Studies in Systems, Decision and Control 456

Artur Zaporozhets
Oleksandr Popov *Editors*

Systems, Decision and Control in Energy IV

Volume II. Nuclear and Environmental Safety

Springer

Studies in Systems, Decision and Control

Volume 456

The series "Studies in Systems, Decision and Control" (SSDC) covers both new developments and advances, as well as the state of the art, in the various areas of broadly perceived systems, decision making and control–quickly, up to date and with a high quality. The intent is to cover the theory, applications, and perspectives on the state of the art and future developments relevant to systems, decision making, control, complex processes and related areas, as embedded in the fields of engineering, computer science, physics, economics, social and life sciences, as well as the paradigms and methodologies behind them. The series contains monographs, textbooks, lecture notes and edited volumes in systems, decision making and control spanning the areas of Cyber-Physical Systems, Autonomous Systems, Sensor Networks, Control Systems, Energy Systems, Automotive Systems, Biological Systems, Vehicular Networking and Connected Vehicles, Aerospace Systems, Automation, Manufacturing, Smart Grids, Nonlinear Systems, Power Systems, Robotics, Social Systems, Economic Systems and other. Of particular value to both the contributors and the readership are the short publication timeframe and the worldwide distribution and exposure which enable both a wide and rapid dissemination of research output.

Indexed by SCOPUS, DBLP, WTI Frankfurt eG, zbMATH, SCImago.

All books published in the series are submitted for consideration in Web of Science.

Artur Zaporozhets · Oleksandr Popov
Editors

Systems, Decision and Control in Energy IV

Volume II. Nuclear and Environmental Safety

Springer

Editors
Artur Zaporozhets
General Energy Institute of NAS of Ukraine
Kyiv, Ukraine

Oleksandr Popov
State Institution "The Institute
of Environmental Geochemistry of National
Academy of Sciences of Ukraine"
Kyiv, Ukraine

ISSN 2198-4182 ISSN 2198-4190 (electronic)
Studies in Systems, Decision and Control
ISBN 978-3-031-22499-7 ISBN 978-3-031-22500-0 (eBook)
https://doi.org/10.1007/978-3-031-22500-0

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

One of the main components of energy security, along with the energy supply of the economy and the population with necessary for development of fuel and energy resources and energy independence, is the environmental acceptability of energy production and energy consumption. Today, this problem has become global in nature and is in the list of the main threats of sustainable development.

In recent years, the scale of environmental hazards has been growing, emergencies occur more often at special facilities, in particular nuclear power, the largest of which was the accident at the Chernobyl nuclear power plant in Ukraine on 26 April 1986.

With the advent of nuclear power, it was believed that nuclear power reactors were safe enough; control and monitoring systems, protective screens and trained personnel would guarantee their trouble-free operation. There is also a trend now that nuclear power is "environmentally friendly" because it provides a reduction in greenhouse gas emissions with replacing power plants working on fossil fuels. Some countries, such as the USA, have recently classified nuclear energy as a renewable energy source.

Despite this, nuclear power is potentially dangerous due to:

- possible accidents at power plants, accompanied by the ejection of radioactive materials into the environment;
- ejections of about 250 radioactive isotopes into the environment as a result of the operation of nuclear reactors;
- emissions of ^{85}Kr, which changes the electrical conductivity of the atmosphere. This gas behaves like a greenhouse gas in the atmosphere, thereby contributing to anthropogenic climate change on Earth;
- pollution of the biosphere with plutonium;
- radioactive waste is the most important cause of environmental hazard, which remains unresolved. Civilian nuclear power reactors operating throughout the world annually generate large amounts of low-, medium- and high-level radioactive waste.

Radioactive pollution accompanies all parts of the complex production of nuclear energy: the extraction and processing of uranium, the operation of nuclear power plants, the storage and regeneration of fuel, which has a significant impact on the environmental friendliness of nuclear energy.

In addition, up to 300 natural and technogenic emergencies are registered annually, as a result of which people die and great economic damage is caused. The main reasons for the occurrence of technogenic accidents and catastrophes and the strengthening of the negative impact due to the occurrence of natural and technogenic emergencies in Ukraine are: obsolete fixed assets, in particular for environmental purposes; large volume of transportation, storage and use of hazardous substances; the emergency state of a significant part of public utility networks; insufficient investment support for the process of introducing the latest resource-saving and environmentally friendly technologies in environmentally hazardous industries, primarily in the metallurgical, chemical, petrochemical and energy sectors; environmental problems associated with significant changes in the state of the geological and hydrogeological environment and caused by the closure of unprofitable mining enterprises and mines; unwillingness of economic subjects to take measures to prevent accidents and catastrophes at high-risk and potentially hazardous facilities.

All this has led to the formation in Ukraine of a significant pool of scientists and specialists involved in the solution of environmental safety, in particular nuclear safety. Today there is a great need for the accumulation and systematization of this knowledge.

This book consists of two volumes, and this volume consists of two parts: *Nuclear Power Engineering* and *Environmental Safety*.

Scientists from 23 leading scientific and educational institutions of Ukraine took part in the creation of the book: State Institution "The Institute of Environmental Geochemistry of National Academy of Sciences of Ukraine" (Kyiv), Pukhov Institute for Modelling in Energy Engineering of NAS of Ukraine (Kyiv), Institute for safety problems of nuclear power plants of NAS of Ukraine (Chornobyl), Institute of General Energy of NAS of Ukraine (Kyiv), National Science Centre "Kharkiv Institute of Physics and Technology" (Kharkiv), Institute of telecommunications and Global Information Space of NAS of Ukraine (Kyiv), Subbotin Institute of Geophysics of NAS of Ukraine (Kyiv), Institute of Water Problems and Land Reclamation of NAAS of Ukraine (Kyiv), Taras Shevchenko National University of Kyiv (Kyiv), National Aviation University (Kyiv), State University "Zhytomyr Polytechnic" (Zhytomyr), Ivano-Frankivsk National Technical University of Oil and Gas (Ivano-Frankivsk), National University of Life and Environmental Sciences of Ukraine (Kyiv), National University of Food Technologies (Kyiv), Kyiv National University of Technologies and Design (Kyiv), O. M. Beketov National University of Urban Economy in Kharkiv (Kharkiv), National Defence University of Ukraine named after Ivan Cherniakhovskyi (Kyiv), National University of Civil Defence of Ukraine (Kharkiv), State Ecology Academy of Postgraduate Education and Management (Kyiv), National Pedagogical Dragomanov University (Kyiv), Interregional

Academy of Personnel Management (Kyiv), Center for Research on Public Administration Problems (Kyiv) and Administration of the State Border guard service of Ukraine (Kyiv).

A major role in the preparation and creation of this volume of the book was played by employees of State Institution "The Institute of Environmental Geochemistry of National Academy of Sciences of Ukraine", especially by Leading Research Officer, Doctor of Technical Sciences, Senior Researcher **Iatsyshyn Andrii Vasylovych**, and by Leading Research Officer, Doctor of Science in Public Administration, Senior Researcher **Kovach Valeriia Omelianivna**.

This book is for scientists, researchers, engineers, as well as lecturers and postgraduates of higher education institutions dealing with energy sector, power systems, nuclear safety, ecological safety, etc.

Kyiv, Ukraine
March 2022

Artur Zaporozhets
Oleksandr Popov

Contents

Nuclear Power Engineering

On the Issue of Radioecological Conditions of Surface Waters and River Sediments in Ukraine

Grygoriy Kovalenko, Tamara Dudar, and Andrian Iavniuk

Abstract The development and testing of nuclear weapons, nuclear power projects and associated research and technology developments, and also the Chornobyl accident caused an increase in background radiation levels in some parts of Ukraine. The comprehensive survey of ecological status of the Dnipro River and its tributaries was carried out as part of the Ukrainian–Canadian Field Survey and international environmental surveys carried out in the transboundary sections of the Dnipro Basin. During these surveys, significant focus was placed upon assessing the radioecological status of Dnipro and its tributaries and on the Southern Bug River and its tributaries. The given chapter is devoted to a long-term research on radioecological conditions of surface water bodies and river sediments in terms of radionuclides content and their depth distribution. The volumetric activities of radionuclides in water and specific activities in bottom sediments were studied. Radionuclides of ^{3}H, ^{40}K, ^{137}Cs, ^{90}Sr, uranium, thorium, and their decay products were mainly examined. It is shown that the content of natural radionuclides of the uranium and thorium series and ^{40}K in bottom sediments is at the level of background concentrations in the soils of the regions. On the other hand, it is highlighted on the concentration of tritium in the Danube and Styr rivers, which is significantly higher than the background value. The concentration of tritium in the cooling ponds of nuclear power plants exceeds the background value by dozens of times.

Keywords Radioecological conditions · Hydrographic network · Surface water · River sediments · Man-made and natural radionuclides

G. Kovalenko (✉)
Institute of High Energy and Nuclear Physics, National Science Centre "Kharkiv Institute of Physics and Technology", Kharkiv, Ukraine
e-mail: dtv.nau@gmail.com

T. Dudar · A. Iavniuk
Environmental Science Department, National Aviation University, Kyiv, Ukraine

A. Zaporozhets and O. Popov (eds.), *Systems, Decision and Control in Energy IV*,
Studies in Systems, Decision and Control 456,
https://doi.org/10.1007/978-3-031-22500-0_21