Materials and Associated Consumer Products

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Introduction

- Naturally Occurring Radioactive materials (NORM) and associated consumer products have been identified as a source of radiation exposure to human health throughout their life cycle, during processing and production, transportation, use and miss-use stages and after disposal.
- Different studies have also been conducted worldwide to evaluate their radiological effects throughout their life cycle, however, in Korea the radiological information during their transportation is still limited.
- Therefore, this study has been conducted purposely to fill this information gap and providing necessary information in the radiological consequences and risk data bases that can be used to protect people and environment.

Objective

- The objective of this study is to evaluate the dose and risk to the public during transport accident of NORM and associated consumer products through road transport mode

Material and Methods

Accident Scenario

- The accidents occurred in 12 route segments along the expressway connecting Seoul and Gyeongju city
- NORM and NORM-consumer products were transported in bulk in shipping container with loading capacity of 21tons
- ^{238}U, ^{232}Th, and ^{40}K are radionuclides contents released during accident with fraction of 0.1% of the total NORM and associated consumer products
- Aerosol and respirable fractions were both set to 1 and ground deposition of released radionuclide is 0.01m/s for conservatism.
- Sensitivity analysis was conducted by considering variation of release, aerosol, and respirable fractions at 0.1%, 1%, 10% and 100%, respectively.

Employed computer codes

- **MicroShield** was used to estimated the dose rate at 1 m form the transported shipment which serve as an input to RADRAN Code.
- **RADTRAN** was used to estimate the dose and risk based during transport accident scenario

Meteorological data

WRPLOT view freeware 8.0.2 was employed to analyze the data for a period of 10 years, from 2010 to 2020, as presented in Figures 1. The dominant wind direction with an average speed of 2.4 m/s is from the West (W) to East (E) direction and the West North West (WNW) to East South East (ESE) direction

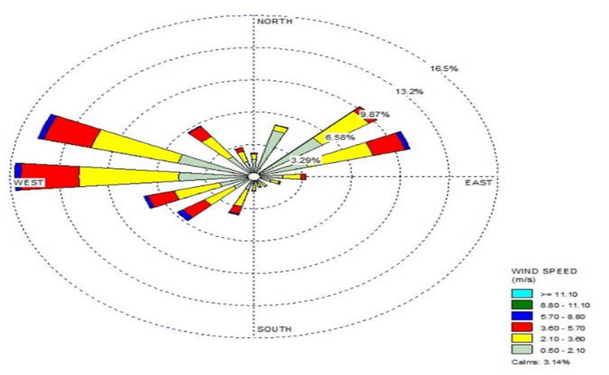

Figure 1: Windrose diagram showing wind speed and direction for Seoul

Input data

Table I. Radiological input data used in RADTRAN code

Items	^{238}U (Bq)	^{232}Th (Bq)	^{40}K (Bq)	Dose rate at 1m (Sv/hr)
Monazite	3.41×10^{7}	3.41×10^{9}	3.04×10^{5}	1.36×10^{-13}
Necklace	9.66×10^{6}	7.22×10^{7}	8.50×10^{5}	3.79×10^{-13}

Table II. Route segments and physical input data

Link name	Length(km)	Speed (km/hr)	Population density (Persons/ km^2)	Rate of fire accident (occurrence/km-car)	Road type
Link_1	16.6	110	22,6654	$6.58\text{x}10^{-14}$	Highway
Link_2	48.7	110	6,906	$9.39\text{x}10^{-14}$	Highway
Link_3	30.9	110	328	$2.39\text{x}10^{-13}$	Highway
Link_4	46.5	110	4,345	$2.30\text{x}10^{-13}$	Highway
Link_5	22.9	110	4,345	$1.12\text{x}10^{-13}$	Highway
Link_6	32.5	110	3,024	$4.32\text{x}10^{-14}$	Highway
Link_7	35.7	110	100	$6.14\text{x}10^{-14}$	Highway
Link_8	30.3	110	136	$5.28\ 10^{-14}$	Highway
Link_9	32.4	110	686	$1.10\text{x}10^{-13}$	Highway
Link_10	37.3	110	4,813	$7.89\text{x}10^{-14}$	Highway
Link_11	45	110	614	$1.00\text{x}10^{-13}$	Highway
Link_12	37	80	204	$3.03\text{x}10^{-12}$	Secondary road

Results and Discussion

Transport accident results

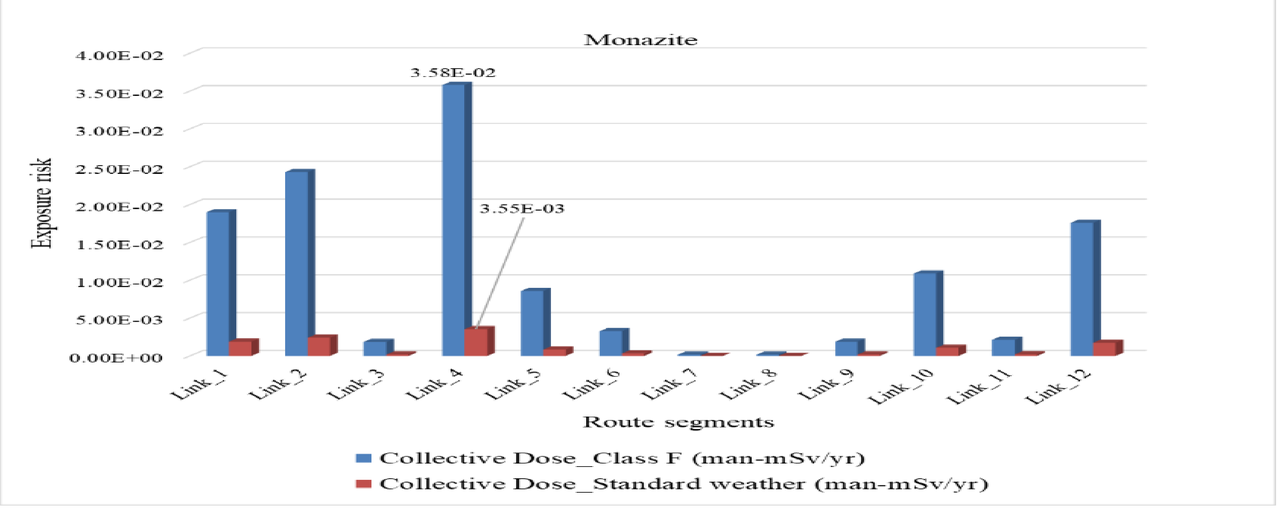

Figure 2: Transport accident result of Monazite (NORM)

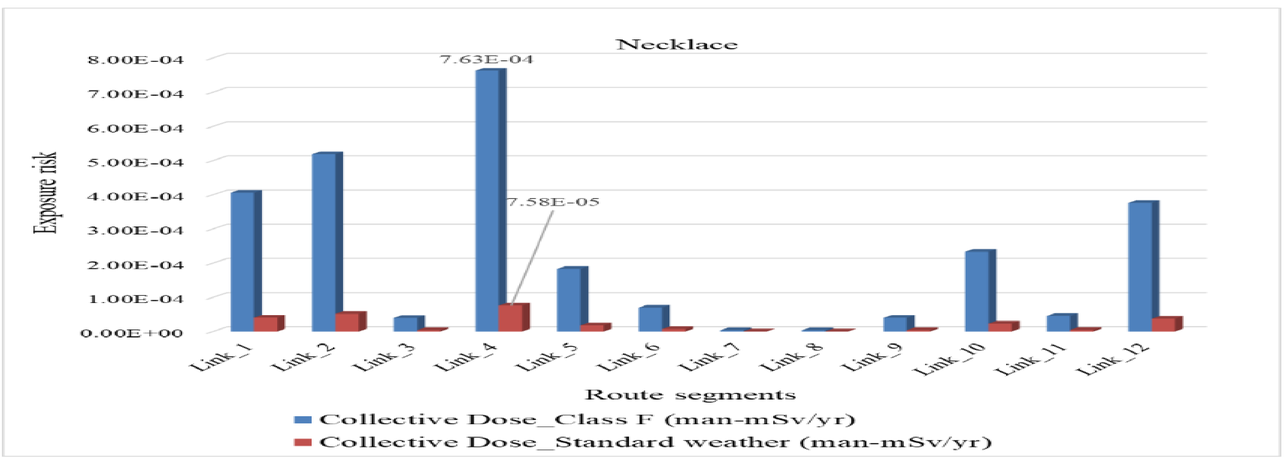

Figure 3: Transport accident result of Necklace (Consumer products)

Sensitivity analysis results

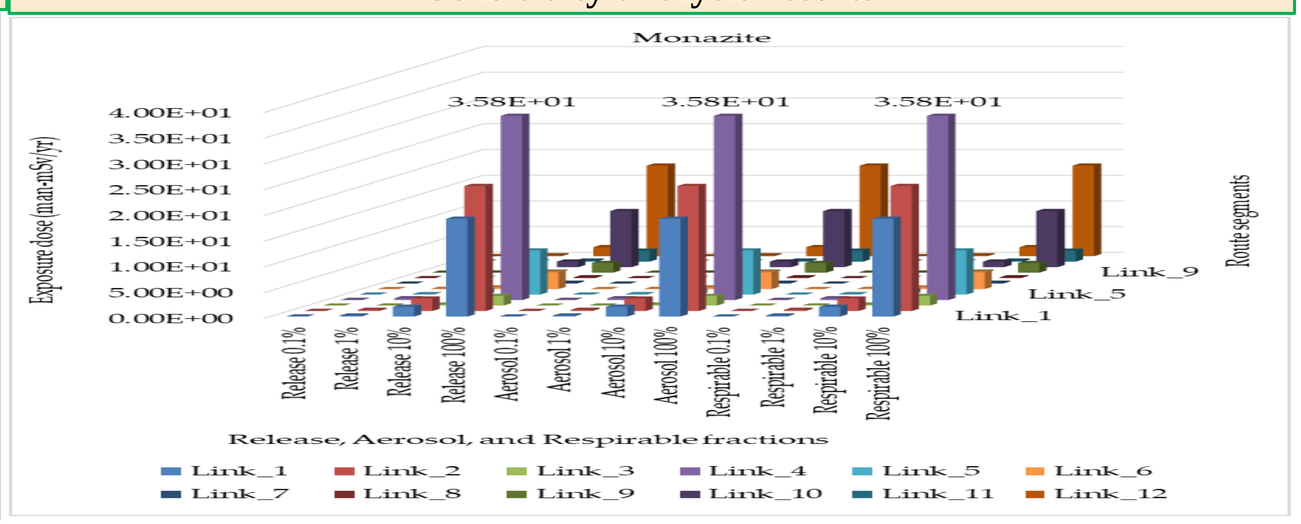

Figure 4: Sensitivity analysis result of Monazite (NORM)

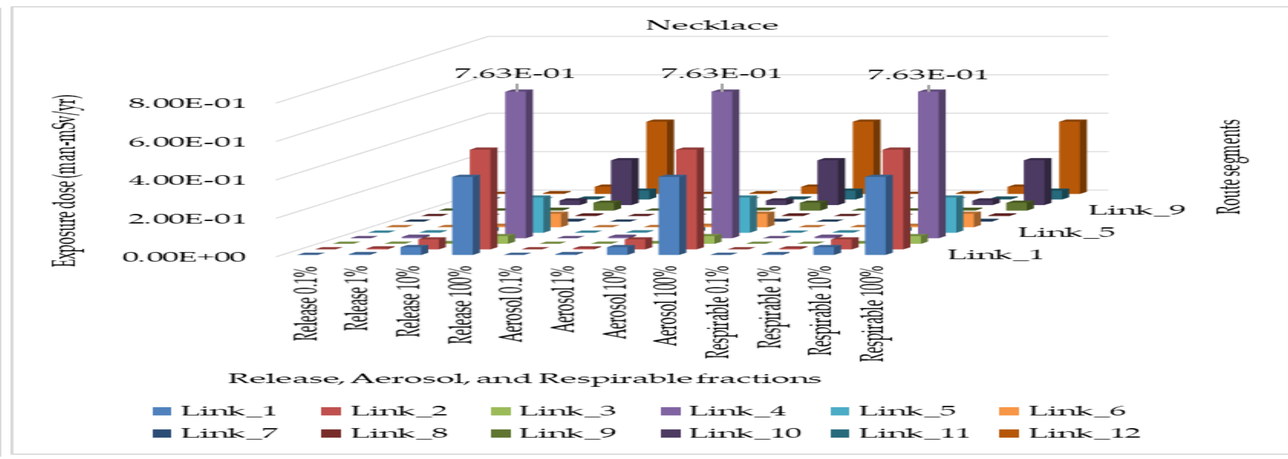

Figure 5: Sensitivity analysis result of Necklace (Consumer products)

- Figure 2 and 3 present that, the highest exposure risks were observed at link-4 of all other links due to higher accident probability. However, link-3 and 12 have higher accident probability than link-4 but their population density and number exposed in individuals are lower than that of link-4 resulting to a lower exposure risks compared to link-4. The accident probability, conditional probability, dispersion of radionuclides and package response are factors that affect the risks of exposure.

- Figure 4 and 5 also indicate that, the results of sensitivity at maximum exposure risks were also below the recommended regulatory limits of 1 man-Sv/year (1000 man-mSv/year).

Conclusion

- The results of public exposure dose and risk were insignificantly far below the annual regulatory limits of 1man-Sv which is recommended by International Atomic Energy Agency (IAEA) transport regulation 2018.
- Sensitivity analysis results also indicated insignificant population exposure dose below the recommended dose limits.
- The dominant wing direction is towards East (E) and East South East (ESE). Therefore, dwellers in the directions of the E and ESE are likely to be more exposed to radionuclides released during the accident scenario.
- Conclusively, safety can be secured during transport accident involving NORM (Monazite) and consumer products containing (Necklace).