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Management of the groundwater resource beneath the city of Ljubljana

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Abstract

Ljubljana is the capital and largest city of Slovenia. It has been developed in the vicinity of the Sava River on an alluvial plain that for more than a century has been used as a local resource for drinking water. Thanks to the natural hydrogeological conditions and protection measures, the groundwater beneath the city is still the city's main resource of drinking water. The city's growing energy demands initiated the search for new alternative sources of energy which could contribute to the reduction of CO_2 and other health hazardous emissions. In this respect, the ground beneath the city, the groundwater especially, offers favorable conditions for the implementation of ground-source heat pump systems, which represent one of the key technologies of renewable energy for heating and cooling. The city's future challenges regarding the subsurface will be related to the sustainable and efficient use of all resources and the avoidance of conflicts in their mutual use, in which drinking water resources will be of paramount concern.

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Keywords: groundwater management; shallow geothermal energy; urban area

1. Introduction

The city of Ljubljana, the capital of Slovenia, has a central position within Slovenia (Fig. 1). It is located on an alluvial plain, which is part of the Ljubljana Basin, formed by tectonic subsidence and the gradual filling with material that the Sava River transported from the alpine periglacial areas. The sediments, forming layers up to 100 m thick, are mostly composed of highly permeable gravel and sand beds that are partly lithified. The basement of the Quaternary aquifer consists of Carboniferous and Permian rocks of which hills and hilly hinterland are mainly composed.

The hydrogeological conditions in the area are characterized by strong interactions between the groundwater and the Sava River. The unconfined aquifer is recharged from the Sava River and rainfall, percolating through an unsaturated zone, which is on average 25 m thick. Approximately 1 m^3/s of the groundwater is abstracted from this highly productive aquifer for drinking water, which represents roughly 90 % of all the water in the system, supplying some 300 000 people with drinking water.

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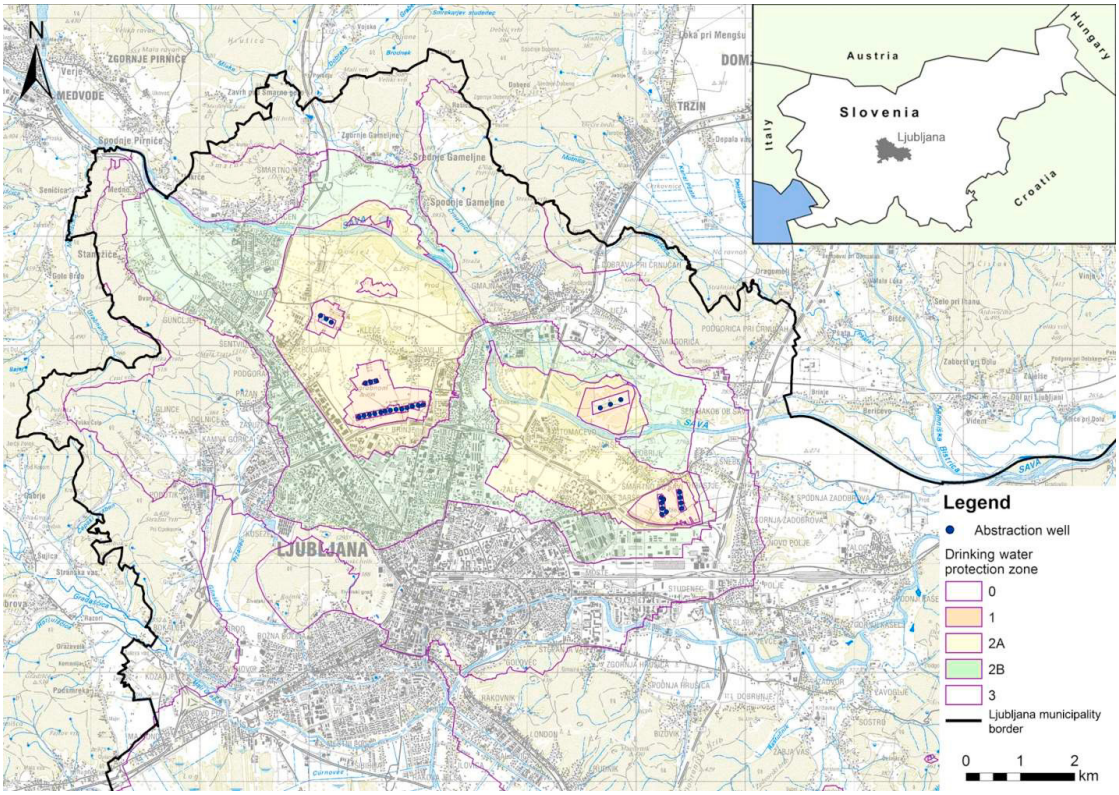

Fig. 1 Map of the city of Ljubljana with drinking water protection zones.

2. Drinking water resource

The drinking water supply of the city has relied on the above-mentioned aquifer for more than a century, thus the concept of groundwater management has been developed during this time. A basic protection of the catchments of abstraction wells is provided by drinking water protection areas. The delineation of the protection areas (Fig. 1) is based on groundwater residence time and the hydrogeological characteristics of the aquifer.

The integration of protection areas into the city's spatial planning documents has a preventive role and reduces the risk of pollution of the groundwater. Human activity and land use within these areas that can have an unfavorable impact on groundwater quality are restricted.

The implementation of drinking water protection areas has influenced the spatial development of the city. The protected areas represent two of five green wedges, which link the city center with the hinterland and are a key macro spatial component section of the urban space, as well as important climate corridors for the city (Fig. 2).