

Multiple Stressors: A Challenge for the Future

NATO Science for Peace and Security Series

This Series presents the results of scientific meetings supported under the NATO Programme: Science for Peace and Security (SPS).

The NATO SPS Programme supports meetings in the following Key Priority areas: (1) Defence Against Terrorism; (2) Countering other Threats to Security and (3) NATO, Partner and Mediterranean Dialogue Country Priorities. The types of meeting supported are generally "Advanced Study Institutes" and "Advanced Research Workshops". The NATO SPS Series collects together the results of these meetings. The meetings are coorganized by scientists from NATO countries and scientists from NATO's "Partner" or "Mediterranean Dialogue" countries. The observations and recommendations made at the meetings, as well as the contents of the volumes in the Series, reflect those of participants and contributors only; they should not necessarily be regarded as reflecting NATO views or policy.

Advanced Study Institutes (ASI) are high-level tutorial courses intended to convey the latest developments in a subject to an advanced-level audience

Advanced Research Workshops (ARW) are expert meetings where an intense but informal exchange of views at the frontiers of a subject aims at identifying directions for future action

Following a transformation of the programme in 2006 the Series has been re-named and re-organised. Recent volumes on topics not related to security, which result from meetings supported under the programme earlier, may be found in the NATO Science Series.

The Series is published by IOS Press, Amsterdam, and Springer, Dordrecht, in conjunction with the NATO Public Diplomacy Division.

Sub-Series

A.	Chemistry and Biology	Springer
B.	Physics and Biophysics	Springer
C.	Environmental Security	Springer
D.	Information and Communication Security	IOS Press
E.	Human and Societal Dynamics	IOS Press

<http://www.nato.int/science>

<http://www.springer.com>

<http://www.iospress.nl>



Series C: Environmental Security

Multiple Stressors: A Challenge for the Future

Edited by

Carmel Mothersill

McMaster University,
Department Medical Physics & Applied Radiation Sciences,
Hamilton, Ontario, Canada

Irma Mosse

Institute of Genetics and Cytology of the National Academy of Sciences,
Minsk, Belarus

and

Colin Seymour

McMaster University,
Department Medical Physics & Applied Radiation Sciences,
Hamilton, Ontario, Canada

 Springer

Proceedings of the NATO Advanced Research Workshop on
Multipollution Exposure and Risk Assessment—A Challenge for the Future
Minsk, Belarus
1–5 October 2006

A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN 978-1-4020-6334-3 (PB)
ISBN 978-1-4020-6333-6 (HB)
ISBN 978-1-4020-6335-0 (e-book)

Published by Springer,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

www.springer.com

Printed on acid-free paper

All Rights Reserved
© 2007 Springer

No part of this work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without written permission from the Publisher, with the exception of any material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work.

CONTENTS

Preface	xi
List of Contributors	xiii
Section 1: Multiple Stressors: General Overviews	
1. Challenges in Radioecotoxicology..... B. Salbu and L. Skipperud	3
2. The Involvement of Pollution with Fish Health	13
Brian Austin	
3. Effects of Ionizing Radiation Combined with Other Stressors, on Non-Human Biota	31
Ronald E. J. Mitchel, Marilyne Audette-Stuart and Tamara Yankovich	
4. Ecotoxicology – How to Assess the Impact of Toxicants in a Multi-Factorial Environment?.....	39
Helmut Segner	
5. A Layperson’s Primer on Multiple Stressors	57
Thomas G. Hinton and Kouichi Aizawa	
Section 2: Multiple Exposure Data – What Responses are Seen?	
6. Effects of Multipollutant Exposures on Plant Populations	73
Stanislav A. Geras’kin, Alla A. Oudalova, Vladimir G. Dikarev, Nina S. Dikareva and Tatiana I. Evseeva	
7. Methodology of Socio-Ecological Monitoring using Cytogenetic Methods	91
Alla Gorova and Irina Klimkina	
8. Role of Genetic Susceptibility in Environmental Exposure Induced Diseases.....	103
Soheir Korrea	

Section 3: Multiple Stressor Data: Long-Term Effects

9. Post-Radiated and Post-Stressed Volatile Secretions:
Secondary Immune and Behavioral Reactions
in Groups of Animals..... 127
B.P. Surinov, A.N. Sharetsky, D.V. Shpagin, V.G. Isayeva,
and N.N. Dukhova
10. Radiation-Induced Genomic Instability in the
Offspring of Irradiated Parents 139
Yuri E. Dubrova
11. Evolution Processes in Populations of Plantain, Growing
around the Radiation Sources: Changes in Plant Genotypes
Resulting from Bystander Effects and Chromosomal Instability 155
V.L. Korogodina and B.V. Florko
12. Clastogenic Factors, Bystander Effects and
Genomic Instability In Vivo 171
Sergey Melnov, Pavel Marozik, and Tatiana Drozd

Section 4: Multiple Stressors: Mechanisms

13. Multidisciplinary Aspects of Regulatory Systems Relevant
to Multiple Stressors: Aging, Xenobiotics and Radiation..... 185
C. David Rollo
14. Genetic Aspects of Pollutant Accumulation in Plants 225
A. Kilchevsky, L. Kogotko, A. Shchur, and A. Kruk
15. Radiation Risks in the Context of Multiple Stressors
in the Environment – Issues for Consideration 235
Carmel Mothersill and Colin Seymour
16. Protection by Chemicals against Radiation-Induced
Bystander Effects 247
Pavel Marozik, Irma Mosse, Carmel Mothersill,
and Colin Seymour
17. Considerations for Proteomic Biomarkers in
Rainbow Trout Ecotoxicology..... 263
Richard W. Smith, Iurgi Salaberria, Phil Cash, and Peter Pärt

18. Genetic Effects of Combined Action of Some Chemicals and Ionizing Radiation in Animals and Human Cells 271
Irma Mosse, L.N. Kostrova, and V.P. Molophei
19. Cytogenetic Biomarkers for Exposure to Multiple Stressors 287
Marco Durante
20. Redox Proteomics – A Route to the Identification of Damaged Proteins..... 295
David Sheehan, Raymond Tyther, Vera Dowling, and Brian McDonagh
21. Exposure Assessment to Radionuclides Transfer in Food Chain 309
Maria de Lurdes Dinis and António Fiúza
22. Radiation, Oxidative Stress and Senescence; The Vascular Endothelial Cell as a Common Target 325
Paul N. Schofield and Jose Garcia-Bernardo
23. Sensitivity of Irradiated Animals to Infection 335
V.S. Nesterenko, I.S. Meshcherjakova, V.A. Sokolov, R.S. Boudagov, and A.F. Tsyb

Section 5: Multiple Stressors: Applied Aspects

24. Features of Somatic Gene Mutagenesis in Different Age Groups of Persons Exposed to Low Dose Radiation..... 343
Alexander S. Saenko and Irina A. Zamulaeva
25. State of Ecosystems at Long-term Contamination with Transuranium Radionuclides..... 351
V. Kudrjashov and E. Konoplya
26. Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) in Non-Nuclear Industry and their Impact into Environment and Occupational Radiation Risk 359
Boguslaw Michalik

27. Steppe Soils Buffer Capacity and the Multipollution Impact of Industrial Enterprises in Ukraine.....	373
Mykola M. Kharytonov, Ann A. Kroik, and Larisa V. Shupranova	
28. Cancer Risk Assessment in Drinking Water of Izmir, Turkey	381
Sukru Aslan and Aysen Turkman	
29. Enhanced Adsorption of Atrazine in Different Soils in the Presence of Fungal Laccase.....	391
Natalia A. Kulikova, Valentina N. Davidchik, Elena V. Stepanova, and Olga V. Koroleva	
30. Problem of Microelementoze and Technology Allowing its Elimination with the Help of Geothermal Mineralized Sources: New Technology of Microelentoze Elimination	405
K.T. Norkulova	
31. Ecology-related Microbiological and Biochemical Parameters in Assessing Soils Exposed to Anthropogenic Pollution	409
Zdenek Filip and Katerina Demnerova	
32. Molecular and Cellular Effects of Chronic Low Dose-Rate Ionizing Radiation Exposure in Mice	429
Andreyan N. Osipov	
Section 6: Multiple Stressors – Risk Assessment and Legal/Ethical Aspects	
33. Modeling the Best Use of Investments for Minimizing Risks of Multiple Stressors on the Environment	441
Ganna Kharlamova	
34. Learning from Chernobyl: Past and Present Responses.....	449
Oleg Udovik	
35. Uncertainties from Multiple Stressors: Challenges in Ecological Risk Assessment	455
Deborah Oughton	

36. Nuclear Pollution Exposure and Risk Assessment – The Case of Nuclear Reactors Accidents Involving Radioactive Emission	467
Bogdan Constantinescu and Roxana Bugoi	
37. Multiple Stressors and the Legal Challenge.....	477
Colin Seymour and Carmel Mothersill	
Section 7: Round Table Discussion Summary	
Round Table Discussion.....	483

PREFACE

Ecotoxicological risk from multiple stressors covers any situation where organisms are exposed to a combination of environmental stressors. These include physical and chemical pollutants as well as other stressors such as parasites and environmental impact (e.g., climate change or habitat loss). The combination of stressors can result in increased risk to organisms (either additive or synergistic effects) or decreased effects (protective or antagonistic effects).

The multiple stressor challenge is an international, multi-disciplinary problem requiring an international, multi-disciplinary approach. The current approach to multiple stressors is to examine one stressor at a time and assume additivity. Little work has been done on combinations of stressors such that potential interactions can be determined.

The problem is very complex. Multiple stressors pose a whole spectrum of challenges that range from basic science to regulation, policy and governance. The challenges raise fundamental questions about our understanding of the basic biological response to stressors, as well as the implications of those uncertainties in environmental risk assessment and management. In addition to the great breadth, there is also great depth in the research challenges, largely due to the complexity of the issues. From a basic science point of view, many of the mechanisms and processes under investigation are at the cutting edge of science — involving new paradigms such as genomic instability and bystander effects. The application of state-of-the-art technologies such as proteomics, transgenic organisms and biomarkers offers new opportunities for breakthroughs in scientific understanding. The problem also has a global dimension, with impacts on boundary issues, vulnerable ecosystems, vulnerable societies and developing countries. Regulatory challenges include harmonisation in risk management and regulation, being relevant for new governance mechanisms such as EU Reach and the UN/WHO Strategic Approach to International Chemical Management (SAICM). Finally, there are important socio-economic aspects connected to law (multi-causality) and stakeholder interests (both public, industry).

The NATO ARW which has led to this book is one of the very first attempts to draw relevant experts together who can address all of the above aspects. We were fortunate to be able to attract specialists with legal, ethics and economics backgrounds as well as a wide spectrum of basic and applied scientists and regulators.

The book is structured in 6 sections ranging from general introductory lectures through basic phenomenology, mechanisms, applied aspects and finally legal and ethical aspects.

We wish to acknowledge the NATO Science committee for supporting this workshop. We are very grateful for their generous support.

LIST OF CONTRIBUTORS

Aizawa Kouichi

University of Georgia, Savannah River Ecology Laboratory, Aiken, South Carolina, USA

Ann A. Kroik

State Agrarian University, Voroshilov Street 25, Dnipropetrovsk 49600, Ukraine

Aslan Sukru

Cumhuriyet University, Department of Environmental Engineering, 58140, Sivas/Turkey

Audette-Stuart, Marilyne

Atomic Energy of Canada Ltd, Chalk River, ON K0J 1J0 Canada

Austin, Brian

School of Life Sciences, John Muir Building, Heriot-Watt University, Edinburgh EH14 AS, UK

Boudagov, R.S.

Medical Radiological Research Center, RAMS, Obninsk, Russia

Bugoi, Roxana

“Horia Hulubei” National Institute of Nuclear Physics and Engineering, P.O. Box MG-6, Bucharest 077125, Romania

Cash, Phil

Department of Medical Microbiology, University of Aberdeen, UK

Constantinescu, Bogdan

National Institute of Nuclear Physics, Horia Hulubei, P.O. Box MG-6, 077125 Bucharest, Romania

Davidchik, Valentina N.

Bach Institute of Biochemistry of the Russian Academy of Sciences, Leninsky Prospect 33, 119071 Moscow, Russia

Demnerova, Katerina

Institute of Chemical Technology, Department of Biochemistry and Microbiology, Technicka 3–5, 166 28 Prague 6, Czech Republic

Dikarev, Vladimir G.

Russian Institute of Agricultural Radiology and Agroecology, Kievskoe shosse, 109 km, 249020, Obninsk, Russia

Dikareva, Nina S.

Russian Institute of Agricultural Radiology and Agroecology, Kievskoe shosse, 109 km, 249020, Obninsk, Russia

Dinis, Maria de Lurdes

Porto University, Engineering Faculty (CIGAR), Rua Dr. Roberto Frias, 4200–465 Porto, Portugal

Dowling, Vera

Department of Biochemistry, University College Cork, Lee Maltings, Prospect Row, Mardyke, Cork, Ireland

Dubrova, Yuri E.

University of Leicester, Department of Genetics, LE1 7RH Leicester, UK

Drozd, Tatiana

Department of Environmental and Molecular Genetics, International Sakharov Environmental University, Dolgobrodskaya 23, 220009, Minsk, Belarus

Dukhova, N.N.

Medical Radiological Research Center of the Russian Academy of Medical Sciences, 249036 Obninsk, Kaluga Region, ul. Koroliova, 4, Russia

Durante, Marco

University Federico II, Department of Physics, Naples, Italy

Evseeva, Tatiana I.

Institute of Biology, Komi Scientific Center, Ural Division RAS, Kommunisticheskaya 28, 167982, Syktyvkar, Russia

Fiúza, António

Geo-Environment and Resources Research Centre (CIGAR)
Engineering Faculty, Porto University, Rua Dr. Roberto Frias, 4200-465,
Porto, Portugal

Florko, B.V.

Joint Institute for Nuclear Research (JINR), 141980 Dubna, Moscow Region, Russia

Garcia-Bernardo, Jose

Department of Physiology, Development and Neuroscience, University of Cambridge, UK

Geras'kin, Stanislav A.

Russian Institute of Agricultural Radiology and Agroecology, Kievskoe shosse, 109 km, 24902 Obninsk, Russia

Gorova, Alla

National Mining University, K. Marks 19, Dnipropetrovs'k, 49006 Ukraine

Hinton, Thomas G.

University of Georgia, Savannah River Ecology Laboratory, Aiken, South Carolina, USA

Isayeva, V.G.

Medical Radiological Research Center of the Russian Academy of Medical Sciences, 249036 Obninsk, Kaluga Region, ul. Koroliova, 4, Russia

Kharlamova, Ganna

Kiev National Taras Shevchenko University, Kiev, Ukraine

Kharytonov, Mykola M.

State Agrarian University, Voroshilov Street 25, Dnipropetrovsk 49600, Ukraine

Kilchevsky, A.

Institute of Genetics and Cytology, Minsk, Belarus

Klimkina, Irina

National Mining University, K. Marks 19, 49600 Dnipropetrovsk, Ukraine

Kogotko, L.

Belarussian State Agricultural Academy, Gorky, Mogilev Region, Belarus

Konoplya, E.

Institute of Radiobiology, National Academy of Sciences of Belarus, Minsk, Belarus

Korogodina, V.L.

Joint Institute for Nuclear Research, 141980 Dubna, Moscow, Russia

Koroleva, Olga V.

Russian Academy of Sciences, National Center for Radiation Research and Technology, Bach Institute of Biochemistry, Leninsky prospect 33, 119071 Moscow, Russia

Korrea, Soheir

Laboratory of Mutagens and Toxigenomics, P.O. Box 29 Nasr City, Cairo, Egypt

Korrea, Soheir

National Center for Radiation Research and Technology, Egypt

Kostrova, L.N.

Institute of Genetics and Cytology, National Academy of Sciences, Minsk, Belarus

Kroik, Ann A.

State Agrarian University, Voroshilov St. 25, Dnipropetrovsk 49600, Ukraine

Kruk, A.

University of Gomel, Gomel, Belarus

Kudrjashov, V.

Institute of Radiobiology, National Academy of Sciences of Belarus, Minsk, Belarus

Kulikova, Natalia A.

Lomonsov Moscow State University, Department of Soil Science, Leninskie Gory GSP-2, 119992 Moscow, Russia

Marozik, Pavel

Institute of Genetics and Cytology, National Academy of Sciences of Belarus, Akademicheskaya 27, 220072 Minsk, Belarus

Mcdonagh, Brian

Department of Biochemistry, University College Cork, Lee Maltings, Prospect Row, Mardyke, Cork, Ireland

Melnov, Sergey

International Sakharov Environmental University, Department
of Molecular Genetics, Dolgobrodskaya 23, 220009 Minsk, Belarus

Meshcherjakova, I.S.

Research Institute of Experimental Microbiology, RAMS, Moscow, Russia

Michalik, Boguslaw

Central Mining Institute, Laboratory of Radiometry, Plac Gwarków 1,
40-166 Katowice, Poland

Mitchel, Ronald E.J.

Atomic Energy Canada, Chalk River Laboratories, K0J 1J0 Chalk River,
Canada

Molophei, V.P.

Institute of Genetics and Cytology, National Academy of Sciences, Minsk,
Belarus

Mosse, Irma

Institute of Genetics and Cytology, National Academy of Sciences
of Belarus, Akademicheskaya 27, 220072 Minsk, Belarus

Mothersill, Carmel

McMaster University, Medical Physics and Applied Radiation Sciences,
1280 Main Street W, L8S 4K1 Hamilton, Canada

Nesterenko, V.S.

Medical Radiological Research Center, Obninsk, Russia

Norkulova, K.T.

Tashkent State Technical University, University Street 2, Tashkent,
Uzbekistan

Osipov, Andreyan N.

N.I Vavilov Institute of General Genetics RAS, Gubkin Street 3, 119991
Moscow, Russia

Oudalova, Alla A.

Russian Institute of Agricultural Radiology and Agroecology, Kievskoe
shosse, 109 km, 249020, Obninsk, Russia

Oughton, Deborah

Department of Plant and Environmental Sciences, Norwegian
University of Life Sciences, P.O. Box 5003, 1432 Aas, Norway

Pärt, Peter

DG JRC, European Commission Joint Research Centre, Ispra,
Italy

Rollo, David C.

McMaster University, Department of Biology, 1280 Main Street W, L8S
4K1 Hamilton, Canada

Rosseland, Bjorn

Norwegian University of Life Sciences, Department of Plant
and Environmental Sciences, P.O. Box 5003, 1432 Aas, Norway

Saenko, Alexander S.

Medical Radiological Research Center, Korolev Street 4, 249036 Obninsk,
Russia

Salaberria, Iurgi

Institute of Environment and Sustainability, European Commission Joint
Research Centre, Ispra, Italy

Salbu, Brit

Norwegian University of Life Sciences, Department of Plant
and Environmental Sciences, P.O. Box 5003, 1432 Aas, Norway

Schofield, Paul N.

Department of Physiology, Development and Neuroscience,
University of Cambridge, UK

Segner, Helmut

Centre for Fish and Wildlife Health, Vetsuisse Faculty, University of Bern,
P.O. Box 8466, CH-3001 Bern, Switzerland

Seymour, Colin

McMaster University, Medical Physics and Applied Radiation Sciences,
1280 Main Street W, L8S 4K1 Hamilton, Canada

Sharetsky, A.N.

Medical Radiological Research Center of the Russian Academy of Medical Sciences, 249036 Obninsk, Kaluga Region, ul. Koroliova, 4, Russia

Shchur, A.

Institute of Radiology, Mogilev Department, Mogilev, Belarus

Sheehan, David

University College Cork, Lee Maltings, Prospect Row, Mardyke Cork, Ireland

Shpagin, D.V.

Medical Radiological Research Center of the Russian Academy of Medical Sciences, 249036 Obninsk, Kaluga Region, ul. Koroliova, 4, Russia

Shupranova, Larisa V.

Dnipropetrovsk National University, Gagarina av.44, Dnepropetrovsk, 49600, Ukraine

Skipperud, L.

Norwegian University of Life Sciences, Department of Plant and Environmental Sciences, P.O. Box 5003, 1432 Aas, Norway

Smith, Richard W.

McMaster University, Department of Biology, 1280 Main Street W, L8S 4K1 Hamilton, Canada

Sokolov, V.A.

Medical Radiological Research Center, RAMS, Obninsk, Russia

Stepanova, Elena V.

Bach Institute of Biochemistry of the Russian Academy of Sciences, Leninsky prospect 33, 119071 Moscow, Russia

Surinov, B.P.

Russian Academy of Medical Sciences, Medical Radiological Research Center, 249036 Obninsk, Kaluga Region, Russia

Tsyb, A.F.

Medical Radiological Research Center, RAMS, Obninsk, Russia

Turkman, Aysen

Dokuz Eylul University, Department of Environmental Engineering,
35160 Buca, Turkey

Tyther, Raymond

Department of Biochemistry, University College Cork, Lee Maltings,
Prospect Row, Mardyke, Cork, Ireland

Udovyk, Oleg

National Institute of Strategic Studies, Kiev, Ukraine

Yankovich, Tamara

Atomic Energy of Canada Ltd, Chalk River, ON K0J 1J0 Canada

Zamulaeva, Irina A.

Medical Radiological Research Center of RAMS, Korolev Street 4,
Obninsk, 249036, Russian Federation

Zdenek, Filip

Institute of Chemical Technology, Department of Biochemistry and
Microbiology, Technicka 3–4, 166 28 Prague 6, Czech Republic