Effect of Ground Surface Roughness on Atmospheric Dispersion and Dry Deposition of Cs-137 in the UAE Environment

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1. Introduction

APR1400 reactors are being constructed on Barakah site in Abu Dhabi, UAE. For radiological environmental impact assessments, at first, the understanding about the characteristics of target environment is necessary. The site of nuclear power plant (NPP) in the UAE has several unique characteristics as a NPP on the desert environment near coastal region. Those characteristics are represented like below:

- Arid ground surface
- Low ground surface roughness length
- Relatively simple (flat) terrain
- Extremely low precipitation
- Intense solar radiation and high temperature in day time
- Sea breeze
- Relatively high humidity of atmosphere
- Etc.

From the review of this desert environment in the UAE, low ground surface roughness is regarded as one of definitively different characteristics from that of other NPP sites. In this context, surface roughness is selected as independent variables for the sensitivity analyses in this research. Another important reason of this selection is that this parameters is less dependent on the day and night change than other parameters. With ground level concentration, dry deposition rate has been chosen as a dependent variable to be considered rather than wet deposition because UAE shows almost zero rainfall especially in summer.

2. Methods

The reference factors of the surface roughness length (z_0) regarding land use and land environment are listed in Table 1 [1] and the surface roughness length of desert usually has the order of 0.001. Including the surface roughness length representing desert, four factors of the surface roughness length were selected as the variables: 0.001, 0.01, 0.1 and 1.0.

ADMS5 (Atmospheric Dispersion Modelling System 5) has been used to simulate atmospheric dispersion phenomena. This software is installing an advanced Gaussian plume model and has a high credibility than simple Gaussian plume model in relatively long distance. [1]

Table 1. The surface roughness length for various land use

Land use	Surface roughness length [m]
Large urban areas	1.5
Cities, woodlands	1
Parkland, open suburbia	0.5
Agricultural areas (max)	0.3
Agricultural areas (min)	0.2
Root crops	0.1
Open grassland	0.02
Short grass	0.005
Sea	0.0001

2.1 Source term

The accidental level of source term from the nuclear power plant was assumed. Cs-137 has been chosen as a source isotope because it is important isotope having relatively long half-life when we consider the deposition of radionuclide to the ground surface. Cs-137 has been assumed to be released with a constant release rate of 1.0 TBq/h as the point source from 50 m height considering the design of the nuclear power plant. The size and density of the particle was input as 0.68 μm and 1.4 g/cm^3 respectively following the reference from Baklanov and Sorensen (2001). [2]

2 .2 Meteorology

Afternoon in August was decided as a representative time evidently showing the characteristics of the seashore desert environment. The statistical data from Al Mifra climate posts near the Barakah site shows that the highest mean temperature of the year and almost zero precipitation appear in August. [3]

Table 2 shows the meteorological input assumptions and average data calculated from Al Mifra climate station at 4 pm of everyday in August 2012. [3] Input assumptions were proved to be quite reasonable after the comparison with statistical data.

In addition, the research by Jeffrey S.Reid et al. found that high temperatures (> 40 ℃), high humidity (> 70%), and afternoon sea breezes (> 6 m/s) along the coast are the meteorological characteristics during August and September in the UAE. [4]

Table 2. Meteorological input assumptions and average data calculated from Al Mifra climate station at 4 pm of everyday in August 2012

	Input assumption	Statistical data
Temperature	40 ℃	41.6 ℃
Sea breeze	Wind from the sea	Wind from the sea
Wind speed	7 m/s	7.1 m/s
Cloud cover	3 okta	3.1 okta
Precipitation	Zero	0
Humidity	70%	-

3. Result and Discussion

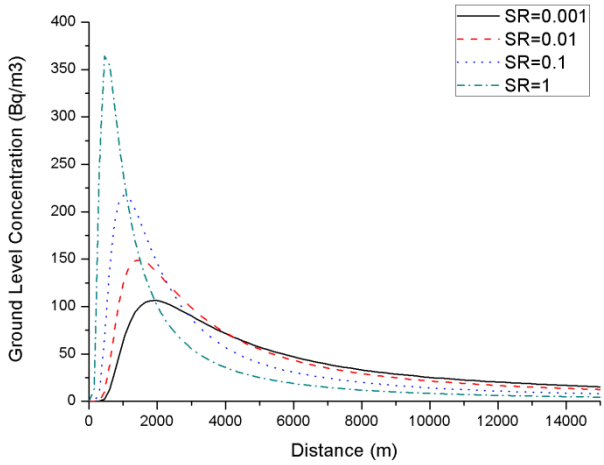

Figure 1. Ground level concentration of Cs-137 with various surface roughness lengths

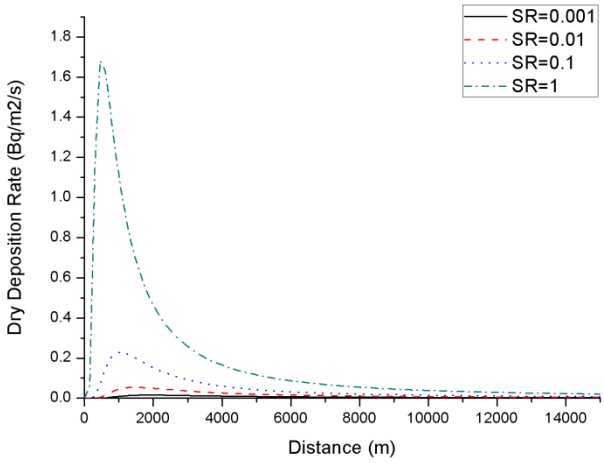

Figure 2. Dry deposition rate of Cs-137 with various surface roughness lengths

Calculated ground level concentration of Cs-137 following the distance is described in figure 1. It shows that higher surface roughness, higher concentration especially about 0-2 km distance from the source. And dispersion of radionuclide on the site with lower ground surface roughness has a tendency to be dispersed more wide range. Therefore the site having lower surface roughness shows little more concentration further than 5 km distance. This result is caused by the fact that the ground surface roughness affected to the atmospheric dispersion of radionuclide as a resistance.

Figure 2 describes the dry deposition rate of Cs-137 on the ground. The dry deposition decreases enormously by decreasing surface roughness length and extremely low dry deposition appears in case of the surface roughness length 0.001. This result is influenced by two factors. The first factor is the ground level concentration of Cs-137 described in figure 1. Low ground level concentration means low source of deposition to the ground surface. The second factor is the effect of the surface roughness to dry deposition velocity.

The dry deposition is parameterized by deposition velocity v_d and it includes a diffusive part v_d' and gravitational settling or terminal velocity part v_s like below equation.

$$v_d = \frac{v_s}{1 - exp\left(-\frac{v_s}{v_d'}\right)}$$

v_d' is comprised of three parts:

$$\frac{1}{v_d'} = r_a + r_b + r_s$$

where r_a is the aerodynamic resistance, r_b is the sub-layer resistance and r_s is the surface layer resistance. r_a and r_b are primarily depending on the surface roughness. [2, 5]

4. Conclusion

Lower ground level concentration of Cs-137 near the site and extremely lower dry deposition of Cs-137 are predicted in the UAE environment because of the lower ground surface roughness of the desert.

REFERENCES

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