GIS-BASED GROUNDWATER VULNERABILITY MAPPING AND CONFLICT AREAS OF REGIONAL SPATIAL PLANNING IN GERMANY

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Abstract – To aide in land use decision-making for the protection of groundwater quality, many countries have consider to apply the aquifer vulnerability maps. A detailed intrinsic groundwater vulnerability assessment was developed by applying the standard “DRASTIC” and “GLA” methods, integrated to a Geographical Information System (GIS), to analyze a variety of hydrogeological settings, besides the land use and land cover data assessment in a small river basin localized in the Rhine-Main plains, central part of Germany. Thus, the superposition of mapped layers showed some relevant conflicts among the areas with the higher index values for groundwater vulnerability and the pre-defined areas by the governmental regional spatial planning. In an overall analysis, the major part of these high groundwater vulnerability areas were not matching the groundwater protection zones. Beyond that, a significant part of the groundwater protection zones was not intersected with the groundwater recharge zones, but matching, essentially, the areas mapped as forest and green lands. However, most of potential pollution sources related to the land use in this catchment (mining, industries, agriculture, settlements etc.) were placed along the river’s banks, but in a relative distance from the groundwater protection zones and the most vulnerable areas.

Resumo – Para auxiliar no uso da terra de tomada de decisões para a proteção da qualidade das águas subterrâneas, mapas de vulnerabilidade do aquífero intrínseca têm sido desenvolvidos em muitos países. Uma avaliação detalhada da vulnerabilidade intrínseca das águas subterrâneas foi realizada pela combinação dos métodos "DRÁSTICO" e "GLA", integrado a um Sistema de Informação Geográfica (SIG), para analisar uma variedade de configurações hidrogeológicas, além dos dados de cobertura do solo e uso da terra em uma bacia pequena, localizada na região dos rios Reno-Meno, parte central da Alemanha. Assim, a superposição de camadas mapeadas mostrou alguns conflitos relevantes entre as áreas com os maiores valores de índices de vulnerabilidade das águas subterrâneas e as áreas pré-definidas pelo ordenamento do território espacial governamental. Em uma análise geral, a maior parte dessas áreas de alta vulnerabilidade não estão inserida nas zonas de proteção das águas subterrâneas. Além disso, uma parte significativa das zonas de proteção de águas subterrâneas não foi interceptado com as zonas de recarga de aquíferos, mas combinando, basicamente, as áreas mapeadas como floresta e terras verdes. No entanto, a maioria das potenciais fontes de poluição relacionadas com os diferentes usos da terra (mineração, indústrias, agricultura, assentamentos etc.) estão ao longo das margens do rio, mas a uma relativa distância das zonas de proteção e das áreas mais vulneráveis para águas subterrâneas.

Key Words: GIS Mapping, Groundwater Vulnerability, DRASTIC Method, Land Use Planning, Rhine-Main Rivers Plains.

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1. INTRODUCTION

For more than 40 years, groundwater vulnerability maps have been used in Europe[1] and the United States (US), where they have become a standard tool for the decision-making process related to land use planning. Governments, planners, and policy-makers can utilize the maps for various purposes such as to assist in land use sustainable development planning, water sources protection, identifying sensitive and prioritizing areas for quantity and quality monitoring etc.

The intrinsic aquifer vulnerability is based on the idea that the natural environment can provide some degree of protection against groundwater contamination from the surface. Besides, the intrinsic vulnerability does not include properties of the contaminant or the hazard related to the threat or likelihood of a contaminant release, or the consequences of the pollutant reaching the groundwater system. Therefore, using the groundwater vulnerability mapping combined with location of major land use types, considered as potential pollution sources (pesticides in agriculture, toxic substances in industry, pathogens in settlements etc.), enables a preliminary evaluation of groundwater risk assessment.

2. METODOLOGY

The groundwater vulnerability assessment was carried using the widely "DRASTIC"[2] developed by the USEPA combined with the GLA[3] method, from which specific range values for some of the parameters where adapted. The DRASTIC method consider seven parameters to calculate the vulnerability index: depth to water table(D); net recharge (R); aquifer media (A); soil media (S); topography (T); impact of the vadose zone (I); hydraulic conductivity (C) of the aquifer, and their respective ratings and weights.

The land use and land cover data of the study area were obtained from the governmental spatial planning, Regional Plan of South Hessen[4]. After digitizing this map, it was possible to identify some conflicts among the areas with high groundwater vulnerability values, groundwater protection zones, and potential sources of pollution related to the land use established.

3. RESULTS ANALYSIS

The DRASTIC Index (DI) sets out a major pattern of groundwater vulnerability for this catchment, as showed in **Figure 1**. The highest DI values are concentrated in the northern

upper part of the study area, represented in red and orange colors in the map, due to the sandy and gravel soil and aquifer media, as well as to the relatively thin vadose zone (0-5m GW depth), some active faults and main rivers drainage in the lower valley.

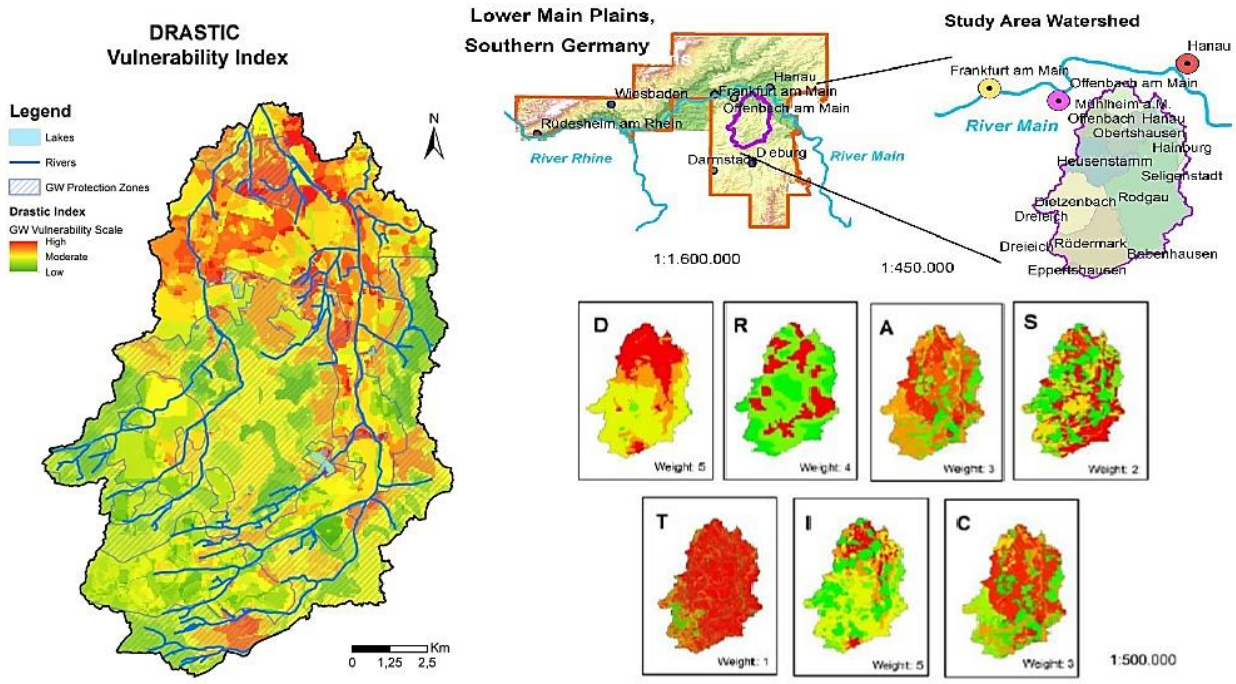

Figure 1 – The study area location and DRASTIC groundwater intrinsic vulnerability index.

Thus, in **Figure 2**, the superposition of mapped layers showed some relevant conflicts among the areas with the higher index values for groundwater vulnerability and the pre-defined areas by the governmental spatial regional planning. In an overall analysis, the major parts of these high groundwater vulnerability areas were not matching the groundwater protection zones. Beyond that, a significant part of the groundwater protection zones was not intersected with the groundwater recharge zones, but matching, basically, the areas mapped as forest and green lands. However, most of potential pollution sources related to the land use in this catchment (mining, industries, agriculture, settlements etc.) were placed along the river's banks, but in a relative distance from the groundwater protection zones and the most vulnerable areas.

Therefore, it was possible to associate the defined groundwater protection zones to the forest and green zones in the catchment, considering its relevance in favor to infiltration of rainwater in the soil. In addition, apparently, the groundwater intrinsic vulnerability and groundwater recharge zones were not taken into account during the groundwater protection

zones definition, as well as the considerations related to the land use and potential pollution sources in the spatial planning.

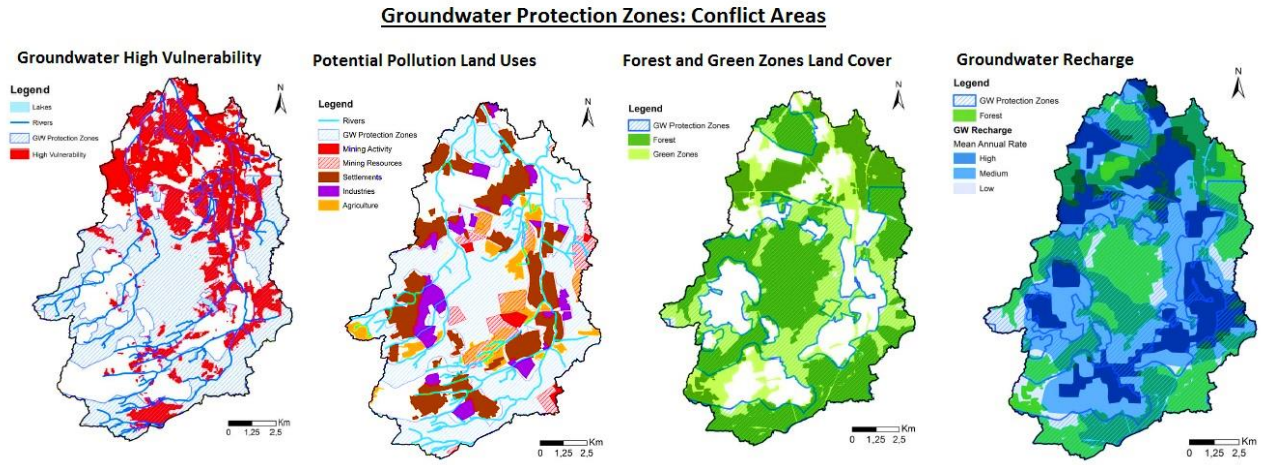

Figure 2 – The conflict areas related to groundwater protection zones in the catchment.

4. REFERENCES

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