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Crime scene investigation in a CBRN environment – Capacity building and innovation

The study focuses on the specific characteristics of forensic crime scene investigation related to criminal offences involving the malicious use of CBRN materials and devices. The introductory section outlines the definitions of CBRN agents, materials, and devices, provides an overview of CBRN-related terrorist incidents recorded in the European Union between 2001 and 2023, and considers short-term trends in emerging threats. The paper examines the general characteristics of crime scene investigations conducted in contaminated CBRN environments, with particular attention to scene safety, contamination control, evidence preservation, and interagency cooperation. It also analyses innovation-driven approaches relevant to forensic crime scene management and realistic directions for capacity building. The study presents the Hungarian procedural framework developed for conducting forensic crime scene investigations involving radioactive materials.

Chemical, Biological, Radiological, and Nuclear (CBRN) – definitions

CBRN materials and agents are defined differently across international organisations and institutional actor**s**, depending on their operational mandates and regulatory focus. As the present study addresses forensic crime scene investigation in a CBRN environment, a brief review of selected institutional definitions is necessary to clarify the conceptual framework applied in the analysis.

European Union: *„The acronym 'CBRN' defines chemical, biological, radiological and nuclear materials and agents that could potentially harm*

society through their accidental or deliberate release, dissemination, or impacts."[1]

European Union Agency for Criminal Justice Cooperation: *„Chemical, biological, radiological and nuclear substances and explosives (CBRN-E) include substances and agents conceived, synthesised, extracted, processed and eventually produced, distributed and used by different actors."*[2]

EU CBRNe Glossary: *„CBRN is the abbreviation commonly used to describe the use of Chemical, Biological, Radiological and Nuclear materials or weapons."*[3]

North Atlantic Treaty Organisation: *„CBRN materials refer to any chemical, biological, radiological, or nuclear substance that may pose a hazard to NATO populations, territories and forces, regardless of origin or whether the material was originally conceived as a weapon."*[4]

Despite differences in terminology, the reviewed definitions share several common characteristics. Each definition refers to chemical, biological, radiological and nuclear materials or agents capable of causing harm to human health, infrastructure, the environment or public safety. The main differences concern conceptual scope: some institutions primarily emphasise hazardous materials and their potential release, whereas others explicitly include weapons, explosives and scenarios involving malicious use.

[1] European Commission (n.d.): Chemical, Biological, Radiological and Nuclear Risk Mitigation.
Source: https://cbrn-risk-mitigation.network.europa.eu/index_en
Accessed: 17.07.2025.
[2] Eurojust (n.d.): CBRN-E.
Source: https://www.eurojust.europa.eu/crime-types-and-cases/crime-types/cbrn-e
Accessed: 17.07.2025.
[3] Joint Research Centre: EU Glossary on Chemical, Biological, Radiological, Nuclear, and Explosive Risks. Publications Office of the European Union. Luxembourg, 2022.
[4] NATO: NATO's Chemical, Biological, Radiological and Nuclear (CBRN) Defence Policy. 2022.
Source: https://www.nato.int/cps/en/natohq/official_texts_197768.htm
Accessed: 17.07.2025.

There is no generally accepted definition of CBRN materials. In the present study, the term CBRN is understood in a broader sense and encompasses chemical, biological, radiological and nuclear materials, agents and devices, including those associated with malicious use and weapon-related purposes.

CBRN terrorism

According to Briefing Paper 2 of the MASC-CBRN[5] programme: *„WMD[6]/CBRN terrorism - cases related to the illicit use of WMD / CBRN materials and information by non-State actors for the purpose of carrying out large-scale politically motivated attacks."*[7]

Nowadays, the CBRN threat is a part of terrorist propaganda; the probability of such attacks occurring is rather low, but their potential impact is considerable.[8] The probability is low due to the technological and logistical requirements of producing, acquiring, handling, and using CBRN materials, which demand specialised expertise and advanced infrastructure. However, such an attack poses a high risk due to its complex, potentially catastrophic impact across nearly all dimensions of security. [9]

[5] MASC-CBRN: Methodology for Assessing States' Capacity for Countering the Hostile Misuse of CBRN Knowledge and Materials. 2022.
Source: https://csd.eu/fileadmin/user_upload/publications_library/files/2022_11/MASC-CBRN_Methodology_EN.pdf
Accessed: 17.07.2025.
[6] WMD: Weapons of Mass Destruction.
[7] MASC-CBR: MASC-CBRN Briefing Paper #2: CBRN Risk Management. 2021. 3. o.
[8] European Commission: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Action Plan to Enhance Preparedness against Chemical, Biological, Radiological and Nuclear Security Risks. European Commission. Brussels, 2017. 2. o.
[9] Despite their low probability, terrorist attacks involving CBRN materials pose a real risk. On March 20, 1995, members of the Aum Shinrikyō terrorist organization carried out a coordinated sarin attack on five lines of the Tokyo subway system. The incident resulted in 13 fatalities and over 6,000 injuries. (USHIYAMA 2023:54)

Between 2001 and 2023, in the territory of the European Union, perpetrators motivated by jihadist ideology were the most active in the terrorist use of CBRN materials. However, the activities of right-wing extremists were also significant. A total of 13 incidents involving CBRN materials were recorded. In addition to these, during the period examined, two further targeted attacks involving CBRN materials were carried out against specific individuals, in which state actors or intelligence operations are suspected of having played a role. The relevant cases have been summarised in a table.

The illegal acquisition or production of CBRN materials in sufficient quantities for committing terrorist acts poses significant challenges for terrorist actors.[10] However, technological advancements and the increasing availability of information online are steadily reducing these barriers. Potential impacts of armed conflicts in the Middle East and the Russia–Ukraine war must also be taken into account. Ukraine had already been involved in the illicit trade of firearms and radioactive materials before the outbreak of the Russia–Ukraine war. [11] In several terrorist incidents in the Middle East, chemical agents were used. The online sharing of information related to the production and deployment of IEDs capable of dispersing CBRN substances represents a serious risk.

CBRN materials at a crime scene

The main components that determine on-scene operations are the technical equipment (with what), the responsible unit (by whom), and the methods and procedures applied (how).[12] While organisational and technical aspects

[10] Europol: European Union Terrorism Situation & Trend Report 2020 (EU TE-SAT 2020). Publications Office of the European Union. Luxembourg, 2020. 21. o.
[11] Zaitseva, Lyudmila – Steinhäusler, Friedrich: Nuclear Trafficking Issues in the Black Sea Region. Non-Proliferation Papers, No. 37. EU Non-Proliferation Consortium. 2014. 7–87. o.
[12] Hausner, Gábor (ed.): Fundamentals of National Defence [Honvédelmi alapismeretek, in Hungarian]. Ludovika. Budapest, 2022. 41. o.

play an important role in shaping the protocol for the crime scene investigation, the procedure is ultimately determined by the specific characteristics of the scene - such as its scale, the number of victims, and any special conditions (e.g., the presence of CBRN materials) - as well as the objective of the investigation (the mission).

CBRN materials have a dual nature in the context of crime scene investigation. On the one hand, they are hazardous materials whose presence at the scene requires special safety measures. On the other hand, due to their malicious release, they also serve as instruments of the crime - meaning they are simultaneously pieces of evidence.

A crime scene investigation requires scientific and technical support to ensure both safety and effectiveness. Safety measures include the detection of CBRN materials (their localisation and identification), the designation of zones or perimeters[13], the determination of appropriate levels of personal protective equipment (such as protective suits and respiratory protection), and the provision of a decontamination station. The effectiveness of the investigation is supported by the professional use of specialised equipment, such as detectors, manipulators, and storage and transport devices.

As outlined above, CBRN incidents are low-probability but high-risk events with potentially catastrophic consequences. CBRN response capability is a niche capability that is rarely deployed; however, it is highly costly due to the specialised equipment and expertise required. For effective capacity development, it is advisable to coordinate and utilise existing CBRN capabilities. This requires an appropriate legal framework and the regular organisation of exercises involving the relevant agencies and units.

[13] At crime scenes of this type, a three-zone system is typically applied. The immediate area contaminated by CBRN materials is referred to as the red or hot zone. This is followed by the yellow or warm zone, which includes entry and exit points, contamination control, and decontamination stations. Outside of these lies the green or cold zone, which contains the command post, medical support, and other logistical facilities.

The Hungarian Radiological Crime Scene Management (RCSM) procedure

The Hungarian operating procedure for radiological crime scene management is based on international trends and guidelines,[14] and adapted to the Hungarian legal system and professional experiences. The method has been developed in collaboration with the staff of the Nuclear Forensics Laboratory of the HUN-REN Centre for Energy Research[15] and the Criminal Forensics Department of the National Bureau of Investigation within the framework of a project supported by the Home Affairs Security Fund.[16]

The main goal was to establish a harmonised procedure in which each actor (conventional crime scene investigators and nuclear forensic experts) performs their task, all in a way that best serves safety and the purposes of the criminal investigation. A specific feature of the procedure is that police officers and radiation/nuclear forensic experts work together at the crime scene.

In crime scene investigations involving RN (radiological and nuclear) materials, the key distinction lies in the radiological component, which may consist of radiation from a sealed or intact radioactive source present at the scene or contamination with radioactive substances. RN materials and conventional evidence contaminated by them are given priority during scene processing. Once radioactive materials have been collected, the handling of the scene proceeds similarly to that of conventional crime scenes. This is not a rigid rule; priorities may shift depending on the circumstances. In the event of a suspected terrorist attack, the primary task may be to extract

[14] International Atomic Energy Agency: Radiological Crime Scene Management. IAEA Nuclear Security Series, No. 22-G. International Atomic Energy Agency. Vienna, 2014. 1–93. o.

[15] The analysis of nuclear or other radioactive materials and traditional evidence contaminated with radionuclides is the task of nuclear forensics. In Hungary, the dedicated Laboratory for this purpose is the Nuclear Forensic Laboratory of the HUN-REN CER.

[16] The development of the operating procedure was supported by the Hungarian Ministry of Interior and the European Union within the framework of the Internal Security Fund of Hungary (BBA-5.3.3/3-2017-00010).

data from information-bearing objects (e.g., documents, electronic devices) to prevent the commission of the crime.

To ensure safety and effectiveness, scientific and technical support is essential. This includes the designation of operational zones at the scene, the determination of the appropriate level of personal protective equipment, implementing radiation protection measures (such as defining the allowable time spent on the scene, maintaining safe distances from radiation sources, and applying shielding), radiation detection, and handling other specialised equipment (e.g., manipulators, storage devices).

At radiological crime scenes, the investigation team is supplemented by three radiological experts[17] from the Nuclear Forensic Laboratory of the HUN-REN CER, who support the implementation of procedural protocols. One expert operates in the red (hot) zone. Their tasks include measuring radiation levels, identifying hotspots (radiation sources), detecting RN materials and conventional physical evidence contaminated with such substances, and collecting them (in cooperation with a forensic technician). The second expert, known as the radiation protection specialist, works in the yellow zone at the entrance to the red zone. Their responsibilities include checking items exiting the hot zone for contamination, providing clean equipment, assisting with glove changes, and ensuring the safe removal of personal protective gear. The third expert is the nuclear forensic specialist, whose role is to categorise materials at the scene using gamma spectrometry.

Summary

Terrorist attacks involving the use of CBRN materials are low-probability but potentially catastrophic events. The CBRN threat forms part of terrorist propaganda; however, it represents a real risk, as evidenced by smaller-

[17] A radiological expert is a nuclear physicist or radiochemist who is capable of identifying radioactive materials, detecting them using instruments, and collecting and handling them professionally.

scale incidents in our region and by acts detected during the preparatory phase of planned attacks involving CBRN materials.

Following such an attack, conducting a crime scene investigation requires specialised equipment, expert knowledge, and specialised procedures. CBRN capability is rarely deployed, but because of the expertise and equipment required, it requires substantial financial resources. One possible solution is to integrate and coordinate existing CBRN capabilities across different organisations and units.

In Hungary, experts from the Nuclear Forensic Laboratory of the HUN-REN CER and the Criminal Forensics Department of the National Bureau of Investigation have developed a procedure for processing crime scenes affected by nuclear and radioactive materials. This procedure has been applied in real criminal cases over recent years. Its development is ongoing, with recent efforts focusing on implementing the DVI (Disaster Victim Identification) protocol in CBRN environments and refining the methodology for examining conventional physical evidence contaminated with radionuclides.

Table of CBRN Terrorism and Assassinations Involving CBRN Materials in the EU between 2000 and 2023. Edited by the author.

Incident/Method	Substance used	Year	Country	Motivation
Postal item containing chemical agent (12 cases).[18]	Adamsite[19]	2003	Belgium	unknown

[18] Europol: EU Terrorism Situation & Trend Report 2002–2003. Europol. The Hague, 2003. 20. o.

[19] European Union (2020): Common Military List of the European Union (equipment covered by Council Common Position 2008/944/CFSP, which defines common rules governing the control of exports of military technology and equipment). Official Journal of the European Union, ML 7.d.

Production of a biological agent.[20]	Ricin[21]	2003	UK	jihadism
Postal item containing a chemical agent. (8 cases).[22]	Adamsite	2004	Belgium	jihadism
Murder committed with a radioactive substance.[23]	Polonium-210[24]	2006	UK	assassination
Contamination of the public water supply (in preparatory phase). [25]	unknown	2011	Spain	jihadism
Online publication of training material related to biological toxin processing.[26]	Ricin	2016	Online	jihadism
Postal item containing radiological	Americium[28]	2016	Slovakia	unknown

[20] Europol: EU Terrorism Situation & Trend Report 2002–2003. Europol. The Hague, 2003. 40. o.
[21] Ujváry, István: This isn't just a bean game — ricin is deadly [A mérgező ricin. Nem babra megy a játék]. Élet és Tudomány, Issue 2003/6. 173–174. o.
[22] Europol: EU Terrorism Situation & Trend Report 2003–2004. Europol. The Hague, 2004. 11. o.
[23] The assassination of Alexander Litvinenko, a former agent of the FSB (Federal Security Service, successor to the KGB).
[24] Highly toxic alpha-emitting radioactive material.
[25] Europol: EU Terrorism Situation & Trend Report 2012. Europol. The Hague, 2012. 18. o.
[26] Europol: EU Terrorism Situation & Trend Report 2017. Europol. The Hague, 2017. 16. o.
[28] A synthetic metallic element, with all isotopes exhibiting radioactivity through alpha decay and weak gamma emission.

material (unknown number of cases). [27]				
Preparation of an IED[29] intended for biological agent dispersal (in preparatory phase). [30]	Ricin	2018	France	jihadism
Production of a biological agent.[31]	Ricin	2018	Germany	jihadism
Contamination of the public water supply (in preparatory phase).[32]	unknown	2018	Sardinia	jihadism
Attempted murder committed with a radioactive substance.[33]	Novichok[34]	2018	UK	assasination
Exploration of COVID-19 deployment as a biological weapon.[35]	COVID-19	2020	Online.	right-wing extremism

[27] Ibid. 16
[29] Improvised Explosive Device.
[30] Europol: EU Terrorism Situation & Trend Report 2019. Europol. The Hague, 2019. 19. o.
[31] Ibid. 19
[32] Ibid. 19.
[33] The attempted assassination of Sergei Skripal, a former Russian military intelligence officer convicted of treason and released in a 2010 US-Russia spy swap. Following his resettlement in the United Kingdom, Skripal and his daughter Yulia were poisoned with Novichok.
[34] A chemical agent belonging to the nerve agent category of chemical weapons.
[35] Europol: EU Terrorism Situation & Trend Report 2021. Europol. The Hague, 2021. 30. o.

Scenarios involving the intentional spread of COVID-19 through means such as distributing contaminated masks. [36]	COVID-19	2020	Online	jihadism
Construction of an IED[37] with radioactive content. [38]	Uranium (The specific isotope or chemical compound is not identified.)	2021	France	right-wing extremism
Online publication of training material related to dirty bomb (RDD) processing.[39]	unknown	2022	Online	right-wing extremism

[36] Ibid. 30
[37] A dirty bomb is a form of Radiological Dispersal Device (RDD) designed to release radioactive substances through the detonation of conventional explosives.
[38] Europol: EU Terrorism Situation & Trend Report 2022. Europol. The Hague, 2022. 17. o.
[39] Europol: EU Terrorism Situation & Trend Report 2023. Europol. The Hague, 2023. 18. o.