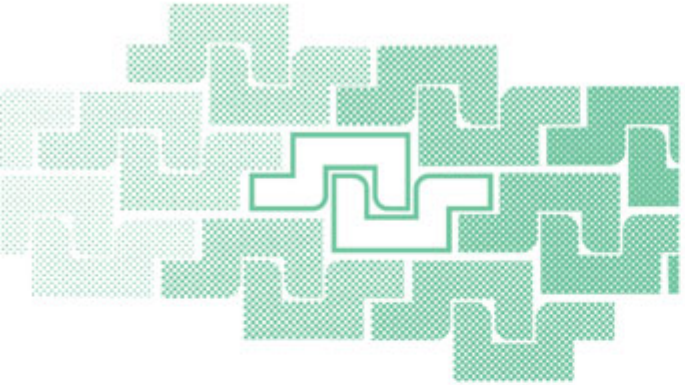

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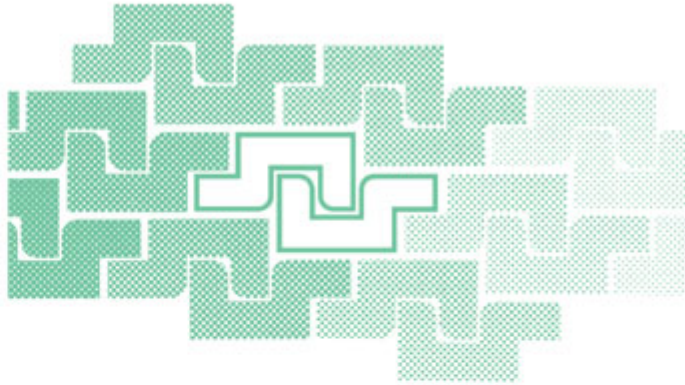

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Soil and Water Pollution Monitoring, Protection and Remediation

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CONTENTS

PREFACE

> In every respect, human development and human security are closely linked to the productivity of ecosystems. Our future rests squarely on their continued viability.
>
> UNDP, UNEP, World Bank, World Resources Institute: *World Resources 2000-2001.People and Ecosystems. The Fraying Web of Life.*

1. OBJECTIVE OF THE BOOK

Soil, surface waters/sediments and shallow unprotected groundwater aquifers are interrelated compartments of the environment that are particularly easy to compromise, sensitive to short- and long-term pollution and directly affect sustainability of ecosystems and human health. Routine human activity such as application of fertilizers and pesticides in agriculture and forestry, or wet and dry deposition of atmospheric pollutants emitted from industrial plants, waste disposal and other practices adversely affect soil and water quality that already increasingly suffers from mismanagement in many areas. The predominant sources of pollution result in non-point contamination that is particularly difficult to reduce and control. Wars, accidents and natural emergency cases such as catastrophic floods that occur partly due to anthropogenically disturbed global water balance also add to overall increase of diverse contaminant loads in soil and water. Beneficial properties of some bulk waste materials such as biosolids (sewage sludge), biowaste (e.g. municipal waste composts) or fly ash from coal combustion

encourage applying these waste to land as a source of nutrients and organic matter, or as a soil amendment. All these human activities result in soil being a sink for all possible chemicals, also new ones, that belong to many groups of xenobiotics - organic compounds such as halogenated organics (AOX), linear alkylbenzene sulfonates (LAS), Di(2-ethylhexyl)phtalate (DEHP), nonylphenol and ethoxylates (NPE), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-dioxins and furans (PCDD/F), organotins (MBT, DBT, TBT), and various pharmaceuticals. Heavy metals and metalloids, and some organic compounds, e.g. polycyclic aromatic hydrocarbons (PAH) that occur in nature but in much lower concentrations, are also of particular concern due to their persistence and toxicity. There is growing evidence of mutagenicity, genotoxicity and endocrine disruption impact of many chemicals on soil and aquatic organisms – primary receptors of soil and water contaminants - and their declining biodiversity. Other organisms – participants of the food web, including humans – have been also endangered.

During the history of human development and industrial revolution, mankind for a longer time ignored warning signs that its activity might damage the capacity of ecosystems to sustain us. Now, at the beginning of the third Millennium we are much more aware of our utter dependence on the productivity of ecosystems that is largely determined by the quality of their essential compartments: soil and water, and of the costs of their degrading and restoration. We also know much more about the processes that govern the fate and migration of contaminants in the environment. Nevertheless, we still know surprisingly little to be able to answer the basic question set up in the special millennial edition of the World Resources Report, *World Resources 2000-2001* (UNDP-UNEP-World Bank-World Resources Institute, 2000): "How best can we manage ecosystems so that they remain healthy and productive in the face of increasing human demands?" And how best can we manage soil and water resources to keep them healthy and productive?

We inherited a huge number of contaminated sites that have to be efficiently and cost-effectively restored, of different size and origin. We still continue to make mistakes in view of current benefits, and ignoring the precautionary principle and our limited knowledge. The development of this knowledge to enable correct prognosis of environmental behavior, bioavailability and impact of chemicals on living organisms is a priority task for better environmental management.

The data on long-term environmental behavior of many xenobiotics and efficient methods of their control are still scarce. Also data on heavy metals of anthropogenic origin are insufficient, in particular with respect to metals mobility, bioavailability and its alteration in time. New concepts and approaches in science that merge biology and chemistry will provide better simulation of contaminant bioavailability in real soil and aquatic systems, and thus a better basis for correct decisions.

A prerequisite of sound ecosystem management decisions is monitoring of soil and waters that should provide reliable data for solid scientific assessment and its validation, and for supporting and verifying environmental management decisions.

Another emerging task of soil and water screening/monitoring comes from the hazards of eco-terrorism, as these compartments are particularly easily available for an attack, consisting of hazardous chemical, microbiological and biochemical poisoning of water. The specific nature of ecoterrorist's attack requires application of specific techniques, in particular identifying unknown substances and mixtures, type of hazardous action, as well as the extent of acute toxicity and its spatial and temporal extinction. Such topics as advanced "field" and "on-site" analytical techniques, optical sensors and immunochemical-based methods, the miniaturization of instrumentation to permit its use in a field setting for screening/ monitoring is of particular timeliness and urgent need.

In all cases, soil and water monitoring tools should provide an early warning, to prevent, intercept or minimize contamination before the environmental damage proceeds too far.

Minimization of potential of soil and water contamination, also due to use of waste materials such as sewage sludge and other biosolids for soil amendment requires source control of contaminants' emission not only from large industries, but also from small artisan enterprises. For this purpose, simple and inexpensive methods, preferably with use of abundant waste materials, e.g. as efficient and cost-effective sorbents of pollutants may be used. In this way the contaminant loads in sewage sludge from municipal treatment plants could be efficiently reduced, therefore reducing also sewage sludge (biosolids) non-point pollution potential to amended soils. In turn, the opportunities that are brought about by application of many rapidly developing techniques such as permeable reactive barriers for either cutting off the accessibility of reagents causing generation of hazardous contaminants, or reacting with hazardous substances that results in bonding, or decomposing, or transforming them into non-hazardous substances are not yet fully utilized. Many novel solutions might be found in this area, or already known solutions might find a new area of application. Permeable reactive barrier techniques and new sorbents might be equally applicable both for prevention of pollution through control of contaminant generation or transformation them into non-hazardous compounds, but also for efficient remediation of soil and/or water contamination or neutralization of an acute toxicity that might result from accident or eco-terrorism. In all cases, the mechanism of action is of the first priority, but optimization of technical construction/application details are of no lesser importance for assuring efficiency and cost-effectiveness. In the permeable reactive barriers, and other preventive/remediation measures, a number of novel integrated physicochemical and biochemical methods can be used.

The remediation solutions for water/sediments and soil pollution should be focused on non-destructive methods that would allow preservation of soil properties during and after decontamination. One such non-destructive method is phytoremediation, i.e. selection of the best contaminant scavengers applicable in the relevant environment and climatic conditions. for contaminant uptake by plants from water/sediment/soil.

Remediation of soils, water/sediments and groundwater contaminated by complex mixtures of organic pollutants and heavy metals is one the greatest challenges facing environmental restoration. There is therefore a significant demand for environmentally safe and economically feasible technologies for treatment of contaminated ecosystems. Although fundamental and applied studies have provided many novel treatment technologies, we must improve the means to bridge between research and practice, and means to combine different capabilities.

Microbial biotransformations of organic contaminants have been widely observed in soils and sediments, while heavy metal contaminants may be immobilized by the action of metal-reducing bacteria or through sulfide precipitation by sulfate-reducing bacteria. Microbial processes are especially attractive, since biodegradation can result in complete mineralization of organic contaminants or lead to significant reduction in their toxicity. Plant based technologies, phytoremediation, are of interest in the ability of plants sequester contaminants on the one hand, and enhance microbial activities in their root zone, on the other. Accelerated in situ decontamination and/or detoxification through stimulation of desirable microbial and plant-mediated processes can shorten the time frame needed for site remediation, thereby reducing the costs of long term monitoring. Remediation that exploits these natural in situ biological processes, combined with in-place containments, potentially avoids redistribution of the contaminants.

The objective of this book is to summarize and critically assess the current status, development trends and needs of three basic defensive elements that safeguard the quality and environmental safety of soil and water/sediments: early warning monitoring, protection and remediation measures, with particular regard to the viability of methods and technologies, i.e. easiness-to-use, reliability, cost-effectiveness, high efficiency and non-destructive character of remediation that is of particular importance considering the scale of application.

The priority aim of the book is to contribute to the improving maintenance of ecosystems, and specifically to summarize and add to information on how best to protect our soils and aquifers, prevent movement and mobilization of pollutants and how to enhance their degradation and/or immobilization. The remediation solutions for soil pollution are focused on non-destructive methods that would preserve soil properties during and after decontamination.