



REACTIVE NITROGEN IN THE ENVIRONMENT

***Too Much or Too Little
of a Good Thing***

UNITED NATIONS ENVIRONMENT PROGRAMME



Copyright © United Nations Environment Programme, WHRC 2007

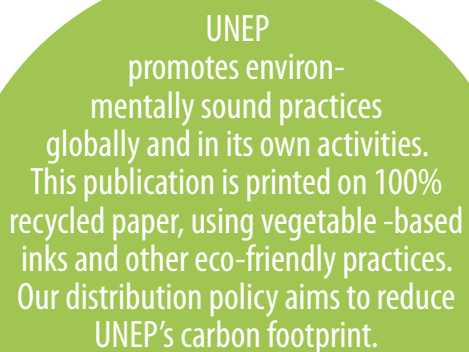
This publication may be reproduced in whole or in part and in any form for educational or non-profit purposes without special permission from the copyright holder, provided acknowledgement of the source is made. UNEP would appreciate receiving a copy of any publication that uses this publication as a source.

No use of this publication may be made for resale or for any other commercial purpose whatsoever without prior permission in writing from the United Nations Environment Programme.

Disclaimer

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the United Nations Environment Programme or the Woods Hole Research Center concerning the legal status of any country, territory, city or area or of its authorities, or concerning delimitation of its frontiers or boundaries. Moreover, the views expressed do not necessarily represent the decision or the stated policy of the United Nations Environment Programme or the Woods Hole Research Center, nor does citing of trade names or commercial processes constitute endorsement.

ISBN: 978 92 807 2783 8
DTI/0904/PA



UNEP
promotes environ-
mentally sound practices
globally and in its own activities.
This publication is printed on 100%
recycled paper, using vegetable -based
inks and other eco-friendly practices.
Our distribution policy aims to reduce
UNEP's carbon footprint.

REACTIVE NITROGEN IN THE ENVIRONMENT

***Too Much or Too Little
of a Good Thing***



**UNEP DTIE
Sustainable Consumption and
Production (SCP) Branch**

15 rue de Milan
75441 Paris CEDEX 09
France
Tel: +33 1 4437 1450
Fax: +33 1 4437 1474
E-mail: unep.tie@unep.fr
www.unep.fr/pc



The Woods Hole
Research Center

The Woods Hole Research Center

149 Woods Hole Road
Falmouth MA 02540-1644 USA
Tel: + 1 508 540 9900
Fax: + 1 508 540 9700
www.whrc.org

Acknowledgments

This review was authored by Elizabeth Braun on a commission from UNEP-DTIE.

Overall supervision of the project and reviews of the document were provided by Charles Arden-Clarke (UNEP-DTIE) and Eric Davidson (Woods Hole Research Center). Drafts were also reviewed by an editorial committee consisting of Mateete Bekunda (INI Steering Committee, Africa Regional Centre), Marion Cheate (UNEP-DEWA), Jan Willem Erisman (INI Steering Committee, European Regional Centre), Jim Galloway (INI Steering Committee, Chair), Cees van de Guchte (UNEP-GPA), Luiz Martinelli (INI Steering Committee, Latin American Regional Centre), Frank Moser (UNEP-Chemicals), Kilaparti Ramakrishna (UNEP-OED) and Yonglong Lu (Chinese Academy of Science). Specific inputs on policy instruments associated with Regional Seas Agreements were provided by Chris Corbin of the Caribbean Regional Coordinating Unit and Kaj Forsius of the Helsinki Commission which supports implementation of the Baltic Sea Action Plan. Additional comments were provided by government and industry stakeholders who participated in the UNEP-WHRC workshop in March 2006.

UNEP and WHRC would like to thank all who participated in the process of producing this review.

Cover Background Image:

Wheat Field. Photo copyright © Julien Boisard (www.julienboisard.fr).

Cover Inset Image:

Red Tide Tolo Harbour. Photo copyright © Michael Pitts (www.biosphoto.com)

Recommended Citation: UNEP and WHRC. *Reactive Nitrogen in the Environment: Too Much or Too Little of a Good Thing*. United Nations Environment Programme, Paris, 2007.

Table of Contents

| | |
|---|-----------|
| Executive summary | 5 |
| Introduction | 9 |
| Understanding the role of reactive nitrogen in the environment | 11 |
| Impacts of excess reactive nitrogen in the environment | 17 |
| Impacts of excess reactive nitrogen on environmental quality and ecosystem services.. | 17 |
| Impacts of excess reactive nitrogen on human health. | 18 |
| Economic considerations of excess reactive nitrogen in the environment | 19 |
| Addressing effects of reactive nitrogen in the environment.. | 21 |
| Case Study: Nitrogen excesses in Latin America and the Caribbean.. | 23 |
| Biomass burning in Brazil | 23 |
| Coastal and marine pollution. | 24 |
| Case Study: Nitrogen excesses in Europe. | 27 |
| The Convention on Long-Range Transboundary Air Pollution.. | 27 |
| The Sofia Protocol. | 27 |
| The Gothenberg Protocol | 28 |
| Eutrophication in the Baltic Sea | 30 |
| Case Study: Nitrogen excesses in Asia | 33 |
| Estuary and river water quality.. | 33 |
| Case Study: Nitrogen excesses in North America.. | 35 |
| The Chesapeake Bay Program. | 35 |
| Case Study: Nitrogen deficiencies in Africa | 39 |
| Famine in sub-Saharan Africa | 39 |
| Conclusion and recommendations | 41 |
| The impacts of reactive nitrogen in the environment | 41 |
| Varying impacts, scales, and responses to reactive nitrogen | 41 |
| Assessment, monitoring and designing effective multi-stakeholder responses.. | 42 |
| Information sharing and collaboration for effective policies on reactive nitrogen | 43 |
| Glossary | 45 |
| Annex A: Roster of policies and relevant institutions | 47 |
| Annex B: References and further reading | 49 |

Executive summary

Nitrogen is an essential, fundamental building block for life. It is the most plentiful element in the earth's atmosphere, yet in its molecular form (N_2), it is unusable by the vast majority of living organisms. It must be transformed, or fixed, into other forms, collectively known as reactive nitrogen (See Glossary), before it can be used by most plants and animals. Without an adequate supply of nitrogen, crops do not thrive and fail to reach their maximum production potential. In many ecosystems, nitrogen is the limiting element for growth. However, when present in excess, reactive nitrogen causes a range of negative environmental effects, poses risks to human health and consequently can have negative economic and social consequences. This non-technical review seeks to convey an understanding of the effects of reactive nitrogen in the environment, focusing mainly on those caused by excesses of reactive nitrogen. It also examines experience with some policies developed to address those effects, and offers recommendations to advance understanding and policy responses to them.

Natural production of reactive nitrogen includes nitrogen fixation by legumes, blue-green algae and a few other organisms and by lightning. Although substantial amounts of nitrogen are fixed through these naturally occurring processes, those rates are not sufficient to meet the food demands of an increasing world population. Because of this, scientists and technologists have found ways to increase its availability by artificially fixing nitrogen and producing synthetic fertilizers. Application of reactive nitrogen, in the form of synthetic fertilizers, plays a central role in modern crop production. These applications have a two-fold consequence: (1) the fertilizers enable increased crop production, supporting a larger human population; (2) at the same time this increases unintended releases of reactive nitrogen to the broader environment through agricultural runoff and additional sewage. These are important factors in the redistribution of reactive nitrogen, especially as it is introduced into groundwater, rivers and estuaries, causing overgrowth of algae in coastal zones, a process known as eutrophication.

Another major source of reactive nitrogen is associated with the growing use of fossil fuels for energy. Combustion of fossil fuels leads to the creation of nitrogen oxides (NO_x) in the atmosphere, and these emissions have increased dramatically since the beginning of the industrial revolution. In the last 150 years, the annual inputs of reactive nitrogen primarily from these agricultural, industrial and transportation sources to the earth's atmosphere, soils, and water bodies have increased by more than a factor of ten and now exceed the annual rate of production of reactive nitrogen from natural sources.

While the overall amount of reactive nitrogen production has increased, it is not evenly distributed around the world. In some areas, primarily industrialized nations, there is an excess of reactive nitrogen. It is accumulating in the air, the soil and the water, moving between each and causing subsequent environmental, human health and related economic problems. In areas where there is too little nitrogen, primarily in the developing world, agriculture cannot meet the basic

challenge of producing enough food to sustain the population, nor fulfill its potential contribution to economic development. Insufficient nitrogen and other agricultural nutrient inputs can also lead to land degradation, soil erosion, desertification and their attendant long-term environmental and economic consequences.

A single nitrogen-containing molecule can have a series of impacts on the environment because reactive nitrogen can so easily move among the different media of air, soil and water. In the air, it can contribute to higher levels of ozone in the lower atmosphere, causing respiratory ailments and damaging vegetation. From the atmosphere, it generally falls to the surface in atmospheric deposition, generating a series of effects — corrosion of buildings, bridges and other human-made structures, acidification of soils and water bodies, and inadvertent fertilization of trees and grasslands, creating unnatural growth rates, nutrient imbalances, and decreasing or altering biodiversity. Leaching out of the soils, reactive nitrogen can make groundwater and surface water unfit for human consumption. Reactive nitrogen also promotes eutrophication in coastal ecosystems, which can negatively impact fish stocks and biodiversity. Eventually, most reactive nitrogen is denitrified back to molecular nitrogen, but a portion is converted to nitrous oxide which contributes to both the greenhouse effect and to stratospheric ozone depletion.

The complex environmental, human health and economic issues surrounding reactive nitrogen (whether in excess or in deficiency) require monitoring, research and assessment of their effects, as well as broader information sharing to inform the design of specific policy responses at local, national and regional levels. Experience shows that well designed policy instruments can play a major role in rectifying reactive nitrogen imbalances and their resulting effects. However, developing effective policies is not a simple matter because the effects of reactive nitrogen are not limited to a single medium — air or soil or water — and a policy to remedy one issue may inadvertently aggravate another. Thus, a comprehensive and coherent understanding of the issue, and of the status of related policy initiatives, is an initial requirement for any action, regardless of scale. It is incumbent upon all the stakeholders — including scientists, policymakers and private sector leaders — both to broadly understand and to specifically address this range of concerns to work towards solutions.

The most successful policy initiatives that have been implemented reflect the integrated nature of the actions needed to address air, water and soil pollution resulting from the excessive release of reactive nitrogen

预览已结束，完整报告链接和二维码如下：

https://www.yunbaogao.cn/report/index/report?reportId=5_10891

