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SITE-SPECIFIC ATMOSPHERIC DISPERSION CHARACTERISTICS OF KOREAN NUCLEAR POWER PLANT SITES

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Abstract - Site-specific atmospheric dispersion characteristics have been analyzed. The northwest and the southwest wind prevail on nuclear sites of Korea. The annual isobaric surface averaged for twenty years around Korean peninsula shows that west wind prevails. The prevailing west wind is profitable in the viewpoint of radiation protection because three of four nuclear sites are located in the east side. Large scale field tracer experiments over nuclear sites have been conducted for the purpose of analyzing the atmospheric dispersion characteristics and validating a real-time atmospheric dispersion and dose assessment system FADAS. To analyze the site-specific atmospheric dispersion characteristics is essential for making effective countermeasures against a nuclear emergency.

INTRODUCTION

Emergency planning is one part of the defense in depth for minimizing the radiological consequences resulting from a nuclear accident[1]. In Korea, a national computerized technical advisory system for radiological emergency (CARE) has been used to diagnose plant safety, estimate atmospheric dispersion of radioactive materials released into the environment and assess the projected radiation doses to the public on a real-time base[2]. A real-time dose assessment system named FADAS has been applied to CARE for providing the functions of atmospheric dispersion and estimation of radiation doses[3].

To estimate the trajectory of the released radioactive materials and the following radiological exposure dose is important in nuclear emergency preparedness. Dispersion of the radioactive materials in the atmosphere depends on the environmental conditions such as meteorology and geography. For the realistic calculation of atmospheric dispersion and radiation doses resulting from a nuclear accident, it is necessary to generate a realistic wind field considering the environmental conditions. It would only be possible if the whole environment could be accurately described and modeled. Field tracer experiments over nuclear sites have been carried out for the purpose of analyzing the site-specific atmospheric dispersion characteristics and improving the accuracy of the atmospheric dispersion module of FADAS. A tracer gas SF6 was released and the sampled gas was analyzed using gas chromatography. During the experiments, meteorological data were measured on several points using measuring equipment such as SODAR, portable systems and Air Sonde.

In this paper, the atmospheric dispersion characteristics of Korean nuclear sites were analyzed with the meteorological conditions and the results obtained through the field tracer experiments over nuclear sites. Annual isobaric surface of Korean peninsular and the wind roses of nuclear sites were analyzed to investigate the atmospheric dispersion characteristics.

SITE CHARACTERISTICS AND RADIATION PROTECTION

1. General Description of Meteorology

Korea is located in the mid-latitude of the northern hemisphere and belongs to the temperate zone in which four distinct seasons can be enjoyed. In the spring, migratory high pressure systems from China often remain in Korea, yielding mild but somewhat dry weather. In the summer, the polar front formed between the Northern Pacific High Pressure and Okhostsk Sea High Pressure, and after mid-June the rainy season begins. In the autumn, the precipitation suddenly drops and the dry season begins. In the winter, the bitterly cold northwest monsoon covers the mountainous regions, sometimes the entire peninsula.

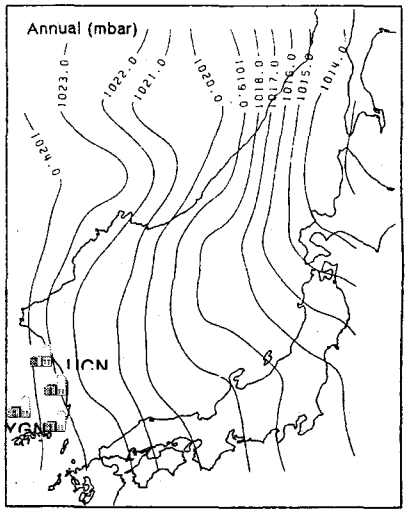

Fig. 1. Annual Isobaric Surface around Korean Peninsular.

Winds are distinguishable to the season, usually the northwest monsoon prevails in the winter and the southwest monsoon in the summer. Fig. 1 represents the annual isobaric surface averaged for twenty years around Korean peninsula. This figure shows that west winds prevail[4].

There are four nuclear sites in Korea. Three sites are located in the east side and only Younggwang nuclear (YGN) site is located in west side. The distribution of wind directions is important in the viewpoint of radiation protection. Annual wind rose of YGN and Ulchin nuclear (UCN) site are shown in Fig 2 and Fig 3, respectively. Fig. 2 shows the prevailing winds are from the northwest and southwest in YGN site[5]. In case of UCN site, the prevailing wind blows from northwest. The seasonal averaged wind speeds on the UCN site are 3.8 m/sec in spring, 2.8 m/sec in summer, 3.1 m/sec in autumn and 4.1 m/sec in winter. The annual average wind speed on UCN site is 3.5 m/sec[6].

The wind roses obtained on nuclear sites agree with the annual isobaric surface around Korean peninsula shown in Fig. 1. It is considered that the site-characteristics of the three nuclear sites located in east side is better than YGN site in the viewpoint of radiation protection.

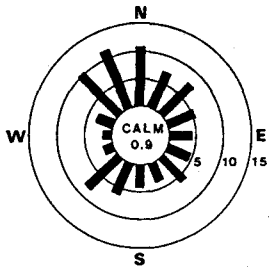

Fig. 2. Wind Rose of YGN site

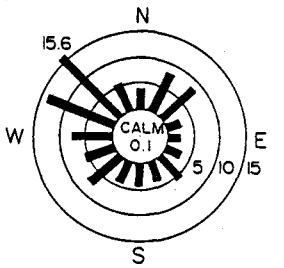

Fig. 3. Wind Rose of UCN site.

2. Field Tracer Experiments over Nuclear Sites

Field Tracer experiments have been carried out over nuclear sites for the purpose of analyzing the site-specific atmospheric dispersion characteristics. In these experiments, sulfur hexafluoride (SF6) which is an extremely stable atmospheric tracer gas was used as a tracer gas[7]. Release rate

of the tracer gas was designed considering the background concentration of SF6 in the atmosphere and the detection limit of the gas chromatography. Before the release of the tracer, automatic gas samplers with which 12 time interval sampling is possible were distributed along the sampling points along the roads. Fig. 4 shows the sampling points along two arc roads around Kori site. During the experiment, meteorological data were measured on several points using measuring equipments such as SODAR, portable systems and Air Sonde. The measured data were analyzed to be used as the input data of a real-time dose assessment system FADAS for comparative studies between the simulated and the measured concentration distributions. Fig. 5 shows the scene of measuring wind data with portable wind system NOVA and sampling the tracer gas with a sampler at a sampling point. The sampled gas was analyzed using a gas chromatograph.

3. Current Status of Emergency Preparedness System

A national emergency plan is necessary to protect the environment against a nuclear emergency. In Korea, radiological emergency planning is based on the Civil Defense Plan, and Korea Institute of Nuclear Safety (KINS) is a competent body in which the Emergency Technical Advisory Center (ETAC) is established in emergency[1]. A national Computerized technical Advisory system for the Radiological Emergency (CARE) has been developed as a basic technical tool for ETAC.

A real-time atmospheric dispersion and radiological dose assessment system named FADAS (Following Accident Dose Assessment System) has been developed [2]. FADAS is composed of three main modules. A mass-consistent wind field module was adopted for the generation of a wind field over the whole domain using several measured wind data. A random-walk dispersion module is used for the calculation of the distribution of radionuclides in the atmosphere. Also a volume-equivalent numerical integration method was developed for the assessment of external gamma exposure given from randomly distributed radioactive materials, and a dose data library has been made for rapid calculation.

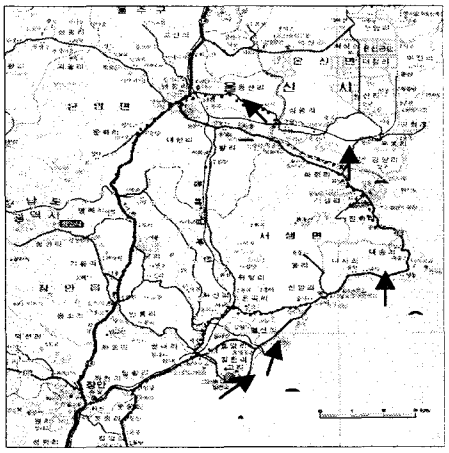

Fig. 4. Tracer Sampling Points around Kori site.

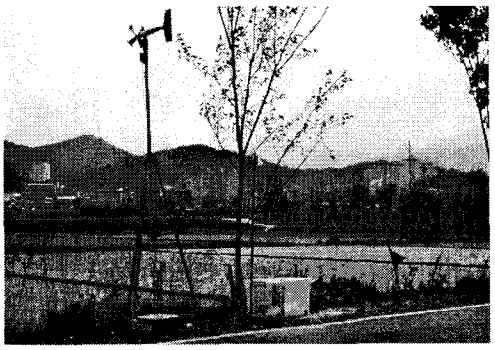

Fig. 5. Tracer Sampling and Wind Measurement.

FADAS has been used as a basic tool for providing the function of the atmospheric diffusion and the radiological dose assessment to CARE system since 1995. Figs 6 and 7 show the generated wind fields and the estimated radiological dose using in CARE, respectively.

RESULTS AND DISCUSSIONS

The tracer experiment over YGN site was conducted in 1996. Fig. 8 shows the geography and sampling points around YGN site. The site is located in west side and terrain around the site is flat compared to the sites in east side. The sampling points were selected along two

arc lines along the roads on the east side with the radius of about 3km(A-line) and 8km(B-line). For the comparative study between the measured and the simulated concentration distribution with FADAS, a three dimensional wind field was generated over the domain of 15 x 20 km2 in X-Y plane, and 990 m in vertical direction. The domain was considered to be consisted of the cell with the size of $\triangle x = \triangle y = 1$ km, and $\triangle z = 30$ m. Fig. 9 represents the concentration distributions along A-line obtained by both the measured and the simulated with FADAS. During the experiment, wind blew from the west consistently. The angles in which the maximum concentration is represented are in quite good agreement between the measured and the simulated distributions. The concentration distributions along B-line is also similar to Fig. 8. The overall ratios between the measured and simulated results for the experiments over YGN site are about factor of 3. It is quite good agreement between the measured and the simulated concentration. It is considered that the good agreement is due to the realistic simulation of wind field over flat terrain of YGN site. But the experiments conducted on UCN and Wolsung nuclear (WSN) site did not show the good agreement like as in YGN site. The terrain around UCN and WSN sites is much more complex than that of YGN site.

Kori is a special site in the viewpoint of atmospheric dispersion. As shown in Fig. 4, Kori site (Point A) is located at the bottom of protrusion. So it is surrounded by sea in three sides except north side. The tracer experiments on Kori site were performed in 2000 and 2001. Simulation of the experiment is going to be made in the second half of 2001. Five points in Fig. 4 represent the measuring points of wind data with the portable wind system NOVA and the arrows represent the wind direction measured at the same time. At the release point, wind blows to north east and it is considered that the tracer gas is to be released to the East Sea. But the arrows measured at the other points show different wind directions. Therefore, it is necessary to generate the wind field carefully over Kori site.

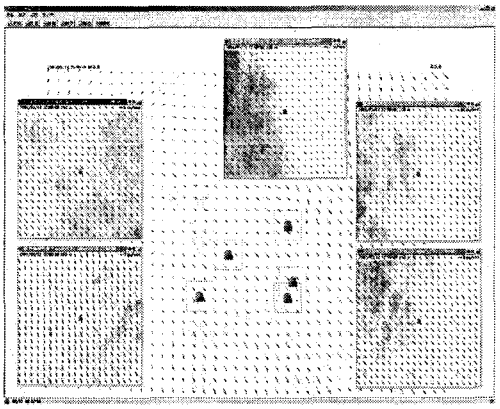

Fig. 6. Wind Fields Generation using FADAS in CARE.

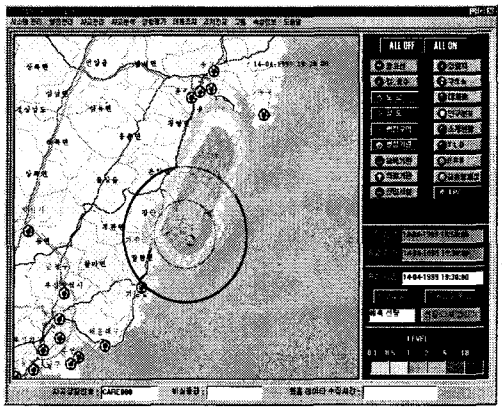

Fig. 7. Radiation Dose Estimation Around Kori

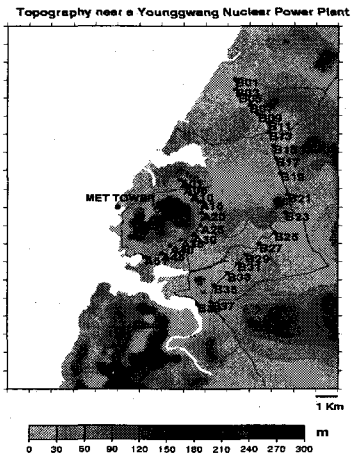

Fig. 8. Sampling Points Around YGN site.

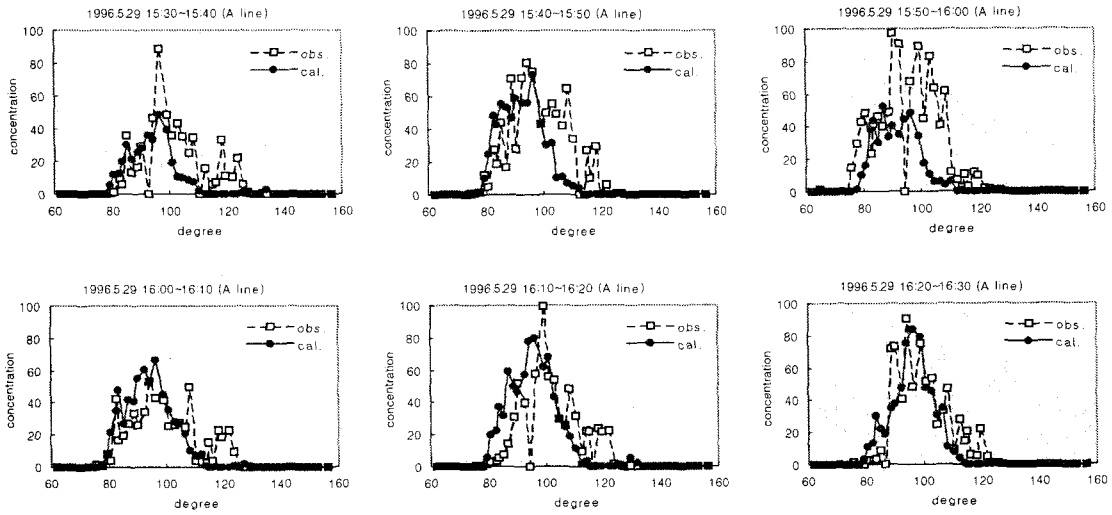

Fig. 9. Concentration Distribution along A-line in YGN site.

CONCLUSIONS

The distribution of the wind direction is important in the viewpoint of radiation protection. The prevailing winds of Korea has been investigated. The northwest monsoon prevails in the winter and the southwest monsoon in the summer. Twenty years averaged annual isobaric surface around Korean peninsula shows that west winds prevail. The wind roses of nuclear sites also show that west winds prevail. The prevailing west winds are profitable in the viewpoint of radiation protection because three of the four nuclear sites are located in east side.

For the purpose of analyzing the site-specific atmospheric dispersion characteristics, field tracer experiments over nuclear sites have been conducted. The measured atmospheric concentration distribution was compared with the simulated distribution by a real-time radiological dose assessment system FADAS. The comparative studies show that the experiments performed on flat terrain gives a good agreement between the measured and the simulated concentration distributions. Kori is a special site in the viewpoint of atmospheric dispersion because it is located at the bottom of protrusion. To analyze the site-specific specific atmospheric dispersion characteristics is essential for making effective countermeasures against a nuclear emergency.

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