

## Evaluation of Traditional Wells in Hiznah Village, Albaha Region, Saudi Arabia

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### ABSTRACT

This study aimed at evaluating 73 traditional wells in Hiznah village, Albaha region (Saudi Arabia). All information about the availability of water, well status, irrigation and drinking uses and associated plant species were recorded. The statistical method in terms of the determination of relationships between wells characteristics was analyzed using Spearman's correlation coefficient. Forty-seven (65.75%) of wells were concentrated in the north of study area, 14 wells (17.81%) in the middle and 12 wells (16.4%) in the south of the study area. The majority of wells (79.5%) showed water availability and almost (46.6%) of such wells were used for both irrigation and drinking purposes. Approximately, 58.9% of wells were open followed by 34.2% and 6.8% of covered and fenced, respectively. Plant species were associated with 35.6% of open and fenced wells. The plant species were; *Ficus palmata* (31.5%), *Celtus africana* (2.7%) and *Ficus vasta* (1.4%). The availability of water in most wells may reflect the energy of groundwater to feed them, which they are concentrated in the north of the study site and this may be due to increased recharge rates in these areas. Groundwater wells need further investigations regarding their quality to avoid any health hazards to crops, animals, and humans if water is to be used for irrigation and drinking.

**KEY WORDS:** ALBAHA, HIZNAH, VILLAGE, HYDROLOGY, WELLS, IRRIGATION, DRINKING, TOPOGRAPHY.

### INTRODUCTION

Freshwater is considered to be an important requirement for life, however, it represents only less than 3% of the total water volume in the world (Hahn, 2006). Groundwater is the one form of freshwater on earth and considered to be a renewable resource of water (APHA, 1998, 2012). Saudi Arabia is known as arid country and most of Saudi lands are deserts. The average of rainfall in Saudi Arabia is < 100 mm per year with

no permanent lakes or rivers. The main sources of water are surface water, groundwater and desalination. The surface water consists of water that mainly captured in approximately 260 dam reservoirs. On the contrary, the amount of groundwater depends on the recharge rate which is higher in shallow wells than deep wells (Ouda, 2013). Groundwater in Saudi Arabia has long been used as the main source for the accomplishment of different purposes, such as domestic and agriculture supply, especially during 1970s and 1980s (Alsuhaime et al., 2019).

The depth and water volume can be varied between traditional wells (hand-dug systems) (Yakubu, 2013). The agricultural sector consumes about 70% to 80% of freshwater in Saudi Arabia. However, up to five thousand litres of water are consumed for the production of 3 meals per person per day (Alsalah et al., 2015). In Saudi Arabia, quality assessments of groundwater have been

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studied previously (Al-Hasawi et al., 2018; Alsalah et al., 2015; Alsuhami et al., 2019; Bob et al., 2015; Ouda, 2013). To the best of author's knowledge, evaluating large number of traditional wells in one village in terms of scientific explanations for the distribution of wells, availability of water, well status, associated plant species and the possibility of water utilization for drinking and irrigation have not been addressed yet. Thus, the main objectives of this study are to evaluate all traditional wells in Hiznah village, Saudi Arabia during 2019, and to determine the relationships between the characteristics of these wells.

## MATERIAL AND METHODS

**The study sites:** The study area Hiznah is located west of Baljurashi, between lat. 19.85387 and lat. 19.827907 and between long. 41.53561 and 41.55814, with altitude ranges between 1900 and 2167 (Fig. 1). Hiznah is a 3 km<sup>2</sup> village located in the south of Albaha region, Saudi Arabia (Fig. 1). Almost 1.25 thousand people currently live in Hiznah village. All traditional wells of Hiznah village (73 wells) were selected during 2019, (Table 1). All information about each well in terms of the availability of water, well status, irrigation and drinking uses and associated plant species were recorded (Table 1). Statistical analysis: The statistical package of SPSS, version 20 (IBM) was used to analyze the data of wells characteristics (availability of water, well status, irrigation and drinking use and also associated plant species). Spearman's rank correlations coefficient (*r<sub>s</sub>*) was applied to examine the relationships between wells characteristics (Field, 2009).

## RESULTS AND DISCUSSION

In Hiznah village, numerous traditional wells (total of 73 wells) are distributed in its valley and were used for irrigation and drinking. Geographically, the wells were distributed as follow; 47 (64.4%) of wells were concentrated in the north of the village, 14 wells (19.2%) in the middle, and 12 wells (16.4%) in the south (Figure 3). Each well was owned by different families and each one of them had a day of watering. Each family also was responsible for maintaining and protecting the well.

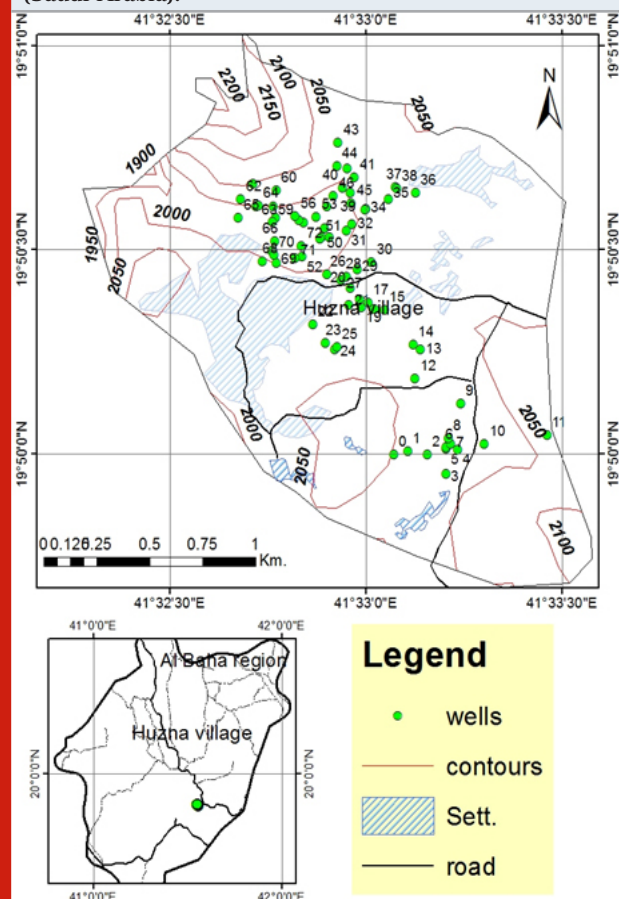
**Area topography and recharge of wells:** The age of Hiznah wells is unknown for exact. Structurally, most of the wells seem to be similar to each other reflecting the same period of time of the construction. The depth of the wells almost ranged from 15-25 m and the width range from 3 to 4 m. After precipitation of rain water, storing or moving of the water stream depends on geological locations (Plummer et al., 2013), topography, and climate (Condon & Maxwell, 2015; Grinevskii, 2014; Shahbazi et al., 1967). Groundwater moves from higher altitude areas to lower zones culminating in recharging of wells and increase water levels in this zone (Plummer et al., 2013).

In Hiznah village, wells are concentrated near agricultural fields located on the bottoms of the valleys and near the

settlements, especially in the north of the study area at the southern side of Hiznah mountain where most wells (64.4%) were seen below Hiznah mountain (Figure 1). Indeed, the topography features of this region resembling a water basin that contributes to the conservation and recharge of groundwater in large quantities. Condon & Maxwell (2015) found a strong relationship between topographic gradients and the fluxes of groundwater. Additionally, the study conducted by Rukundo & Dogan (2019) highlighted the role of spatial variations in determining groundwater recharge rates in the Ergene River catchment in Turkey. The middle part of Hiznah village contains a water basin that receives the water descends from the northern side of Madhan mountain and recharge the nearby wells (19.2%) (Figure 2). On the contrary, the wells in the south of Hiznah village represent (16.4%) of total wells (Figure 2). This area is rocky and surrounded by plateaus with agricultural terraces that absorb water and the wells are poorly fed as a result. Some of the water flows southward and not westward towards the boreholes. Also, the concentration of the population is low in this location compared to the north of the village. However, wells in this area are concentrated below the south of Madhan mountain.

**Availability of groundwater:** The availability of groundwater depends upon the recharge rates and not

Figure 1: The location of the study area with targeted wells (n=73) in Hiznah village in Albaha region (Saudi Arabia).



just the amount of residence water (Healy et al., 2007). These rates can be physically and directly measured by estimating water fluxes. Age of groundwater can be also estimated by tracing isotopes (Plummer et al., 2013). Availability of water in Hiznah village is presented in (Table 1) and (Figure 3A). Approximately 79.5% of the studied wells have water available, while just 20.5% of them showed no water available and this may be due to the low amount of rainfall that recharge groundwater. Geologically, weathering, recharge rate, and human activities can affect the physicochemical and microbial quality of groundwater (Sethy et al., 2016; Yakubu, 2013). This water can be unsafe for drinking and irrigation due to numerous health hazards that result from polluted water (WHO, 2017). The open system represents the majority of wells (58.9%), while covered and fenced wells represent 34.2% and 6.8%, respectively (Figure 3B). This open system in the village may affect the quality of water in terms of the ease of pollutants to access the water from the surrounding area.

The uses of water for drinking and irrigation in Hiznah village are presented in (Table 1) and (Figure 3C). Approximately, 46.6% of wells that have water available are used for drinking and irrigation, while other wells (53.4%) are not used for the same purposes. The reason for the low use in the village is that some people are no longer interested in agriculture because they are tenured governmental employees with a higher income than the agricultural sector. In addition, drinking water is now available via public municipal networks (desalination).

**Associated plants species:** Plant species associated with open wells in Hiznah village are presented in (Table 2) and (Figure 3D). Approximately, 35.6% of plant species

associated with open and fence system of the top of wells, while the remaining covered wells (64.4%) showed no association with any plant species. The natural plant species were *Ficus palmata* (31.5%), *Celtis africana* (2.7%) and *Ficus vasta* (1.4%) (locally called Hamat, Shopareq, and Roqqah, respectively). These three species are recorded from Albaha region, *Ficus palmate* and *Ficus vasta* are recorded between 1800 and 2800 m, and *Celtis Africana* between 1500 and 2500 m. The three species are not harmful and have economic uses (Al-Khulaidi, et al., 2016). A study on rare and endangered plant species in Albaha region conducted by Al-Khulaidi, et al., (2018) considered *Celtis africana* and *Ficus vasta* are rare species with frequency percentage of 1.56 and 1.25, respectively.

Green and blue-green algae are common and can be found in well water. The distinct green color in water can result from green algae with no potential health hazards. However, certain cyanobacteria (blue green algae) can produce toxins in the water that can be harmful to humans and animals (Gerba & Pepper, 2019; Sheath & Wehr, 2003). Up to 5.5% of wells showed a growth of green algae floated on the surface of water. All are open wells located in the north of the village and are not used for drinking and irrigation. The growth of green Algae in these wells may as a result of agriculture activities (in the form of fertilizers) and wastes of humans and animals, reaching into wells through runoff.

Figure 2: Figure 2. The distribution of targeted wells (n=73). Forty-seven (65.75%) of wells are in the north of the village, 14 wells (17.81%) in the middle, and 12 wells (16.44%) are located in the south.

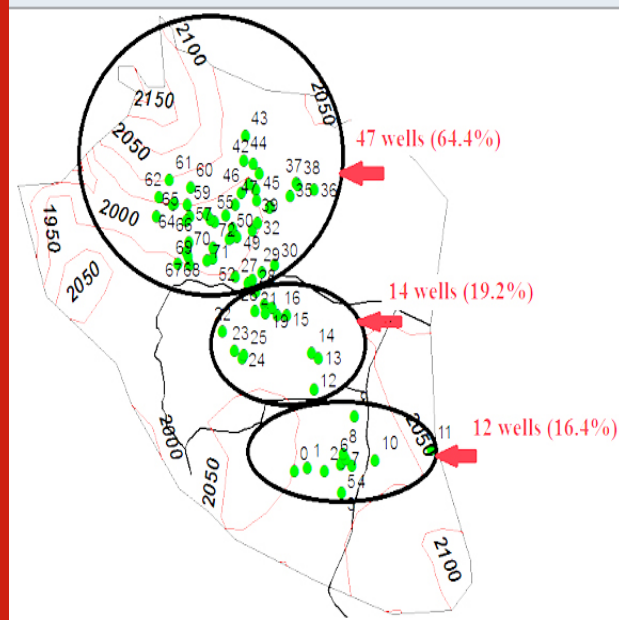


Table 1. Characters of targeted wells in Hiznah village, Albaha region, KSA (n=73).

Character of wells	North	Middle	South	Total
Wells with available water n (%)	41 (70.69)	11 (18.96)	6 (10.34)	58 (79.45)
Wells used for drinking & irrigation n (%)	26 (78.79)	5 (15.15)	3 (9.09)	33 (45.20)
Well status				
Covered	15 (65.22)	4 (17.39)	4 (17.39)	23 (31.51)
Fenced	4 (57.14)	2 (28.57)	1 (14.28)	7 (9.59)
Open	29 (67.44)	7 (16.28)	7 (16.28)	43 (58.90)

Table 2. Number of wells associated with different plant species in different locations of Hiznah village, Albaha region, KSA

Plant	Well's location		
	North	Middle	South
<i>Celtis africana</i>	1 (2.08)	0 (0)	0 (0)
<i>Ficus palmata</i>	17 (35.42)	3 (23.08)	3 (25)
<i>Ficus vasta</i>	1 (2.08)	0 (0)	0 (0)

Table 3. Relationships between different characteristics of wells in Hiznah village, Albaha region Saudi Arabia

characteristics	Availability of water	Well status	Irrigation and drinking use	Associated plants
Availability of water	-	N.S.	rs = .475**, p < 0.001	rs = -.330**, p < 0.001
Well status	N.S.	-	N.S.	rs = .375**, p < 0.001.
Irrigation and drinking use	rs = .475**, p < 0.001	N.S.	-	N.S.
Associated plants	rs = -.330**, p < 0.001	rs = .375**, p < 0.001.	N.S.	-

Key symbols: SU: standard unit, N.S.: not significant, rs: Superman's rank correlation.

Figure 3. Overall characteristics of wells and their utilization purposes in Hiznah village, KSA

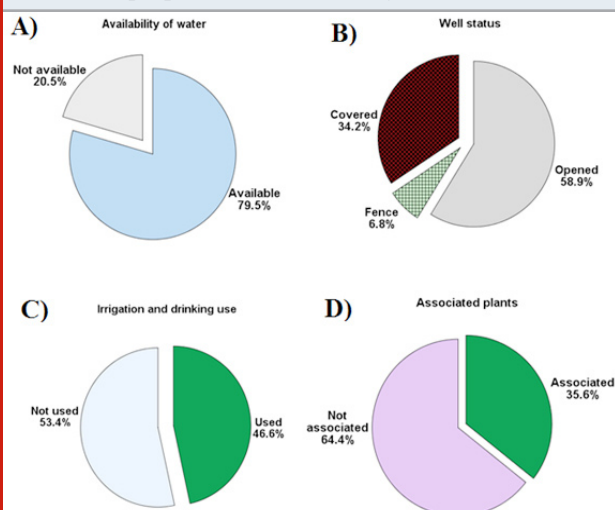
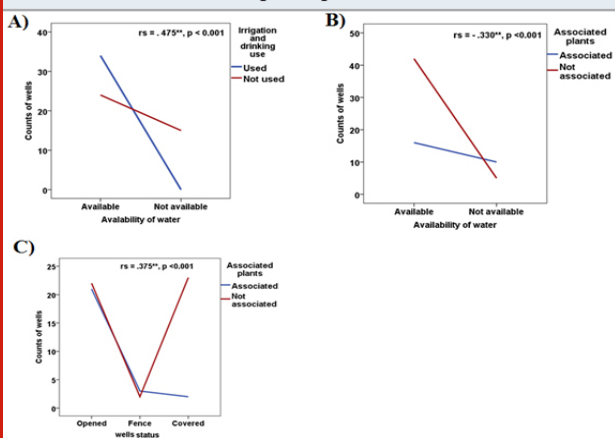


Figure 4. Relationship between wells' characters in Hiznah village, Albaha region, Saudi Arabia. Association of availability of water with utilization purposes (A), water availability and presence of associated plants (B), and well status association with plant presence (C).



Mohamed & Al-Shehri (2008) identified two cyanobacterial species (*Chroococcus minutus* and *Pannus spumososus*) in all samples of groundwater wells in Asir in Saudi Arabia. These species are known to produce toxins and can be harmful to human (Karan et al., 2017; John et al., 2015). In the investigation of twenty wells in Arar city in Saudi Arabia, Al-Shaikh (2017) detected six types of algae in four water wells. These types are *Amphora*, *Navicula*, *Nitzschia*, *Euglena*, *Cyclotella* and *Opephora*. This study recommended that the proper treatment of some wells water should be done before drinking.

#### Significant relationships between characteristics of wells:

Correlations analysis between all characteristics of wells in Hiznah Village is presented in table 3 and figures 4. The availability of water was positively correlated with irrigation and drinking use (rs = 0.475\*\*, p < 0.001) (Figure 4A). However, the availability of water was negatively correlated with associated plant species (rs = -0.330\*\*, p < 0.001) (Figure 4B). Well statuses were positively correlated with associated plant species (rs = 0.375\*\*, p < 0.001) (Figure 4C). Open and fenced systems of wells in the village showed the growth of plant species.

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