Inhalation Dose Assessment at Phosphate and Potassium Industries

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1. Introduction

Phosphate and potassium are naturally occurring radioactive materials (NORM). Therefore, the workers in the phosphate and potassium industries are subjected to internal exposure due to inhalation of airborne particulates containing radioactive materials. International Atomic Energy Agency (IAEA) suggested industry sectors as being required some form of regulation consideration [1].

Inhalation dose to workers varies with particulate properties including airborne particulates concentration and radioactive concentration. International Commission on Radiological Protection (ICRP) recommends that site-specific information on particulate properties should be measured and then used for inhalation dose assessment [2]. Therefore, the actual measurement data of particulate properties is required for accurate dose assessment.

The objective of this study was to assess inhalation dose based on the actual measurement data of airborne particulates. Assessment of inhalation dose was implemented for phosphate and potassium industries in Korea.

2. Materials and Methods

The properties of airborne particulates were characterized at major processing area. The particulate properties included concentration in the air, size distribution, mass density, shape, and radioactive concentration. In this study, we selected two fertilizer facilities. One handles mainly phosphate materials and the other handles mainly potassium materials.

Cascade impactor was used to collect airborne particulates (Fig. 1). The measurement of the radioactivity concentration of materials taken from the major process was performed using HPGe detector (Fig. 1). The mass density and physical shape of airborne particulates were analyzed using pycnometer and scanning electron microscopy respectively.

Inhalation dose coefficients were derived from the ICRP-66 human respiratory tract model and particulate properties. Inhalation doses to workers were calculated using inhalation does coefficients and exposure scenarios at fertilizer facilities.

Fig. 1. Cascade impactor and HPGe detector.

3. Results and Discussion

Fig. 2 shows airborne particulate concentrations collected in two NORM facilities. Airborne particulates concentration widely ranged 0.075-203.32 μg/L. Airborne particulate concentration was the highest for phosphate rock warehouse. Lots of airborne particulates were scattered at the phosphate rock warehouse while on the work.

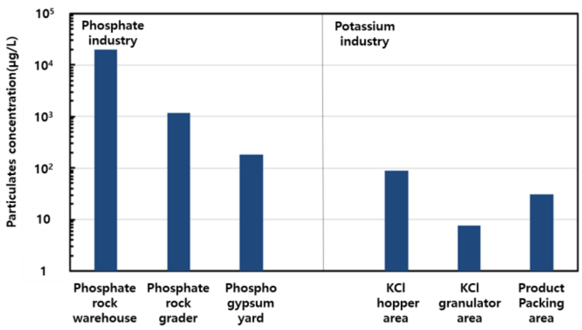

Fig. 2. Airborne particulates concentration in phosphate handling facility and potassium handling facility.

Fig. 3 shows the radioactivity concentrations. Radioactivity concentrations of the materials ranged 33-866 Bq/kg for uranium series, 0-2 Bq/kg for thorium series, and 0-15,400 Bq/kg for K-40. Radioactivity concentrations were the highest in phosphate rock for uranium decay series and phospho-gypsums for thorium decay series. Potassium chloride had the highest K-40 concentration.

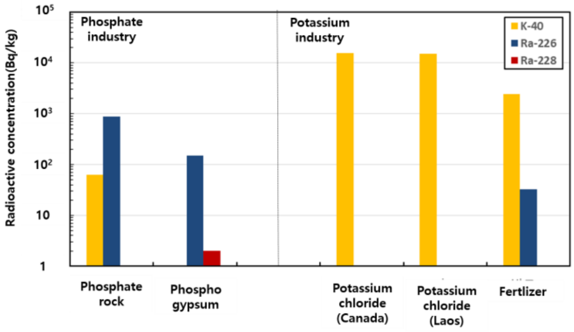

Fig. 3. Radioactivity concentrations of NORM materials in phosphate handling facility and potassium handling facility.

Mass densities were about 3.40 g/cm^3 for phosphate rock, 2.1 g/cm^3 for phospho-gypsum, 1.97 g/cm^3 for KCl, and 2.0 g/cm^3 for fertilizer. The airborne particulates appeared to be spherical in most processing area. Therefore, unity was assigned as shape factor for internal dose assessment.

Inhalation doses were calculated using the particulate properties and exposure scenarios. Inhalation doses widely ranged 3.95×10^{-9}-4.02×10^{-1} mSv/y. Inhalation dose was the highest at phosphate rock warehouse as 0.402 mSv/y. Airborne particulate concentration at the warehouse was up to 20 times higher than the other areas. The difference in radiation doses was mainly due to airborne particulate concentration and radioactivity concentration.

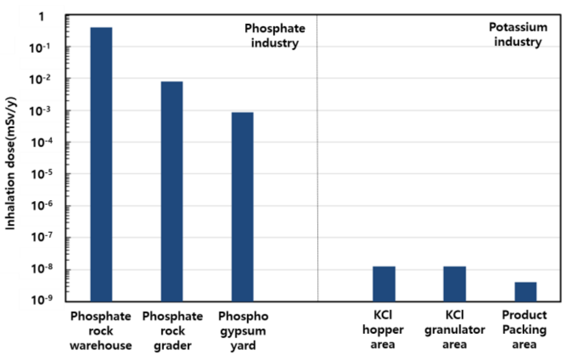

Fig. 4. Inhalation doses in phosphate handling facility and potassium handling facility.

4. Conclusion

We accessed inhalation doses to the workers phosphate handling facility and potassium handling facility. Inhalation doses widely varied with airborne particulates properties. Therefore, optimization of radiation protection in NIORM industry is necessary. The results of this study can be used for characterizing radiation exposure at Korean NORM industries.

ACKNOWLEDGMENTS

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