GROUNDWATER RESOURCE MANAGEMENT USING DIMENSIONLESS MOVING AVERAGE TIME SERIES ANALYSIS — (A CASE STUDY: SHAHREKORD AQUIFER)

GESTION DES RESSOURCES EN EAU SOUTERRAINE UTILISANT LA METHODE DIMENSIONLESS MOVING AVERAGE TIME SERIES ANALYSIS (ETUDE DE CAS: AQUIFERE DE SHAHREKORD)

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ABSTRACT

One of the most important natural resources is groundwater, particularly in arid and semi-arid areas. The Shahrekord Aquifer is in a semi-arid area and thus groundwater has the major role in meeting the water demands for drinking, industrial and agricultural activities in this area. The aim of this study is time series evaluation and analysis of the shahrekord Aquifer in short and long term by a new method is named dimensionless moving average time series analysis. In this regard 25 years (1984-2008) climatological and piezometric information are assessed. Assessment of the data shows that absolutely wet year occurred in 1993, while absolutely dry year occurred in 2000 and was continued to 2004 in the central parts. During 1984 to 2008; 1984-1986 were dry, 1987-1990 were moderate and 1991-2000 again dry. The 2001-2004 period in the north-west and in the south were moderate, whereas, the central parts was dry. Short term groundwater fluctuation is responds to seasonal precipitation variation with a time lag. In total whole aquifer particularly the central is in stress. Optimal management of the groundwater in this aquifer is essential by making artificial recharge and disallowing new well drillings.

Key words: *Groundwater management, Time series, Hydrodynamics, Wet and dry years, Artificial groundwater recharge.*

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RESUME

L'eau souterraine est l'une des plus importantes ressources naturelles, particulièrement dans les zones arides et semi-arides. L'aquifère Shahrekord est situé dans une zone semi-aride et donc les eaux souterraines jouent un rôle important dans la satisfaction des besoins en eau potable, industrielle et agricole. Cette étude vise à évaluer et analyser à court et à long terme les séries dans le temps de l'aquifère de Shahrekord par une nouvelle méthode d'analyse appelée « dimensionless moving average time series analysis ». À cet égard, sont évaluées les informations climatologiques et piézométriques de 25 ans (1984-2008). L'évaluation des données montre que l'année absolument humide est survenue en 1993, alors que l'année absolument sèche en 2000 et s'est poursuivie jusqu'à 2004 dans les parties centrales. Au cours des années 1984 à 2008 : les années 1984-1986 étaient sèches, les années 1987-1990 étaient modérées et les années 1991-2000 étaient de nouveau sèches. La période de 2001-2004 était modérée au nord-ouest et au sud, alors que, dans les parties centrales elle était sèche. La fluctuation à court terme des eaux souterraines répond aux variations saisonnières des précipitations avec un décalage. En fait, tout aquifère des parties centrales fait face à la situation de stress hydrique. Dans cet aquifère, la gestion optimale de l'eau souterraine est essentielle. Pour atteindre cet objectif, il est nécessaire d'encourager la recharge artificielle et d'interdire la construction des nouveaux puits forés.

Mots clés: *Gestion des eaux souterraines séries dans le temps, hydrodynamique, années humides et sèches, recharge artificielle.*

1. INTRODUCTION

Increasing groundwater uses in many parts of the world especially in arid and semi arid regions, cause changes in the hydrodynamic behaviour of aquifers. Hydrodynamic assessment of groundwater aquifer will help making decisions for sustainable water resource management. The aquifer system of Shahrekord Plain mainly consists of deposits eroded from surrounding mountainous areas, which are deposited during ages on the plain. This aquifer has been the main source of water to meet agricultural, drinking, industrial and municipal needs since 50 years up to now. The largest groundwater supply of the aquifer system is recharge from the surrounding mountainous, which is injected to the plain aquifer.

Location of study area

Shahrekord Plain, covering about 650 km^2 and surrounded by Shahrekord Basin of 1211 km^2 area is located in the northeast of Charmahal and Bakhtiari province in the west of Iran. It is situated in the northern UTM latitude boundary from 3555460 to 3603530 and eastern UTM longitude boundary from 457948 to 515864. Figure 1 shows the schematic map of the study area. The climate in the study area is semi-humid or semi-dry depending on the classification method. The long term mean monthly temperature varies from -1.5°C in January to 24°C in July. Water supply is a very important issue in the study area, especially during summer.

2. OVERVIEW OF MONITORING NETWORK AND OBSERVATION DATA

In the study area, the groundwater monitoring network comprises 31 piezometric wells, at different depths. Distribution of piezometric wells is shown in Figure 1. The piezometric network has been completed in the central part. However it seems that in the margins, the network still needs to be extended. Until now, measurements have been done periodically by water level meter around the middle of each month.

3. DIMENSIONLESS MOVING AVERAGE TIME SERIES ANALYSIS

Plots of time-variant data with time shows fluctuations. Moving averages smooth a data series and make it easier to spot trends. One of the most frequently used methods for smoothing a time series is the method of the simple moving average (Alizadeh, 1999; Fox, 1975). Using of number of orders is depending on the fluctuation of data. To smoothen the monthly and seasonal effects on groundwater fluctuations, a simple moving average of 12th order is applied in Shahrekord Plain aquifer as:

$$\bar{h}_{12mav} = \frac{\sum_{i=1}^{12}(h_i + h_{i-1} + h_{i-2} + ... + h_{i-11})}{12}$$

Where, $\bar{h}_{12mav}$ is 12th order simple moving average of groundwater level, h is groundwater level of 12th order, $\bar{h}_{i-1}$ is groundwater level of first backward order and h_{i-11} is groundwater level of 11th backward order. Making dimensionless data reduces the range of fluctuation to facilitate comparison. In order to making the data dimensionless, the results of moving average is divided by long term average of groundwater level as shown below:

$$\bar{h}_{dmles} = \frac{\sum_{i=1}^{12}(h_i + h_{i-1} + h_{i-2} + ... + h_{i-11})}{12\,\bar{h}_{long}}$$

Whwre, $\bar{h}_{dmles}$ and $\bar{h}_{long}$ are 12 order dimensionless moving average and long term moving average of piezometric groundwater level, respectively.

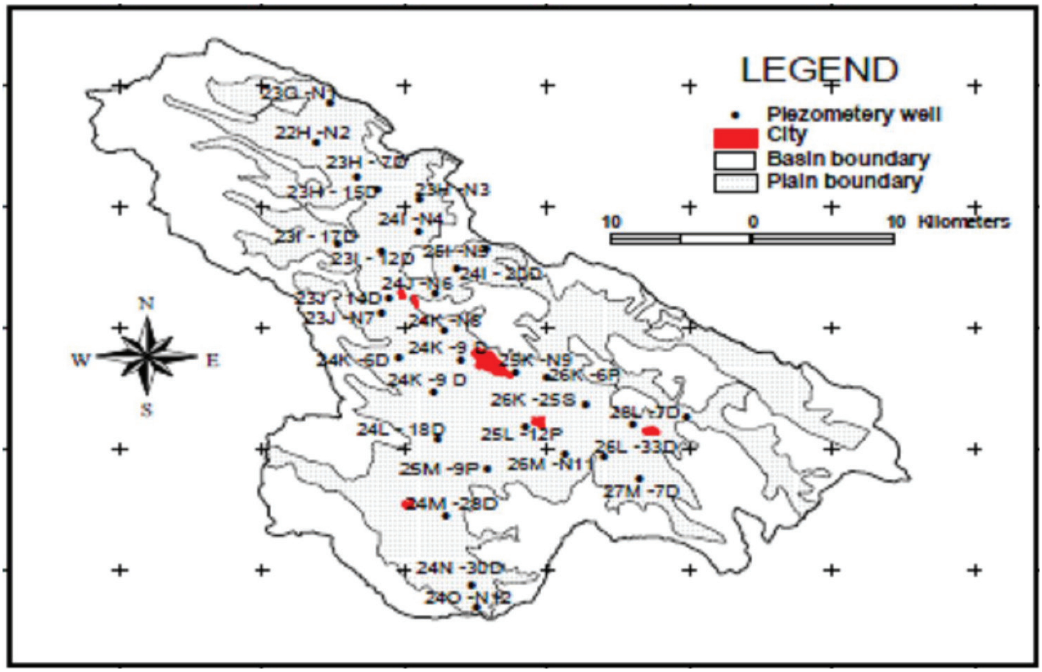
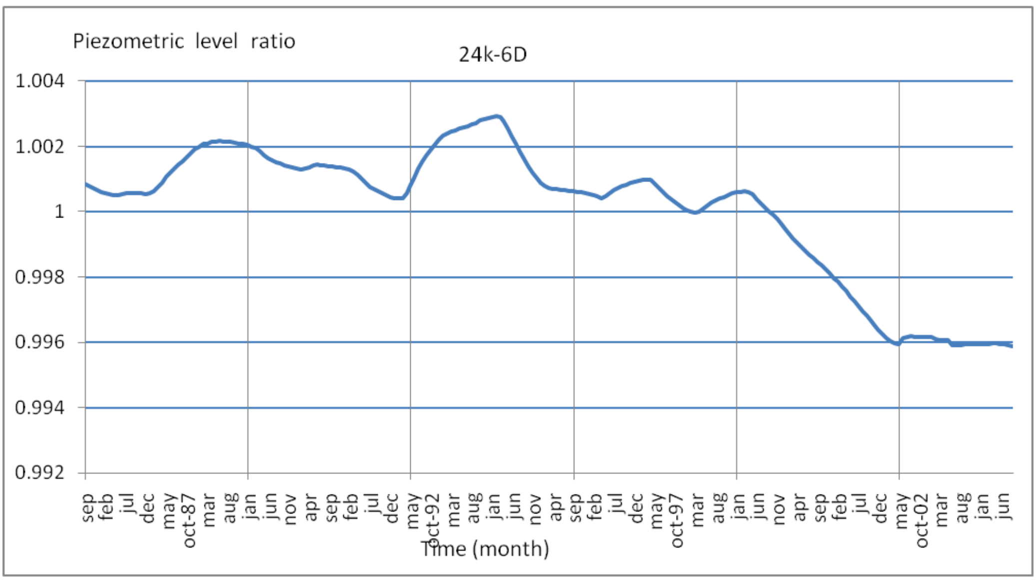
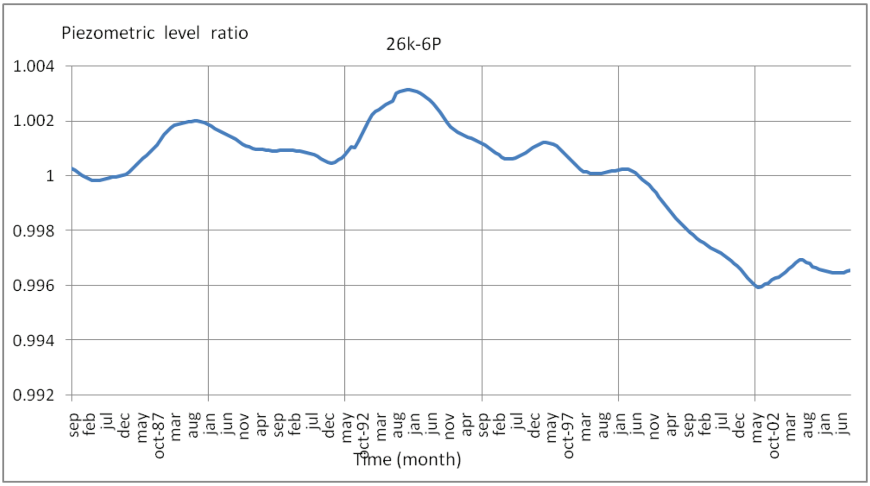


Fig.1: Location of piezometers in the study area

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1.002
1
0.998
0.996
0.994
0.992
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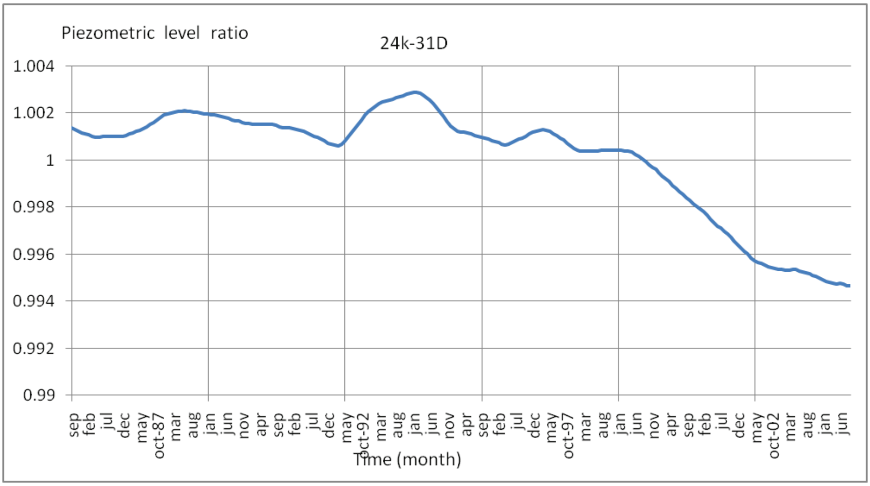
Time (month)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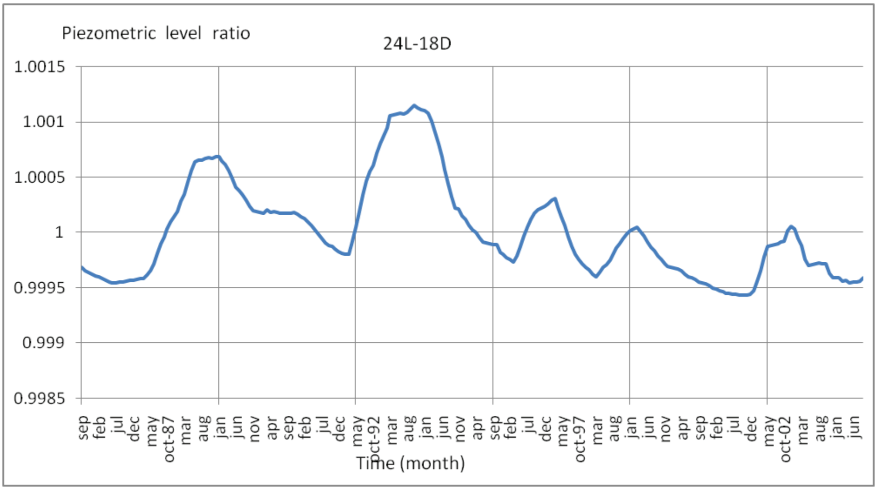
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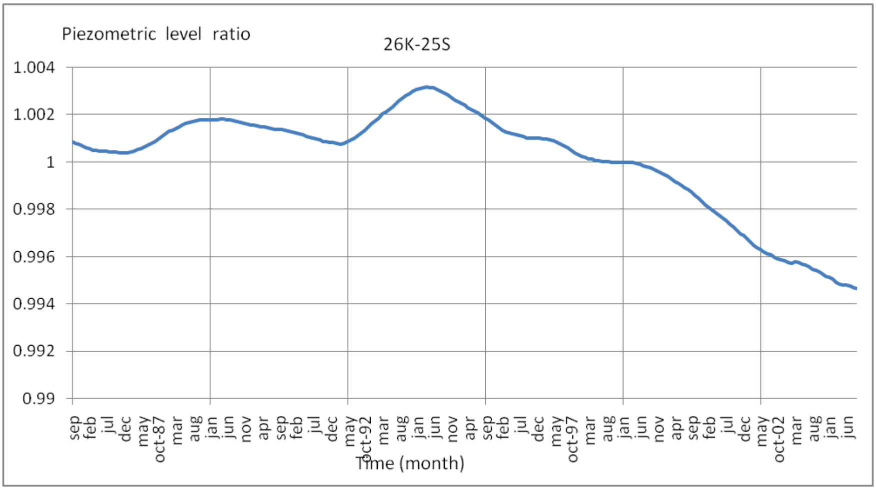
Time (month)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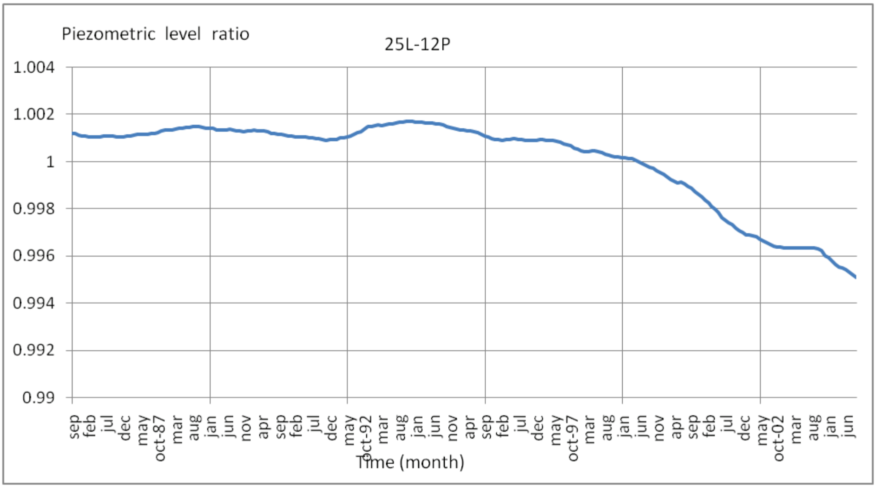
Time (month)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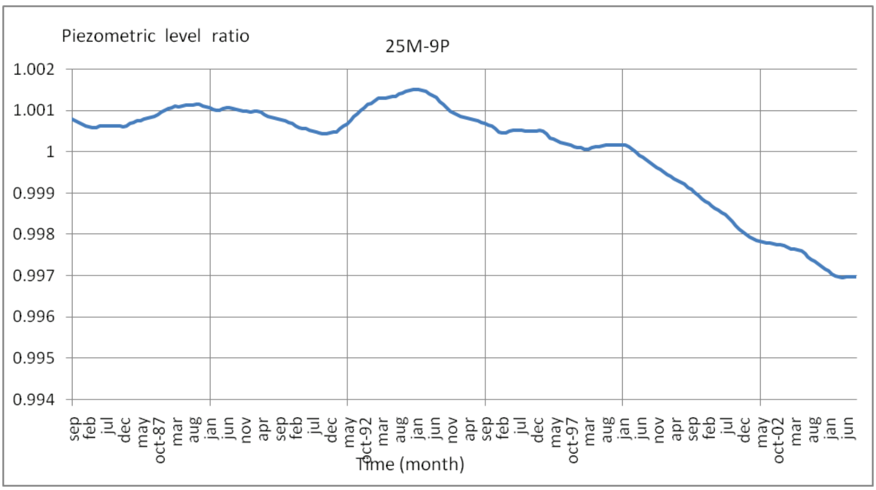
Time (month)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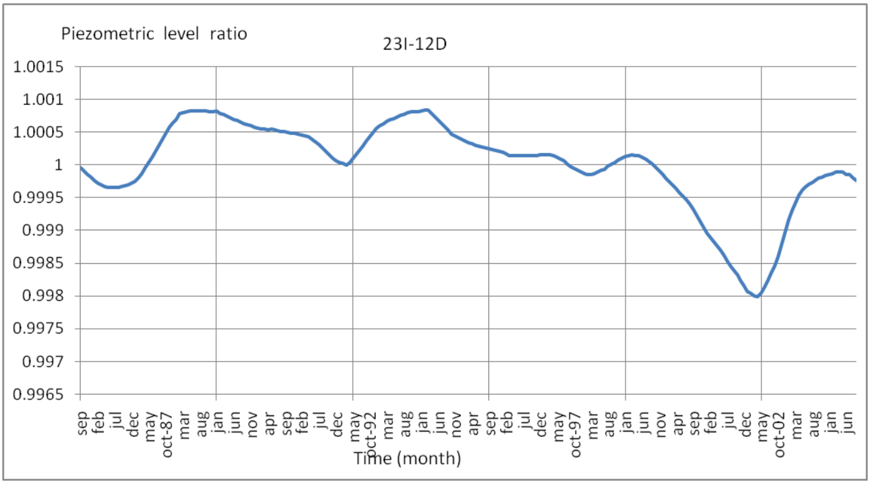
Time (month)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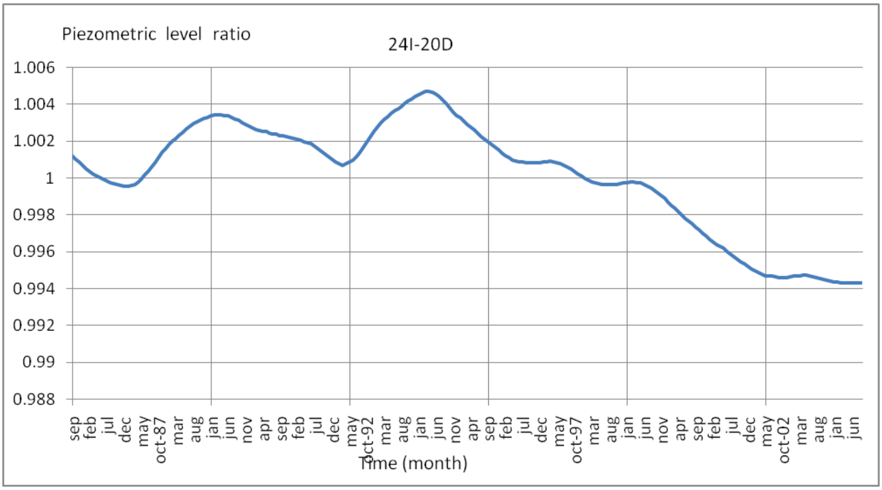
Time (month)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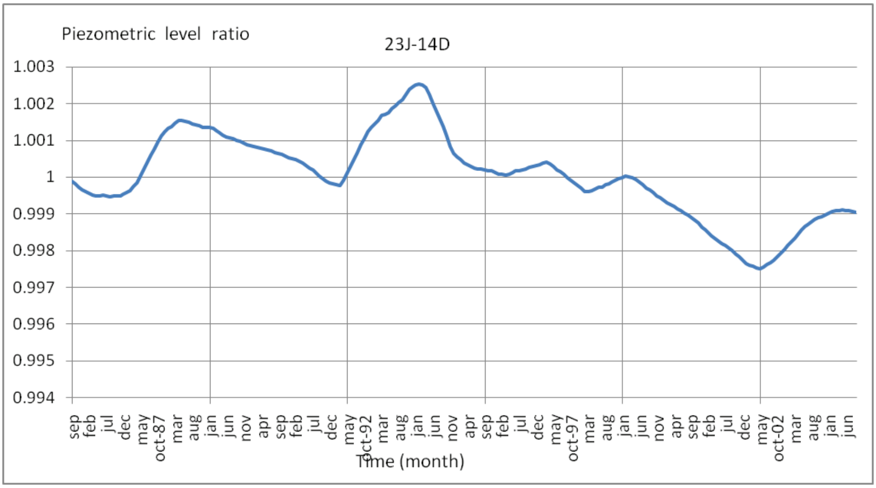
0.99
0.988
Time (month)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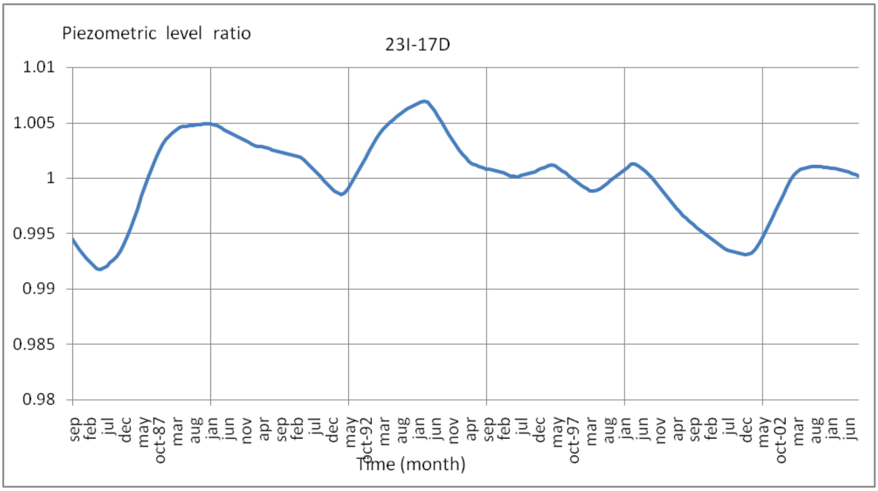
0.998
0.997
0.996
0.995
0.994
Time (month)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0.99
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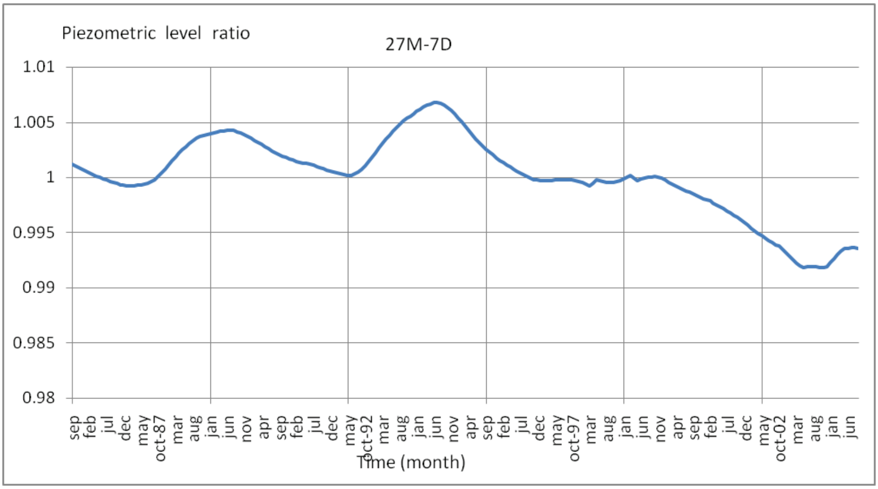
0.98
Time (month)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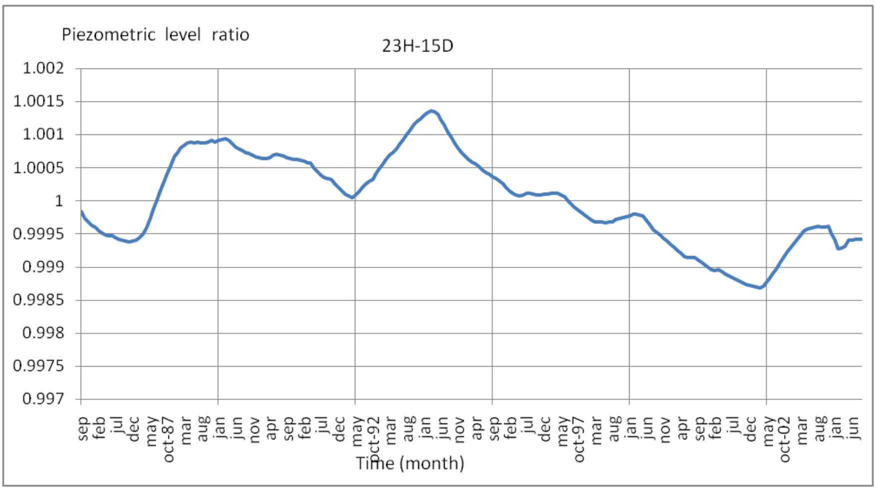
Time (month)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Time (month)

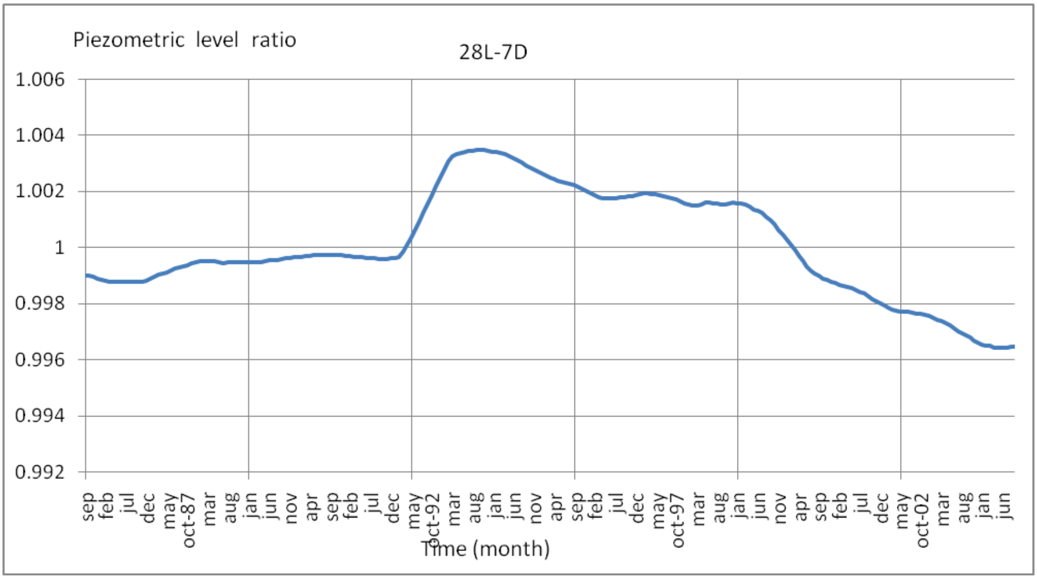

Fig. 2. Dimensionless Long term Groundwater level fluctuation in piezometers

4. RESULTS AND DISCUSSION

Results for all 19 piezometers are shown in Figure 2. As shown the new method analysis gives very good idea about the condition of fluctuation in the aquifer system. By paying attention to the behaviour of whole smoothing graphs, the absolutely highest groundwater levels were recorded in the whole study area in 1992-93, while the absolutely lowest levels were found in 2000-2001 in the north-west and at the outlet, whereas in the central part, lowering of levels was continued till 2003-04 as shown in Figure 1.

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