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Radiological risk and legal issues analysis for Terrorism attack scenario Using Radiological Dispersion Devices

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ABSTRACT

The biggest threat to national security is the use of radiological dispersion devices (RDDs) in terrorist attacks. Known as a dirty bomb, RDD is an explosive device combined with radioactive material. In addition to posing an immediate risk to people's lives and property, the explosion contaminates a large area with radioactivity. Decontamination is expensive and time-consuming. limited radiation exposure may result in long-term health issues, psychological issues, and social repercussions. Depending on the kind of radioactive material used and how well it is dispersed, an RDD can have different effects. This work aims to assess the radiological risk resulting from direct exposure to radiation sources used in radiation dose distributions as well as related legal issues. Using the Hot-spot computer code, simulations were run for radiation sources of ^{137}Cs and ^{90}Sr. To simulate radiological effects and ground deposition, calculations for radioactive material dispersion models are being carried out, considering the worst-case scenario. The parameters for ground surface deposition, ground shine dose rate, and total effective dose equivalent change as one gets farther away from the radiation source. Examined are the effects of variables like location, wind speed, radiological risk, and emergency response. There have been comparisons made between the radioactive material dispersion model and the considered radiation sources. Legal issues are also deliberated within the context of both national framework and international law.

1.INTRODUCTION

Radiological terrorism using dirty bombs represents a significant threat where their construction is not complicated; moreover, the radionuclides used are not affected by the heat generated due to detonation. Terrorists are focused on sources with high radioactivity and effective dispersal to cause a direct radiological hazard at the explosion and societal disturbance. Due to their high energy and protracted decay constant, radiological attack sources cause broad contamination that must be cleaned up over an extended period of time in order to minimize the effects on the general populace [1]. The radiation hazard from an RDD depends on the kind and quantity of radioactive material, the method of dispersion, the weather conditions, and the distance from the source. Cesium chloride (^{137}Cs) and strontium (^{90}Sr) are widely spread powders, so they could be seen as the radioactive material of choice to cause contamination of wide areas, and intensive cleanup is necessary [2]. ^{137}Cs is commonly used as gamma emitter in industrial and medical applications. It easily moves through the air after an explosion, dissolves easily in water, and binds strongly to soil and concrete, causing building and surface contamination [3]. ^{90}Sr is a beta-emitting source and generates heat as it decays. It is used in industrial gauges and Radioisotope Thermoelectric Generators (RTGs). Such a power generator was discovered by three woodcutters from Georgia in December 2001, and they brought it back to their settlement to use as a source of heat. Within hours, they developed severe radiation illness and went to the hospital for care. [4]. ^{90}Sr can be inhaled, but the greatest threat to health occurs when ingesting it via food and water. Scenarios of radiological attacks with ^{137}Cs and ^{90}Sr radionuclides have gotten much attention

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because of the societal impact, the health consequences on those who live close to the detonation area, and the radiation contamination of surfaces as well as infrastructure with significant economic implications [5]. The dispersal of radioactive dust brought on by an explosive explosion such as trinitrotoluene (TNT) depends on the weather conditions [6,7]. Along with the time of day, wind direction, speed, and rainfall are significant factors. Terrorists frequently choose subway systems as targets because they present difficult emergency countermeasures in the event of a bombing, which leads to many casualties and fatalities [8,9]. RDD event scenarios are established and evaluated to increase preparedness and response capacity. The primary purpose of the atmospheric dispersion model of radioactive materials into the environment is to aid decision-makers in responding to nuclear emergencies. [10–14]. Hotspot Code, which was developed by the National Atmospheric Release Advisory Centre (NARAC), is simple software. This software uses a low-range, cautious Gaussian plume model (less than 10 km) [15, 16]. The aim of this work is to estimate the radiation dispersion in an affected area by an RDD attack containing ^{137}Cs or ^{90}Sr, respectively, using the Hot-Spot code. The goal of emergency estimation is to help the decision-maker Assemble the responders so they can efficiently minimize the effects of the released hazardous material. There have been comparisons made between the radioactive material dispersion model and the considered radiation sources. Legal issues are also discussed in the structure of international and national law.

2. SCENARIO DESCRIPTION

The Hotspot model was created by Lawrence Livermore National Laboratory (LLNL) in the United States. It has a unique advantage as a radiological response to an emergency, with some capacity to simulate radiation dispersal as a result of an explosion. Equation 1 is the Gaussian model that the HOTSPOT code uses to calculate the concentration of gases or aerosols in the air.

$$C(x,y,z,H) = \frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \times \left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}\exp\left[-\frac{\lambda x}{u}\right]$$

Where:

C: The concentration of air (Ci.s)/(m^3).

Q : Source term (Ci).

H: Height of effective release (in meters)

λ: Radioactive decay constant (s^{-1}).

x,y are the horizontal axis (downwind, crosswind)distance respectively and z vertical axis (m).

$\sigma_{(y,z)}$: Standard deviation (m)

u: Wind speed on average (m/s) at the effective release height.

L: Height of the inversion layer (m).

Plume Depletion factor, DF(x)

The HOTSPOT 3.1.2 code was used to model radiation exposure and potential contamination levels after RDD spreading. Based on general explosion (radioactive isotopes in atmospheric dispersion defined using the Sandia National Laboratories explosion model), analysis has been done. RDD postulates that the event occurred in a crowded square, using two sources of ^{137}Cs and ^{90}Sr had activity 51 TBq and 770 TBq respectively with 45 lbs. of high explosive (TNT). Estimates were based on their suitability for terrorists because of their high radioactivity, long half-lives, and relatively easy availability from their various uses both in medical and industrial applications. ^{137}Cs is an external gamma-ray hazard, and ^{90}Sr is a beta-emission radioisotope. Weather conditions include normal northwest winds of 3 m/s at average daytime (D stability) and calm nighttime (F stability). Table 1 outlines the selected sources for RDD. Cases are run as Table 2 illustrates.

Table (1): Information for selected sources for RDD postulated scenario

Radiation source	Chemical form	Decay mode	Radiation energy (MeV)	
			Medical	Industry
^{137}Cs	Cesium chloride	β, IT, ϒ	0.01–1010–1000	0.01–1010–1000
^{90}Sr	Strontium chloride, fluoride, titanate	β	1–10	101–10,000

Table (2): RDD postulated scenario cases

Even	Material activity	(TNT)explosive (lbs)	Stability class
1	51TBq ^{137}Cs	45	D
2			F
3	770 TBq ^{90}Sr	45	D
4			F

Table (3): Results for the two scenarios

Scenario Number	Radio-nuclide	Source Term (TBq)	Maximum TED (mSv)	Maximum red area (km2)	Maximum ground deposition (kBq/m2)	Maximum ground deposition red area (km^2)
1	^{137}Cs	51	70	0.058	3.0E+05	0.058
2	^{90}Sr	770	661	1.2	4.5E+06	1.2

3.THE THEORETICAL CALCULATION FOR ABSORBED DOSE

To estimate the effective dose at a certain distance from a source to the public or emergency workers due to the exposure to RDD accident can be calculated theoretically using the following equation [2]:

$$E(ext.) = \frac{A.T.cf}{x^2} \qquad (2)$$

Were, E: The effective dose from a source [mSv]

A: The source activity (kBq)

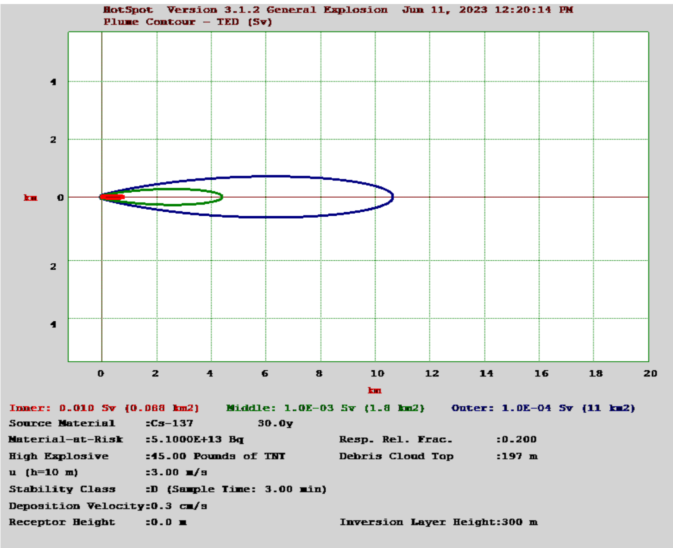
T: Exposure duration time (hr)

C_f: Source conversion factors at a distance 1 meter from the source, For ^{137}Cs equal 6.2E-08((mSv/h)/(kBq))

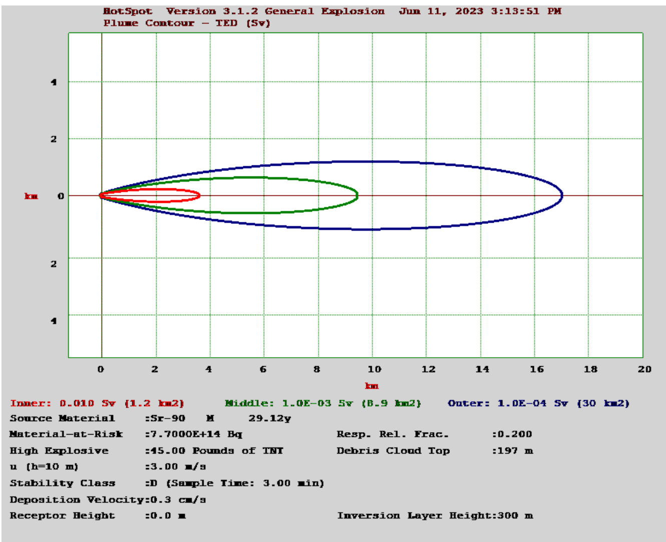
Distance from the source X (in meters)

4. RESULT AND DISCUSSION

The physical and chemical characteristics of the radioactive material determine how dispersible RDD is. An RDD would disperse powdered forms most effectively, and soluble chemical forms would most likely affect water systems. ^{137}Cs is frequently found in the perfect form for spreading.^{90}Sr is a soft metal that decays to ^{90}Y, which in turn decays by beta radiation. Because of the beta radiation, ^{90}Y poses a risk of burns to the eyes and skin from external exposure. ^{137}Cs and ^{90}Sr are released into the atmosphere and contaminate water. Table 3 represents the results for the two scenarios. Figure1(a&b) shows the general explosion plume contour Total Effective Dose (TED) obtained from the ^{137}Cs and ^{90}Sr scenarios respectively. Figures 2(a&b) show the ground deposition contours for two scenarios. The maximum TED level is more than 10 mSv for the inner red curve, about 0.056 Km^2 for ^{137}Cs, and 1.2 km^2 for ^{90}Sr. Google Earth output for plume contour Total effective dose (Sv) for ^{137}Cs scenario is shown in Figure 5. Figure 3(a&b) displays the maximum deposition curve distances from the zero point (hotspot) downwind distance. Figure 3 (a) shows a maximum ground deposition of 5.5x10^5kBq/m^2 and an inner area of about 2.5 km^2. The maximum ground deposition for ^{90}Sr is more than that from ^{137}Cs with a factor of about a tenth shown in Figure 3 (b). The ground deposition contour plot as a function of the distance for two scenarios is shown in Figure 4. The highest values in the case of ^{137}Cs are located in the hot region, 0.3 km from the zero point and between zero point to 0.6 Km distance for ^{90}Sr. The intermediate deposition area is within the distance from 0.3 to 2.00 km for ^{137}Cs and about 7 Km^2 for ^{90}Sr. The last curve reached to distance of 8.00 km and 16 Km for ^{137}Cs and ^{90}Sr respectively. It is obvious that a high dose is concentrated over about 1 km. Results indicate that using ^{90}Sr has greater radiological risks and more widespread consequences than using ^{137}Cs. At each receptor point, the maximum value obtained through RDD simulations is chosen around 60 minutes after the event's start

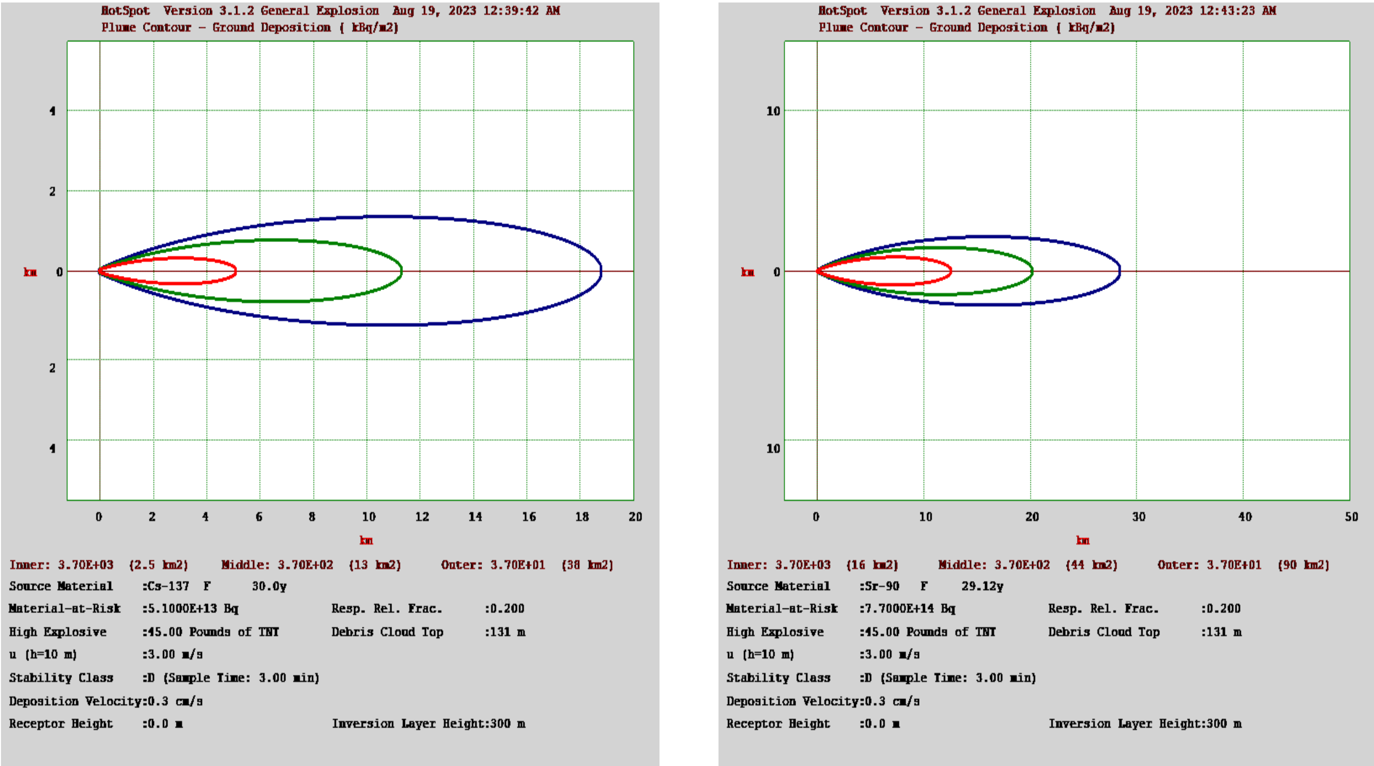


(A)^{137}Cs



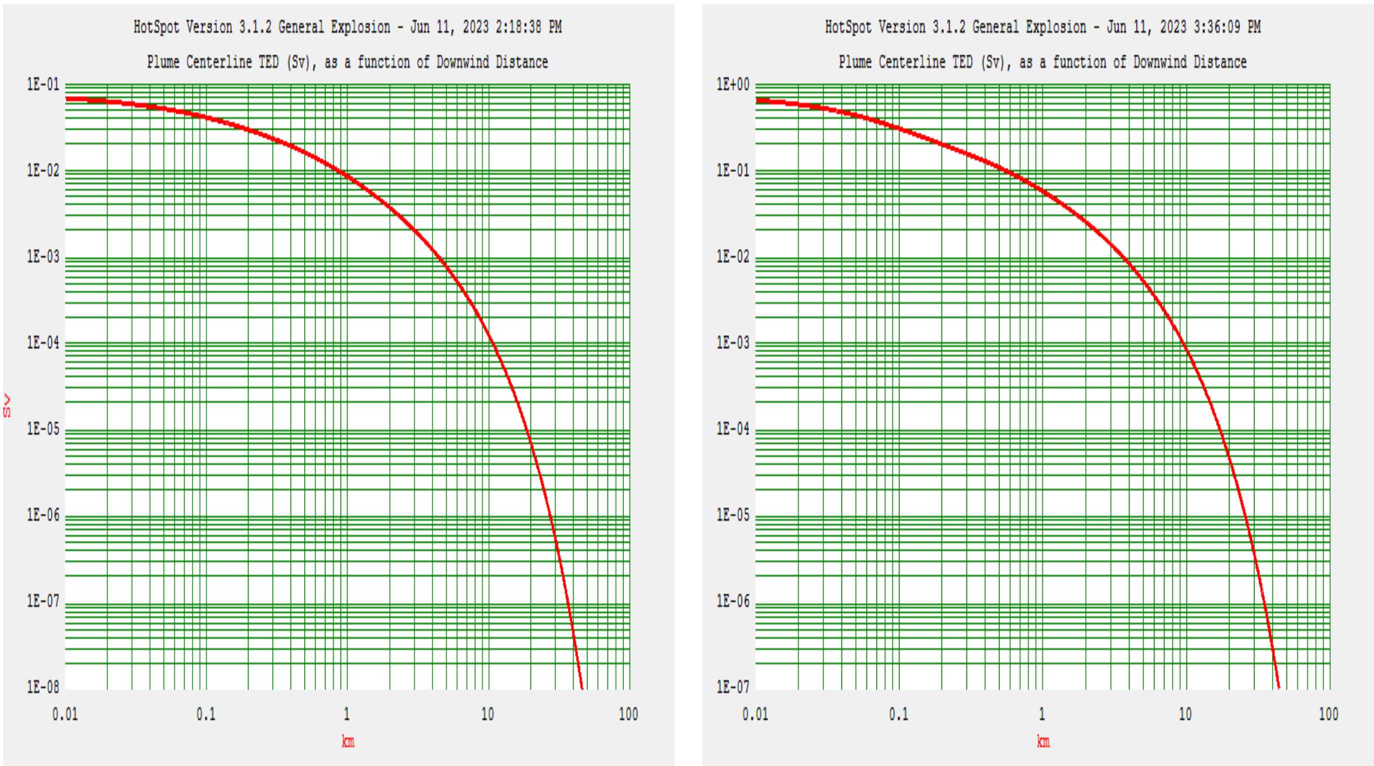
(B) ^{90}Sr

Fig. (1): Total effective dose contour plot for (a) ^{137}Cs and (b) ^{90}Sr



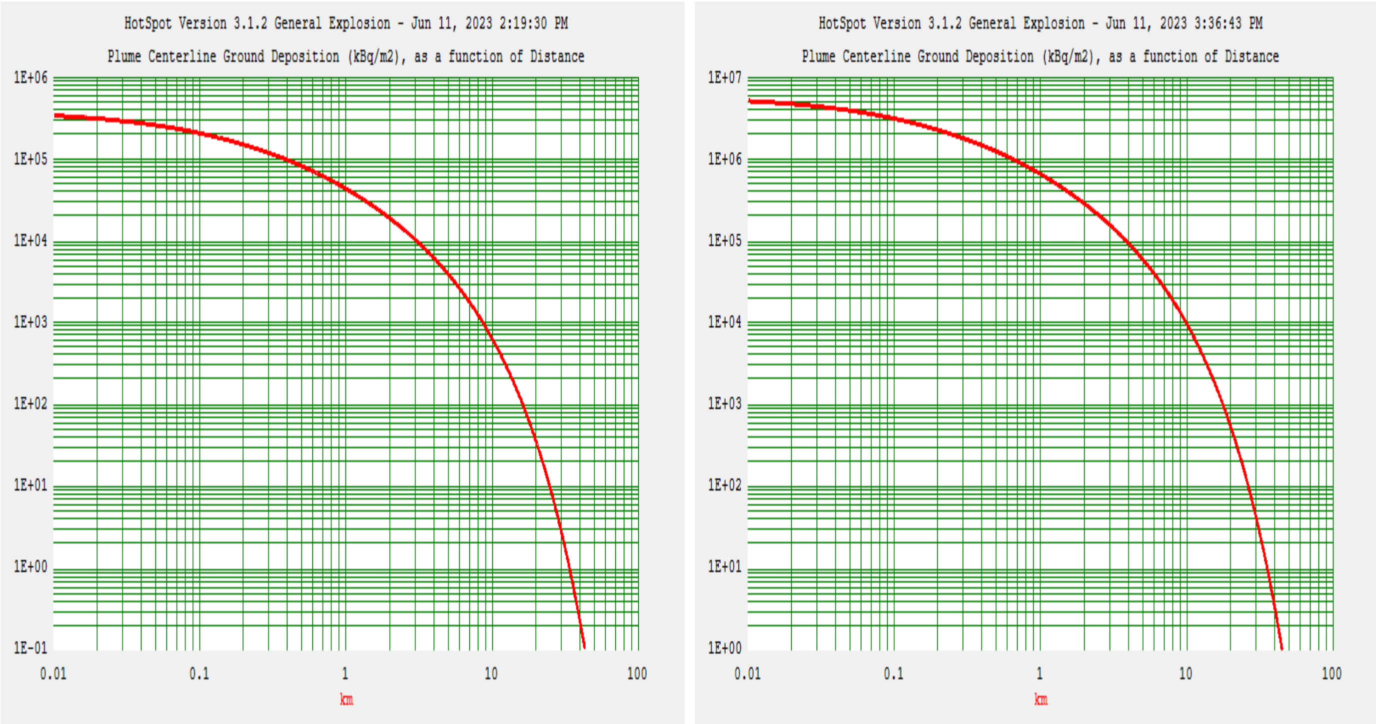
(a) ^{137}Cs **(b) ^{90}Sr**

Fig. (2): Ground deposition contour plot for RDD (a) ^{137}Cs and (b) ^{90}Sr



(a) ^{137}Cs **(b) ^{90}Sr**

Fig. (3): Plume contour plot TED for RDD (a) ^{137}Cs and (b) ^{90}Sr versus downwind distance.



(a)^{137}Cs **(b)^{90}Sr**

Fig. (4): Ground dose contour plot for (a)^{137}Cs and (b)^{90}Sr versus distance

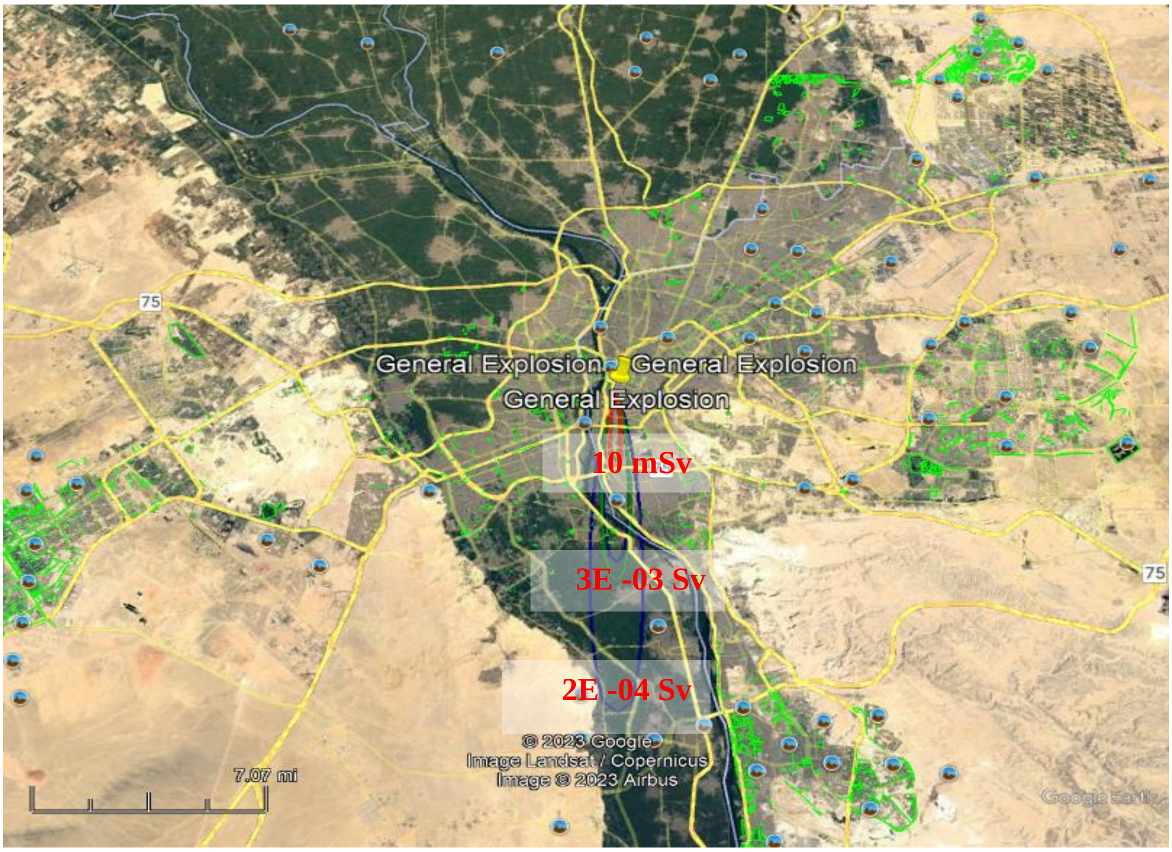


Fig. (5): Google Earth output for plume contour effective dose (Sv), as a function of downwind distance for ^{137}Cs scenario

5. Protective Actions and Emergency Measures:

Protective action for the effective dose according to International Commission on Radiological Protection (ICRP) recommendation was shown in Table 4[17].

Table (4): Protection (ICRP) recommendation

TED	Protective action
10 mSv for two weeks.	Indoor sheltering
50 mSv for one week	Temporary evacuation
100-1000 mSv for 1 year	Relocation

The radiation doses from an RDD can range from very low to dangerously high and can cause different health effects depending on the level of exposure. The Radiation Hazard Scale uses five categories to indicate the relative hazards of radiation exposure. Each category has a corresponding range of radiation doses, measured in sievert.

Category 1: No immediate health effects. Dose range: less than 0.001 Sv.

Category 2: No immediate health effects, but increased risk of cancer over a lifetime. Dose range: 0.001 to 0.02 Sv.

Category 3: Increased risk of cancer in the years ahead. Dose range: 0.02 to 1 Sv

Category 4: Dangerous levels of radiation that can cause radiation sickness. Dose range: 1 to 2 Sv.

Category 5: Lethal levels of radiation that can cause death. Dose range: more than more than 2 Sv.

The primary focus of emergency response planning should be to minimize radiation exposure to responders. Emergency workers should put on dust masks as well as overshoes. If there is no additional information available, IAEA guidelines also specify that emergency first responder personnel, including police and firefighters, have the duty to make a 300-meter-radius cordon a restricted area for explosions until technical radiation teams show up at the location with their equipment. [18, 19]. Using equation 2 calculation and the result from the simulation code this distance is very safe for the first responder. The simulation result agreed with IAEA guidelines of 300 meters. In both scenarios, there is direct radiation exposure, with high-energy gamma rays being the most dangerous emitted by ^{137}Cs and beta particles from ^{90}Sr and contamination. Stay time" refers to the maximum amount of radiation exposure that a responder should get, measured by splitting the exposure rate by the total permissible dose. [20]. The stay time in the red area according to the simulation result should not exceed 6 hours. Reduce the period of spent time within this zone as much as possible by exchanging the responder crew. When waiting to exit the building for the decontamination procedure, residents of the court's building—which is situated in the red and intermediate areas—should shelter indoors with their windows closed. Uninjured personnel within the outer boundary zone at the moment of the RDD explosion can be told to return straight home and take a shower in the absence of contamination surveying at the scene. A water sample must be taken to ensure that it is not contaminated with radionuclide dispersion. The public has been familiar with the protective actions to be implemented. The radiation survey continues for the red and intermediate areas and establishes an extreme caution zone. It is helpful to use a hotspot code scenario to establish radiation limits at the harm zones to help decision makers. Initial decontamination should occur in the intermediate area to restrict access to essential personnel. The outer boundary of this area.

6. LEGAL ISSUES

There are several legal issues that may arise. It's important to note that specific laws and regulations can vary between countries. The state for meeting nuclear security objectives is establishing, implementing, maintaining, and sustaining a nuclear security regime. This regime should be applicable to nuclear and radiation sources associated with facilities and activities in the state. The competent authority is responsible for coordinating under its national security regime in case of any breach of nuclear security obligations according to national law. Regarding the civil liability of radiation accidents, it will be claimed according to the normal civil law in the state. That means the victims must prove the fault of the license or the license holder.

FIRST: Possession and acquisition of radioactive materials: Unauthorized possession, acquisition, or theft of radioactive materials for the purpose of constructing an RDD is a serious offense. Egyptian legal framework establishes legal foundations for nuclear and radioactive material security. Nuclear Law No. 7 contains provisions governing all these objectives. The General objective of the law in this field is to reduce the possibility of the transfer of nuclear or radioactive materials into or through the nation, as well as to have a solid response strategy in place in case the state experiences a discovery event. A legislative framework for the safe management of all radiation sources is also established by the law. Additionally, it has clauses that govern and control the import, export, and transit of radioactive sources. It includes clauses that subject used sources to regulatory oversight. In order to identify the trafficking of nuclear or radioactive material, customs have radiation monitors. Egypt installs radiation-detecting portals at ports, airports, and border entry and exit points to help customs officers identify and stop any unauthorized movement of radioactive sources across borders. To avoid such behavior, the law makes any unauthorized possession of nuclear materials a crime that is subject to national legal penalties. Chapter 4 of the Egyptian nuclear law includes provisions for nuclear and radiological emergency preparedness and response. The nuclear law contains a chapter for penalties (Article 97 -100) [21].

Second: RDD attacks can result in environmental contamination due to the dispersion of radioactive materials. Legal issues may arise concerning the responsibility for cleanup, decontamination efforts, and the proper disposal of radioactive substances. The responsible parties may face civil or criminal liability for the environmental damage caused. Regarding decontamination operations resulting from the explosion, each party concerned with the intervention shall bear the necessary costs to complete its role in accordance with what is contained in the Egyptian National Plan for Nuclear and Radiological Emergencies [22]. If the investigation indicates the licensee of the source that was used in the explosion, will be responsible for compensation for environmental damage.

Third: RDD terrorism is a global concern, and international legal frameworks exist to address these threats. Treaties and agreements, for instance, the International Convention to Suppress Nuclear Terrorism, establish guidelines for international cooperation in preventing, investigating, and prosecuting acts involving RDDs. Suppose the effects of the RDD on a transboundary release may have significant radiological safety implications for a different state. The early notification of a nuclear accident convention and assistance in the case of a nuclear accident or radiological emergency convention should govern the application of international legal obligations. By fostering greater international collaboration and information sharing, the early notification of a nuclear accident convention seeks to minimize any accident's effects [23]. It will be applicable in the event of any accident involving a state party's facilities or activities that releases radioactive material or is expected to release it, and that release has resulted in or is likely to result in an international transboundary release that may have significant radiological safety implications for another state. One of the main obligations according to Article 2 is that, in the event of an accident, the State Party shall promptly notify the States, directly or through the International Atomic Energy Agency (IAEA), of any information that is or may be available to them regarding the nature, exact location, and timing of the accident. The State Party shall also promptly furnish the States, directly or through the Agency, with any information that is pertinent to minimizing the radiological consequences in the states.

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency [24] states that help is available in the event of a nuclear or radiological accident. It will be applicable if a state requests aid in the event of a radiological emergency or nuclear accident [25]. According to Article 2, A state party may request assistance from any other state party, either directly or through the agency, or, if necessary, from other international intergovernmental organizations, in the event of a nuclear accident or radiological emergency, regardless of whether the accident or emergency occurs on its territory, under its jurisdiction, or under its control. [26]. It is worth emphasizing that nuclear civil liability does not cover radioactive liability. Nuclear civil liability covers the case of a nuclear accident according to all international legal instruments (nuclear liability conventions and treaties) as well as the national nuclear law. That means the operator of the nuclear facility is liable without the need for the victims to prove the fault of the operator.

7. Crime scene management

An incident site may contain scant evidence and include nuclear materials, radioactive sources, or other radioactive materials. It is necessary to ensure that all procedures at the accident site are carried out in a way that maintains the integrity of the criminal investigation. A radiological crime scene is managed with the same processes used to manage a scene without the presence of nuclear materials, radioactive sources, or other radioactive materials, considering the need to control the following points.

(a) Time duration in the control area.

(b) The distance between the radioactively contaminated evidence and the individual responsible for collecting the evidence.

(c) Radiation shielding between the evidence and the individual responsible for collecting the evidence.

(d) Personal contamination resulting from contact with radioactive materials.

(e) Personal exposure to radiation.

All operations at the radiological crime scene are carried out in coordination between the radiological protection at the accident site, the incident commander, forensic evidence collection officials, and all those responsible for Operations inside the scene of events. Figure 6 illustrate the structure for response to radiation incidents of a security nature, including terrorist threats involving nuclear materials or radioactive sources. The Supreme Committee for Nuclear and Radiological Emergencies is responsible for managing the emergency accident according to Nuclear Law No. 7.

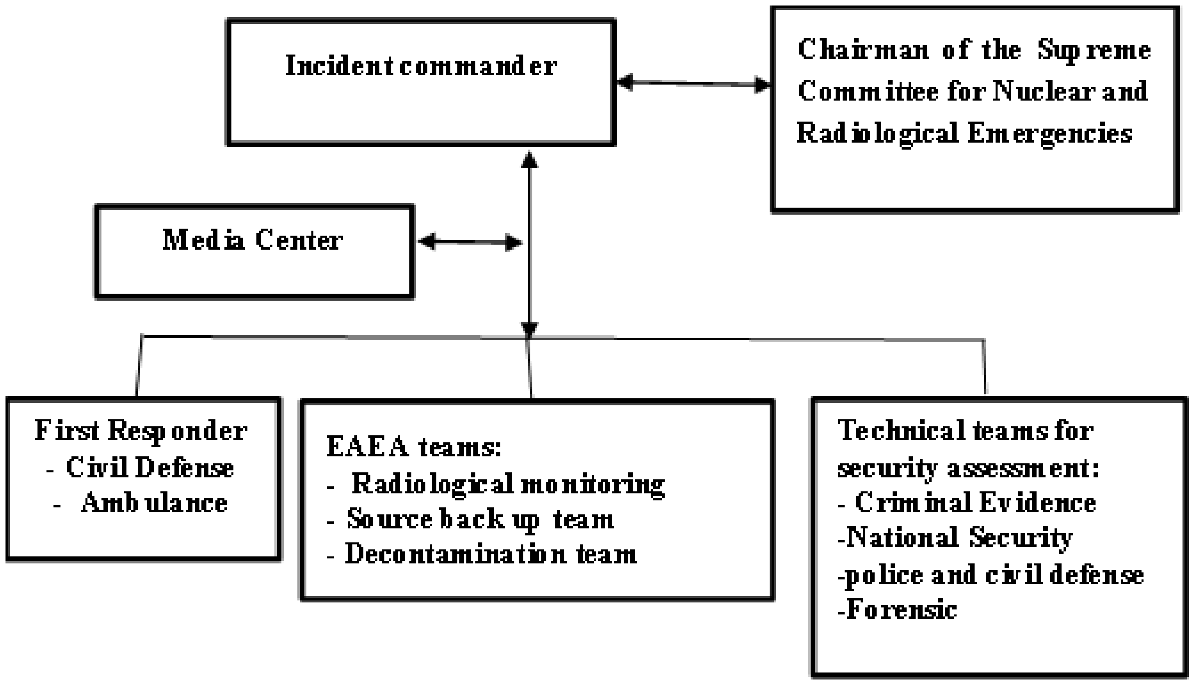


Fig. (6): Response to radiation incidents structure including terrorist threats.

8. CONCLUSIONS

Both ^{137}Cs and ^{90}Sr represent potential radiation hazards for a long time due to their long half-lives. ^{90}Sr is a strong beta emitter source, so it represents potential external radiation hazards. The simulation results demonstrate that, when considering the total effective dose, the radiological hazard associated with ^{137}Cs is higher than that of ^{90}Sr. It can be said that indoor sheltering is needed for the center area of 1.2 Km^2. It was observed that the ground deposition of ^{90}Sr covered a larger area than that of ^{137}Cs. The findings suggested that the social unrest, the ensuing cleanup of the contaminated area, and the financial expenses would probably be the most detrimental effects of a dirty bomb. The number of zones or radiation boundary areas depends on the event, in this scenario were three zones. Sources that are misplaced represent radiation hazards because terrorists can use them to cause harm and pose a threat. This highlights the significance of global collaboration in the management and oversight of radioactive substances. Creating drill and exercise data for use in emergency response training tabletop exercises is one of the main goals of creating realistic RDD scenarios. The vital information required for a basic action flow chart and a list of contact numbers may not be available to the intervention entities that have not yet taken part in national exercises or drills. Given that the crisis' psychosocial component may be more severe than its radiological component, developing a public outreach communication plan would be crucial. Illegally obtaining or possessing radioactive materials is a serious offense in many countries. Laws and regulations are in place to control the acquisition, storage, transportation, and use of such materials. Unauthorized acquisition or possession of radioactive materials can result in criminal charges.

REFERENCES

[1] H. Shin, J. Kim, Juyoul Kim "Development of realistic RDD Scenarios and their radiological consequence analyses", Applied Radiation and Isotopes 67(2009)1516–1520.

[2] Leonard W. Connell, PhD, Senior Scientist, "Dirty bomb risk and impact ". Technical report SAND (2017).

[3] Robin M. Frost ,"Dirty bombs: Radiological dispersal and emission devices", Taylor and Francis Online, pages 75-78 | Published online: 24 Nov 2006

[4] Sohier, A., & Hardeman, F. "Radiological Dispersion Devices: Are We Prepared? " Journal of Environmental Radioactivity, (2006). 85, 171-181.

[5] Homeland Security Council (HSC). "Radiological attack – Radiological dispersal devices, Scenario 11". In: HSC Planning scenarios. Executive summaries.

Version 2.0; 2004. http:// www. Global security. org/ security/ library/ report/ 2004/ hsc- planning-scenarios- jul04_ execs um. pdf. Accessed 10 June 2020.

[6] H.Shin and J. Kim. "Development of realistic RDD scenarios and their radiologicalconsequence analyses." Appl Radiat. Isot 67(7-8) pp: 1516-1520, (2009).

[7] S. G. Homann, HotSpot Health Physics Codes Version 2.07 User's Guide. Livermore, CA Lawrence Livermore National Laboratory, (2009).

[8] Kaplan DE. Aum Shinrikyo (1995). In: Tucker JB, editor. Toxic terror. Assessing terrorist use of chemical and biological weapons. Cambridge: Monterey Institute of International Studies, MIT Press; 2000.

[9] Strandberg V. Preparing and responding to mass-casualty terrorist attacks -a comparative analysis of the response to five terrorist attacks targeting rail bound traffic. Swedish National Conference on Peace and Conflict. Gothenburg; 14–15 June 2012.

[10] Leung W.H., Ma W.M., Chan P.K.Y. 49 Nuclear Accident Consequence Assessment in Hong Kong using JRODOS. J. Environ. 51 Radioact. 2018. 183(December 2017):27– 52 36.

[11] Benamrane Y J-L Wybo, Armand P. "Chernobyl and Fukushima Nuclear Accidents: What has Changed in The Use of Atmospheric Dispersion Modeling?". Environ. Radioact.Journal. 2013. 126:239–52.

[12] Zhang X, Raskob W, Landman C, Trybushnyi D, Haller C, Yuan H. "Automatic plume episode identification and cloud shine reconstruction method for ambient gamma dose rates during nuclear accidents". Environ. Radioact. Journal . 2017. 178–179:36–47.

[13] Argyris N., French S. Emergency Decision 66 Support: A Behavioral OR Perspective. Eur. J. Oper. Res. 2017. 262(1):180–93.

[14] Moehrle S., Raskob W. Structuring and Reusing Knowledge from Historical Events for Supporting Nuclear Emergency and Remediation Management. Eng. Appl. Artif. Intell. 2015. 46:303–11.

[15] Homann S.G., Aluzzi F. HotSpot User's Guide. Livermore, CA 94550: National Atmospheric Release Advisory Center, Lawrence Livermore National Laboratory; 2014.

[16] Malizia A., Cafarelli C., Milanese L., Pagannone S., Pappalardo A., Giovanni D. Di, et al. Simulation of ^{137}CS radioactive contamination due to an accident in a biomass plant for energy production : the importance of Decision Support System (DSS) in the emergency planning 2 Problem Formulation. 2009.:308–14.

[17] IAEA-TECDOC-1162, ″Generic procedures for assessment and response during a radiological emergency″, Vienna, 2000.

[18] IAEA. IAEA EPR-First Responders: Manual for First Responders to a Radiological Emergency; IAEA: Vienna, Austria, 2006.

[19] IAEA International Atomic Energy Agency. "Method for developing arrangements for response to a nuclear or radiological emergency ", IAEA-TECDOC No. 953, Vienna, 2005

[20] Conference of Radiation Control Program Directors, "Handbook for Responding to a Radiological Dispersal Device ", Inc. CRCPD Publication 06-6 www.crcpd.org, September 2006

[21] Egyptian nuclear law no 7, 2010, Egyptian Official Gazette No. 12 bis (A), 30 March 2010.

[22] National Plan for Preparedness and response to Nuclear and Radiological Emergencies, 2020

[23] Convention of Early Notification of Nuclear Accident, International Atomic Energy Agency (IAEA).INFCIRC /335, 21 November 1986.

[24] Article 2, Convention of Early Notification of Nuclear Accident, Op.Cit.pP2-3

[25] Article 2, Item 2. Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.Op.Cit.P4.

[26] Article 2, Item 3. Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. Op. Cit.p4. other international intergovernmental organizations such as World Health Organization (WHO)