XXXVIII IAH Congress

Groundwater Quality Sustainability
Krakow, 12–17 September 2010

Extended Abstracts

Editors:
Andrzej Zuber
Jarosław Kania
Ewa Kmiecik

University of Silesia Press 2010

abstract id: **310**

topic: **1**
Groundwater quality sustainability

1.10
Decision support tools for sustainable groundwater management

title: **Evaluation of piezometric trends by seasonal Kendall test in the alluvial aquifers of the Elqui river basin, North-Central Chile**

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keywords: piezometry, trends, Kendall test, Sen slope test, principal component analysis

Now more than ever there is a need to apply robust statistical methodologies to ensure the proper evaluation of water resources data in order to help the decision makers in the water resources planning and management. Graphing or mapping data for people to see is the easiest way to communicate trends, especially to a non-technical crowd.

In this paper a joint methodology using Seasonal Kendall test, Sen slope test and Principal Component Analysis (PCA) is used to detect and map monthly trends and their magnitude of piezometric time series from 1979–2008 obtained in 23 shallow wells in the alluvial aquifers of Elqui River situated in the central part of Chile. This is an arid area characterized by water resources scarcity where intense agricultural and mining activities occur.

An initial exploratory data analysis of the 23 piezometric historical time series observed in the alluvial aquifers of Elqui river show significant seasonal variations (intra annual), but also variations induced by the ENSO phenomenon (inter annual), depicting influences of climatic and anthropogenic factors. However from the simple look of these time series is very difficult to visualize regional and seasonal trends. From the results from the application of seasonal Kendall and Sen slope tests to the time series we conclude that the about 2/3 of the monitoring wells present significative downward trends with values of decrease of piezometry reaching an average of 0.049 meters per month. Only two time series analyzed show a small upward trend of about 0.029 m/month, the remaining ones present a no-trend behavior.

Reasons for these downward trends could be found in the significant decrease of precipitation rates especially in the rainfall months and the reduction of snowmelt. These trends are in consonance with similar decrease trends in streamflow rates in Elqui river water catchment.

Reasons for the upward trends observed in the wells in low plains can be found by the increase of aquifer recharge induced by irrigation return flows in these areas. In order to better visualize the relationships between wells a PCA was applied to the slope trend matrix. This analysis provides the calculation of two factorial indexes for each monitoring well, indicating the relative magnitude of trend and its monthly influence.

Trend maps are very useful tools for the decision-makers because they can reinforce the implementation of actions in areas where economic sectors (agriculture and mining) are important, managing water scarcity conflicts in an arid region such as Elqui river water catchment towards a monitoring network optimization.

Also in a scenario of impact of climatic change on water resources due to the expected reduction of precipitation and increase of snowmelt, these decision support tools can help in the implementation of the most adequate adaptation measures to climate change effects in the water resources management.

International Association of Hydrogeologists

AGH University of Science and Technology

2-vol. set + CD
ISSN 0208-6336
ISBN 978-83-226-1979-0