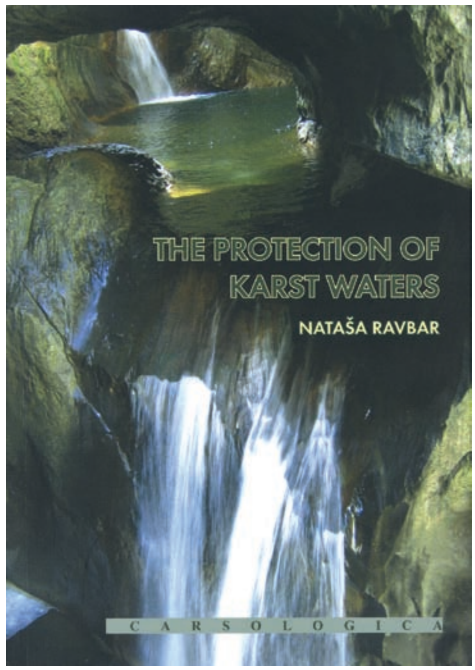
A SLOVENE APPROACH - A NEW METHODOLOGY OF GROUNDWATER VULNERABILITY AND RISK MAPPING



The author of the work is **Dr. Nataša Ravbar**, a researcher from the Karst research Institute, Scientific Research Centre of the Slovenian Academy of Sciences and Arts (Postojna, Slovenia). The presented book is a summary of her doctoral thesis defended in 2007 at the Graduate Programme Karstology, Faculty of Graduate Studies at the University of Nova Gorica.

The subtitle of the book *The protection of karst waters is "A comprehensive Slovene approach to vulnerability and contamination risk mapping"* and it is designed not only for the researchers and scientists doing research on karst hydrogeology and vulnerability assessment and mapping, but also for practitioners and decision-makers dealing with the protection and management of karst groundwater resources. The book 240 x 168 mm includes 254 pages and 136 pictures, of which are only 16 black and white. Maps, photos, sketches and diagrams are of excellent quality and an expressive supplement to most intelligible and readable book.

The work is divided into 2 parts (Methodology and Application) with 12 chapters and additional chapters Introduction, General conclusions and outlook and References. At the end of the book is a 20 pages summary of the work written in Slovene.

Coming out from the goals and objectives of the work, in chapter 2 general characteristics of karst aquifer systems concerning their natural vulnerability to contamination are shortly described. General characteristics of karst landscapes in Slovenia and examples of human impact on karst water quality in Slovenia follow. Chapter Karst water sources in Slovenia deals with description of drinking water distribution from karst aquifers in Slovenia, as well as with peoples' attitude towards drinking water. Chapter 4 is a good overview of the management of karst water sources in Slovenia. It treats legislative background for karst drinking water sources protection and related shortcomings resulting from an old legislation which is still reflecting in the field of karst drinking sources protection. A short explanation of laws and rules in force and their deficiency in methodology for water protection zones delineation are described as well.

Chapter vulnerability assessment and mapping describes the concept of vulnerability proposed by the COST Action 620 (Vulnerability and Risk Mapping for the Protection of Carbonate (Karstic) Aquifers) and the concerning terminology. The most frequently used methods for karst aquifers vulnerability assessment and mapping are listed and described in a few words. Some of the methods (EPIK, PI, SINTACS, the Irish method) are described more in detail; their methodological procedures of vulnerability assessment are also shown on related figures. The origin – pathway – target conceptual model; factors representing the intrinsic characteristics of the aquifer system: Concentration of flow (C), Precipitation regime (P), Overlaying layers (O) and Karst network development (K); the distinction between the source and resource protection, all as parts of generally written non-prescriptive European Approach to intrinsic vulnerability and risk mapping are explained and schematically showed on figures. Quite a few of lately developed methods of vulnerability mapping base on this approach. In work Simplified method and a COP method as a basis for the Slovene Approach are explained. In chapter 6 we find a short description of so far made vulnerability maps in Slovene karst regions and an explanation of general methodological problems related to vulnerability assessment arising from special physical characteristics of Slovene karst regions. Both indicate a need for a new method proposal, which is the main goal of this work.

Chapter 7 (The Slovene Approach to intrinsic vulnerability mapping) is the very heart of the work. In case of specific characteristics of Slovene karst, the author found the COP method as being most appropriate as a basis for the development of the Slovene Approach. In addition the Approach was also influenced by the EPIK, PI methods and the European Approach. The comparison of Slovene Approach with other intrinsic vulnerability methods, considered factors, the most important advantages and drawbacks of each method are shown in a special table. The adaptation of the COP method includes a slight modification of the O factor, taking into account topsoil thickness, porosity, permeability and the diversity of soil thickness in karst. The latter is possible within the conception of effective soil thickness, which gives the transfer time of water through the soil before it enters into the karst system. In avoidance to methodological problems in the regions with deep unsaturated zone and absence of soil cover, an innovative modification of the O factor with an additional value for extremely karstified areas was introduced. A significant contribution to the vulnerability assessment and mapping is the incorporation of hydrological variability of flow and surface waters consideration, both as parts of C factor assessment scheme. Hydrological variability has many implications for contaminant transport and groundwater vulnerability mapping, but to this point has not been considered as important in existing methodologies. It takes into account the variability of sinking water bodies' presence. Since one of the concepts of vulnerability mapping is also the idea that it is more important to protect most vulnerable areas, the author also made some modifications of C factor concerning the reduction of concentration point recharge catchments areas extent. Some modification concerning slope inclination and vegetation cover protection values of C factor, based on the fact, that the steeper the slope and sparser the vegetation, the higher is the vulnerability, were done as well. In comparison to the COP method the P factor of the Slovene Approach has been fully modified. The aspects of precipitation quantity and intensity are considered, but in a different way. Despite some improvements in the assessment of P score, which is a valuable contribution to the international research in the field of vulnerability mapping, some common problems, such as consideration of dilution (higher quantities of precipitation) in vulnerability assessment, remain unsolved. Scientists doing research on vulnerability assessment and mapping need to focus on this issue in the future. The Slovene Approach concerns with source vulnerability assessment and thus the horizontal path in the saturated zone is considered (factor K). The Approach suggests that the K factor assessment should be based mainly on flow velocities, connection and contribution to the source, which are the most important contamination aspects. Duration of a contamination and information on active conduit network should be considered too. Assessment scheme for K factor includes three subfactors: travel time, information on karst network and connection and contribution. The primary basis on the groundwater flow velocities within the saturated zone, the second indicates the presence of an active conduit network, and the latter indicates parts of the catchment that either always or rarely contribute to the source and are either directly or indirectly connected to and drained by the source. The distinction between inner and outer zone is similar as it is used in Ireland and basis on the hydrogeological structure of the recharge area. At the end of the chapter the Slovene approach to resource and source intrinsic vulnerability assessment scheme is shown on a figure.

Slovene Approach to hazard and risk mapping presented in chapter 8 is based on the European Approach. Hazard weighting and ranking is adapted to Slovene circumstances. Encouraged by some previous initiatives the author additionally included the aspect of source importance into risk assessment scheme. The evaluation of re(source) importance thus considers its social importance, conducive to public benefit, economic importance for either agricultural or other activities and ecologic importance. The author also suggests that the protection zoning should take the importance of the source together with the vulnerability map as the basis. The final risk intensity assessment map is obtained by taking into consideration both an intrinsic vulnerability map (resource or source) and a hazard map. Adding a re(source) importance index to risk intensity index, a total risk can be acquired. Such a risk assessment scheme is very understandable also for the land use managers and decision-makers.

In the second part of the book the application and verification of the Slovene Approach in the catchment of the karst spring Podstenjšek at the foot of the Snežnik plateau is explained. In chapter 9 hydrogeological characteristics of the studied area are described. The characterization of the Podstenjšek spring and its catchment was obtained using a wide range of different geological, geomorphological and hydrological methods and techniques, including detailed geological mapping, monitoring of springs, hydrochemical analysis and tracing experiments. In order to evaluate the applicability of the proposed new Approach five intrinsic vulnerability methods have been applied to the Podstenjšek karst spring catchment in order to compare and validate the results obtained by different evaluation of definite parameters. In chapter 10 the comparison of these maps is presented, showing significantly different and sometimes contradictory results though using the same database. Since the method has only been applied to abovementioned test site, it has not been sufficiently tested. Nevertheless, the results are consistent.

Chapter 11 deals with the hazard and risk mapping of the test site. The classified hazard map obtained by the mapping of actual and potential sources of contamination (settlement Šembije, agriculture activities, traffic, waste disposal dumps, excavations) shows that the majority of the catchment is assigned as no or very low hazard. Similarly, the total risk map shows that only 2 % of the catchment is assigned as medium and all the rest as low risk. Nevertheless, the author suggested several necessary measurements for the spring's protection.

An important contribution to the science is the proposed methodology for the validation of vulnerability maps, explained in chapter 12. In many cases worldwide different methodologies for intrinsic vulnerability mapping have been applied, but not many of them have been validated. Therefore no common technique for vulnerability map validation has been accepted so far. For validation, artificial conservative tracer test are recommended and the author suggests that tracer test results should be evaluated on the basis of two criteria. The first one should be the time of the tracer's first arrival or the time of maximum concentration. The second is the ratio between the integral of the breakthrough curve and the tracer input quantity (normalized tracer recovery). The validation of the obtained maps (chapter 10) was performed by carrying out the multi-tracer test. The results show that the performance of artificial tracer test can be used as simulation of a contamination event from the origin point to the target. Because of the integration of hydrological variability into vulnerability mapping methodology scheme, the newly proposed Slovene Approach gave most plausible results, whereas shows the same degree of vulnerability at all the injection sites as validated.

In General conclusion and outlook (chapter 13) the significance of the results, applicability of the Slovene Approach and new research challenges regarding the proposed methodology are discussed giving a good overview over the methodological and applicable part of this book.

The book contains a list of 199 references and additionally a list of 11 other data sources. Where and how to order the book, see p.527.

Gregor Kovačič