HYDROGEOPHYSICAL APPROACH TO MEASURE HYDRAULIC PARAMETERS ON UNSATURATED ROCKS

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ABSTRACT

In the past decade, over-exploitation has led to a depletion of water resources, with impact both on quality and quantity. A sustainable groundwater management needs a detailed scientific knowledge of the behaviour of the unsaturated zone. Particularly, the evaluation of the flow rate in the unsaturated zone is important to estimate the travel time of the infiltrated water in the subsurface and, hence, to assess the recharge rate and groundwater vulnerability.

A quarry of calcarenite near the town of Canosa, in South Italy, has been chosen to perform the field tests using an integrated hydrogeophysical approach, combining infiltrometer measurements with electrical resistivity tomography (ERT).

The infiltration data were collected using a metallic infiltrometer ring of 0.5 m in diameter, installed directly on the rock, filled with about 8 L of water. The test was conducted for many hours at falling head condition, and the water level within the ring was measured by means of a pressure transducer and a metric rod fixed to the ring.

Simultaneously, electrical resistivity measurements were carried out using “time-lapse” technique, in order to monitor the dynamics of infiltration/redistribution of the water in the unsaturated zone.

Hydrogeophysical data have been acquired for several hours to obtain a reliable hydrogeological model of the subsurface investigated.

Field-saturated hydraulic conductivity has been determined for the calcarenite, and ERT surveys support these results.

KEYWORDS: Hydrogeophysics, unsaturated zone, field-hydraulic conductivity, infiltrometer test, ERT

1 INTRODUCTION

In the Mediterranean basin, groundwater represents the most important resource for drinking water and economic activities, such as agriculture and industry.

In the coastal areas, groundwater is increasingly affected by saltwater intrusion caused by over pumping with impact both on quantity and quality of water resource.

The scientific community has been involved in many efforts to implement effective strategies for the safeguarding, protection and remediation of aquifers. Great interest concerns the knowledge of the flow and transport processes occurring within the unsaturated zone, the portion of the soil above the groundwater level. Such portion is essential for the sustainable groundwater management, and for the assessment of groundwater vulnerability.

A great amount of information regarding the hydraulic properties of the unsaturated zone is necessary in order to achieve a detailed evaluation of the travel time of the infiltrated water, and/or a pollutant in the subsurface. The knowledge of the infiltrated water travel time allows to estimate the recharge rate of the aquifer; hence, the time available to put a remediation plan into action, in case of potential contamination due to an accident.

Over the past few decades, the characterization of aquifer and the unsaturated zone has relied on conventional methods, such as pumping tests [1], infiltrometer tests [2], tracer tests [3] that do not provide any spatial information. Moreover, in situ measurements of the water content or other hydraulic properties are difficult and expensive, above all when the unsaturated zone consists of rock. In fact, conventional devices that can provide measurements of water content (i.e. TDR, TDT, etc.) are hard to install because of the difficulty to insert brittle probes into the rock. In these cases, the geophysical methods can allow the characterization of the subsurface at large-scale by means visualizing the unsaturated flow processes in order to obtain reliable hydrological models. The scientific literature presents many papers about hydrogeophysical tests, almost all conducted on soils [4, 5]. Very few works have been performed on the rocky subsurface, in order to determine the hydraulic properties of the rock. Among these, a new