Environmental Gamma Distribution of Ulsan City with the Highest Nuclear Power Plant Density in Korea

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1. Introduction

A system that can quickly check the distribution of radiation based on a mobile instrument was developed. The developed system was applied to the Ulsan area, which has the highest density of nuclear power plants. The nearby site of Ulsan's major non-destructive testing facility and radioactive material treating industry are scanned and the radiation dose rate distribution was measured. In addition, hospitals, transportation points such as airports, bus terminals and train stations, residential areas and three commercial areas were measured and compared. In this validation, the system was able to detect unexpected hot spots quickly in the affected environments.

2. Methods

2.1 Concept of system

The proposed system is consisted of the hardware of a detector for gamma spectrometry and the radiation dose measurement leading to radiation level distribution display at the laptop/desktop along with the software of the radiation information mapping program. The contour mapping program, which enables radiation level distribution displayed in 2D and 3D by one click of mouse right after the scanning of the corresponding area by the portable gamma radiation detector was finished and was composed by using the commercial software of MATLAB. The simultaneous display at both laptops of the on-site measurement and desktop at the main office is implemented by data transmission using CDMA method.

2.2 Monitoring sites

The major non-destructive testing industries and radioisotope treatment industries in Ulsan city were selected for validation of the rapid radiation distribution display system. In addition, three hospitals, three transportation hubs including an airport, bus terminal and train station, three apartment complexes, and three commercial areas were also measured for comparison. Scanning around each industrial site was performed in a vehicle with the installed system. The information on latitude, longitude, and radiation dose rate were obtained through actual measurements and used as data sets for the radiation contour mapping.

3. Results and Discussion

The system was tested and its performance was evaluated by applying it to environmental radiation monitoring in Ulsan city.

3.1 Quick contour mapping program for radiation distribution

Fig. 1 shows the result of contour mapping program for radiation distributions. The figures verify that the radiation distributions were shown in the 2D and 3D contour maps with geographical information.

The laptop used for this validation had an Intel® core i7-3537U CPU, 2.00 GHz processor, and 8 GB of memory; the time required by the proposed system’s code using the “Profiler” function in MATLAB. The time required to generate the radiation distribution contours immediately after the measurement was approximately 11 s to process 10,000 data items whereas existing techniques for radiation distribution monitoring require more than 1h.

The designed monitoring system finds contamination by comparing detected radiation data with those of neighboring points; hence, this system can be used to find radiation hotspots. Therefore, the developed monitoring system could be efficiently used when such hotspots need to be detected quickly, such as during a radiation emergency or at a large site, including D&D sites.

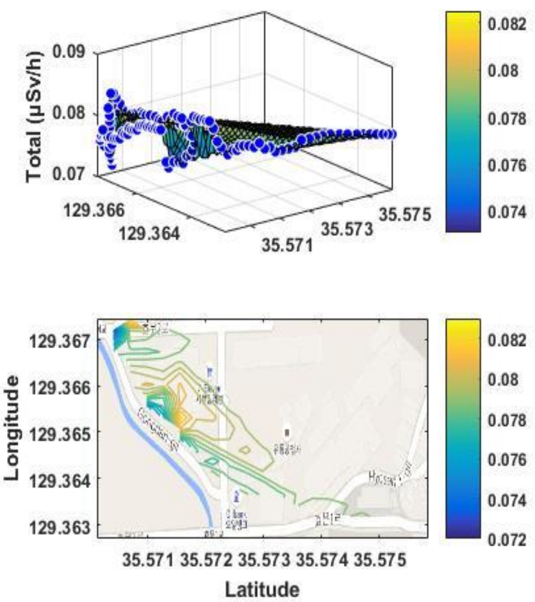

Fig. 1. The result of contour mapping program for radiation distributions.

3.2 Application to environmental radiation monitoring of Ulsan city

The radiation distribution measured for specified areas, including industrial facilities, hospitals, transportation hubs, and residential regions in Ulsan city can be checked in Table 1. It shows the maximum, minimum, and mean values of radiation dose distributions for each type of location.

The scanning of 17 sites around Ulsan city showed radiation levels ranging between 0.065–0.163 μSv/h, which are within the normal environmental level in Korea, demonstrating that Ulsan city is safe in terms of its radiation environment. The proposed Nuclide Recognizing Rapid Environmental Radiation Distribution Monitoring System could be directly applied to in-situ hotspot detection in the vast areas subject to D&D of NPPs. The system could also be effectively used in conjunction with drone technology to scan radioactive contamination in both rural and urban environments after a nuclear disaster.

4. Conclusion

Real measurement-based quick radiation distribution monitoring system with radionuclide recognition was established by employing the fundamental concept of combining detector-based hardware and MATLAB. The scanning of 17 sites of Ulsan city showed the radiation level had a range of 0.065 ~ 0.163 μSv/h falling on normal environmental level of Korea. It was demonstrated the Ulsan city were kept safe in terms of radiation environment from the measurement by using Nuclide Recognizing Rapid Environmental Radiation Distribution Monitoring System.

Table 1. Minimum, maximum and mean value of detected data at each monitoring point

Monitoring Site		Maximum (μSv/h)	Minimum (μSv/h)	Mean (μSv/h)
Industry	A	0.0830	0.0720	0.0779
	B	0.0930	0.0720	0.0821
	C	0.1220	0.0820	0.0963
	D	0.0833	0.0720	0.0776
	E	0.0980	0.0710	0.0803
Hospital	A	0.096	0.079	0.088
	B	0.110	0.077	0.086
	C	0.163	0.072	0.088
Market	A	0.092	0.065	0.079
	B	0.103	0.07	0.082
	C	0.100	0.086	0.094
Bus terminal		0.093	0.07	0.079
Airport		0.079	0.067	0.072
Train station		0.078	0.062	0.07
Apartment	A	0.087	0.074	0.078
	B	0.091	0.072	0.079
	C	0.099	0.081	0.093

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