The On-site Dose Assessment Using a Nuclide Recognizing Prompt Radiation Distribution Monitoring System

Uk Jae. Lee*, Dong Han. Yoo, Hee Reyoung. Kim
Ulsan National Institute of Science and Technology, Banyeon-ri, Eonyang-eup, Ulju-gun, Ulsan, Korea
*Corresponding author:dldnrwp@unist.ac.kr

1. Introduction

Nuclide Recognizing Prompt Radiation Distribution Monitoring System, which has been developed since 2012 [1,2], has the function that visualize distribution of radiation level as 2D and 3D contour map on the map image of the measured area. In the emergency situation such as nuclear or radiation accidents, the effective dose assessment should be carried out as quickly as possible for the public health. In this study, the fundamental method for assessing the effective dose promptly by using the measured radiation values by the Nuclide Recognizing Prompt Radiation Distribution Monitoring System. External and internal exposure scenario in the specific situation is considered, and the calculation of the committed effective dose is suggested for determining whether it is safe or not.

2. Methods and Results

In this section concept and some processes to make 'The On-site Dose Assessment Using a Nuclide Recognizing Prompt Radiation Distribution Monitoring System' are included. Concept of system, generating exposure scenario, calculation formula for equivalent dose and application to calculation formula are in this section.

2.1 Concept of System

This system is based on existing system which is 'Nuclide Recognizing Prompt Radiation Distribution Monitoring System' [1,2]. The concept of this system is shown in Fig. 1.

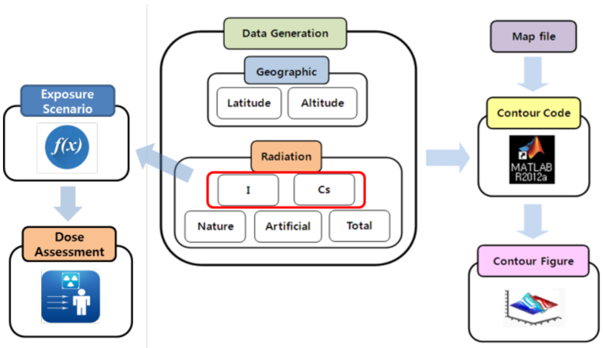

Fig. 1. Conceptual diagram of 'The On-site Dose Assessment Using a Nuclide Recognizing Prompt Radiation Distribution Monitoring System'

When the system is operated, user can check the distribution of radiation and also the result of dose assessment in real time based on real detected data.

2.2 Generating Exposure Scenario

Before dose assessment, generating exposure scenario is essential process because there are many factors which can affect to radiation dose. Such as kind of radionuclide, exposure time and so on. So suppose some exposure situation like experiment in laboratory and nuclear accident

2.3 Calculation Formula for Equivalent Dose

The case of internal exposure, accumulation dose must be considered because radionuclides cause radiation exposure in body after intake as time goes by. Then committed dose equivalent can be the way to do dose assessment. The 50-year committed dose equivalent to a target T after deposition of 1 Bq can be calculated with Eq. (1)[3]

$$H_{50,T} = \frac{1.6 \times 10^{-13} \times \sum_j \frac{A_{Sj}}{\lambda_{Ej}} \times SEE(T \leftarrow S) \frac{MeV}{t/Kg}}{1 \frac{J/Kg}{Gy}} \quad (1)$$

$H_{50,T}(T \leftarrow S)$: The 50-year committed dose equivalent
A_{Sj} : Activity deposited of compartment j
λ_{Ej} : Effective clearance constant of compartment j
$SEE(T \leftarrow S)$: The specific effective energy absorbed per gram of target tissue from each radiation, R, emitted from activity in the source organ.

Also $SEE(T \leftarrow S)$ can be calculated by Eq.(2)

$$SEE(T \leftarrow S) = \sum_R \frac{Y_R \frac{particles}{trns.} \times (E \times w_r) \frac{effectiveMeV}{particle}}{m_T Kg} \times 1.6 \times 10^{-13} \frac{J}{MeV} \times AF(T \leftarrow S)_R \times \frac{\frac{1Sv}{eff.J}}{trans} = \frac{Sv}{trans} \quad (2)$$

Y_R : The fractional yield
w_r : Radiation weighting factor
$AF(T \leftarrow S)_R$: The absorbed fraction from radiation R

m_T : Mass of T

Also we can get committed effective dose equivalent by multiply intake and dose coefficient. Dose coefficients are can be checked at Table. I.[3]

Table I: Dose Coefficients for Selected Radionuclides

Radionuclide	**Path**	**Target**	**Dose coefficient (Sv/Bq)**
^{3}H	Respiration	Body	$1.73\text{x}10^{-11}$
^{32}P	Ingestion	Red Marrow	$8.09\text{x}10^{-9}$
^{32}P	Ingestion	Body	$2.37\text{x}10^{-9}$
$^{90}Sr\_^{90}Y/D(F)$	Respiration	Bone	$7.27\text{x}10^{-7}$
$^{90}Sr\_^{90}Y/D(F)$	Respiration	Body	$6.47\text{x}10^{-8}$
$^{137}Cs/D(F)$	Respiration	Body	$8.63\text{x}10^{-9}$
^{137}Cs	Ingestion	Body	$1.35\text{x}10^{-8}$
^{226}Ra	Ingestion	Bone	$6.83\text{x}10^{-6}$
$^{239}Pu/W(M)$	Respiration	Bone	$2.11\text{x}10^{-3}$

2.4 Application to Calculation Formula

Some information is needed to do a dose assessment such as kind of radionuclide, exposure scenario, the type of human and so on. So some assumption is considered. The condition of exposure is 'Adult man inhales only radionuclide ^{137}Cs rapidly' and the value of dose rate is 0.660μSv/h' like Fig.2.

Fig. 2. The result screen of radionuclide (^{197}Cs) recognized

Two types of exposure are considered. These are external and internal exposure. The case of external exposure dose assessment can be calculated easily by multiplying dose rate and exposure time. Next case is internal exposure. Before doing the internal dose assessment, the radioactivity value which is about the amount of intake is needed. It can be calculated by unit translation, disintegration energy (0.661MeV/decay in case of ^{137}Cs) and so on. So the value of intake radioactivity is $1.74\times 10^{6}\ Bq$ in this assumption case. Finally committed effective dose is calculated by multiplying intake of radioactivity and effective dose coefficient. In this case the value of effective dose coefficient is 4.6×10^{-9} Sv/Bq[3]. Finally the result of internal dose assessment of this case is $8.0\times 10^{-3}\ Sv$.

3. Conclusions

This study is about dose assessment by using exposure scenario and radioactivity about each radionuclide data from detector. If there is a region that has high value of radiation in the result of 'Development of Nuclide Recognizing Prompt Radiation Distribution Monitoring System', dose assessment can provide the way to determine the safety of the region. This process is can be operated quickly with the measured data. It is thought 'The On-site Dose Assessment Using a Nuclide Recognizing Prompt Radiation Distribution Monitoring System' is applicable to response to the emergency situation such as radiation accidents. More study about exposure scenario is needed to apply many cases of condition.

REFERENCES

[1] Uk Jae. Lee*, Dong Han. Yoo, Hee Reyoung. Kim, The Nuclide Recognizing Prompt Radiation Distribution Monitoring System, Korean Nuclear Society, 2013.
[2] Uk Jae. Lee*, Dong Han. Yoo, Hee Reyoung. Kim, Development of Nuclide Recognizing Prompt Radiation Distribution Monitoring System, Korean Nuclear Society, 2014.
[3] Herman Cember et. al. , "Introduction to Health Physics", 2009
[4] ICRP Publication 119,"Compendium of Dose Coefficients based on ICRP Publication 60", 2012
[5]ICRP Publication 66, "Human Respiratory Tract Model for Radiological Protection", 1994