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Analysis of Temporal and Periodic Changes of Groundwater Depth and Nitrate Concentration Using Time Series Modeling (Case Study: Kabudarahang Plain)

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ABSTRACT:

In this study, ground water level fluctuations and nitrate concentrations of kabudarahang aquifer were investigated with application of time series models for modeling of ground water quantity and quality parameters. For data regarding the status of groundwater level and nitrate concentration fluctuations in project area, time series models were used to forecast the groundwater level and nitrate concentration. Residual error analysis, comparison of observed and calculated ground water levels and nitrate concentrations performed and finally a prediction model for ground water conditions in Kabudarahang aquifer developed. Predicted values were calibrated by the Box-Jenkins, Holt Winters and extrapolation methods. A residual error analysis, based upon calculated and observed groundwater level and nitrate concentrations performed as a model verification tool and finally the Box Jenkins models were evaluated through Portmanteau method and Akaike information criterion. The model verification results showed that the SARIMA model is the optimum algorithm to simulate seasonal input data variables. Model results showed that the groundwater level in this aquifer will endure a 5 meter decline in three upcoming years and indicated that the maximum nitrate concentration would reach 50 mg/l in Bahman and Shahrivar of 1390.

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1- Introduction

Groundwater is one of the most important and valuable resources. Therefor a correct understanding and principled pumping especially in the arid and semiarid areas have an important role in sustainable development strategy. Water level in aquifer is an important parameter in groundwater hydrology assessment. A precise analysis of its temporal and spatial variables could provide enormous information about aquifer system behavior. A groundwater depth analysis is a valuable information source about potential of hydrologic stress within a groundwater system. An accurate forecasting needs to be conducted in order to make a better recognition of oscillating nature of groundwater levels and its qualitative properties. Proper model selection has significant importance in groundwater resource management strategy. Proposed models include Man-Kendal method, T-test and Cradock tests, Artificial Neural Network approach, and time series analysis methods like spectral and correlation analysis and moving average. In regions where accurate hydrologic and quality data are inaccessible the groundwater fluctuations and chemical concentrations can be predicted using stochastically methods like principle component analysis and cross correlation analysis methods.

2- Methodology

In this study, fluctuations of groundwater depth and nitrate concentration of Kabudarahang aquifer as one of the main aquifers in Hamedan province investigated using time series models. Time series models were used to forecast the groundwater depth and nitrate concentration. The groundwater level data during years 1375 through 1386 and nitrate concentration data during 1385 through 1389 are calibrated and analyzed using Box-Jenkins models. Residual error analysis and comparing of observed and calculated groundwater depth and nitrate concentration performed. Finally a prediction model for Kabudarahang valley developed. Trend analysis tools from Box-Jenkins models provided by MINITAB14 were used to simulate and predict hydrograph for three upcoming years and Nitrate changes for the upcoming year.

A seasonal ARIMA model described as ARIMA (p, d, q)×(P, D, Q)S, where (p, d, q) non-seasonal part of the model and (P, D, Q) seasonal part of the model with a seasonality S were used for simulation procedure. Predicted values were calibrated by the Box-Jenkins, Holt Winters and extrapolation axes models. A residual error analysis, based upon calculated and observed groundwater depth performed as a model verification procedure.

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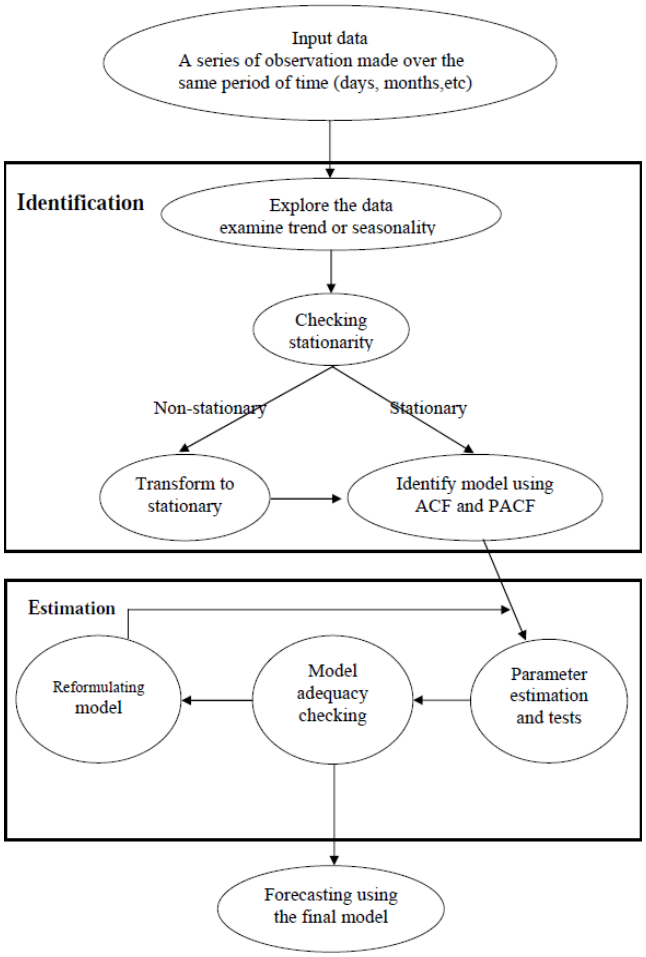

Figure 1: Functional diagram of the Box-Jenkins modeling strategy

The optimum preferred and selected model was the Box-Jenkins. The Box-Jenkins models were evaluated through Portmanteau method and Akaike criterion. Therefore the optimum model were selected as SARIMA(1,1,0)(1,1,1)12 for groundwater level and SARIMA(0,1,1)(0,1,1)12 model for nitrate concentration through stochastically tests and criteria. Finally, a SARIMA model was developed to predict groundwater depth of Kabudarahang valley. The model was used for predicting the aquifer fluctuation in a period beginning in year 1387 until 1390.

3- Simulation Results

Model results showed that the groundwater depth in Kabudarahang valley aquifer will endure a 5 meter decline in three upcoming years. The groundwater aquifer fluctuation level was simulated and predicted in Mehr 1387 up-to 1390 by the model and it shows high correlation coefficient (%93) to the observed data. The Box-Jenkins model results indicated that groundwater depth of Kabudarahang valley would decline for 5 meter depth in the next 3 upcoming years. The model results indicated that the maximum nitrate concentration would reach 50 mg/l in Bahman and Shahrivar of 1390 and the average nitrate concentration was about 48.08 mg/l in 1390.

4- Conclusions

The model verification results confirmed that the SARIMA model is an optimum and logical choice due to its high correlation coefficient.

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