4. Present status on TENORM in Japan

4.1 TENORM Utilization in Japan[8)]

The UNSCEAR 2000 report described the minerals containing NORM and those activities and concentrations. RP-122 also referred to the case where the percentage of the contents of uranium and thorium in the residues or by-products could unintentionally increase through the process of the extraction of useful materials from certain minerals. Furthermore, these minerals are chemically and physically processed and often occur in our living environment as consumer products. For these reasons, on site dose rate measurement and activity concentration analysis as to the industrial application of typical minerals and other materials and some consumer products containing NORM were performed to prepare basic information for developing exemption policies by the Nuclear Safety Division (Office of Nuclear Reactor Regulation and Office of Radiation Regulation) of MEXT.

4.1.1 Industrial Application

The investigation was conducted for monazite, phosphate ore, titanium minerals, bastnasite and zircon as the materials which may contain NORM with relatively high concentration, and coal as the material which is massively imported and which volume reduction is expected through the operation.

The results of analysis were summarized in Table 3. The BSS exemption levels of ^{232}Th and ^{238}U series are 1Bq/g. If we use 1Bq/g as provisional reference criteria for activity concentrations of minerals in raw materials, monazite, phosphate ore, zircon and bastnasite exceed the reference criteria. The phosphate ores only from Jordan and Morocco exceeded the criteria. This reveals that activity concentrations of the minerals vary with the producing countries.

It was found that the dose rate at 1m from the material reaches to several μSv/hr in several cases, due to the adhesion of scales or accumulation of sludge in the operation process. However, in consideration of working time, the annual dose of workers is estimated to be about 0.40mSv at most for the work at a bastnasite product yard. When workers handle raw material powders and other powdery substances, the amount of dust inhaled by the workers are estimated to be small because of they usually wear dust protective masks.

Table 3 Survey Results of Actual State of Application of Minerals including Uranium and Thorium

Mineral	Annual imports (producing countries)	Products (by-products)	Process	Nuclide analysis *4 concentratoin (Bq/g) Sample	^{238}U	^{232}Th	radiation dose rate *5 (μSv/h)	Estimated effective dose (mSv/y)
Monazite	Tens of tons in the past (Vietnam, Malaysia)	Spa bathing element, paint	Sandy monazite is pulverized to use raw materials for health products, paint and spa bathing elements.	Monazite	About 40	About 300*6	Monazite warehouse Surface: 100 (Th concentration 7%) Product fabrication place 1 m: 0.8	0.3 (work at product fabrication place) (Annual working time: About 360 hours, workplace dose rate*7: 0.75 μSv/h)
Phosphate ore	About 0.9 million tons (China, Morocco, Jordan, South Africa, etc.)	Diammonium Hydrogen phosphate (gypsum/ fluorite/ soda silicofluoride)	Phosphate ore is decomposed with the addition of sulfuric acid into phosphoric acid and gypsum. Diammonium hydrogen phosphate is produced by having this phosphoric acid react with ammonium.	Phosphate ore (Jordan)	0.74	0.0078	Phosphate ore warehouse Surface: 0.32-0.46 1 m: 0.19-0.22 Phosphate ore storage Floor surface: 0.26 1m: 0.17 Phosphate ore (Morocco) Surface: 4.6 Product warehouse Surface: 0.05 1m: 0.05	0.28. (Work at phosphateore warehouse) (Annual working time: About 1,600 hours, workplace radiation rose rate*7: 0.18 μSv/h)
				Phosphate ore (Morocco)	1.2	0.0084		
				Phosphate ore (China)	0.10	0.0019		
				Enriched phosphate	0.8	0.0038		
				Diammonium hydrogen phosphate	0.73	0.0044		
Titanium	About 400,000 tons (South Africa, India, Vietnam, Australia, Canada, etc.)	Titanium oxide (Gypsum/ Iron oxide)	Titanium mineral is decomposed with the addition of sulfuric acid, and titanium oxide is then produced after still standing, filtering, baking and drying processes.	Titanium mineral (South Africa)	0.074- 0.44	0.13- 0.16	Raw material minerals yard (South Africa) Surface: 0.20-0.40 1 m: 0.15-0.25 Still standing tank Surface: 0.30 1 m: 0.15 Industrial waste yard Surface: 0.30 1 m: 0.15	0.27(work at minerals yard) (Annual working time: About 1,400 hours, workplace radiation dose rate*7: 0.19 μSv/h)
				Titanium oxide products	0.018	0.0013		
				Industrial waste	0.21	0.23		
Bastnaesite	About 2,000-3,000 tons (USA)	Abrasive	Bastnaesite is crushed with a wet comminutor, and abrasives are produced after filtering, drying, roasting, crushing and classifying processes	Bastnaesite raw materials	1.1	5.8	Raw material yard Surface: 1.9 1 m: 0.6 Raw material input hopper Surface: 2.0 1 m: 0.10 Product yard Surface: 3.6 1 m: 0.88	0.40 (Work at product yard) (Annual working time: About 480 hours, workplace radiation dose rate*7: 0.84 μSv/h)
				Solid separated through a filter	1.0	4.9		
				Abrasive products	1.4	7.1		
Zircon	About 70,000 tons (South Africa, Australia, etc.)	Refractory	Zircon is weighed and firebricks are then produced after mixing, molding, drying and baking processes.	Raw material (zircon sand)	4.2	0.77	Raw material yard (zircon flour for firebricks) Surface: 2.7 1 m: 1.0 80 % zircon-content refractor Surface: 1.8 1 m: 1.2 Waste temporary storage yard 1 m: 0.15	0.14 (Work at product yard) (Annual working time: About 120 hours, workplace radiation dose rate*7: 1.13 μSv/h)
				Firebricks (zircon 100%)	3.5	0.81		
				Dust collected at waste provisional storage yard	0.17	0.037		

Coal	About 155 million tons (Australia, China, Indonesia, Canada, etc.)	Fly ash clinker	When burning coal in a boiler, clinkers and fly ash are collected from the bottom of the boiler and from a dust collector, respectively.	Coal (China)	0.015	0.018	Coal-storage yard Surface: 0.03 1: 0.03 Clinker warehouse Surface: 0.15 1 m: 0.15 Ash disposal Surface: 0.15 1 m: 0.10	0.13 (work at clinker warehouse) (Annual working time: About 1,100 hours, workplace radiation dose rate*7: 0.12 μSv/h)
				Clinker	0.097	0.072		
				Fly ash	0.095	0.091		

(Surveyed by the Nuclear Safety Technology Center and other organizations in fiscal 2003)

*4: The representative concentrations in the sample found in a mineral-by-mineral survey to have relatively high activity concentrations are shown. (2003 Survey by the Office of Nuclear Reactor Regulation, Nuclear Safety Division, Ministry of Education, Culture, Sports, Science and Technology).

*5: The representative dose rates at the points found in a mineral-by-mineral survey to give relatively high dose rates are shown. The figure of 1 m means that the dose rate was measured at a point of 1 m away from a target substance.

*6: The materials are subject to regulation due to that their thorium concentration and quantity exceeds 370 Bq/g and 900 g, respectively.

*7: The dose rate determined by subtracting a background dose rate (measured at a site boundary) from an ambient radiation dose rate at 1 m from a target substance.

4.1.2 Consumer Products

NORM-containing minerals are chemically or physically processed and often used in living environment as consumer products. Table 4 shows several examples of consumer products containing NORM with the results of analysis on activity concentrations.

Table 4 Activity Concentrations in Typical Consumer Products

Sample	Analysis results (activity concentration): (Bq/g)	
	^{238}U	^{232}Th
Radon spa bathing element A	34	270
Ship bottom paint pigment	12	81
Radon spa bathing element B	10	81
Bracelet/necklace (ceramics)	1.7-8.8	12-71
Health appliances (containing powders)	5.4	34
Refractory fire brick	2.9-3.5	0.49-0.57
Muffler catalyst	3.3	210
Clothes (incorporating NORM in fabrics)	1	8.8
Supporter/wristband (incorporating NORM in fabrics)	0.011-0.94	0.093-8.5
Odor-eating paint	0.4-0.82	2.9-5.5
Socks (incorporating NORM in fabrics)	0.7	6.2
Seat (incorporating NORM in fabrics)	0.67	5.4
Shoe socking (containing powders)	0.085-0.42	0.63-6.2
Bedclothes (incorporating NORM in fabrics)	0.043-0.26	0.01-2.3
Abrasive	0.2	0.7
Phosphate fertilizer	0.038-0.073	0.0014-0.0015
Sinter or mineral encrustations left by hot springs	0.00084-0.012	0.00081-0.029

(Surveyed by the Nuclear Safety Technology Center and other organizations in fiscal 2002)

They are utilized for various purposes ranging from the products with which only few people could come in contact such as pigment for painting the bottom of ships and catalyst applied to automobile mufflers to those which people could touch easily such as clothing materials and bedclothes.

As the results of the analysis, some consumer products were found to exceed the BSS exemption level. An external dose represented 110 μSv/y for a radon spa-bathing element, 220 μSv/y for underclothes, 90 μSv/y for bedding clothes (futon), 10 μSv/y for wallpaper. Therefore, the external dose of a person using these consumer products may neither exceed nor reach to 1 mSv/y.

4.2 Japanese Regulation on TENORM

TENORM containing natural nuclides which activity concentration is less than 370 Bq/g is not subject to practical regulation in the current Japanese legislative system. In the process of introduction of the concepts provided in ICRP publication 60 into the Japanese legislative system, the Radiation Council had its General Administrative Group launch to review incorporation of the international basic safety standards of IAEA (BSS) to the legislative system and regulations since April 1999. It submitted the report on "Exemption" to the Radiation Council in October 2002[9)], noting that "exemption of NORM needs to be reviewed in the future based on investigation of their actual use in Japan and international developments." The Radiation Council decided in February 2003 that exemption of NORM would be reviewed by the General Administrative Group. After discussions in the nine meetings, the Group submitted the report in October 2003[8)].

The report describes the results of investigation on status of actual use of NORM in Japan. Various kinds of minerals, monazite, phosphate rock, titanium ore and etc. with radionuclides of Uranium and Thorium series and ^{147}Sm were found to be widely used for industrial purpose. The annual dose to workers handling these materials would not exceed 1 mSv/y. Ship bottom paint and various kinds of health promoting product such as apparatus for artificial hot spring, clothes, bedclothes, etc. were used as consumer products in Japan. The estimated dose of users due to these materials would not exceed 10 μSv/y under normal conditions of use.

The Group discussed concept for future regulation of NORM in Japan. Use of NORM would not be only related to "practice" but also subject to "intervention." NORM out of control in essential (including radiation sources present in the environment such as soil and ^{40}K in the body) should be "excluded" from the scope of regulation. NORM, extending from those with a very low level of radioactivity to those causing significant exposure, are broadly distributed in the general environment and show extensively different ranges of radioactivity concentration. Therefore, it is difficult to regulate them by establishing a uniform exemption level of concentration. Various types of raw materials containing NORM are widely used without awareness of their radioactivity. They would be considered to be existing sources, which would be subject to intervention.

Taking into account these points of view, actual use of NORM should be classified by artificiality or possibility of actual exposure. Then adequate methods of regulation, exemption or intervention exemption may be necessary to be determined in accordance with their characteristics based on the radiation dose. Approaches based on the radiation dose instead of the amount or the concentration should be established. Table 5 shows Classification of NORM. Categories 1, 2 and 3 should be exempted from regulation. Categories 4, 5 and 6 should be newly subject to regulation. Categories 7 and 8 were excluded from consideration of exemption by the General Administrative Group this time.

Table 5 Classification of and Proposed Approaches to Materials Containing NORM

Category (examples)		Exclusion, Practice or Intervention	Regulation by Legislation System	Approaches	Dose Target /Criteria to Take Approaches
1	Raw materials such as mineral ore without procedure of enhancing concentration. (except categories 2, 3, 4, 5 and 6).	Exclusion	Not regulated	—	—
2	Waste rock residues from past mine or industrial activities.	Intervention	Not regulated	Action level will be considered	Examined in the future (1-10 mSv/y)
3	Ash, scale, etc. produced by industries (concentration of substances treated as raw materials should be exemption level or below)	Intervention	Not regulated	Action level will be considered	Examined in the future (1-10 mSv/y)

4.3 Some Events Related to TENORM

Some events related to TENORM were reported in these years. The examples of those events were the waste from uranium mining and milling and titanium residue, the storage of large amount of monazite ore, some consumer products using NORM (air purification device, artificial radon spa) etc. Almost all events were taken up as a scandal by the mass media even in the no illegal case. There could be pointed out the importance of (1) the provision of countermeasure corresponding to the situation and (2) the enlightenment and education of the general public on the knowledge of radiation.

4.3.1 NORM Waste from Uranium Mining and Milling Facility

A reclamation program on waste generated from uranium mining and milling at the Ningyo-toge, Okayama, Japan is being conducted (Fig.3). Related wastes are mainly composed of uranium mill tailings and waste rocks left after a domestic exploitation project from mid 50's to late 80's. Dismantling debris that will be generated from the decommissioning of mining facilities is also expected (Table 6).

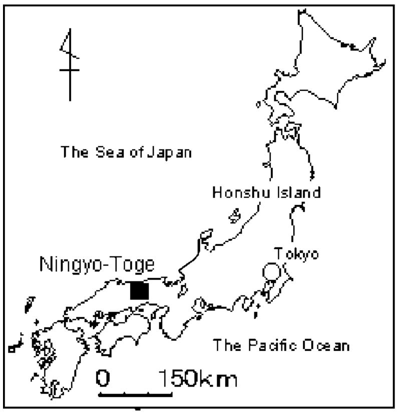

Fig.3 Locality of Ningyo-toge

Table 6 Major characteristic on waste

Waste	Volume	Average U Concentration (Bq/g)	Average ^{226}Ra Concentration (Bq/g)
Waste Rock (17 sites)	ca 200,000 m^3	< 0.09 - 0.42	-
Mill tailings	ca 34,000 m^3	ca 3	ca 16
Heap Leaching Facility [a] (Tank, Valve, Ion Exchange Resin, Concrete, etc)	ca 10,000 drums (estimated)	-	-

a) Demolition of heap leaching facility is now under consideration, therefore waste volume described here is based on estimation.

Radionuclides contained in waste rock are considered to be uranium and its progeny, whereas mill tailings that is residue of ore extracted by sulfuric acid, is depleted in uranium only (relatively rich in ^{226}Ra).

Currently, they are maintained for the purpose of environmental protection including radiological and non-radiological hazard in accordance with the Mine Safety Law (MSL). Regarding radiological hazard, management of these waste is currently controlled by the limit of 1 mSv/a at site boundaries under MSL, and would be also applied a policy regarding exemption of NORM/TENORM formulated by the Radiation Council in 2003. Radionuclides in the waste consist of uranium-series with long half-lives, and require long-term waste management. Measures will be principally carried out with encapsulation in accordance with MSL which is similar to remediation measures on uranium mill tailings and mining sites applied in several countries (Fig.4). The objectives of the site measures are; solids containment, control of radiation exposure, control of radon gas, control of liquids, stability and integrity of site structures. Monitoring and surveillance will be carried out in every phase of the reclamation in order to verify the efficiency of site measures. Management of the site would be maintained under the institutional control.

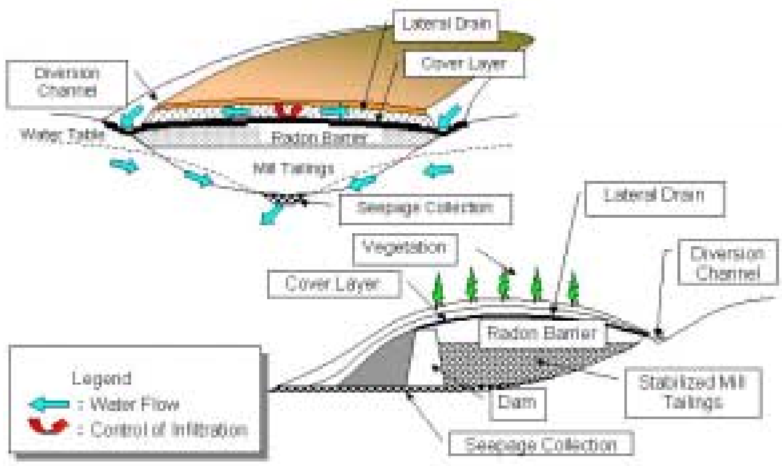

Fig.4 Suppositional measures on uranium mill tailings

Concept of measures has been established with a perspective through safety analysis after a series of discussion at boards consisting of specialists and experts from other organizations. Current phase is the stage to perform various field measurements, laboratory-scale tests and demonstration-scale tests in order to collect data for safety analysis and site designing including analysis to evaluate site stability.

A current topic of the program is on measures of waste rock in the Katamo site, one of 17 yards around the Ningyo-toge (Fig.5). Following a decision of the Supreme Court, it is required to displace waste rock from the yard, which was estimated about 3,000 m^3 according to an agreement between a local community and the Power Reactor and Nuclear Fuel Development Corporation, former JNC, in 1990. Radioactivity of the waste rock is equivalent to the part of higher than 0.3 μSv/h. Suppositional measures would be displacement and disposal in an inclined shaft or a shaft with plugging. The site and methodology for disposal does not come to an agreement with interested parties i.e. local communities and/or local governments, and JNC due to difference of their opinions.

Fig.5 Waste rock yard with relatively high radioactivity
The lower right portion shows a hole left after illegal and compelling displacement of waste rocks in a flexible container by a citizen's group

4.3.2 Storage of Large amount of Monazite Ore

The existence of the monazite ore was clarified in June, 2000 by the investigation of the police in several places in the country starting with the fact that suspicious mails which enclosed the powder of the monazite ore had been sent to the official residence etc.

Science and Technology Agency (STA, present MEXT) received the report from the police, investigated the situation of its storage on each site, confirmed safety, and guided the owner to manage it appropriately.

The surface dose rates of the container and the door in the building in which the monazite ore was put were several tens μSv/h at the maximum, and some of the monazite ore contained the thorium weighing more than 100kg, which needed the written report of use as the nuclear source material.

The whole picture of the monazite and the intention of the use by the owner was confirmed by the investigation, and the written report of the use of the monazite ore in two places as the nuclear source material was performed.

In response to the above-mentioned problem, STA reported on "Appropriate management of the radioactive materials" including the following contents at the end of 2000.

- The appropriate united system on the management of the nuclear source materials that aren't used for energy with the management of other radioisotopes is to be examined in the future from the viewpoint of the prevention from radiation hazard.
- The clarification of the exclusion and the exemption of the material with low dose level from regulatory control is to be aimed at as maintenance of the standard concerning the radioactive materials to be controlled based on the international discussion.

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