HYDROGEOLOGICAL AND HYDROGEOCHEMICAL MONITORING IN THE CUMAE ARCHAEOLOGICAL SITE (PHLEGRAEAN FIELDS, SOUTHERN ITALY)

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The Cumae archaeological site is extended over about 2.0 km^2 along the Tyrrhenian coast of the Campania region (southern Italy), in the western sector of the Phlegraean Fields active volcanic field (Celico et al., 1991; Celico et al., 1992), about 10 km of the Naples city. It is the first Greek colony in mainland Italy, was founded in the 8th century B.C., and the site remained continuously occupied until the 12th century A.D.. Cumae site hosts an important archaeological park, among the most visited of southern Italy, located inside the Phlegraean Fields Regional Park and of the wetlands of the Mount of Cuma's Forest.
During the Holocene epoch, it has changed significantly, due to endogenous and exogenous phenomena, such as volcanic eruption and eustatic sea-level variations, associated to the creation of lake environments and palustrine wetlands. As a result of these natural processes, the coastal plain is characterized by a complex volcanic-sedimentary sequence formed by sands, silts, clays and volcanoclastic sediments, resting on a substrate of yellow tuffs and trachytic laves, outcropping in the surrounding reliefs.
A hydrogeological and hydrogeochemical monitoring from December 2013 to February 2015 on 13 wells (6 shallow wells and 7 deep wells), together with radon levels determination in groundwater have been carried out, with a monthly frequency. The study was motivated by the frequent flooding of archaeological excavations due to the rise of groundwater level, which threatens the integrity of ancient Roman ruins and the continuation of archaeological researches. Therefore the reconstruction of a comprehensive hydrogeological model of the archaeological site was considered an important goal to achieve for designing mitigation measures of hydrogeological risk.
The hydrostratigraphic and hydrogeological data allowed recognizing a multi-layered aquifer system, formed by shallow unconfined and deep semi-confined aquifers. The groundwater flow was assessed being strongly controlled by vertical and lateral lithological heterogeneities of volcanic-sedimentary deposits, as well as by groundwater pumping and drainage channel system. The dominant hydrochemical facies were Cl^--SO_4^{2-}-Na+-K+, HCO_3^--Ca^{2+}-Mg^{2+} and HCO_3^--Na^+-K^+ types. Variations in space and time of the hydrochemical facies were

affected by: i) dissolution and chemical weathering, ion exchange with volcanic-sedimentary deposits, ii) localised rise, along faults and fractured zones of the western edge of Campanian Ignimbrite caldera boundaries, of deep and highly mineralized fluids, indicated by outstanding levels in deep groundwater of F^-, 6.4 mg L-1, and 222Rn, 31,500 Bq m-3, and in shallow groundwater, respectively with 3.3 mg L-1 and 5400 Bq m-3; iii) freshwater-saltwater interactions, induced by groundwater exploitation.

References

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