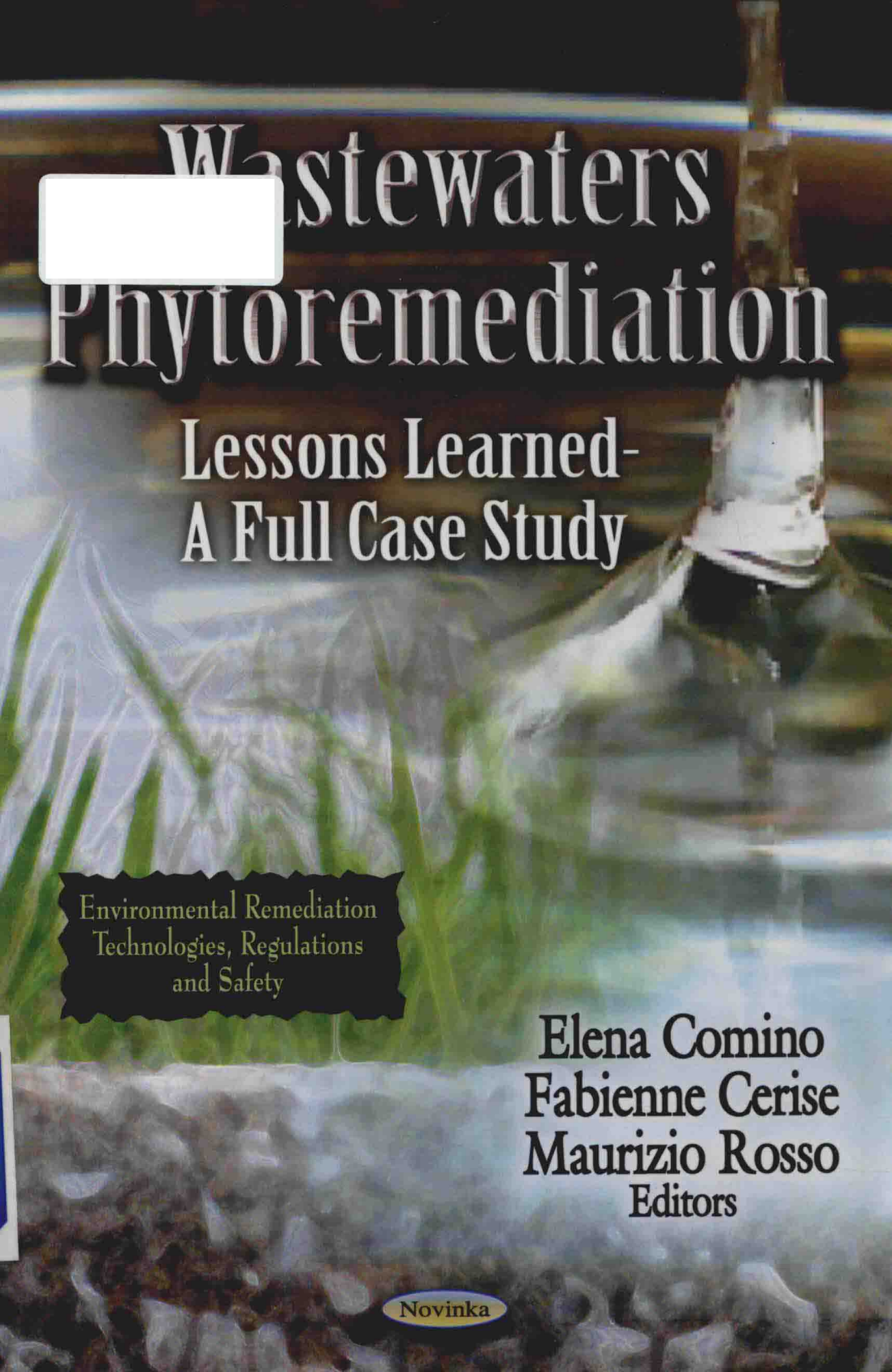
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Lessons Learned-
A Full Case Study
Environmental Remediation
Technologies, Regulations
and Safety
Elena Comino
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Editors
Novinka

ENVIRONMENTAL REMEDIATION TECHNOLOGIES, REGULATIONS AND SAFETY

WASTEWATERS PHYTOREMEDIATION

LESSONS LEARNED - A FULL CASE STUDY

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PREFACE

Life quality of all living beings is strongly dependent on environmental quality. A safe and healthful environment is essential to grant, to both present and future generations, the possibility to satisfy their needs. This is the reason that led governments worldwide to the development of new policies in the last decades, focused on the need to preserve, protect and improve natural ecosystems quality. The European Community developed the Sixth Environment Action Programme 2002-2012 that focuses on climate change, on the need to protect both nature and biodiversity, on the improvement of environmental quality and on a sustainable use of natural resources and an appropriate waste management.

Among environmental concerns, water protection and management is of great importance, as water is a primary need for life. The Water Framework Directive 2000/60/EC requires a sustainable exploitation of natural resources protecting aquatic ecosystems health, improving water quality. The principal aim is to preserve water, an essential resource.

Water environment has been used by man for generations to discharge pollutants, exploiting its self-treatment ability. This capacity is limited, and human society development leads to a constant increase in anthropic pressure on ecosystems. The protection of aquatic environments from depletion, pollution and degradation can be achieved only decreasing societies impact on natural waters.

A large fraction of human pressure on aquatic environment is represented by municipal and industrial effluents. The improvement of discharge quality, limiting as much as possible pollutant release, is indispensible to grant natural water bodies quality. This goal can be achieved only through a long term protection and safeguard, that means a constant engagement to provide

technological development and concrete answers to environmental issues. In this sense it is important to build and develop instruments able to grant environmental safeguard and a sustainable management of natural resources.

Treatment wetlands meet these needs and represent a valid instrument for wastewaters treatment. This technology gives the opportunity to provide an effective wastewater treatment minimizing environmental pressures. Energy requirement for plant operation is generally small, as well as required maintenance. Constructed wetlands, rather than being an impact on the landscape, are aesthetically pleasing and they support wildlife habitat. A large number of treatment wetlands are operating all over the world, and many studies are available about applications and features of such systems.

This work has been developed as a contribution to the current knowledge concerning constructed wetland. It consists of two parts: the first one reports an overview about constructed wetlands, the second deals with a complete case study, from design to monitoring phase, that lasted three years.

CONTENTS

PART I. TREATMENT WETLANDS: STATE OF THE ART OVERVIEW

ABSTRACT

Treatment wetlands are engineered ecosystems conceived to reproduce, in a controlled environment, all the processes occurring in a natural wetland, able to perform wastewater remediation. This technology spread and developed worldwide for more than a half century, joining the set of technologies available for an effective water quality improvement. This chapter presents an overview of treatment wetlands state of the art, dealing with all the aspects involved in the multidisciplinary nature of the subject. It begins describing how and why this remediation technique was born, developed and spread worldwide, from Dr. Seidel's experiments in 1950s to nowadays. Clean-up mechanisms and removable pollutants are reported and explained both biologically and chemically, to give the reader instruments for an efficient design and management of treatment wetlands. All the principal layouts of engineered wetlands are described, explaining which are principal clean-up mechanisms and giving details about the best application of each model. Eligible plant species are reported, explaining their role in remediation processes and giving the best application for each species, considering the role of both substratum composition and water depth in plant selection. Different application fields are described and reported, because constructed wetlands are used to treat wastewater produced by different sources, as a result of their effectiveness and adaptability. Treatment wetlands most spread application is for municipal wastewater and stormwater, but this technology can be effectively applied also to wastewaters coming from other sources, such as for different kinds of industrial wastewater or for acid mine drainage. Treatment wetlands effectiveness may be very variable, depending on the considered pollutant and on different environmental factors. Parameters influencing remediation rates are described, and average remediation efficiencies, based on literature analysis, are reported.

Chapter 1

INTRODUCTION

Natural wetlands were considered dangerous for man's health for centuries, and they were re-evaluated only in the last decades. During human history, often societies discharged produced wastewater in wetlands, using their ability in promoting wastewater remediation, and, often, degrading these ecosystems. During the first decades of the 20th century, a growing awareness about wetlands function and value led to a change of attitude towards them, and the importance in their protection and safeguard has become evident.

In the 1950's, a German biologist, Käthe Seidel, started researches to exploit natural depuration processes, trying to reproduce them in a controlled environment. Since Seidel's early investigations to nowadays, the use of constructed wetlands to treat wastewater spread and developed worldwide, advancing on all fronts.

This technology guarantees many advantages compared to traditional treatment plants, such as low capital and management costs, low energy need, low waste generation, simple management. Besides treatment wetlands are environmentally-friendly, meeting the need to safeguard and protect landscape, ecosystems and biodiversity.

In the last decades, a large number of treatment wetlands were built all over the world. Many studies were made to understand mechanisms involved in remediation processes, and to investigate remediation performances achieved applying treatment wetlands to various wastewater kinds and with different system layouts. Development and spread of engineered wetlands technology led to the discovery of new application fields and to the definition of new layouts. As a result of both laboratory investigations and data relative to working systems, much is known at present about processes occurring

inside treatment wetlands, even if a deep and complete understanding is still not reached. Available knowledge base makes possible to understand how complex are constructed wetland systems, and how many factors influences their performances.

This chapter is intended to provide an overall survey about the state of the art of treatment wetlands, reporting what is knew at the present time. It is addressed to designers, regulators, managers, owners, and everybody who is interested in studying and applying this technology, to allow a deep understanding of treatment wetland. This chapter is designed as a tool for an informed approach to engineered wetland, providing the need know-how for a learned assessment of their applicability, giving instruments useful for their design, providing a complete overview about the state of the art.

Chapter 2

ORIGINS AND HISTORY

"Wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as saltmarshes, mangroves and seagrass beds, but also coral reefs and other marine areas no deeper than six meters at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs."

The Ramsar Convention Manual, 4th edition, 2006

In human history, the perception of wetlands was mainly negative. In the past centuries, they were considered insane and dangerous, because of malaria, and an hindrance to land development and exploitation. Many major reclamations are known, since roman era, such as Pontine marshes reclamation; more recently, in the 19th century, the U.S. Congress, through the Swamp Land Acts (1849, 1850 and 1860), granted to States the reclamation of all swamps and overflow lands to reduce the destruction caused by flooding and eliminate mosquito-breeding swamps (U.S. Congress, Office of Technology Assessment, 1984).

In the 20th century, a new ecological awareness was born and developed, and the importance of wetlands and the necessity to protect and preserve them, become more and more evident. However, the intrinsic recreation values and the need to preserve the unique flora and fauna present in wetlands, that motivated their protection, were no universally appreciated. It was necessary to investigate more tangible ecological services provided by wetlands.

During the last decades many studies demonstrated the existence of practical advantages and services provided by wetlands, and their importance in the improvement of human life and economy now is recognized and

appreciated worldwide. To state this awareness, in 1971 many countries participated to the Convention on Wetlands (Ramsar, Iran), an intergovernmental treaty whose mission is the conservation and wise use of all wetlands; in December 2006, 153 nations joined the Convention as Contracting Parties; Ramsar List of Wetlands of International Importance includes at present more than 1600 wetlands from all over the world, covering 145 million hectares (Ramsar Convention Manual, 4th edition).

Ramsar Convention focuses the attention on the need of a wise use of all wetlands. This implies that wetlands can provide many services for people; in effect they play an important role for human life, for example providing fish and fiber, regulating nutrient cycles (such as carbon and nitrogen, but also water) delivering fresh water and giving additional services such as aesthetic, educational, cultural and spiritual values and opportunities for recreation and tourism.

The most relevant functions of natural wetlands are:

- Provisioning of
  - Food;
  - Fresh water;
  - Fiber and fuel;
  - Biochemical products;
  - Genetic material;
- Regulating of
  - Climate region;
  - Biological regulation;
  - Hydrological regimes;
  - Pollution control and detoxification;
  - Erosion protection;
  - Natural hazards;
- Cultural
  - Spiritual and inspirational;
  - Recreational;
  - Aesthetic;
  - Educational;
- Supporting
  - Biodiversity;
  - Soil formation;
  - Nutrient cycling;
  - Pollination.