COMPARATIVE STUDY OF WATER LEVEL FOR GROUNDWATER RESOURCES MANAGEMENT AT URBAN AREA IN THE SOUTHEASTERN PART OF THE ARABIAN PENINSULA REGION

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ABSTRACT

Groundwater resources are playing a vital role in the sustainability and development of the natural resources of the United Arab Emirates (UAE). In previous decades, the studied area in the southeastern part of the Arabian Peninsula region and the UAE has witnessed intensive developments and urban constructions, which have led to water demand increasing for farming, landscaping, as well as for domestic uses. The study area belongs to quaternary and limestone aquifer. The quaternary aquifer is composed of sand, gravel, silt as well as intercalated clay and shale layers. However, the limestone aquifer is represented by carbonate rocks as well as interbedded shale, clay and evaporate deposits. The main objectives of this study are to investigate groundwater condition represented by water level fluctuation and to analyze the setting of water level and its possible environmental risk. The objectives of this study were achieved by comparing water levels in 2010 and 2014.The water levels within the study area have risen to be between 2.3 m to 15 m from the ground surface. The results showed that the water levels are not uniform, rather than vary from one zone to another depending on the nature of the soil, sources of recharge and the population growth. The groundwater rising phenomenon in some zones is due to the inability of the aquifer to store and transmit more water due to weak hydrological properties as well as the occurrence of perched layers at the shallowest depths. By contrast, the deepest groundwater levels may reflect the impact of excessive pumping from the aquifer and improper well design. Additionally, the water level fluctuations in the study area resulted from seasonal rainfall and the stream runoff, which takes place in winter, and increase in temperature associated with semi-arid conditions in summer season. The outcomes of this study may be regarded as an early warning for the stockholders and decision makers in the municipality for consideration ahead of licensing of new buildings.

Keywords: Groundwater level, Arabian Peninsula, Groundwater resources, Management

1. Introduction

The groundwater plays a significant role as destructive or constructive upon the environment. The constructive impact can be observed easily in the development process such as domestic, agriculture and industrial water uses. In addition, it can play a destructive role as groundwater level rise and effects foundations of civil constructions. Sheab Al Ashkher represents one of the urban districts in Al-Ain city, which was targeted by study the water level regime by Murad *et al* (2010). The groundwater level rise in Al-Ain city became a true problem due to the intensive urban, agricultural, industrial as well as the touristic development through the last decade, which included the study area and other new residential districts. This problem and its environmental impact upon the foundation of the urban zones has been investigated and surveyed by many researchers. El Saiy *et al*. (2013) indicated how far the water level rise affect the basement foundation of Al Shuaiba residential area in Al-Ain area because of the complex nature of the subsurface quaternary deposits and the underlained carbonate rocks. In addition, other study combined the hydrogeological data with subsurface geological conditions and indicated that constructors of buildings and infrastructure in most central part of the city need to pay attention to the changing situation in groundwater level and related effects on the stability of foundation substrate (Murad *et al*., 2013). Also, Murad *et al*. (2010) revealed that it the fluctuation of water level that was varying from shallowest levels to the same depth to the groundwater level controlled by the nature of sediments and the poor characteristics of the underneath carbonate aquifer that had a very low permeability and transmissivity values. Eventually, the impact of climate change in the study area may not be considered as an effective reason for water level rise because the area lies in the arid and semi-arid region. This study is aimed to find the historical variability in groundwater level, and its probable positive or negative impact upon the foundations of the existing buildings. This could be done by comparing the water level setting in 2010 and 2014 to be as an early warning indication to safe and secure the area from the environmental hazards that may be occurred due to water level fluctuations especially when it moves upward and cover the basement areas of the present residential buildings. In addition to that, this study is aimed to analyze the setting of water level and its probable environmental risk upon the foundation of the present buildings. Also, assisting the municipality decision makers to put an early warning plane to protect the area from any upcoming groundwater level negative impacts on the present foundations in case of its rise up.

2. Geological and hydrogeologial conditions of the study area

The study area is situated in Al-Ain city that lies in the eastern part of the Abu Dhabi Emirate, UAE, near the border with Sultanate of Oman and at the western margin of the northern Oman Mountains (Figure 1).It lies between longitude/latitude 55°42'01.3"E and 24°11'29.2"N and occupies about 40 Km². Locally, it is bordered from the north by the Zoo district, from the south-south west by Mubazarah tourist, forest area and Ayn Al Fayda spring, from the east and south east by western wing of Hafit anticline and cement factory quarry and from the west by residential and forest districts, respectively.it represents one of the new urban districts in Al Ain city which established through the last decades (Figure 2).

Figure 1: Map showing the location of the study area relative to the Arabian Peninsula.

However, the study area is situated adjacent to western side of Jabal Hafit it includes similar geological settings. Jabal Hafit is a 28 km long and 4 km wide asymmetric, doubly-plunging, NNW-SSE trending anticline which consists of shallow-marine carbonates of Eocene to Miocene age (Figures 3 and 4). Jabal Hafit is one of several prominent Tertiary structures in the frontal northern Oman Mountains, which trend parallel with the mountain range. It lies about 25 km from the western edge of the northern Oman Mountains and is separated from the latter by the Al Jaww plain. The Hafit structure consists of two en échelon anticlines, the Hafit anticline to the south and the Al-Ain anticline to the north (Noweir, 2000; Warrak, 1996). The study area belongs to quaternary and limestone groundwater aquifers. The quaternary aquifer is composed of sand, gravel, silt as well as intercalated clay and shale layers. On the other hand, limestone aquifer represented by carbonate rocks variable in density, fracturing properties as well as interbedded by shale, clay and evaporite deposits like gypsum and anhydrite. In addition to the basic hydrogeological conditions, there are recent water recharge sources around the area as shown.

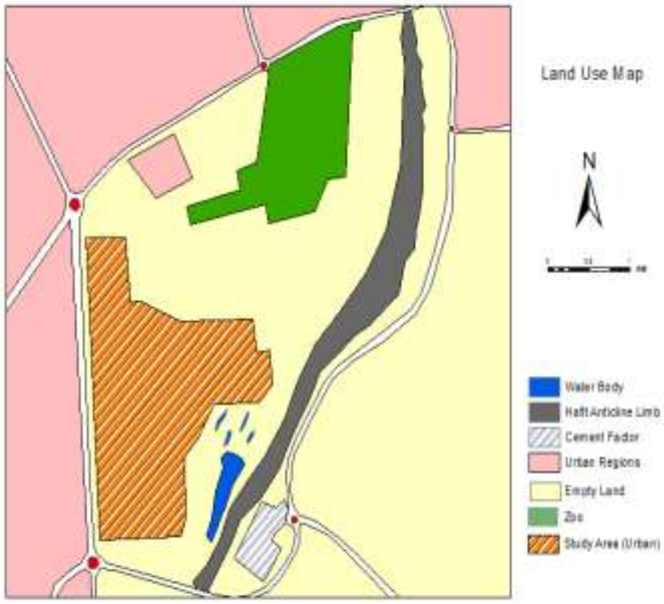

Figure 2: Land use map of the study area.

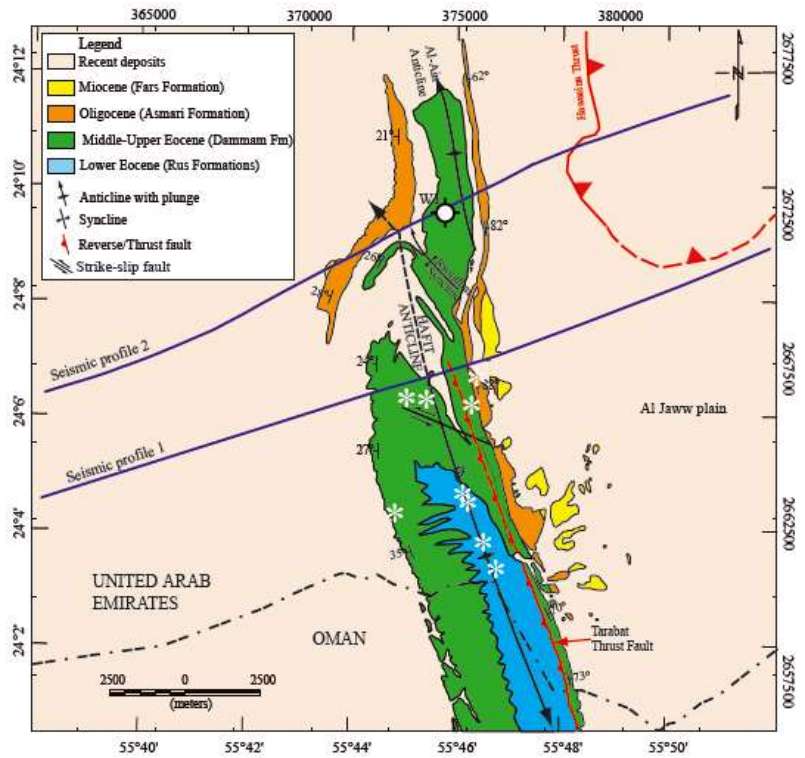

Figure 3: Geological map of Jabal Hafit and surrounding areas. Dark blue lines show the location of the seismic profiles. White filled circle indicates the location of well W1, which intersected the Tarabat thrust fault (ADNOC, 1990). White asterisks indicate the locations of rock samples taken for density analysis. Also shown is the extent of the Hawasina thrust sheet to the NE of the study area (Ali *et al*., 2008).

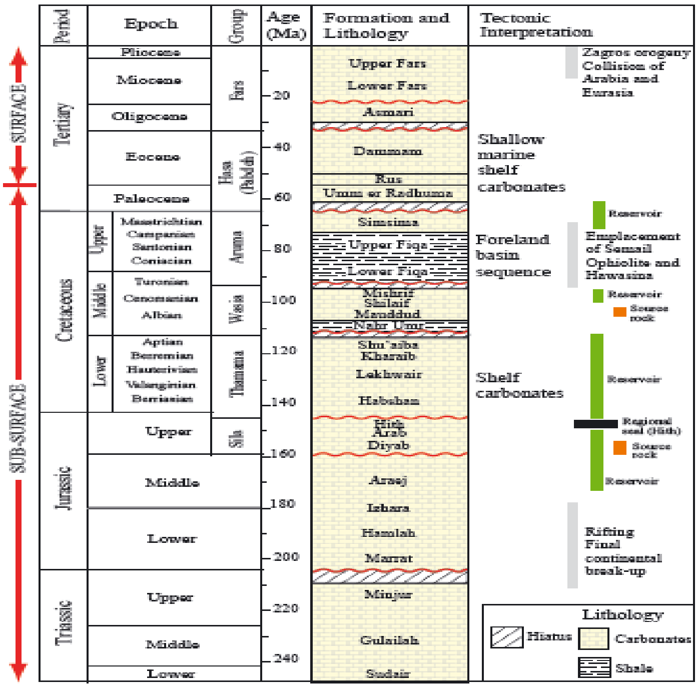

Figure 4: Stratigraphy of Jabal Hafit (modified from Noweir, 2000).

3. Methodology

Field visits were carried out along the study area and mainly targeted groundwater wells, dug and surface water points to detect the depth to groundwater level as well as sources of discharge and recharge. Groundwater level measurements were recorded in 2014 for 37 water points varied between groundwater wells, open pits and excavations (Figure 5). Depth to groundwater level was used as essential part of the water conditions criteria. An electric sounder was used to measure the depth of the groundwater level from the ground surface, as well as GPS (Garmin series 650) was used for measuring the coordinates.

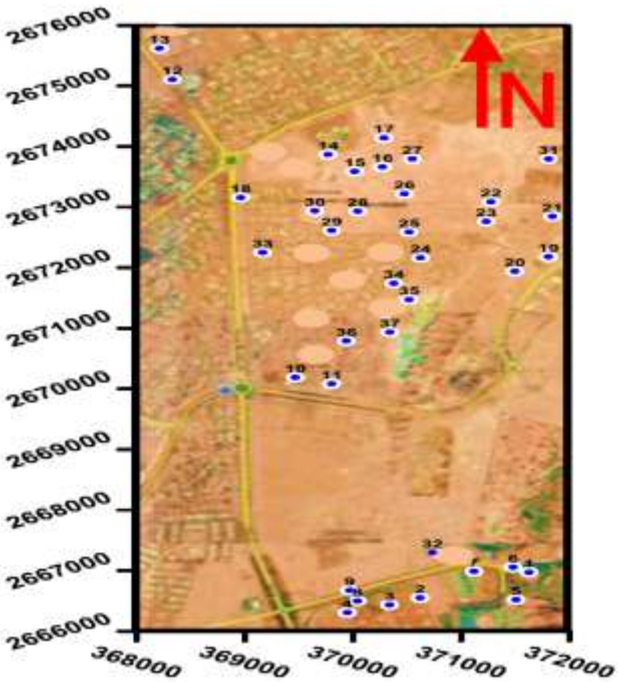

Figure 5: Location map of water points from the study area.

4. Results and discussions

The measured water level depths along the study area in 2014 varied from <3m to >15m from the well head level. As shown in Figure 6, the minimum water level depth attained in the west to south west sectors of the study area, while the maximum values appeared toward the east, south and north east directions. When these data are compared with the water level records in 2010 (Figure 6) (Murad *et al*., 2010), it revealed relatively the same range and directions of increase and decrease of water level except in the western and south western parts of the study area, where there was spreading out in the zone area which achieved water level depth<3m (see Figures 6 and 7). Furthermore, the constructed water table and flow direction contour map of the study area (Figure 8) exhibited visible consistency with the 2008 general water table and flow direction of Al Ain area (Faris Mahgoub, 2008), whereas the equipotential lines oscillated between 240-260 m above sea level along the area of study.

The recognizable variation of the water level depth in the study area could be ascribed to many acting factors as observed during the implementation of this work or confirmed in the previous works. The upsurge of water level seems to be directed by leakage of giant quantities of surface water into the upper most quaternary deposits which had limited thickness and overlain a complex nature sediments of carbonate aquifer that had poor properties of the (Murad *et al*, 2010), which relatively reduce the downward water movement. Additionally, the occurrence of clay or shale lenses inter-bedded in the quaternary deposits lead to the perched water feature that confirm shallower water depths <3m. On the contrary, the increase of groundwater level depths in the area >15m could be attributed to one of the following reasons or all of them such as severe groundwater exploitation, improper water well design, failure of the screening section of some wells, well dating expiry and finally the existence of numerous number of wells inside the buildings which are working far away from governmental legislations.

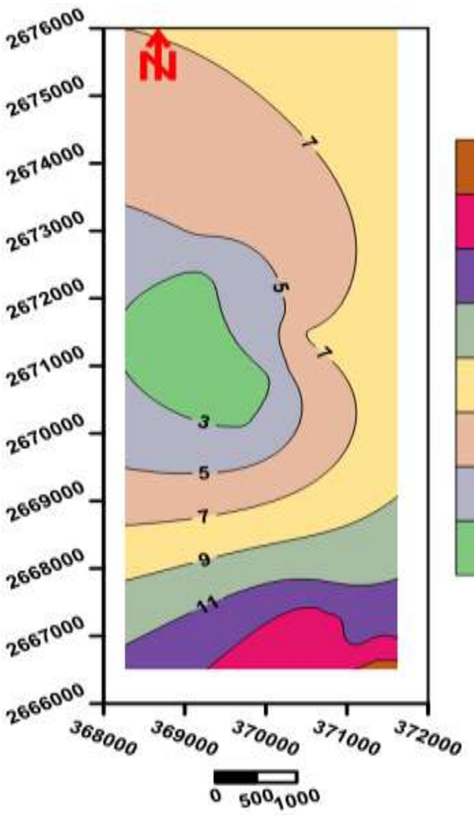

Figure 6: Water level contour map (2010).

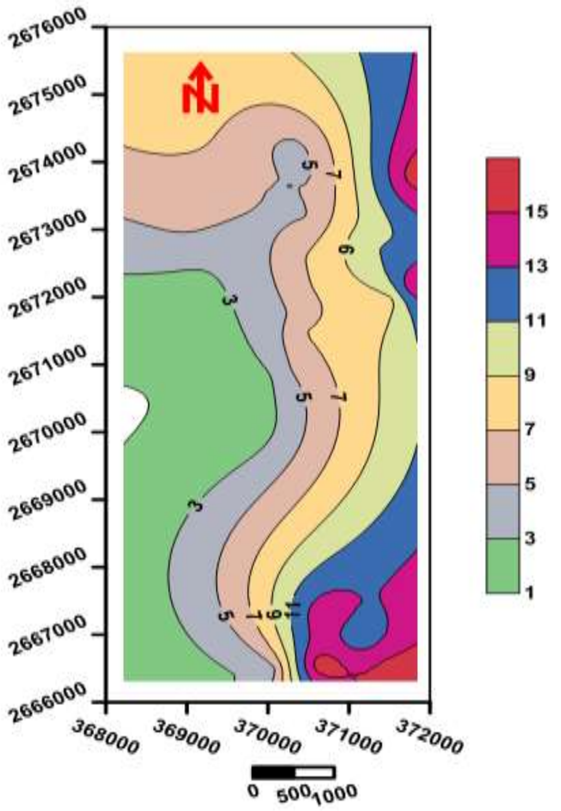

Figure 7: Water level contour map (2014).

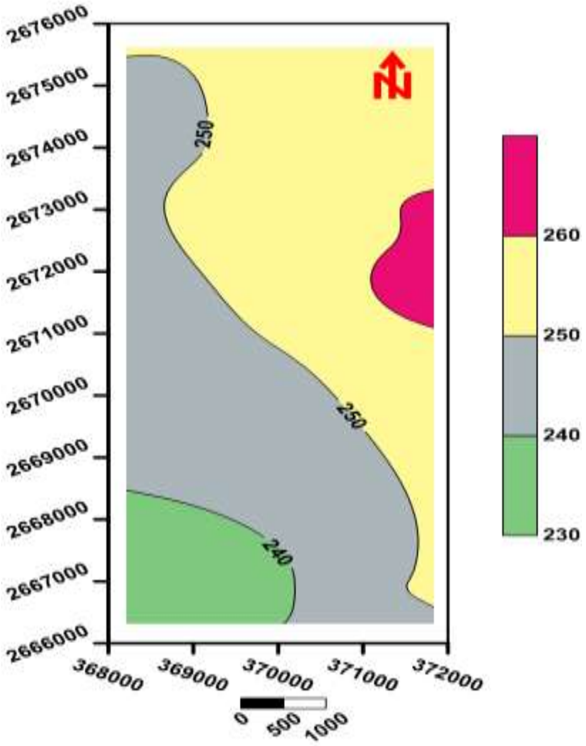

Figure 8: Water table & flow direction map 2014.

5. Conclusion and recommendation

Groundwater level setting is a vital part for municipal development and sustainability. This study showed high variability in water level records and relative consistency in water table and flow direction along the study area. As shown the shallowest water level zone <3m was recognized in the west and south western part of the study area that seems to be at the same level of the foundations basement which may for future will be affected by groundwater level rise and quality. Establishing groundwater monitoring wells network in the study area will support the availability source of records on groundwater level fluctuation and quality as well as early warning safety of the study area. In addition, true identification of foundation bedrocks as well as safety aspects of engineering constructions are required to discover the water rock interaction especially through the shallower water level zone of the study area. This is to establish models for upcoming probable variations in groundwater level, which could affect the soil and buildings stability.

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