INTERNATIONAL CBRNE MASTER COURSES SERIES

COLLANA DI SICUREZZA CHIMICA, BIOLOGICA, RADIOLOGICA E NUCLEARE

7

Scientific Board

INTERNATIONAL CBRNE MASTER COURSES SERIES

COLLANA DI SICUREZZA CHIMICA, BIOLOGICA, RADIOLOGICA E NUCLEARE

> Peace cannot be kept by force; it can only be achieved by understanding.
>
> Albert Einstein

The CBRNe Book Series was born as an initiative of the Directive Board and of the Scientific Committee of "International Master Courses in Protection Against CBRNe events" (www.mastercbrn.com) at the University of Rome Tor Vergata. The evolution and increase in Security and Safety threats at an international level place remarkable focus on the improvement of the emergency systems to deal with crisis, including those connected to ordinary and non–conventional events (Chemical, Biological, Radiological, Nuclear, and explosives). In every industrial Country there are multiple entities with specialized teams in very specific fields, but the complexity of the events requires professionals that not only have specific know-how, but also expertise in the entire relevant areas. Given the global interest in these issues, the Department of Industrial Engineering and the Faculty of Medicine and Surgery of the Tor Vergata University organize the international Master Courses in "Protection against CBRNe events": I Level Master Course in "Protection against CBRNe events" (120 ECTS) and II Level Master Course in "Protection against CBRNe events" (60 ECTS). These courses aim at providing attendees with comprehensive competences in the field of CBRNe Safety and Security, through teaching and training specifically focused on real needs. Both Master Courses are designed according to the spirit of the Bologna Process for Higher Education, the Italian law and educational system. The Master Courses are organized also in cooperation with the following Italian Public Entities:

— Presidenza del Consiglio dei Ministri (Prime Minister's Office);
— Ministero della Difesa (Ministry of Defence);
— Ministero dell'Interno (Ministry of The Interior);
— Istituto Superiore di Sanità (National Health Institute);
— Istituto Nazionale di Geofisica e Vulcanologia (National Institute for Geophysics and Vulcanology);
— ENEA (Italian National Agency for New Technology, Energy and Sustainable Economic Development);

— University Consortia CRATI, MARIS and SCIRE;
— Comitato Parlamentare per l'Innovazione Tecnologica (Parliamentary Committee for Technological Innovation).

And together with the following International Entities:

— OPCW (Organization for the Prohibition of Chemical Weapons)
— NATO Joint Centre Of Excellence (Czech Republic);
— NATO SCHOOL of Oberammergau (Germany);
— HotZone Solutions Group (The Netherlands);
— VVU–026 Sternberk (Czech Republic);
— Seibersdorf Laboratories GmbH (Austria);
— Chernobyl Centre (Ukraine).

All the above–mentioned organizations have signed official cooperation agreements with the University of Rome Tor Vergata in the aim of Master course activities. The Master have also cooperation with OSCE, IAEA, ECDC, KEMEA in the aim of the didactical activities and we are working to formalize this collaboration with a formal cooperation agreement.

Both Master Courses have been officially granted the "NATO selected" status and have been included in the NATO Education and Training Opportunities Catalogue (ETOC) and also they are supported by OPCW.

The purpose of the CBRNe book series is to give a new perspective of the safety and security risks from both a civil and military point of view, touching all the aspects of the risks from the technological to the medical ones, talking about agents and effects, protection, decontamination, training, emergency management, didactic, investigation, communication and policy.

The authors will be experts of the sector coming from civil, military, academic/research and private realities. A special thanks for the realization of this series goes to Prof. Carlo Bellecci for his initial encouragement, continuous support and help.

Nel mese di Agosto 2016 il Ministero dell'Istruzione, dell'Università e della Ricerca (MIUR) ha inserito la collana nella lista di quelle ufficialmente riconosciute con i seguenti riferimenti:

— codice di classificazione: E237557;
— titolo: CBRNE BOOK SERIES.

During the month of August, 2016, the Italian Minister for Instruction, University and Research (MIUR) has officially added this book series in the list of the official publications recognized by the Minister itself with the following references:

— classification code: E237557;
— title: CBRNE BOOK SERIES.

Romeo Gallo

Radioactivity

A textbook for First Responders

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Preface

The global crisis related to the reduction of energy fossil resources, the reduction of potable water resources and the war for the control of energy sources are part of the causes which can lead to an intentional CBRNe (Chemical, Biological, Radiological, Nuclear, and explosive) event. These kind of events could also be the consequence of an unintentional release of substances (i.e., an accident of a truck containing a Toxic Industrial Chemical), or of natural events like a tsunami or an earthquake. Thus the high percentage of risk connected to their occurrence is clear. A CBRNe emergency has not to be intended exclusively as a war or terroristic event, but also as deriving from an unintentional or natural one.

Speaking about accidental event, from a radiological point of view, is the one that perhaps impressed us the most, but negatively: the Fukushima Daiichi nuclear disaster, a catastrophic failure at the Fukushima I Nuclear Power Plant on March 11, 2011. The failure occurred after the tsunami triggered by the Tohoku earthquake hit the nuclear plant and substantial amounts of radioactive materials were released starting on March 12. This has become the largest nuclear incident since the 1986 Chernobyl disaster, and the second (with Chernobyl) to measure Level 7 on the International Nuclear Event Scale (INES). 300,000 people had to be evacuated from the area, approximately 18,500 died in the earthquake and tsunami events, and, as in August 2013, approximately 1,600 deaths were attributed to the evacuation conditions, such as living in temporary housing and hospital closures. It is easy to associate a nuclear event to war: Hiroshima and Nagasaki are two unforgettable shocking moments of our contemporary history. The atomic bombings of the cities of Hiroshima and Nagasaki in Japan were conducted by the United States during the final stages of World War II in 1945. The two events are the only use of nuclear weapons in war to date. The Little Boy atomic bomb was dropped on the city of Hiroshima on August 6, 1945, followed by the Fat Man bomb on the city of Nagasaki on August 9. Within the first two to four months of the bombings, the acute effects killed 90,000–166,000 people in Hiroshima and 60,000–80,000 in Nagasaki, with roughly half of the deaths in each city occurring on the first day. During the following months, large numbers died from the effect of burns, radiation sickness and other injuries, compounded by illness. In both cities, most of the dead were civilians, although Hiroshima had a sizeable garrison. Finally, to give a more general description of the international scenario, it is necessary to describe some CBRNe events related to terrorism. Speaking about R–N terrorist attack, one of the most known was the Alexander Litvinenko murder. In UK, Litvinenko became a journalist for a Chechen separatist site. On November 1, 2006, Litvinenko suddenly fell ill and was hospitalized. For several days he suffered of severe diarrhea and vomiting. At one point, he could not walk without assistance. For several weeks, Litvinenko's health conditions worsened and doctors began to investigate the causes of his illness. Litvinenko became physically weak, and spent periods unconscious. He died three weeks later, becoming the first confirmed victim of lethal Polonium–210 induced acute radiation syndrome. According to the doctors, "Litvinenko's murder represents an ominous landmark: the beginning of an era of nuclear terrorism".

This analysis has a unique conclusion: the proper way to face these emergencies is to build a team of highly prepared Tech Advisors and First Responders to support Top Decision Makers, not only to deal with the agents released, but mainly to manage the consequences on the territory of occurrence, immediately and in the medium and long term. At the present moment, experts of the kind are really few and usually concentrated in the central administrative bodies.

This book is an important and useful tool for First Responders to have a base–practical knowledge about radiation and associated risks and to learn how evaluate the risks for them and for the population. Exercises, examples and case studies makes the test interesting and interactive. It is one of the most interesting and complete training text book for first responders that have to face with R–N events.

Chapter I

Radioactivity

Before moving on to specific treatments, it is appropriate to recall some basic concepts about radioactivity.

1.1. Some helpful reminders

The *atom* can be modeled as a planetary system consisting of the nucleus and the electrons that revolve around atomic orbitals. Electrons have an electric charge, negative, of 1.602176565 10–19 coulomb. The core is composed of neutrons and protons. Neutrons are neutral particles, while protons have a positive electric charge, equal in value to that of the electrons. Overall, the atom is neutral, so the number of electrons is equal to that of the protons. The chemical characteristics of the elements derive from the number and distribution of the electrons. The molecules, the smallest particles of a substance which possesses the properties, are obtained from the chemical combination of atoms, of the same or different elements. The mass is concentrated almost exclusively in the nucleus. The electrons have a mass almost 2,000 times smaller than the mass of protons or neutrons, which in turn have nearly equal masses and equal to 1 atomic mass unit. The elements are characterized by the *atomic number* (number of protons, equal to the number of electrons), indicated with Z, and the *mass number* (number of protons plus the number of neutrons), indicated by A. The generic element X is so designated:

$$^{A}_{Z}X.$$

Currently known chemical elements are 118 and they are ranked in the *periodic table*based on their atomic number. Those with

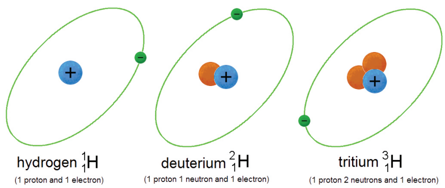

Figure 1.1. Hydrogen isotopes.

the atomic number greater than 92 were artificially obtained and are commonly called transuranic, being the uranium the natural element with the highest value of Z, precisely equal to 92.

In the indication of the element sometimes the atomic number is omitted, as characteristic and constant for each individual element. It has importance instead, particularly in radiology, the number of mass that, for equal elements, may be variable. For simplicity the elements can be therefore identified with their symbol followed only by the mass number. For example, the radio ^{226}Ra, with atomic number equal to 88 and mass number equal to 226, can be indicated as Ra–226. The atoms of the same element, therefore, may exist with different number of neutrons. The chemical characteristics remain unchanged, while changing the nuclear characteristics, having different mass numbers. These atoms are called *isotopes* or *nuclides*. Some isotopes of an element may be radioactive and are called radioisotopes or radionuclides. In the Fig. 1.1 hydrogen and its isotopes are represented: deuterium, stable isotope, and tritium, the radioactive isotope.

1.2. Radioactivity

The term radioactivity means the phenomena originated from the "radionuclides", nucleuses of atoms unstable because of their composition (number of neutrons and protons). Radionuclides tend to a stable condition through a process in time called "disintegration" or "Decay", with the emission of radiation in the form of particles (alpha radiation, beta radiation, neutrons) and/or electromagnetic waves. Following the decay the radionuclide turns itself into another nuclide. Even if the latter is not stable, the process will be repeated through a so–called *decay chain*, until a stable isotope is obtained. The radionuclides can be of natural or artificial origin, created by man varying the structure of nucleuses of stable atoms. In their path the nuclear radiations are able to transfer their energy to the electrons of the atoms of the substances that they cross, enabling them to escape from the atom resulting in the so–called phenomenon of *ionization*. For this reason it is called *ionizing radiation*. Ionizing radiation may be *directly ionizing* (alpha, beta) or *indirectly ionizing* (gamma rays, X–rays, neutrons). The energy lost by the radiation towards an atom's electron, may also be not enough to produce ionization but only for the electron transition to a higher orbit. In this case we have the excitation of the atom to which follows a de–excitation with the emission of a photon.

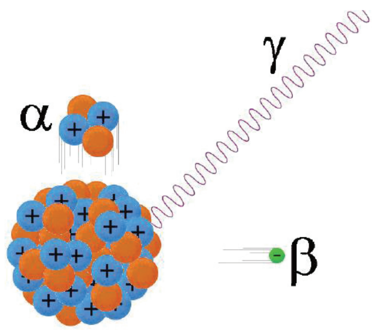

Figure 1.2. Radiations.

1.2.1. *Directly ionizing radiation*

The directly ionizing radiation are so called because in their path they interact in a direct and continuous way with the atoms of matter, through their electric fields, transferring their energy to the electrons that can be ionized. This happens if the transferred energy is higher than the one of the bond, and the electron acquires kinetic energy equal to that excess. The so produced electrons may in turn ionize, in their path, other atoms.