Radiological Dose Assessment of Nigerian Research Reactor 1 (NiRR-1)

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Introduction

- **Objective:** Using HOTSPOT Health Physics Computer code to assess TEDE from accidental release of radionuclides to the public during hypothetical severe accident condition from 34kW NiRR-1
- **Location:** Nigerian Research Reactor (NiRR-1)
- **Target:** Offsite residents living in the surroundings of NiRR-1.
- **Method:** HOTSPOT code, accident scenario and meteorological data
- **Procedures**:
  - Choosing a hypothetical accident scenario.
  - Calculating the source term from NiRR-1 during accident.
  - Inputting source terms, duration of release, wind speed, wind direction and atmospheric stability.
- **Factors**: Accident scenario, source terms, wind speed, wind direction
- **Final output**: TEDE and Ground Deposition

Methods

- **Accident Scenario:** Heavy earthquake resulted in reactor building collapsed, reactor pressure vessel leaked water at a rate of 4 m^3/hr, resulted in core damage.
- **Source term:** The source term (Extracted from IAEA TECDOC 1844) was calculated based on the inventory of one fuel assembly multiplied by 347 number of fuel rods, times the transfer factor to air. The resulting LEU source terms for dose calculation are presented in the table below.

Table I: Radiological source term of NiRR-1

Isotopes	Categories	LEU Core Inventory (Bq) x 347	Transfer Factor to Air	LEU Source Term (Bq)
^{83m}Kr	Noble Gas	6.56E+12	2.00E-02	1.31E+11
^{85m}Kr	Noble Gas	1.54E+13	2.00E-02	3.08E+11
^{85}Kr	Noble Gas	4.89E+11	2.00E-02	9.79E+09
^{87}Kr	Noble Gas	3.12E+13	2.00E-02	6.25E+11
^{88}Kr	Noble Gas	4.41E+13	2.00E-02	8.81E+11
^{131m}Xe	Noble Gas	3.50E+11	2.00E-02	7.01E+09
^{133}Xe	Noble Gas	8.19E+13	2.00E-02	1.64E+12
^{135}Xe	Noble Gas	7.32E+13	2.00E-02	1.46E+12
^{137}Xe	Noble Gas	7.29E+13	2.00E-02	1.46E+12
^{138}Xe	Noble Gas	7.60E+13	2.00E-02	1.52E+12
^{131}I	Halogens	3.54E+13	1.00E-04	3.54E+09
^{132}I	Halogens	5.27E+13	1.00E-04	5.27E+09
^{133}I	Halogens	8.19E+13	1.00E-04	8.19E+09
^{134}I	Halogens	9.26E+13	1.00E-04	9.26E+09
^{135}I	Halogens	7.63E+13	1.00E-04	7.63E+09
^{137}Cs	Alkali Metal	4.16E+12	1.00E-06	4.16E+06
^{99}Mo	Alkali Metal	7.29E+13	1.00E-06	7.29E+07
^{89}Sr	Alkali metal	5.79E+13	1.00E-06	5.79E+07
^{90}Sr	Alkali Metal	3.99E+12	1.00E-06	3.99E+06

- **Meteorological data:** A conservative meteorological model was used, fixing the meteorological conditions to Pasquill stability **class F** with 1 m/s of wind speed and a variable direction within a 22.5° sector for the time period.

Results

- The result of the simulation using hotspot computer codes are presented in the Figures below
- From figure(1) below, the maximum TEDE is 1.3 mSv at a distance of 0.05 km for stability class A, while B, C and D shows the maximum TEDE of 1.1mSv at 0.1 km respectively, slightly above ICRP public dose limit of 1mSv.

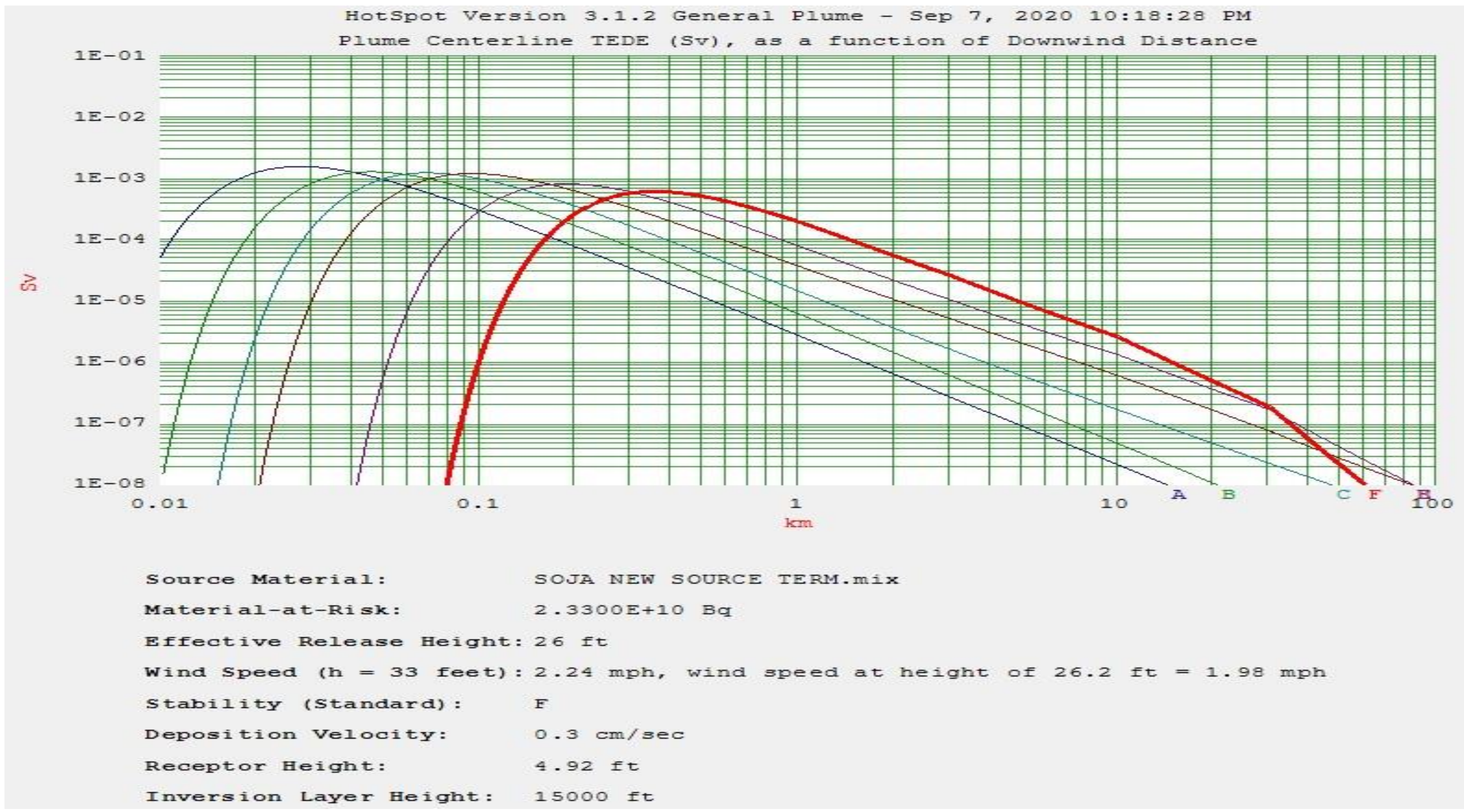

Fig. 1. Plume centerline TEDE downwind distance for all stability classes A–F under normal condition.

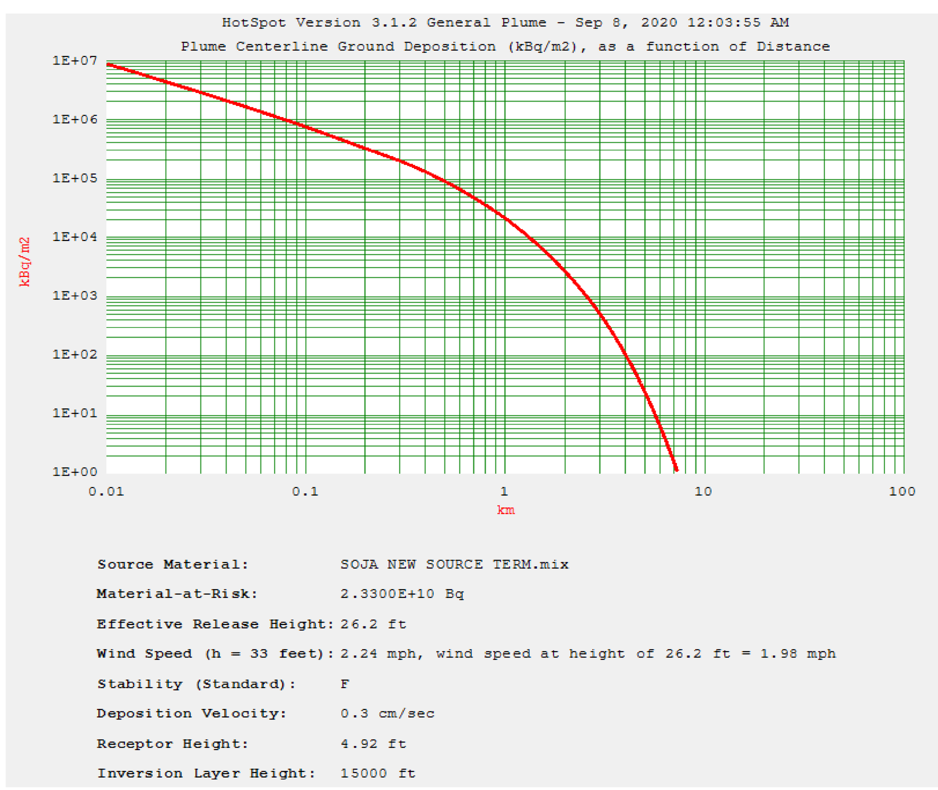
Fig.2 Ground deposition , single stability class.

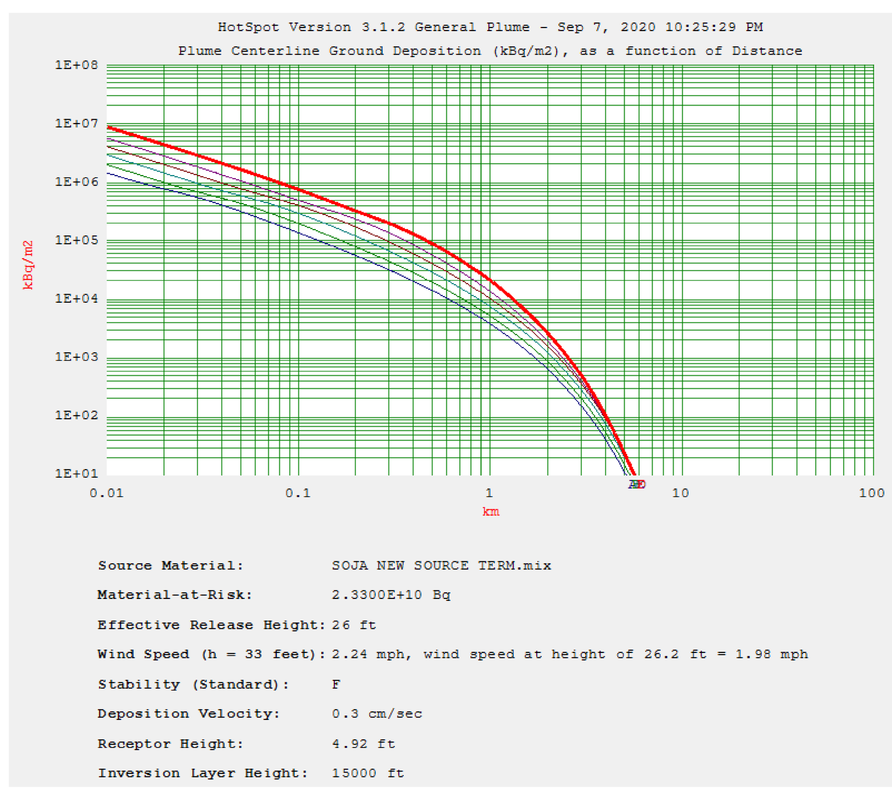
Fig.3 Ground deposition , all stability classes.

- Fig. 2 and 3 above shows maximum ground contamination between 1E+06 to 1E+07 kBq/m^2 at a distance of 0.01 km for single and all stability classes and 1E+00 kBq/m^2 with deposition distance of approximately 8km respectively.

Conclusion

- Radionuclides released to the atmosphere are transported downwind and distributed to the environment by usual atmospheric mixing phenomenon resulting to offsite dose.
- The result of the assessment shows the TEDE downwind distance slightly above the ICRP recommended public dose limit of 1mSv
- Offsite population within shorter distance from the release point receive higher dose due to inhalation of radionuclides and external dose as a result of beta and gamma radiation
- In this situation, protective measure should be adopted to avoid inhalation of radionuclides in the case of reactor accident

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