Review of Radioactivity Concentration and NORM Management in Phosphate Industry

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1. Introduction

Since 1990s, the possibility of exposure by high concentrations uranium in phosphate deposits has been discussed. Phosphate deposits generally contain naturally occurring radionuclides, including U-238 and Th-232. As a result, exposure of workers may occur in phosphate industries. In addition, exposure of public may occur by products containing the radionuclides.

The IAEA recommended that internal exposure should be considered for safety management of NORM industry workers[1]. Especially, the IAEA emphasized the importance of internal exposure by particle inhalation. The internal exposure of workers is affected by radioactive concentration of substance existed in NORM industry. Therefore, it is necessary to evaluate radioactive concentration for radiation exposure management.

In this study, as part of analysis of the status in NORM industries, the radioactive concentration in domestic and foreign phosphate industries was analyzed. To analyze radioactive concentration for phosphate industry, we investigated case of the IAEA for foreign and Korea Institute of Nuclear Safety (KINS) for domestic. In addition to analyze the NORM management status, the recommendations of the IAEA and the domestic regulatory system were investigated.

2. Radioactive concentration in phosphate industries

2.1 IAEA

The IAEA evaluated 10 major industries related to phosphate industry[2]. Among them, 6 industries related to raw materials and processed products in the domestic act on radiation in natural environment[3]. The 6 related phosphate industries include phosphate ore mining, phosphate production by wet processing, ammonium phosphate fertilizer industry, super phosphate fertilizer industry, nitride phosphate fertilizer industry, and animal feed industry. The IAEA presented U-238 and Th-232 radioactive concentrations by detailed process of each phosphate industry.

The IAEA presents radioactive concentration for each phosphate industry. The radioactive concentrations of U-238 and Th-232 were 0.03 to 3.51 Bq/g and 0.001 to 11.0 Bq/g respectively. The radioactive concentrations of U-238 and Th-232 were shown to represent the maximum value in the hydrochloric acid decomposition process of the phosphate production by wet processing. Table 1 shows the radioactive concentration in phosphate industries suggested by the IAEA.

Table 1: Radioactive concentration of phosphate industries

Industry	Detailed process	Radioactive concentration (Bq/g)	
		U-238	Th-232
Phosphate ore mining	Mining	0.10 – 3.00	0.10 – 0.40
	Dressing	0.20 – 2.50	0.01 – 0.10
	Transporting	0.03 – 0.18	-
Phosphate production by wet processing	Sulfuric acid decomposition	0.10 – 2.60	0.001 – 0.39
	Hydrochloric acid decomposition	< 3.51	< 11.0
Ammonium phosphate fertilizer	MAP, DAP production	0.25 – 2.96	0.003 – 0.30
	Residues management	-	-
Super phosphate fertilizer	SSP production	0.41 – 1.10	-
	TSP production	0.22 – 2.10	-
Nitride phosphate fertilizer	Nitride phosphate fertilizer production	0.26 – 0.40	-
Animal feed	TCP animal feed production	-	-
	MCP-DCP animal feed production	0.06 – 2.47	0.07 – 0.43

2.2 KINS

The KINS evaluated phosphate fertilizer industries[4]. In the evaluation, KINS measured the radioactive concentration contained in major handling substances including phosphorite. Radioactive concentration of U-238, Th-232, U-234, and Th-230 were measured by alpha spectroscopy. And Ra-226, Ra-228, and K-40 were measured by gamma spectroscopy.

The radioactive concentration ranges of U-238 and Th-232 were 0.092 to 0.85 Bq/g and 0.0007 to 0.009 Bq/g, respectively. The radioactive concentrations of U-238 and Th-232 were shown to represent the maximum value in the raw materials. The radioactive concentration of K-40 was shown to represent the maximum value in the products. In addition, the radioactive concentration of all substances evaluated in Korea were less than the criteria for ‘registration’ in Act on protective action guidelines against radiation in the natural environment. Figure 1 shows the radioactive concentration of each substance evaluated by the KINS.

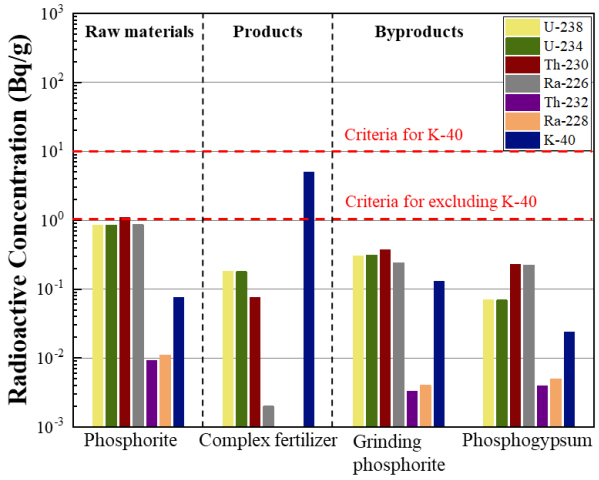

Fig. 1. Radioactive concentration of each substance

3. NORM management in phosphate industries

The IAEA recommended that radioactive concentration of raw materials, byproducts, and residues be concerned for regulatory and safety management of NORM industry. The IAEA recommended that regulations should be considered if the concentrations of U-238 and Th-232 exceed 1 Bq/g and K-40 exceed 10 Bq/g[5]. In Korea, the same radioactive concentration criteria are applied.

The IAEA recommended that the characteristics of process, which are expected to have high radioactive concentrations like tailing and scale, should be reflected for safety management of phosphate industries. In addition, when establishing the regulatory system, it was recommended to apply the graded approach based on the risks in the industry and to regulate by notification, registration and licensing. However, in Korea, there is a single regulation, 'registration' when radioactivity concentration is exceeded criteria and there is no specific guideline on reflection of process characteristics. Table 2 shows comparison of IAEA and domestic NORM management systems about radioactive concentration.

Table 2: Comparison of IAEA and domestic NORM management systems

	Criteria	Safety management measurement
IAEA	· 1 Bq/g (U/Th) · 10 Bq/g (K-40)	· Considering raw material, byproduct and residues · Considering process characteristics · Regulate by notification, registration and licensing
Korea	· 1 Bq/g (U/Th) · 10 Bq/g (K-40)	· Considering raw material, byproduct and residues · Regulate by registration

4. Conclusion

In this study, as part of the analysis of the NORM industries status, radioactive concentration and NORM management status of phosphate industries were investigated. To analyze radioactive concentration for phosphate industry, we investigated case of the IAEA for foreign and KINS for domestic. In addition to analyze the NORM management status, the recommendations of the IAEA and the domestic regulatory system were investigated.

The radioactive concentration of the domestic phosphate industry was lower than foreign countries. However, only the fertilizer production industry was evaluated in Korea. Therefore, additional evaluation like phosphoric acid and animal feed industries is required to understand the current status of the phosphate industry. Moreover, for the additional safety management of NORM industry workers, it is necessary to introduce a guideline that reflects process characteristics and a regulatory system that applies graded approach. The result of this study can be used as a basis for deriving of regulation based on graded approach on the NORM industry.

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