Characterization of airborne particles in Korea potassium chloride industry

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1. Introduction

In the potassium chloride industry in Korea, a large amount of Naturally Occurring Radioactive Materials (NORM) is treated. Therefore the workers can be exposed by particle inhalation from NORM aerosol.

Internal exposure dose by particle inhalation can be estimated by Human Respiratory Tract Model (HRTM) in Publication 66 of the International Commission on Radiological Protection (ICRP). According to HRTM, radiation dose by particle inhalation containing NORM depends on particle properties. ICRP provides the reference values which can be applied if it is impossible to measure the particle properties. However, when using these values, there can be a large difference with actual dose assessment. Consequently, the ICRP recommends that site-specific information on aerosol physic-chemical properties should be measured and then used in the worker dose assessment [1]. Therefore, the actual measurement data of particle properties is required for reliable dose assessment.

The objective of this study is to estimate particle properties in potassium chloride industry in Korea. This study estimated the particle size distribution, particle concentration, density, shape, chemical composition and radioactivity concentrations.

2. Materials and Methods

In this study, we analyzed actual measurement data of airborne particle generated at work for the chemical product industry and fertilizer product industry among the domestic potassium chloride industry.

The cascade impactor was selected for analyzing the concentration and size distribution of airborne particles. Airborne particles were collected at a flow rate of 28.3 L / min.

The measurement of the radioactivity concentration of the particles taken from the main process of potassium chloride industry was performed using HPGe detector. The radioactive equilibrium of thorium and uranium series maintaining equilibrium on the natural source material originally can be lost due to the physical and chemical process. Therefore, we analyzed the radioactivity concentration of K-40 and Ra of collected samples after being radioactive equilibrium by sealing it for a few days in marinelli beaker.

Additionally, particle shape, chemical composition and density are the factors for radiation dose. The analyze of particle shape and chemical composition was conducted for particles collected by cascade impactor with Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDXS), respectively. The density analyze was implemented by using a pycnometer for the bulk products at main process of potassium chloride industry.

3. Results and Discussions

Figure 1 and Figure 2 shows the concentration and size distribution of the particles in fertilizer and chemical products industry. Particle size was widely distributed to 0.1 ~ 100 μm, the concentration of particles appeared to about 0.015 ~ 4.4 μg/L for processing site. Particle concentration in the main process of the chemical products industry was the highest in the storage of potassium chloride because storage is located indoor and dust are generated in the storage resulting from the work with heavy machinery. Particle concentration in the main process of the fertilizer manufacturing industry was the highest in the granulation region because a large amount of dust is generated due to the vibration and rotation of the granulation. On the other hand, unlike particle concentration of chemical products industry in the storage, that of fertilizer products industry had quite low value. It is because the amount of potassium chloride treated in the industry is granular state, therefore dust was rarely generated. Concentration of airborne particle in the potassium chloride industry depends on the type of operating equipment, existence of work, ventilation equipment, ventilation conditions and weather.

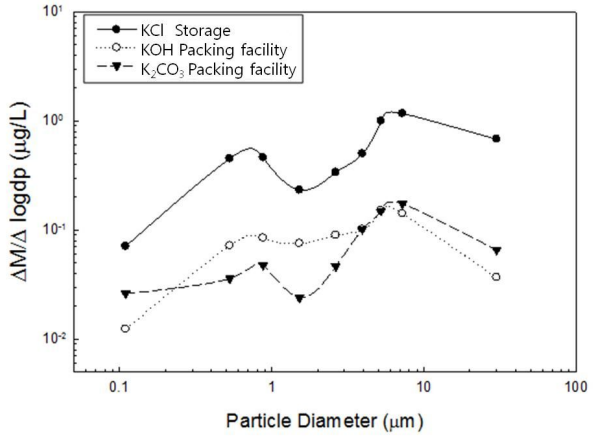

Fig. 1. Size distribution and concentration in chemical products industry

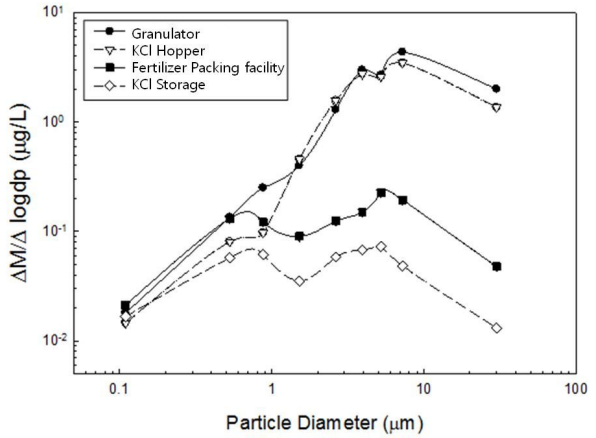

Fig. 2. Size distribution and concentration in fertilizer products industry

The radioactivity concentration values of Ra-228 and Ra-226 of the source material (KCl) in the potassium chloride industry showed below Minimum Detectable Activity (MDA). On the contrary, the radioactivity concentration value of K-40 was high of 16-20 kBq/kg, due to a large amount of potassium. The radioactivity concentration of K_2CO_3 and KOH where KCl is concentrated was higher about 5% than the source material (KCl). Fertilizer A, B products contains 9%, 16% of potassium respectively. Radioactivity concentration of K-40 of fertilizer B was relatively higher than fertilizer A, but it was one quarter of that of the source material (KCl). Average radioactivity concentration of Ra-226 and Ra-228 in Fertilizer A was 8 Bq/kg, 18 Bq/kg, and in fertilizer B was 39 Bq/kg, 19 Bq/kg, respectively.

As a result of the measurement of density and the chemical composition analysis about the particles, the source material (KCl) is composed of K and Cl, and the fertilizer product mainly contained N, P and K.

Importing country of potassium chloride is different from each potassium chloride facility, but the average density of the potassium chloride was about 2 g/cm^3 level equally. The density of K_2CO_3 and KOH which are the final products of chemical products industry were 1.8, 2.2 g/cm^3, respectively. The density of fertilizer products industry was 2.0, 1.8 g/cm^3, respectively. These values are similar to that of the source material (KCl).

Figure 3 shows the shape of airborne particles collected in the chemical products industry. The airborne particles appeared to be spherical in every processing site. Therefore, it is possible to use the value of 1 for the shape factor in the internal radiation dose assessment by inhalation.

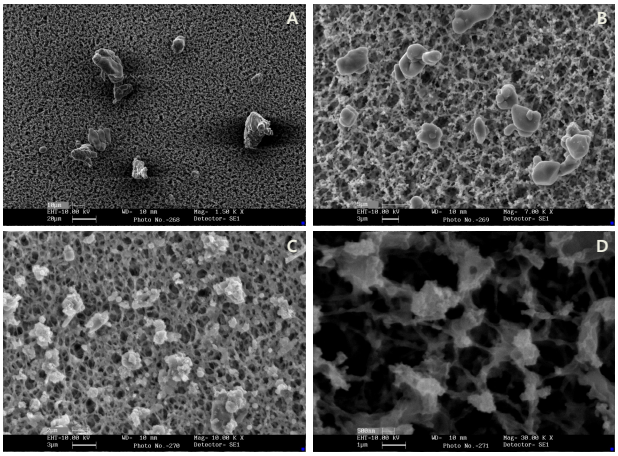

Fig. 3. Shpae of airborne particle in chemical products industry

3. Conclusions

In this study, we evaluated the properties of the particles generated from the potassium chloride industry treating a large amount of materials containing natural radioactive nuclides in Korea. The characteristic valuesof the particles measured will contribute to internal exposure radiation dose assessment by particle inhalation of the workers. Furthermore, it can provide a reasonable means of radiation protection as basic data for establishing a system of natural radiation safety management.

Acknowledgement

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REFERENCES

[1] ICRP, Recommendations of the International Commission on Radiological Protection, ICRP 66; 1994.