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Extended Abstracts

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title: **Criteria for the definition of the protection areas in the Viterbo hydrothermal area (Central Italy)**

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The definition of the protection areas of thermal springs and wells is a recurring problem, which is locally approached depending on the specific complexity of the hydrogeological conceptual model. Unlike the wide literature concerning the protection areas of drinking water, a lack of specific criteria for the hydrothermal areas results. In some cases, the drinking water criteria have been applied to the thermal springs and wells. It should be noted that the methods used for the protection areas of drinking water mainly consider the horizontal component of flow in the saturated aquifer and pollutants coming from the ground; moreover specific quality standards must be attained. Therefore these methods are hardly applied to the hydrothermal resource, if one considers the special chemical characteristics of the thermal waters, the vertical component of fluid circulation and the possible interactions among overlapped aquifers.

This study examines the delineation of the protection areas of the thermal waters in the Viterbo area (central Italy) tapped either directly at the springs or in wells and used primarily for the supply of thermal spas and pools for public use. In this area hot waters (30–60°C) of the sulphate-alkaline-earthy type, result of deep circulation, co-exist with fresh water circulating in the shallow volcanic aquifer. A suitable method was developed to define the protection areas based on the hydrogeological model, optimisation of the use of the hydrothermal resource, and considering the conjunctive use of the shallow aquifer for drinking and irrigation purposes. The historical, cultural and environmental values of the area were taken into account as well.

The plan was focused on the safeguard of the quality and quantity of the hydrothermal resource and interacting groundwater of the shallow volcanic aquifer. The hydrogeological equilibrium between the thermal aquifer and shallow volcanic aquifer, the impact of the withdrawals from the thermal aquifer and the economic importance of the spas were considered. At the same time the maintenance of the withdrawals from the shallow volcanic aquifer supplying drinking water and irrigation were taken into account. The different uses of groundwater often clash each other.

Three protection areas with different restraints were determined (Fig. 1): an immediate protection zone of the thermal springs and wells (ZT), an intermediate protection zone (ZPI) and a distant protection zone (ZPII); ZPI and ZPII zones are indispensable for the hydrogeological and environmental safeguard of the hydrothermal area.

The ZT immediate protection zone covers restricted areas near the springs and flowing wells of thermal waters. This is the consequence of the fact that the thermal waters are naturally protected to pollution from ground due to the vertical hydraulic gradient existing between the overlapped aquifers.

The ZPI intermediate protection zone includes all areas surrounding the ZT zone. This zone has been identified considering: i) the present and past locations of the thermal springs, ii) the outcrops of travertine, and iii) the areas of the shallow volcanic aquifer in which mixing between the thermal and fresh waters were found. Restraints and appropriate land use have been set for the ZPI zone to safeguard quality and quantity of the hydrothermal resource.

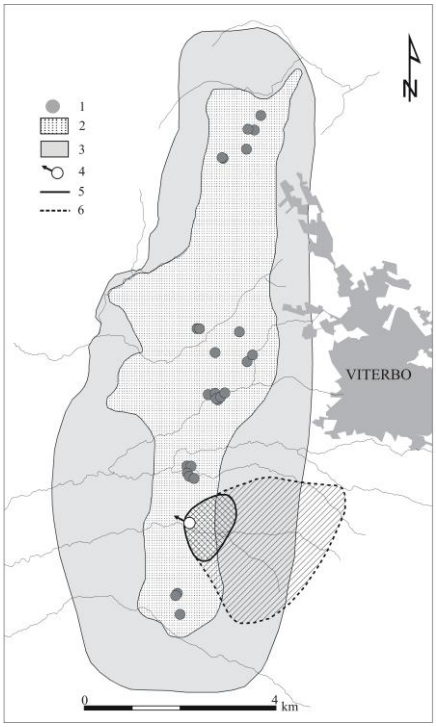

Figure 1. Protection zones of the hydrothermal area of Viterbo: 1) thermal spring and well, and ZT immediate protection zone (not to scale); 2) ZPI intermediate protection zone; 3) ZPII distant protection zone; 4) drinking water spring; 5) 90-day isochrone for drinking water spring; 6) 365-day isochrone for drinking water spring.

The ZPII distant protection zone has been determined considering the hydrostratigraphy and structural setting, and the heat flow map. In this zone it is important a control of the withdrawals from the shallow volcanic aquifer, based on its recharge rate and hydraulic characteristics, in view of a correct usage of groundwater with different qualities.

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