ENVIRONMENTAL CONTAMINATION FROM THE FUKUSHIMA NUCLEAR DISASTER

The 2011 accident at the Fukushima Daiichi Power Station led to serious radioactive contamination of the environment. Due to transportation by seasonal wind and ocean currents, these radioactive materials have now been observed in many places in the Northern Hemisphere. This book provides a unique summary of the environmental impact of the unprecedented accident. It covers how radioactive materials were transported through the atmosphere, oceans and land. The techniques used to investigate the deposition and migration processes are also discussed including atmospheric observation, soil mapping, forest and ecosystem investigations and numerical simulations. With chapters written by international experts, this is a crucial resource for researchers working on the dispersion and impact of radionuclides in the environment. It also provides essential knowledge for nuclear engineers, social scientists and policymakers to help develop suitable mitigation measures to prepare for similar large-scale natural hazards in the future.

TERUYUKI NAKAJIMA is an Emeritus Professor at the University of Tokyo. He is currently serving as Chief Scientist of the Earth Observation Research Center (EORC) at the Japan Aerospace Exploration Agency (JAXA). At the time of the Fukushima accident he was a member of the Science Council of Japan, Section President of Atmospheric and Hydrospheric Sciences at the Japan Geoscience Union and an executive member of the Japan Meteorological Society. In these roles, he helped investigate and organise the emergency response to the disaster. He is a fellow of the American Geophysical Union, and in 2017 he was awarded the 2017 Japan Purple Ribbon medal.

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Dispersion, Monitoring, Mitigation and Lessons Learned

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Preface

A large area that includes Fukushima Prefecture was seriously contaminated by radioactive materials emitted into the atmosphere and the ocean by the accident at the Fukushima Daiichi Nuclear Power Station (hereafter, FDNPS[1]) of the Tokyo Electric Power Company, which was caused by the Tohoku Region Pacific Coast Earthquake in 2011. The emitted radioactive materials were transported by seasonal wind and ocean currents to a wide area of the globe and have been observed in various places in the Northern Hemisphere. These materials have also been detected in soil, forests, lakes, rivers and seas due to fallout and direct discharge, and continued movement in the environment.

Radioactive materials emitted by the accident were thus transported widely and exist in our environment in different forms. Various efforts have been made to accurately understand the material transport; such efforts are indispensable for determining suitable mitigation measures. However, the devastating accident related to the radioactive materials was their first experience of such for most scientists, and researchers have since fumbled with trial-and-error activities. This confusing situation also occurred in the actions taken by the government and related organisations, as manifested in the accident investigations by private, government and Diet committees that began in 2012. After more than seven years since the accident, it is important for long-term mitigation and impact assessment to reflect on the current and past, as well as to analyse what we did, what we understood and what was not sufficient.

This motivation drove the development of this publication. The original Japanese book was published in 2014, and the English edition was started shortly thereafter. Professionals in each scientific field drafted this book to summarise the scientific knowledge accumulated in the years since the event, as well as the trajectories of the research community's activities. The main theme of the present

[1] There are several other expressions, such as FDNPP. See also the Glossary.

book, which was drafted by groups of professionals specialising in the study of the atmosphere, ocean, land and radioactive materials, is the migration of the radioactive materials emitted into the environment by the FDNPS accident. Other books by professionals in the fields of nuclear power engineering and nuclear reactor physics should be consulted to understand the events that played out inside the power station.

This book comprises three parts. Part I discusses the migration of the radioactive materials in the environment. Chapter 1 summarises the basic concepts and fundamental knowledge regarding the environmental migration related to the accident. Chapter 2 estimates the amount of radioactive material emitted by the accident. Chapter 3 shows investigation results of radioactive material pollution in the atmosphere and simulation of atmospheric transport, and deposition using atmospheric transport models, while Chapter 4 presents global model simulation results. Chapter 5 describes investigation results in the ocean and marine ecosystem, and presents simulation analyses using ocean transport models. Chapter 6 treats deposition and migration processes of radioactive materials and describes investigations of soil mapping, forest investigation and migration of radioactive materials into the forest biosphere and agricultural products.

Part II examines the current status of the infrastructure for disaster prevention and discusses the problems and issues with improving the system. Chapter 7 introduces the current status of the monitoring system for nuclear power stations and discusses how this could be improved. It was found that numerical simulations are useful for investigating the wide area of contamination. In reality, there was confusion related to the governmental use of the emergency rapid radioactivity impact prediction network system (SPEEDI). Chapter 8 presents the thoughts of scientists related to the SPEEDI problem. Chapter 9 summarises the decontamination actions that are useful for reconstructing living areas.

Part III reflects on the thoughts and actions from the perspective of scientists related to the future, based on an analysis of inadequate activities. Chapter 10 discusses the method of dissemination of scientific knowledge that has the largest societal impact. Chapter 11 provides a detailed report of urgent activities that immediately followed the accident and cross-field research activities by volunteer researchers, with messages for future generations.

There were many instances of extremely sensitive care in the investigations and actions by the government and related organisations that were reflected in the psychological reaction to the radioactivity resulting from the disaster, which was akin to that of an atomic bomb. Difficult situations were encountered when attempting to distribute scientific facts and limit harmful rumours. Throughout the development of the accident investigations, the public wanted to receive information that would help them take actions of their own instead of being

restricted. The disseminated information was also useful for efficient mitigation actions. Hence, we thought we should express frankly to the public what we thought as scientists. At the same time, we made notes for future generations based on our urgent actions and our thoughts regarding the large-scale environmental pollution. It will be important to prepare for similar large-scale disasters such as earthquakes, tsunami, torrential rain, volcanic eruptions and others. From this perspective, as scientists, we wrote our message to society and policymakers.

The role of scientists is to present accurate facts and disseminate information, but scientific investigations require much time. We should be persistent in solving problems. This effort is needed for the dissemination of important scientific knowledge to the public for long-term mitigation.

Important progress has been made in the last three years, following the publication of the first edition; namely, the establishment of action guidelines for emergent large-scale disasters by the Science Council of Japan (SCJ) and the Japan Academic Network for Disaster Reduction, which includes 56 academic societies. The SCJ guideline was invoked for the first time following the Kumamoto earthquake in 2015, when the SCJ collaborated with the academic network to provide well-prepared dissemination of scientific information to the public. We have incorporated these new events and scientific studies that were published after the publication of the Japanese edition. In addition, new international co-authors have provided their knowledge and recommendations from an international viewpoint, as presented in Chapter 12.

The cover images are the composite of the geographical and temporal changes of the air dose rate map on land (see Section 1.10) and the radiocaesium concentration of the coastal surface sediments off Fukushima (see Section 5.6) in the summer of 2011, the summer of 2012 and the winter of 2014–15. The images show the radionuclide migration from land to the coastal sea over time, with radioactive decay and dilution.

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