

Environmental Earth Sciences

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Management of Water Resources in Protected Areas

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Management of Water Resources in Protected Areas: An Introduction

Biodiversity is one of the most important elements in defining a protected area. However, the protection of these areas requires a holistic understanding, keeping in mind all of the elements of the natural and social environments.

On a global scale, there are more than 100,000 protected land and marine sites. These areas cover almost 19 million square kilometers (nearly 4 % of the global surface). An immense majority of the sites are terrestrial. Among them, 149 are of exceptional natural value in the most varied environmental conditions. The terrestrial aquatic ecosystems only occupy a small area of the planet, but it may consist of the most threatened biomass and habitat by human activities (Dudley 2008).

Natural ecosystems are heavily dependent on water, as it is essential for the development of life. The ecology and landscape play an important role in the quality and availability of water. It is no coincidence that exceptional hydrological phenomena are found in protected areas. Such is the case of the geothermic occurrences (principally, geysers) in US Yellowstone National Park, the oldest park in the world. The Ramsar wetlands (where the ecosystem dependency on water is strongly evident), the Iguazu Falls (on the border of Argentina and Brazil), or the Zapata Swamp (the largest of its kind on the Caribbean islands) further exemplify this point.

The relationship between the protected areas and the conservation of terrestrial waters is complex. Many real and perceived incompatibilities and challenges arise when considering this relationship (Dudley 2008). However, in many cases, the conservation strategies of the hydraulic resources in protected areas are ignored, or simply deprived of the attention they require. There are many types of suitable management strategies for planning and protecting our valuable treasures. Therefore, water resources management in protected areas is an issue not to be separated from the rest of the conservation measures. The relative considerations to terrestrial waters should be integrated in the administration of all the outstanding protected areas that, on the other hand, should be negotiated in function of their bioregional context and of that of their hydrographical basin in the widest sense (Dudley 2008).

The first *Symposium for the Management of Hydraulic Resources in Protected Areas* held in Viñales National Park, western Cuba, was intended to be a framework

of communication about experiences with water resources management in protected areas. Advances in research and possible solutions to the problems within these areas were discussed.

Forty papers from Europe and America were accepted in this meeting. They are grouped under six main parts. The first part is dedicated to **Purification and Reuse of Wastewaters in Rural Communities**. Four chapters (10 % of the book) are related to the theoretical aspects of these processes and present several case studies, especially those that refer to extensive methods. These methods comprise multiple environmental compensations as compared with conventional or intensive treatment systems. The most important are low energy consumption, CO₂ absorption, landscape integration, new habitats for flora and fauna, low sludge production, and solid waste reuse (de Armas et al. 2006). These characteristics render these methods suitable for the integration of protected areas. Proposals to integrate these strategies in the normative document and management plan of protected areas and two examples of their application in Spain and Mexico are presented.

The **Impact of Public Use on Water Resources** (8 % of the book) is analyzed in the second part. The first chapter shows a combined strategic environmental assessment and impact characterization procedure to analyze the impact of human activities on water resources in protected areas through an example from Salamanca, Spain. Other two chapters show the effect of human activities in coastal karst aquifers of Cuba by means of hydrogeochemical analysis. One evidences the human influence over the chemical denudation rate, and the second examines it on the acting hydrochemical processes.

For protected areas, groundwater vulnerability maps are highly desired as management tools, because they help in delimiting protection zones, classifies their importance, and thus show where most management attention is required (Williams2008). Several studies (13 %) of **Vulnerability and Risks of Aquifers** are presented in the third part. Research related with vulnerability of groundwater and strategies for defining the protection zones in selected study areas are presented in this part. The part begins with two chapters on the use of geophysical methods in sensitive zones of Cuba and Spain. The next chapter comprises three papers that exemplify the importance of vulnerability mapping and an adequate definition of protection zone in karst terrains. The fourth chapter the results of the application of EPIK and PaPRIKa in tropical karst areas. The part ends with the first approach for the assessment of groundwater resource protection zone at Viñales National Park, western Cuba.

The applications of Geographic Information Systems (GIS), remote sensing, mathematical models, and hydrochemical studies are presented as tools for the **Design and Management of Water Resources in Protected Areas** of Cuba, Ecuador, and Spain, exemplified in seven chapters. In this part (18 %), the use of GIS and remote sensing is presented in three chapters, one of which determines flood risk assessment in a river basin at the southwest of Salamanca, Spain. Other two chapters show the application of a distributed water balance method model for assessment water excess in the high and medium basins in Ecuador and other, the use of GIS as a platform for integrate diverse database and as results, a 3D geomodel design in a detrital aquifer located in

Madrid, Spain, are presented. An application example of a simulation model based on system dynamics in a protected area and its urban surrounding area in Cuba is presented. Two studies in wetlands are also discussed: one, related to hydrogeochemical studies, is used to define the relationship between surface water and groundwater in an important coastal wetland of Almería, Spain, and the second deals with the analytical framework for the study, planning, and management in an important Ramsar site in Ecuador. The management techniques applied to small watersheds in the mountain karst of the Humid Tropics are exemplified in the case of the Santo Tomas Cave hydrologic system, highlighting the most hydrological features controlling surface and underground runoff and the related biogeochemical hydrodynamics.

Forty-three percent of the book is dedicated to exemplifying the importance of **Research and Monitoring of Water Resources in Protected Areas**. A great diversity of studies on protected areas of America and Europe are presented. The importance of fundamental and applied research in these areas and the design and operation of bio- and hydrochemical monitoring networks are expressed in the chapters presented. Major and minor changes in biodiversity and in the physical framework sustaining the local environment could not be detected without efficient operation of properly designed monitoring networks (Molerio and Parise 2009). Adequate research on the environmental and particularly on the ecohydrological variables is still needed in protected areas. In the particular case of the tropics, the transport of nutrients remains one of the most important tasks to be achieved.

This part begins with a preliminary hydrogeological characterization in a protected area of the Dominican Republic, followed by a chapter about underground water of deep circulation in karst terrains of western Cuba and a study of the capacity of recharge in a protected area of Mexico. Two chapters on rainfall-runoff relationships in Spain and Cuba and nine related to studies of chemical and microbiological composition of water showed interesting examples of contamination by bacteriological and emergent contaminants. A study of seawater intrusion by means of hydrochemical models and geophysical methods in coastal karst aquifers show the importance of multidisciplinary studies. The part concludes with a study about the seasonal behavior of the vegetation at the complex lagoons.

The last part is dedicated to **Information, Popularization, and Training**, occupying 10 % of the book. Four chapters are included, one of which is related to the strategies used in Cuba for effective management of water. The second one is dedicated to exemplifying the use of geodiversity and hydrological heritage as a tool for educational itineraries that help promoting their conservation through knowledge. In the third chapter, recent observations on the geology of the Cuban occident as well as the most important aquifers and the geomorphology of their basins are exposed. The last chapter is a revision of the importance of Alexander von Humboldt's work in Cuba that is integrated nowadays in the National System of Protected Areas in Cuba.

The diversity of topics discussed in this book makes it a valuable consulting document for the personnel that work directly or indirectly in the field of water research, especially in protected areas. Thus, they deal with common interests identified in protected areas and underline the importance of knowing properly

the qualitative and quantitative characteristics of water resources, in order to establish efficient measures for management and conservation of natural resources in protected areas.

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This book is a contribution to the improvement of the Management Plans of Protected Areas, offering a more holistic focus to the study of those natural ecosystems that come under the diverse handling categories defined by the UICN.

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