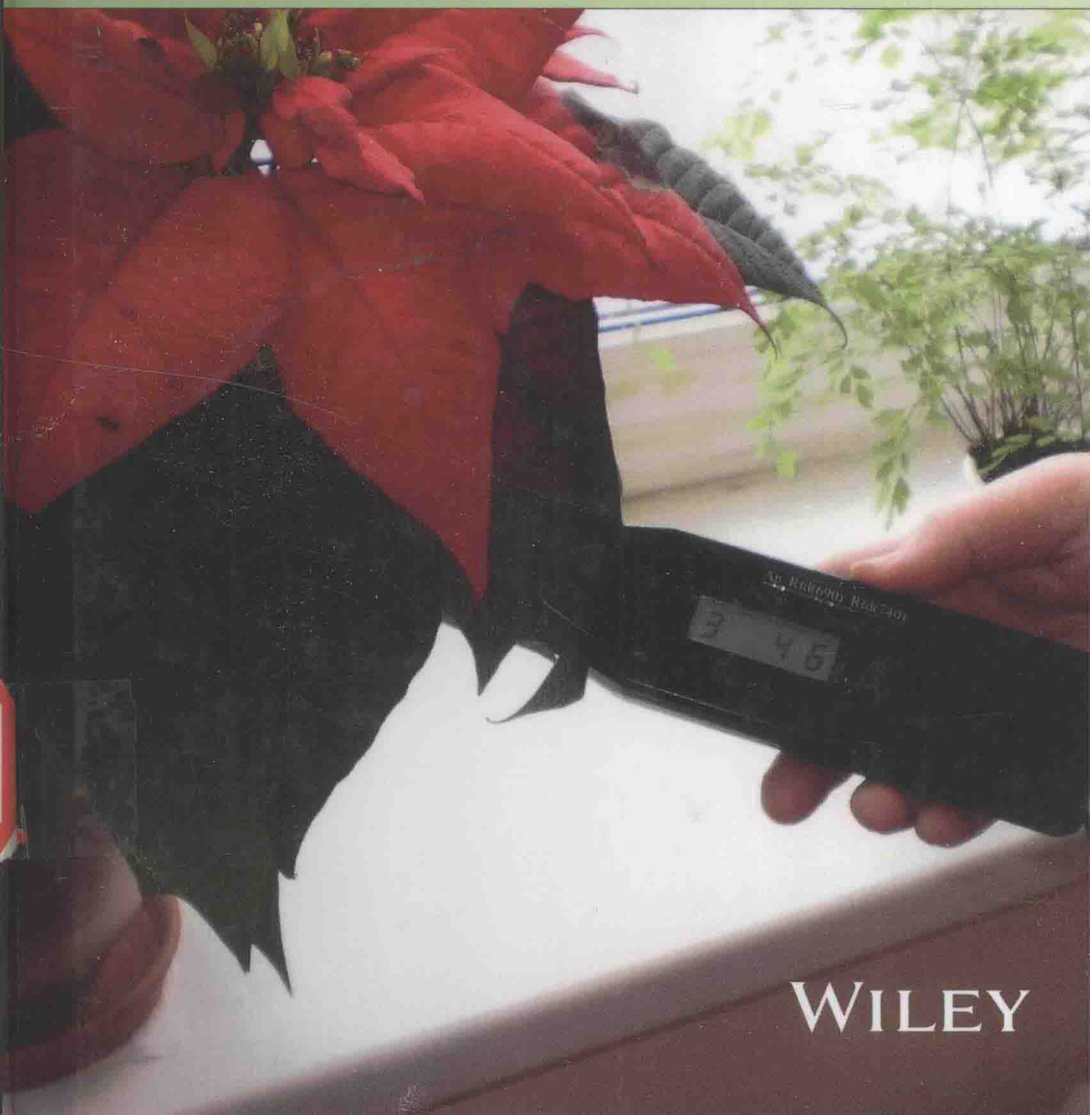
Methods of

MEASURING ENVIRONMENTAL PARAMETERS

YURIY POSUDIN



WILEY

METHODS OF MEASURING ENVIRONMENTAL PARAMETERS

YURIY POSUDIN
National University of Life
and Environmental Sciences of Ukraine
Kiev, Ukraine

WILEY

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

Library of Congress Cataloging-in-Publication Data:

Posudin, Yu.I. (Yuriy Ivanovich)
Methods of measuring environmental parameters / Yuriy Posudin, National University of Life and Environmental Sciences of Ukraine, Kiev, Ukraine.
pages cm
Includes index.
ISBN 978-1-118-68693-5 (cloth)
1. Pollution–Measurement. 2. Environmental monitoring. I. Title.
TD193.P68 2014
628.5028′7–dc23

2014008365

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

To Professor Stanley J. Kays,
a good friend, gentleman, and my supervisor

Understanding that the world does not belong to any one nation or generation, and sharing a spirit of utmost urgency, we dedicate ourselves to undertake bold action to cherish and protect the environment of our planetary home.

Al Gore
September 16, 1992
Sioux Fall, South Dakota

PREFACE

The world population reached 7 billion October 31, 2011 and continues to grow at an unprecedented rate. The United Nations has projected the possible world population in 2300 using differing scenarios based on changes in fertility: declining growth (2.3 billion), average growth (9 billion), and high growth (36.4 billion).

Two primary processes impact population growth: (1) industrialization—the large-scale introduction of manufacturing, advanced technical enterprises, and other productive economic activities into an area, society, or country. There are typically significant social and economic changes during the transition between preindustrial and industrial societies; and (2) urbanization—the physical growth of urban areas as a result of rural migration into cities and concentration of large number of people in small areas, forming cities. The net effect is the emergence of megacities (cities with populations of over 1 million inhabitants) that are a characteristic feature of demographic growth. About 22 cities worldwide had populations that exceeded 10 million inhabitants in 2010.

The exponential growth of the world population is accompanied by increasing energy consumption, fertilizer use, and the concentration of pollutants in the environment (e.g., carbon dioxide, nitrogen dioxide, hydrogen sulfide, sulfur dioxide, hydrocarbons); a shortage of arable land; and the accumulation of radioactive waste. Mankind has reached or will reach its highest level of fossil fuel extraction in the near future: oil—in 2007, coal—in 2025, gas—in 2025. Electricity production by hydroelectric power stations will increase by 40% by 2050.

It is highly probable that armed conflicts around the world will increase due to the inequitable distribution of essential resources such as fossil fuels, fresh water, and other requisites. The rate of growth of the world population and the associated increase in energy consumption, lack of adequate food, deteriorating water and air quality due to the rapid rate of industrialization and urbanization, and the impact of biosphere pollution on climate, biogeochemical cycling, and the fauna and flora—all point toward an unprecedented environmental crisis in the immediate future.

The "greenhouse effect" is resulting in significant changes in the heat balance in the biosphere, which is precipitating potentially extreme climatic alterations. Increasing global temperature leads to melting of the polar ice, thermal expansion in the volume of the ocean water, elevated sea levels, and an appreciable reduction in the amount of dry land. Elevated temperature results in an increasing frequency of natural disasters such as severe floods, hurricanes, tsunamis, and drought. Changes in climate and sea level will also instigate extensive population migration.

Indications of this emerging crisis are natural and man-made environmental disasters that are accompanied by fatalities and irreversible harmful effects on the environment. Recent examples include the intense earthquakes and tsunamis in the Indian Ocean in 2004 (225,000 deaths), earthquakes in Pakistan in 2005 (74,500 deaths), China in 2008 (69,000 deaths), Haiti in 2010 (320,000 deaths); there were victims of hurricane "Katrina" in 2005, the most destructive hurricane in US history; the cyclone "Nargis" in 2005 (Burma or Myanmar); and the earthquake and tsunami in Japan in 2011.

In 2010, about one half of Europe was covered with dangerous ash as a result of the eruption of Eyjafjallajökull, a volcano in Iceland that paralyzed air travel for several weeks. The 2011 eruption of Grímsvötn, also in Iceland, similarly disrupted air travel in Northwestern Europe.

In 2003, an unexpected heat wave in Europe resulted in ~40,000 deaths; extremely high ambient temperatures in Russia in 2010 caused ~15,000 deaths and numerous fires.

Powerful floods occurred in Australia and Brazil in 2010–2011, in Amur district, Russia, in 2013.

Man-made disasters included an explosion at the AZF chemical factory in Toulouse (France) in 2001; an extremely serious accident on a British Petroleum oil well platform in the Gulf of Mexico in 2010 was the largest environmental disaster in US history; a fractured reservoir resulted in the release of toxic "red mud" in the Hungarian region of Veszprem in 2010; and the detection of dioxin in pig and poultry feed on farms in Germany in 2010.

It is impossible to ignore the harmful environmental impact of military activity and technology, and space exploration. A Ukrainian military tactical rocket struck a house in the town of Brovary, near Kiev, killing three people in 2000; a Ukrainian missile accidently shot down a Russian jet during military exercises in the Crimea in 2001, resulting in death of 78 people. There were a series of fires and explosions at military arsenals in Donetsk (2003), near the village of Novobohdanivka (2004) and in Lozova (2008) in Ukraine, that caused great losses and in Ulyanovsk (2009), Bashkortostan and Udmurtia (2011) in Russia.

There were also serious incidents in space. For example, the Russian "Cosmos-2251" and American "Iridium-33" satellites collided at an altitude of 790 miles over Siberia in 2009. In 2006, the wreckage of the Russian military satellite nearly struck a Latin American Airbus with 279 passengers on board. Tests of Chinese antisatellite weapons in 2007 led to the dispersal of considerable "space junk," adding to an estimated 2300 fragments and countless number of smaller items that greatly increase the possibility of a catastrophic loss of a manned spacecraft or satellites. Other accidents that resulted in debris in space include accidents or failures such as the cargo spaceship Progress M-12M (2011), the Russian interplanetary station "Phobos-Soil" that failed to reach Mars, and the Russian satellite "Meridian," that fell onto the street of Cosmonauts in the village Vahaytsevo in the Novosibirsk region. In addition to the tremendous number of debris fragments in space, each launch of a rocket is accompanied by the contamination of biosphere with dangerous fuel, pollutants and pieces of the spacecrafts.

We live in a very intense and harmful time from the point of view of damage to the environment and the resulting impacts on the biosphere. It is essential, therefore, that we utilize environmental monitoring and measurement of environmental parameters to obtain the essential information on changes in abiotic and biotic factors, and air, soil, and water quality. This may be accomplished using modern automated methods of measurement and remote sensing technologies. Understanding the nature and extent of environmental problems is essential for identifying and putting into action viable solutions.

ACKNOWLEDGMENTS

The author of the textbook had the opportunity to cooperate with a number of scientists, researchers, and educators during his scientific and academic activities, namely:

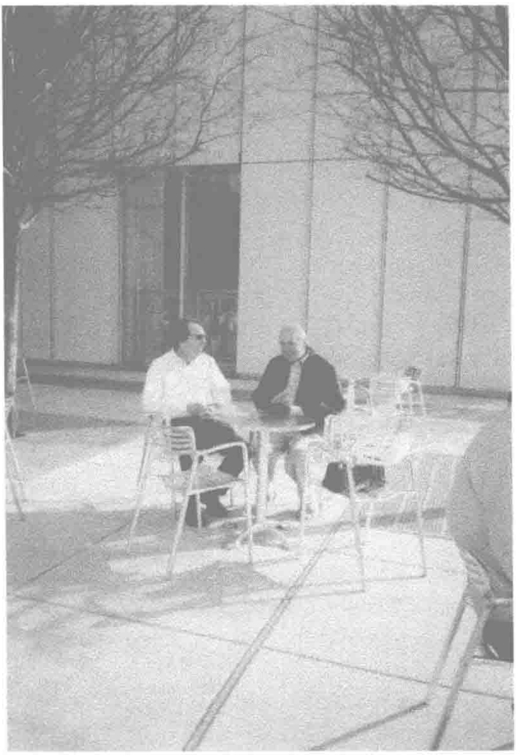
Prof. E. Bazarov, Dr. G. Gerasimov, 1972–1975, Institute Radiotechnics and Electronics of the Academy of Sciences of USSR, Moscow, Frjazino, USSR; Prof. F. Lenci, Dr. G. Colombetti, 1979–1980, Institute of Biophysics CNR, Pisa, Italy; Prof. N. Massjuk, Dr. G. Lilitskaya, 1980–2010, M. G. Kholodny Institute of Botany of the National Academy of Sciences of Ukraine, Kiev, Ukraine; Prof. I. Lisker, 1992, Agrophysical Institute, St. Petersbourg, Russia; Prof. D.-P. Häder, 1993, Friedrich-Alexander-University Erlangen-Nuremberg, Germany; Dr. Chi N. Thai, 1996, Driftmier Engineering Center, University of Georgia, U.S.A.; Prof. H. K. Lichtenthaler, 1997, University of Karlsruhe, Germany; Prof. A. Flores-Moya, 2000, University of Malaga, Spain; Prof. Stanley J. Kays, 1996, 2000, 2008, Department of Horticulture, University of Georgia, U.S.A.; Prof. Hiroshi Kawai, 2002, Research Center for Inland Seas, Kobe University, Japan; Prof. C. Wiencke, Prof. D. Hanelt, 2003, Alfred-Wegener-Institute for Polar and Marine Research, Bremenhaven, Germany; Prof. Kyoichi Otsuki, Dr. Atsushi Kume, Dr. Tomo'omi Kumagai, 2007, Kyushu University, Toyama University, Japan; Dr. Gerry Dull, 2008, Department of Horticulture, University of Georgia, U.S.A.; Prof. Shunitz Tanaka, Dr. Kazuhiro Toyoda, 2010, Hokkaido University, Sapporo, Japan; Prof. R. Mnatsakanian, 2010, Central European University, Budapest, Hungary; Prof. Aimo Oikari, Prof. Timo Älander, 2010, Jyväskylä University, Finland.

These visits and collaboration undoubtedly influenced the forming of expanding horizons and world view of the author, who has a brilliant opportunity to express his sincere gratitude to all the above-mentioned supervisors, colleagues, and collaborators.

The author of this textbook, Fulbright Scholar in 1996, expresses his deep gratitude to the administration of the Fulbright Program in Ukraine, for organizational assistance to establish useful contacts with the US colleagues.

Special thanks to Prof. Stanley J. Kays for his moral support and encouragement, editorial revision, criticism, and suggestions during the preparation of the manuscript.

The author would like to thank the following reviewers of the manuscript: Prof. Motoyoshi Ikeda, The University of Hokkaido, Graduate School of Environmental Science, Sapporo, Japan; Dr. Atsushi Kume, Director of Ashoro Research Forest, Kyushu University, Ashoro, Hokkaido, Japan; Prof. Yuriy Masikevych, Head of Department of the Ecology and Law, Chernivtsi Faculty of the National Technical University "Kharkiv Polytechnic Institute," Chernivtsi, Ukraine; Prof. Yarema Tevtul', Chernivtsi National University, Chernivtsi, Ukraine; Anatoly Vid'machenko, Head, The Department for Physics of Solar System Bodies, Main Astronomical Observatory of the National Academy of Sciences of Ukraine, Kiev, Ukraine; Prof. Igor Yakymenko, Department of Biophysics, Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine, as well as several anonymous reviewers, whose valuable opinions contributed greatly to the success of this manuscript.



Professor Stanley Kays (left) and author of the textbook (right) in Georgia

ABOUT THE BOOK

The *main objective* of the textbook "*Methods of Measuring Environmental Parameters*" is to introduce students of Environmental Science and Engineering in current methods of environmental control and principles of devices used for measuring environmental parameters.

Specific aims of the textbook are:

1. a brief description of the main climatic (pressure, wind, temperature, humidity, precipitation, solar radiation), atmospheric, hydrographic, and edaphic factors;
2. assessment of abiotic factors, their effect on quality of atmosphere and indoor air, soil, water;
3. assessment of biotic factors, bioindication, and biomonitoring as perspective methods of observing the impact of external factors on ecosystems;
4. study the principal effects of environmental factors on living organisms, human health, and ecosystems;
5. review the basic methods and principles of modern instrumentation that can be applied for measuring environmental (mostly physical) parameters, with special emphasis on automated and remote sensing components of the environment;
6. comparative analysis of the advantages and disadvantages of the main methods of measurement presented in the textbook;
7. monitoring of student learning through practical exercises, tasks, problems, and tests.

The textbook has practical exercises, which allow a better understanding of the textbook content; the examples with solutions, and control exercises; questions and problems to provide self-testing the material presented in the textbook; constructive tests, for which there are no direct answers, but the student must find the answer himself. Examples of extreme environmental situations are given for the curious students. The list of references, electronic references and further reading is given at the end of each chapter. An appendix and a subject index are included at the end of the textbook.

The content of the textbook is based on course in *Methods of Measuring Environmental Parameters* given by author to students at National University of Kyiv-Mohyla Academy and undergraduates at National University of Life and Environmental Sciences of Ukraine, Kiev, Ukraine.

Methods of Measuring Environmental Parameters is intended to be a useful overview reference for professional ecologists, environmental scientists, meteorologists, climatologists, atmospheric physicists, aerobiologists, and soil and water managers. It can also serve as a suitable textbook for undergraduate and graduate students in these academic disciplines.

ABOUT THE AUTHOR

Professor Yuriy Posudin, Doctor of Biological Sciences, National University of Life and Environmental Sciences of Ukraine, Kiev, Ukraine.

He studied at the Kiev State University (Radiophysical Faculty) 1964–1969, the Institute of Radiotechnique and Electronics, Moscow (1972–1975), and the Agrophysical Institute, St. Petersburg (1992).

Dr. Posudin's principal scientific interests are the investigation of photobiological reactions of algae and plants, and the non-destructive quality evaluation of agricultural and food products.

Academic duties of Dr. Posudin include lecturing of a cross-section of environmental topics, such as "Environmental Biophysics," "Methods of Measuring Environmental Parameters," and "Environmental Monitoring with Fundamentals of Metrology."

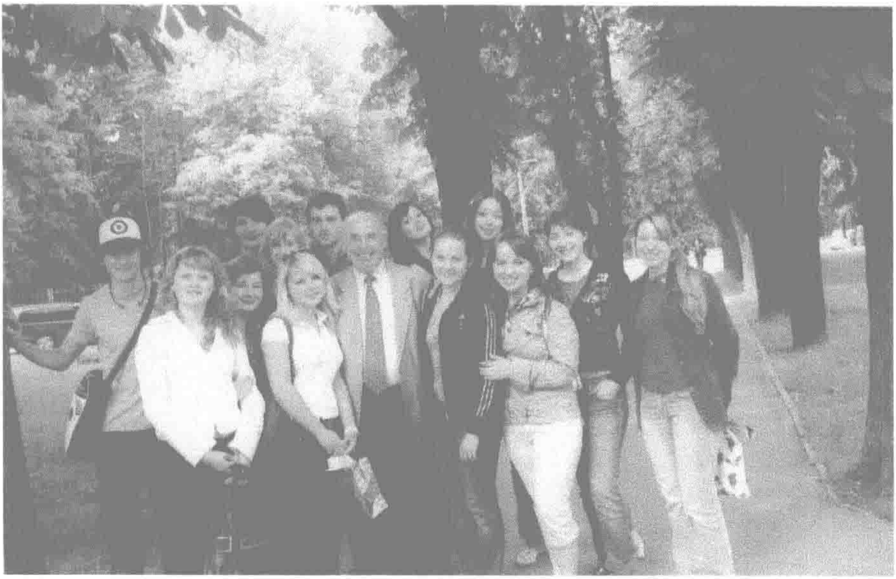
The main publications of Yuriy Posudin are:

Posudin, Yuri. 1998. *Lasers in Agriculture.* Science Publishers, Ltd, USA, p. 220.

Posudin, Yu. I. 2003. *Physics with Fundamentals of Biophysics.* Agrarna Nauka, Kyiv, p. 195.

Posudin, Yuriy. 2007. *Practical Spectroscopy in Agriculture and Food Science.* Science Publishers, Enfield, p. 196.

Posudin, Yu. I., Massjuk, N. P., and Lilitskaya, G. G. 2010. *Photomovement of Dunaliella Teod.* Vieweg + Teubner Research, p. 224.



Prof. Yuriy Posudin with the students of Environmental Sciences, Kiev, Ukraine.

CONTENTS