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[63] STATISTICAL ANALYSIS OF RAINFALL, RIVER HEAD AND PIEZOMETRIC LEVEL DATA OF CENTRAL-ADRIATIC ALLUVIAL AQUIFERS

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Introduction

The statistical and hydrogeological analysis of the relationships between rainfall, river and piezometric level historical data can be useful to characterize the aquifers and to manage the groundwater resources. For this purpose measurements acquired every three days, relative to 1986-2009 period, concerning the Pescara river alluvial plain (Fig. 1), were analyzed with several statistical methods. The alluvial bodies of the Pescara river (Desiderio et al. 2001) is mainly silty-sandy. The plain aquifer is supported by Plio-Pleistocenic clayey deposits. The three wells (Fig. 2) are located in the medium-low alluvial plain. Autocorrelation and spectral univariate analysis, cross-correlation and bivariate spectral analysis have been implemented with the purpose to evaluate memory effect, the delay of the piezometric level response to rainfall and river head/discharge impulse, and the periodical components of the time series (Mangin, 1984; Larocque et al. 1998; Polemio and Dragone 1999).

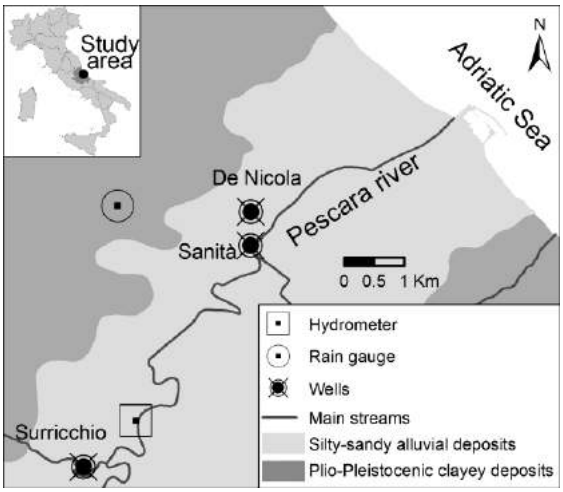

Fig.1 – Schematic geological setting of the study area and sites location.

Materials and methods

Rainfall, river and piezometric level data are due to the courtesy of Hydrologic Service of Abruzzo Region. The wells are characterized by a low - very low depth of the water table. In Fig. 3 behavior differences between piezometric level diagrams of the three selected wells are visible: in Surricchio diagram is self-evident the presence of a multi-year periodical cycle; the seasonal periodic structure describing the dry-wet season alternation can be observed in Sanità and De Nicola diagrams. River and rainfall data of Pescara Santa Teresa and Spoltore sites show that apparently the variability is mainly due to the seasonal effect.

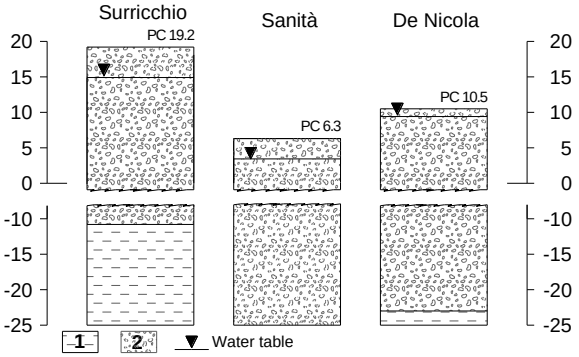

Fig. 2 - Schematic hydrogeological settings of observed wells (1. Plio-Pleistocenic clayey deposits, 2. Silty-sandy alluvial deposits).

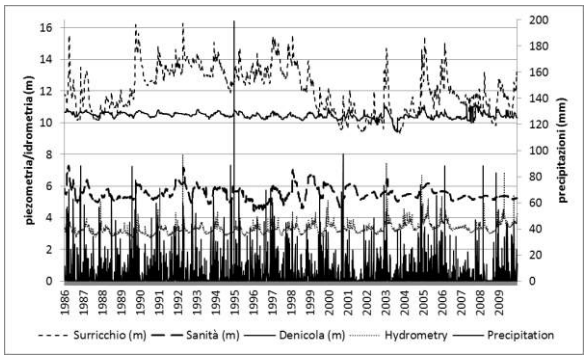

Fig. 3 – Rainfall, river and piezometric level diagram from 1986 to 2009.

Piezometric level autocorrelation

In all sites it is possible to point out that the daily piezometric level depends strongly from the level of the previous day. Especially the correlogram of Surricchio well shows the lowest gradient, reaching the decorrelation threshold value (Auto Correlation Function = 0.2) after more than 180 days. It means that this site is characterized by a longer "memory effect" respect to De Nicola and Sanità sites (Fig. 4).

Rainfall-piezometric level cross-correlation
In all sites the response time, "lag", of the piezometric level to the rainfall impulse is weakly correlated (Fig. 5).

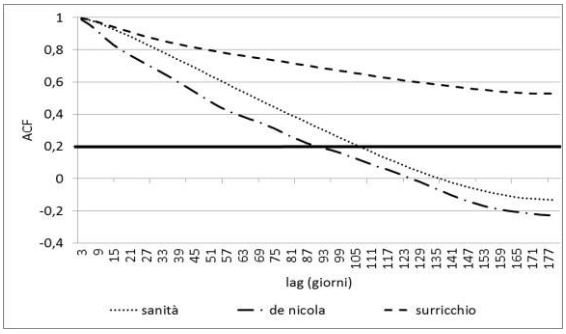

Fig. 4 – Autocorrelation results for the time series of Sanità, De Nicola and Surricchio wells.

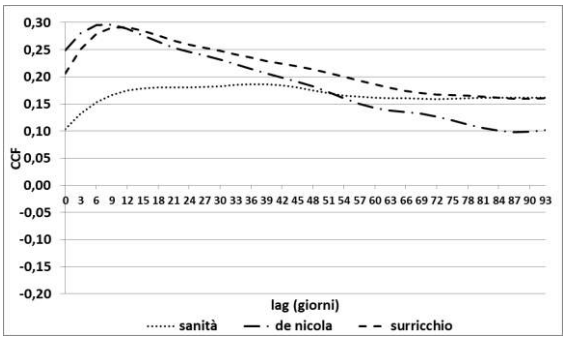

Fig. 5 – Cross-correlation rainfall-piezometric level.

Surricchio and De Nicola have a similar behavior and strongest maximum cross-correlation coefficient (0.29). They present a quick response to rainfall (12 and 9 days respectively). Sanità well has the weakest maximum CCF (0.18) and the curve form describes a site with a gradual response (18-39 days) and longest outflow.

Hydro-piezometry cross-correlation
The response of piezometric level (Fig. 6) to the river head impulse is of 9 days for Sanità, 6 days for Surricchio and immediate for De Nicola (3 days); Sanità has the strongest CCF (0.45) with a long-time descendent gradient. Surricchio and De Nicola site instead are characterized by weaker maximum cross-correlation (0.21 and 0.29) and a more rapid return to initial conditions (60 days).

Univariate and bivariate spectral analysis
Spectral densities of rainfall, river head and piezometric level present a peak in correspondence of f=0.0083, confirming the existence of the annual cycle. River time series points out the existence of a second spectrum peak in correspondence of f=0.00134 detecting a six-year periodicity; also Surricchio and Sanità wells show, in addition to the annual cycle, a 12-year and a 6-year long periodicity.

The bivariate spectral analysis, expressed by the cross-amplitude function, also identifies for the two wells the 12 and 6 years multy-year repetition behavior. These periodicities can now be better focused also in the raw data graph represented in Fig. 3.

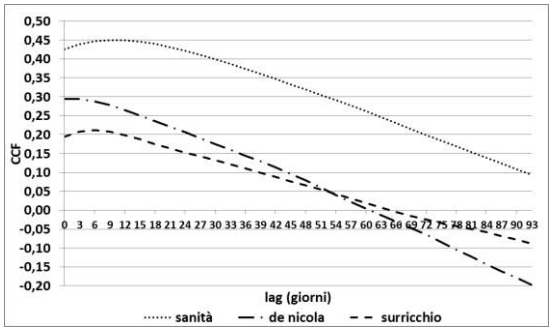

Fig.6 – Cross-correlation river head-piezometric level.

Preliminary considerations
Piezometric level and river head data show a strong memory effect with similar decreasing autocorrelation; cross correlations give us the chance to point when the "rainfall input" affects less the "piezometric level output" than the "river input" that reaches the wells trough the underground aquifer system inducing its fluctuation. The spectral analysis of all parameters identifies the presence of the annual cycle and it detects also multy-year periodicity. The studied groundwater resources are also influenced by the hydrometry behavior of the close Pescara river. The deepening of the hydrogeological framework will permit to verify these purely preliminary statistical considerations to proceed eventually to their validation. The used methodology for the Pescara river alluvial plain is being used for other central-Adriatic aquifers.

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