectively. We measured the radon concentrations using α-track in parallel with direct-reading radon detectors and compared two metric methods for radon monitoring. Paired t-test for the two sampling methods was showed that there is no difference between the average radon concentrations ($p<0.05$).

○ Radium concentration of personal air samples and area samples that collected at processes where handled a phosphogypsum showed 0~0.8 Bq/㎥ in range, were mostly below MDA (Minimum Detectable Activity Level, MDA).

○ Particle number concentration of overall feeders were 137696.3 #/㎤ (GSD 3.3), mass concentration were 0.07 ㎎/㎥ (GSD 2.3) with geometric mean, respectively. The proportion of nanoscale particles showed 34.6%, the particle size 65.7 ㎚ (GSD 1.9), density of particle 1.2g/cc, respectively. Nucleation mode of activity median aerodynamic diameter(AMAD) occupied 12.3±19.7% (2.0~40.5%), accumulation mode 45.0±18.2%(17.8~55.0%), coarse mode 5.7±9.1% (0.8~16.6%), respectively. It was found to account for most occupying the accumulation mode.

4. Conclusion

Ionizing radiation resulting from radioactive materials such as radon, no matter how small doses (> 100 mSv), which lead to the risk of cancer,

which is proportional to the dose of radiation, and is reported to have no threshold value (NRC, 2006).

International organizations such as ICRP, UNSCEAR and NCRP, had recommended the guidelines for radon. we analyzed the relation the dose conversion factors with the annual effective doses. we suggest that OELs of radon need to establish 150 Bq/m^3 for office room and 1,000 Bq/m^3 for the workplace.

In the future, to assess based on a precisely analysis raw materials and process by-products containing NORM is continuously necessary to study standardization of analytical methods for radioactive materials, build-up of monitoring systems of radon and radon progeny, etc.

Keywords Radon, NORM, Phosphogypsum, Cement, Activity median aerodynamic diameter(AMAD), ICRP